Government of Nunavut

Recommendations for the Development of Nunavut Municipal Wastewater Management Standards

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Executive Summary

This report provides recommendations for the Government of Nunavut - Community and Government Services in support of the development of territorial standards for municipal wastewater effluent limitations and monitoring programs. Community and Government Services identified that Nunavut-wide municipal wastewater standards are necessary to promote consistency and clarity in the licensing process. Community and Government Services has defined the course of promulgating such a standard differs depending on if the standards are to be a regulation or a guideline. A wastewater regulation could be developed under the Government of Nunavut authority through legislation. A wastewater guideline could be developed under the Water Board authority. Both courses require the framework for the standard be defined.

Community and Government Services retained the services of **exp** to provide the framework and recommendations for the territorial standards. The effluent limitations and the monitoring program recommendations were developed based on scientific studies and best practice jurisdictional review. It is recommended effluent discharge limitations be determined based on a tiered approach: technology-based limitations applied at a minimum augmented with site-specific water quality-based limitations if determined to be necessary.

Technology-based limitations establish a minimum level of effluent quality that is attainable using demonstrated technologies that are economically available. This approach parallels the United States Environmental Protection Act. Lagoons and wetlands are the most economical and practical technology for Nunavut communities. Scientific studies assessing the performance of lagoons and wetlands in Nunavut show that Biological Oxygen Demand and Total Suspended Solids of 100 mg/L and 120 mg/L respectively are attainable. Wetland treatment areas in the north are now better understood and models have been developed to predict the treatment capacity of systems. Adopting a standardized framework for delineating and optimizing wetland areas will reduce the uncertainties in the performance of wetlands, and will provide substantiation for inclusion of wetlands in the wastewater treatment facility definition. Technology-based limitations for Biological Oxygen Demand and Total Suspended Solids of 100 mg/L and 120 mg/L respectively are recommended.

Water-quality based limitations should be informed by water quality standards with consideration of aquatic and public health. Scientific studies in Nunavut have demonstrated the environmental health of the receiving water is protected for flows less than 2,500 m^3/day at discharge concentrations of Biological Oxygen Demand and Total Suspended Solids of 100 mg/L and 120 mg/L respectively. It is recommended water quality based limitations more stringent than the technology based limitations be applied on a case-by-case basis, informed by the sensitivity and use of the receiving environment and applied at the edge of a mixing zone.

It is recommended sampling programs be site specific depending on the receiving environment's risk level, type of system, and the size of system. Given the challenges associated with maintaining sample integrity when shipping to an accredited laboratory, it is recommended onsite- testing for time sensitive biological parameters is assessed.

The recommendations in this report can be drawn on to inform the policies, legislation, regulations, or guidelines required to progress a territorial municipal wastewater standard.

Table of Contents

List of Tables

List of Figures

Appendix A: Section 1 Supplemental Tables
Appendix B: Section 2 Supplemental Tables

List of Abbreviations

List of scientific abbreviations

BOD	Five Day Biological Oxygen Demand
cBOD	Five-Day Carbonaceous Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CFU	Coliform Forming Units
DO	Dissolved Oxygen
FC	faecal coliform
ha	hectare
HRT	Hydraulic Retention time
lpcd	litres per capita day
NH_3-N	Un-ionized Ammonia Nitrogen
pop	population
TOC	Total Organic Carbon
TRC	Total Residual Chlorine
TSS	Total Suspended Solids
WET	Whole Effluent Toxicity

List of agency and regulatory abbreviations

AANDC	Aboriginal Affairs and Northern Development Canada
CAEAL	Canadian Association of Environmental Analytical Laboratories
CCME	Canadian Council of Ministers of the Environment
CSSP	Canadian Shellfish Sanitation Program
CWA	Clean Water Act
ECCC	Environment and Climate Change Canada
GN	Government of Nunavut
GN-CGS	Government of Nunavut Department of Community and Government Services
GN-DoE	Government of Nunavut Department of Environment
GN-DoH	Government of Nunavut Department of Health
INAC	Indigenous and Northern Affairs Canada
MWWE	Municipal Wastewater Effluent
NPDES	National Pollutant Discharge Elimination System
NWB	Nunavut Water Board
NWT	Northwest Territories
NWNSRTA	Nunavut Waters and Nunavut Surface Rights Tribunal Act
SNP	Surveillance Network Program
SCP	Spill Contingency Plan
US EPA	United States Environmental Protection Agency
WSER	Wastewater Systems Effluent Regulations
WQS	Water Quality Standards

Introduction

The Government of Nunavut Department of Community and Government Services (GN-CGS) contracted **exp** Services Inc (**exp**) to develop a recommendation report to reference as part the discussions for appropriate wastewater standards in Nunavut. The GN-CGS does not currently have regulatory authority or enforcement power over wastewater discharges however, the GN-CGS is responsible for the implementation of any wastewater guidelines or regulatory standards adopted, and therefore needs to be an integral stakeholder in their development. This report can be used to support discussion during the development of wastewater standards, as well as can support the substantiation of appropriate water licence effluent limitations and monitoring program requirements.

A companion report to this Recommendations Report is the August 2017 Background Report. The Background Report presents a regulatory overview, highlights the relevant findings from various research programs, and provides a review of current municipal water licences. The Background Report is structured to be easily referenced for a list of technical papers and documents pertinent to wastewater management in Nunavut; for responses to media and community queries regarding past research; and for reference information for briefing notes.

It is practical the wastewater guidelines and conditions in water licences be informed by the findings from the Dalhousie University - Centre for Water Resources Studies wastewater treatment research, other northern wastewater research, other jurisdictions' regulatory practices, and with considerations of the unique challenges for wastewater management in Nunavut. **Exp** and their supporting team have prepared this recommendations report based on the northern and Arctic wastewater research findings, a review of the current water licences, and a review of other jurisdictions' regulatory practices.

In the development of this report, all Nunavut water licences were current to the time of their assessment through the Nunavut Water Board Public Registry (March 2017), and any subsequent amendments and/or licence renewals were not reviewed. For purposes of this report, a sample (ten) of the NWT water licences were reviewed (Inuvik, Fort Smith, Hay River, Fort Liard, Dettah, Enterprise, Fort Resolution, Fort Simpson, Fort Providence, Tulita). These were selected to provide a subset of varying treatment systems (mechanical, engineered lagoon and natural lake), population variations (100-4000 people), and issuance by three different Land and Water Boards.

Section 1 - Recommendations for Wastewater Effluent Limitations

Wastewater treatment systems must be designed to operate in Nunavut and to protect environmental and human health. The six-year collaborative research campaign lead by GN-CGS with Dalhousie University Centre for Water Resources Studies has confirmed that passive wastewater treatment systems are effective in treating wastewater under Arctic conditions. The research demonstrated that the current level of treatment in Nunavut small communities is sufficient to produce minimal impacts on the receiving environment, however there is a flow threshold combined with receiving water characteristics, that have severe impacts.

Increasing the stringency of effluent limitations is, therefore, seen as an investment that places an unnecessary and long-term socio-economic burden on Nunavut communities. Formally recognizing this in the development of wastewater standards through policies, guidelines and regulations would reduce the socio-economic burden of justifying applicable wastewater effluent limitations during each water licence application. The recommendations for wastewater effluent limitations to inform the development of standards are outlined in this Section.

1-1 Application of Regulations

There are numerous regulations and guidelines that may apply to a specific wastewater treatment facility. The applicable regulation(s) and guideline(s) are commonly determined based on flow rates, influent characteristics and/or receiving water characteristics. Select regulations, and the triggers that determine their application, are reviewed in this Section.

1-1.1 Wastewater Systems Effluent Regulations

Authorized under the Fisheries Act, the Wastewater Systems Effluent Regulations (WSER) came into force for Southern Canada in 2012. The WSER require technology-based secondary treatment. The WSER apply to any wastewater system designed to, or collects on average, a daily volume of 100 m^3 or more of influent. The WSER do not apply to Nunavut.

To better appreciate the territorial context of 100 m^3/day, the estimated sewage generation rates for the 25 Nunavut communities were calculated using the assumptions and equations presented in the Water and Sewage Facility Capital Program Standards and Criteria as published by the Government of the NWT. The actual water usage as reported in the most recent Annual Report[1] was also tabulated for comparison. Six communities were well below the 100 m^3/day trigger. Five communities were within ±15% of 100 m^3/day and fourteen communities were above 100 m^3/day. Eleven of the fourteen were below 300 m^3/day with three outliers; Resolute Bay above 900 m^3/day, Rankin Inlet above 1700 m^3/day and Iqaluit approaching 3000 m^3/day. Appendix A Table 1 presents this analysis.

[1] 2014 – 2016 reports, downloaded March 2017

1-1.2 United States National Pollutant Discharge Elimination System

The United States Environmental Protection Agency (US EPA) promulgated regulations under the Clean Water Act (CWA) establishing technology-based secondary treatment standards that are federally regulated. A National Pollutant Discharge Elimination System (NPDES) permit is required for any wastewater discharged to waters of the United States (US) with the exception of wastewater originating from a toilet and hand washing wastewater of less than 1500 gallons per day (~5.7 m^3/day).

The CWA section 301 (h) provides a variance from meeting secondary treatment standards for facilities that discharge into well-flushed marine waters. For the issuance of a section 301 (h) modified permit, the applicant must satisfy nine criteria. These criteria are further examined in Section 1-2.2.4.

1-1.3 Nunavut Water Licences

The Nunavut Waters Regulations Schedule 3 "Licensing Criteria for Deposit of Waste" states a licence is required for any deposit of waste. The water withdrawal rate for the municipality determines the type of licence required (Type A or Type B). The type of licence has no regulatory bearing on the effluent quality objectives.

1-2 Wastewater Effluent Limitations

Wastewater effluent limitations are typically established under two scenarios; technology-based and water quality-based. Technology-based effluent limitations are established based on the treatment that can be achieved by present-day technology under the geographic and climatic conditions of the treatment system. Water quality-based effluent limitations are established based on the sensitivity and the use of the receiving water environment.

1-2.1 Wastewater System Effluent Regulations

The CCME Municipal Wastewater Effluent Strategy (CCME Strategy) details effluent requirements for a technology-based approach and an environmental risk-based approach. The WSER, as authorized under the Fisheries Act, regulate the technology-based limitations. The WSER authorize the deposit of the deleterious substances: carbonaceous biological oxygen demand (cBOD); total suspended solids (TSS); total residual chlorine (TRC); and un-ionized ammonia subject to certain conditions.

The inclusion of Environmental Effects Monitoring program was proposed as part of the CCME Strategy however was not promulgated. This approach proposed the effluent be evaluated for a one-year period to characterize the effluent. An assessment of the receiving environment would then be conducted to determine whether the levels of substances being discharged are negatively impacting the receiving environment. For levels of a substance that are not protective of human health or the receiving environment, a more stringent effluent limitation would be required than those prescribed by the technology-based effluent limitations.

1-2.1.1 Technology-Based Effluent Limitations

The effluent limitations for cBOD, TSS, TRC and un-ionized ammonia are those considered equivalent to what can be "achieved with a minimum of conventional secondary treatment".[2] Only TSS, cBOD and unionized ammonia are presented in this report as chlorine disinfection is not currently used in Nunavut's wastewater systems, and is not anticipated to be used at any time in the foreseeable future.

1-2.1.1.1 Total Suspended Solids

The WSER define TSS as a deleterious substance with a minimum treatment requirement of 25 mg/L. The WSER allow for variances above 25 mg/L of TSS in the summer months as defined in Section (6) Authorization to Deposit:

> *6 (5) For an intermittent wastewater system or a continuous wastewater system with a hydraulic retention time of five or more days, the determination of the average [suspended solids] is not to take into account the result of any determination of the concentration of suspended solids in a sample of effluent [ ] that was taken during the month of July, August, September or October, if that result is greater than 25 mg/L.*
>
> *6 (6) If subsection (5) applies to every sample [ ] that is used to determine the average [ ], that average is deemed to be 0 mg/L.*

1-2.1.1.2 cBOD

The WSER define cBOD as a deleterious substance with a minimum treatment requirement of 25 mg/L.

