Government of Nunavut

Operation and Maintenance Manual
Volume I

Type of Document
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Project Name
Kimmirut Waste Water Facility

Project Number
OTCD00018881A

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Date Submitted
04/10/2011

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1 Introduction

This Manual has been produced to establish standard operation and maintenance protocols for the management and treatment of sewage within the Hamlet of Kimmirut. Information presented in this manual has been developed based on the document "*Guidelines for the Preparation of an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories, 1996*".

This operation and maintenance (O&M) manual is intended to instruct designated operators of the sewage lagoon facility on the O&M procedures required to comply with conditions set forth by the Nunavut Water Board (NWB) in water licence 3BM-KIM0911 found in Appendix A.

1.1 Preceding Lagoon

The Hamlet is currently discharging untreated wastewater directly into the sea approximately 750 m south of the community and adjacent to the existing solid waste disposal site. In 2000-2001, a new sewage lagoon was constructed approximately 1.5 km to the west of the end of the airport runway. This facility has never been used and details regarding the construction of the lagoon are unavailable; however, it is believed the facility was constructed based in principle on a report prepared by Dillon Consulting Ltd. entitled "*Sewage & Solid Waste Site Selection Kimmirut, NT – Final Report*:" Dated February 11, 1999.

1.2 Existing Water Supply

The Hamlet currently obtains its drinking water from Lake Fundo, a natural lake located 1,200 metres west of the community. The water supply facility is located on the east side of the lake with inclined pipes leading out into the lake where water is withdrawn. Chlorination is required for disinfection of the raw water, and treated drinking water is delivered by water truck to homes and facilities within the Hamlet.

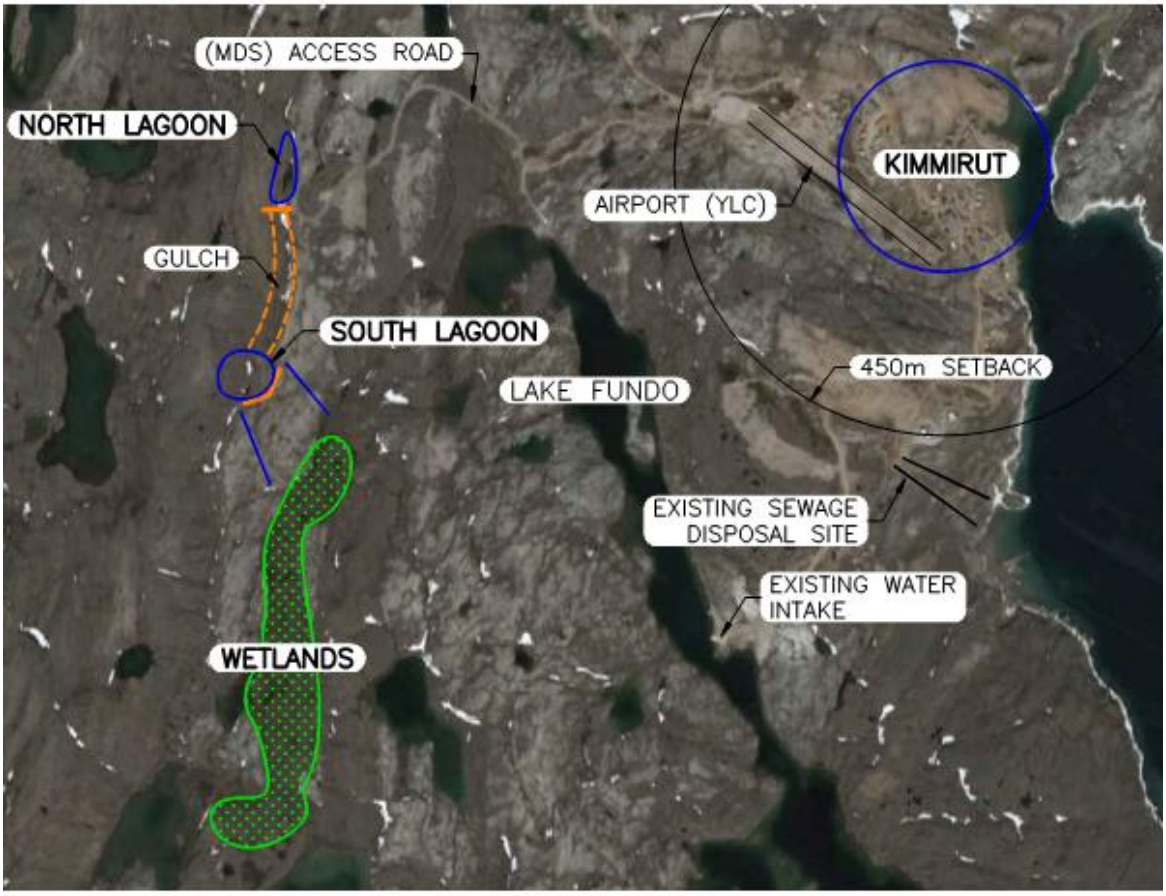
The existing water supply and its corresponding watershed are not influenced by the current location of the sewage disposal facility. The two sites are separated by approximately 700 metres with the sewage draining directly into the harbour.

1.3 Site Selection

The site location was based on the scope prepared by Dillon Consulting Ltd and to determine the existing facility and suitability for use as a sewage lagoon system for the Hamlet and, if required, recommend necessary upgrades to ensure the facility would meet the long term requirements of the Hamlet and the requirements of the regulatory agencies through the water licensing process as administered by the (NWB).

The proposed site complies with the separation requirements of the Public Health Act (450 metre buffer) and the community water supply (400 metre buffer). The existing road has been resurfaced, updated, and guardrails installed to provide a reliable access route to the lagoon system and solid waste site. Figure 1-1 shows the location of the lagoon site with respect to the Hamlet centre, water supply lake, and the airport.

Figure 1-1: Location Plan and Setbacks



1.4 Sewage Treatment

The proposed sewage treatment facility must meet the long term needs of the Hamlet, as well as the regulatory requirements of the Hamlet's water licence. The Water and Sewage Facility Capital Program Standards and Criteria indicate the design horizon for sewage lagoons is to be between 15 – 20 years. As per the direction of the Community and Government Service, Government of Nunavut, the design horizon for this facility shall be the year 2028.

The wastewater treatment system utilizes the sewage lagoons as the main method of treatment, with the wetlands providing additional treatment prior to the release to the environment.

The project will not have long term negative effects on the environment or wildlife. Most effects are related to construction activities and are short term, and all effects can be mitigated by applying suitable mitigation measures.

As monitoring the performance of natural wetlands is difficult, the Hamlet of Kimmirut's water licence has set the compliance point for the wastewater treatment system at the discharge of the lower lagoon. This point represents the last point of measurement and control for the system. The water licence further recognizes the treatment potential of the natural wetland and has set the compliance criteria recognizing the treatment the effluent will receive through the wetland.

1.5 Population Projections

The Nunavut Bureau of Statistics population projections provide projected populations of the Nunavut communities to the year 2020. As a planning horizon for this project is past the current population projections available from the Nunavut Bureau of Statistics, the population projection from 2020 to 2028 was estimated using the average annual growth rate for the Hamlet between the year 2000 and 2020 of 2.28%. The table below summarizes the population projections over the life of the proposed facility.

Table 1-2: Population Projections

Planning Year	Year	Population	Planning Year	Year	Population
	2000	450	7	2015	636
	2001	461	8	2016	649
	2002	474	9	2017	662
	2003	485	**10**	**2018**	**675**
	2004	496	11	2019	688
	2005	506	12	2020	706
	2006	519	13	2021	722
	2007	530	14	2022	739
0	**2008**	**546**	**15**	**2023**	**755**
1	2009	560	16	2024	773
2	2010	573	17	2025	790
3	2011	589	18	2026	808
4	2012	601	19	2027	827
5	**2013**	**612**	**20**	**2028**	**846**
6	2014	624			

The design population for the end of the design horizon 2028, is projected to be 846 persons.

1.6 Sewage Generation

Sewage generation rates are generally assumed to be equal to the water consumption rates for a community, with the water consumption rate being the total of the residential and non-residential water consumption. The Water and Sewage Facility Capital Program Standards and Criteria provide the following design values and formulae for estimating the water consumption and therefore the sewage generation rates for communities.

The residential water usage (RWU) for a community is based on the method of water delivery and sewage collection in the community. The litres per capita per day (lpcd) water usage rates for the different methods of water delivery and sewage collection are summarized in the Table 1-3.

Table 1-3: Residential Water Usage

Service Method	Residential Water Usage (RWU)
Trucked water and sewage	90 lpcd
Piped water and sewage	225 lpcd
Piped water supply and truck sewage pump out	110 lpcd
Trucked water delivery and individual septic fields	100 lpcd

The Hamlet of Kimmirut has a trucked water and sewage system, therefore the RWU for the community from Table 1-3 is equal to 90 lpcd.

Non-residential water usage by a community tends to increase with increases in the population. To determine the Total Community Water Usage (TCWU), the Residential Water Usage is adjusted based on population to provide a Total Water Usage Per Capita. The daily water consumption by the community is equal to the population multiplied by the Total Water Usage Per Capita. The Total Water Usage Per Capita, including residential and non residential activities are estimated based on the equations in Table 1-4 – Total Community Water Usage.

Table 1-4: Total Community Water Usage

Community Population	Total Water Use Per Capita
0 – 2000	RWU x (1.0 + 0.00023 x Population)
2000 – 10,000	RWU x [-1.0 + {0.323 x Ln(Population)}]
Over 10,000	RWU x 2.0

The daily water consumption, and therefore the sewage generated by the community, is equal to the population multiplied by the Total Water Usage Per Capita. Based on the design population of 846 for the year 2028, and a total water usage per capita rate of 107 lpcd, the daily sewage generation rate is equal to 91,000 lpd. This is equal to a yearly sewage generation rate of 33,200 m^3.

1.7 Seasonal Climatic Conditions

The average precipitation in Kimmirut is broken down monthly in Table 1-5. Temperatures in the summer range between 0°C and 15°C and in winter between -22°C and -30°C. It is generally quite windy with an average wind speed of 15 km/h and permafrost is present in the soil.

Table 1-5: Monthly Precipitation

Month	Precipitation Rate	Volume of Precipitation on Upper Lagoon Drainage Area	Volume of Precipitation on Lower Lagoon Drainage Area
January	21 mm	456 m^3	2,007 m^3
February	15 mm	324 m^3	1,427 m^3
March	22 mm	471 m^3	2,074 m^3
April	28 mm	610 m^3	2,683 m^3
May	27 mm	581 m^3	2,559 m^3
June	35 mm	757 m^3	3,329 m^3
July	59 mm	1,284 m^3	5,650 m^3
August	66 mm	1,420 m^3	6,250 m^3
September	55 mm	1,189 m^3	5,232 m^3
October	37 mm	793 m^3	3,491 m^3
November	29 mm	629 m^3	2,768 m^3
December	18 mm	393 m^3	1,731 m^3

1.8 Contact List

Title	Phone Number
Senior Administrative Officer (SAO)	867-939-2247
Baffin Regional Director (Timoon Toonoo)	867-897-3601
Municipal Planning Engineer (Bhabesh Roy)	867-899-7314
Spill Contact: Territorial 24-hour Spill Line	867-920-8130
Indian and Northern Affairs Canada Inspector	867-669-2761
GN-Emergency Measures Officer	888-624-4043
Kimmirut Health Centre	867-939-2217
RCMP (Kimmirut)	867-939-0123
Environment Canada (Emergency) Iqaluit	867-975-4644
GN Environment Health Office	867-975-4817
First Air Cargo	1-800-267-1247

2 Sewage Disposal System

2.1 Site Personnel

The responsibility of the Hamlets lagoon operations are overseen by the Senior Administrative Officer (SAO). The SAO is responsible for the foreman who conducts the day to day operation and maintenance of the sewage system together with one or two Hamlet employed laborers to operate the sewage collection vehicles and help maintain the system.

2.2 Operational Procedures

The following details the proposed operations of the sewage treatment system for the Hamlet.

2.2.1 Operation and Maintenance Duties

Daily

- Collection of municipal wastewater from holding tanks and delivery to the sewage lagoon system.
- Minimize spills, and immediately clean up when they occur.
- Repairs to equipment when breakdowns occur.
- Maintain road, discharge point, and truck turning pads as required and keep free of snow.
- Record Operation and Maintenance information as required.

Weekly

- Remove non-sewage materials from the lagoon. Floating materials such as plastic bags should be removed and solid items disposed at the solid waste site adjacent to the lagoon.
- Assess truck discharge location and containment berms for erosion.
- Record Operation and Maintenance information as required.

Monthly

- Preventative measures and maintenance on sewage trucks.
- Assess inventory of parts for truck maintenance.
- Grade and maintain the access road as required.
- Conduct monitoring program as required.
- Record Operation and Maintenance information as required.

Yearly

- Conduct annual monitoring program.
- Decanting pump maintenance
- Review the operation and maintenance records to evaluate the effectiveness of the sewage treatment system and plan for the upcoming year.

2.3 Operational Plan

The sewage lagoon system for Kimmirut comprises of an upper holding cell, spillway corridor, lower holding cell and wetlands. The system is designed to treat the municipal sewage generated over the period of one year prior to decanting.

2.3.1 Collecting Operations

Wastewater is collected from the holding tanks of each residential and municipal serviced structure within the Hamlet. Suction trucks pump the wastewater out of the holding tanks through an outside service pipe accessible to the truck. The quick-connect fitting, on the service pipe and truck intake hosepipe, gives the operator a fast and reliable connection reducing spills and speeding up the operation.

The service truck will follow a predetermined set circuit throughout the Hamlet collecting the wastewater until the holding tank is full. Once full, the truck will travel out to the lagoon site, discharge the contents and then return to the collection circuit where it left off. Some structures will have to be serviced more then once per circuit, the Hamlet office, hotel, and other high wastewater producing structures may require a higher frequency. These high producers will have to be scheduled on a more regular basis.

Each time the wastewater is trucked and discharged into the lagoon the truck must back up to a chute on the gravel pad at the lagoon, a valve is opened, and wastewater is discharged through the chute into the lagoon or spillway corridor.

2.3.2 Treatment Operations

October 1 to Start of Freeze-up - Early Winter Storage

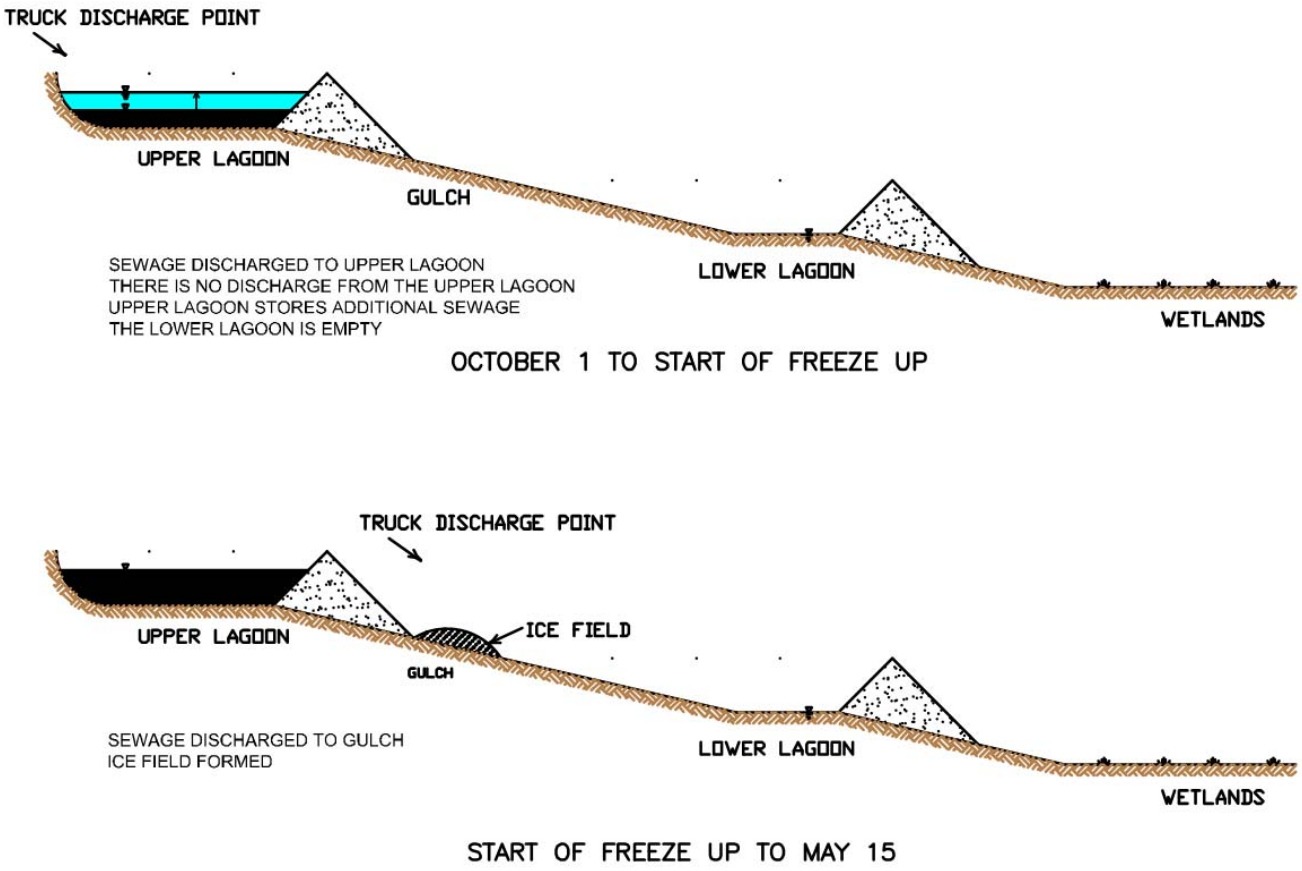
At this stage, both the upper and lower lagoons should be at their lowest operational levels. Sewage trucks begin by discharging to the decanted upper lagoon. As the average temperature drops below freezing, the trucks will change operations and discharge to the spillway.

Start of Freeze-up – May 15 - Over Winter Storage

Sewage trucks discharge directly to the spillway corridor where the sewage begins to freeze and form the ice pack.

The daily average temperature for October, as published in the Canadian Climate Normal's 1971-2000 by Environment Canada for Iqaluit is -4.9°C. It is reported that the number of days with a minimum temperature of greater than 0°C is one, and the number of days with a maximum temperature of less than 0°C is twenty. It therefore is concluded that freeze will start in October, and sewage discharged to the spillway corridor will freeze and form the ice pack.

Figure 2-1: Over Winter Storage



May 16 – June 15 - Spring Melt Begins

The truck discharge point is changed from the gulch to the Upper Lagoon. The Upper Lagoon has 7,900 m^3 capacity, the equivalent of approximately 65 days of the sewage not considering precipitation and runoff.

The ice pack and accumulated snow begins to melt and drain towards the Lower Lagoon, where it is retained. Based on a 2 month spring runoff, mid May until mid July, the Lower Lagoon should have capacity to retain half of the estimated flow from the ice pack and spring runoff. It is estimated that it will take approximately 1 month to fill the Lower Lagoon.

There is no discharge to the wetlands.

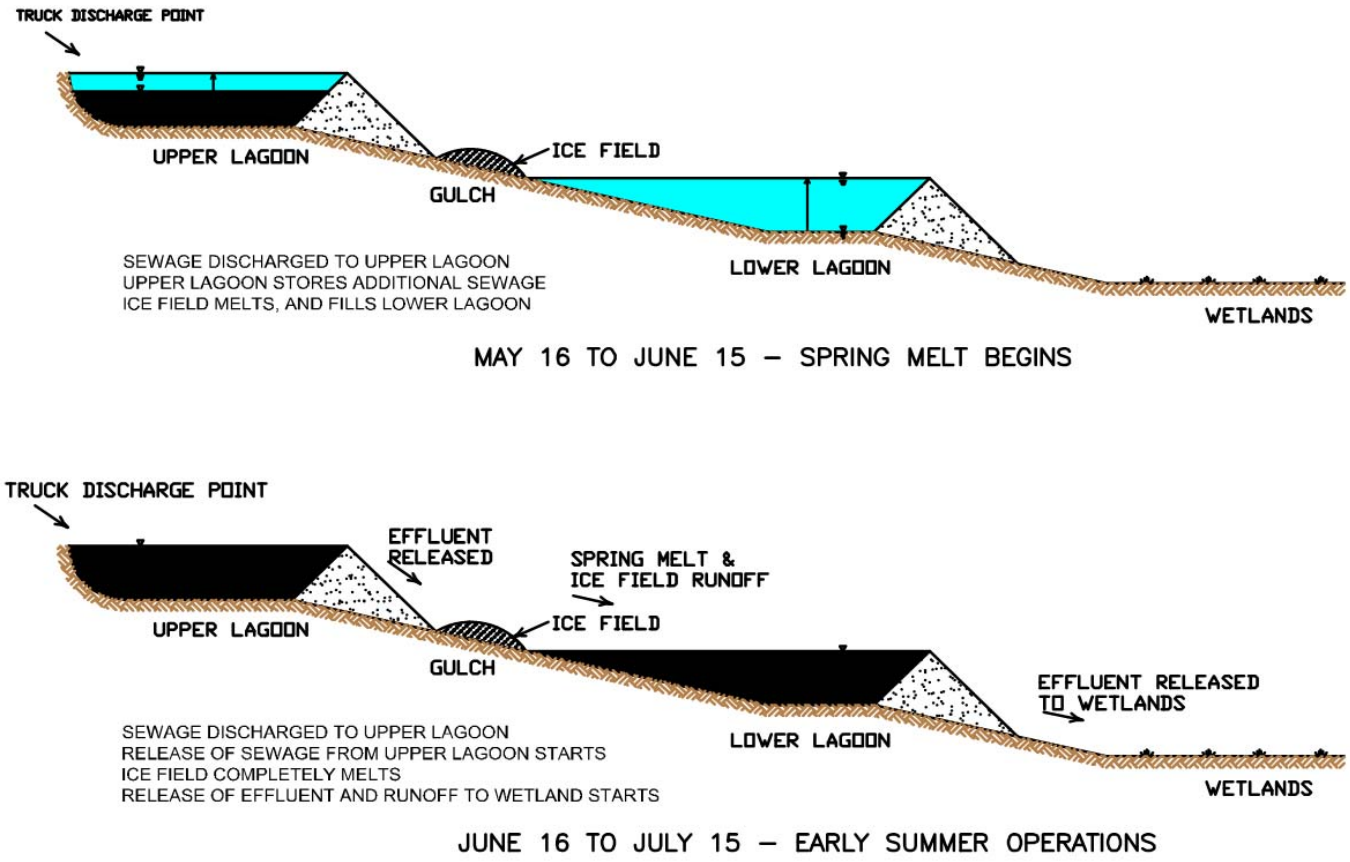
June 16 – July 15 – Earlier Summer Operations - Discharge Begins

The sewage trucks continue to discharge to the Upper Lagoon which has filled and begins to operate as a detention lagoon with continuous release of sewage over the spillway.

The Lower Lagoon has filled and begins to operate as a detention lagoon with a continuous release of sewage over the spillway. Effluent from the Lower Lagoon is released to the wetlands for further treatment.

The ice pack and snow accumulation finishes melting.

Figure 2-2: Early Summer Operations – Discharge Begins



July 16 – August 31 – Summer Operations

The sewage trucks continue to discharge to the Upper Lagoon which operates as a long detention lagoon with a continuous release rate equal to the inflow.

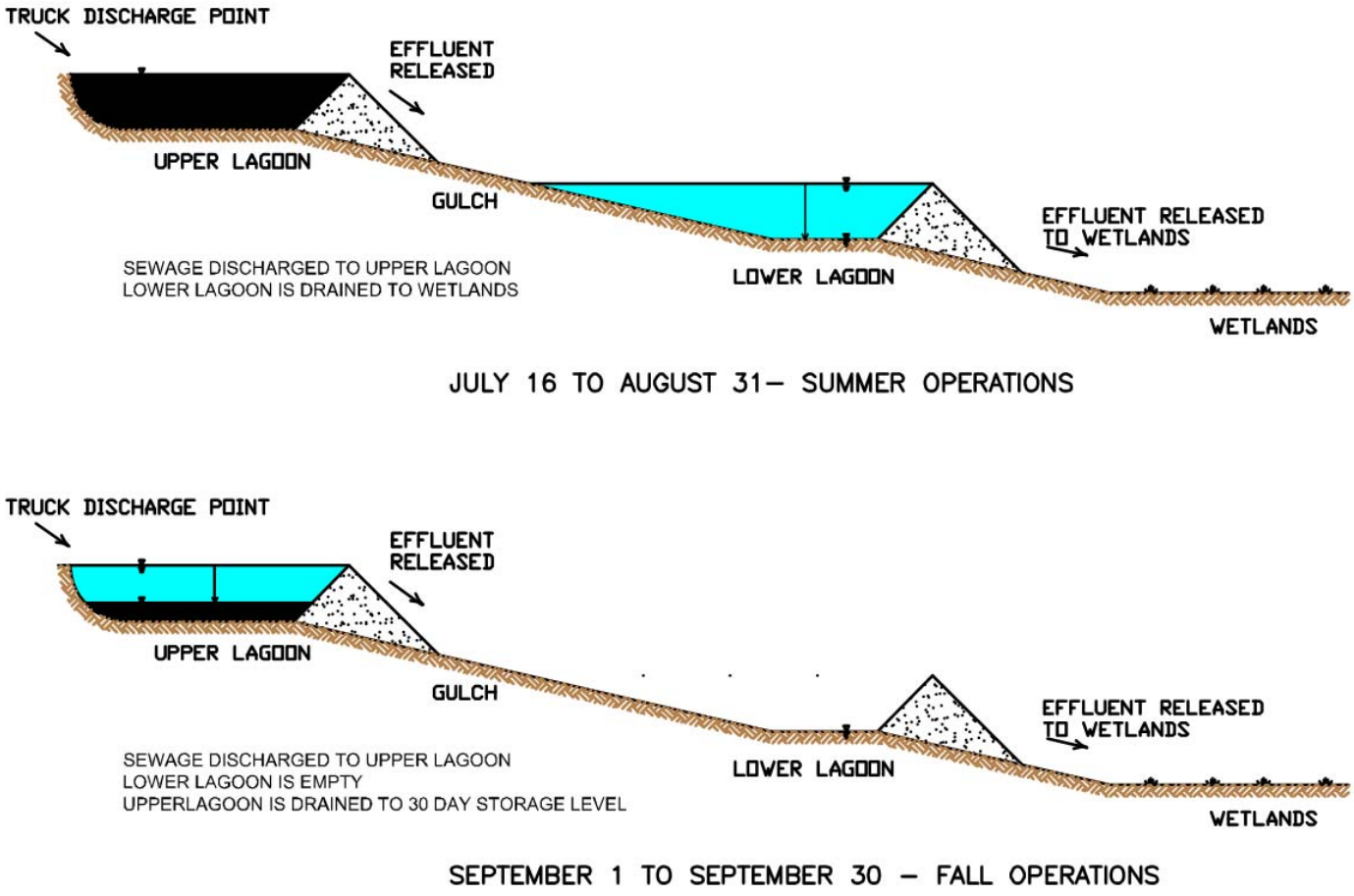
The Lower Lagoon is drained during this period to provide a continuous release of effluent to the wetlands over the optimal period for treatment. The release rate would be controlled by pumping.

September 1 – September 30 – Fall Operations

The sewage trucks continue to discharge to the Upper Lagoon. The operating level of the Upper Lagoon is lowered by pumping to a level equivalent to 15 days storage which allows for storage of the sewage generated in last 2 weeks of September until the subsequent year.

The Lower Lagoon is emptied.

Figure 2-3: Summer / Fall Operations



2.4 Decanting Method

One of the significant challenges in the operation of a sewage lagoon in a northern location is the process of decanting or emptying the lagoon. Pumping the effluent from the lagoon is the most operator demanding, however this method is also the most dependable and provides the most control on effluent release rates. The pumps are to be installed and removed each year, and during operation must be checked on a regular basis. The operation of a pump is a relatively dependable operation, and in the case of failure, a relatively easy system to replace. They also provide a reliable method for controlling the time and rate of discharge which is important for lagoons which use a wetlands as a secondary or additional treatment. The operation and maintenance manual for the pump can be found in Appendix B.

2.5 Release Rates

2.5.1 Upper Lagoon

The Upper Lagoon acts as a storage cell from May 16 until June 15 and therefore there is no effluent released from the lagoon. From June 16 until August 31, the lagoon acts as a detention cell and sewage is released over the spillway at the rates shown in Table 2-4 – Upper Lagoon Release Rates. From September 1 to September 30, the level of the lagoon is reduced through pumping at the daily rate shown.

Table 2-4: Upper Lagoon Release Rates

From	To	# of Days	Sewage Released	Release Rate
May 16	Jun 15	31	-	-
Jun 16	Jul 15	30	5,731 m^3	191 m^3/day
Jul 16	Aug 31	47	6,336 m^3	135 m^3/day
Sep 1	Sep 30	30	9,389 m^3	313 m^3/day

2.5.2 Lower Lagoon

The Lower Lagoon acts as a storage cell from May 16 until June 15 and therefore there is no effluent released from the lagoon. From June 16 until August 31, the lagoon acts as a detention cell and sewage is released over the spillway. From September 1 to September 30, the level of the lagoon is reduced through pumping. The daily release rates from the Lower Lagoon are shown in Table 2-5.

Table 2-5: Lower Lagoon Release Rates

From	To	# of Days	Sewage Released	Release Rate
May 16	Jun 15	31	-	-
Jun 16	Jul 15	30	29,273 m^3	975 m^3/day
Jul 16	Aug 31	47	37,407 m^3	795 m^3/day
Sep 1	Sep 30	30	14,621 m^3	487 m^3/day

2.6 Record Keeping and Recording

Records should be kept to assist in planning for yearly operations and to assist in the evaluation of the effectiveness of the sewage treatment facility. Copies of records pertaining to operation and maintenance of the sewage lagoon should be kept at both the Hamlet Office and the Maintenance Garage and be maintained by the Hamlet foreman. Information that must be included in these records is listed below:

- Approximate volume of any effluent discharged to the environment.
- Cell levels before and after discharge.
- Time required discharging each lagoon cell.
- Details of any maintenance undertaken at site.
- Volume of municipal potable water
- Dates of collecting and submitting samples to laboratory.
- Record sheets.

- Copy of the Hamlet's water licence.
- Copies of all manuals pertaining to the operation and maintenance of the Sewage Lagoon Facility.

Wastewater volumes will be approximated by the monthly municipal water volumes. Sewage trucks are not equipped with flow meters and therefore the last form of reliable consumption measurement is made at the water treatment plant. This flow measurement will reflect the approximate wastewater volume generated by the Hamlet and must be included in the records.

2.7 Health and Safety

Due to the potential health hazards associated with sewage handling and treatment, the following safety procedures should be obeyed in order to minimize health risks to personnel working in and around the wastewater facilities:

- Equipment is to be kept clean.
- Wear protective clothing such as gloves and boots at all times.
- Work clothes should not be worn home.
- Hands to be washed frequently, as a minimum before eating and after work.
- Personnel should receive appropriate vaccinations and ensure they are kept up-to-date.
- Change rooms for changing in and out of work clothes as well as storage lockers to store work clothes should be provided on site.
- Clothes washing facilities should be available on site to wash soiled work clothes.
- Visit the Health Clinic for all injuries. When working with wastewater the smallest cut or scratch is potentially dangerous.

Lagoons cells are facilities for treating human and industrial wastes, and as such people should be advised to keep away from them.

2.8 Spill Contingency Plan

A spill contingency plan has been developed for the Hamlet that identifies the procedures to follow when a spill of any hazardous material has occurred and can be found in Appendix C. Information presented in the spill contingency plan has been developed based on the document "*Guidelines for Spill Contingency Planning; Indian and Northern Affairs Canada, April 2007"* (INAC, 2007).

3 Maintenance

The wastewater treatment lagoons are designed and constructed for the purpose of providing the right environmental conditions for the bacteriological processes to proceed. They should be easily and safely operated without causing any adverse effects to the environment. The requirements of good wastewater treatment can be met if lagoon cells are constructed and maintained in such a way as to:

- Contain the quantity of effluent without interfering with the desired freeboard.
- Maintain an access road to the cells for inspection purposes.
- Provide the required treatment before discharging into the environment.

