Sewage Treatment Plant Design Basis

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1. General

1.1 Introduction

Baffinland Iron Mines Corporation is developing an Iron Ore Mine Site on Baffin Island named the Mary River Project. This design basis will be for several new sewage treatment plants (STPs) that will support the mine. It is anticipated that there will be a four (4) year construction phase followed by approximately twenty (20) years of operation of the mine. These new systems will therefore be designed to accommodate the expected flows of sewage from the various mine camps for both the construction and operation phases.

During the development of the project there will be seven (7) separate sites each housing a varying number of people. Three (3) sites will have sewage treatment plants. These are:

- Mine Site;
- Steensby Port; and
- Milne Port.

There will be four (4) temporary rail camps. Sewage from the rail camps will be treated at either the Mine Site or Steensby Port.

The wastewater discharge criteria will be based on the Nunavut Water Board licence requirements for discharge. These licence requirements are for the existing sewage treatment plants. These guidelines are summarized in the document “Wastewater Management Plan”, Table 3-2 Water License Discharge Requirements. At the Mine Site an opportunity exists to reclaim and reuse the treated effluent for toilets and urinals. This will offset the potable water demand and reduce the volume discharged. As such, treated effluent at this site will also meet the Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing (January 2010, Cat: H128-1/10-602E). Where applicable, the more stringent requirements of the two guidelines shall be implemented.

1.2 Description

This Design Criteria provides the basis for the engineering design of the sewage treatment plants (STPs), as part of the sewage water treatment requirements for the Mary River Baffinland Iron Ore mine.

Information relating to sewage production and sewage composition has been summarized in the subsequent sections.

Separate STP units are to be provided to meet the construction needs and the operation needs of the mine. The new STPs are to be designed to function without using any of the existing equipment or infrastructure.

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The STPs will be required to treat sewage from lavatories, showers, laundry wastewater and sinks from the plant areas.

2. References

2.1 Codes and Standards

Unless specifically stated otherwise, the design of the sewage equipment will be in accordance with the latest revision of the following codes, standards and regulations. In addition, the design will comply with any laws or regulations of local authorities and Certificate of Approval.

Table 2-1: Applicable Regulations, Standards and Codes

Number/Acronym	Title
AWWA	American Water Works Association
IBC	International Building Codes
Nunavut Waters and Nunavut Surface Rights Tribunal Act, SC 2002, c 10	
Northwest Territories Water Act	
Northwest Territories Water Regulations (SOR/93-303)	
Canadian Fisheries Act	
Canadian Environmental Protection Act (1999)	
CCME Water Quality Guidelines for the Protection of Aquatic Life	
Ontario Guidelines for Sewage Works 2008	
CCME Guidelines for Compost Quality	
Health Canada, Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing (January 2010, Cat:H128-1/10-602E)	
NSF	National Sanitation Foundation
OSHA	Occupational Safety and Health Administration

3. Existing Equipment Description

As the project is already in the preliminary stages of development there is some existing sewage treatment equipment at two of the sites. Descriptions of the existing systems follow:

3.1 Existing Sewage Treatment Systems

Mary River Camp: The wastewater treatment facility consists of a Rotating Biological Contactor (RBC) and ultra-violet light (UV) disinfection.

Milne Inlet Camp: The wastewater treatment facilities at Milne consist of a RBC (complete with UV disinfection).

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The reported capacities of these existing systems are:

Table 3-1: Capacities of Existing Systems

Facility Type	Water/Sewage Quantity (Lpcd)	BOD_5/TSS (Avg. - mg/L)	No. of Persons (Capita)	Total Daily Flow (L/d)	Total Flow 400 days (m^3)
Design Criteria for Mary River Camp	225	460/490	150	33,750	13,500
Design Criteria for Milne Inlet Camp	225	460/490	60	13,500	5,400

Source: Wastewater Management Plan, Appendix 10D-3 of the Mary River Project Environmental Impact Statement, Issued September 15, 2007

3.2 Condition of Existing Sewage Treatment Systems

- Milne Port: Operating and meeting effluent requirements. During first two years of operation intermittent periods where effluent was not meeting discharge criteria; and
- Mine Site: Operating but having trouble meeting Phosphorus effluent requirements of 0.5 to 1.0 mg/L.

4. Design Parameters

The sewage treatment requirements of the sites will be split between temporary and permanent sewage treatment plants. Both systems will be required during the construction phase while only the permanent facilities will be required during the operation phase. The temporary plants will be demobilized after the construction phase. During the operations phase, the temporary STP components may be considered as a supply of spare parts or for additional redundancy purposes.