1-2.1.1.3 Ammonia

The WSER define un-ionized ammonia as a deleterious substance with a minimum treatment requirement of 1.25 mg/L, expressed as nitrogen (N), at 15 degrees C.

1-2.1.2 Water Quality-Based Criteria

Canadian Environmental Quality Guidelines or jurisdictional equivalents, establish water quality objectives that should be met for the protection of aquatic health. Human health criteria are captured in Health Canada's Recreational Water Quality Guidelines. These guidelines, in conjunction with any Territorial/Provincial water quality guidelines provide the basis for the development of site-specific water-based criteria.

1-2.1.2.1 Human Health Criteria

The Federal Government has presented that "the purpose of the Wastewater Systems Effluent Regulations is to reduce the threats to fish, fish habitat and human health from fish consumption by decreasing the level of deleterious substances deposited into waters frequented by fish, from wastewater effluent."

The WSER's risk assessment, to establish the timeframe for when upgrades are required, allocates a weighted ranking from 5 (lower risk) to 25 (higher risk). The ranking of 20 points is

[2] MWWE Tech Supplement 2

allocated to any wastewater system for which the final discharge point is within 500 m of shellfish harvesting. The WSER's limitations are silent on specific faecal coliform limitations.

Health Canada's Recreational Water Quality Guidelines recommend faecal coliform limitations for primary contact, such as swimming, not exceed 200 CFU/100 ml (mean of 5 samples) and for secondary, such as boating, not exceed 1000 CFU/100 ml. The guidelines also note limitations for enterococci, an indicator organism that is often used in place of *E. coli* in marine environments as 75 CFU/100 ml for primary contact and 135 CFU/100 ml for secondary contact. Guideline values for faecal indicator concentrations in marine recreational waters established by other countries or organizations are summarized in the Guidelines for Canadian Recreational Water Quality.

The Canadian Shellfish Sanitation Program (CSSP) is led by the Canadian Food Inspection Agency in collaboration with Environment Canada and Fisheries and Oceans Canada so that:

- bivalve molluscan shellfish are harvested from growing areas meeting approved federal water quality criteria;
- potential pollution sources in these areas are identified; and
- all shellfish sold commercially are harvested, transported and processed in an approved manner.

The CSSP specifies five main categories of classification; approved, conditionally approved, restricted, conditionally restricted and prohibited. In relation to faecal coliform, the approved classification requires "Most Probable Number of the water does not exceed 14/100 ml, and not more than 10% of the sample exceed a faecal coliform MPN of 43/100 ml, for a five-tube decimal test."[3]

1-2.1.2.2 Acute Lethality

The WSER define acute lethality as effluent that at 100% concentration kills, during a 96-hour period, more than 50% of the rainbow trout subjected to it. The WSER Subsection 6 (1) permit "the deposit of effluent that contains any of the deleterious substances prescribed in Section 5 via the system's final discharge point in any water or place referred to in Subsection 36(3) [Fisheries Act] if the effluent is not acutely lethal".

1-2.2 United Stated National Pollutant Discharge Elimination System

The US EPA regulates discharges of pollutants from municipal wastewater treatment plants through a system of permitting. A permit provides two types of control: technology-based limitations (based on the technological and economic ability of the dischargers) and water quality-based limitations (to protect the quality of the specific waterbody).

[3] Canadian Shellfish Sanitation program – manual of operations (http://www.inspection.gc.ca/food/fish-and-seafood/manuals/canadian-shellfish-sanitation-program/eng/1351609988326/1351610579883)

1-2.2.1 Technology-Based Effluent Limitations

The US EPA established technology-based effluent limitations to regulate secondary treatment for TSS, BOD and pH.[4] The limitations represent a minimum level of effluent quality that is attainable using demonstrated technologies that are economically available. US Congress recognized that unless alternative standards were set for facilities with biological treatment technologies, such as lagoons, costly new treatment systems may be required to meet the secondary treatment standards even though the existing treatment facilities were achieving their original design performance levels.[5] The EPA thus established an alternate set of technology-based effluent limitations termed 'equivalent to secondary treatment' to regulate TSS, BOD and pH discharges from lagoon systems.

1-2.2.2 TSS

The TSS technology-based effluent limitation for secondary treatment and equivalent to secondary treatment are presented in Table 1. The federal regulations also allow individual States to make upward TSS adjustments for lagoons on a case-by-case basis. The allowable upward adjustment is determined by what has been shown achievable by similar lagoon systems within the State or a contiguous geographical area that are achieving the effluent limitation for BOD (45 mg/L) 90% of the time. Table 2 provides a summary of the adjusted TSS requirements for each State (as of 2010).[6]

Table 1 NPDES TSS technology-based effluent limitations

TSS Technology Based Secondary	**30-day average**	**7-day average**
Concentration (mg/L)	30	45
SS removal (concentration)	Not less than 85%	
TSS Technology Based Equivalent to Secondary	**30-day average**	**7-day average**
Concentration (mg/L)	45	65
SS removal (concentration)	Not less than 65%	

[4] Code of Federal Regulations: Title 40; Chapter 1; Part 133
[5] Code of Federal Regulations: Title 40; Chapter 1; Subchapter D; Part 133; Section 133.105
[6] US Environmental Protection Agency NPDES Permit Writers' Manual. 2010

Table 2 US States with adjusted TSS effluent limit limitations

Alternative TSS limitation (mg/L)	Number of states with alternative TSS limitations	States
> 45 and ≤ 75	13	Alaska, Colorado (aerated), Indiana, Maine, Michigan, New Hampshire, North Dakota (North and east of Missouri R) New York, Ohio, Oregon (West of Cascade Mnts), Rhode Island, Vermont, Virginia, Washington
> 75 and ≤ 90	21	Alabama, Arizona, Arkansas, Georgia, Kansas, Kentucky, Louisiana, Maryland, Missouri, Nebraska, North Carolina, Nevada, New Mexico, Oklahoma, Oregon (East of the Cascade Mnts), South Carolina, Texas, Virginia (West of Blue Ridge Mountains), West Virginia, Wisconsin
> 90 and ≤ 120	7	California, Colorado (non-aerated ponds), Montana, North Dakota (South and west of Missouri R), South Dakota, Tennessee, Wyoming

1-2.2.3 BOD

The BOD and cBOD technology-based effluent limitation for secondary treatment and equivalent to secondary treatment is presented in Table 3. The US EPA has recognized that chemical oxygen demand (COD) and Total Organic Carbon (TOC) laboratory tests can provide an accurate measure of the organic content of wastewater in a shorter time frame than a BOD/cBOD test. The relation between BOD:COD/TOC is one that is site specific and a long-term correlation must be demonstrated to allow for a substitution of a TOC/COD organic content limitation.[7]

Table 3 NPDES BOD and cBOD technology-based effluent limitations

BOD and cBOD Technology-Based Secondary	30-day average BOD (cBOD)	7-day average BOD (cBOD)
Concentration (mg/L)	30 (25)	45 (40)
Removal (concentration)	Not less than 85%	
COD / TOC	Correlation to BOD	Correlation to BOD
BOD and cBOD Technology Based Equivalent to Secondary		
Concentration (mg/L)	45 (40)	65 (60)
Removal (concentration)	Not less than 65%	

[7] Regulations section 133.104(b)

1-2.2.4 Water-Based Effluent Limitations

State Water Quality Standards (WQS) establish the basis for developing water quality-based effluent limits in NPDES permits. Limitations must control all pollutants that will cause, have the reasonable potential to cause or contribute to an increase above any state water quality standard.[8] In instances where the effluent is deposited to a well-flushed ocean environment there is a provision in the CWA to apply for a modified permit with less stringent treatment limitations than the secondary or equivalent to secondary treatment limitations. In general, the modified permit can allow for primary treatment achieving not less than 30% concentration reductions for TSS and BOD. For the issuance of a modified permit the applicant must demonstrate capability to:[9]

- Attain or maintain water quality that allows recreational activities in and on the water;
- Attain or maintain water quality that allows protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife;
- Meet water quality standards (or federal guidance values for pollutants without standards);
- Establish a monitoring program to assess impacts;
- Provide a minimum of primary or equivalent treatment;
- Have an approved pretreatment program and establish toxics controls;
- Provide enhanced urban area pretreatment, for systems serving greater than 50,000 population;
- Prohibit variances in stressed estuaries; and
- Protect water supplies.

An applicant with a modified permit is required to monitor the impact of its discharge on the water quality and marine biota. The US EPA uses the monitoring results to evaluate applications for permit renewal and compliance with NPDES permit terms and conditions.

1-2.2.4.3 Whole Effluent Toxicity

Whole Effluent Toxicity (WET) requirements are state specific and defined under the state specific WQS. The WQS for WET is compared against the effluent WET after accounting for the applicable dilution allowance or mixing zone made available in the water quality standards.

1-2.2.5 Human Health

The state WQS determine the effluent limitations that are required for human health objectives. The Alaska WQS were reviewed as well as several Alaska NDPES permits for human health considerations. The permits indicate that faecal coliform limitations are often set at the discharge point, in ranges seen from 200 CFU/100 ml to 1 x 106 CFU/100 ml with a second compliance point at the edge of the mixing zone reflective of the water use categories of the WQS.

The applicable Alaska WQS are as follows:

[8] 40 CFR 122.44(d)
[9] CWA Section 301 (h)

Water Supply seafood processing:

For products normally cooked, the geometric mean of samples taken in a 30-day period may not exceed 200 faecal coliform/100 ml, and not more than 10% of the samples may exceed 400 faecal coliform/100 ml.[10]

Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life:

The geometric mean of samples may not exceed 14 faecal coliform/100 ml.

Water recreation-contact:

In a 30-day period, the geometric mean of samples may not exceed 35 enterococci CFU/100 ml, and not more than 10% of the samples may exceed a statistical threshold value of 130 enterococci CFU/100 ml.

1-2.3 Nunavut Water Licences

The Nunavut Water Board website provides links to the applicable legislation and guideline documents for determining effluent quality limitations.

1-2.3.1 Technology-Based Effluent Criteria

The Nunavut Water Board website refers licence applicants to the 1992 Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories (1992 Guidelines). It is the authors understanding that the NWB made efforts to develop a similar guideline for Nunavut, however that guideline never progressed past a Draft version that was developed in the year 2000 titled "Guidelines for the Discharge of Domestic Wastewater in Nunavut"[11]. This Draft NWB Guideline is similar in rationale, content, and effluent limitations as presented in the 1992 Guidelines. The Draft NWB Guidelines identifies that in most cases the effluent quality from a single-cell lagoon provides the basis for the recommended effluent criteria.

1-2.3.2 Water Quality-Based Effluent Criteria

The Draft NWB Guidelines describe that the purpose of treating wastewater before it is discharged is to maintain the quality of the receiving water within reasonable and acceptable limits. The Draft NWB Guidelines prescribe an approach to determine a mixing zone for various receiving water environments and provide various scenarios under which more stringent criteria may be necessitated to protect the receiving water quality.

The complete effluent criteria presented in the Draft NWB Guidelines is provided in Appendix A, Table 2. The criteria presented for marine discharge (majority of Nunavut wastewater discharges) has been reproduced in Table 4.

[10] Alaska, Department of Environmental Conservations; Water Quality Standards, 2017. 18 AAC70
[11] Guidelines for the Discharge of Domestic Wastewater in Nunavut: Draft Version, 2000

Table 4 Draft NWB guidelines for marine discharges

		BOD		TSS		Faecal Coliform	
		Open Coastline	Bay or Fjord	Open Coastline	Bay or Fjord	Bay or Fjord	Open Coastline
<150 Lcd	Summer	360	100	300	120	f	f
	Winter	360	120	300	120	f	f
>150 and < 500 Lcd	Summer	120	120	180	180	f	f
	Winter	120	120	180	180	f	f
>500 Lcd	Summer	80	80	70	70	f	f
	Winter	80	80	70	70	f	f

While there is no qualifier in the Draft NWB Guidelines regarding the note (f) the authors have surmised that it would be referencing a similar note as that in the 1992 Guidelines which states "Guidelines for faecal coliform levels are intended to limit concentrations everywhere outside the initial mixing zone so that the geometric mean of the faecal coliform density does not exceed 100 CFU/dL (100 CFU/100 ml). Treated effluent does not ordinarily need to be disinfected; however, disinfection will be required in any case where site-specific studies show that it is needed for protection of public health."