3.1 Berm Composition

3.1.1 Existing Berm Rehabilitation – Upper Lagoon

As per the recommendations of the geotechnical report, the existing earth berm was upgraded to flatten the downstream slope of the dyke to 3H:1V. The elevation of the berm was increased from 97 m to 98.5 m with a spillway elevation of 97.5 m. This provides 7,900 m^3 of storage between the spillway elevation of 97.5m and the top of the dead zone of 95m, meeting the storage requirements set out above in Section 2 of 7,900 m^3. The elevation of the top of the berm was set at 98.5 m to provide the 1.0 m of freeboard as per the Canadian Dam Safety Guidelines. The berm core is comprised of compacted Granular 'C', and where the original cell berms were used, Granular 'C' was keyed into the side slopes.

3.1.2 New Berm Construction – Lower Lagoon

The berm constructed to create the Lower Lagoon was constructed similar to the berm at the Upper Lagoon with side slopes of 3H:1V and a crest width of 4 m. The berm incorporated an overflow spillway at an elevation of 71.4 m to prevent uncontrolled overtopping and allow for continuous discharge during spring melt and runoff. The elevation of the top of the berm was set at 72.4 m to provide the 1 m freeboard as recommended by the Canadian Dam Safety Guidelines. The lagoon also incorporates an approximately 1 m deep dead storage to allow for accumulation of sludge with the top of the dead zone being at elevation 68 m. The total volume provided in the Lower lagoon is 20,700 m^3.

3.2 Berm Monitoring

Berm monitoring will be vital during the early operational years to ensure the proper freeze-back of permafrost into the base soils and berm core. The settlement readings should be undertaken at the beginning of spring and prior to the onset of winter. The settlements should be referenced to the bench mark noted in the site plans.

3.3 Sludge Management

Effluent quality will guide when a sludge management program is implemented. Monitoring of the effluent from the lagoon will indicate when the performance of the lagoon starts to degrade. Degradation of the performance of a lagoon is normally caused by sludge accumulation and will be the indicator to de-sludge the lagoon.

Prior to disposal, the sludge must be tested to ensure the disposal method chosen is safe and environmentally responsible. Sludge removed from the lagoons can be disposed of in a separate cell constructed at the landfill site. The sludge will be covered with granular material and allowed to freeze.

3.3.1 Assessment Criteria

Evaluating the analytical results obtained by sludge sampling, the Government of Nunavut defaults to criteria established by the Canadian Council of Ministers of the Environment (CCME). For soil, the CCME Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (updated September 2007) is used to compare the metals and VOC analytical results. The CCME has also established the Canada-Wide Standards (CWS) for Petroleum Hydrocarbons (PHC) in Soil (April 2001), which is the federal remedial standard for petroleum impacted soils. The CCME and CWS criteria are based on four land use categories: i) agricultural; ii) residential/parkland; iii) commercial; and iv) industrial. As the sludge is to be disposed of at the landfill site, the industrial land use category is utilized for assessing the sledge management.

3.4 Treatment from the Wetlands

An assessment of the wetlands capacity to provide treatment to the effluent released from the sewage lagoons proposed for the Hamlet was prepared under a report entitled Kimmirut Wetlands Planning Study prepared by Earth Tech and found in Appendix D.

The Kimmirut Wetlands Planning Study presents an estimate of the wetlands' water quality improvement performance based on the preliminary design and operational plans prepared in September 2007. The total quantity of sewage release is constant at approximately 33,000 m^3 over a time of approximately 107 days. Minor changes to the release rates have occurred due to refinement in the design and construction of the lagoons, and finalizing the available volume. Changes in the release rates and effluent quality from the lagoon were relatively minor, and therefore the estimated water quality improvement performance of the wetlands in the Kimmirut Wetlands Planning Study continues to provide a good estimation of the treatment that would be received. The estimated wetlands water quality improvements from the Kimmirut Wetlands Planning Study are summarized in the tables below.

Table 3-1: Summary of Treatment Levels

Parameter	Units	Criteria	Influent	Effluent from Lower Lagoon	Effluent from Wetland
BOD_5	mg/L	120	460	216	38
TSS	mg/L	180	490	172	39
FC	#/100ml	1×10^6	1×10^7	1×10^7	157,000

3.5 Filter Strip Protection

Arctic tundra and wetland vegetation communities are very sensitive to physical damage and take a long time to recover from disturbances. Arctic plant species have very slow growth rates and areas damaged by construction activities will not re-vegetate for many years. It is therefore important that construction equipment and trucks do not enter the wetland area. Damage to the wetland area would result in a decrease in treatment efficiency.

4 QA/QC

4.1 Quality Assurance and Quality Control Monitoring

A key component to the operations and maintenance of the sewage lagoon system is a sampling/monitoring program. The following quality assurance (QA) and quality control (QC) program should be implemented to ensure that the analytical results received are accurate and dependable. A QA/QC program is a system of documented checks that validate the reliability of the data collected regarding any given site. Quality Assurance is a system that ensures that quality control procedures are correctly performed and documented. Quality Control refers to the established procedures observed both in the field and in the laboratory, designed to ensure that the resulting end data meet intended quality objectives.

The proposed program will help monitor the treatment while verifying compliance with regulations. As well, it will model the treatment process which will help to understand the performance of the lagoon for future development and modifications to the current system.

It is important such a program be implemented by the Hamlet as a part of the annual operations for the facility. Local members of the community that operate the system are to be trained on the proper operation and procedure methods used in the sampling/monitoring program. In addition, quality and safety training will also be included which will ensure that the high quality data will be obtained.

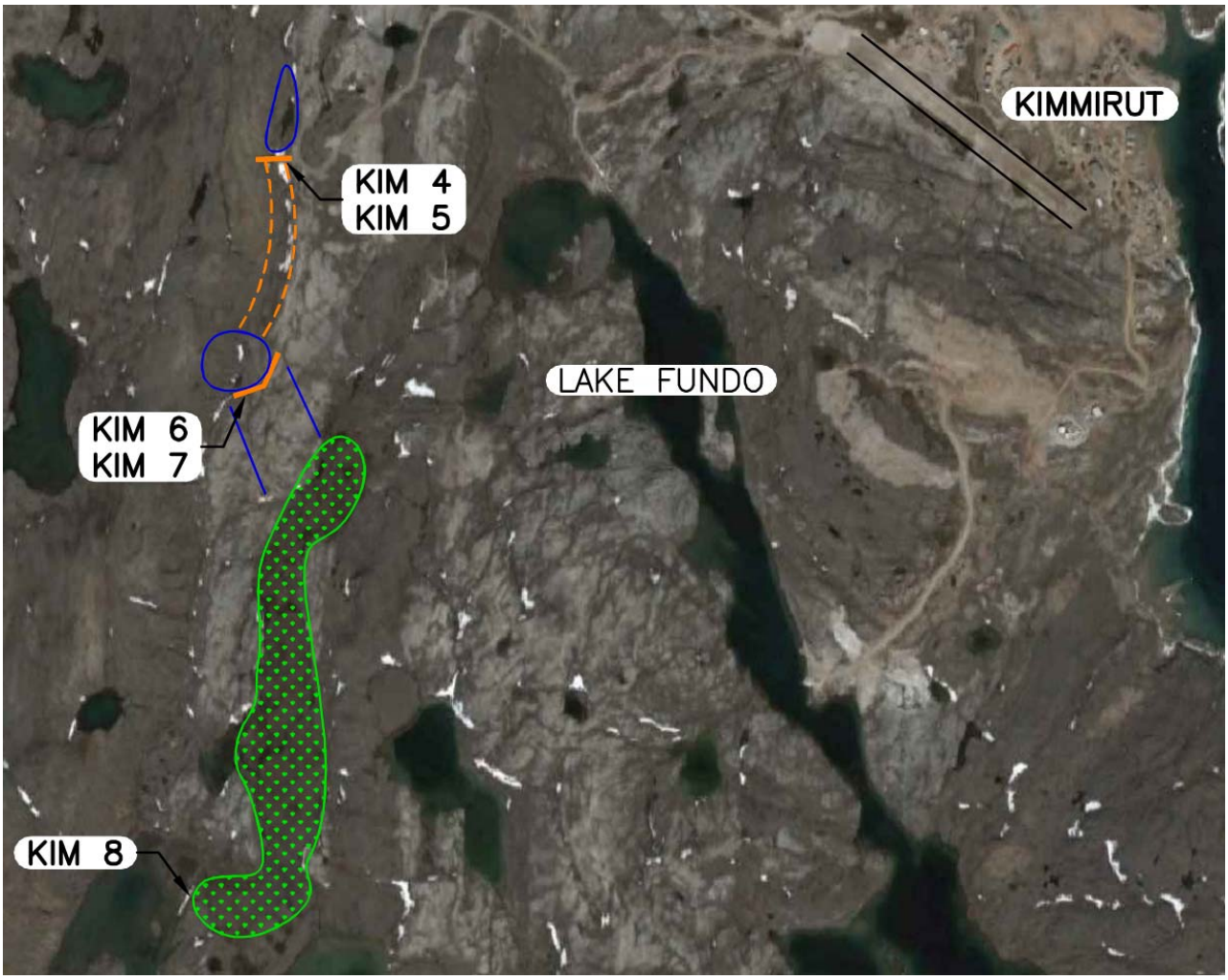
4.2 Sampling Points

Monitoring the operation and efficiency of the system will be accomplished through the establishment of five sampling points. Sampling will provide information regarding the performance of the system and help identify any degradation to the treatment provided. Table 4-1 provides coordinates of the sampling points as shown in Figure 4-2.

Table 4-1: Sampling Points

Monitoring Program Station Number	Description	Latitude	Longitude
KIM-4	Upper Lagoon Spillway	N62°50’49”	W69°54’26”
KIM-5	Upper Lagoon Pump Discharge	N62°50’49”	W69°54’24”
KIM-6	Lower Lagoon Spillway	N62°50’36”	W69°54’32”
KIM-7	Lower Lagoon Pump Discharge	N62°50’36”	W69°54’30”
KIM-8	End of Wetlands	N62°49’57”	W69°54’39”

Figure 4-2: Sampling Points Location Plan



4.3 Sampling Frequency

The following outlines the Sampling, Testing and Compliance requirements of the Wastewater Facility. Any other additional sampling during the year will be at the request of the regulatory agencies. Once collected, the samples will be shipped to the laboratory and analyzed using the same test/method/procedure.

Table 4-3: Sampling Frequency

Monitoring Program Station Number	Description	Frequency
KIM-4	Upper Lagoon Spillway	Water Quality: Twice Annually - Start of overflow/start of decanting
KIM-5	Upper Lagoon Pump Discharge	Water Quality: Twice Annually - Start of overflow/start of decanting
KIM-6	Lower Lagoon Spillway	Water Quality: Twice Annually - Start and end of decanting
KIM-7	Lower Lagoon Pump Discharge	Water Quality: Twice Annually - Start and end of decanting
KIM-8	Surface water at the end of the Wetland Area	Water Quality: Monthly during periods of flow from spring to freeze-up.

4.4 Sampling Parameters

Samples should be analyzed for the following parameters:

Biochemical Oxygen Demand – BOD5	Fecal Coli forms
Total Suspended Solids	pH
Conductivity	Nitrate-Nitrite
Oil and Grease (visual)	Total Phenols
Magnesium	Calcium
Sodium	Potassium
Chloride	Sulphate
Total Hardness	Total Alkalinity
Ammonia Nitrogen	Total Zinc
Total Cadmium	Total Iron
Total Cobalt	Total Manganese
Total Chromium	Total Nickel
Total Copper	Total Lead
Total Aluminum	Total Arsenic
Total Mercury	Total Organic Carbon (TOC)

4.5 Influent Characteristics

The characteristics of sewage generated in a community are heavily dependent on the type of installation and sanitary facilities. The Hamlet's water and sewage system utilizes holding tanks within the building and truck delivery and collection systems. The waste generated from this arrangement is considered to be "Moderately Diluted Wastewater", as per the Cold Climate Utility Manual. Table 4-4 - Characteristics of Basic Wastewater Categories is an excerpt from the Cold Climate Utilities Manual, summarizing the characteristics of moderately diluted wastewater.

Table 4-4: Waste Water Characteristics

Parameter	Units	Moderately Diluted
BOD_5	mg/L	460
COD	mg/L	1000
Suspended Solids	mg/L	490
Total Nitrogen	mg/l as N	--
Phosphorus	mg/L as P	--

'Canadian Society for Civil Engineering, 1986, *Cold Climate Utilities Manual*

4.6 Compliance Points

The water licence has set the lagoon discharge as the compliance point for the new wastewater facility as it is the last point of measurement and control. The effluent released from the Lagoon must meet the criteria list in Table 4-5. This criteria recognizes the treatment ability of the wetlands.

Table 4-5: Effluent Quality Standards at Monitoring Points KIM-6 and KIM-7

Parameters	Maximum Average Concentration
BOD_5	120mg/L
Total suspended solids (TSS)	180mg/L
Faecal coli-forms	1×10^6 CFU/100ml
Oil and grease	No visible sheen
pH	6 and 9

4.7 Laboratory Requirements

All analyses shall be performed by a laboratory certified by the Canadian Association for Laboratory Accreditation (CALA), or as otherwise approved by an Analyst.

4.8 Sampling Procedures

The sampling procedures should be as per "Quality Assurance (QA) and Quality Control (QC) Guidelines for use by Class "B" Licences in Collecting Representatives water samples in the field".

All sampling, sample preservation and analyses will be in accordance with methods described in the current edition of Standard Methods for the Examination of Water and Wastewater (American Public Health Association, American Water Works Association, and Water Environment Federation, most current edition).

To obtain meaningful results from the analysis, the following five factors are of particular importance:

- Sample collection at designated time and location.
- Correct usage of container/sample bottle for parameter being tested.

- Correct labeling of sample bottles and filling out record/field sheet.
- Correct procedure for field sampling.
- Proper and timely shipment of samples to the laboratory.

4.9 Lagoon Water and Sludge Sampling

Prior to sampling, the appropriate sample bottles/vials, along with coolers and ice packs should be requested from the analytical laboratory.

Latex gloves should be worn during sampling and should be replaced with fresh gloves after all sample containers are filled at each sampling location. Sampling equipment such as sampling poles should be cleaned with soap and water after each sample is collected to prevent cross-contamination.

For lagoon water samples

- Using a sampling pole, plunge the container into the lagoon water neck first. Immerse to a depth of 10 to 20 cm, depending on the depth of the lagoon. Fill the sampling container with the mouth facing slightly upwards.

For lagoon sludge samples

- Using a sampling pole, plunge the container into the lagoon water neck first to maintain an air pocket within the container. Once contact with the sludge is felt, immerse container into sludge neck first to a depth of 5 to 10 cm. Fill the sampling container with sludge and raise sample bottle neck first to prevent sample spillage.

All sample containers should be tightly sealed and properly labeled with the sample ID, date and time of sample collection, location of sample collection and parameters to be analyzed. The outside of the bottles should be cleaned with soap and water prior to placing the samples in the cooler. The samples should be stored on ice in a cooler until delivery to the laboratory. A chain of custody form should be filled out completely and be used to track the samples. Keep the last page and give it to the project manager along with the field notes.

4.10 Quality Assurance and Quality Control Program

Prevention of Cross Contamination

Proper field protocols reduce the chances of cross contamination in the field. As outlined above, latex gloves should be worn during sampling and should be replaced with fresh gloves after all sample containers are filled at each sampling location. Sampling equipment such as sampling poles should be cleaned after each sample is collected to prevent cross-contamination.

Proper Field Note Taking Procedures

Proper documentation of all aspects of the sampling program (i.e., field notes and Chain of Custody forms) is essential. Be sure to note any deviations that could potentially cause sampling bias (i.e., broken bottles). It is also important that field notes include the date and time of the sampling event, the meteorological conditions at the time of sampling (ambient temperature, whether it is raining or snowing, etc.).

Quality Control Samples

Cross contamination is a common source of error in sampling procedures. QC samples help you identify when and how contamination might occur. There are various types of QC samples including: blind duplicates, field blanks, and trip blanks. A blind duplicate is a duplicate sample that is not labeled as such. The purpose of the blind duplicate sample is to ensure analytical precision. A field blank is a sample of analyte free (i.e., clean) water poured into the container in the field, preserved and shipped to the laboratory with field samples and is analyzed along with field samples to check contamination from field conditions during sampling. A trip blank is a clean water sample that stays unopened and that

remains with collected samples during transportation and is analyzed along with field samples to check residual contamination (i.e., to determine if cross contamination occurs during shipping).

Exp recommends the following number of quality control samples based on the number of samples collected:

- 10% field blanks
- 10% blind duplicates
- 1 trip blank per shipping container (cooler)

If the total number of samples collected is less than five, include at a minimum, one blind duplicate and one trip blank.

Sampling Containers, Preservation and Hold Times

Containers, preservatives, holding times, and sample volumes with respect to the target analyses should be selected in accordance with the appropriate protocols (Canadian Council for Ministers of the Environment or CCME). All water samples should be collected in laboratory approved containers with the proper preservative, where applicable.

Sample Identification Requirements

All sample containers must be labeled to prevent misidentification of samples. As mentioned above, the sample containers should be identified with the sample ID, the client ID, date and time of sample collection, location of sample collection and parameters to be analyzed.

Chain of Custody

A chain of custody must accompany the shipment of samples to the laboratory. A legal Chain of Custody is a special type of sample custody that requires the physical possession, transport and storage of a sample be documented in writing. On the chain of custody, you indicate what analyses are to be done by the laboratory and who should receive the results. Keep the last page and give it to the project manager along with the field notes.

Sample Transmittal Documentation

All samples should be logged into the laboratory to verify that all records were complete, correct and entered into the sample custody records.

Initial Check of Samples and Documentation

The following checks are generally performed by the laboratory upon receipt:

- Verification of the integrity and condition of all sample coolers.
- Verification of the integrity and condition of all sample containers.
- Checks for leakage, cracked or broken closures or containers, evidence of grossly contaminated container exteriors or shipping cooler interiors, and obvious odors, etc.
- Verification of receipt of complete documentation for each container.
- Verification that sample identification numbers on sample transmittal forms corresponds to sample identification numbers on the sample containers.
- Verifications that holding times were met and samples were kept cool during transit.

Appendix A – Water Licence

P.O. Box 119
Gjoa Haven, NU X0B 1J0
Tel: (867) 360-6338
Fax: (867) 360-6369

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NUNAVUT WATER BOARD
NUNAVUT IMALIRIYIN KATIMAYINGI
OFFICE DES EAUX DU NUNAVUT

File No.: 3BM-KIM0911

January 19, 2009

Mr. Akeego Ikkidluak
Acting Senior Administrative Officer
Hamlet of Kimmirut
Box 120
Kimmirut, NU X0A 0N0
E-mail: saokim@qiniq.com

RE: NWB Licence No. 3BM-KIM0911

Dear Mr. Ikkidluak:

Please find attached Licence No. 3BM-KIM0911 issued to the Hamlet of Kimmirut by the Nunavut Water Board (NWB) pursuant to its authority under Article 13 of the *Agreement between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada*. The terms and conditions of the attached Licence related to water use and waste disposal are an integral part of this approval.

If the Licensee contemplates the renewal of this Licence, it is the responsibility of the Licensee to apply to the NWB for its renewal. The past performance of the Licensee, new documentation and information, and issues raised during a public hearing, if the NWB is required to hold one, will be used to determine the terms and conditions of the Licence renewal. Note that if the Licence expires before the NWB issues a new one, then water use and waste disposal must cease, or the Licensee will be in contravention of the *Nunavut Land Claims Agreement* (NLCA) and the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA). However, the expiry or cancellation of a licence does not relieve the holder from any obligations imposed by the licence. The NWB recommends that an application for the renewal of this Licence be filed at least three months prior to the Licence expiry date.

If the Licensee contemplates or requires an amendment to this licence, the NWB may decide, in the public interest, to hold a public hearing. An application for amendment will be required for the construction of the proposed new solid waste disposal facility. The Licensee should submit applications for amendment as soon as possible to give the NWB sufficient time to go through the amendment process. The process and timing may vary depending on the scope

of the amendment, however a minimum of sixty (60) days is required from time of acceptance by the NWB. It is the responsibility of the Licensee to ensure that all application materials have been received and acknowledged by the Manager of Licensing.

The NWB strongly recommends that the Licensee consult the comments received from interested persons on issues identified. This information is attached for your consideration.

Sincerely,

Thomas Kabloona
Nunavut Water Board, Chair

TK/tla/kt

Enclosure: Licence No. 3BM-KIM0911
Comments from EC, GN-DoE and INAC

cc: Qikiqtani Distribution List

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NUNAVUT WATER BOARD
NUNAVUT IMALIRIYIN KATIMAYINGI
OFFICE DES EAUX DU NUNAVUT

DECISION

LICENCE NUMBER: 3BM-KIM0911

This is the decision of the Nunavut Water Board (NWB) with respect to an application for a Licence renewal received August 20, 2007 and application for amendment received February 15, 2008, made by:

HAMLET OF KIMMIRUT

to allow for the use of water and disposal of waste for the Hamlet of Kimmirut, located within the Qikiqtani region of Nunavut. With respect to this application, the NWB gave notice to the public that the Hamlet had filed an application for a water licence renewal.

DECISION

After having been satisfied that the application was exempt from the requirement for screening by the Nunavut Impact Review Board in accordance with S. 12.3.2 of the *Nunavut Land Claims Agreement* (NLCA), the NWB decided that the application could proceed through the regulatory process. After reviewing the full submission of the Applicant and written comments expressed by interested parties, the NWB, having given due regard to the facts and circumstances, the merits of the submissions made to it and to the purpose, scope and intent of the *NLCA* and of the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA), decided to waive the requirement to hold a public hearing and determined that:

Licence Number 3BM-KIM0911 be issued subject to the terms and conditions contained therein. (Motion #: 2008-10-L03)

SIGNED this 9th day of January, 2009 at Gjoa Haven, NU.

Thomas Kabloona
Nunavut Water Board, Chair

TABLE OF CONTENTS

I. BACKGROUND

The Hamlet of Kimmirut is a small community with a population of approximately 546. The Hamlet is located on the southern tip of Baffin Island in Nunavut, at $62^0$50'06''N and $69^0$52'04''W within the Qikiqtani region of Nunavut.

The Hamlet of Kimmirut currently discharges its sewage to a ditch which drains directly to the ocean. In 2001 a new sewage lagoon was constructed 1.5 km from the community to improve the treatment of sewage. However, due to the unsafe condition of the access road to the lagoon, the lagoon has never been used.

An assessment of the existing facility as designed, determined that the existing lagoon would not have sufficient capacity to meet the over winter storage requirements of the Hamlet. Thus much of the over winter sewage would accumulate in the form of an ice pack in the gulch downstream of the sewage lagoon. The sewage in the ice pack would then be released in an uncontrolled manner and without treatment during the spring melt.

Further investigations were carried out on the existing facility to determine what works were required in order to meet the requirements of the Hamlet. Based on these investigations, a sewage treatment facility has been proposed utilizing the existing lagoon as the primary cell and the construction of a second lagoon at the bottom of the gulch to provide additional retention followed by wetlands. Rehabilitation of the existing access road is a requirement to allow use of the old lagoon and upgraded facility once completed.

The project has been designed for a twenty (20) year lifetime and a yearly sewage generation rate of approximately 33,195 cubic meters projected for the year 2028. Construction was to begin during the summer of 2008.

II. PROCEDURAL HISTORY

The NWB issued a municipal water licence to the Hamlet of Kimmirut on September 1, 2002, to allow for the use of water and disposal of waste under Licence NWB3KIM0207. The municipal water licence expired on August 31, 2007. The Hamlet of Kimmirut, in conjunction with the Government of Nunavut Department of Community and Government Services (CGS), submitted an application for water licence renewal to the NWB on August 20, 2007. Following a preliminary review of the application, the NWB noted the following documents/reports had not been received:

- Operations and Maintenance Plan of the sewage and solid waste facilities – required by September 1, 2003 and not received;
- Quality Assurance/ Quality Control Plan – required November 1, 2002 and not received.

On September 6, 2007, the NWB notified the Applicant that the above documents would be required prior to the issuance of a renewed licence.

On November 23, 2007, the NWB publicly posted notice of this application, in accordance with Section 55.1 of the Act and Article 13 of the *Nunavut Land Claims Agreement* (NLCA). This assessment process included the referral of the application to a variety of Federal, Territorial and local organizations for their review and comment. Information contained in the submission for review included:

- Application cover letter dated August 20, 2007;
- Letter dated November 30, 2006 from Municipality of Kimmirut to NWB regarding work of GN-CGS on Hamlet's behalf;
- NWB Licence renewal application; and
- Technical Summary Report in English and Inuktitut

The scope of the renewal application included water use, and ongoing disposal of sewage and solid waste. No public concern was expressed during this review. Therefore, the NWB waived the requirement to hold a public hearing and proceeded with the application process.

The NWB received comments on the application from interested parties including Environment Canada (EC) and the Government of Nunavut Department of Environment (GN-DOE) on or prior to January 11, 2008. The review identified a number of issues with the Application and the file in general that needed to be addressed including: (1) Compliance with the existing water licence; (2) Effluent discharge predictions and criteria; and (3) The need for an amendment application.

On February 15, 2008, the GN-CGS submitted an application for the amendment of the expected renewed water licence for the Hamlet of Kimmirut (NWB3KIM0207) suggesting in the cover letter that the NWB combine the two applications. The documents submitted with the amendment application included:

- Application Cover Letter dated February 15, 2008, received February 18, 2008;
- NWB Licence amendment application, received February 28, 2008;
- Facsimile Transmittal and Attachment re: Motion and approval of Preliminary design of Lagoon and Wetland Treatment dated November 1, 2007
- Authorization email from the Hamlet of Kimmirut;
- *Design Brief Rehabilitation and Expansion of Existing Sewage Lagoon for the Hamlet of Kimmirut* prepared for Department of Community Government and Services by Trow Associates Inc., dated January 2008, OTCD00018881A;
- Technical Summary Report in English and Inuktitut, received February 28, 2008;
- Cover Letter dated February 13, 2008 from S. Douglas, Trow Associates to B. Roy, GN-CGS, re: Kimmirut Wetland Planning Study (OTCD00018881A)

- *Kimmirut Wetland Planning Study* prepared for Trow Associates by Wetland Management Services, dated January 2008, 99559-03;
- *Geotechnical Investigation Sewage Lagoon Hamlet of Kimmirut, Nunavut* prepared for CGS-Projects, prepared by Trow Associated Inc., dated September 24, 2007, OTGE00018881B;
- Drawing No. 1, entitled *Borehole Location Plan-Septic Lagoon Rejuvenation* prepared by Trow Associates Inc., project no. 0TGE00018881B dated 21/08/07;
- Drawing No. 2 entitled *Borehole Location Plan-Proposed Landfill Site* prepared by Trow Associates Inc., project no. 0TGE00018881B dated 21/08/07;
- Drawing No. 3 entitled *Borehole Location Plan-Investigation of Diversion Berm* prepared by Trow Associates Inc., project no. 0TGE00018881B dated 21/08/07;
- Drawing No. SP-1 entitled *Lagoons and Wetlands Site Plan* prepared by Trow Associates Inc., project no. OTCD00018881A dated 4/01/2008, signed and stamped by an Engineer;
- Drawing No. L-1 entitled *Upper Lagoon* prepared by Trow Associates Inc., project no. OTCD00018881A dated 4/01/2008, signed and stamped by an Engineer;
- Drawing No. L-2 entitled *Lower Lagoon* prepared by Trow Associates Inc., project no. OTCD00018881A dated 4/01/2008, signed and stamped by an Engineer;
- Drawing No. DE-1 entitled *Lagoon Dewatering Details* prepared by Trow Associates Inc., project no. OTCD00018881A dated 4/01/2008, signed and stamped by an Engineer; and
- Drawing No. T-1 entitled *Topographic Map* prepared by Trow Associates Inc., project no. OTCD00018881A dated 11/02/2008, signed and stamped by an Engineer.

The scope of the amendment application includes:

- Rehabilitation of the existing access road to the Sewage Disposal Facility;
- Upgrading of the existing Sewage Disposal Facility comprised of a sewage lagoon (upper lagoon);
- Construction of a second sewage lagoon at the bottom of the gulch hydraulically below the existing lagoon (lower lagoon); and
- Effluent release to a Wetland Area that is approximately 15 - 20 ha.

Following a preliminary review of the application, the NWB concluded that the amendment application met the requirements of section 48(1) of the Act and advised the Applicant and distribution list accordingly on March 31, 2008. In addition, having completed its review of the application for licence renewal for the same licence, the NWB determined that, given the timing of the NWB final review of the renewal and the receipt of the amendment application, it would be in the best interest of all parties to combine both applications for maximum clarity and efficiency.

On May 5, 2008, the NWB received comments on the combined application from Indian and Northern Affairs Canada (INAC). Upon consideration of the submissions from EC and GN-DOE in January 2008 as well as the submission from INAC, the NWB identified the following

key issues that were forwarded to the Applicant on June 18, 2008 and that clarification was required prior to the Board considering a decision:

- Response to the NWB's letter of September 6, 2007, concerning the Operations and Maintenance Plan for the sewage and solid waste facilities and status of the QA/QC Plan;
- Status of the access road;
- Status of existing landfill and location of the proposed solid waste disposal facility and issues identified in the document entitled *Geotechnical Investigation Sewage Lagoon Hamlet of Kimmirut* (Trow Associates Inc., September 24, 2007);
- Hazardous materials storage location;
- Required follow-up to the January 8, 2008 municipal inspection report;
- Confirmation of the location of the sewage treatment facility;
- Design and operation of the sewage treatment facility;
- Quarry source for construction materials; and
- Location of waste disposal facilities in relation to the location of the Hamlet's water supply.

On August 7, 2008, GN-CGS submitted a letter response to the Board's June 18, 2008 request for clarification.

Based upon the results of the detailed assessment of the renewal and amendment application file, including consideration of any potential accidents, malfunctions, or impacts to water that the overall project might have in the area, the Board has approved the application and has issued Licence 3BM-KIM0911.

III. ISSUES

Term of Licence

In accordance with section 45 of the Act, the NWB may issue a licence for a term not exceeding twenty-five years. In determining an appropriate term of a water licence, the Board considers a number of factors, including the results of INAC site inspections and the compliance record of the Applicant. In review of the previous water licence NWB3KIM0207 inspection reports, the NWB has noted compliance issues identified by the Inspector in a Municipal Water Use Inspection Report dated December 4, 2002 for an inspection conducted on August 1, 2002 including:

- Storage of hazardous materials and metals; and
- Posting of signs at all surveillance network program stations.

A subsequent inspection was conducted on August 26, 2003 and reported the same day identifying additional compliance issues including:

- Maintenance of a copy of the Licence at the site of operations; and
- Maintenance of the Sewage Disposal Facility.

On September 15, 2003, the Inspector issued direction to the Hamlet of Kimmirut by way of a *Deposit of Waste in Contravention of Water Licence 3NWB3KIM0207* letter requiring the Licensee to (1) immediately ensure that any 45 gallon drums of oil, fuel and solvent are consolidated and properly stored and (2) to ensure that no drums of waste oil, fuel or other associated waste products from industrial sources are deposited to the municipal waste facilities.

The most recent inspection conducted on July 13, 2007 and reported on January 8, 2008 provided the following updated concerns:

- Collection and analysis of samples required under the Monitoring Program;
- Submission of the required annual reports;
- Installation of a volumetric measuring device on the water intake system;
- Posting of signs at surveillance network program stations;
- Segregation of bulk metals and hazardous wastes;
- Submission of Sewage and Solid Waste Disposal Facility Operation and Maintenance Plan;
- Presence of the Sewage Disposal Facility;
- Submission of Abandonment and Restoration Plan; and
- Submission of a Quality Assurance/ Quality Control Plan.

In its August 7th, 2008 response to intervener comments, the Hamlet clarified its request for a term of five year(s) for the Licence renewal and amendment. No comments were received from interested parties with respect to the length of term, however, the NWB has decided on a two (2) year term for the Licence based on issues with non-compliance, including non-compliance with administrative and reporting requirements.