4.1 Sewage Generation Rates

Average sewage generation will be calculated based on the number of workers at the site and a per capita sludge generation rate. The per capita generation rate is established based upon the following project details:

Inputs:

- Staff breakdown at Mine Site by function;
  a) Admin (corporate, HR, finance): 9%.
  b) Operations (mine operations): 41%.
  c) Plant Services (maintenance): 23%.
  d) Visitors (food prep, contractors): 27%.

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Source: Mary River Site Staffing, Occupant Load, Office and Locker Allocations in Buildings, Document No. H337697-0000-40-109-0002

- Typical Female/Male split per function;

Function	% Male Workers	% Female Workers
Admin Workers	50%	50%
Operations Workers	90%	10%
Plant Services Workers	90%	10%
Visitors	50%	50%

- Shower, toilet, urinal and wash basin water consumption per usage;

Function	Average Water Use	Units	Duration of Use (min)
Shower	11	L/min	7
Toilet (standard tank)	23	L/use	
Urinal	3.5	L/use	
Washbasin	11	L/min	0.5

Source: "Wastewater Engineering: Treatment and Reuse", Metcalf and Eddy (2003)

- Number of usages per shift per gender; and

Item	Frequency of Washroom Use (# of times per shift)	
	Males	Females
Toilets	2	4
Urinals	2	0
Washbasin	4	4

- Shower Use by Function.

Function	Shower Use
Admin Workers	25%
Operations Workers	100%
Plant Services Workers	100%
Visitors	0%

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Based upon the above data and considering two shifts per day the calculated per capita potable water consumption and sewage generation rate is 281 L/capita/day. Typical North American Value is 300 L/p/day. In previous project work by AMEC the sewage generation rate was projected to be 300 L/p/day. Source: Design Basis for sewage treatment system for Mary River, Milne Inlet and Tote road (issued for feasibility study) – Nov. 29, 2010 prepared by AMEC. Document No. 165926-6780-131-TDR-0001. The per capita water consumption at the Baffinland exploration camp was 143 L/p/day during the 2008 year. Source: Environmental Impact Statement Appendix 10D-3 Wastewater Management Plan, 2010.

As such, for conservatism the higher per capita potable water consumption and sewage generation rate of 300 L/p/day will be used. Any design allowance above this value will be specified in the document Technical Specification – Sewage Water Treatment Plant, Document Number H337697-4000-10-123-0002.

The only significant difference between potable water use and sewage generated will be infiltration into the sewage system – in this case that should be negligible since all sewage collection areas are indoors.

4.1.1 Population

Worker populations for the different STP facilities are provided in the document Technical Specification – Sewage Water Treatment Plant, Document Number H337697-4000-10-123-0002.

4.2 Peak Flow

Based upon the project details given in Section 4.1 it is calculated that the peak sewage generation rate is ~5.8 times the average generation rate.

This assumes the peak potable water demand and sewage generation will occur at the end of the day shift and is based upon the shower use by function (as specified in Section 4.1).

The Ontario Guidelines for Drinking Water Systems also provides peaking factors or peak hourly flowrate above the average demand. This factor is an estimate that is based upon the total number of people that are served by the sewage treatment system. For design purposes these values will be used with a design allowance of 50% to produce a value that more closely matches the peak flow calculated for the Mine Site.

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Table 4-1: STP Peak Sewage Flow Design Basis[1]

Equivalent Population	Night Minimum Hour Factor	Maximum Day Factor	Peak Hour Factor	Design Peak Hour Factor[2,3]
30	0.1	9.5	14.3	21.5
150	0.1	4.9	7.4	11.1
300	0.2	3.6	5.4	8.1
450	0.3	3	4.5	6.8
500	0.4	2.9	4.3	6.5
1000 (and larger)	0.4	2.75	4.13	6.2

Notes:

1. The source for the peak sewage flow rates design basis is the Ontario Design Guidelines for Drinking Water Systems, 2008.
2. A 50% design allowance was added to the Peak Hour Factor.
3. The design peak hour factor will be used in sizing the equalization tank, upstream of the sewage treatment plant.
4. The sewage treatment plant will be designed to handle the average flowrate.

4.3 Raw Sewage Characteristics

The quality of the raw sewage to be used for the design of the STPs is established based upon the project details given in section 4.1 in addition to the following inputs.

Inputs

- Loadings of BOD, TSS, TKN and TP

Item	Loading	Unit
BOD5 organic loading	0.077	kg per capita per day
TSS loading	0.090	kg per capita per day
BOD5 organic loading	26	kg per day
TSS loading	30	kg per day

Source: Water Environment Federation, "Wastewater Treatment Plant Design" (pg. 2-9), 2003 and Hatch experience.