1-2.3.2.4 TSS

The Nunavut water licences require TSS limitations ranging from 70 mg/L to 180 mg/L for lagoon treatment to as strict as 25 mg/L if wetland treatment is included as part of the treatment train. Table 5 summarizes the TSS limitation in each community water licence.[12] Some licences have two compliance points; one at the lagoon discharge location and one at the end of the wetland, both compliance points are identified in the Table.

Table 5 Nunavut TSS limitations

TSS Limitation (mg/L)	Number of licences	Community
180	16	Arctic Bay, Cape Dorset, Clyde River, Grise Fiord, Hall Beach, Kugaaruk (lagoon), Kugluktuk, Kimmirut, Pangnirtung, Pond Inlet, Qikiqtarjuaq (lagoon), Resolute Bay (lagoon), Resolute Bay (WWTP, if flow 150-600 lpcd), Sanikiluaq, Taloyoak (lagoon), Whale Cove
120	2	Cambridge Bay, Igloolik
100	4	Arviat, Baker Lake, Chesterfield Inlet, Gjoa Haven

[12] Nunavut Water Board: Downloaded March 2017

TSS Limitation (mg/L)	Number of licences	Community
70	2	Naujaat, Resolute Bay (WWTP, if flow >600 lpcd)
45	2	Kugaaruk (wetland), Qikiqtarjuaq (wetland)
30	1	Coral Harbour (wetland)
25	1	Taloyoak (wetland)

1-2.3.2.5 BOD/cBOD

The Nunavut water licences require BOD/cBOD limitations ranging from 80 mg/L to 120 mg/L for lagoon treatment to as strict as 25 mg/L if wetland treatment is included as part of the treatment train. Table 6 summarizes the BOD limitation in each community's water licence.[13]

Table 6 Nunavut BOD limitations

BOD Limitation (mg/ml)	Number of licences	Community
120	16	Arctic Bay, Cape Dorset, Clyde River, Grise Fiord, Hall Beach, Kugaaruk (lagoon), Kugluktuk, Kimmirut, Pangnirtung, Pond Inlet, Qikiqtarjuaq (lagoon), Resolute Bay (lagoon), Resolute Bay (WWTP, if flow 150-600 lpcd) Sanikiluaq, Taloyoak (lagoon), Whale Cove
100	2	Cambridge Bay, Igloolik
80	6	Arviat, Baker Lake, Chesterfield Inlet, Gjoa Haven, Naujaat; Resolute Bay (WWTP, if flow >600 lpcd)
30	1	Coral Harbour (wetland)
45	2	Kugaaruk (wetland), Qikiqtarjuaq (wetland)
25	1	Taloyoak (wetland)

[13] Nunavut Water Board: Downloaded March 2017

1-2.3.2.6 Aquatic Species and Human Health

The Nunavut water licences require faecal coliform limitations ranging from 1 x 10^3/100 ml to 1 x 10^6/100 ml. Table 7 summarizes the faecal coliform limitation in each community's water licence.[14]

Table 7 Nunavut faecal coliform limitations

Faecal Coliform Limitation (CFU/100ml)	Number of licences	Community
1 x 10^6	14	Arctic Bay, Cambridge Bay, Clyde River, Grise Fiord, Hall Beach, Igloolik, Kimmirut, Kugluktuk, Pond Inlet, Naujaat, Resolute Bay (lagoon), Sanikiluaq, Taloyoak (lagoon), Whale Cove
1 x 10^4	8	Baker Lake, Cape Dorset, Chesterfield Inlet, Coral Harbour (wetland), Gjoa Haven, Kugaaruk (lagoon and wetland), Qikiqtarjuaq (lagoon and wetland), Taloyoak (wetland)
1 x 10^3	1	Pangnirtung
No limit	1	Resolute Bay (WWTP)-*licensee must conduct a site-specific study to determine FC limit that maintains the quality of the receiving water within reasonable and acceptable limits*

1-2.4 Northwest Territories

The NWT Land and Water Boards have various guidance documents published on their websites. The *1992 Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories* remains the most updated territorial guidance document for municipal effluent deposits. Discussion with territorial government staff, and as evidence in a sampling of 10 NWT water licences reviewed, indicates the limitations prescribed in NWT are not reflective of the 1992 Guidelines. In the licences reviewed, BOD/cBOD limitations ranged from 20 – 300 mg/L; TSS limitations ranged from 25 – 300 mg/L; and faecal coliform limitations ranged from 1 x 10^3 – 1 x 10^6 CFU/100 ml.

1-3 Final Wastewater Discharge Point

The terms "final discharge point" and "point of compliance" are critical in defining effluent limitations and determining compliance with those limitations.

1-3.1 Wastewater Systems Effluent Regulations

The WSER define "final discharge point" as the "the point, other than an overflow point, of a wastewater system beyond which its owner or operator no longer exercises control over the quality of the wastewater before it is deposited as effluent in water or a place." Compliance with the WSER's limitations must be met at the final discharge point.

[14] Nunavut Water Board: Downloaded March 2017

1-3.2 United States National Pollutant Discharge Elimination System

The recommended effluent compliance point for NPDES limitations are "just prior to discharge to the receiving water".[15] A review of the Scammon Bay, Alaska permit was undertaken with respect to compliance points. The permit authorized two compliance points; one for technology-based compliance and one for water quality-based compliance. The technology-based compliance point was "at the end of the treatment process prior to discharge to the Kun River". The BOD and TSS average monthly limitations at the compliance point are 45 mg/L and 70 mg/L respectively.

The water quality-based compliance point for the receiving area is defined at the "boundary of the mixing zone". The mixing zone is defined "as the area extending 100 meters downstream from the compliance point of discharge". The receiving area limitations include 20 FC/100 ml and ranged for pH and dissolved oxygen of 6.5 - 8.5, and 7 – 17 mg/L respectively.

1-3.3 Nunavut Water Licences

A water licence typically defines the final discharge point as: "an identifiable discharge point of a Waste Disposal Facility beyond which the Licensee no longer exercises care and control over the quality of the effluent." In general, the point of compliance is described as: "effluent discharged from the Final Discharge Point."[16] By way of these definitions the compliance point is equated with the final discharge point.

For many Nunavut wastewater treatment systems, the term 'control' is a misnomer. The licensee does not exercise control over the quality of the effluent flowing from a natural pond or exfiltrating berm (permeable berm). The timing of effluent flow is temperature dependent and occurs when the natural pond thaws and discharges naturally. In an impermeable lagoon (typically fully lined, lined berms keyed-in to permafrost or frozen core berms) the licensee has increased control as theoretically the effluent quality improves as the detention time increases. Therefore, in an impermeable system the licensee can delay the discharge to improve the effluent quality; however, the length of time the discharge can be delayed is limited by the onset of winter and limited lagoon capacity.

1-4 Application of Wetlands for Wastewater Treatment

Wetlands provide sewage treatment through complex physical and biological processes. The performance of wetlands is affected by the unique set of natural physical attributes of each site. Therefore, design and management strategies for these systems should recognize and address these intersystem differences.[17]

The plants within a wetland act as natural purifiers for the effluent. The plants also provide a natural media for bacteria to grow on. These bacteria, many identical to those present in a mechanical sewage treatment plant, remove carbon and nutrients from the effluent. As the

[15] US Environmental Protection Agency NPDES Permit Writers' Manual. 2010
[16] Nunavut Water Board: Downloaded March 2017
[17] Guidelines for the Design and Assessment of Tundra Wetland Treatment Areas in Nunavut; Dalhousie University. 2016

treated effluent flows across the land the sunlight penetrates killing some pathogenic organisms and reducing the number of microorganisms in the water.

The various research campaigns since the mid-90's have all confirmed the same findings; natural tundra wetlands achieve treatment for domestic wastewater in the Arctic and subarctic. In all wetlands studied, there was notable reduction in the concentration of the parameters. While much of this concentration reduction may be attributed to dilution, the studies confirmed that the contaminants are degrading at rates similar to those in cold climates in southern Canada.[18] The findings all confirmed that slow discharge rates over several months support a healthier wetland and promote improved treatment. Nunavut design guidelines for wetland areas have been derived which enable a scientific predictive approach for wetland design. This will allow for an engineered approach to reduce the risks to human health and the environment within these unique and functionally important wetlands.

1-5 Impact on Receiving Waters

The Dalhousie University research campaign demonstrated that wastewater effluent is causing mild enrichment of sediments on scales of less than 200 m from the point of wastewater discharge. This was in contrast to sediments in Iqaluit which showed clear signs of negative impact in the vicinity of 500 m from the wastewater discharge point. This contrast strongly suggests that the total volume and duration of effluent discharged are the most important factors influencing the scale and magnitude of the environmental impact.[19]

The findings from various components of the Dalhousie University research are summarized in Table 8. It can be extrapolated that there are minimal impacts from seasonal discharges of less than 2500 m^3/day into a marine environment that is not subjected to exposed tidal flats.

[18] Summary of Site Specific Studies on Tundra Wetland Treatment Areas in Nunavut; Dalhousie University. 2015
[19] Assessment of Arctic Community Wastewater Impacts on Marine Benthic Invertebrates: Dalhousie University, 2015

Table 8 Impact zone in relation to effluent quality and flow

Community	cBOD/TSS (mg/L) entering receiving environment	BOD/TSS (mg/L) leaving treatment facility	Flow rate measured (m^3/day)	Receiving Environment	Intertidal Zone	Impact Zone (m)
Pond Inlet	47/77	118/86 (leaving lagoon)	1300-2400	Open coastline	<5 m rocky	0-75
Pangnirtung	104/253	104/253	105-260	Fiord	200-300 m sandy	75-225
Kugaaruk	12/3	150/25 (leaving lagoon)	1578*	Small bay	10 m rocky	70-100
Grise Fiord	75/280	94/438 (leaving the lagoon)	269*	Fiord mouth	200 m sandy	20-150
Iqaluit	620/310	620/310	1514	Large bay	1000 m sandy	580

*not measured; predicted based on actual wastewater produced, external hydraulic inputs, and a 25-day discharge period

1-6 Design Considerations for Wastewater Treatment

In a paper authored by Ken Johnson, a northern planner and engineer, and Anne Wilson, Team Lead for Water Quality Division of Environment and Climate Change Canada (ECCC), the preference for passive wastewater systems in remote northern communities was presented. The paper reflected that all the mechanical systems installed in NWT and Nunavut communities had failed and communities have thus fallen back on the use of simpler lagoon and wetland systems.[20]

Mechanical systems can theoretically produce more consistent and higher quality effluent. These systems however, have proven unsuccessful in remote northern settings. The high capital and operational cost compounded by the complexity of operations and maintenance makes these systems ill-suited for Nunavut. Northern wastewater process design engineers consistently recommend that lagoon and wetland systems are the best available treatment option for remote northern communities.[21]

There are generally three types of lagoon discharge systems: pumped discharge lagoons, exfiltrating lagoons or overtopping lagoons. Exfiltrating and overtopping lagoons often in combination with a wetland such as Taloyoak, Sanikiluaq and Coral Harbour, provide adequate treatment to protect the environment with minimal operational requirements. There has been a trend in more recent years to design impermeable lagoons to meet the 'point of control' for regulatory requirements. Impermeable lagoons have proven challenging in Nunavut with seepage occurring from the outset of construction (Cape Dorset) to shortly into the operating life (Kugluktuk and Kugaaruk). These failures create a significant burden on communities and the GN both financially and operationally.

[20] Sewage Treatment Systems in Communities and Camps of the Northwest Territories and Nunavut Territory; Ken Johnson, MASc PEng, Anne Wilson, BSc.
[21] Sewage Treatment Best Available Technology; Ferguson Simek Clark Engineers and Architects; 2001

Design guidelines for northern lagoons and wetlands have been published by Dalhousie University. Frameworks for predicting wetland treatment have also been developed by Fleming College. Additionally, Canadian Standards Association is in the process of developing design standards for northern lagoon and wetland treatment systems.