The two (2) year Licence term is intended to send a clear message to the Hamlet and regulatory authorities that the Board will not passively encourage the Hamlet's failures to comply with the Licence conditions and associated legal requirements. The Board fully expects the Hamlet to take immediate steps towards full compliance with all Licence requirements for its existing facilities. Upon submission of an application to renew the Licence in approximately twenty one (21) months, the Board expects the Hamlet to be in full compliance with the licence. This shorter licence duration also permits the Board to increase its level of confidence of the Licensee that the facilities are operating as they should. As per Part B, Item 11 of the Licence, the Licensee must submit a Plan for Compliance that clearly demonstrates how the Hamlet will achieve full compliance with the Licence conditions during this time period.

The NWB reminds the Licensee of its responsibility to be in compliance with the conditions of the Licence. If monitoring results demonstrate that effluent does not meet discharge limits, the Licensee is required to take the necessary measures to remedy the situation.

Annual Report

The NWB has imposed on the Licensee, the requirement to produce an Annual Report. These Reports are for the purpose of ensuring that the NWB has an accurate annual update of municipal activities during a calendar year. This information is maintained on the Public Registry and is available to interested parties upon request. A *"Standardized Form for Annual Reporting"* is to be used by the Licensee and is available from the NWB file transfer protocol (FTP) site under the Public Registry link at the NWB Website.

Website Public Registry:
(ftp://nunavutwaterboard.org/ADMINISTRATION/Standardized%20Forms/).

Operational Plans

Under the original licence NWB3KIM0207 Part F Item 1, the Licensee was required to submit a Plan for the Operation and Maintenance (O&M) of the Sewage and Solid Waste Facilities. This Plan was not submitted in accordance with the previous Licence.

INAC, GN-DOE and EC noted in their comments to the NWB that Operations and Maintenance Procedures should be provided. INAC recommended that this Licence renewal and amendment again require the submission of the previously requested Operations and Maintenance Manual and that a revision of this Manual be provided to the Board by the end of the first operating

season of the Enhanced Sewage Disposal Facility with updates included as part of annual reporting. INAC further recommended that this Manual should address hazardous waste management, as well as plans for spill contingency and accidents and malfunctions. In addition, the NWB deems INAC's comments with respect to annual reporting of plans for modifications to stream and water bodies, including water crossings as relevant to Operations and Maintenance planning.

The GN-DOE noted that details related to the treatment and management of sewage sludge should be provided and that a spill contingency plan should be provided for review related to the sewage lagoon and other facilities related to the water licence with reference to the DOE's *Spill Contingency Planning and Reporting Regulations* and *Spill Reporting in Nunavut: A Guide to the New Regulations*. EC's submission supported the recommendations made by INAC and GN-DOE, and offered further details with respect to those recommendations.

The Board agrees with all parties on this issue and is again requiring that this Operations and Maintenance Manual be submitted within ninety (90) days of licence issuance for the existing Sewage and Solid Waste Facilities. Following the first operating season of the Enhanced Sewage Disposal Facility the Board is requiring that the O&M Manual be revised and submitted for approval of the Board. This Manual needs to be developed to the satisfaction of the NWB for (1) the operation and maintenance of the sewage and solid waste facilities; (2) hazardous waste management procedures; (3) the management of sludge from the Enhanced Sewage Disposal Facility; (4) the protection of the environment with regard to potential spills through day-to-day operations; (5) planning modifications to streams and water bodies, including water crossings; and (6) include a monitoring program Quality Assurance/Quality Control Plan.

The purpose of the O&M Manual noted above is to assist Hamlet staff in carrying out the procedures relating to the waste disposal facilities. The O&M Manual should demonstrate to the NWB that the Hamlet is capable of operating and maintaining the infrastructure related to water use and waste disposal and to meet the requirements of the Licence. The O&M Manual should be based, at a minimum on the various NWB-approved guidelines available (i.e. *Guidelines for the Preparation of an Operations and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories,* Duong and Kent, 1996) and other regulatory guidelines as deemed appropriate.

Quarry

The proposed design of the Enhanced Sewage Disposal Facility and access road rehabilitation requires approximately 8,200 cubic meters of granular material which may be exploited from a quarry referred to as Deposit #2. The Applicant is advised that any new quarry development requires screening by the Nunavut Impact Review Board (NIRB) in accordance with Article 12 of the NLCA. The Board cannot authorize water use or waste disposal associated with the proposed development of Deposit #2 or any other new deposit until NIRB has completed its

review of the proposed activity. Further, any new quarry development(s) that receive an approval to proceed from the NIRB will require an amendment to this Licence.

INAC, in its May 5, 2008 submission, recommended that the Licensee provide a quarry design plan to the Board prior to construction that assesses any impacts to freshwater quality that may result from the development and includes mitigation measures. The Board agrees with INAC, however it is not clear to the Board where material for construction of the road access and Enhanced Sewage Lagoon will be obtained.

Therefore, the Board requires as a condition in Part D Item 9 of this Licence, that the Licensee use clean material for construction, operation, and maintenance activities that is obtained from an approved source and which has been demonstrated not to produce Acid Rock Drainage and to be non-Metal Leaching.

In addition, for any approved source of aggregate material within the municipality, the Board requires as a condition in Part D Item 10 that the Licensee submit a quarry management plan to the Board for approval sixty (60) days following licence issuance that (a) confirms that material from the quarry does not produce acid rock drainage and is non-metal leaching; (b) provides an assessment of any potential impacts to freshwater quality; and (c) provides measures to mitigate any potential impacts to freshwater quality.

Water Use

The Hamlet of Kimmirut currently utilizes Fundo Lake as a source of potable water with the quantity used not to exceed 30,000 cubic metres annually. No concerns were raised by the parties in their written submissions as to the amount of water required by the Hamlet, the manner in which it is obtained or in the manner in which this water will be used. The NWB has renewed the terms and conditions associated with water use by the Hamlet accordingly.

Sewage

The Hamlet of Kimmirut currently discharges its untreated wastewater directly to a ditch which discharges into the sea, adjacent to the existing Solid Waste Disposal Facility, approximately 750 metres south of the community. In 2001 a new sewage lagoon was constructed approximately 1.5 km to the west of the community but has never been operated. An assessment of this existing facility determined that it did not have sufficient capacity to meet the over winter storage requirements of the Hamlet. A geotechnical investigation recommended that the existing earth berm which forms the lagoon be upgraded to provide slope stability and to prevent overtopping erosion. An assessment of wetlands potential for treatment determined that the large area below the sewage lagoon and gulch provided potential for meeting treatment requirements. Based on these assessments, construction of a second lagoon at the bottom of the gulch is being proposed to work in series with the existing lagoon prior to the release of sewage for wetland treatment. It

is proposed that in order to meet the requirements of the wetland assessment, sewage not be released to the wetlands until approximately mid June, when the wetlands are active.

As noted by INAC in its comments dated May 5, 2008, the Water Licence Application consists of a report, drawings, and recommendations prepared by the consultant (Trow Associates Inc.(Trow)) retained by the Applicant (Government of Nunavut, Department of Community Government Services (GN-CGS)). However, the Applicant does not specify which recommendations of its consultants would be implemented.

For greater certainty, the NWB has included a condition in Part E Item 1 of the Licence that requires the Licensee to implement the recommended options identified in the Water Licence Application document entitled *Design Brief Rehabilitation and Expansion of Existing Sewage Lagoon for the Hamlet of Kimmirut* dated January 2008 and prepared by Trow, and to follow the design as provided in the signed and stamped drawings numbered SP-1, L-1, L-2, DE-1, and T-1, dated 04/01/2008, Project No, OTCD00018881A, also prepared by Trow. In the event of a conflict between the conditions of this Licence and the above referenced document, the conditions of this License shall prevail.

INAC, in its comments dated May 5, 2008, also raised an issue regarding the potential effect on wastewater treatment due to changes to the Solid Waste Disposal Facility which may be relocated upstream of the Enhanced Sewage Disposal Facility. On August 7th, 2008, the Applicant clarified that relocation of the Solid Waste Disposal Facility is not being considered under the amendment application.

EC, in its comments dated January 10, 2007 recommended that parameter limits from the previous licence, which in EC's opinion are consistent with the 1992 Guidelines, should be carried forward to the renewal, assuming that the final discharge point is at the lagoon outlet and treatment does not include a wetland. This recommendation was provided prior to the Applicant's submission of the amendment application documents including the document entitled *Design Brief Rehabilitation and Expansion of Existing Sewage Lagoon for the Hamlet of Kimmirut* dated January 2008 and prepared by Trow which included the applicant's proposal to meet the previous licence parameter limits at the end of the Wetland Area. No further comments were received from EC regarding the applicant's updated proposal, however, the Board continues to agree with EC's comments and is therefore carrying forward effluent quality criteria from the previous licence to Part D Item 2 of the Licence renewal and amendment to be met at the lagoon outlet. To address the appropriate discharge limits to be used, the Hamlet may need to investigate operational parameters, using the system to hold sewage in one cell while a longer decant is carried out from the second cell, taking advantage of the growing season without overwhelming the wetlands vegetation. If the shorter decant is used, then lower, more stringent limits may be appropriate, with some allowance made for the polishing by the wetlands. Adequate monitoring of the site specific wetland treatment is necessary to confirm projected efficiencies and provide sufficient evidence for either less stringent limits to be regulated at the

lagoon discharge or relocating the compliance point from the lagoon discharge to the wetland outlet.

As noted by EC in its January 10th, 2008 submission, the Licensee must also ensure that any effluent discharged from the system's final discharge point is in compliance with Section 36(3) of the Fisheries Act. According to Section 36(3) of the Fisheries Act, the deposition of deleterious substances of any type, under any conditions where the deleterious substance, or any other deleterious substance that results from the deposit of the deleterious substance, may enter such water, is prohibited. The Licensee is advised that compliance with this Licence does not absolve the Licensee from the responsibility to comply with other applicable legislation.

Sewage Sludge

EC, in its January 10th, 2008 submission, recommended that prior to desludging, the Licensee should submit for approval a Sewage Sludge Management Plan that clearly outlines the chemical composition of the sludge and how sludge will be stored, treated and eventually disposed of. The Plan should also include estimates of the quantities of sludge likely produced and the required frequency of extraction. The GN-DOE also commented on January 9th, 2008, that the details related to the treatment and management of sewage sludge should be submitted for review.

The Board agrees with EC and the GN-DOE and requires that the O&M Plan referred to above, include procedures for the management of sludge from the Enhanced Sewage Disposal Facility.

Solid Waste

The Hamlet's Solid Waste Disposal Facility located just west of the location where sewage is currently discharged. According to the *Hamlet of Kimmirut Municipal Questionnaire for Water Licence Application Renewal of Water Licence #N514-1441* dated April 15, 2002, the Solid Waste Disposal Facility includes a waste oil storage area and a bulky scrap metal disposal area.

As stated by the Applicant in its response dated August 7th, 2008, no changes or modifications to the landfill are being considered under this renewal and amendment application. However, the Board notes that concerns regarding the management of hazardous materials, including waste oil, have been raised in inspection reports and intervener comments. As such, the Board requires that the O&M Plan referred to above include procedures for the management of hazardous materials. The Licensee is referred to the Government of Northwest Territories *Guide to the Used Oil and Waste Fuel Management Regulations* for guidance.

Abandonment and Restoration

To ensure that all existing end-of-life facilities are reclaimed in an appropriate manner, the NWB requires Licensees to submit an *Abandonment and Restoration Plan.* This Plan is to be submitted at least six (6) months prior to final closure of any licensed facility or upon the planned construction of new facilities to replace existing ones. The requirements for the Plan are outlined in Part G, Item 1 of this Licence.

Monitoring

Monitoring stations for the raw water supply and runoff from the Solid Waste Disposal Facility have been carried forward into the Licence renewal and amendment from the previous licence NWB3KIM0207.

New monitoring stations at the sewage lagoon discharge and compliance points as well as surface water at the end of the Wetland Area have been added to reflect the changes in the design of the Sewage Disposal Facility as proposed by the Applicant in the document entitled *Design Brief Rehabilitation and Expansion of Existing Sewage Lagoon for the Hamlet of Kimmirut* dated January 2008 and prepared by Trow.

Additional monitoring parameters have also been incorporated into the Licence renewal and amendment for the new monitoring stations to identify potential contaminants of concern.

LICENCE 3BM-KIM0911

Pursuant to the *Nunavut Waters and Nunavut Surface Rights Tribunal Act* and the *Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada*, the Nunavut Water Board, hereinafter referred to as the Board, hereby grants to

HAMLET OF KIMMIRUT

(Licensee)

of **BOX 120, KIMMIRUT, NUNAVUT X0A 0N0**

(Mailing Address)

hereinafter called the Licensee, the right to alter, divert or otherwise use water or dispose of waste for a period subject to restrictions and conditions contained within this Licence:

Licence Number	**3BM-KIM0911**
Water Management Area	**NUNAVUT 05**
Location	**KIMMIRUT, QIKIQTANI REGION, NU (Latitude 62°50'6"N and Longitude 69°52'4"W)**
Purpose	**WATER USE AND WASTE DISPOSAL**
Description	**MUNICIPAL UNDERTAKINGS**
Quantity of Water Not to Exceed:	**30,000 CUBIC METRES ANNUALLY**
Date of Licence	**JANUARY 9, 2009**
Expiry Date of Licence	**JANUARY 29, 2011**

Dated this 9th of January, 2009 at Gjoa Haven, NU.

Thomas Kabloona
Nunavut Water Board,
Chair

PART A: SCOPE AND DEFINITIONS

1. Scope

a. This Licence allows for the use of water and the disposal of waste for municipal undertakings at the Hamlet of Kimmirut, Qikiqtani Region, Nunavut (62°50' N; 69°52'W);

b. This Licence is issued subject to the conditions contained herein with respect to the taking of water and the depositing of waste of any type in any waters or in any place under any conditions where such waste or any other waste that results from the deposits of such waste may enter any waters. Whenever new Regulations are made or existing Regulations are amended by the Governor in Council under the Nunavut Waters and Nunavut Surface Rights Tribunal Act, or other statutes imposing more stringent conditions relating to the quantity or type of waste that may be so deposited or under which any such waste may be so deposited, this Licence shall be deemed, upon promulgation of such Regulations, to be subject to such requirements; and

c. Compliance with the terms and conditions of this Licence does not absolve the Licensee from responsibility for compliance with the requirements of all applicable Federal, Territorial and Municipal legislation.

2. Definitions

In this Licence: **3BM-KIM0911**

"Act" means the *Nunavut Waters and Nunavut Surface Rights Tribunal Act;*

"Amendment" means a change to original terms and conditions of this Licence requiring correction, addition or deletion of specific terms and conditions of the Licence; modifications inconsistent with the terms of the set terms and conditions of the Licence;

"Analyst" means an Analyst designated by the Minister under Section 85 (1) of the *Act*;

''Appurtenant undertaking'' means an undertaking in relation to which a use of waters or a deposit of waste is permitted by a licence issued by the Board;

"Average Concentration" means the arithmetic mean of the last four consecutive analytical results for composite or grab samples collected from the monitoring stations identified in Part H;

"Board" means the Nunavut Water Board established under the *Nunavut Land Claims*

Agreement;

"Chief Administrative Officer" means the Executive Director of the Nunavut Water Board;

"Effluent" means treated or untreated liquid waste material that is discharged into the environment from a structure such as a settling pond or a treatment plant;

"**Engineer**" means a professional engineer registered to practice in Nunavut in accordance with the *Engineering, Geological and Geophysical Act (Nunavut)* S.N.W.T. 1998, c.38, s.5;

"Enhanced Sewage Disposal Facility" comprises the area and engineered upper and lower sewage lagoons, and decant structures designed to contain and treat sewage as described in the Application for Water Licence renewal and amendment filed by the Applicant on February 15, 2008 and illustrated in Drawings SP-1, L-1, L-2, and DE-1 prepared by Trow Associates Inc., project no. OTCD00018881A dated 4/01/2008;

"Final Discharge Point" in respect of an effluent means an identifiable discharge point of a facility beyond which the operator of the facility no longer exercises control over the quality of the effluent;

"Freeboard" means the vertical distance between water line and crest on a dam or dyke's upstream slope;

"Geotechnical Engineer" means a professional engineer registered with the Association of Professional Engineers, Geologist and Geophysicists of Nunavut and whose principal field of specialization with the engineering properties of earth materials in dealing with man-made structures and earthworks that will be built on a site. These can include shallow and deep foundations, retaining walls, dams, and embankments;

"Greywater" means all liquid wastes from showers, baths, sinks, kitchens and domestic washing facilities, but does not include toilet wastes;

"**Inspector**" means an Inspector designated by the Minister under Section 85 (1) of the Act;

"Licensee" means the holder of this Licence;

"Maximum Average Concentration" means the average concentration of any four consecutively collected samples taken from the identical sampling location and taken during any given timeframe.

"Modification" means an alteration to a physical work that introduces new structure or eliminates an existing structure and does not alter the purpose or function of the work, but does not include an expansion, and changes to the operating system that are consistent with the terms of this Licence and do not require amendment;

"Monitoring Program" means a monitoring program established to collect data on surface water and groundwater quality to assess impacts to the freshwater aquatic environment of an appurtenant undertaking;

"Nunavut Land Claims Agreement" (NLCA) means the "*Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in right of Canada*", including its preamble and schedules, and any amendments to that agreement made pursuant to it;

"Sewage" means all toilet wastes and greywater;

"Sewage Disposal Facility" comprises the area and engineered lagoon and decant structures designed to contain sewage, as described in the Application for Water Licence filed by the Applicant on May 17, 2001;

"Solid Waste Disposal Facility" comprises the area and associated structures (landfill site) designed to contain Solid Waste as described in the Application for Water Licence filed by the Applicant on May 17, 2001;

"Toilet Wastes" means all human excreta and associated products, but does not include greywater;

"Waste" means, as defined in S.4 of the Act, any substance that, by itself or in combination with other substances found in water, would have the effect of altering the quality of any water to which the substance is added to an extent that is detrimental to its use by people or by any animal, fish or plant, or any water that would have that effect because of the quantity or concentration of the substances contained in it or because it has been treated or changed, by heat or other means;

"Waste Disposal Facilities" means all facilities designated for the disposal of waste, and includes the Sewage Disposal Facility, the Enhanced Sewage Disposal Facility, and the Solid Waste Disposal Facility;

"Water Supply Facilities" comprises the area and associated intake infrastructure at Fundo Lake, as described in the Application for Water Licence filed by the Applicant on May 17, 2001;

"Wetland Area" comprises approximately 15 - 20 hectares of flat land immediately downstream of the lower sewage lagoon, at the bottom of a steep 25% slope, as described in the Application for Water Licence filed by the Applicant on February 15, 2008.

3. Enforcement

a. Failure to comply with this Licence will be a violation of the *Act*, subjecting the Licensee to the enforcement measures and the penalties provided for in the *Act*;

b. All inspection and enforcement services regarding this Licence will be provided by Inspectors appointed under the *Act*;

c. For the purpose of enforcing this Licence and with respect to the use of water and deposit or discharge of waste by the Licensee, Inspectors appointed under the *Act*, hold all powers, privileges and protections that are conferred upon them by the *Act* or by other applicable law; and

d. The Licensee shall, in relation to any application to renew or amend the Licence, have in place a Plan for Compliance approved by the Board in writing, to achieve full compliance with the conditions of this Licence, or a Plan for Compliance must be submitted at the time of Application, in order for the Application to be deemed complete.

PART B: GENERAL CONDITIONS

1. The Licensee shall file an Annual Report with the Board not later than March 31st of the year following the calendar year reported which shall contain the following information:

a. tabular summaries of all data generated under the "Monitoring Program" and an indication of wastewater treatment levels upstream and downstream of the Wetland Area;

b. modifications to the "Monitoring Program" in accordance with Part H Item 11;

c. the monthly and annual quantities in cubic metres of fresh water obtained at the Water Supply Facilities;

d. the monthly and annual quantities in cubic metres of each and all waste discharged;

e. the annual quantity in cubic meters and tones of sludge removed from the Enhanced Sewage Disposal Facility along with the treatment, storage, and

disposal provided as required in Part H Item 6;

f. the results of sampling and analyses of sewage sludge in accordance with the Operations and Maintenance Manual referred to in Part F Item 2 and as required in Part H Item 5;

g. a summary of modifications and/or major maintenance work carried out on the Water Supply and Waste Disposal Facilities, including all associated structures and facilities;

h. a list of unauthorized discharges and summary of follow-up action taken;

i. a summary of any abandonment and restoration work completed during the year and an outline of any work anticipated for the next year;

j. any updates or revisions for manuals and plans (i.e., *Operations and Maintenance Manual*) as required by changes in operation and/or technology;

k. detailed minutes of any public consultation and participation with local organizations and the residents of the community regarding licence amendments;

l. a summary of any studies or reports requested by the Board that relate to water use and waste disposal or restoration, and a brief description of any future studies planned; and

m. any other details on water use or waste disposal requested by the Board by November 1st of the year being reported.

2. The Licensee shall comply with the "Monitoring Program" described in this Licence, and any amendments to the "Monitoring Program" as may be made from time to time, pursuant to the conditions of this Licence.

3. The "Monitoring Program" and compliance dates specified in the Licence may be modified at the discretion of the Board.

4. Meters, devices or other such methods used for measuring the volumes of water used and waste discharged shall be installed, operated and maintained by the Licensee.

5. The Licensee shall, within ninety (90) days after the first visit by the Inspector following issuance of this Licence, post the necessary signs to identify the stations of the "Monitoring Program". All signage postings shall be in the Official Languages of Nunavut.

6. The Licensee shall post signs in the appropriate areas to inform the public of the location of the Water Supply Facilities and the Waste Disposal Facilities. All signage postings shall be in the Official Languages of Nunavut.

7. The Licensee shall immediately report to the 24-Hour Spill Report Line (867-920-8130) any spills of Waste, which are reported to, or observed by the Licensee, within the municipal boundaries or in the areas of the Water Supply or Waste Disposal Facilities.

8. The Licensee shall ensure a copy of this Licence is maintained at the Municipal Office at all times. Any communication with respect to this Licence shall be made in writing to the attention of:

(a) Manager of Licensing:
Nunavut Water Board
P.O. Box 119
Gjoa Haven, NU X0B 1J0
Telephone: (867) 360-6338
Fax: (867) 360-6369
Email: licensing@nunavutwaterboard.org

(b) Inspector Contact:
Water Resources Officer
Nunavut District, Nunavut Region
P.O. Box 100
Iqaluit, NU X0A 0H0
Telephone: (867) 975-4295
Fax: (867) 979-6445

(c) Analyst Contact:
Taiga Laboratories
Department of Indian and Northern Affairs
4601 – 52 Avenue, P.O. Box 1500
Yellowknife, NT X1A 2R3
Telephone: (867) 669-2781
Fax: (867) 669-2718

9. The Licensee shall submit one paper copy and one electronic copy of all reports, studies, and plans to the Board. Reports or studies submitted to the Board by the Licensee shall include a detailed executive summary in Inuktitut.

10. The Licensee shall ensure that all document(s) and correspondence submitted by the Licensee, to the Board, are received and acknowledged by the Manager of Licensing.

11. The Licensee shall submit to the Board for approval, within ninety (90) days of Licence issuance or upon the filing of any application in relation to the Licence within that time, a Plan for Compliance that clearly demonstrates the measures the Licensee will undertake, including an implementation schedule, to achieve full compliance with the conditions of this Licence, including the issues raised in the Inspector's Reports.

12. The Licensee shall, for all Plans submitted under this Licence, include a proposed timetable for implementation. Plans submitted, cannot be undertaken without subsequent written Board approval and direction. The Board may alter or modify a Plan if necessary to achieve the legislative objectives and will notify the Licensee in writing of acceptance, rejection or alteration of the Plan.

13. The Licensee shall, for all Plans submitted under this Licence, implement the Plan as approved by the Board in writing.

14. Every Plan to be carried out pursuant to the terms and conditions of this Licence shall become a part of this Licence, and any additional terms and condition imposed upon approval of a Plan by the Board become part of this Licence. All terms and conditions of the Licence should be contemplated in the development of a Plan where appropriate.

15. This Licence is not assignable except as provided in Section 44 of the Act.

PART C: CONDITIONS APPLYING TO WATER USE

1. The Licensee shall obtain all fresh water from Fundo Lake using the Water Supply Facilities or as otherwise approved by the Board in writing.

2. The annual quantity of water, used for all purposes, shall not exceed thirty thousand (30,000) cubic metres.

3. The Licensee shall equip all water intake hoses with a screen of an appropriate mesh size to ensure that fish are not entrained and shall withdraw water at a rate such that fish do not become impinged on the screen.

4. The Licensee shall not remove any material from below the ordinary high water mark of any water body unless otherwise approved by the Board in writing.

5. The Licensee shall not cause erosion to the banks of any body of water and shall provide necessary controls to prevent such erosion.

6. Sediment and erosion control measures shall be implemented prior to and maintained during the operation to prevent entry of sediment into water.

PART D: CONDITIONS APPLYING TO WASTE DISPOSAL

1. Prior to commissioning the Enhanced Sewage Disposal Facility, the Licensee shall direct all Sewage to the Sewage Disposal Facility. Following construction of the Enhanced Sewage Disposal Facility, the Licensee shall direct all Sewage to the Enhanced Sewage Disposal Facility, or as otherwise approved by the Board in writing.

2. All Effluent discharged from the Sewage Disposal Facility at Monitoring Program Station KIM-3 and the Enhanced Sewage Disposal Facility at Monitoring Program Stations KIM-6 and KIM-7 shall not exceed the following Effluent quality limits:

Parameter	Maximum Average Concentration
BOD_5	120 mg/L
Total Suspended Solids	180 mg/L
Faecal Coliforms	1×10^6 CFU/100mL
Oil and grease	No visible sheen
pH	between 6 and 9

3. A Freeboard limit of 1.0 meter, or as recommended by a qualified geotechnical Engineer and as approved by the Board in writing, shall be maintained at all dams, dykes, or structures intended to contain, withhold, divert or retain water or wastes.

4. The Licensee shall provide at least ten (10) days notification to an Inspector, prior to initiating any decant of the sewage lagoon.

5. The Sewage Disposal Facility and the Enhanced Sewage Disposal Facility shall be maintained and operated, in such a manner as to prevent structural failure.

6. The Licensee shall dispose of and permanently contain all Solid Wastes at the Solid Waste Disposal Facility or as otherwise approved by the Board in writing.

7. The Licensee shall segregate and store all hazardous materials and/or hazardous waste, including waste oil, within the Solid Waste Disposal Facility in a manner as to prevent the deposit of deleterious substances into any water until such a time as proper disposal arrangements are made.

8. The Licensee shall implement measures to control wind-blown litter at the Solid Waste Disposal Facility.

9. The Licensee shall use clean material for construction, operation, and maintenance activities that is obtained from an approved source and which has been demonstrated not to produce acid rock drainage and to be non-metal leaching.

10. For any approved source of material within the municipality, the Licensee shall submit to the Board for approval sixty (60) following licence issuance, a quarry management plan that includes the following:

    a. Confirmation that the quarry material does not produce acid rock drainage and is non-metal leaching;
    b. An assessment of any potential impacts to freshwater quality; and
    c. Mitigation measures.

PART E: CONDITIONS APPLYING TO MODIFICATION AND CONSTRUCTION

1. The Licensee shall implement the recommended options identified in the Water Licence Application document entitled *Design Brief Rehabilitation and Expansion of Existing Sewage Lagoon for the Hamlet of Kimmirut* dated January 2008, and shall follow the design as provided in the signed and stamped drawings numbered SP-1, L-1, L-2, DE-1, and T-1, dated 04/01/2008 (Trow Associates Inc. Project No. OTCD00018881A). In the event of a conflict between the conditions of this Licence and the above referenced document, the conditions of this License shall prevail.

2. The Licensee shall submit to the Board for approval, design drawings stamped and signed by a qualified engineer registered in Nunavut, 6 months prior to the construction of any dams, dykes or structures intended to contain, withhold, divert or retain water or wastes.

3. The Licensee may, without written approval from the Board, carry out modifications to the Water Supply and Waste Disposal Facilities provided that such modifications are consistent with the terms of this Licence and the following requirements are met:

    a. the Licensee has notified the Board in writing of such proposed modifications at least sixty (60) days prior to beginning the modifications;
    b. these modifications do not place the Licensee in contravention of the Licence or the Act;
    c. the Board has not, during the sixty (60) days following notification of the proposed modifications, informed the Licensee that review of the proposal will require more than sixty (60) days; and
    d. the Board has not rejected the proposed modifications.

4. Modifications for which all of the conditions referred to in Part E, Item 3, have not been met, may only be carried out upon written approval from the Board. The Licensee shall provide as-built plans and drawings of the Modifications referred to in this Licence within ninety (90) days of completion of the Modification. These plans and drawings shall be stamped by an Engineer.

5. All activities shall be conducted in such a way as to minimize impacts on surface drainage and the Licensee shall immediately undertake any corrective measures in the event of any impacts on surface drainage.

6. The Licensee shall ensure that sediment and erosion control measures are implemented prior to and maintained during activities carried out under this Part to prevent the release of sediment and minimize erosion.

7. The construction or disturbance of any stream/lake bed or banks of any definable water course are not permitted, unless authorized by the Board in writing.

PART F: CONDITIONS APPLYING TO OPERATION AND MAINTENANCE

1. The Licensee shall submit to the Board for approval, within ninety (90) days following issuance of the Licence, an Operation and Maintenance (O&M) Manual for the Sewage Disposal Facility and Solid Waste Disposal Facility, prepared where appropriate in accordance with the *"Guidelines for the Preparation of an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories; 1996"*. The Manual shall take into consideration the comments received during the application review process.

2. The Licensee shall submit to the Board for approval, immediately following the first operating season of the Enhanced Sewage Disposal Facility, a revision to the Operations and Maintenance (O&M) Manual referred to in Part F Item 1, The Manual shall take into consideration the comments received during the application review process and shall contain the following plans:

    a. *Sewage and Solid Waste Operation and Maintenance Plan*;
    b. Hazardous Waste Management Plan;
    c. Sludge Management Procedures;
    d. Spill Contingency Plan;
    e. A plan for the modification of streams and bodies of water within the municipality including crossing; and
    f. Monitoring Program Quality Assurance/Quality Control Plan (QA/QC Plan).

3. The Licensee shall review the O&M Manual referred to in Part F, Items 1 and 2 as required by changes in operation and/or technology and modify accordingly. Revisions are to be submitted in the form of an Addendum to be included with the Annual Report.

4. An inspection of all engineered facilities related to the management of water and waste shall be carried out annually in July or August by a Geotechnical Engineer. The engineer's report shall be submitted to the Board within sixty (60) days of the inspection,

including a covering letter from the Licensee outlining an implementation plan addressing each of the Engineer's recommendations.

5. The Licensee shall perform more frequent inspections of the engineered facilities at the request of an Inspector.

6. If, during the period of this Licence, an unauthorized discharge of waste occurs, or if such a discharge is foreseeable, the Licensee shall:

   a. employ the appropriate contingency measures as approved under the Operation and Maintenance Manual for the Hamlet of Clyde River
   b. report the incident immediately via the 24-Hour Spill Reporting Line at (867) 920-8130 and to the Inspector at (867) 975-4295; and
   c. submit to the Inspector, a detailed report on each occurrence, not later than thirty (30) days after initially reporting the event, that provides the necessary information on the location (including the GPS coordinates), initial response action, remediation/clean-up, status of response (ongoing, complete), proposed disposal options for dealing with contaminated materials and any preventative measures to be implemented.

PART G: CONDITIONS APPLYING TO ABANDONMENT AND RESTORATION

1. The Licensee shall submit to the Board for approval an *Abandonment and Restoration Plan*, at least six (6) months prior to a) abandoning of any facilities and b) the construction of new facilities to replace existing ones. Where applicable, the Plan shall include information on the following:

   a. solid waste facility;
   b. water intake facilities;
   c. the water treatment and waste disposal sites and facilities;
   d. petroleum and chemical storage areas;
   e. any site affected by waste spills;
   f. leachate prevention;
   g. an implementation schedule;
   h. maps delineating all disturbed areas, and site facilities;
   i. consideration of altered drainage patterns;
   j. type and source of cover materials;
   k. future area use;
   l. hazardous wastes; and
   m. a proposal identifying measures by which restoration costs will be financed by the Licensee upon abandonment.