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- Typical Composition of Untreated Domestic Water:

Item	Concentration (mg/L)		
	Low	**Medium**	**High**
BOD_5	110	190	350
TSS	120	210	400
Total nitrogen Organic Free ammonia	20 8 12	40 15 25	70 25 45
Total phosphorus Organic Inorganic	4 1 3	7 2 5	12 4 8

Source: "Wastewater Engineering: Treatment and Reuse", Metcalf and Eddy (2003).

We will assume that half the nutrients are generated while each person is at work and half are generated at home. None are generated during sleeping hours. Based upon the above data the raw sewage characteristics are calculated to be:

Item	Concentration (mg/L)
BOD_5	280
TSS	330
TKN	47
TP	12

This shows that the sewage is anticipated to be medium to high strength. The existing sewage treatment plants at the site were based upon the equipment supplier's sewage characteristic estimates. Seprotech (RBC equipment supplier) estimates were based upon "Cold Region Utilities Monograph" Third Edition 1996 assuming "moderately diluted wastewater". Characteristics estimated were as follows:

Item	Concentration (mg/L)
BOD_5	460
TSS	490
TKN	65
TP	10

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As such, for conservatism the higher values will be used as the design basis with a range allowance. The main water quality parameters of the all raw water sources (after equalization) are as follows:

Table 4-2: Raw Sewage Quality

Design	Units	Value
$cBOD_5$	mg/L	350 – 550
TSS	mg/L	400 – 600
NH3-N*	mg/L	55 – 75
TP	mg/L	7 – 13

Notes:

1. It was assumed that 100% of the influent TKN hydrolyses to form NH_3-N.

4.4 Sewage Treatment

Sewage will be generated at several facilities and be pumped to the equalization tank. Sewage from remote locations may be collected locally in holding tanks, then, trucked to the main STP equalization tank for treatment.

The new STP will consist of the following:

- Equalization tank for influent sewage flow normalization and homogenization of sewage characteristics. This tank will come complete with a single piped connection for all piped sewage. This sewage will come from both the accommodation facility as well as other nearby facilities such as the administration building. The equalization tank will also have a suitable connection to receive sewage by vacuum truck;
- Treatment to remove total suspended solids (TSS), reduce biochemical oxygen demand (BOD_5) and stabilize biosolids;
- Disinfection of treated water prior to discharge; and
- Treated effluent tank and discharge pumps.

4.4.1 Equalization Tank Sizing

Normally equalization tanks are sized using a hydrograph to estimate the volume accumulated during peak periods. In this case we do not have a hydrograph available and as such we'll make some conservative assumptions.

In the industrial setting the largest peak wastewater flowrate during the day will be during shift changes at a plant, when one shift ends and a number of employees use the shower facilities at the site.

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There are two constraints that must be met:

- Capacity for end of day shift (assumes entire shift uses shower and toilet); and
- Capacity for end of night shift (assumes entire shift uses shower and toilet) plus 15 m^3 sewage truck delivery.

Based upon the input values given in section 4.1 the build-up in the equalization tank at end of day shift is approximately equal to about 18% of daily generation or ~ 4.3 hr retention.

Similarly the build-up in the equalization tank at end of day the night shift will be approximately equal to about 7.5% of daily generation or ~ 1.8 hr retention.

Typical value for municipalities is about 10 - 20% of daily flow required as buffer volume or maximum of about 5 hours retention. Source: Flow Equalization, EPA 1974 Technology Transfer document.

As such, for conservatism the tank should be designed with 6 hour retention capacity or 2 hours retention plus 15m^3, whichever is larger.

4.5 Discharge/Outfall Locations

For this phase of the project the proposed treated effluent discharge locations are given in Table 4-3. If the proposed discharge locations change, this report shall be revised/updated.

Table 4-3: Treated Effluent Discharge/Outfall Locations

Camp/Site	Discharge/Outfall Location	
	Summer	Winter
Milne Inlet (Port)	Ocean at Milne Inlet	
Mary River (Mine Site)	Mary River	Storage Pond
Steensby (Port)	Ocean at Steensby Port	
Ravn River Area	Conveyed to Mary River Sewage Treatment	
Mid-Rail Area	Conveyed to Mary River Sewage Treatment	
North Cockburn Area	Conveyed to Steensby Sewage Treatment	
South Cockburn Camp	Conveyed to Steensby Sewage Treatment	

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Notes:

1. In previous project consultant studies, the discharge/outfall locations have been presented for Milne, Mary River, and Steensby Sites. This information was provided in the document "Mary River Project EIS – Volume 3 Project Description, by BIM", or "Mary River Project EIS – Volume 8 Marine Environment by BIM". In addition the discharge locations for the rail camp sites was presented in the document "Technical Decision Memo, TDM-159952-8000-131-001, by AMEC".
2. In the previous consultant studies, some consideration was made for alternative discharge locations into Mary River or Mary River Lake. However, for the current phase of the project, the STP will be designed to discharge the treated effluent to Sheardown Lake, which has the lowest discharge limits, particularly for Total Phosphorus.
3. The Nunavut Water Board discharge criteria are based upon the characteristics of the water body where the sewage is proposed to be discharged as well as the expected flows of waste. The phosphate limit for instance was developed after a study of the overall phosphorus loadings to Sheardown Lake (the discharge point for the mine site) and modeling results. "Total phosphorus (TP) is also an important nutrient parameter that can trigger eutrophication of arctic lakes. The Canadian Council of Ministers of the Environment (CCME) has thresholds for increases in TP and water quality modelling will consider these thresholds." Excerpt from Summary of Effluent, Waste and Emission Guidelines prepared by Knight Piesold (Document Number – NB08-00767).
4. Insufficient information is available from the previous reports and studies regarding the allowable discharge limits for the temporary rail camp sites. For the current project, the temporary rail camps shall be designed to meet the strict discharge limits derived in the EIS for Sheardown Lake (at Mary River site). When updated information is available, this design basis will be revised.

4.5.1 Storage or Polishing Pond Considerations

Previous studies had recommended the use of Polishing Waste Stabilization Ponds (i.e. Mary River Project Appendix 10D-3 Wastewater Management Plan, March 31, 2010). The existing infrastructure at the Mary River (mine site) includes these ponds in part to allow for secondary treatment of the STP effluent which was not meeting the phosphorus discharge limit. However, based upon practical experience at the site with the STP it was projected that secondary polishing would not be required in the future.

Baffinland has incorporated the temporary storage ponds to be used during periods of start-up, shut-down or during periods of system upset. At this time, the stabilization ponds will not be required as part of the proposed STP design, for the following reasons:

- The proposed new STPs shall be designed to meet the discharge criteria, and discharge year-round to their respective discharge points. Therefore, the ponds are not required;
- The proposed new STPs will be modular with extra design capacity such that shut-downs and start-ups can be staggered to avoid performance losses in system capacity;

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- The STP trains are better able to handle upsets by using the available spare capacity to operate the equipment at more conservative flow rates; and
- Construction costs for a pond suited to the future flowrates would be exorbitant due to the size as well as the requirements for lining and heating.

4.6 Treated Sewage Effluent Quality

The quality of the sewage treatment plant effluent shall be in accordance with the applicable site discharge limits as listed in the following table. Treated sewage discharge limits have not been provided for the temporary rail camps. This is because no work has been undertaken to evaluate the impact of discharge from these sites into the receiving water bodies.

Table 4-4: Treated Sewage Discharge Limits

Parameter	Unit	NWB Licence Req.		Water Reclaim/Reuse Req.	Design - Mary River	Design - Milne Inlet/Steensby Port
		Mary River	Milne Inlet/Steensby Port			
BOD_5	mg/L	10	20	10 – 20	< 10	< 20
TSS	mg/L	10	20	10 – 20	< 10	< 20
Faecal Coliform	cfu/100 mL	< 200 counts per 100 ml	< 200 counts per 100 ml	N/A	< 200 counts per 100 ml	< 200 counts per 100 ml
Oil and Grease*	mg/L	No visible sheen	No visible sheen	N/A	No visible sheen	No visible sheen
pH	---	Between 6.0 and 9.5	Between 6.0 and 9.5	N/A	Between 6.0 and 9.5	Between 6.0 and 9.5
Toxicity	---	Final effluent not acutely toxic	Final effluent not acutely toxic	N/A	Final effluent not acutely toxic	Final effluent not acutely toxic
Ammonia	mg/L NH3-N	2	2	N/A	< 2	< 2
Total Phosphorus	mg/L	< 0.1	N/A	N/A	< 0.1	N/A
Turbidity	NTU	N/A	N/A	2 – 5	< 5	< 5
Escherichia Coli	cfu/100 mL	N/A	N/A	ND – 200	< 200 counts per 100 ml	< 200 counts per 100 ml
Thermo - tolerant Coliforms	cfu/100 mL	N/A	N/A	ND – 200	< 200 counts per 100 ml	< 200 counts per 100 ml

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Notes:

1. NWB refers to the Nunavut Water Board who prepared the water licence requirements based upon Nunavut water quality guidelines. These limits are summarized in the document "Wastewater Management Plan", Table 3-2 Water License Discharge Requirements and the Original Design Basis.
2. The phosphorus limit was determined by a study of the receiving environment (Sheardown Lake) as documented in the Knight Piesold, Memorandum – Progress Report, Water Supply and Sewage Disposal during the Construction Phase, December 17, 2008.
3. There will be oil and grease traps provided by others for kitchen waste.
4. The water reclaim and reuse criteria is taken from the Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing (January 2010).
5. N/A – No criteria provided.

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