1-6.1 Lagoon Design Considerations

Dalhousie University has proposed a multi-component system design for northern lagoons (Figure 1) based on field observation of the biogeochemistry in northern lagoons, and laboratory scale testing. The process design consists of three treatment components. All wastewater would be discharged to the primary treatment cell and then pumped to the secondary cells during the summer months. The secondary cells would then discharge passively (exfiltrating) to the polishing filter before final discharge to the receiving environment. The polishing filter could either be a geotextile membrane incorporated into the exfiltrating berm of the secondary cells, or rock filters subsequent to the secondary cells. The expected treatment performance for the lagoon system is reproduced in Table 9.[22]

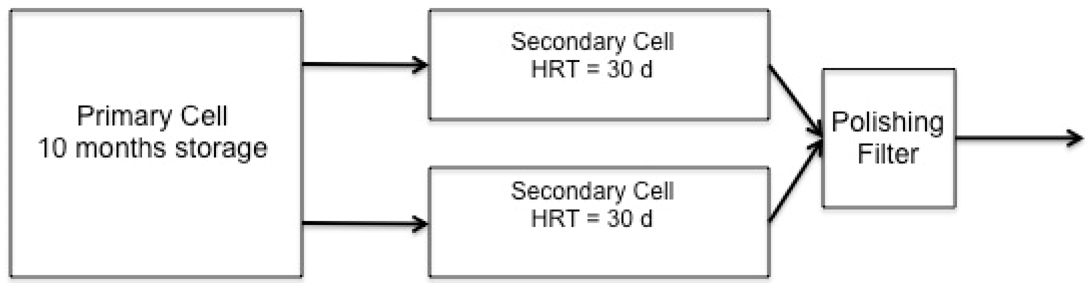

Figure 1 Dalhousie University lagoon design concept

Table 9 Expected treatment performance for proposed WSP configuration

Treatment System Component	cBOD (mg/L)	TSS (mg/L)
Primary Cell	< 175 mg/L	< 75 mg/L
Secondary Cell	< 40 mg/L	> 100 mg/L
Polishing Filter	< 30 mg/L	< 30 mg/L

This system would theoretically produce effluent quality well below the effluent quality achievable of typical single cell lagoon systems in Nunavut. Unless there are water quality based effluent limitations required, the investment in this type of system would have a diminishing return.

Another consideration for a lagoon system, as discussed in the 2000 NWB Guideline Background Report, is site selection that accommodates two (or more) lagoon cells in parallel. The rationale behind this design includes a number of practical considerations:

[22] Guidelines for the Process Design of Wastewater Stabilization Ponds in Nunavut; Dalhousie University. 2017

- The site selected is the optimal site based on the planning study; any future sites for new lagoons will therefore be sub-optimal.
- The decommissioned lagoon site will be a contaminated site and require significant remediation to reclaim the land. Adding future cells to the current system to increase capacity will be at the optimal site and will not require future remediation.
- If the treatment system includes a wetland treatment area, extending the life of the system will allow for the maturity of the wetland therefore increasing treatment performance of the wetland.
- A parallel multi-cell lagoon configuration allows for sludge management. When sewage sludge must be removed from one cell, it can be taken offline and the other cells can be used.

1-6.2 Wetland Design Considerations

Historical wetland systems in Nunavut have demonstrated that the area of tundra between a lagoon and the receiving water body naturally matures into a wetland treatment area and provides effluent quality improvements. Lack of modelling tools or standardized design process for tundra wetlands in climates like Nunavut challenged regulators to include these systems in the licensing process.

Wetland treatment areas in the north are now better understood and models have been developed to predict the treatment capacity of systems. Standardized processes for delineating and optimizing wetland areas have been developed by Fleming College and Dalhousie University. Adopting a standardized framework will reduce the uncertainties in the performance of wetlands, and will provide substantiation for inclusion of wetlands in the wastewater treatment facility definition.

1-6.3 Siting and Operational Considerations

The receiving environment characteristics and uses impact the level of treatment required. During the planning phase for a wastewater treatment system determination of the optimal site needs to consider the final discharge environment.

Protecting the environment and human health are the basis for establishing water-quality based effluent limitations. The optimal receiving environment will be one characteristic of good dilution, mixing and dispersion capabilities. In circumstances where the optimal site for receiving environment characteristics is not present, strategies can be employed to mitigate environmental and human health risks.

Operational practices such as strategic timing of discharging or controlling the flow rate may be required to minimize impact to receiving environments with exposed tidal flats or shallow bathymetries. Discharging at high tide in areas with a large intertidal zone will help to minimize the area of impact. If there are known fish and mammal migration or passage routes, timing of discharges to avoid this can also be planned.

Community education would inform residents and users of the receiving waters on this potential area of impact. Recreational activities should be avoided in these areas and on-site signage can also be used to inform the public. Signage at both the discharge location and along the shore near the discharge mixing zone is optimal to inform of the presence of municipal wastewater.

More complex strategies for minimizing the impact zone in receiving environments characteristic of poor mixing and dispersion is to change the discharge method. For example, in receiving environments with high currents, such as Pond Inlet, using single or multi-port diffusers promote mixing and dispersion in the water column at the discharge point.

1-7 Discussion

The common approach for establishing wastewater effluent limitations in the WSER, NPDES and the 1992 Guidelines is a two-tiered determination for effluent limitations, based on technology and on water-quality. Applying this two-tier approach in Nunavut would result in each municipal wastewater treatment system potentially having different effluent limitations. The process to establish the effluent discharge limitations however, would follow an established set of steps for each facility.

The first step is to determine technology-based effluent limitations. Technology-based limitations differ depending on the wastewater treatment system employed. If applied to Nunavut, the technology-based effluent limitations must be based on what the technology has been shown to achieve in Nunavut, not southern Canada. The selection of technology will be driven by site-specific considerations and public engagement.

The second step is to determine water quality-based effluent limitations. Water quality-based limitations are driven by the final discharge point and are determined for protection of the water quality and water use. These conditions are applied at the extent of the approved mixing zone.

1-7.1 Technology-Based Effluent Limitations

Northern research and operational experience highlights the sensitivity of lagoon and wetland systems to the characteristics of the raw influent and to climatic variability. This is highlighted by the instances of irregular algae blooms and their impact on TSS, ammonia and pH, as well as the influence of dilution in some natural wetland areas. It is important that technology-based effluent limitations consider the seasonal variability of treatment.

Technology-based effluent limitations should be applied with the understanding that theoretically the effluent limitations can be achieved under normal and reasonable operational conditions. Therefore, if systems are not reasonably meeting these limitations, it may be an indication of poor operations (undersized, sludge accumulation, etc.) or atypical climatic conditions affecting system performance.

Raw wastewater quality in Nunavut is typically two to three times higher in strength than raw wastewater in southern localities. This means that Nunavut lagoons have a tendency to become overloaded with contaminants, and despite reductions of 52 – 88% for cBOD and 62 – 92% for

TSS, the WSER standards for secondary treatment are not achievable.[23] The *Treatment Performance of Municipal Stabilization Ponds in Nunavut* was prepared for the GN as part of the Dalhousie University research campaign.[24] In the four systems studied (Pond Inlet, Clyde River, Kugaaruk and Grise Fiord) the BOD concentrations did not meet secondary treatment as defined by the WSER. The TSS concentrations observed, depended on the operating depth of the lagoon and the presence of algae blooms. In the event of an algae bloom the TSS concentrations increased.

Dalhousie University researchers provided a summary of the overall expected water quality from one- year detention lagoons operating in arctic conditions. The expected effluent quality differs depending on the operating depth of the lagoon. This has been reproduced in Table 10.

Table 10 Dalhousie University predictive effluent quality from shallow and deep lagoons

Parameter	Shallow (<2.5 m)	Deep (>2.5 m)
cBOD (mg/L)	80 – 120	120 – 160
TSS (mg/L)	50 – 100	25 – 50
NH_3-N (mg/L)	<1.25	<1.25

The US regulations account for the inherent variability of lagoon systems by allowing for secondary treatment equivalents. The NPDES requires 85% concentration reductions for secondary treatment whereas equivalent to secondary treatment requires 65% concentration reductions. Table 11 presents comparison of these concentration reductions applied to typical wastewater composition for cBOD and TSS in Nunavut versus southern Canada. Based on achieving equivalent to secondary treatment reductions (65%), 166 mg/L cBOD and 134 mg/L TSS effluent concentration discharge would be expected of Nunavut lagoon systems

Table 11 Concentration reductions for lagoon treatment in Nunavut versus southern Canada

	Nunavut		Southern Canada	
	cBOD (mg/L)	TSS (mg/L)	TSS (mg/L)	cBOD (mg/L)
Raw	474	384	190	210
85% reduction	71	58	29	32
65% reduction	166	134	67	74

1-7.2 Water-Quality Based Effluent Limitations

Dalhousie University assessed the impact of effluent deposited in Nunavut on receiving water and the benthic community. The research found the benthic community is more susceptible to effluent deposited to exposed tidal flats. The distance the effluent travels in the water is influenced based on the mixing action of the receiving environment. Tidal action, wave action, and discharge rate all influence the mixing and dispersion of the effluent and needs to be considered on a site basis.

[23] Treatment Performance of Municipal Wastewater Stabilization Ponds in Nunavut; Dalhousie University. 2015
[24] Treatment Performance of Municipal Wastewater Stabilization Ponds in Nunavut; Dalhousie University. 2015

Drawing on this research it can be extrapolated that effluent limitations of 120 mg/L cBOD and 100 TSS mg/L will be protective of the environment for seasonal flows less than 2,500 m^3/day that do not discharge onto exposed tidal flats. Effluent concentrations of 120 mg/L cBOD and 100 mg/L TSS is equivalent to achieving approximately 75% reduction from raw wastewater (Table 12). This is above the percentage reduction of 65% equated with alternative secondary treatment in the United States.

Table 12 Effluent quality based on a 75% concentration reduction for Nunavut systems

	cBOD (mg/L)	TSS (mg/L)
Raw	474	384
75% reduction	118	96

Discharge flow rates from lagoons are typically dependent on the system design. An exfiltrating or overtopping lagoon has uncontrolled flow rates however the flows are typically dispersed over the entire summer season (2 – 3 months). When lagoons are decanted with a pump the discharge rate can be controlled and is typically over several weeks. Relating discharge flow rate of 2500 m^3/day to population size under different discharge scenarios is presented in Table 13. Discharging the lagoon over a longer period not only lessens the stress on the receiving environment it also simultaneously improves the treatment performance within the wetland area.

Table 13 Predictive populous for 2500 m^3/day discharge rate

Discharge period (days)	Approximate population*
15	740
30	1480
90	4440

*based on a 125 lpcd wastewater production rate as determined from the average of the total water per capital usage based on NWT equations.

Nunavummiut are frequently engaged in traditional activities and harvests in the marine environment. Exposure pathways may differ from elsewhere in Canada and need to be considered carefully by each community. If the receiving environment is an area of shellfish harvesting, fishing, or boating; water quality-based limitations need to be applied.

1-8 Recommendations

The technical review for this report has brought to light reoccurring conclusions that have been documented over the past decades regarding wastewater management in Nunavut and NWT:

- Negligible environmental impacts from wastewater effluent have been observed
- Natural wetlands are capable of achieving treatment
- Lagoon and wetland systems are the best appropriate technology for small, remote northern communities
- Site specific effluent discharge limitations should be considered

Dialogue at all levels of government regarding the appropriate effluent discharge limitations for the north has been ongoing for decades. The 2000 Draft NWB Guidelines recommended a balanced approach between what is reasonably achieved by current technologies and protecting the environment and human health. This remains the recommended approach and is supported by the recent research and numerous publications. The prolonged discussions regarding appropriate northern treatment despite the wealth of confirmed evidence that lagoon systems are protecting the environment highlights the need to reach consensus among the stakeholders and adopt a territorial standard.

This section outlines recommendations for consideration in the development of territorial standards for the discharge of municipal wastewater effluent. It is recommended effluent limitations be determined based on a tiered approach: technology-based limitations applied at a minimum augmented with site-specific water quality-based limitations if they are determined to be more stringent.