PART H: CONDITIONS APPLYING TO THE MONITORING PROGRAM

1. The Licensee shall maintain Monitoring Program Stations and implement the program as described in the table below and the conditions under this Part.

Monitoring Program Station Number	Description	Frequency	Status
KIM-1	Raw water supply intake at Fundo Lake	Volume Monthly and Annually	Active (Volume)
KIM-2	Runoff from Solid Waste Disposal Facilities	Water Quality Once at the beginning, middle and near the end of the season when flow is observed	Active (Water Quality)
KIM-3	Effluent discharge from existing Sewage Disposal Facility	Volume Monthly and Annually Water Quality Monthly during months of May to August inclusive	Active (Volume and Water Quality)
KIM-4	Enhanced Sewage Disposal Facility - Upper Lagoon Spillway	Volume Monthly and Annually Water Quality Twice Annually – start of overflow/start of decanting	New (Volume and Water Quality)
KIM-5	Enhanced Sewage Disposal Facility - Upper Lagoon Pump Discharge	Volume Monthly and Annually Water Quality Twice Annually – start of overflow/start of decanting	New (Volume and Water Quality)
KIM-6	Enhanced Sewage Disposal Facility - Lower Lagoon Spillway	Volume Monthly and Annually Water Quality Twice Annually - start and end of decanting	New (Volume and Water Quality)

KIM-7	Enhanced Sewage Disposal Facility - Lower Lagoon Pump Discharge	Volume Monthly and Annually Water Quality Twice Annually – start and end of decanting	New (Volume and Water Quality)
KIM-8	Surface water at end of Wetland Area	Water Quality Monthly during periods of flow from spring to freezeup	New (Water Quality)

2. The Licensee shall confirm the locations and GPS coordinates for all monitoring stations referred to in Part H Item 1 with an Inspector.

3. The Licensee shall collect samples at Monitoring Program Stations KIM-2, KIM-3, KIM-4, KIM-5, KIM-6, KIM-7, and KIM-8 according to the frequency provided in Part H Item 1. Samples shall be analyzed for the following parameters:

Biochemical Oxygen Demand – BOD_5	Faecal Coliforms
Total Suspended Solids	pH
Conductivity	Nitrate-Nitrite
Oil and Grease (visual)	Total Phenols
Magnesium	Calcium
Sodium	Potassium
Chloride	Sulphate
Total Hardness	Total Alkalinity
Ammonia Nitrogen	Total Zinc
Total Cadmium	Total Iron
Total Cobalt	Total Manganese
Total Chromium	Total Nickel
Total Copper	Total Lead
Total Aluminum	Total Arsenic
Total Mercury	Total Organic Carbon (TOC)
Total Petroleum Hydrocarbons (KIM-2 and KIM-13 only)	

4. The Licensee shall measure and record in cubic meters, the monthly and annual quantities of water pumped from Monitoring Program Station KIM-1 for all purposes and effluent pumped or discharged from Monitoring Program Stations KIM-3, KIM-4, KIM-5, KIM-6, and KIM-7.

5. The Licensee shall sample and analyse sludge in accordance with the approved Operations and Maintenance Manual referred to in Part F Item 2.

6. The Licensee shall measure and record the annual quantities of sludge removed from the Enhanced Sewage Disposal Facility along with the methods of treatment, storage, and disposal provided.

7. Additional monitoring stations, sampling and analysis may be requested by an Inspector.

8. All sampling, sample preservation and analyses shall be conducted in accordance with methods prescribed in the current edition of *Standard Methods for the Examination of Water and Wastewater*, or as approved by the Board in writing.

9. All analyses shall be performed by a laboratory certified by the Canadian Association of Environmental Analytical Laboratories (CAEAL), or as otherwise approved by an Analyst.

10. The Licensee shall include all of the data and information required by the Monitoring Program as well as an indication of wastewater treatment levels upstream and downstream of the Wetland Area in the Licensee's Annual Report, as required *per* Part B, Item 1, or as requested by an Inspector.

11. The Licensee shall, within sixty (60) days of Licence issuance, submit to the Analyst for approval, a Quality Assurance/ Quality Control (QA/QC) Plan, which addresses both field and laboratory requirements. The Plan shall be submitted to the Board upon approval by the Analyst for inclusion with the O&M Manual, required under Part F, Item 2(f).

12. Modifications to the Monitoring Program may be made only upon written approval from the NWB.

Appendix B – Pump Operation and Maintenance

Use With: OM--04402

PUBLICATION NUMBER MR--05244
July 27, 2001
Rev. B 10-03-02

GORMAN-RUPP PUMPS

PRIME-AIRE® SERIES
PA6C Pumps

MANUAL PART 3 of 3

MAINTENANCE AND REPAIR WITH TROUBLESHOOTING

THE GORMAN-RUPP COMPANY ● MANSFIELD, OHIO

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GORMAN-RUPP OF CANADA LIMITED ● ST. THOMAS, ONTARIO, CANADA Printed in U.S.A.

The engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects or other reproductive harm.

INTRODUCTION

Thank You for purchasing a Gorman-Rupp Prime-Aire® Series priming-assisted pump. **Read this manual** carefully to learn how to safely maintain and service your pump. Failure to do so could result in personal injury or damage to the pump.

A set of three manuals accompanies your pump. The Installation/Operation Manual contains essential information on installing and operating the pump, and on making electrical connections. The Parts List Manual provides performance curve(s), a pump model cross-section drawing, and parts list for your pump.

This Maintenance and Repair Manual provides troubleshooting instructions required to properly diagnose operational problems. Maintenance instructions within this manual are limited to the pump hydraulic and drive components only. For maintenance and repair of the engine or air compressor, consult the separate literature provided by the manufacturers.

This pump is a PA Series®, priming-assisted centrifugal model. The unit is designed for handling non-volatile, non-flammable liquids containing specified entrained solids. For specific service, contact your Gorman-Rupp distributor or the Gorman-Rupp Company.

As described on the following page, this manual will alert personnel to known procedures which require special attention, to those which could damage equipment, and to those which could be dangerous to personnel. However, this manual cannot possibly anticipate and provide detailed precautions for every situation that might occur during maintenance of the unit. Therefore, it is the responsibility of the owner/maintenance personnel to ensure that **only** safe, established maintenance procedures are used, and that any procedures not addressed in this manual are performed **only** after establishing that neither personal safety nor pump integrity are compromised by such practices.

If there are any questions regarding the pump which are not covered in this manual or in other literature accompanying the unit, please contact your Gorman-Rupp distributor or the Gorman-Rupp Company:

The Gorman-Rupp Company
P.O. Box 1217
Mansfield, Ohio 44901--1217
Phone: (419) 755--1011
or:
Gorman-Rupp of Canada Limited
70 Burwell Road
St. Thomas, Ontario N5P 3R7
Phone: (519) 631--2870

CONTENTS

CONTENTS (Cont'd)

RECORDING MODEL AND SERIAL NUMBERS

Please record the pump model and serial number in the spaces provided below. Your Gorman-Rupp distributor needs this information when you require parts or service.

Pump Model: _____

Serial Number: _____

WARRANTY INFORMATION

The warranty provided with your pump is part of Gorman-Rupp's support program for customers who operate and maintain their equipment as described in this and the other accompanying literature. Please note that should the equipment be abused or modified to change its performance beyond the original factory specifications, the warranty will become void and any claim will be denied.

The following are used to alert personnel to procedures which require special attention, to those which could damage equipment, and to those which could be dangerous to personnel:

DANGER!

Immediate hazards which WILL result in severe personal injury or death. These instructions describe the procedure required and the injury which will result from failure to follow the procedure.

WARNING!

Hazards or unsafe practices which COULD result in severe personal injury or death. These instructions describe the procedure required and the injury which could result from failure to follow the procedure.

CAUTION

Hazards or unsafe practices which COULD result in minor personal injury or product or property damage. These instructions describe the requirements and the possible damage which could result from failure to follow the procedure.

NOTE

Instructions to aid in installation, operation, and maintenance or which clarify a procedure.

SAFETY – SECTION A

The following information applies throughout this manual to Gorman-Rupp Prime Aire® Series pumps.

This manual will alert personnel to known procedures which require special attention, to those which could damage equipment, and to those which could be dangerous to personnel. However, this manual cannot possibly anticipate and provide detailed instructions and precautions for every situation that might occur during maintenance of the unit. Therefore, it is the responsibility of the owner/maintenance personnel to ensure that only safe, established maintenance procedures are used, and that any procedures not addressed in this manual are performed only after establishing that neither personal safety nor pump integrity are compromised by such practices.

WARNING!

Before attempting to install, operate, or service this pump, familiarize yourself with this manual, and with all other literature shipped with the pump. Unfamiliarity with all aspects of pump operation covered in this manual could lead to destruction of equipment, injury, or death to personnel.

WARNING!

Before attempting to open or service the pump:

1. **Familiarize yourself with this manual.**
2. **Shut down the engine and disconnect the positive battery cable (engine driven units) or lock out and tag out incoming power to the control box (electric motor driven units) and take precautions to ensure that the pump will remain inoperative.**
3. **Allow the pump to completely cool if overheated.**
4. **Check the temperature before opening any covers, plates, or plugs.**
5. **Close the suction and discharge valves.**
6. **Vent the pump slowly and cautiously.**
7. **Drain the pump.**

WARNING!

This pump is may be used to handle materials which could cause illness through direct exposure or emitted fumes. Wear adequate protective clothing when working on the pump or piping.

WARNING!

Use lifting and moving equipment in good repair and with adequate capacity to prevent injuries to personnel or damage to equipment. Attach lifting equipment to the lifting device fitted to the pump. If chains or cable are wrapped around the pump to lift it, make certain that they are positioned so as not to damage the pump, and so that the load will be balanced. The bail is intended for use in lifting the pump assembly only. Suction and discharge hoses and piping must be removed from the pump before lifting.

After the pump has been installed, make certain that the pump and all piping or hose connections are tight, properly supported and secure before operation.

Do not remove plates, covers, gauges, pipe plugs, or fittings from an overheated pump. Vapor pressure within the pump can cause parts being disengaged to be ejected with great force. Allow the pump to completely cool before servicing.

Overheated pumps can cause severe burns and injuries, and produce explosive fumes. If overheating of the pump occurs:

1. **Stop the pump immediately.**
2. **Ventilate the area.**
3. **Allow the pump to completely cool.**
4. **Check the temperature and make sure it is cool before opening any covers, plates, gauges, or plugs.**
5. **Vent the pump slowly and cautiously.**
6. **Refer to instructions in the manuals accompanying the pump before restarting the pump.**

Do not operate the pump without the guards in place over the rotating parts. Exposed rotating parts can catch clothing, fingers, or tools, causing severe injury to personnel.

Use **only** replacement parts provided or approved by Gorman-Rupp. Use of non-authorized parts may result in damage to the equipment and/or injury to personnel and **will** invalidate the warranty.

Make sure the pump is level. Lower jack stands and chock the wheels, if so equipped. Use caution when positioning the skid-mounted unit to prevent damage to the fuel tank.

Do not operate an internal combustion engine in an explosive atmosphere. When operating an internal combustion engine in an enclosed area, make sure exhaust fumes are piped to the outside. These fumes contain carbon monoxide, a deadly gas that is colorless, tasteless and odorless.

Fuel used by internal combustion engines presents an extreme explosion and fire hazard. Make certain that all fuel lines are securely connected and free of leaks. Never refuel a hot or running engine. Avoid overfilling the fuel tank. Always use the correct type of fuel.

Never tamper with the governor on engine driven units to gain more power. The governor establishes safe operating limits that should not be exceeded. Refer to the pump Performance Curve for the maximum continuous operating speed.

TROUBLESHOOTING – SECTION B

Review all SAFETY information in Section A.

WARNING!

Before attempting to open or service the pump:

1. **Familiarize yourself with this manual.**
2. **Shut down the engine and disconnect the positive battery cable (engine driven units) or lock out and tag out incoming power to the control box (electric motor driven units) and take precautions to ensure that the pump will remain inoperative.**
3. **Allow the pump to completely cool if overheated.**
4. **Check the temperature and make sure pump is cool before opening any covers, plates, or plugs.**
5. **Close the suction and discharge valves.**
6. **Vent the pump slowly and cautiously.**
7. **Drain the pump.**

TROUBLE	POSSIBLE CAUSE	PROBABLE REMEDY
PUMP FAILS TO PRIME	Discharge check valve contaminated, damaged, or unable to seat.	Clean or replace check valve.
	Air compressor head 180° out.	Consult factory.
	Air leak in suction line.	Correct leak.
	Lining of suction hose collapsed.	Replace suction hose.
	Leaking or worn seal or pump gasket.	Check pump vacuum. Replace leaking or worn seal or gasket.
	Eductor safety valve leaking.	Check and replace safety valve.
	Suction lift or discharge head too high.	Check piping installation and install bypass line if needed. See **INSTALLATION**.
	Pump speed too slow (engine driven units).	Check driver output; consult driver operation manual.
	Eductor clogged.	Check and clean eductor.
	Air compressor damaged or belts broken.	Check and repair/replace.
	Strainer clogged.	Check strainer and clean if necessary.

TROUBLE	POSSIBLE CAUSE	PROBABLE REMEDY
PUMP STOPS OR FAILS TO DELIVER RATED FLOW OR PRESSURE	Eductor clogged.	Check and clean eductor.
	Air leak in suction line.	Correct leak.
	Lining of suction hose collapsed.	Replace suction hose.
	Leaking or worn seal or pump gasket.	Check pump vacuum. Replace leaking or worn seal or gasket.
	Strainer clogged.	Check strainer and clean if necessary.
	Discharge check valve clogged.	Check and clean check vavle.
	Suction intake not submerged at proper level or sump too small.	Check installation and correct submergence as needed.
	Impeller or other wearing parts worn or damaged.	Replace worn or damaged parts. Check that impeller is properly centered and rotates freely.
	Impeller clogged.	Free impeller of debris.
	Discharge head too high.	Install bypass line.
	Suction lift too high.	Measure lift w/vacuum gauge. Reduce lift and/or friction losses in suction line.
	Pump speed too slow (engine driven units).	Check driver output; consult driver operation manual.
	Belt or flexible coupling broken.	Check and replace as necessary.
PUMP REQUIRES TOO MUCH POWER	Pump speed too high (engine driven units).	Check driver output.
	Extreme ambient temperature.	Reduce pump output.
	Discharge head too low.	Adjust discharge valve.
	Fuel filter clogged (engine driven units.	Check & replace often in extreme operating conditions.
	Liquid solution too thick.	Dilute if possible.
	Fuel contaminated (engine driven units.	Check and replace as required.
	Pump or jack shaft bearing(s) frozen.	Disassemble, check and replace bearing(s) as required..
PUMP CLOGS FREQUENTLY	Discharge flow too slow.	Open discharge valve fully to increase flow rate, for engine driven units, run engine at maximum governed speed.
	Suction check valve or foot valve clogged or binding.	Clean valve.
	Liquid solution too thick.	Dilute if possible.

TROUBLE	POSSIBLE CAUSE	PROBABLE REMEDY
EXCESSIVE NOISE	Cavitation in pump.	Reduce suction lift and/or friction losses in suction line. Record vacuum and pressure gauge readings and consult local representative or factory.
	Pumping entrained air.	Locate and eliminate source of air bubble.
	Pump or drive not securely mounted.	Secure mounting hardware.
	Impeller clogged or damaged.	Clean out debris; replace damaged parts.
BEARINGS RUN TOO HOT	Bearing temperature is high, but within limits.	Check bearing temperature regularly to monitor any increase.
	Low or incorrect lubricant.	Check for proper type and level of lubricant.
	Suction and discharge lines not properly supported.	Check piping installation for proper support.
	Drive misaligned.	Align drive properly.
	Excessive tension on drive belt.	Check belt tension. Adjust as required.

PREVENTIVE MAINTENANCE

Since pump applications are seldom identical, and pump wear is directly affected by such things as the abrasive qualities, pressure and temperature of the liquid being pumped, this section is intended only to provide general recommendations and practices for preventive maintenance. Regardless of the application however, following a routine preventive maintenance schedule will help assure trouble-free performance and long life from your Gorman-Rupp pump. For specific questions concerning your application, contact your Gorman-Rupp distributor or the Gorman-Rupp Company.

Record keeping is an essential component of a good preventive maintenance program. Changes in suction and discharge gauge readings (if so equipped) between regularly scheduled inspections can indicate problems that can be corrected before system damage or catastrophic failure occurs. The appearance of wearing parts should also be documented at each inspection for comparison as well. Also, if records indicate that a certain part (such as the seal) fails at approximately the same duty cycle, the part can be checked and replaced before failure occurs, reducing unscheduled down time.

For new applications, a first inspection of wearing parts at 250 hours will give insight into the wear rate for your particular application. Subsequent inspections should be performed at the intervals shown on the chart below. Critical applications should be inspected more frequently.

Preventive Maintenance Schedule

Item	Service Interval*				
	Daily	Weekly	Monthly	Semi-Annually	Annually
General Condition (Temperature, Unusual Noises or Vibrations, Cracks, Leaks, Loose Hardware, Etc.)	I				
Pump Performance (Gauges, Speed, Flow)	I				
Bearing Lubrication		I			R
Seal Lubrication (And Packing Adjustment, If So Equipped)		I			R
V-Belts (If So Equipped)			I		
Air Release Valve Plunger Rod (If So Equipped)			I	C	
Front Impeller Clearance (Wear Plate)				I	
Rear Impeller Clearance (Seal Plate)				I	
Check Valve					I
Pressure Relief Valve (If So Equipped)					C
Pump and Driver Alignment					I
Shaft Deflection					I
Bearings					I
Bearing Housing					I
Piping					I
Driver Lubrication – See Mfgr's Literature					

Legend:
I = Inspect, Clean, Adjust, Repair or Replace as Necessary
C = Clean
R = Replace

* Service interval based on an intermittent duty cycle equal to approximately 4000 hours annually. Adjust schedule as required for lower or higher duty cycles or extreme operating conditions.

PUMP MAINTENANCE AND REPAIR – SECTION C

Review all SAFETY information in Section A.

Follow the instructions on all tags, label and decals attached to the pump.

WARNING!

Before attempting to install, operate, or service this pump, familiarize yourself with this manual, and with all other literature shipped with the pump. Unfamiliarity with all aspects of operation or maintenance could lead to destruction of equipment, injury or death to personnel.

WARNING!

Use lifting and moving equipment in good repair and with adequate capacity to prevent injuries to personnel or damage to equipment. If slings or chains are used to move the pump or components, make sure that the load is balanced; otherwise serious personal injury or death could result. The bail is intended for use in lifting the pump assembly only. Suction and discharge hoses and piping must be removed from the pump before lifting.

The maintenance and repair instructions in this manual are keyed to the sectional views and the corresponding parts identification lists on the following pages. Refer to the separate Parts List Manual for replacement parts.

This Maintenance and Repair Manual provides troubleshooting instructions required to properly diagnose operational problems. Maintenance instructions within this manual are limited to the pump hydraulic, priming and drive components only. The pump assembly may be close-coupled to either a factory-supplied or customer-supplied engine. Maintenance of engines and factory-supplied air compressors are detailed in separate literature provided by the manufacturer(s).

Check **TROUBLESHOOTING**, Section B to determine causes and remedies of pump problems. Disassemble the pump only as far as required.

As described in the **SAFETY** Section, this manual will alert personnel to known procedures which require special attention, to those which could damage equipment, and to those which could be dangerous to personnel. However, this manual cannot possibly anticipate and provide detailed precautions for every situation that might occur during maintenance of the unit. Therefore, it is the responsibility of the owner/maintenance personnel to ensure that **only** safe, established shop procedures are used, and that any procedures not addressed in this manual are performed **only** after establishing that neither personal safety nor pump integrity are compromised by such practices.

Select a suitable location, preferably indoors, to perform required maintenance. All work must be performed by qualified personnel.

Lifting

Use lifting equipment with a capacity of **at least five times the weight of the component being lifted**. When lifting the complete unit, the lifting equipment must also be capable of lifting the weight of any options or customer-installed accessories. Suction and discharge hoses or piping **must** be removed before attempting to lift the pump.

For the approximate weight of your pump, refer to the pump specification data sheet or contact your Gorman-Rupp distributor or the Gorman-Rupp Company.

SECTION DRAWING

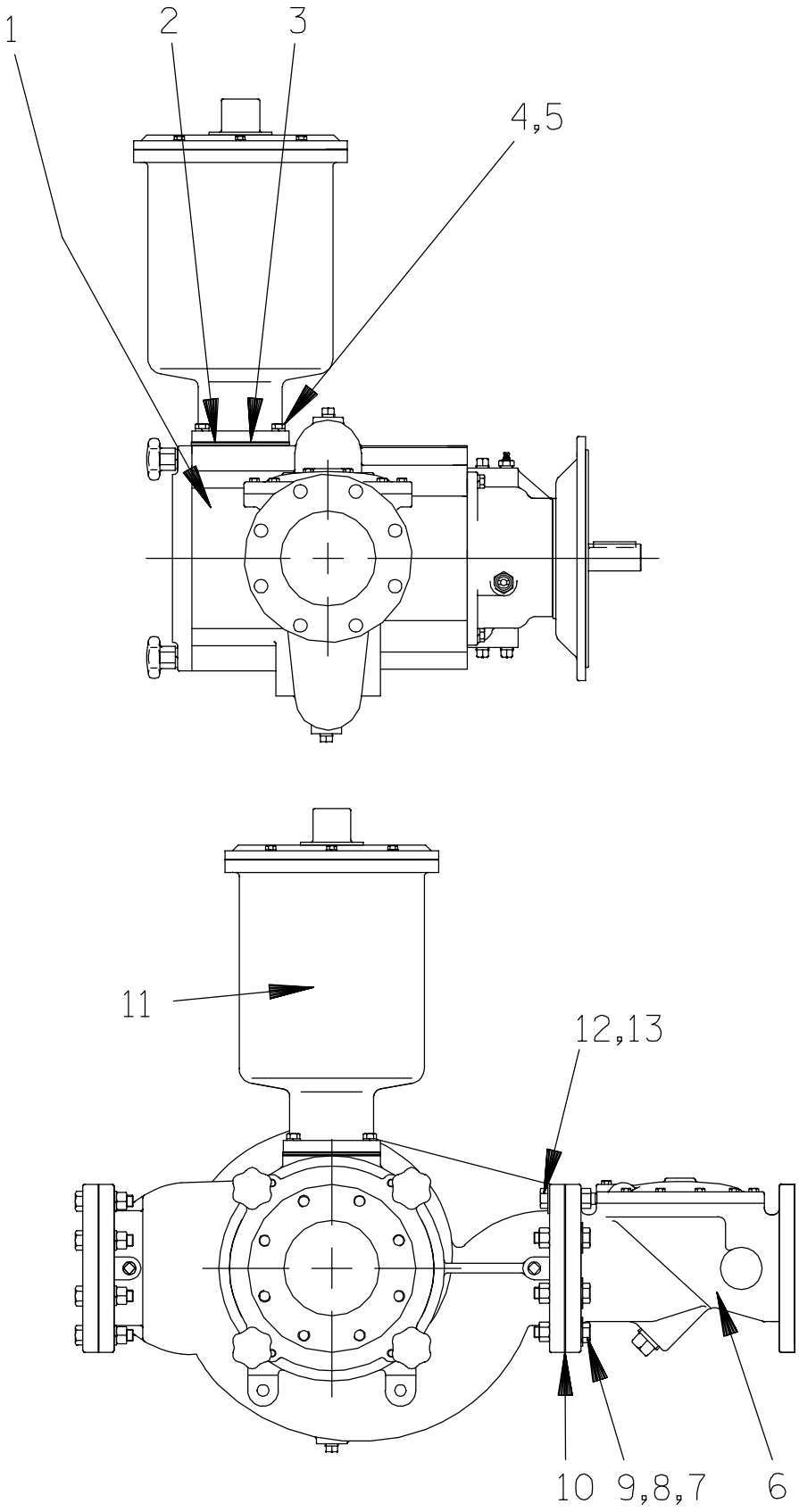

Figure C--1. PA6C60 Pump Model Assembly

PA6C60 Pump Model Assembly
Part Identification List

Refer to the separate Parts List Manual for serviceable parts, part numbers and quantities.

ITEM NO.	PART NAME
1	PUMP END ASSEMBLY
2	BAFFLE
3	GASKET
4	HEX HEAD CAPSCREW
5	LOCKWASHER
6	CHECK VALVE ASSEMBLY
7	HEX HEAD CAPSCREW
8	LOCKWASHER
9	HEX NUT
10	GASKET
11	PRIMING CHAMBER ASSEMBLY
12	HEX HEAD CAPSCREW
13	HEX NUT

NOTE: Maintenance instructions in this manual are limited to the pump hydraulic, priming and drive components only. Maintenance of engines and factory-supplied air compressors are detailed in separate literature provided by the manufacturer(s).

SECTION DRAWING

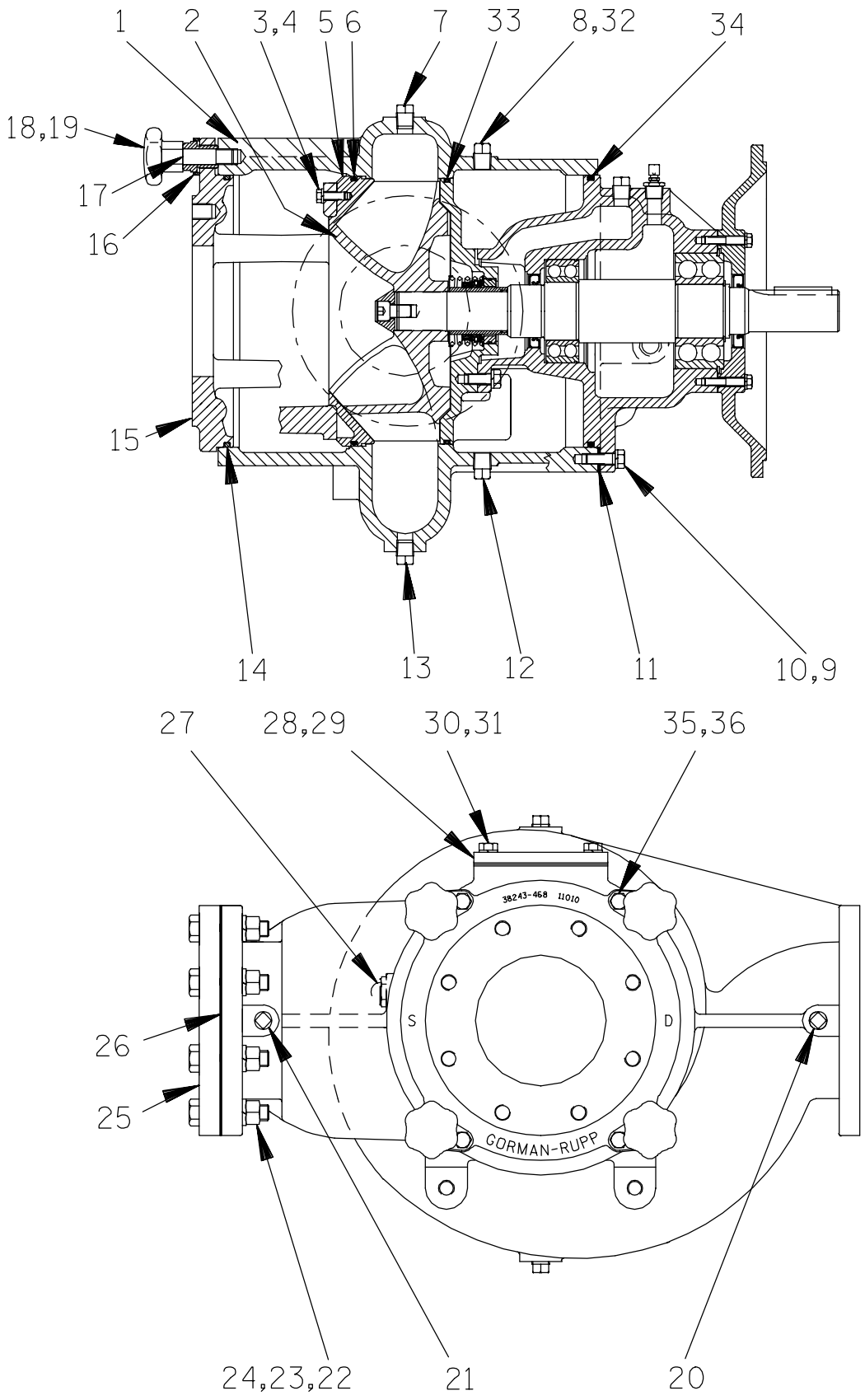

Figure C--2. 66F60 Pump End Assembly

66F60 Pump End Assembly
Part Identification List

Refer to the separate Parts List Manual for serviceable parts, part numbers and quantities.

ITEM NO.	PART NAME
1	PUMP CASING
2	REPAIR ROTATING ASSEMBLY
3	HEX HEAD CAPSCREW
4	LOCKWASHER
5	WEAR RING
6	WEAR RING O-RING
7	PIPE PLUG
8	VENTED PLUG
9	HEX HEAD CAPSCREW
10	LOCKWASHER
11	ADJUSTING SHIM SET
12	PIPE PLUG
13	CASING DRAIN PLUG
14	BACK COVER PLATE O-RING
15	BACK COVER PLATE
16	ADJUSTING SCREW
17	LOCKING COLLAR
18	STUD
19	HAND KNOB
20	PIPE PLUG
21	PIPE PLUG
22	HEX HEAD CAPSCREW
23	LOCKWASHER
24	HEX NUT
25	BLIND FLANGE ASSEMBLY
26	FLANGE GASKET
27	SIGHT GAUGE
28	COVER PLATE
29	COVER PLATE GASKET
30	HEX HEAD CAPSCREW
31	LOCKWASHER
32	SHIPPING PLUG
33	SEAL PLATE O-RING
34	BEARING HOUSING O-RING
35	HEX HEAD CAPSCREW
36	LOCKWASHER

SECTION DRAWING

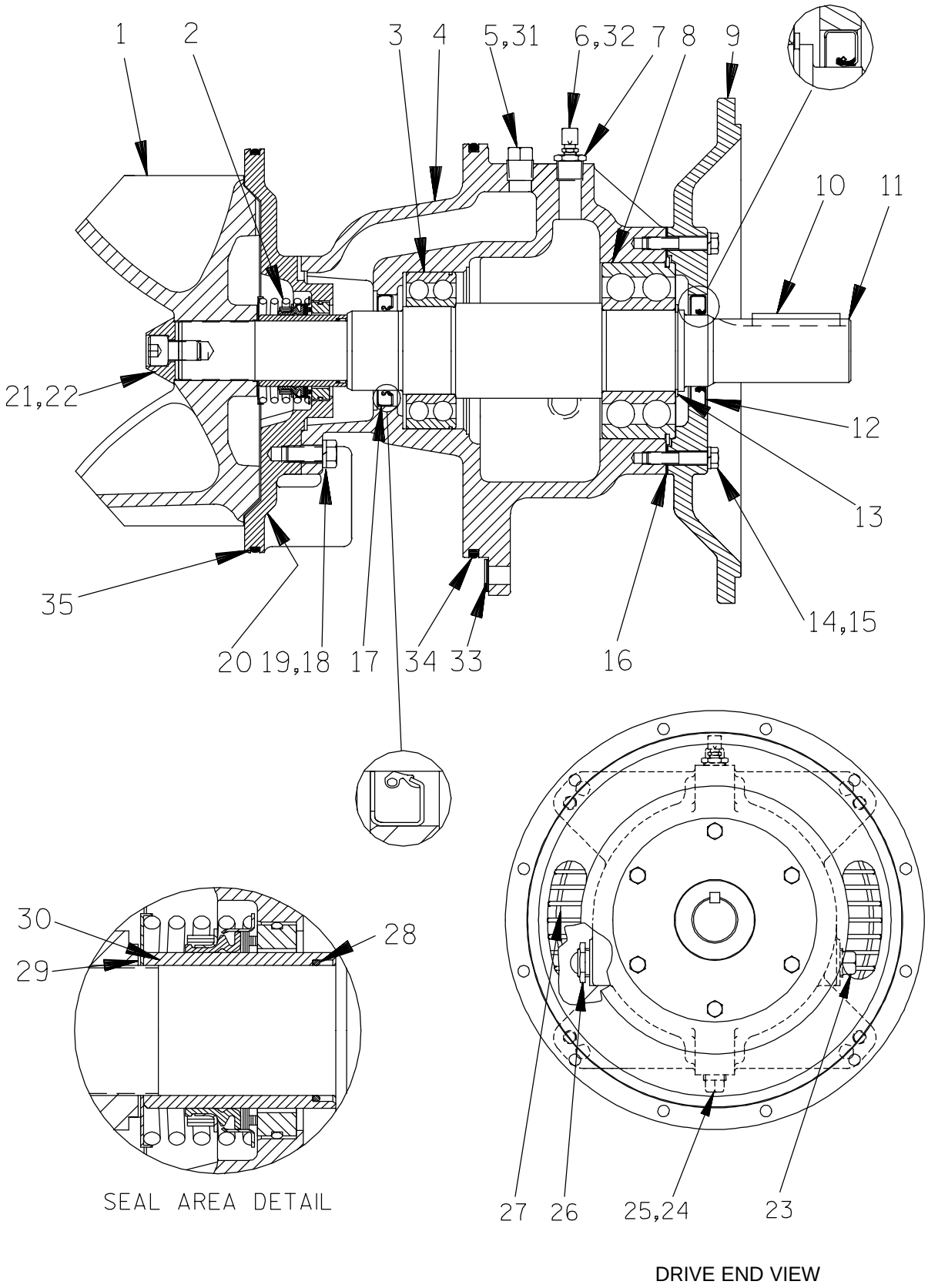

Figure C--3. Repair Rotating Assembly

Repair Rotating Assembly
Part Identification List

Refer to the separate Parts List Manual for serviceable parts, part numbers and quantities.

ITEM NO.	PART NAME
1	IMPELLER
2	SEAL ASSEMBLY
3	INBOARD BALL BEARING
4	BEARING HOUSING
5	VENTED PLUG
6	AIR VENT
7	RED PIPE BUSHING
8	OUTBOARD BALL BEARING
9	DRIVE FLANGE
10	IMPELLER SHAFT KEY
11	IMPELLER SHAFT
12	OIL SEAL
13	SNAP RING
14	HEX HEAD CAPSCREW
15	LOCKWASHER
16	BEARING HOUSING GASKET
17	OIL SEAL
18	HEX HEAD CAPSCREW
19	LOCKWASHER
20	SEAL PLATE
21	SOCKET HEAD CAPSCREW
22	IMPELLER WASHER
23	PIPE PLUG
24	PIPE PLUG
25	BEARING CAVITY DRAIN PLUG
26	SIGHT GAUGE
27	INTERMEDIATE GUARDS
28	SHAFT SLEEVE O-RING
29	IMPELLER ADJ SHIM SET
30	SHAFT SLEEVE
31	SHIP PLUG
32	SHIP PLUG
33	ADJ SHIM SET
34	BRG HOUSING O-RING
35	SEAL PLATE O-RING

SECTION DRAWING

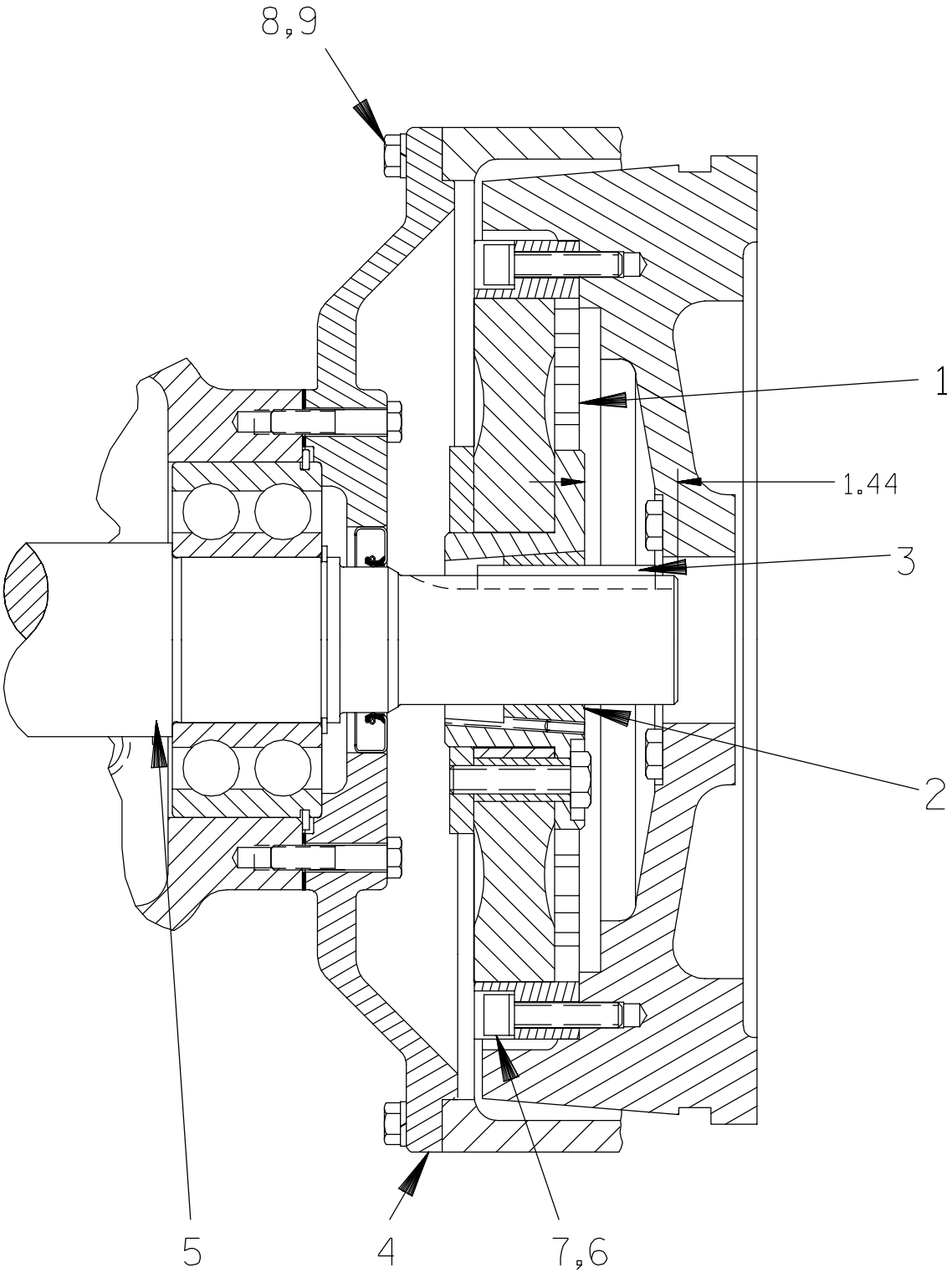

Figure C--4. Drive Assembly (Engine Driven Units)

Drive Assembly (Engine Driven Units)
Part Identification List

Refer to the separate Parts List Manual for serviceable parts, part numbers and quantities.

ITEM NO.	PART NAME
1	COUPLING ASSEMBLY
2	BUSHING
3	–KEY
4	DRIVE FLANGE (REF)
5	IMPELLER SHAFT (REF)
6	LOCKWASHER
7	SOC HD CAPSCREW
8	HEX HD CAPSCREW
9	LOCKWASHER

SECTION DRAWING

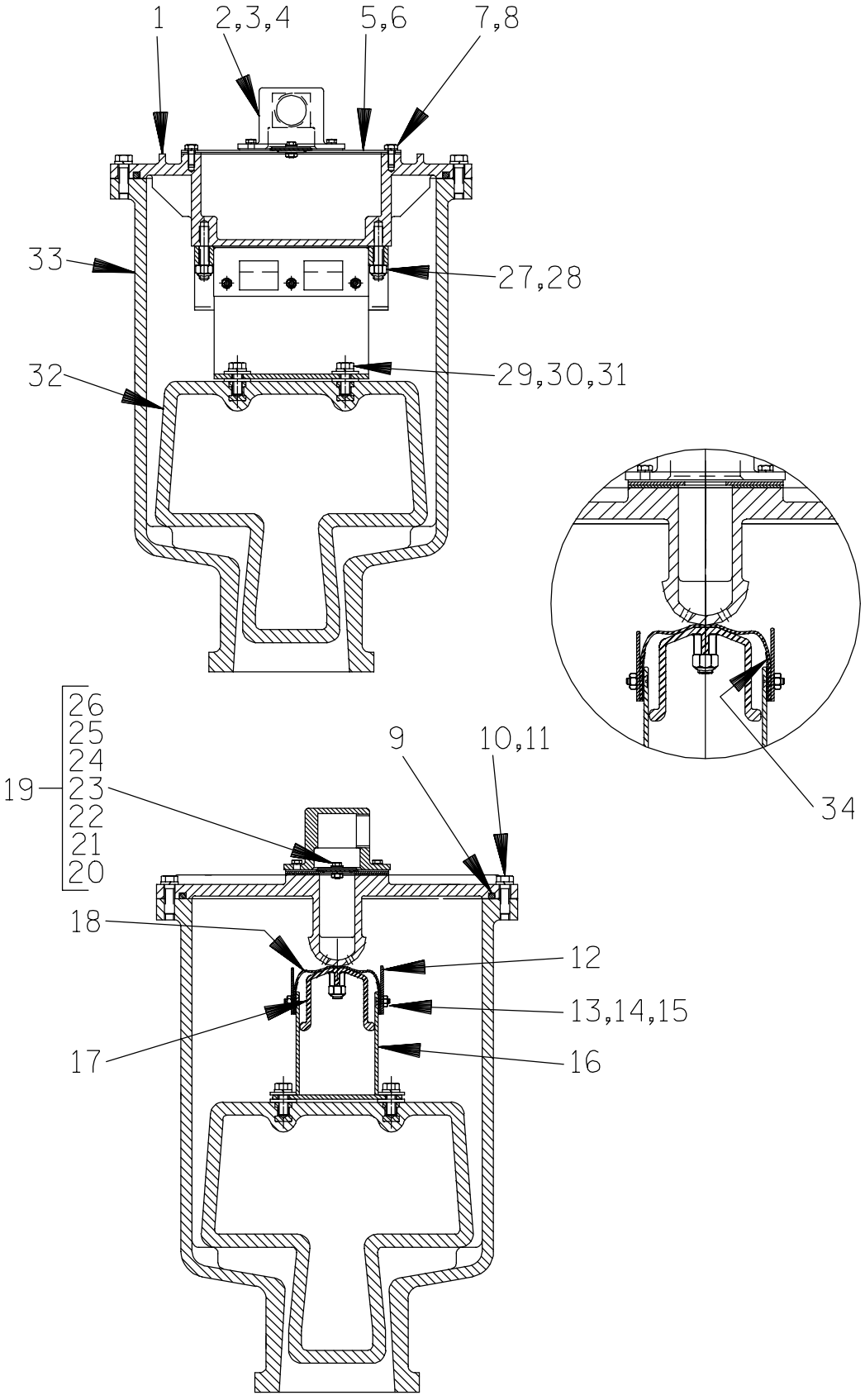

Figure C--5. Peeler Type Priming Valve

Peeler Type Priming Valve
Part Identification List

Refer to the separate Parts List Manual for serviceable parts, part numbers and quantities.

ITEM NO.	PART NAME
1	PRIMING CHAMBER LID
2	PEELER VALVE NECK
3	HEX HEAD CAPSCREW
4	LOCKWASHER
5	VALVE PLATE GASKET
6	VALVE PLATE
7	HEX HEAD CAPSCREW
8	LOCKWASHER
9	LINEAR O-RING
10	HEXHEAD CAPSCREW
11	LOCKWASHER
12	GUIDE PLATE
13	FLAT HEAD CAPSCREW
14	LOCKWASHER
15	HEX NUT
16	VALVE STRAP BRACKET ASSEMBLY
17	CLAMP PLATE
18	VALVE STRAP
19	CHECK VALVE ASSEMBLY
20	--CHECK VALVE
21	--LOCKWASHER
22	--HEX NUT
23	--FLAT WASHER
24	--HEX HEAD CAPSCREW
25	--FLAT WASHER
26	--SEALING WASHER
27	STUD
28	HEX LOCK NUT
29	HEX HEAD CAPSCREW
30	LOCKWASHER
31	FLAT WASHER
32	PRIMING VALVE FLOAT
33	PRIMING CHAMBER
34	VALVE STRAP PROTECTOR

PUMP AND SEAL DISASSEMBLY AND REASSEMBLY

Review all SAFETY information in Section A.

Follow the instructions on all tags, label and decals attached to the pump.

This pump requires little service due to its rugged, minimum-maintenance design. However, if it becomes necessary to inspect or replace the wearing parts, follow these instructions which are keyed to the Sectional Views (see Figures C–1, C–2, C–3, C–4 and C–5) and the corresponding Parts Identification Lists. Maintenance and repair instructions for the engine and air compressor are covered separately in the specific literature supplied by the manufacturers.

For part numbers and quantities for your specific pump, refer to the separate Parts List manual accompanying the pump.

Many pump service functions may be performed without separating the pump end assembly from the power source. However, the following instructions assume complete disassembly of the pump is required.

Before attempting to service the pump, shut down the engine and disconnect the positive battery cable (engine driven units) or lock out and tag out incoming power to the control box (electric motor driven units) take precautions to ensure that the pump will remain inoperative. Close all valves in the suction and discharge lines, allow the pump to completely cool, and drain the pump casing.

WARNING!

This manual will alert personnel to known procedures which require special attention, to those which could damage equipment, and to those which could be dangerous to personnel. However, this manual cannot possibly anticipate and provide detailed instructions and precautions for every situation that might occur during maintenance of the unit. Therefore, it is the responsibility of the owner/maintenance personnel to ensure that only safe, established maintenance procedures are used, and that any procedures not addressed in this manual are performed only after establishing that neither personal safety nor pump integrity are compromised by such practices.

WARNING!

Before attempting to open or service the pump:

1. **Familiarize yourself with this manual.**
2. **Shut down the engine and disconnect the positive battery cable (engine driven units) or lock out and tag out incoming power to the control box (electric motor driven units) and take precautions to ensure that the pump will remain inoperative.**
3. **Allow the pump to completely cool if overheated.**
4. **Check the temperature and make sure it is cool before opening any covers, plates, gauges, or plugs.**
5. **Close the suction and discharge valves.**
6. **Vent the pump slowly and cautiously.**
7. **Drain the pump.**

WARNING!

This pump is designed to handle material which could cause illness through direct exposure or emitted fumes. Wear adequate protective clothing when working on the pump or piping.

WARNING!

Use lifting and moving equipment in good repair and with adequate capacity

to prevent injuries to personnel or damage to equipment. The bail is intended for use in lifting the pump assembly only. Suction and discharge hoses and piping must be removed from the pump before lifting. If chains or cables are used to lift pump components, make certain that they are positioned so as not to damage the pump, and so that the load will be balanced.

CAUTION

Use **only** replacement parts provided or approved by Gorman-Rupp. Use of non-authorized parts may result in damage to the equipment and/or injury to personnel and **will** invalidate the warranty.

Priming Chamber Removal And Disassembly

(Figure C--1)

Disconnect both the suction piping and the air discharge tubing from the priming chamber assembly (11). Support the priming chamber assembly using a sling and a suitable lifting device. Remove the hardware (4 and 5) and separate the priming chamber assembly, baffle (2) and gasket (3) from the pump assembly (1).

(Figure C--5)

Remove the hardware (10 and 11) securing the priming chamber lid (1) to the priming chamber (33). Carefully lift the lid and valve components from the priming chamber. If the priming valve float (32) is stuck or the check valve assembly (19) is clogged, they can usually be cleaned without further disassembly.

Inspect the O-ring strip (9) and, if replacement is required, remove the gasket and **all** of the old adhesive.

To remove the float (32), disconnect the hardware (29, 30 and 31).

To replace the valve strap (18), disengage the hardware (13, 14 and 15) and separate the guide plates (12), clamp plate (17) and valve protector (34) from the valve strap. Disengage the hardware (27 and 28) and remove the valve strap.

To remove the check valve assembly (19), disengage the hardware (3 and 4). Remove the peeler valve neck (2) and check valve assembly.

Inspect the check valve components. If the check valve (20) requires replacement, remove the hardware (22, 24 and 25) securing the valve weights (23 and 26) to the check valve.

It is not necessary to remove the valve plate (6) unless the gasket (5) requires replacement. To remove the valve plate, disengage the hardware (7 and 8).

Discharge Check Valve Removal and Disassembly

(Figure C--1)

Support the discharge check valve assembly (6) using a sling and a suitable lifting device. Remove the hardware (7, 8 and 9) securing the discharge check valve assembly and gasket to the pump assembly.

The flapper and gasket are the only serviceable parts of the check valve. If the flapper requires replacement, remove the hardware securing the cover and gasket. Separate the cover and remove the flapper.

Back Cover Plate and Wear Plate Removal

(Figure C--2)

The wear plate (5) is easily accessible and may be serviced by removing the back cover (15). Before attempting to service the pump, remove the pump casing drain plug (13) and drain the pump. Clean and reinstall the drain plug.

Remove the hand knobs (19) and pry the back cover and assembled wear plate from the pump casing (1).

NOTE

An alternate method of removing the back cover from the pump casing is to remove the hand knobs (19) and two diagonally opposing locking collars (17). Use the adjusting screws (16) to press the back cover out of the pump casing.

Remove and discard the O-rings (6 and14).

Inspect the wear plate (5) and, if replacement is required, remove the hardware (3 and 4) securing it to the back cover plate.

Separating Pump End From Power Source

Further disassembly of the pump requires separating the pump end from the power source. Disconnect the discharge piping from the pump casing.

Remove the hardware securing the drive flange (9, Figure 3) to the guard (not shown, motor driven units only) or bellhousing (engine driven units). On electric motor driven units, remove the coupling guard and separate the coupling halves.

Pull the pump end straight away from the power source. Remove the coupling half from the impeller shaft (motor driven units).

(Engine Driven Units, Figure C--4)

As the assemblies separate, the flexible portion of the coupling assembly (1) will remain on the shaft. To remove the coupling from the shaft, unscrew the two allen head setscrews from the bushing (2). Screw one of the setscrews into the puller hole on the circumference of the bushing. As the coupling and bushing separate, remove the bushing, and slide the coupling off the shaft. Remove the shaft key (3).

It is not necessary to remove the outer ring of the coupling from the engine flywheel unless the coupling must be replaced. To remove the ring, disengage the hardware (6 and 7) securing it to the flywheel.

Move the pump end to a clean, well equipped shop area for further disassembly.

Draining Oil From Seal Cavity

(Figure C--2)

If any further disassembly is to be performed on the pump, the seal cavity oil must be drained to prevent the oil in the seal cavity from escaping as the pump casing is removed.

Position a large (3 gallon [11,4 liter] minimum), **clean** container under the seal cavity drain plug (12). Remove the drain plug and drain the oil from the seal cavity into the container. Clean and reinstall the drain plug. Inspect the oil for water, dirt or a cloudy condition which could indicate seal failure.

Loosening Impeller

(Figures C--3 and C--6)

With the pump end separated from the engine, insert a block of wood through the pump discharge and wedge it between the vanes of the impeller and the pump casing to prevent rotation. Remove the impeller capscrew and washer (21 and 22).

Install the shaft key (10) in the shaft keyway. Install a lathe dog on the drive end of the shaft (11) with the "V" notch positioned over the shaft key.

With the impeller rotation still blocked, see Figure C--6 and use a long piece of heavy bar stock to pry against the arm of the lathe dog in a counterclockwise direction (when facing the drive end of the shaft). **Use caution** not to damage the shaft or keyway. When the impeller breaks loose, remove the lathe dog, key and wood block.

NOTE

Do not remove the impeller until the rotating assembly has been removed from the pump casing.

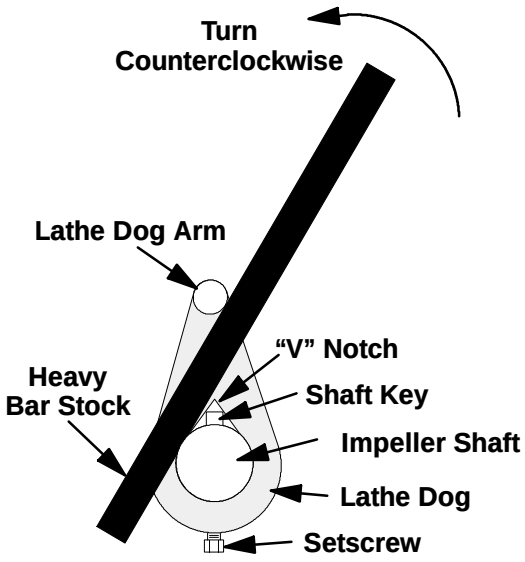

Figure C--6. Loosening Impeller

Pump Casing Removal

(Figure C--2)

Support the pump casing using a suitable hoist and sling, and remove the hardware (9 and 10).

Install four 1/2–13 UNC x 2-inch long jacking screws in the tapped holes in the bearing housing (4, Figure C–3). Tighten the jacking screws in an alternating pattern until the pump casing is pushed off of the bearing housing. Remove the jacking screws.

Impeller Removal

(Figure C–3)

To remove the impeller (1), unscrew it in a counterclockwise direction (when facing the impeller). Use caution when removing the impeller; tension on the shaft seal spring will be released as the impeller is unscrewed. Inspect the impeller and replace it if cracked or badly worn.

Seal Removal

(Figures C–3 and C–7)

Slide the impeller adjusting shims (29) off the impeller shaft (11). Tie and tag the shims or measure and record their thickness for ease of reassembly.

Remove the spring centering washer and seal spring. Slide the shaft sleeve (30) and rotating portion of the seal (consisting of the bellows, retainer, and rotating element) off the shaft as a unit.

Apply oil to the sleeve and work it up under the rubber bellows. Slide the rotating portion of the seal off the sleeve.

Remove the seal sleeve O-ring (28).

Slide a pair of stiff wires with hooked ends along the shaft and hook the stationary seat from the back side. Pull the stationary seat and O-ring from the seal plate.

An alternate method of removing the stationary seal components is to remove the hardware (18 and 19) and separate the seal plate from the bearing housing (4). Position the seal plate on a flat surface with the impeller side down. Use a wooden dowel or other suitable tool to press on the back side of the stationary seat until the seat and O-ring can be removed.

Remove the seal plate O-ring (35).

If no further disassembly is required, refer to **Seal Installation**.

Shaft and Bearing Removal and Disassembly

(Figure C–3)

When the pump is properly operated and maintained, the bearing housing should not require disassembly. Disassemble the shaft and bearings **only** when there is evidence of wear or damage.

Shaft and bearing disassembly in the field is not recommended. These operations should be performed only in a properly-equipped shop by qualified personnel.

Remove the bearing housing drain plug (24) and drain the lubricant. Clean and reinstall the drain plug.

Disengage the hardware (14 and 15) and remove the drive flange (9), gasket (16) and oil seal (12). Use a suitably sized dowel to press the oil seal from the drive flange.

Place a block of wood against the impeller end of the shaft (11) and tap the shaft and assembled bearings from the intermediate. Press the inboard oil seal (17) out of the bearing housing.

Remove the bearing housing O-ring (34).

After removing the shaft and bearings, clean and inspect the bearings **in place** as follows.

To prevent damage during removal from the shaft, it is recommended that bearings be cleaned and inspected **in place**. It is **strongly** recommended that the bearings be replaced **any** time the shaft and bearings are removed.

Clean the bearing housing, shaft and all component parts (except the bearings) with a soft cloth soaked in cleaning solvent. Inspect the parts for wear or damage and replace as necessary.

WARNING!

Most cleaning solvents are toxic and flammable. Use them only in a well ventilated area free from excessive heat, sparks, and flame. Read and follow all precautions printed on solvent containers.

Clean the bearings thoroughly in **fresh** cleaning solvent. Dry the bearings with filtered compressed air and coat with light oil.

CAUTION

Bearings must be kept free of all dirt and foreign material. Failure to do so will greatly shorten bearing life. **Do not** spin dry bearings. This may scratch the balls or races and cause premature bearing failure.

Rotate the bearings by hand to check for roughness or binding and inspect the bearing balls. If rotation is rough or the bearing balls are discolored, replace the bearings.

The bearing tolerances provide a tight press fit onto the shaft and a snug slip fit into the bearing housing. Replace the bearings, shaft, or bearing housing if the proper bearing fit is not achieved.

If bearing replacement is required, remove the snap ring (13) and use a bearing puller to remove the inboard and outboard bearings (3 and 8) from the shaft.

Shaft and Bearing Reassembly and Installation

(Figure C--3)

Inspect the shaft for distortion, nicks or scratches, or for thread damage on the impeller end. Dress small nicks and burrs with a fine file or emery cloth. Replace the shaft if defective.

Clean and inspect the bearings as indicated in **Shaft And Bearing Removal And Disassembly**.

CAUTION

To prevent damage during removal from the shaft, it is recommended that bearings be cleaned and inspected **in place**. It is **strongly** recommended that the bearings be replaced **any** time the shaft and bearings are removed.

NOTE

*The inboard bearing (3) comes from the manufacturer with a retaining ring installed on the bearing O.D. This retaining ring **must** be removed prior to installation.*

The bearings may be heated to ease installation. An induction heater, hot oil bath, electric oven, or hot plate may be used to heat the bearings. Bearings should **never** be heated with a direct flame or directly on a hot plate.

NOTE

If a hot oil bath is used to heat the bearings, both the oil and the container must be **absolutely** *clean. If the oil has been previously used, it must be* **thoroughly** *filtered.*

Heat the bearings to a uniform temperature **no higher than** 250°F (120°C), and slide the bearings onto the shaft, one at a time, until they are fully seated. This should be done quickly, in one continuous motion, to prevent the bearings from cooling and sticking on the shaft.

After the bearings have been installed and allowed to cool, check to ensure that they have not moved away from the shaft shoulders in shrinking. If movement has occurred, use a suitably sized sleeve and a press to reposition the bearings against the shaft shoulders.

If heating the bearings is not practical, use a suitably sized sleeve, and an arbor (or hydraulic) press to install the bearings on the shaft.

CAUTION

When installing the bearings onto the shaft, **never** press or hit against the outer

race, balls, or ball cage. Press **only** on the inner race.

Secure the outboard bearing (8) to the shaft with the retaining ring (13).

Apply a light coating of oil to the lip of the inboard oil seal (17) and press it into the bearing housing with the lip positioned as shown in Figure C–3. Press the oil seal into the housing until the face is **just flush** with the machined surface on the housing.

Slide the shaft and assembled bearings into the intermediate bore until the inboard bearing is fully seated against the bore shoulder. Use caution not to damage the lip seal on the shaft threads.

CAUTION

When installing the shaft and bearings into the bearing bore, push against the outer race. **Never** hit the balls or ball cage.

Apply a light coating of oil to the lip of the outboard oil seal (12) and press it into the drive flange (9) with the lip positioned as shown in Figure C–3. The face of the oil seal should be just flush with the outer face of the drive flange.

Install the drive flange gasket (16) and secure the drive flange to the bearing housing with the hardware (14 and 15). **Be careful** not to damage the lip of the oil seal (12) on the shaft keyway.

Lubricate a new bearing housing O-ring (34) with grease and install it in the groove in the bearing housing.

Lubricate the bearings as indicated in **LUBRICATION** at the end of this section.

Seal Reassembly and Installation

(Figures C–3 and C–7)

Clean the seal cavity and shaft with a cloth soaked in fresh cleaning solvent.

WARNING!

Most cleaning solvents are toxic and flammable. Use them only in a well ventilated area free from excessive heat, sparks, and flame. Read and follow all precautions printed on solvent containers.

The seal is not normally reused because wear patterns on the finished faces cannot be realigned during reassembly. This could result in premature failure. If necessary to reuse an old seal in an emergency, **carefully** wash all metallic parts in **fresh** cleaning solvent and allow to dry thoroughly.

Handle the seal parts with extreme care to prevent damage. Be careful not to contaminate precision finished faces; even fingerprints on the faces can shorten seal life. If necessary, clean the faces with a non-oil based solvent and a clean, lint-free tissue. Wipe **lightly** in a concentric pattern to avoid scratching the faces.

Inspect the seal components for wear, scoring, grooves, and other damage that might cause leakage. Clean and polish the shaft sleeve, or replace it if there are nicks or cuts on either end. If any components are worn, replace the complete seal; **never mix old and new seal parts**.

If a replacement seal is being used, remove it from the container and inspect the precision finished faces to ensure that they are free of any foreign matter.

To ease installation of the seal, lubricate the O-rings and bellows with water or a very **small** amount of oil, and apply a drop of light lubricating oil on the finished faces. Assemble the seal as follows, (see Figure C–7).

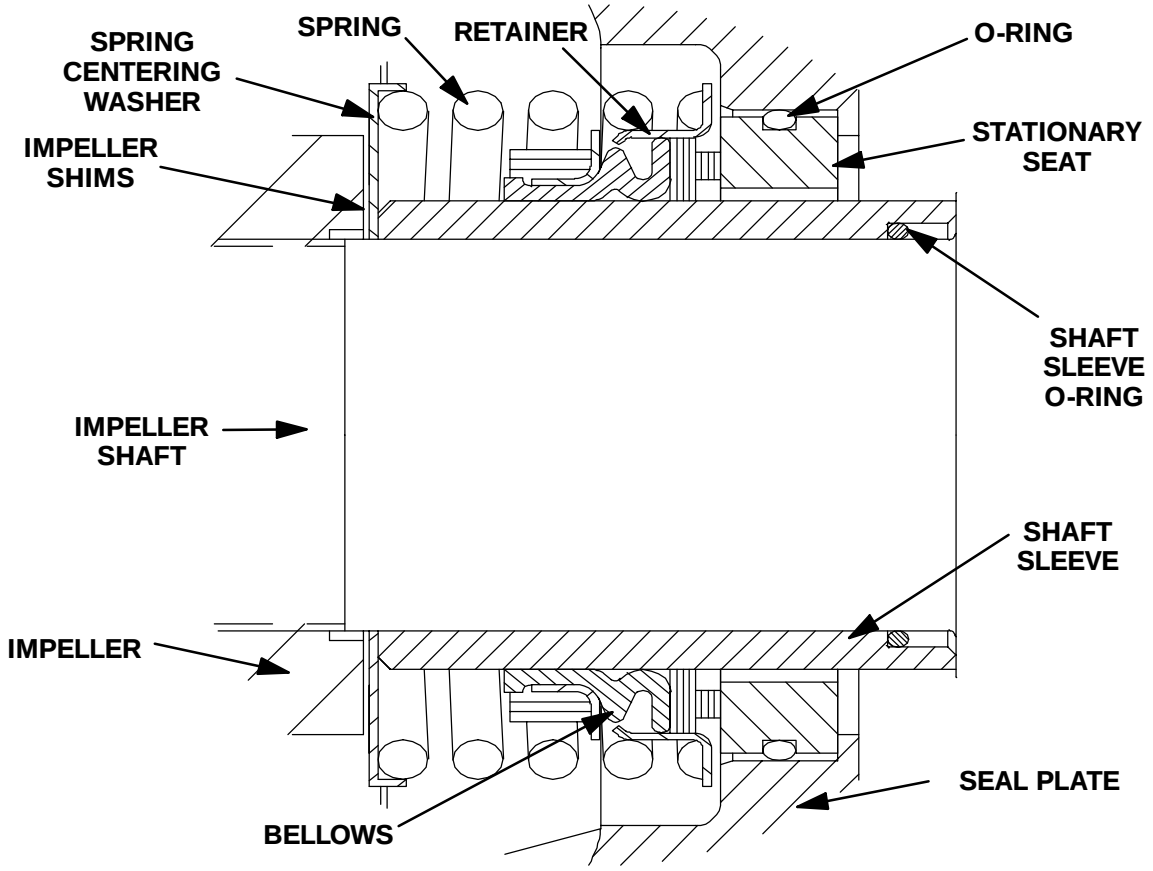

Figure C--7. Seal Assembly

CAUTION

This seal is not designed for operation at temperatures above 160°F (71°C). Do not use at higher operating temperatures.

Lubricate the stationary seat O-ring with water or light oil. Press the stationary seat into the seal plate (20) until fully seated.

Position the seal plate over the shaft and secure it to the bearing housing (4) with the hardware (18 and 19). **Be careful** not to damage the stationary seat on the shaft threads.