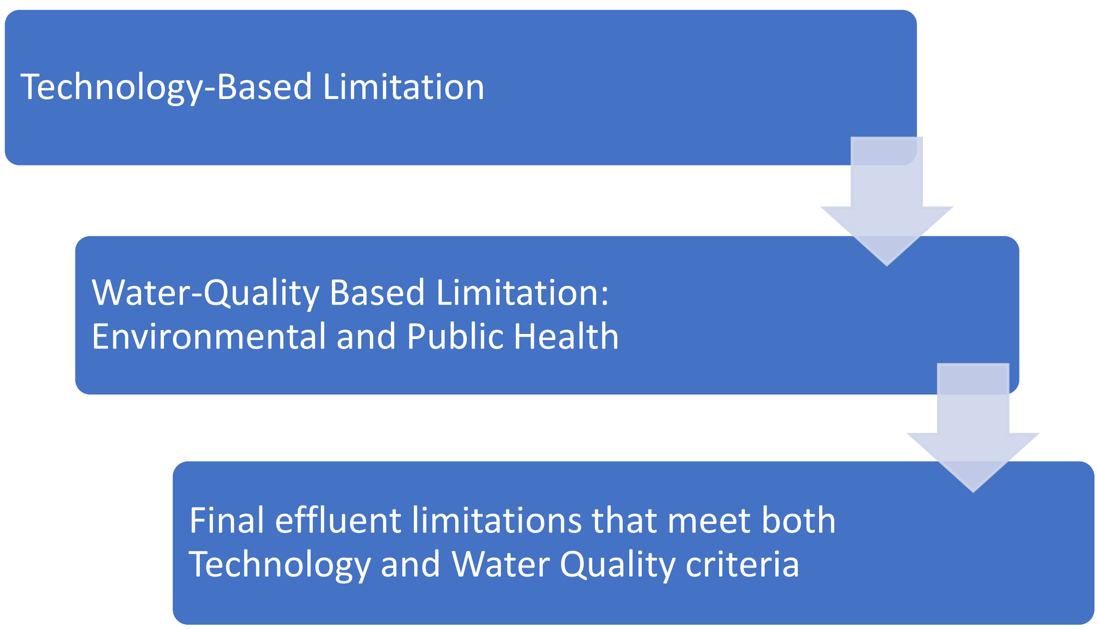

Figure 2 Tiered approach for determining applicable effluent limitations

1-8.1 Final Discharge Point

A consistent definition of final discharge point in Nunavut water licences is necessary for a clear and transparent application of effluent limitations. It is recommended that the definition of final discharge point not include the requirement of ‘control’ as this limits the application of exfiltrating and overtopping lagoons and wetlands. The final discharge point definition should consider only the location where the effluent enters the receiving waters (marine or fresh). Effluent discharge limitations should apply at the final discharge point, if accessible. If the final discharge point is not accessible, a compliance point upstream of the final discharge point should be established.

Natural wastewater treatment systems, particularly those with wetlands, tend to be dynamic and seepage and/or discharge locations can change from year to year. It is necessary licensees and the operators have a good understanding of this so they can identify when/if sampling locations need to change accordingly. Wetland system final discharge points should be monitored and amended as required if flow patterns throughout the wetland are dynamic.

1-8.2 Technology-Based Effluent Limitations

Lagoons and wetlands are recommended as the best available treatment for Nunavut. Mechanical treatment and primary treatment with diffuser to marine environment should only be considered if the geographical and social considerations restrict the use of lagoon and wetland systems. Technology-based effluent limitations are recommended according to the treatment system and presented in Table 14.

These recommended technology-based limitations have demonstrated adequate protection of the dominant receiving environments observed in Nunavut (marine open coastline or marine bay) and have been observed capable by single cell lagoon systems. In the absence of Nunavut specific research for freshwater discharges, it is recommended the 2000 NWB Guidelines be applied if more stringent than the recommendations in Table 14. Meeting more stringent limitations will not necessarily require mechanical treatment; different design options for lagoon configuration and optimization of a wetland may be capable of higher levels of treatment (as presented in Section 1-6).

Table 14 Technology-based effluent limitation recommendations for Nunavut

Treatment	Consideration	Flow Rate	Limitations for discharge to intertidal marine environment	
			TSS (mg/L)	cBOD (mg/L)
Mechanical treatment (secondary)	Required due to constraints that limit lagoon and wetland systems	All municipal systems	40	40
Mechanical treatment (primary)	In some instances (e.g. small populations) primary screening of wastewater may be adequate to protect the environment and public health. It is recommended that if this type of treatment is proposed, water-quality based effluent limitations be determined		Site specific study	Site specific study
Lagoon and wetland	Passive biological treatment systems have proven to provide adequate treatment to protect the receiving waters in Nunavut. The systems can be composed of various configurations of lagoons and/or wetlands.	< 2500 m^3/day	120	100
		> 2500 m^3/day	Site specific study	Site specific study

1-8.3 Water Quality-Based Effluent Limitation

The site-specific water-quality effluent limitation must be determined on a case-by-case basis. This will be informed by water quality standards such as Canadian Environmental Quality Guidelines as well as traditional knowledge of the marine water use such as any aquatic migratory routes or breeding grounds. The recreational water use will also need to be considered during this process and Health Canada's Guidelines applied, or as otherwise directed by GN-DoH. It is recommended the water quality-based effluent limitations be applied at the edge of a prescribed mixing zone. The Draft NWB Guidelines recommends mixing zones of 100 m with additional considerations. This is in line with those of the other jurisdictions reviewed. The application of a 100 m mixing zone delineation should be reviewed and revised accordingly in cases of tidal zones and strong ambient currents.

Table 15 Water quality-based effluent limitation recommendations for Nunavut

	Water-quality based limitations	Guidelines
Aquatic health	The water-quality limitations should be applied at the edge of the mixing zones. Water quality-based limitations will typically include: • pH • DO • ammonia • metals of concern	*Territorial Guidelines:* • DoE Environmental Guideline for Industrial Waste Discharges *Federal Guidelines:* 1. CCME Water Quality Guidelines for the Protection of Aquatic Life
Public health	The water-quality limitations should be applied at the edge of the mixing zones. Water quality-based limitations will typically include: 2. faecal coliform (fresh water) 3. enterococci (marine water)	*Federal Guidelines:* 4. Health Canada's Guidelines for Canadian Recreational Water Quality 5. Canadian Shellfish Sanitation Program

Section 2 Recommendations for Monitoring Programs

Monitoring programs are a useful tool for operators, licensees and regulators to periodically evaluate compliance with wastewater effluent limitations, evaluate the efficacy of the treatment systems, and to monitor the effects of an effluent on the receiving water. Monitoring results can be used to inform if changes to the wastewater effluent limitations or treatment process are required.

Regulations and/or guidelines typically stipulate requirements for monitoring wastewater effluent. A monitoring program will typically identify sampling locations, the frequency of sampling, the water quality parameters, the sample collection methods, and reporting and record keeping requirements. Often there are sampling requirements for compliance (regulatory) purposes and sampling requirements for data collection purposes. Data collection may be required to build a data library and to monitor potential contaminants of concern. This data can inform appropriate effluent limitations for future treatment systems.

In Nunavut, there has been reoccurring non-compliance issues with monitoring programs. This section provides a brief overview of other jurisdictions' typical requirements and provides recommendations for monitoring requirements in Nunavut given due consideration to sampling and analyzing challenges, costs, best available technology and system size.

2-1 United States National Pollutant Discharge Elimination System

The US EPA Permit Writer Manual describes the purpose of monitoring is to "determine compliance with effluent limitations established in NPDES permits, establish a basis for enforcement actions, assess treatment efficiency, characterize effluents and characterize receiving water."[25]

2-1.1 Location

The location of a monitoring station is typically selected by the permit writer based on where the final effluent limitation applies and often is the point just before discharge to the receiving water. Depending on the permit requirements such as external waste stream inputs and the treatment processes employed, influent and internal monitoring locations may be required as follows:

- Influent monitoring is typically only required if the permit stipulates percent removals of parameters be achieved (rather than prescribing effluent concentrations) by the treatment system.
- Internal monitoring at points within the treatment facility may be required to determine compliance with technology-based effluent limitations if for example the waste stream commingles with other waste streams and where dilution may occur. Typically, internal monitoring points are not required for determining compliance with water quality-based limitations.

[25] US Environmental Protection Agency NPDES Permit Writers' Manual. 2010

2-1.2 Frequency

Monitoring frequency is determined on a case-by-case basis through consideration of the following factors:

- Design capacity of the treatment facility: more monitoring if reaching its design capacity
- Treatment method used: similar frequency for similar treatment processes
- Compliance history: a facility with problems achieving effluent limitations requires more frequent monitoring
- Cost of monitoring relative to permittee's capabilities: should not be excessive and what is only necessary to provide sufficient information about the discharge
- Location of discharge: in sensitive waters frequency of monitoring is increased
- Nature of pollutants: increase of frequency for wastewater with highly toxic pollutants or where nature of pollutant varies
- Frequency of discharge: intermittent versus continuous
- Number of monthly samples used in developing effluent limitations

State-specific monitoring requirements are incorporated as required. For example, Alaska's monitoring frequency guidelines are flow-based as outlined in Table 16.

Table 16 Alaska State permit sampling frequency

Permit Type	Flow	Sampling for BOD/TSS/FC
Class A	250,000 – 1,000,000 gallons per day (3,785 m^3 per day)	2/month
Class B	5,000 – 250,000 gallons per day (946 m^3 per day)	1/month
Class C	>5,000 gallons per day (19 m^3 per day)	1/quarter

Permits may also establish a tiered monitoring schedule which reduces or increases the monitoring frequency during a permit cycle based on demonstration of excellent or poor compliance. This may be established to lead to lower monitoring costs for permit holders.

2-1.3 Parameters

The NPDES minimum requirement for monitoring is for the effluent limitations identified in the permit. Individual state authorities may require additional monitoring of parameters (with no effluent limits) to gather effluent and receiving water data. This data is assessed to inform if additional effluent limits are required and/or to monitor effluent impact on the receiving water body quality. For example, The City of Valdez's Wastewater Treatment Facility Permit requires the conventional parameters to be monitored (which have prescribed effluent limits) and in addition requires reporting on total ammonia, total recoverable copper, and temperature. These parameters are not given effluent limitations but have been identified as pollutants of concern. They are required to be monitored to conduct a future *reasonable potential analysis*. Reasonable potential analyses are conducted "to determine if the discharge has the potential to cause an exceedance of the water quality standards in the receiving water body for the subject parameters."[26]

The Alaskan permit application requires reporting on various water quality parameters depending on flow rates (Table 17). There are no prescribed monitoring regimes for these parameters and the permitee is only required to report on this information for water permit application purposes. The only guidelines are that the effluent testing data must be based on at least three samples and must be no more than four and one-half years apart.

Table 17 Alaska permitting requirements

Flow	Parameters (# of specific parameters)
<100,000 GPD (379 m^3/day)	• BOD or cBOD • Faecal Coliform • Flow Rate • pH • Temperature • TSS
≥100,000 GPD (379 m^3/day) and <1,000,000 GPD (3,758 m^3/day)	• All of the above • Ammonia • TRC • DO • Nitrate/Nitrite • Kjeldahl Nitrogen • Phosphorus • TDS
≥1,000,000 GPD (3,758 m^3)	• All of the above • Hardness • Metals (Total Recoverable; 13) • Cyanide • Total Phenols • Volatile Organic Compounds (28) • Acid-Extractable Compounds (11) • Base-Neutral Compounds (46)

WET testing is established on a case-by-case basis and frequency of WET testing gives consideration to the test cost. In the Valdez Permit, WET testing is only required during the year prior to permit expiry to inform the renewal consideration of the permit.

[26] US Environmental Protection Agency NPDES Permit Writers' Manual. 2010

2-1.4 Collection

The method to collect samples is dependent on the parameter being sampled for. The NPDES provides criteria for when grab or composite samples are required.

2-2 Wastewater Systems Effluent Regulations

Similar to the United States, the WSER provide monitoring requirements for regulated limits and individual provinces/territories may require more stringent monitoring and sampling requirements.