Lubricate a new seal plate O-ring (35) with grease and install it in the groove in the seal plate.

Lubricate the shaft sleeve O-ring (28) and position it over the last thread on the impeller shaft. **Use caution** not to cut the O-ring on the threads.

Slide the shaft sleeve (30) onto the shaft until the O-ring is fully seated in the undercut. Continue to press the sleeve onto the shaft until fully seated against the shaft shoulder.

Lubricate the O.D. of the seal sleeve with a **small** amount of light oil. Slide the rotating subassembly (consisting of rotating element, bellows and retainer), onto the sleeve until the seal faces contact.

Install the seal spring and centering washer. Lubricate the seal as indicated in **LUBRICATION** after the impeller is installed.

Impeller Installation And Adjustment

(Figure C--3)

Inspect the impeller (1) and replace it if cracked or badly worn.

CAUTION

The shaft and impeller threads **must** be completely clean before reinstalling the impeller. Even the slightest amount of dirt on the threads can cause the impeller to seize

to the shaft, making future removal difficult or impossible without damage to the impeller or shaft.

Install the same thickness of impeller adjusting shims (29) as previously removed and screw the impeller assembly onto the shaft until tight.

NOTE

*At the slightest sign of binding, **immediately** back the impeller off, and check the threads for dirt. **Do not** try to force the impeller onto the shaft.*

A clearance of .025 to .040 inch (0,64 to 1,02 mm) between the impeller and the seal plate is necessary for maximum pump efficiency. Measure this clearance, and add or remove impeller adjusting shims as required.

Secure the impeller to the shaft with the impeller washer and capscrew (21 and 22).

Pump Casing Installation

(Figure C–2)

Lubricate the rotating assembly O-rings (34 and 35, Figure C–3) with a light coating of grease. Use a suitable hoist and sling to slide the pump casing (1) over the rotating assembly.

Install 0.120 inch (3 mm) of shims (11) at each mounting location and secure the casing to the rotating assembly (2) with the hardware (9 and 10).

Drive Assembly Installation (Engine Driven Units Only)

(Figure C–4)

Install the shaft key in the shaft keyway. Position the flexible portion of the coupling assembly (1) on the shaft as shown in Figure C–4.

NOTE

*The flexible portion of the coupling must be properly positioned on the shaft. The heads of the capscrews in the center of the coupling **must be positioned away from the pump end of the shaft**.*

Align the keyway in the bushing (2) with the shaft key, and slide it onto the shaft to the dimension shown in Figure C–4. Rotate the flexible portion of the coupling until the tapped holes for the two setscrews align with those in the bushing, and install the setscrews.

CAUTION

Make certain that the flexible portion of the coupling is mounted as shown in Figure C–4. **This is critical.** If the coupling is not properly positioned on the shaft, the coupling parts may not fully engage, or a pre-load condition can cause premature bearing failure.

The coupling must be positioned 1.44 inches (37 mm) from the end of the shaft. This will allow the two portions of the coupling to fully engage when the drive flange is secured to the engine bellhousing, without pre-loading the bearings.

With the flexible portion of the coupling and the bushing properly positioned on the shaft, tighten the two setscrews in an alternating sequence until the bushing and coupling are fully secured. Torque the setscrews to 14.6 ft. lbs. (175 in. lbs. or 2 m. kg.).

If the complete coupling assembly is being replaced, apply ‘Loctite Retaining Compound No. 242’ or equivalent to the threads of the hardware (6 and 7), and secure the outer ring of the coupling to the engine flywheel by torquing the hardware to 45 ft. lbs. (540 in. lbs. or 6,2 m. kg.).

Securing Pump End to Power Source

(Engine Driven Units Only, Figure C–4)

Using a suitable lifting device, position the pump end assembly and coupling so the flexible portion of the coupling seats inside the outer ring attached to the engine flywheel.

NOTE

*To ease installation, **lightly** lubricate the rubber portion of the coupling with a **non-petroleum based lubricant** such as vegetable oil or glycerin, or a silicon-based lubricant such as “WD40” or equivalent. **Do not** use petroleum-based lubricants, or any oth-*

er substance which may soften or otherwise damage the rubber.

If removed, install the guards (27, Figure C--3), and secure the drive flange to the engine bellhousing with the previously removed hardware (8 and 9).

(Electric Motor Driven Units Only, Not Shown)

Install the coupling half on the impeller shaft. Using a suitable lifting device, position the pump end assembly on the base. Align the coupling halves and reinstall the attaching hardware. Install the coupling guard and secure the drive flange to the guard with the previously removed hardware.

Wear Plate And Back Cover Plate Installation And Adjustment

(Figures C--2 and C--6)

If the wear plate (5) was removed for replacement, carefully center it on the back cover (15) and secure it with the hardware (3 and 4).

Lubricate the O-rings (6 and 14) with light grease and install them in the grooves in the wear plate and back cover.

Clearance between the impeller and wear plate is adjusted using four hand knobs (19) and locking collars (17). There are 18 detents on the I.D. of each locking collar. Indexing the collars one detent on the adjusting screws represents approximately .005 inch (0,13 mm) of wear plate clearance. The recommended clearance between the wear plate and the impeller is .010 to .020 inch (0,25 to 0,50 mm).

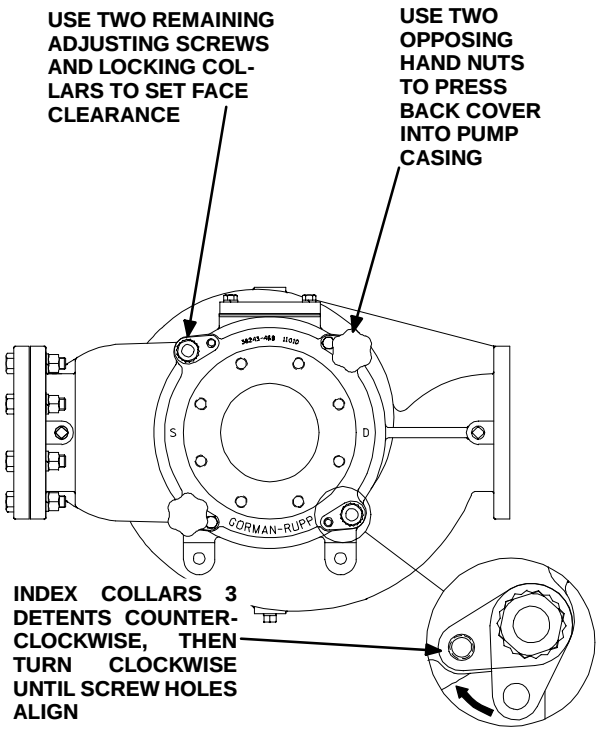

Figure C--6. Installing and Adjusting Back Cover

Screw the four adjusting screws (16) into the tapped holes in the back cover plate until they are **just flush** with the machined surface on the back side of the cover plate.

Align the back cover plate over the studs (18) and slide it into the pump casing. Use two hand knobs (19) on diagonally opposing studs to press the back cover into the pump casing until the wear plate **just touches** the impeller when the shaft is turned by hand. **Tighten the hand knobs evenly to avoid binding.**

With the wear plate just touching the impeller, turn the two free adjusting screws until they engage the pump casing. Position the locking collars over the adjusting screws so the holes in the collars for the locking screws align approximately with the holes in the cover plate.

Loosen the hand knobs used to press the back cover into the pump casing one full turn.

Pull the collars off the adjusting screws, index them three detents counterclockwise, and reinstall the collars on the adjusting screws. Use the collars to turn the adjusting screws clockwise until the holes in the locking collars realign with the tapped screw holes in the back cover plate. Secure the locking

collars to the back cover plate with the hardware (35 and 36). Install the two remaining hand knobs snugly against the adjusting screws.

Remove the first two hand knobs from their studs. Turn the adjusting screws clockwise until they engage the pump casing. Install the locking collars and hardware (35 and 36). Reinstall the hand knobs.

Be sure the wear plate does not scrape against the impeller.

Over time it may be necessary to repeat the adjustment process to compensate for normal wear between the impeller and wear plate. When all of the adjustment has been used on the back cover side of the pump, an additional 0.125 inch (3,2 mm) of adjustment may be obtained by removing the rotating assembly adjusting shims (11).

Allow an installed pump to completely cool before draining liquid from the pump casing. Disengage the hardware (9 and 10), remove the rotating assembly adjusting shims, then reinstall the hardware securing the rotating assembly to the pump casing. Reach through the suction opening and measure the clearance between the wear ring and impeller. Perform the back cover adjustment procedure described above to obtain the proper face clearance.

Priming Chamber Assembly And Installation

(Figure C--5)

Assemble the valve strap (18), guide plates (12), and protectors (33), and **loosely** attach them to the bracket assembly (16) with the hardware (13, 14 and 15). The smooth side of the valve strap **must** be positioned **away from** the bracket assembly.

Position the priming chamber lid (1) upside down on a flat work surface. Install the preassembled valve strap and bracket over the studs (27). Allow the valve strap to fully wrap over the peeler valve to ensure a proper seal without any wrinkles in the strap, and fully tighten the hardware (13, 14, and 15).

Position the clamp plate (17) over the studs (27). Apply “Loctite Threadlocker No. 242” or equivalent compound to the studs, and secure with the lock nuts (28).

Lay the lid and preassembled valve strap components on its side. Apply “Loctite Threadlocker No. 242” or equivalent compound to the capscrews (29) and secure the bracket assembly (16) to the float (32) with the hardware (29, 30 and 31).

Apply 3-M Scotchgrip Adhesive No. 847” or equivalent compound to the linear O-ring (9) and install the O-ring in the groove in the priming chamber lid (1).

NOTE

Cut the lap joint where the two ends of the O-ring (9) meet at a 45° angle.

Carefully lower the assembled lid and float into the valve body (33). Secure the lid to the body with the hardware (10 and 11).

If removed, install the gasket (5) and secure the valve plate (6) to the lid with the hardware (7 and 8).

If the check valve (19) was disassembled for replacement, install the sealing washer (26) against the head of the capscrew (25). Install the large valve weight (25) against the sealing washer. Install the check valve (20) and small valve weight (23), and secure the assembly with the lockwasher and hex nut (21 and 22).

Position the check valve assembly over the holes in the valve plate (5) with the large weight (25) facing up. Position the valve neck (2) over the check valve assembly and secure with the hardware (3 and 4).

(Figure C--1)

Install the gasket (3) and use a sling and suitable lifting device to position the priming chamber assembly against the baffle plate (2) and cover plate (28, Figure C--2). Secure the priming chamber assembly with the hardware (4 and 5).

Reconnect both the suction piping and the air discharge tubing to the priming chamber assembly.

Discharge Check Valve Assembly And Installation

(Figure C--1)

The flapper and gasket are the only serviceable parts of the check valve (6). If the flapper requires replacement, remove the hardware securing the cover and gasket. Separate the valve cap and replace the flapper.

Install the valve cap gasket and secure the cap with the previously removed hardware.

Install the discharge check valve assembly in the discharge piping with the hardware (7, 8 and 9).

Wear Ring Adjustment

(Figure C--2)

Pump performance is adversely affected by increased clearance between the wear ring (5) and the impeller. When it becomes necessary to adjust the clearance, loosen the hand knobs (19) and pry the back cover approximately 1/8 inch (3,2 mm) out of the pump casing.

Disengage the hardware (9 and 10), remove the shims (11) and reinstall the hardware (9 and 10).

Reach through the suction opening and measure the clearance between the wear ring and impeller. Adjust the wear ring-to-impeller clearance as previously described in **Wear Plate And Back Cover Plate Installation And Adjustment**.

LUBRICATION

Seal Assembly

(Figure C--2)

Fill the seal cavity through the hole for the vented plug (8) with SAE No. 30 non-detergent oil. Check the oil level regularly at the sight gauge (27) and refill as required. When lubricating a dry seal cavity, add approximately approximately 8 U.S. quarts (7,6 liters) of oil to the center of the sight gauge.

NOTE

The white reflector in the sight gauge must be positioned horizontally to provide proper drainage.

Bearings

(Figure C--3)

The bearing housing was fully lubricated when shipped from the factory. Check the oil level regularly through the sight gauge (26) and maintain it at the midpoint of the gauge. When lubrication is required, remove the air vent (6) and add SAE No. 30 non-detergent oil through the opening. When lubricating a dry (overhauled) bearing housing, fill the bearing cavity with approximately 40 ounces (1,2 liters) of oil. Clean and reinstall the air vent. **Do not** over-lubricate. Over-lubrication can cause the bearings to over-heat, resulting in premature bearing failure.

NOTE

The white reflector in the sight gauge must be positioned horizontally to provide proper drainage.

Under normal conditions, drain the bearing housing once each year and refill with clean oil. Change the oil more frequently if the pump is operated continuously or installed in an environment with rapid temperature change.

CAUTION

Monitor the condition of the bearing lubricant regularly for evidence of rust or moisture condensation. This is especially important in areas where variable hot and cold temperatures are common.

For cold weather operation, consult the factory or a lubricant supplier for the recommended grade of oil.

Power Unit

Consult the literature supplied with the power unit, or contact your local power unit representative.

For U.S. and International Warranty Information,
Please Visit www.grpumps.com/warranty
or call:
U.S.: 419—755—1280
International: +1—419—755—1352

For Canadian Warranty Information,
Please Visit www.grcanada.com/warranty
or call:
519—631—2870

THE GORMAN-RUPP COMPANY ● MANSFIELD, OHIO
GORMAN-RUPP OF CANADA LIMITED ● ST. THOMAS, ONTARIO, CANADA

Appendix C – Spill Response Plan

Government of Nunavut

Spill Response Plan - Wastewater Treatment Site
Kimmirut, Nunavut

Project Name:
Kimmirut Waste Water Facility

Project Number:
OTCD00018881A

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01/09/11

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1.0 Introduction

Exp Services Inc. (**exp**) formerly Trow Associates Inc. was retained by the Government of Nunavut – Department of Community and Government Services to prepare a Spill Response Plan (SRP) as part of the operation and maintenance of the Hamlet of Kimmirut's (Hamlet) wastewater treatment site (sewage lagoons). This SRP also demonstrates the Hamlet's stewardship in environmental management.

The purpose of the SRP is to address potential environmental spill incidents that may occur during the routine operation and maintenance activities of the wastewater treatment site. The SRP is designed to be protective of the local natural environment.

The SRP includes a review of appropriate Government acts and regulations, the identification of foreseeable spill scenarios, spill response procedures and general health, safety and emergency response requirements necessary when conducting activities that may require contact with the subsurface materials. The SRP does not replace any Health & Safety protocols, procedures, etc. already established by the Hamlet but rather is intended to be complimentary to existing protocols.

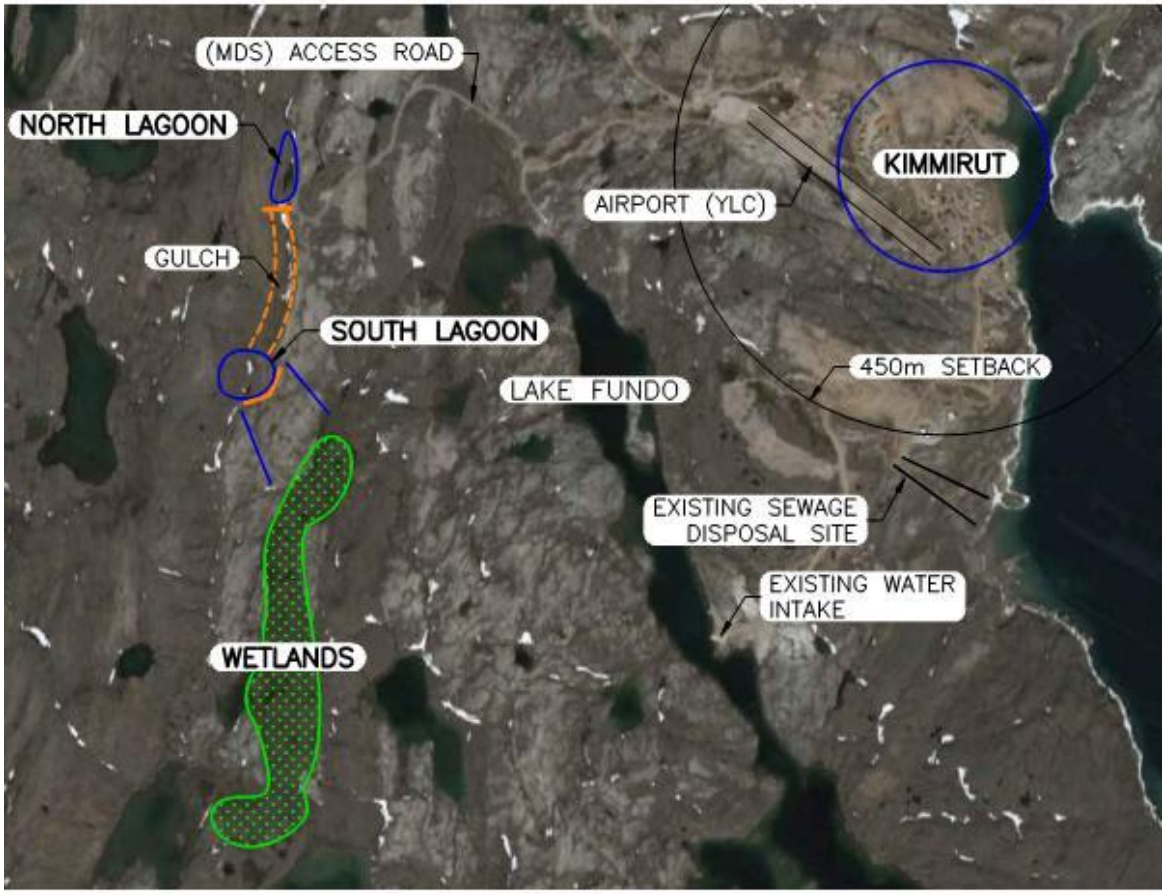
Situations may arise during the site work that are beyond the scope of the safety procedures stated in this document. In such a situation, it may be necessary to stop on-site work until a revised procedure or SRP is prepared to reflect the changing conditions.

It is recommended that all persons involved with on-site operations read the SRP. If there are any questions regarding any aspect to this document, individuals are encouraged to contact Trow for additional information or clarification.

2.0 Site Description

The wastewater treatment site (sewage lagoons) in the vicinity of the Hamlet, for which this SRP was developed, is shown on Figure 1 (below). The sewage treatment facility comprises of the north lagoon, gulch, south lagoon and wetlands.

Figure 1: Location of the Wastewater Treatment Site, Kimmirut, NU



3.0 Regulations

With respect to spills, the Guidelines for Spill Contingency Planning[1] and Environmental Protection Act (R-068-93) require that all spill response plans include:

- The name, address and job title of the owner or person in charge, management or control of the facility;
- The name, job title and 24-hour telephone number for the person(s) responsible for activating the spill response plan;
- A description of the facility, a description of the type and amount of contaminants normally stored at the facility and a site map of the facility;
- The steps to be taken to report, contain, clean up and dispose of contaminants in the case of a spill;
- The means by which the spill response plan is activated;
- A description of the training provided to employees to respond to a spill;
- An inventory of and the location of response and clean-up equipment available to implement the spill response plan; and,
- The date the spill response plan was prepared.

[1] Prepared by Water Resources Division Indian and Northern Affairs Canada Yellowknife, NT April 2007

4.0 Contacts & Regulatory Authorities

The following table includes the contact information for the persons responsible for the facility. The persons listed below should be contacted in the event of a spill.

Table 1: Contacts

Name	Job Title	24-Hour Telephone #

In each instance that a spill is identified, the Emergency Spill Hotline and the INAC Water Resources Inspector shall be contacted as soon as possible. A NT-NU Spill Report Form (included) should also be completed and faxed to the Emergency Spill Hotline. The necessity to contact the other agencies will be contingent upon direction from the Emergency Spill Hotline.

Emergency Spill Hotline: Phone: (867) 920-8130, Fax (867) 873-6924

INAC Water Resources Inspector: Phone: (867) 975-4295

In addition to the local contacts described above, the following table summarizes the additional regulatory authorities that have a vested interest in the event of a spill.

Table 2: Additional Agencies

Agency	Legislation	Contact Phone #
Nunavut Water Board	Nunavut Waters and Surface Right Tribunal Act	(867) 360-6338
Nunavut Impact Review Board	Nunavut Land Claims Agreement Act	(867) 983-2593
Environment Canada	Canadian Environmental Protection Act, 1999	(867) 975-4464
Transport Canada (Coast Guard)	Transportation of Dangerous Goods Act	(867) 979-5269
Department of Fisheries and Oceans	Fisheries Act	(867) 645-2871

5.0 Potential Contaminants and Spill Scenarios

Potential spill scenarios are dependent on the types and volumes of materials that are being used on the sites and the activities being carried out. For the purpose of this SRP, spill sizes are described as small (<10 litres), medium (>10 litres and <100 litres) or large (>100 litres).

The primary potential contaminants at the wastewater treatment site include raw sewage and sewage sludge. Other materials (potential contaminants) that are anticipated to be present on the site include gasoline, diesel fuel, hydraulic oil, motor oil and other lubricants, antifreeze and coolants from sewage delivery trucks and any heavy equipment in use for maintenance purposes. Spills may be the result of any of the following occurrences:

- Leaks or breaches of the sewage lagoon berms;
- Spill during transfer of liquids (sewage);
- Leaks or ruptures of vehicular fuel or hydraulic oil storage tanks;
- Valve or line failure in systems on vehicles or operating equipment;
- Heat expansion due to overfilling;
- Vehicular accidents; and/or,
- Vandalism.

6.0 Reportable Spill Quantities

In the event of a spill, the following table is to be used as a guide to determine if the spill should be reported to the proper authorities. Any spilled quantities that exceed the specified amounts must be reported to the **Emergency Spills Hotline**. Spills of any quantity that occur near or into fish-bearing waters or sensitive environment, wildlife or habitat must be reported. In addition, spills of any quantity that pose an imminent threat to human health or life or listed species at risk or critical habitat must also be reported. It is recommended that any spill of significant size be reported and the advice received should be followed.

Table 3: Reportable Quantities[1]

Item	TDGA[2] Class	Contaminant	Amount Spilled
1	2	Explosives	Any amount
2	2.1	Compressed Gas (flammable)	Any amount of gas from containers with capacity greater than 100 kg
3	2.2	Compressed Gas (non-corrosive, non-flammable)	Any amount of gas from containers with capacity greater than 100 kg
4	2.3	Compressed Gas (toxic)	Any amount
5	2.4	Compressed Gas (corrosive)	Any amount
6	3.1, 3.2, 3.3	Flammable Liquid	100 L
7	4.1	Flammable Solid	25 kg
8	4.2	Spontaneously Combustible Solids	25 kg
9	4.3	Water Reactant Solids	25 kg
10	5.1	Oxidizing Substances	50 L or 50 kg
11	5.2	Organic Peroxides	1 L or 1 kg
12	6.1	Poisonous Substances	5 L or 5 kg
13	6.2	Infectious Substances	Any amount
14	7	Radioactive	Any amount
15	8	Corrosive Substances	5 L or 5 kg
16	9.1(in part)	Misc. products or Substances Excluding PCB Mixtures	50 L or 50 kg
17	9.2	Environmentally Hazardous	1 L or 1 kg
18	9.3	Dangerous Wastes	5 L or 5 kg
19	9.1 (in part)	PCB Mixtures of 5 or More Parts Per Million	0.5 L or 0.5 kg
20	None	Other Contaminants	100 L or 100 kg

Notes:

[1)] *Environmental Protection Act*, Consolidation of Spill Contingency Planning and Reporting Regulations
[2)] TDGA Class – Transportation of Dangerous Goods Class under the *Transportation of Dangerous Goods Act*.

7.0 Spill Response Procedures

The following section describes the appropriate spill response procedures that should be followed in the event of a spill to various media (bedrock, gravel, soil, water, ice or snow).

7.1. Spills on Land

For spills on land (soil, gravel, sand, rock, and vegetation), the following procedure should be followed:

1. Extinguish all sources of ignition (i.e., shut off engines, no smoking).
2. If possible, identify the spilled material.
3. Make sure the area is safe for entry and the spill does not represent a threat to the health or safety of the responder or others at the spill site.
4. Assess whether the spill can be readily stopped or brought under control and if safe and possible, stop the source of the spill (i.e., plug hole, close valve, install upright container) or place tarp under spill source and build up tarp edges to contain spill.
5. If the spill is sufficiently large that it cannot be controlled with the materials at hand, the spill should be reported immediately.
6. Stop spilled liquids from spreading or entering waterways using absorbent materials or a soil dyke down slope from the spill.
7. Contact facility supervisor and report the spill.
8. If possible with materials at hand, clean up remaining spilled material and store in a secure container for disposal. Do not flush area with water.
9. If possible, pump any contained liquid into drums.
10. Complete a Spill Reporting Sheet.
11. Contact: Emergency Spill Hotline: Phone: (867) 920-8130, Fax (867) 873-6924 for additional advice.
12. Contact: INAC Water Resources Inspector: Phone: (867) 975-4295 to report the spill.
13. Submit to the INAC Water Resources Inspector, a detailed report including the GPS location of the spill, no later than thirty (30) days after initially reporting the event.

7.2. Spills on Water

For spills on water, the following procedure should be followed:

1. Extinguish all sources of ignition (i.e., shut off engines, no smoking).
2. If possible, identify the spilled material.
3. Make sure the area is safe for entry and the spill does not represent a threat to the health or safety of the responder or others at the spill site.
4. Assess whether the spill can be readily stopped or brought under control and if safe and possible, stop the source of the spill (i.e., plug hole, close valve, upright container).
5. If the spill is sufficiently large that it cannot be controlled with the materials at hand, spill report the spill immediately.
6. Use sorbant booms to contain spill for recovery, place sorbant sheets on water within boomed perimeter. For narrow waterways, place one or more booms across the waterway, down stream of the spill location and anchor boom ends on each bank. Store saturated sorbant sheets and booms in drums for disposal.

7. Contact facility supervisor and report the spill.
8. If possible with materials at hand, clean up remaining spilled material and store in a secure container.
9. Complete a Spill Reporting Sheet.
10. Contact: Emergency Spill Hotline: Phone: (867) 920-8130, Fax (867) 873-6924 for additional advice.
11. Contact: INAC Water Resources Inspector: Phone: (867) 975-4295 to report the spill.
12. Submit to the INAC Water Resources Inspector, a detailed report including the GPS location of the spill, no later than thirty (30) days after initially reporting the event.

7.3. Spills on Snow and Ice

Spills on ice present the potential for immediate access of the contaminants to water therefore, immediate response to the spill is essential. For spills on snow and ice, the following procedure should be followed:

1. Extinguish all sources of ignition (i.e., shut off engines, no smoking).
2. If possible, identify the spilled material.
3. Make sure the area is safe for entry (i.e., ice thickness) and the spill does not represent a threat to the health or safety of the responder or others at the spill site.
4. If the spill is sufficiently large that it cannot be controlled with the materials at hand, the spill should be reported immediately.
5. Assess whether the spill can be readily stopped or brought under control and if safe and possible, stop the source of the spill (i.e. plug hole, close valve, install upright container) or place tarp under spill source and build up tarp edges to contain spill.
6. Stop spilled liquids from spreading or entering waterways using absorbent materials or a snow/soil dyke.
7. Contact facility supervisor and report the spill.
8. If possible with materials at hand, clean up remaining spilled material and store in a secure container (i.e., drum, polyethylene bags). Store impacted snow in drums for disposal.
9. Contact: Emergency Spill Hotline: Phone: (867) 920-8130, Fax (867) 873-6924 for additional advice.
10. Contact: INAC Water Resources Inspector: Phone: (867) 975-4295 to report the spill.
11. Submit to the INAC Water Resources Inspector, a detailed report including the GPS location of the spill, no later than thirty (30) days after initially reporting the event.

7.4. Additional Spill Delineation/Monitoring

As a result of a large spill in which not all of the spilled material can be readily recovered as described above, additional delineation in the form of a subsurface investigation (i.e., test pits, boreholes, and monitoring wells) may be required to determine the lateral and vertical extents of the impacts to the subsurface soil and/or groundwater. The additional delineation/monitoring information will be used to develop an appropriate remediation plan. In such cases, a qualified environmental consultant should be retained to provide advice with respect to how to proceed with the additional assessment.

8.0 Spill Kit and Training Requirements

The following section presents the recommended minimum requirements for the content and number of spill kits that should be present.

8.1. Spill Kit

Each spill kit should be inspected regularly to ensure that it contains, as a minimum, the following:

- 1 – 205 litre, open top steel drum with a lid, bolting ring and gasket;
- 1 Spark proof shovel;
- 1 package of 10 disposable 5 mil polyethylene bags (approx. 65 cm x 100 cm);
- 4 – 12.5 cm (approx. 5") x 3 m (approx. 10') sorbant (oil-absorbing) booms;
- 10 kg bag of sorbant particulate;
- 1 bail of 50 cm x 50 cm (approx.) sorbant sheet (100 Sheets/bail);
- 1 x 5m x 5m approx. plastic tarp;
- 2 pairs of oil resistant gloves; and,
- 2 pairs of splash protective goggles.

8.2. Additional Spill Response Supplies

In addition to the materials contained in the spill kits, an inventory of the following supplies should be available for use if required.

- 10 – 205 litre, open top steel drum with a lid, bolting ring and gasket;
- 2 Spark proof shovels;
- 5 packages of 10 disposable 5 mil polyethylene bags (approx. 65 cm x 100 cm);
- 10 – 12.5 cm x 3 m sorbant (oil-absorbing) booms;
- 5 x 10 kg bags of sorbant particulate;
- 5 bails of 50 cm x 50 cm (approx.) sorbant sheet (100 Sheets/bail);
- 2 pairs of oil resistant gloves; and,
- 2 pairs of splash protective goggles.

8.3. Spill Kit Locations

The spill kit, with the exception of the shovel, can be contained within the 205 L drum which should be sealed securely to protect the contents. The drum should also be accessible without the use of tools (i.e., bolt ring only finger tight). The bolt ring should be inspected regularly to ensure that it turns freely and lubricated if it does not.

8.4. Training

To ensure the effectiveness of the SRP, the following actions should be followed:

1. The SRP should be reviewed, as a minimum, on an annual basis and updated as required by changes in operation and/or technology.
2. The SRP should be distributed to the personnel on the site.
3. The personnel should be informed of the locations of all potentially hazardous materials and their associated Material Safety Data Sheets (MSDS).
4. The personnel should be trained in the use of the MSDS and the techniques and materials used to contain and remediate spilled materials.
5. The personnel should be informed as to the importance of first response with respect to the protection of human health and safety, the environment, property, wildlife and the ecosystem by reducing the impact of spills.

9.0 General Safety Practices and Site Rules

The following is a list of site rules that should be followed to maintain safe working conditions during a spill response:

1. Eating, drinking, chewing gum and smoking are prohibited in contaminated or potentially contaminated areas, or where the possibility for the transfer of contamination exists. This would include areas of active excavation and metal removal.
2. Personnel who have worked on-site shall wash their hands and face thoroughly with soap and water and remove themselves from the spill area prior to eating, drinking or smoking.
3. All field crew workers should be aware of potentially dangerous situations that they should avoid (i.e. the presence of strong, irritating or nauseating odours). Field crew workers should also be familiar with the physical characteristics of the site including:
    - wind direction in relation to areas of known contamination;
    - accessibility to equipment and vehicles;
    - communications; and,
    - site access.

Table 4: Outside Emergency Contacts

Agency	Function	Phone Number
Hamlet of Kimmirut	On-site Supervisor	(867) 939-2247
Kimmirut Health Centre	Medical Emergency	(867) 939-2217
Fire	Fire, Accident or Rescue	(867) 939-4422
RCMP (Kimmirut)	Security, Vandalism	(867) 939 -1111

10. Closure

This Spill Response Plan has been prepared for the Hamlet of Kimmirut's wastewater treatment site. It does not replace, nor is intended to replace, the general provision of the applicable Federal and Territorial statutes regarding workplace safety or any protocols previously established by the Hamlet. Instead, it may be used to augment any existing plans.