2-2.1 Location

Monitoring and reporting requirements in the WSER are at the final discharge point (defined as: the point, other than an overflow point, of a wastewater system beyond which its owner or operator no longer exercises control over the quality of the wastewater before it is deposited as effluent in water or a place.) Provincial regulations may require monitoring at other locations as well.

2-2.2 Frequency

The sampling frequency in the WSER is based on the method of discharge (intermittent or continuous) and the volume or length of discharge as outlined in Table 18.

Table 18 WSER sampling frequency

Discharge Method				
Intermittent Systems				
Length of decant	> 30 days		< 30 days	
Sample Frequency	Every 2 weeks (at least 7 days apart)		Sample once during each decant if more than one	
Continuous Systems				
Volume (average daily volume deposited annually)	≤ 2500 m^3	>2500 m^3 and ≤17,500 m^3	>17,500 $m^3$and ≤ 50,000 m^3	>50,000 m^3
Sample Frequency	Monthly (at least 10 days apart)	Every 2 weeks	weekly	3 days per week

2-2.3 Parameters

The WSER regulate only for the conventional water quality parameters; TSS, cBOD, ammonia, and total residual chlorine. Depending on the provincial requirements, inputs to the wastewater and receiving environment, other parameters may also be regulated.

2-2.4 Collection

The effluent limitations in the WSER are based on average concentrations. The WSER define the averaging period for effluent limitations depending on the daily flow volumes and type of discharge as outlined in Table 19. For example, for an intermittent discharge system with an average daily flow of less than 17,500 m^3, effluent limitation compliance is determined based on the average concentration of all samples taken within that calendar year.

Table 19 WSER averaging period

Averaging period	**Flow (average daily volume of effluent deposited during the previous calendar year)**	**Discharge Method**
Each Calendar Year	≤17500 m^3	Intermittent
	≤2500 m^3	Continuous (with retention time of 5 days or more)
Each Quarter	>2500 $m^3$and ≤17500 m^3	Continuous (with retention time of 5 days or more)
	≤17500 m^3	For any other continuous system
Monthly	>17500 m^3	For all systems

Grab or composite samples are required for facilities with average daily volumes less than 2500 m^3 and composite for facilities greater than 2500 m^3. The WSER do not provide restrictions on maximum allowable concentrations of a parameter included in calculating the average. This suggests that throughout the averaging period, some samples are "allowed" to be over the effluent limit criteria given the combined average of the samples during the averaging period is not.

2-3 Northwest Territories

Water licences in the NWT have Surveillance Network Programs (SNP) which are defined as "a monitoring program established to define environmental sampling and analysis requirements to collect water quality data, and to assess discharge quality, licence compliance, and potential for impacts to the environment." One licence identifies "They are developed to collect water quality data and to build an understanding of the treatment efficacy and potential impacts of the sewage and solid waste disposal facilities on the environment".

2-3.1 Location

The 1992 Guidelines recommend "both the effluent and the receiving water need to be monitored to ensure that effluent quality and receiving water quality meet licence limits and water quality objectives" but provide no other guidelines as to determining appropriate sampling locations.

Three of the NWT licences reviewed had monitoring programs with a single sampling location (compliance point). The other seven also included either environmental surface water monitoring and/or internal locations within the treatment train. Rationale is typically provided as to why each location is required.

Raw wastewater sampling requirements varied for the ten NWT water licences reviewed. There were only two that included a raw sewage sampling location with the rationale "to characterize the quality of sewage" however required sampling parameters are not identified. These two water licences were issued in 2010 and 2011 and it appears the newer licences have since removed this requirement. For example, the Fort Providence Licence indicates: "SNP 1412-3: This location was chosen to monitor the quality of raw sewage from the pump out truck and is discontinued as the quality of sewage discharge is of concern to the Board, not the influent."

The 1992 NWT Guidelines for the Discharge of Treatment Municipal Wastewater in the Northwest Territories does not discuss the requirement for raw wastewater quality monitoring.

2-3.2 Frequency

The typical sampling frequency observed in the NWT water licences reviewed are presented in Table 20.

Table 20 NWT typical sampling frequency requirements as observed in licences

Discharge Type	Frequency
Continuous	monthly
Intermittent-controlled	Prior to discharge and weekly during discharge
Intermittent-uncontrolled (during open water season)	Varies: monthly during open water season or beginning, middle and end of open water season

The 1992 Guidelines provide recommendations dependent on the operational nature of the discharge and the volume and varies depending on the parameter being analyzed (Table 21). However, it does not appear that this guideline is currently followed based on the sampling NWT licences reviewed.

Table 21 NWT 1992 Guidelines sampling frequency

Type of Discharge	Volume of Discharge	
Continuous Discharge	<500 m^3/d	>500 m^3/d
	FC: monthly BOD and SS: quarterly	BOD, SS, FC and temp: weekly Oil and Grease: quarterly
Lagoon Discharge during open water season only (annual discharge)	<10^6 m^3/d	>10^6 m^3/d
	BOD, SS Temp in lagoon before discharge	BOD, SS, FC and temp = weekly Oil and Grease = quarterly (before discharge)

2-3.3 Parameters

It appears that the Water Boards in the Northwest Territories require monitoring of the typical conventional water quality parameters. If the effluent in a wetland treatment area mixes with solid waste site run-off then additional parameters are required for monitoring.

Typical sampling parameters for sewage effluent only:

- pH
- cBOD
- TSS
- Ammonia-*not all licences*
- Total Phosphorus-*not all licences*
- Nitrate-*not all licences*
- Nitrite-*not all licences*
- Faecal Coliforms
- Oil and Grease

Typical sampling parameters for sewage effluent with solid waste leachate influence:

- TSS
- cBOD
- Cadmium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Oil and grease
- Petroleum hydrocarbons
- BTEX (not in all)
- Phenols
- Phosphate
- Manganese
- Calcium
- Potassium
- Sodium
- Sulphate
- Zinc
- pH
- conductivity

2-3.4 Collection

Typical licences in NWT indicate the effluent limitations according to the maximum average concentration defined as:

> **“Average Concentration"** means the discrete average of four consecutive analytical results, or if less than four analytical results, the discrete average of the results collected during a batch decant, and as submitted to the Board in accordance with the sampling and analysis requirements specified in the Surveillance Network Program.
>
> **"Average Concentration for Faecal Coliform"** means the running geometric mean of any four consecutive analytical results submitted to the Board in accordance with the sampling and analysis requirements specified in the Surveillance Network Program.

The Hay River Licence provides maximum concentrations for the compliance parameters that any one sample used to determine the average may not exceed:

Table 22 Hay River example for maximum concentrations

Parameter	Average	Maximum
BOD_5 (mg/L)	20	30
TSS (mg/L)	20	40
Faecal Coliform (CFU/100 ml)	1000	2000

2-4 Nunavut Water Licences

The NWB municipal water licences define monitoring program as: "monitoring programs are designed to collect data on surface water and groundwater quality to assess impacts to the freshwater aquatic environment of an appurtenant undertaking". The word "freshwater" is excluded from Rankin Inlet's and Iqaluit's definitions of monitoring program. Under this definition, the monitoring program would be limited to monitoring the receiving environment's surface and groundwater quality only. The Draft NWB Guidelines for Wastewater Treatment indicate that the Water Board will typically arrange for sampling of the receiving environment but may require the licensee to do so in specific cases.

2-4.1 Location

The Draft NWB Guidelines identify raw sewage, treated effluent, and sewage sludge need to be sampled to ensure that licensed requirements are being met. The current licences appear to be a combination of these locations while some licences also include environmental monitoring locations outside the treatment facility and other licences only require monitoring at the compliance point. The number of sampling locations specific to wastewater varies among licences from one station to fourteen stations.

Four of the 25 municipal water licences require raw wastewater quality sampling. Some renewal licences have discontinued this requirement. It is unclear the rationale for either inclusion or the removal of raw wastewater sampling.

The Draft NWB Guidelines indicate that raw wastewater sampling is required to monitor industrial inputs and provide quality limits of various parameters. Both the NWB Draft Guidelines and the DoE Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities provides wastewater quality criteria for which industrial process effluent shall meet to be accepted into a municipal wastewater treatment system.

2-4.2 Frequency

The current licences do not provide easily discernible rationale for the frequency of sampling required in the monitoring programs. It varies from weekly, to monthly, to three times during the decant and does not seem to be based on population or volume of flow. There is a general trend for systems that discharge seasonally to sample monthly or once at the beginning, middle and end of decant however this is not consistent across the licences. In Cape Dorset's water licence, the P-Lake lagoon monitoring frequency is weekly during decant, whereas the Clyde River monitoring frequency is at the beginning, middle and end of the decant period. Both system designs have controlled decant. Of the three continuous systems (Rankin, Pangnirtung and Resolute Bay), two have monthly sampling requirements and one is monthly from May to August only.

The Draft NWB Guidelines identifies that sampling frequency should vary depending on method of discharge. For continuous discharge system, frequency depends on the category of effluent (high quality, secondary, primary, screened, untreated). This is outlined in Table 23 below.

Table 23 Draft NWB Guidelines sampling frequency

Type of Discharge	Frequency	Parameters
Annual (one-time) discharge	3 samples: start, middle and end of decant	All parameters*(marine does not require sampling for phosphorus)
Intermittent and/or seasonal	monthly	All parameters* (marine does not require sampling for phosphorus)
Continuous (for secondary effluent discharge)	Twice per month	BOD, TSS, FC
	Monthly	Ammonia (NH_3-N), Phosphorus (PO_4-P) (discharge to freshwater only)
	quarterly	Heavy Metals and other parameters of interest

* All parameters= BOD, TSS, ammonia, Phosphorous, Faecal Coliform, heavy metals and other parameters of interest

2-4.3 Parameters

All water licences require analyzing for the conventional wastewater parameters in addition to parameters which typically are characterized as industrial inputs. Table B-1 in Appendix B outlines the sampling parameters required in each municipal licence. The number of parameters varies across the licences from a minimum of 23 to a maximum of 44 with a total variation of 47 different parameters.

The Government of Nunavut Department of Environment has issued *Environmental Guidelines for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities.* The Guidelines indicate that the generator of an industrial waste is responsible for its safe management from cradle-to-grave. Municipal waste facilities may choose to reject some types of industrial waste as it may impact the treatment process of the wastewater treatment facility. The Guidelines provide recommended process effluent criteria (Appendix B, Table B-2) that if met, can be discharged to a municipal sewage treatment system should the owner accept it. If the industrial process effluent does not meet the recommended criteria, the generator is responsible for treatment prior to discharge.

2-4.4 Collection

The NWB licences either stipulate effluent quality compliance based on a “maximum average concentration” (Cape Dorset, Kimmirut, Hall Beach) or the “maximum of any grab sample” (all others). Maximum average concentration is defined as “the arithmetic mean of the last four consecutive analytical results for composite or grab samples collected from the monitoring stations”.

2-5 Discussion

Wastewater sampling has inherent challenges in Nunavut; the 2007-2008 Summer Sampling program undertaken by the Canada wide strategy for the management of municipal wastewater effluent-Northern Research Working Group identified common challenges during their sampling program. Most notably, access to the sampling sites, ensuring laboratory holding-time criteria are met and maintaining sample temperatures during transit were the biggest challenges. They found that only 53% of the sampling sites were easily accessible and 22% had no access. [27]

Communities in Nunavut do not have access to water quality analysis equipment, and there are no accredited analytical laboratories in the Territory. Wastewater samples must to be flown to Yellowknife, Winnipeg or Ottawa making it a challenge both financially and logistically due to limited scheduled flights, frequent flight cancellations and delays, and high priority shipping rates. In the Summer Sampling program, the 48-hour holding time for the time-sensitive water quality parameters was very difficult to achieve in most circumstances. Sample transit was five days from Grise Fiord to the laboratory in Yellowknife. Considering the prevalence of flight delays and cancellations in Nunavut, meeting holding times and maintaining recommended sample temperatures are often not achieved providing unreliable analytical test results.

Given the inherent challenges with wastewater sampling and testing in Nunavut, it is prudent monitoring programs be strategically designed for practicality with considerations to cost, balanced with sufficient monitoring to ensure protection of the environment and human health.

Although monitoring programs need to be tailored to site-specific considerations, there are practical reasons to apply guidelines based on system size, type, and receiving environment characteristics. It is reasonable that discharges which have a greater risk of impact to the environment should be monitored more frequently and for more parameters. This is true for continuous discharges, large daily flow volumes and effluent with high industrial and/or commercial inputs.

There is a large variation between the monitoring programs of current licences and these variations have resulted in errors in the annual reporting. Twelve annual reports were compared against the monitoring requirements in the licence and only two correctly reported on what the parameters of the monitoring program were. This has also been noted by the NWB as the Grise Fiord Licence front end procedural history points out that samples were taken from the trucks but were not required, and concludes "it is unclear what sampling program the municipality has been following".

Additionally, the disproportionate requirements of monitoring programs without due rationale is not equitable for the municipalities. Three community's sampling programs were compared and as shown in Table 24, the variations obligate one licensee to a significantly greater amount of time, resources and financial commitment.

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[27] Johnson, 2010. Wastewater Sampling Challenges in Grise Fiord and Other Northern Communities, Journal Northern Territories Water and Waste Association.

Table 24 Comparison of three Nunavut sampling programs

	Cape Dorset	Gjoa Haven	Baker Lake
# monitoring locations (wastewater only)	14 (2007 system)	1	1
Sampling frequency	Weekly (one week prior to decant and weekly during decant)	Monthly (May to August)	Annually (during period of observed flow)
# of sampling parameters	11 stations = 44 parameters, 3 stations = 24 parameters	25	33
# of sampling events	11 stations = 5 events (assume 4-week decant period); 3 stations = 1 event	4	1
Total # of samples	58	4	1
Total # of analytical tests (assuming separate test for each parameter)	**2486**	**100**	**33**

The Dalhousie University research program reported that for smaller communities the spatial impacts on the receiving environment are more localized compared to those impacts observed in larger communities. This provides justification that wastewater treatment systems serving larger populations or with larger effluent volumes, should require more rigorous monitoring programs and is an appropriate trigger for monitoring criteria.

2-5.1 Location

Selection of monitoring stations, at a minimum, must consider what is being regulated within the licence. Similar to the WSER, sampling locations must be at the final discharge point where the effluent discharge limitations are regulated. It is reasonable the authorities may require additional sampling locations for data collection purposes.

Influent and internal sampling provides valuable data from an engineering, design and operational perspective. However, this sampling can be considered burdensome and costly for communities.

Raw water sampling has value for operational purposes. For example, mechanical systems are specifically designed to treat a certain type of wastewater. If other inputs are introduced that were not considered in the design it can have detrimental impacts to the treatment ability of the system. The mechanical plant in Pangnirtung for example, had a “foaming event” where the wastewater foamed and overflowed the treatment tanks. This was believed to be caused by an unfamiliar input into the raw wastewater causing a change in the pH that went unnoticed.

Raw wastewater sampling can have regulatory meaning if percent reductions are required to be achieved. The City of Valdez's permit, for example, has requirements to achieve minimum percent reductions of TSS and BOD and therefore raw wastewater sampling is necessary. Additionally, raw wastewater sampling has data collection value to monitor changes in the raw water quality and to identify new contaminants of concern.

Similar to raw wastewater sampling, intermediate monitoring locations may have more operational or data collection purposes than regulatory value. Sampling at the discharge point of a lagoon in a lagoon/wetland system gives valuable information on the treatment efficiency of the lagoon however does not provide regulatory meaning if the compliance point is after the wetland prior to discharge to the receiving environment.

2-5.2 Frequency

Frequency should be established using good judgement; discharges with higher potential to impact receiving environments and human health should be monitored more frequently.

Given the variability of exfiltrating lagoons, sampling frequency based on "at the start, middle, and end of the decant" may pose challenging. It may be difficult to predict when the middle or end of the decant period will be for a dynamic system. Regular interval monitoring based on flow volumes and system types, similar to Alaska State regulations and the WSER, are more practical in most circumstances and easier to manage operationally.

Using the tiered approach to monitoring frequency, similar to some US permits, would be a practical method for Nunavut as it allows for a reduced monitoring frequency conditional on good compliance history. Many systems in Nunavut, especially those with wetlands, have a track record of consistently achieving effluent limitations, and frequent monitoring of these systems may be redundant and unnecessary.

Toxicity testing in Nunavut is a considerable burden, costly and logistically challenging to ship samples within required holding time. Minimizing the frequency of this test is therefore practical for operational purposes. A reasonable alternative to annual requirements is a similar regime to the Valdez permit which requires toxicity testing only in the year prior to permit expiry. This may also be a practical frequency for non-regulated sampling parameters and/or locations such as raw water testing. It will allow the water board to identify any significant changes and/or contaminants of reasonable concern.

2-5.3 Parameters

Water licences allow for the discharge of contaminants, subject it is discharged at levels that are not considered toxic to the receiving water environment. These contaminants and levels must be defined to establish compliance requirements. Sampling parameters therefore should be established based on these contaminants of concern. Current water licences in Nunavut have anywhere from 23 to 44 parameters to be monitored however only provide compliance restrictions on five of those parameters. Based on the Draft NWB Guidelines, it is reasonable to assume monitoring a larger group of parameters has been required for data collection purposes.

Permits issued in the US can require monitoring of parameters which do not have associated effluent discharge limits. Parameters of concern may be identified if there are sensitive receiving environments, or industrial waste streams accepted at the wastewater treatment facility. Often monitoring of non-conventional parameters in these instances is required in order to conduct a future reasonable potential analysis. In Alaska, each permit has a “Fact Sheet” included which provides the basis for the requirements of the permit including the rationale why certain additional toxic parameters are required to be monitored.

2-5.4 Collection

Determination of collection methods should consider the sample location (type of wastewater sample), and the type of wastewater treatment technology being employed.

2-5.4.1 Grab vs Composite

Composite sampling is a time-consuming method and can increase burden on public works staff. Composite sampling may be practical however for raw wastewater sampling as the sewage strength has shown to be highly variable from truck to truck. Grab sampling is more appropriate for systems in Nunavut given consideration of the sampling challenges.

2-5.4.2 Maximum vs Average

If a licence defines the effluent limit as determined by the “maximum of any grab sample” each and every sample taken must not exceed the effluent limit. Contrary, if the licence defines the effluent limit as “maximum average concentration” this allows for more variability in the effluent quality and exceeding the effluent limit of some samples is acceptable. Passive treatment system performance is influenced by external environmental conditions with very little operator control, thus it is expected to see variability in the effluent quality making “maximum average concentration” more suitable for these systems.

2-5.5 Analytical Analysis

The NWB municipal water licences require all analytical water quality analyses be conducted by a laboratory certified by the Canadian Association of Environmental Analytical Laboratories (CAEAL) or in an accredited laboratory according to the ISO/IEC Standard 17025. Therefore, all samples must be sent out of the Territory for analytical testing. The primary challenge with this requirement is transporting the samples within the required holding times for the samples to obtain results which are defensible. In the Agnico Eagle - Meliadine Mine water licence, all compliance analyses are required to be conducted in an accredited laboratory. The mine licence allows the mine to conduct on-site analyses for their general monitoring for operational and management purposes while analyses for water quality with compliance limitations must be analyzed by an accredited lab.

There are several commonly used measurement methods for identifying the amount of organic matter in wastewater, including biochemical oxygen demand (BOD/cBOD), chemical oxygen demand (COD), and total organic carbon (TOC). The US permit systems allows for COD or TOC to be alternative parameters for BOD if a long-term site-specific correlation has been determined. The advantages of COD and TOC testing over BOD/cBOD testing is it is comparatively simplistic and can be completed in a few hours rather than days. TOC is particularly attractive for community-based monitoring as it is green chemistry.

2-6 Recommendations

It is recommended the definition of "monitoring program" be updated to better reflect the intention and objective of these programs. As currently defined in the licences, monitoring programs collect data on surface water and groundwater quality to assess impacts to the freshwater aquatic environment with no mention of compliance monitoring, effluent quality monitoring, treatment performance monitoring, etc. A definition similar to the NWT's or US permits is more encompassing and allows for the inclusion of monitoring requirements for reasonable potential analysis.

There are many factors which must be considered when developing monitoring programs. The overarching consideration is the risk level of the wastewater treatment system to the receiving environment and human health. To assist with establishing the risk level of the facility, the following should be considered:

- Type of treatment system employed
    - Waste stream and process variability
    - Discharge frequency (e.g., continuous versus intermittent)
    - Pollutants discharged
- Receiving Environment
    - Presence of exposed tidal flats
    - Ambient water mixing regimes
    - Effect of flow or pollutant load or both on the receiving water
    - Receiving water use
    - Effluent limitations
    - Environmental significance
    - Nature of the pollutants in wastewater
- Monitoring history
    - Licensee's compliance history with effluent limitations
    - Emerging contaminants of concern
    - Effluent quality variability
- Logistical considerations
    - Access to sample locations
    - Cost of monitoring relative to the discharge capabilities and benefit obtained

The tables in the following sections have been developed based on the above considerations, on the recommendation the monitoring programs be streamlined and triggered by system size, and the considerations for sampling and analytical testing in Nunavut. It is recognized that not all systems may fit within the parameters identified in the tables and each monitoring program must be developed on a case specific basis with considerations of the above, however the following provides recommendations for general guidelines.

2-6.1 Location

At a minimum, every monitoring program must require monitoring at the compliance point. The table below recommends the compliance point sampling location based on the type of treatment system. The table also identified potential additional locations should there be reasonable concern or reason to.

Table 25 Recommended sampling locations according to type of wastewater treatment facility

Type of System	Sampling Location(s)	Rationale
Single Cell Lagoon or Natural Lake	• Discharge location to receiving environment (compliance point)	• To monitor effluent quality prior to discharge to environment.
Primary and Secondary Cell Lagoon System	• Discharge from secondary cell (compliance point) • Discharge from primary cell	• To monitor effluent quality prior to discharge to environment • To monitor treatment performance of primary cell*
Mechanical Treatment Plant	• End of Pipe (compliance point)	• To monitor effluent quality prior to discharge to environment.
Any of the above with Treatment Wetland	• End of wetland (compliance point) • Above locations	• To monitor effluent quality prior to discharge to environment • To monitor treatment performance of preceding treatment components and/or to monitor wetland influence of TSS*
Wetland treatment only with retention berms	• End of wetland (compliance point) • Exfiltration location from retention berms	• To monitor effluent quality prior to discharge to environment • To monitor wetland influence of TSS*
Wetland treatment only	• End of wetland (compliance point)	• To monitor effluent quality prior to discharge to environment
Raw Wastewater Sampling	• Industrial/commercial input location	• To ensure the quality of wastewater does not exceed recommended limitations

*If required for data collection

2-6.2 Frequency

The frequency of monitoring should consider the risk level of the facility and the purpose of the monitoring requirement. Compliance monitoring should be more frequent with data collection monitoring less frequent. It is recommended a risk matrix be developed to establish monitoring frequency which considers the following:

- Effluent discharge flow rate
- Receiving water sensitivity
- Receiving water use

The recommendations in the below tables are for systems that do not experience significant changes in the population size and wastewater inputs. If there are new industrial inputs into the wastewater treatment system, more frequent monitoring may be required.

Table 26 Recommended sampling frequency at compliance point

Operational Effluent Discharge Method	Sampling Frequency
Intermittent Controlled Discharge: **Pumped Discharge from lagoon**	At beginning of decant and every two weeks there after
Seasonal Continuous: **-Exfiltrating berm lagoon** **- Overflow berm lagoon/natural lake**	Monthly during periods of flow
Continuous: **-discharge all year -mechanical plants**	Same as WSER (see Section 2-2.2)

Table 27 Recommended sampling frequency for data collection

Location/Parameter	Frequency	Considerations
Raw Water Sampling	Once during year prior to license expiry or every five years; whichever is more frequent	Additional testing required for any new commercial or industrial discharges that come online during the licence period
Acute Lethality	Once during year prior to license expiry or every five years; whichever is more frequent	Additional testing as required if discharging to a sensitive fish habitat

2-6.3 Parameters

At a minimum, the conventional wastewater parameters need to be monitored. If there is reasonable concern of additional toxic parameters, these can be included with the appropriate rationale. The NWB has required municipal licensees to monitoring a long list of parameters for quite some time and as a result, there should be sufficient background data to inform this reasonable concern.