Appendix 1 – NT-NU Spill Report Form

NT-NU SPILL REPORT

OIL, GASOLINE, CHEMICALS AND OTHER HAZARDOUS MATERIALS

NT-NU 24-HOUR SPILL REPORT LINE
TEL: (867) 920-8130
FAX: (867) 873-6924
EMAIL: spills@gov.nt.ca

REPORT LINE USE ONLY

A	REPORT DATE: MONTH – DAY – YEAR	REPORT TIME	☐ ORIGINAL SPILL REPORT, OR ☐ UPDATE # _____ TO THE ORIGINAL SPILL REPORT	REPORT NUMBER ____-_____
B	OCCURRENCE DATE: MONTH – DAY – YEAR	OCCURRENCE TIME		

C	LAND USE PERMIT NUMBER (IF APPLICABLE)	WATER LICENCE NUMBER (IF APPLICABLE)
D	GEOGRAPHIC PLACE NAME OR DISTANCE AND DIRECTION FROM NAMED LOCATION	REGION ☐ NWT ☐ NUNAVUT ☐ ADJACENT JURISDICTION OR OCEAN
E	LATITUDE DEGREES MINUTES SECONDS	LONGITUDE DEGREES MINUTES SECONDS

F	RESPONSIBLE PARTY OR VESSEL NAME	RESPONSIBLE PARTY ADDRESS OR OFFICE LOCATION	
G	ANY CONTRACTOR INVOLVED	CONTRACTOR ADDRESS OR OFFICE LOCATION	
H	PRODUCT SPILLED	QUANTITY IN LITRES, KILOGRAMS OR CUBIC METRES	U.N. NUMBER
	SECOND PRODUCT SPILLED (IF APPLICABLE)	QUANTITY IN LITRES, KILOGRAMS OR CUBIC METRES	U.N. NUMBER
I	SPILL SOURCE	SPILL CAUSE	AREA OF CONTAMINATION IN SQUARE METRES
J	FACTORS AFFECTING SPILL OR RECOVERY	DESCRIBE ANY ASSISTANCE REQUIRED	HAZARDS TO PERSONS, PROPERTY OR ENVIRONMENT
K	ADDITIONAL INFORMATION, COMMENTS, ACTIONS PROPOSED OR TAKEN TO CONTAIN, RECOVER OR DISPOSE OF SPILLED PRODUCT AND CONTAMINATED MATERIALS		

L	REPORTED TO SPILL LINE BY	POSITION	EMPLOYER	LOCATION CALLING FROM	TELEPHONE
M	ANY ALTERNATE CONTACT	POSITION	EMPLOYER	ALTERNATE CONTACT LOCATION	ALTERNATE TELEPHONE

REPORT LINE USE ONLY

N	RECEIVED AT SPILL LINE BY	POSITION STATION OPERATOR	EMPLOYER	LOCATION CALLED YELLOWKNIFE, NT	REPORT LINE NUMBER (867) 920-8130

LEAD AGENCY ☐ EC ☐ CCG ☐ GNWT ☐ GN ☐ ILA ☐ INAC ☐ NEB ☐ TC | SIGNIFICANCE ☐ MINOR ☐ MAJOR ☐ UNKNOWN | FILE STATUS ☐ OPEN ☐ CLOSED

AGENCY	CONTACT NAME	CONTACT TIME	REMARKS
LEAD AGENCY			
FIRST SUPPORT AGENCY			
SECOND SUPPORT AGENCY			
THIRD SUPPORT AGENCY			

Appendix D – Wetlands Study

Kimmirut Wetland Planning Study

Prepared for:

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January 08, 2008

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Introduction

This report presents an estimate of wetland water quality improvement performance based on the operations plan of September 28, 2007 (Trow, 2007). The suggested configuration of the Kimmirut system includes retaining wastewater in winter in the existing (modified) lagoon and a second lagoon at the base of the downstream gulch. The area between the lagoons (gulch) will be used to retain the winter wastewater icefield. These new treatment and storage facilities are needed to contain the entire winter discharges from the town. The end of gulch lagoon discharges to an extensive wetland, which will provide further treatment.

The total annual design flow from Kimmirut is expected to be approximately 33,000 m^3. Winter wastewater storage, summer wastewater flows, and runoff will be discharged from the expanded lagoon system over a 107-day warm window of opportunity. The unfrozen period is assumed to span mid-June to late September, or three and a half months, during which the water temperatures are estimated to be 5°C. Flows from the gulch currently flow down a steep incline (>40%) to a large wetland at lower elevation, and it is envisioned that future flows will follow this same path. That wetland currently drains from north to south, away from Lake Fundo, toward Lake Tulsit (Dillon, 2001). The large lower wetland has been identified as muskeg, with dwarf birch, willow shrubs and grasses; but has also been termed a river valley (Dillon, 2001). These descriptions are consistent with the observation that the lower wetland, of more than 15 hectares, is a channelized area of multiple streams embedded in the wetland (**Figure 1**). The wetland slopes gently to the south, at about 0.5%. Because of channelization, it is estimated that only about 20% of the wetland area, or 3 ha, would be in the flow path of the new wastewater lagoon discharges. The assumption is that the lagoon flow will use 20% of the wetland area, and effectively stay separate from the rest of the wetland and the runoff flow going through it. The real situation would probably be somewhere between this assumed segregated flow and completely mixed flow, but here the effects of dilution are not considered.

As an estimate of treatment potential, it is assumed that lagoon treatment will occur in the unfrozen lagoons, and that the combined meltwater and warm weather flows will have BOD and TSS of approximately 230 and 245 mg/L respectively. The discharge season is the three and a half month unfrozen period, during which the water temperatures are estimated to be 5°C, with a range of only from 2 – 8 °C. That period will see flows from the wastewater glacier and lagoons, which are controlled as indicated in Trow (2007), accompanied by melting and seepage phenomena. Stored water is estimated to be gone by the end of the warm season. The warm season flow to the wetlands will average approximately 761 m^3/d, or about eight (8) times the daily rate of generation.

Wetland Forecasting Procedure

Three principal themes have been prevalent in the history of constructed treatment wetland design: consideration of the pollutant and hydraulic loadings, first order removal models, and regression equations. The strategy advocated here is to utilize the existing data sets to maximum advantage, while retaining as much simplicity as possible. The strategy used here attempts to salvage the good features of past work, and to improve upon past methods as much as data can support. The strategy is not simpler than previous methods, because it includes more pieces; that is, it is an integrated rational approach to forecasting. The calculations are implemented via spreadsheets on a desktop computer, because of the level of detail in the procedure.

Figure 1. Location of Wetland

Kimmirut Wetland Planning Study

January, 2008

EarthTech
A tyco International Ltd. Company

RH Kadlec, PhD, PE

The key features of the forecasting procedure are:

Basis:

1. Set inlet concentrations
2. Set inflow and seepage
3. Determine rain, evapotranspiration (ET), temperature
4. Select wetland area

Parameter Selection and Calculation:

5. Select rate constants and seasonality
6. Select detention time distribution (DTD) (hydraulic) efficiency = P value (Select compartmentalization).

Constraint Checks:

7. Set estimated growth cycle
8. Check biogeochemical cycles for consistency
9. Check constraints (hydraulic and chemical)
10. Check loading graph for intersystem comparison.

Water Budget

The annual water budget forms the basis for a first approach to understanding pollutant reductions and the area required. Under the assumption of a constant water level, the flows out of the wetland may be computed from the inflow and the meteorological data. Some infiltration is assumed here, if leakage is present in the wetland. The relevant equations are:

$$Q_{out} = Q_{in} + A \cdot (P - ET - I) \quad (1)$$

or

$$q_{out} = q_{in} + (P - ET - I) \quad (2)$$

where
- A = wetland area, m^2
- ET = evapotranspiration rate, m/d
- I = infiltration rate, m/d
- P = precipitation rate, m/d
- q = hydraulic loading rate, m/d
- Q = flow rate, m^3/d

The inlet hydraulic loading will be increased by rainfall (ca. 1.6 mm/d in the discharge season), and decreased by evapotranspiration (ca 3.0 mm/d). These amounts are important if the wetland is to have a very low hydraulic loading, or correspondingly, a long detention time. The ratio $\alpha = (P-ET)/q_i$ is the atmospheric augmentation.

The pollutant mass balances will be conducted on a cells-in-series basis. Results of the overall water mass balance are apportioned to the cells according the chosen number of tanks in series (PTIS), which is presumed to be three, the average of tracer testing results of a large number of wetlands. For the first unit in the series:

$$Q_1 = Q_{in} + A_1(P - ET - I) \qquad (3)$$

where: A_1 = area of tank number 1, m^2

Q_1 = flow rate out of tank 1, m^3/d

Flows are thus computed sequentially, from inlet to outlet, for the number of tanks chosen (PTIS = 3).

Flow Rates

The flow from the community is expected to be 91 m3/d, for a total of 33,356 m^3/yr. This flow is augmented by 48,106 m^3/yr of precipitation accumulated in the drainage area of the lagoons and gulch. The total water leaving the area of the two lagoons is thus 81,462 m^3/yr, which is discharged over the period of 107 days. Thus the average flow to the wetlands is 761 m^3/d during discharge.

Seepage is expected to be negligible, because of the hard rock base of the region, presumably including the wetland.

Pollutant Mass Balances

Water passes through P tanks in series, and loses contaminant in each. For the case of no water losses or gains, the steady flow contaminant mass balance for the j^{th} tank is:

$$(QC_{j-1} - QC_j) = kA(C_j - C^*) \qquad (4)$$

where Cj = concentration in and leaving tank "j", gm/m^3

C* = background concentration, gm/m^3

k = removal rate constant, m/d

(or with unit conversion, m/yr)

For the entire sequence of tanks, these mass balances combine to:

$$\frac{(C - C^*)}{(C_0 - C^*)} = \left(1 + \frac{k\tau}{Ph}\right)^{-P} \qquad (5)$$

where C_o = concentration entering the wetland, gm/m^3

h = water depth, m

P = number of tanks in series, PTIS

τ = nominal detention time, d

Note that there are two reaction parameters in this model: the rate constant "k" and the hydraulic parameter "P". However, wetlands typically have inputs of rain, and outputs of evaporation and infiltration. Therefore, the flows are not spatially uniform, and a tank to tank calculation must be invoked. Also note that for very large P-values, this model becomes the exponential, plug flow model of Kadlec and Knight (1996).

The tanks in series model is then carried forward via a sequential calculation of pollutant concentrations for each "tank" in the chosen hydraulic model.

A first order areal model with rate constant k is selected, with a wetland background concentration C* as necessary. The pollutant mass balance for the first of the wetland segments, designated by subscript "1", for steady state, non-uniform flow is:

$$Q_1C_1 = Q_{in}C_{in} - I \cdot A_1C_1 - \alpha ETA_1C_1 - k \cdot A_1 \cdot (C_1 - C^*) \qquad (6)$$

In this simple version, rainfall has been assumed to have a zero pollutant concentration, but it is easy to add an atmospheric input of the pollutant if it exists. Infiltration is assumed to occur at the outlet concentration. Transpiration flow of the contaminant has been included. Combining (3) with (6) gives the concentration exiting hypothetical segment number one:

$$C_1 = \frac{Q_{in}C_{in} + k \cdot A_1 \cdot C^*}{Q_1 + (\alpha ET) \cdot A_1 + I \cdot A_1 + k \cdot A_1} \qquad (7)$$

or

$$C_1 = \frac{q_{in}C_{in} + k \cdot C^*}{q_1 + (\alpha ET) + I + k} \qquad (8)$$

Note that the hydraulic loading rates in (8) are the tank loading rates, not the system loadings. This computation is then repeated sequentially for the remaining segments, in each case using the outlet concentrations and flows from the preceding unit. The wetland outlet concentration is that exiting from the final hypothetical segment.

The additional input data requirements for the pollutant mass balances are:

1. Input concentration (C_{in});
2. Background concentration (C*);
3. Transpiration fraction (β);
4. Rate coefficient (k).

Inlet Concentrations

The wastewater from the community has high strength, due to the restricted use of water. However, water reaching the wetlands will have that strength reduced, due to (1) lagoon treatment, (2) cascade oxygenation, and (3) mixing with runoff water. There will be about forty (40%) percent dilution with precipitation water. The inlet concentrations in **Table 1** are estimated to be approximately half of the raw water strength.

Background Concentrations

Wetland systems are dominated by plants (autotrophs), which act as primary producers of biomass. However, wetlands also include communities of microbes (heterotrophs) and higher animals, which act as grazers and reduce plant biomass. Most wetlands support more producers than consumers, resulting in a net surplus of plant biomass. This excess material is typically buried as peat or exported from the wetland. The net export results in an internal release of particulate and dissolved biomass to the water column, which is measured as non-zero levels of BOD, TSS, TN, and TP. These wetland background concentrations are typically denoted by the term C*. Enriched wetland ecosystems (such as those treating wastewater) are likely to produce higher background concentrations. The background concentrations in **Table 1** are estimated from the literature.

Transpiration

The fraction of water loss due to transpiration is assumed to be twenty (20%) percent. This flow draws water into the root zone for enhanced treatment.

Contaminant Removal Rate Coefficients

The rate coefficients used to calculate estimated removals vary from substance to substance. The mechanisms and chosen values are discussed in this section.

Suspended Solids

A major function performed by wetland ecosystems is the removal of suspended sediments from water moving through the wetland. These removals are the end result of a complicated set of internal processes, including the production of transportable solids by the wetland biota.

Low water velocities, coupled with the presence of litter on the wetland bottom, promote fallout and trapping of solid materials. This transfer of suspended solids from the water to the wetland sediment bed has important consequences both for the quality of the water and the properties and function of the wetland ecosystem.

A wetland processes sediments and suspended solids in a number of ways. After the suspended material reaches the wetland, it joins large amounts of internally-generated suspendable materials, and both are transported across the wetland. Sedimentation and trapping, and resuspension, occur en route, as does "generation" of suspended material by activities both above and below the water surface. Chemical reactions may cause the formation of solids that can deposit. Algal and plant debris may form at one location and deposit downgradient in the wetland. Thus it is clear that the TSS leaving a treatment wetland of moderate to long detention is more reflective of generation and resuspension than of unsettled incoming solids.

Table 1. Performance calculation sheet, FWS wetland

Kimmirut
Nunavut
Uniform Discharge

N = 3 RTD Parameter

With P & ET, N TIS

T =	5.0	°C	
I =	0.00	cm/day	
P =	0.16	cm/day	
ET =	0.30	cm/day	
Trans =	0.06	cm/day	0.200 =T/ET
α =	-0.14	Augmentation	

81462 m3
107 d

Design Flow, m3/d Q = 761 m3/d 0.201 mgd

leff = 0.22 m/yr Effective Leakage
ψ = 1.00 Fraction NH4-N Nitrified

		TSS	BOD	TP	Org-N	NH4-N	NOx-N	TN	TKN	FC
Influent Concentration, mg/L	Ci =	245	230	5.00	20.00	40.00	0.00	60.00	60.00	10,000,000
Influent Loadings, kg/ha/day		62.2	58.4	1.3	5.1	10.2	0.0	15.2	15.2	
Permit Effluent Conc., mg/l	Ce =									
Permitted Load to Receiving Water, kg/day										
Max Month/Annual Factor										
Design Target Conc., mg/L	Cd =									
Wetland Background Limit, mg/l	C* =	20.0	20.0	0.002	1.50	0.00	0.00	1.50		50
Areal Rate Constant, 20°C, m/y	k20 =	35	35	2	10	8	27	15		83
Temperature Factor	θ =	1.000	1.000	1.000	1.000	1.050	1.100	1.060		1.000
Areal Rate Constant, m/y	k =	35	35	2	10	4	6	6		83

Porosity = 0.95
Bed Depth = 0.30 m

HRT = 11.6 days
HLR in = 2.54 cm/d
HLR out = 2.39 cm/d

Area = 322,780 ft2
7 acres
3 ha

		TSS	BOD	TP	Org-N	NH4-N	NOx-N	TN	TKN	FC
Calculated Effluent Concentrations , mg/l	Co =	39.2	37.9	3.97	8.7	34.7	10.7	54.1	43.5	156,918
Effluent Loadings, kg/ha/day		9.38	9.07	0.95	2.09	8.32	2.55	12.95	10.40	
Effluent Loadings, kg/day		28	27	3	6	25	8	39	31	

Table 1 Performance calculation: FWS wetland

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Accordingly, the estimated k-value for TSS has been chosen as 35 m/yr, with no effect of water temperature. In any case, the water temperature in the wetlands is expected to range only from 2 – 8°C, with a mean discharge season value of 5°C. This rate coefficient is sufficiently high to drive the wastewater TSS down close to the background value of 20 mg/L.

Biochemical Oxygen Demand

Carbon compounds interact strongly with wetland ecosystems. The carbon cycle in wetlands is vigorous and typically provides carbon exports from the wetland to receiving ecosystems. Many internal wetland processes are fueled by carbon imports and by the carbon formed from decomposition processes.

Treatment wetlands frequently receive large external supplies of carbon in the added wastewater. Any of several measures of carbon content may be made, with Biochemical Oxygen Demand (BOD) being the most frequent in the treatment of municipal wastewater. Degradable carbon compounds are rapidly utilized in wetland carbon processes. At the same time, a variety of wetland decomposition processes produce available carbon. The balance between uptake and production provides the carbon exports. In general, the amounts of carbon cycled in the wetland are comparable to the quantities added in domestic wastewater. The wetland cycle of growth, death, and partial decomposition uses atmospheric carbon, and produces gases, dissolved organics, and solids. Decomposition involves the sugars, starches and low molecular weight celluloses in the dead plant material. Gaseous products include methane and regenerated carbon dioxide. A spectrum of soluble large organic molecules, collectively termed humic substances, are released into the water. The solid residual of plant decomposition is peat or organic sediment, which originated as celluloses and lignins in the plants. These wetland soil organics are broadly classified as fulvic material, humic material, and humin.

The P-k-C* first order model can readily account for observations, for appropriate values of parameters. There are four (4) levels of inlet concentration to be considered: tertiary ($0 < C_i < 30$ mg/L); secondary ($30 < C_i < 100$ mg/L); primary ($100 < C_i < 200$ mg/L); and "super" ($C_i > 200$ mg/L). The Kimmirut situation is expected to be in the fourth group, with high incoming BOD. At high strength, the k-values for BOD are relatively high, with a median value of 189 m/yr for forty-three (43) wetland datasets. Further, temperature effects have been found to be minimal. For purposes of forecasting, k = 35 m/yr has been selected, which is the 20th percentile of the distribution across wetlands (Kadlec and Wallace, 2008). This rate coefficient is sufficiently high to drive the wastewater BOD down close to the background value of 20 mg/L.

Nitrogen

Nitrogen compounds are among the principal constituents of concern in wastewater because of their role in eutrophication, their effect on the oxygen content of receiving waters, and their toxicity to aquatic invertebrate and vertebrate species. These compounds also augment plant growth, which in turn stimulates the biogeochemical cycles of the wetland. The most important inorganic forms of nitrogen in wetlands treating municipal or domestic wastewater are ammonia (NH_4^+) and oxidized nitrogen (NO_2^- and NO_3^-). Nitrogen is also invariably present in wetlands in organic forms. Both dissolved and particulate forms may be present, but in most cases there is little particulate nitrogen in settled wetland surface waters.

Organic Nitrogen

Wastewaters contain varying amounts of organic nitrogen, depending upon the source. Nitrogen in domestic sewage is comprised of about sixty (60%) percent ammonia, and forty (40%) percent organic nitrogen. Lagoon effluents may retain approximately the same proportions while reducing total nitrogen. For Kimmirut, it has been assumed that there are 20 mg/L of organic nitrogen that survive passage through the two lagoons and the two aeration cascades, compared to 40 mg/L of ammonia nitrogen.

Ammonification is the biological transformation of organic nitrogen to ammonia and is the first step in mineralization of organic nitrogen. This process occurs both aerobically and anaerobically, and releases ammonia from dead and decaying cells and tissues. Kinetically, ammonification proceeds more rapidly than nitrification, thus creating the potential for increasing ammonia concentrations along the flow-path of a wetland and requiring design for nitrogen removal to include both ammonification and the slower nitrification process. The ammonification process does not proceed to completion in wetlands, although the removal of ammonia can go to completion for long enough detention. There is an organic nitrogen background concentration which may consist of irreducible residuals, or be due to return fluxes of organic nitrogen from decomposing solids, which is typically 1.5 mg/L.

The median net period-of-record removal rate for 54 FWS systems receiving more than 5 mg/L of organic N is 97 g/m^2•yr. The median k-value for organic nitrogen is 17.3 m/yr, but the range is wide. The 10^{th} to 90^{th} percentile range is 3.6 – 39.9 m/yr. For purposes of forecasting, k = 10 m/yr has been selected, which is the 25^{th} percentile of the distribution across wetlands (Kadlec and Wallace, 2008). There appears to be little or no temperature dependence of organic nitrogen k-values.

Ammonia Nitrogen

Ammonia is an intermediate in the sequential processing of nitrogen in treatment wetlands, which is produced by ammonification of organic nitrogen, and reduced by aerobic and possibly anaerobic ammonia oxidation processes. Because of toxicity of free ammonia in receiving aquatic ecosystems, this nitrogen species is often singled out for regulation. Free ammonia depends upon water temperature as well as total dissolved ammonia.

When the TN loading to the wetland is less than the growth requirements of the plants and algae by a considerable margin, the removal of TN is very likely to be mediated by the growth and decay of biomass. As a rough guideline, this situation occurs for TN loading less than approximately 120 gmN/m^2•yr. In the Kimmirut situation, plant growth requirements are insignificant, and the processing of ammonia is likely to be entirely due to microbial functions.

The median net period-of-record removal rate for one hundred and eighteen (118) systems receiving more than 1 mg/L ammonia N is 127 g/m^2•yr. The value C* = 0.0 mg/L is used, and the remaining model parameter is the k-value. Calibration included ammonification (production) and nitrification (destruction), as well as return of organic nitrogen from the decomposition of biomass. The median annual rate constant was k= 14.7 m/yr. The 10^{th} to 90^{th} percentile range is 4.7 – 85.6 m/yr. For purposes of forecasting, k_{20} = 8 m/yr has been selected, which is the 25^{th} percentile of the distribution across wetlands (Kadlec and Wallace, 2008). There is a significant temperature dependence of ammonia k-values, with a theta value of 1.05. Therefore, at the mean water temperature of 5°C, the rate coefficient for ammonia is, k = 4 m/yr.

Oxidized Nitrogen

Nitrate is potentially tied quite closely to the process of nitrification in wetlands that receive both ammonia and oxidized nitrogen, because incoming nitrate loads may be supplemented by produced nitrate. For wetlands which receive and reduce large amounts of organic and ammonia nitrogen, the inferred denitrification is much different from the net loss or gain of nitrate from inflow to outflow. Nitrate is entirely consumable in treatment wetlands. The value for C* is zero, because no investigation has shown a lower limit to the reduction of nitrate.

Seventy-two (72) nitrate-dominated wetlands were calibrated for k. The median annual rate constant was k_{NN} = 26.5 m/yr, while the average was k_{NN} = 30.0 m/yr. The 10th to 90th percentile range is 9.6 – 54.4 m/yr (Kadlec and Wallace, 2008). For purposes of forecasting, k_{20} = 27 m/yr has been selected, which is the 50th percentile of the distribution across wetlands (Kadlec and Wallace, 2008). There is a significant temperature dependence of nitrate k-values; thus even on an average annual basis, temperature or season may be an important determinant of the rate constant, and these factors are thus responsible for the some of the intersystem variability in annual k-values. The median theta value for twenty (20) wetlands was 1.10 (Kadlec and Wallace, 2008). Therefore, at the mean water temperature of 5°C, the rate coefficient for nitrate is k = 6 m/yr.

Phosphorus

Treatment wetlands are capable of phosphorus (P) removal from wastewaters, on both short-term and long-term bases. Phosphorus is a nutrient required for plant growth, and is frequently a limiting factor for vegetative productivity. P-cycling in wetlands may be visualized as consisting of several compartments: water, plants, microbiota, litter, and soil. There are three principal categories of P removal processes in wetlands: sorption, utilization to build a bigger biomass compartment, and storage as newly created, refractory residuals (burial). The first two are transitory processes, and the corresponding capacities are used up. The third, accretion of new materials with structural phosphorus, is sustainable. There is a misconception that wetlands provide phosphorus removal only through sorption processes on existing soils. It is true that most soils do have sorptive capacity for phosphorus, but this storage is soon saturated under any increase in phosphorus loading. There are two direct effects of vegetation on phosphorus processing and removal in treatment wetlands:

1. The plant growth cycle seasonally stores and releases P, thus providing a "flywheel" effect for a P removal time series.
2. The creation of new, stable residuals which accrete in the wetland. These residuals contain phosphorus as part of their structure, and hence accretion represents a burial process for P.

Despite the apparent complexity of the several removal mechanisms, data analysis shows that relatively simple equations can describe the sustainable processes. Profiles of phosphorus concentration within wetlands typically show a decreasing trend that approaches the background concentration asymptote if the wetland is large enough. Global first order removal rates characterize such removal profiles, but do not incorporate any biotic features. Results across systems are given here, for measured P-values, or for the mean of those (P = 3.4) when not measured. The value C* = 0.002 mg/L is used, and the remaining model parameter is the k-value, selected to fit the model. Across 282 wetlands, the median annual rate constant was k = 10.0 m/yr. The 10th to 90th percentile range is 1.4 – 60 m/yr. (Kadlec and Wallace, 2008). For purposes of forecasting, k_{20} = 2 m/yr has been selected, which is the 15th percentile of the distribution across wetlands (Kadlec and Wallace, 2008). This low value is selected because of the perceived low amount of biological activity in the Kimmirut wetland. There appears to be little or no temperature dependence of phosphorus k-values.

Pathogens

Pathogens are present in untreated domestic wastewaters. Wetlands have been found to reduce pathogen populations with varying but significant degrees of effectiveness. Bacteria, protozoa, helminths and viruses typically do not survive longer than about thirty (30) days in freshwater environments, and about fifty (50) days in soil environments. Similar survivals might therefore be predicted for wetlands, but there are many site specific factors and processes which may materially increase or decrease survival. Ultraviolet radiation is a potent agent for killing bacteria. Most bacteria are food for nematodes, rotifers and protozoa. Among these, rotifers and flagellated and ciliated protozoa have been implicated as important contributors to the reduction of bacteria in treatment wetlands. A measurable proportion of wastewater microorganisms are found either associated with particulates, or as aggregates of many organisms, and are removed by particulate settling and trapping.

First-order models have been used to describe reduction of indicator bacterial populations in lagoons and wetlands. Data from twenty-eight (28) FWS systems, totaling forty-seven (47) wetland-years, was used to estimate fecal coliform k-values for a presumed C* = 40/100ml. These systems were selected for having at least 1,000/ 100ml inlet FC, thus eliminating systems with low incoming FC, whether due to pretreatment disinfection or other factors. Because the critically-important PTIS values were not known, PTIS = 3 (a modest degree of departure from both plug flow and complete mixing), was used. The resulting annual median k-values was 83 m/yr. There are not pronounced seasonal effects or temperature effects for fecal coliform removal in the FWS treatment wetland datasets that are currently available. Until more wetland data becomes available, it is recommended that global wetland fecal coliform reduction be regarded as independent of temperature and season.

Summary of Estimated Wetland Water Quality Improvement

The presumed 3 hectares of lower wetland in the flow path of the effluent, if at a mean depth of 30 cm, would provide about two weeks detention in the wetland. Removal rate coefficients have been assumed to be at the low end of the probability distribution for nutrients, BOD and TSS; and these have been further reduced according to estimates of temperature effects caused by the 5°C water. **Table 1** shows the expected removals, and their relation to the data from other systems, and the implications for nutrient cycling. The forecast for water quality at the downstream end of the lower wetland are shown in **Table 2**.

Table 2 Summary of Estimated Wetland Water Quality

		From Lagoons	Wetland Outlet
TSS	mg/L	245	39
BOD	mg/L	230	38
TP	mg/L	5	4
Org-N	mg/L	20	9
NH_4-N	mg/L	40	35
NOx-N	mg/L	0	11
TN	mg/L	60	54
TKN	mg/L	60	44
FC	#/100ml	10,000,000	157,000

Wetland Cycles

Carbon, phosphorus and nitrogen are all cycled by the wetland ecosystem. It is prudent to examine whether the assigned rates lead to a reasonable set of ecosystem uptakes, releases and burials. These rely upon estimates of the amounts of biomass and nutrient contents, and so are not precise. The analyses are based upon estimates of what the ecosystem will be like. Such estimates cannot be precise, and consequently the analysis is "order-of-magnitude" only. The intent is to gain some insight into the relative importance of wetland processes that will likely be operating if the project is built.

Carbon Cycling

The growth, death and decomposition processes are referred to as part of the wetland carbon cycle, but more than carbon is involved. However, most vegetation and other wetland organisms are about forty (40%) percent carbon, so either dry biomass or carbon serves to track the amount of material involved. Carbon itself is withdrawn from atmospheric sources, as carbon dioxide for photosynthesis. Likewise, carbon is returned to the atmosphere as methane from anaerobic mechanisms, or carbon dioxide from oxidative processes (respiration included). The important estimation quantities are:

- Annual growth rate, g/m2•yr (standing crop phytomass = necromass + biomass times turnovers per year);

- Annual burial fraction (undecomposable residual fraction).

The assumption is made that nutrients taken up, but not buried as accretion, are returned to the water column of the wetland. For nitrogen, this is a maximum estimate, because microbial processes in above-water tissues can transfer nitrogen to the atmosphere without entering the water. These phytomass quantities, together with phytomass nutrient content (% or mg/kg) allow checks on the empirical removal calculations. The wetland carbon cycle is also critical to observed performance, as it relates to sediment oxygen demand and to the carbon supply for denitrification. The implied supply constraints of this carbon cycle are examined in the constraint check section.

The estimates for Kimmirut are given in **Figure 2**. The maximum standing stock of vegetation is assumed to be 500 g/m^2 for each of above and below ground plant parts. Additionally, there is presumed to be 200 g/m^2 of micro-scale biota, including bacteria, algae, and similar. The turnover of the above ground material is in the growing period of about three months, but roots are assumed to turn over more slowly, over a period of two years. Nutrient contents are assigned in accordance with a large body of observations, from warmer climates. About twenty-five (25%) percent of the biomass is assumed to be undecomposed. This carbon cycle is much smaller than would be observed in a warmer climate for similar water conditions, by about a factor of four or five.

Phosphorus Cycling

For phosphorus, the calculated removal is represented as a large uptake, in major part balanced by the return of soluble P from tissue decomposition. For a stable ecosystem past startup, the net P removal associated with the k-rate calculation is assigned to accretion. Sorption and building of additional biomass no longer are sinks for phosphorus.