Table 28 Recommended sampling parameters dependent on inputs to raw wastewater

Type of Effluent	Sampling Parameters (minimum)
Municipal Sewage Only	• Compliance parameters • Any additional contaminants of concern with rationale provided
Municipal Sewage with Industrial Input*	• Compliance parameters • Depending on the type of industrial input other parameters of concern

*Industrial wastewater should meet the DoE Guidelines

2-6.4 Collection

Given the practicalities and small volumes of wastewater discharged in Nunavut, grab sampling is recommended for effluent sampling. If raw influent sampling is required, a composite sample will give a better indication of raw water quality especially for trucked systems.

For passive treatment systems, it is recommended reporting and compliance be based on the average concentration of four (or less depending on the frequency required) analytical testing results to account for environmental influences. Mechanical plants have greater control over system performance and therefore it is recommended compliance is determined based on the maximum of any one sample.

2-6.5 Analytical Analysis

Given the challenges of sampling and water quality testing in Nunavut, it is recommended the GN-CGS consider researching methods for on-site testing. Some analytical testing methods are suitable on-site and there is emerging technology to allow for more convenient and simple on-site testing. This will not only build capacity at the community level, it will also decrease the economic burden of shipping samples to a laboratory. All licences currently stipulate “all analyses shall be performed in a laboratory accredited according to ISO/IEC Standard 17025. The accreditation shall be current and in good standing”. If on-site testing were to be considered, the accredited lab requirement could be amended as a quality control requirement, and periodically samples could be sent to an accredited lab to verify on site test methods are accurate.

Section 3 - Summary of Recommendations

The following presents a summary of the recommendations for municipal wastewater effluent limitations and recommendations for monitoring programs.

3-1 Summary Recommendations for Municipal Wastewater Effluent Limitations

1. **Application of Guidelines**
   - It is recommended that guidelines/regulations be applied to all municipal wastewater treatment facilities in Nunavut regardless of volumes of wastewater processed.
2. **Final Discharge Point/Point of Compliance**
   - It is recommended that the definition of final discharge point not include the requirement of 'control'.
   - It is recommended that the final discharge point only consider the location where the effluent enters the final receiving waters (marine or fresh).
   - It is recommended that effluent discharge limitations apply at the final discharge point, if accessible. If the final discharge point is inaccessible, a compliance point upstream of the final discharge point should be established.
3. **Wastewater Effluent Limitations**
   - It is recommended effluent limitations be determined based on a tiered approach: technology-based limitations applied at a minimum augmented with site-specific water quality-based limitations if they are determined to be more stringent.
   - It is recommended that for freshwater discharges, the technology-based effluent limitations or the effluent limitations in the Draft 2000 NWB Guidelines be applied, whichever is more stringent.
   - It is recommended the Department of Health and Department of Environment be integrally involved in determining the appropriate limitations for public and aquatic health.
   - It is recommended water quality-based effluent limitations be applied at the edge of the mixing zone.

Technology-Based Effluent Limitation Recommendations

Treatment	Flow Rate	Limitations for discharge to intertidal marine environment	
		TSS (mg/L)	**cBOD (mg/L)**
Mechanical treatment	All municipal systems	40	40
Primary treatment		Site specific study	Site specific study
Lagoon and wetland	< 2500 m^3/day	120	100
	> 2500 m^3/day	Site specific study	Site specific study

3-2 Summary of Recommendations for Monitoring Programs

1. It is recommended the definition of monitoring program be updated to reflect the intention and objective of the sampling regime.
2. It is recommended sampling programs be site specific depending on the receiving environment's risk level, type of system, and the size of system.
3. It is recommended the Tables ***i*** though ***v*** are referenced in the development of monitoring programs.
4. It is recommended the sample collection method include:
    - Grab sampling for all effluent sampling. Composite for raw wastewater.
    - For passive treatment systems, it is recommended compliance be based on the average concentration of four (or less depending on the frequency required) analytical testing results.
    - For mechanical treatment facilities, it is recommended compliance is determined based on the maximum of any one sample.
5. It is recommended the GN-CGS evaluate the potential for on-site testing with consideration for COD/TOC proxy.

i. Sampling Locations

Type of System	Sampling Location(s)	Rationale
Single Cell Lagoon or Natural Lake	• Discharge location to receiving environment (compliance point)	• To monitor effluent quality prior to discharge to environment.
Primary and Secondary Cell Lagoon System	• Discharge from secondary cell (compliance point) • Discharge from primary cell	• To monitor effluent quality prior to discharge to environment • To monitor treatment performance of primary cell*
Mechanical Treatment Plant	• End of Pipe (compliance point)	• To monitor effluent quality prior to discharge to environment.
Any of the above with Treatment Wetland	• End of wetland (compliance point) • Above locations	• To monitor effluent quality prior to discharge to environment • To monitor treatment performance of preceding treatment components and/or to monitor wetland influence of TSS*
Wetland treatment with only retention berms	• End of wetland (compliance point) • Exfiltration location from retention berms	• To monitor effluent quality prior to discharge to environment • To monitor wetland influence of TSS*
Wetland treatment only	• End of wetland (compliance point)	• To monitor effluent quality prior to discharge to environment
Raw Wastewater Sampling	• Industrial/commercial input location	• To ensure the quality of wastewater does not exceed recommended limitations

*If required for data collection

ii. Sampling Frequency at Compliance Point:

Operational Effluent Discharge Method	Sampling Frequency
Intermittent Controlled Discharge: **Pumped Discharge from lagoon**	At beginning of decant and every two weeks there after.
Seasonal Continuous: **-Exfiltrating berm lagoon** **- Overflow berm lagoon/natural lake**	Monthly during periods of flow
Continuous: **-discharge all year -mechanical plants**	Same as WSER (see table iii)

iii. Sampling Frequency for Continuous Discharge Systems:

Continuous				
Volume (avg daily vol. deposited annually)	≤ 2500 m^3	>2500 and ≤17500 m^3	>17500 and ≤ 50000 m^3	>50000 m^3
Sample Frequency	Monthly (at least 10 days apart)	Every 2 weeks	weekly	3 days per week

iv. Sampling Frequency for Data Collection:

Location/Parameter	Frequency	Considerations
Raw Water Sampling	Once during year prior to license expiry or every five years; whichever is more frequent	Additional testing required for any new commercial or industrial discharges that come online during the licence period
Acute Lethality	Once during year prior to license expiry or every five years; whichever is more frequent	Additional testing as required if discharging to a sensitive fish habitat

v. Sampling Parameters

Type of Effluent	Sampling Parameters (minimum)
Municipal Sewage Only	• Conventional parameters • Any additional contaminants of concern with rationale provided
Municipal Sewage with Industrial Input*	• Conventional parameters • Depending on the type of industrial input other parameters of concern

*Industrial wastewater should meet the DoE Guidelines

Appendix A: Section 1 Supplemental Tables

Table A-1: Nunavut Communities that trigger WSER

Community	100 m^3 Application Triggered?	Population	Predictive (m^3/d)	Actual (m^3/d)
Arctic Bay	No	876	95	67
Grise Fiord	No	167	16	16
Kimmirut	No	450	45	54
Qikiqtarjuaq	No	616	63	58
Chesterfield Inlet	No	473	47	41
Whale Cove	No	462	46	45
Clyde River	Within % error	1127	128	98
Hall Beach	Within % error	956	105	93
Sanikiluaq	Within % error	887	96	97
Kugaaruk	Within % error	971	107	94
Naujaat	Within % error	1069	120	99
Cape Dorset	Yes	1481	179	143
Igloolik	Yes	1986	260	141
Iqaluit	Yes	7590	3221	2983
Pangnirtung	Yes	1633	202	133
Pond Inlet	Yes	1663	207	121
Resolute Bay	Yes	210	34	917
Cambridge Bay	Yes	1746	220	243
Gjoa Haven	Yes	1483	179	130
Kugluktuk	Yes	1610	199	173
Taloyoak	Yes	1076	121	108
Arviat	Yes	2772	409	251
Baker Lake	Yes	1997	262	190
Coral Harbour	Yes	1080	121	112
Rankin Inlet	Yes	2675	932	1781

Table A-2 Domestic Wastewater Effluent Quality Guidelines (NWB 2000, Draft)

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

Appendix B: Section 2 Supplemental Tables

Table B-1: Sampling parameters required in each municipal water licence

	Arctic Bay	Arviat	Baker Lake	Cambridge	Cape Dorset	Chesterfield	Clyde River	Coral Harbour	Gjoa Haven	Grise Fiord	Hall Beach	Igloolik	Kimmirut	Kugaaruk	Kugluktuk	Pangnirtung	Pond Inlet	Qikiqtarjuaq	Rankin Inlet	Repulse Bay	Resolute Bay	Resolute Bay	Sanikiluaq	Taloyoak	Whale Cove	# Licences
BOD5	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
TSS	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Conductivity	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Oil and Grease	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Magnesium	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Sodium	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Chloride	•		•	•	•	•	•	•		•	•	•	•	•	•	•	•	•		•	•		•	•	•	21
Total Hardness	•		•	•	•	•	•	•		•	•	•	•	•	•	•	•	•		•	•		•	•	•	21
NH3-N	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Total Cadmium	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Total Cobalt	•		•	•	•	•	•	•		•	•	•	•	•	•	•	•	•		•	•		•	•	•	21
Total Chromium	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Total Copper	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Total Aluminum	•		•	•	•	•	•	•		•	•	•	•	•	•	•	•	•		•	•		•	•	•	21
Total Mercury	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•		•	•	•		22
Faecal coliforms	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
pH	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Nitrate-Nitrate	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Total Phenols	•	•	•		•	•			•		•	•	•	•	•	•	•	•	•		•	•		•	•	19
Calcium	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	24
Potassium	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Sulphate	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Total Alkalinity	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•		•	•	•	22
Total Zinc	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25

Total Iron	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Total Manganese	•		•	•	•	•	•	•		•	•	•	•	•	•	•	•	•		•	•		•	•	•	21
Total Nickel	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Total Lead	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	25
Total Arsenic	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	24
TOC	•		•	•	•	•	•	•	•	•	•	•	•	•		•		•		•	•		•	•		19
cBOD			•		•							•			•						•					5
Petroleum Hyrdocarbonate			•																					•		2
Benzene, Toluene, Ethylbenzene, Xylene			•																					•		2
Total Phosphorous		•			•																					2
PAH																								•		1
Antimony					•																					1
Barium					•																					1
Beryllium					•																					1
Lithium					•																					1
Molybdenum					•																					1
Selenium					•																					1
Tin					•																					1
Strontium					•																					1
Thallium					•																					1
Titanium					•																					1
Uranium					•																					1
Vanadium					•																					1
# parameters (47 in total)	30	24	33	29	44	30	29	28	25	29	30	31	30	30	30	30	28	30	23	29	29	23	29	33	28	

Table B-2: Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities

Substance	Process Effluent Criteria
Aluminum	50
Ammonia	NC
Arsenic	1
Barium	5
Biochemical Oxygen Demand (BCOD)	500
Cadmium	2
Carbon Tetrachloride (tetrachloromethane)	NC
Chlorides	1500
Chlorine	NC
Chromium	5
Copper	5
Cyanide	2
Fluoride	10
Iron	50
Lead	5
Mercury	0.1
Methyl Ethyl Ketone	NC
Nickel	5
Non-aqueous Phase Liquids	NC
Oil and Grease	150
pH Range	6.5 to 10.5
Phenolic Compounds	1
Phosphorous	100
Polychlorinated Biphenyls (PCBs)	NC
Polychlorinated Dibenzo Dioxins and Furans	NC
Selenium	NC
Silver	5
Sulphates	1500
Sulphides	2
Suspended Solids	600
Tetrachloroethylene	NC
Tin	5
Trihalomethanes (Total)	NC
Uranium	NC
Vinyl Chloride	NC
Zinc	5