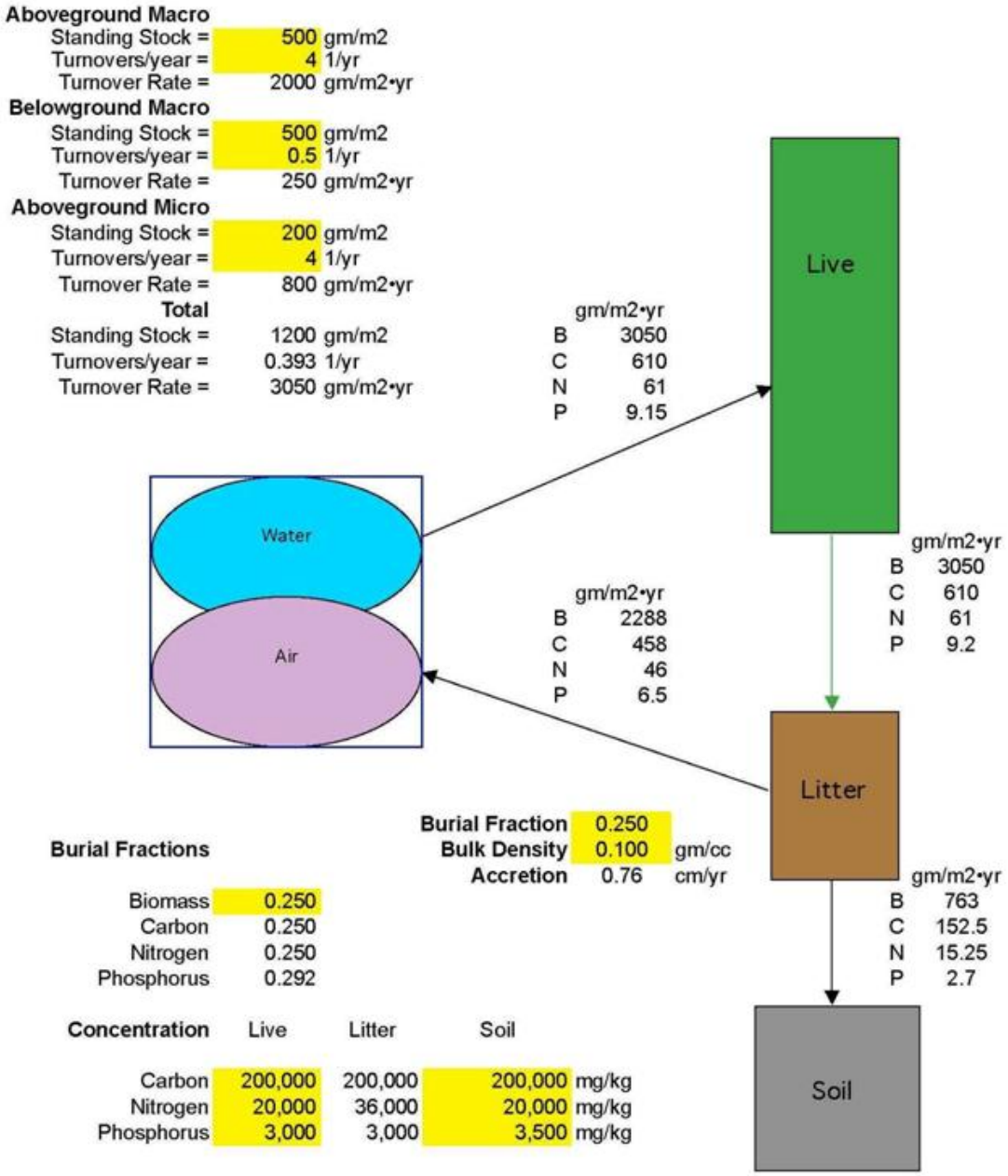

Figure 2. Carbon Processing in Wetland

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Figure 3 shows the estimate of the phosphorus cycle in the wetland. Because the nutrient concentrations are high (5 mg/L P and 60 mg/L TN), it is anticipated that the nutrient rich condition will prevail. The biogeochemical cycle removes 33 gP/m^2•yr from the water column, a large fraction of the loading to the wetland of 46 gP/m^2•yr. The k-rate calculations indicate that 10 gP/m^2•yr are removed, and hence it is deduced that (33 – 10) = 23 gP/m^2•yr are returned to the water from decomposition and leaching of the biomass. The removal to accretion is thus 10/33 = thirty (30%) percent of the biomass uptake. These uptakes and returns involve above ground plant parts, below ground plant parts and microbes and algae.

Nitrogen Cycling

For nitrogen, a more complex situation occurs as a result of the multiple speciation of water column nitrogen. The water column contains organic, ammonium and nitrate nitrogen. Their interconversions are computed from the empirical k-rates. The biogeochemical cycle is linked in a manner analogous to phosphorus, but with abstraction from both the ammonium and nitrate pools in the water, and return from both the ammonium and organic pools in the water. This allocation recognizes a split of plant uptake between ammonium and nitrate, and the fact that decomposition processes produce organic nitrogen. The nitrogen content in accreting sediments is known from extensive data from treatment wetlands to range from ca. 1.0 to 2.5% dry weight. A higher value would be associated with nutrient-rich systems. Again, because the k-rate calculations are independent of the cycle calculation, there is one degree of freedom, which for nitrogen is taken to be an assumed percentage of the cycled nitrogen that is buried in accreting sediments. A nitrogen deficit may be assumed to be supplied by fixation, a process known to occur in N-deficient wetland environments.

As indicated in **Figure 4**, the incoming nitrogen is presumed to be mostly organic (20 mg/L) and ammonia (40 mg/L), comprising all of the 60 mg/L of TN. The nitrogen loading to the wetland is over 555 gN/m^2•yr, which is a high loading that places the system in the category of a microbial system. It is therefore expected that the biogeochemical cycling of nitrogen will not play an important role in the overall reduction. For this proposed performance example, the cycling of biomass nitrogen is small. The required nitrogen to build the annually cycled biomass is 61 gN/m^2•yr, which is eleven (11%) percent of the nitrogen loading (**Figure 4**).

The ultimate fate of removed nitrogen in the forecast is apportioned to accretion [fifteen (15%) percent] and denitrification [eighty-five (85%) percent].

Supply Constraints

Traditional chemistry assumptions indicate a requirement for carbon to support heterotrophic denitrification, and an oxygen requirement to support nitrification. The oxygen requirements for the predicted performance are calculated. Removal of BOD (4.9 gO/m^2•d) and nitrification (2.25 gO/m^2•d) appear to exert a fairly high demand, which must be supplied by the cascade into the wetland and by atmospheric reaeration. The predicted denitrification requires an estimated 90 gC/m^2•yr, which is easily supplied by the 667 gC/m^2•yr of the BOD removed. The vegetation will produce an equivalent amount of carbon via decomposition, and thus the carbon supply is more than adequate to fuel denitrification.

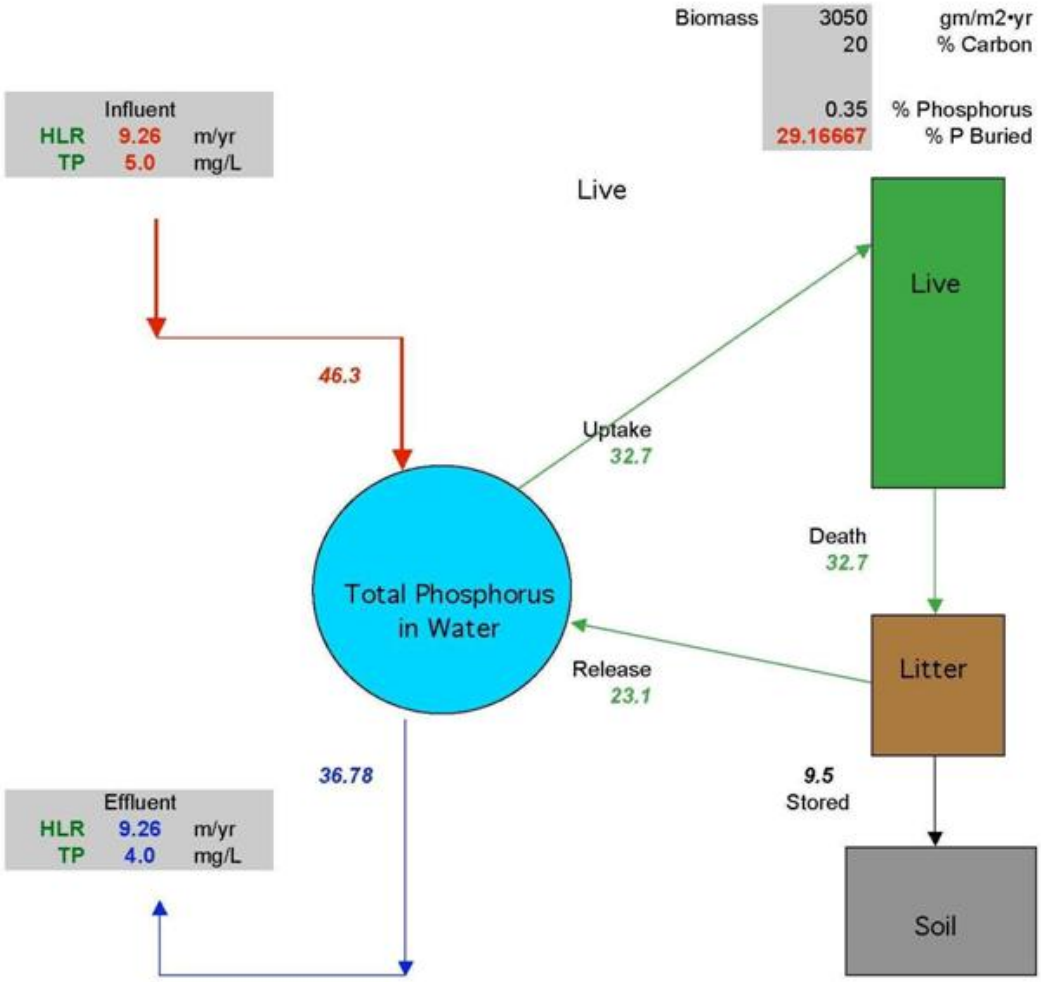

Figure 3. Phosphorous Processing in Wetland

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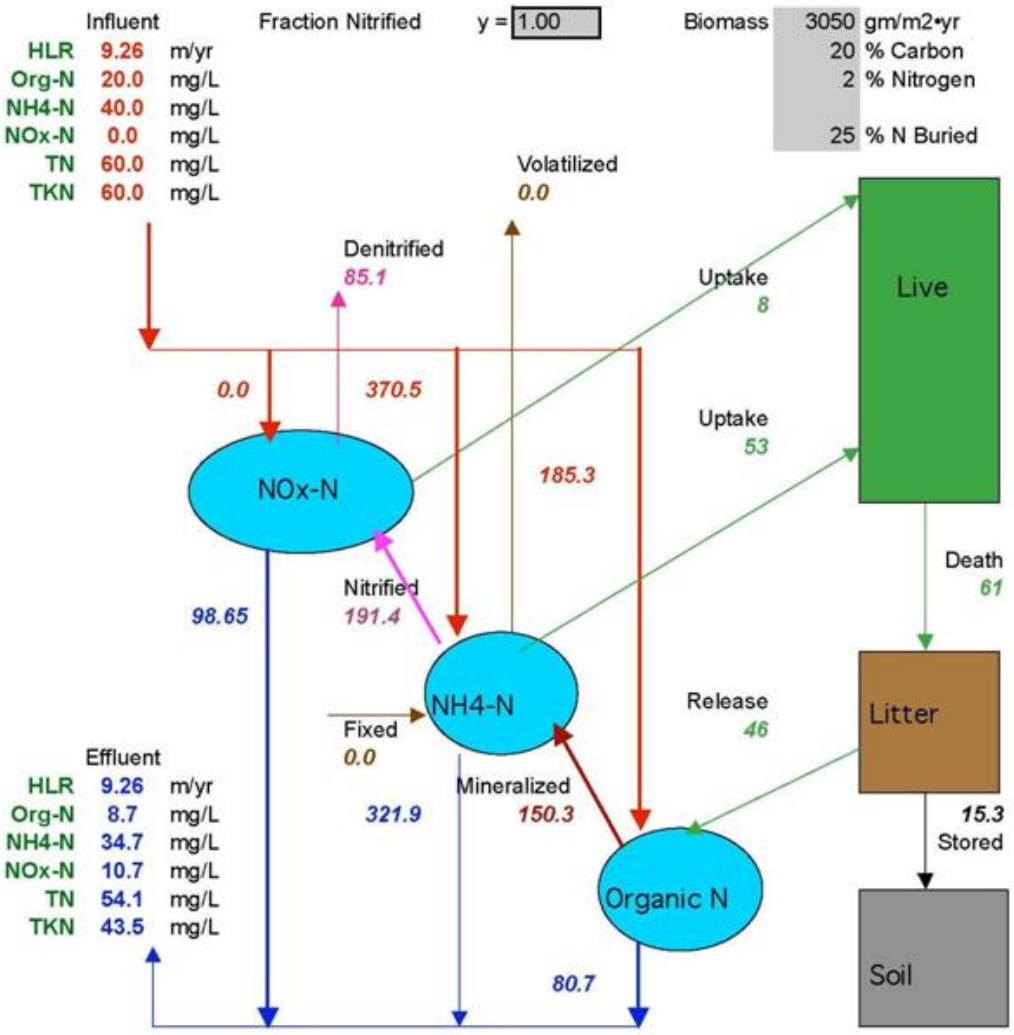

Figure 4. Nitrogen Processing in Wetland

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Inter-System Comparisons

Loading graphs allow inter-system comparisons for common constituents. These are a plot of the wetland outlet concentration (mg/L) versus the constituent loading to the wetland (kg/ha•d or g/m2•d). **Figures 5 – 8** show the position of the Kimmirut forecast with respect to the performance of a large number of operating treatment wetlands.

BOD and TSS

The removal of these contaminants relies upon particulate settling and microbial activity by the general class of heterotrophic bacteria, as well as algal activity. Settling and trapping are known to be effective during all seasons and water temperatures. Bacteria are known to be effective in cold climates, and therefore there is no perceived penalty for the far northern site. The removal rate constants have been selected to produce average removals, and therefore the predicted performance is close to the central tendency of behavior of the comparison systems (**Figures 5** and **6**).

Nitrogen and Phosphorus

The reduction of nitrogen in the wetland relies upon autotrophic nitrification to form oxidized nitrogen, and then upon heterotrophic denitrification. The nitrifying microbes are known to exhibit a rather slow build-up of populations, and are very sensitive to cold temperatures. Denitrifiers are usually present in larger numbers, and do not have a long period for growth, but they are also very temperature sensitive. Therefore, relatively low rate coefficients have been selected for nitrogen processing. The result is that the Kimmirut wetland shows lower TN removals than the comparison database, which reflects more southerly, warmer conditions (**Figure 7**).

Phosphorus removal does not involve microbes as heavily as nitrogen reduction, and a good share of the removal is due to the burial of a small fraction of the plant uptake. Therefore, P removal is tuned to the size of the growth cycle, which is anticipated to be rather small for this far northern site. Accordingly, a low removal rate coefficient has been used in forecasting, which results in a performance prediction well above the majority of comparison system data (**Figure 8**).

Discussion

The foregoing analysis has been based on a set of conservative assumptions. It is virtually certain that the lagoon discharges will not spread over the entire 15 ha wetland, and it has been assumed that only twenty (20%) percent of the wetland (3 ha) will experience wastewater flows. It is also certain that considerable water flows already exist in the wetland, which might cause dilution, depending upon a complicated set of factors concerning the internal hydraulics of the wetland. However, this analysis assumes no dilution, with separate flow paths for existing waters and for wastewater.

The water reaching the wetland will have been subjected to detention in the upper and lower lagoons, which will provide some degree of water quality improvement. Additionally, water cascades from lagoon 1 to lagoon 2, and cascades again from lagoon 2 down into the wetland. Each cascade involves a fall of many meters, and will provide oxygenation of the water, and thus promote treatment. There will be some dilution in the lagoons, from regional rainfall, snowmelt and runoff, which will lessen the wastewater strength and increase the volume to be treated. Accordingly, the water quality entering the wetland has been estimated to be about half-strength, compared to the raw wastewater from the community.

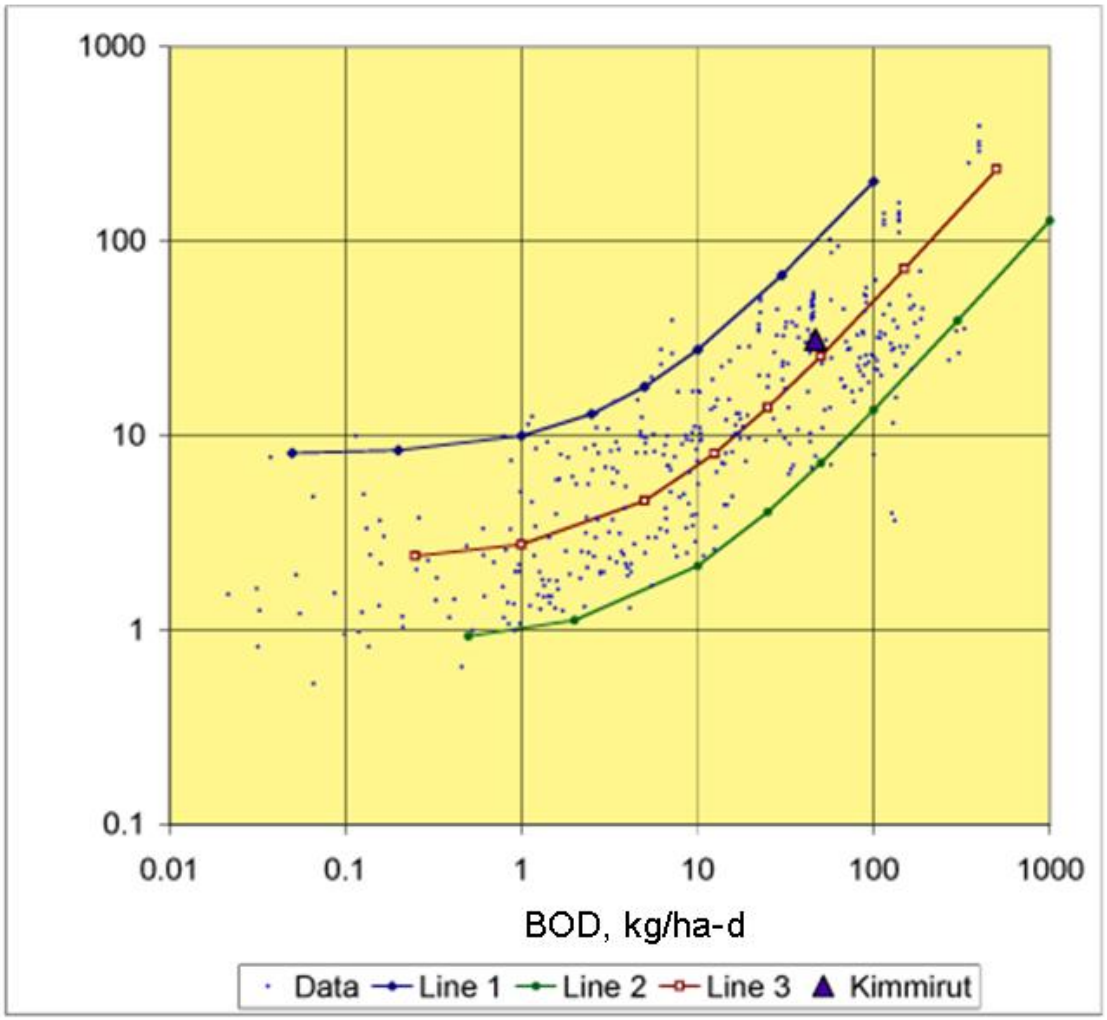

Figure 5. Loading chart for BOD in treatment wetlands. Each of the 383 points represents an annual average for one of 136 wetlands. The lines represent upper and lower bounds, and the central tendency. The Kimmirut forecast is close to the central tendency.

Figure 5. Loading Chart for BOD in Treatment Wetlands

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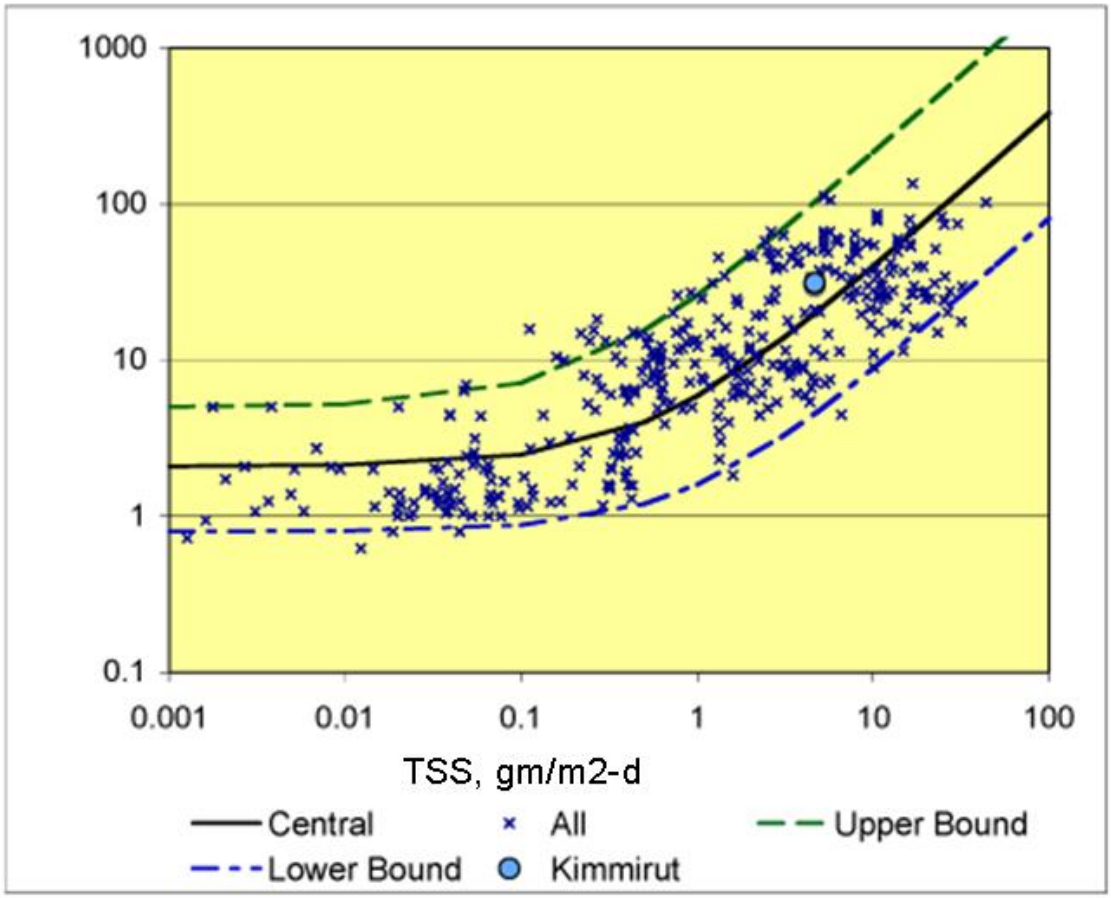

Figure 6. Loading chart for TSS in treatment wetlands. Each of the 449 points represents an annual average for one of 136 wetlands. The lines represent upper and lower bounds, and the central tendency. The Kimmirut forecast is close to the central tendency.

Figure 6. Loading Chart for TSS in Treatment Wetlands

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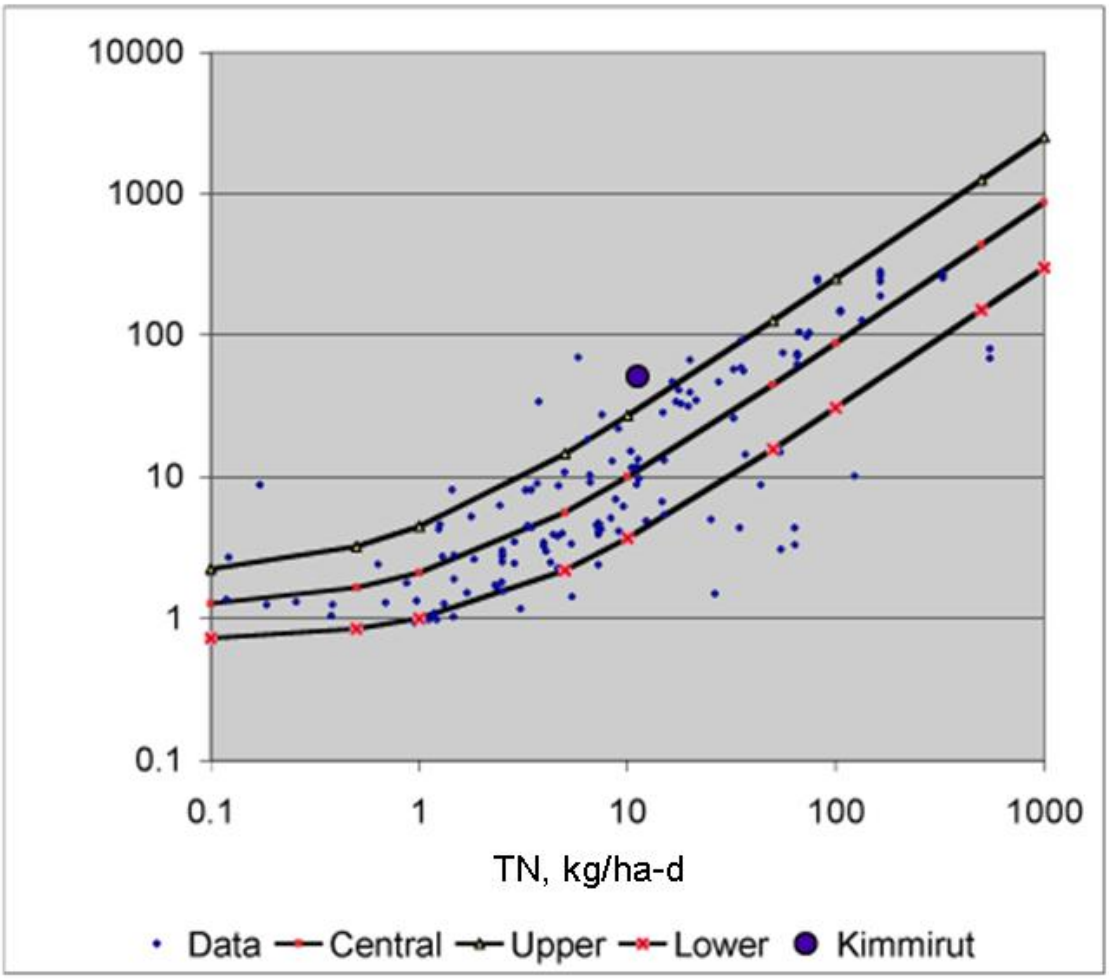

Figure 7. Loading chart for TN in treatment wetlands. Each of the 147 points represents a period of record average. The lines represent upper and lower bounds, and the central tendency. The Kimmirut forecast is well above to the central tendency.

Figure 7. Loading Chart for TN in Treatment Wetlands

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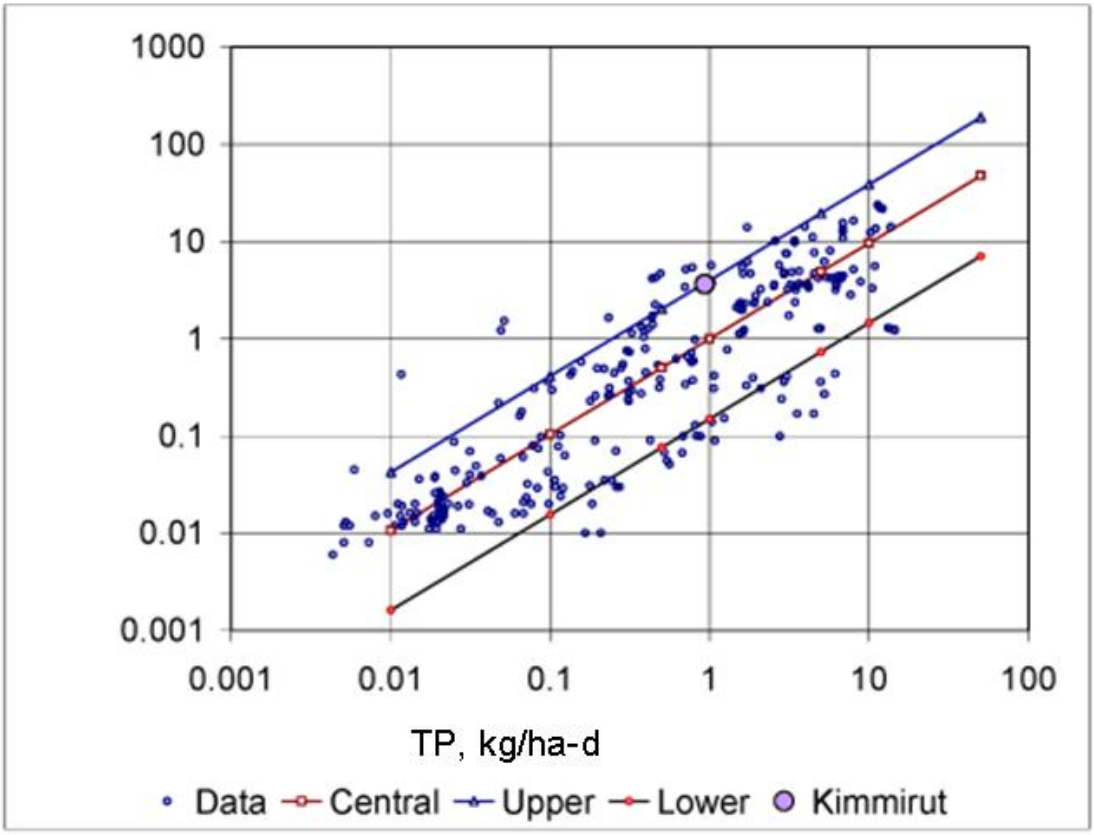

Figure 8. Loading chart for TP in treatment wetlands. Each of the 283 points represents a period of record average. The lines represent upper and lower bounds, and the central tendency. The Kimmirut forecast is above to the central tendency.

Figure 8. Loading Chart for TP in Treatment Wetlands

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Water quality improvement in the wetland has been calculated based upon a large amount of information from more southerly climates. However, the rates of biological processes have been assumed to be at the very low end of other experiences, including plant growth and nitrifier activity. Temperature coefficients have been used to reduce the rates of these processes, as indicated by the anticipated 5°C water temperature. The result of these assumptions is that BOD and TSS removal are likely to be comparable to wetlands in other climatic regions, but nutrient removal will be less. Some disinfection, or removal of pathogenic organisms is anticipated. There will be ample sunlight to promote UV disinfection in the wetland, as well as die-off due to cold temperatures. A two-log reduction [ninety-nine (99%) percent] is expected.

In short, the wetland will complement the two proposed lagoons and cascades, and provide good water quality improvement.

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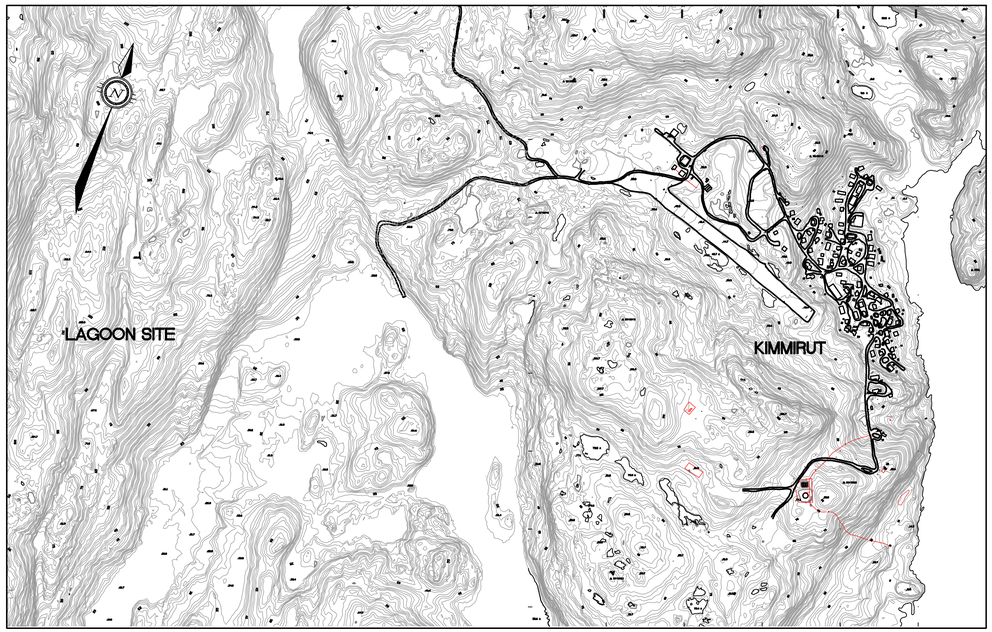
Appendix E – Record Drawings

GOVERNMENT OF NUNAVUT



INDEX OF INCLUDED DRAWINGS

DRAWING NO.	REVISION	DESCRIPTION
		COVER
OTCD00018881A–SP1	REV 3	LAGOONS AND WETLANDS SITE PLAN
OTCD00018881A–SP2	REV 3	UPPER LAGOON SITE PLAN
OTCD00018881A–SP3	REV 3	LOWER LAGOON SITE PLAN
OTCD00018881A–TD1	REV 3	UPPER LAGOON TRUCK DISCHARGE PLAN
OTCD00018881A–TA1	REV 3	LOWER LAGOON TRUCK ACCESS PLAN
OTCD00018881A–DE1	REV 3	DETAILS
OTCD00018881A–DE2	REV 3	DETAILS

HAMLET OF KIMMIRUT
WASTEWATER LAGOONS

Trow Associates Inc.
154 COLONNADE ROAD SOUTH
OTTAWA, ONTARIO K2E 7J5
PHONE (613) 225–9940
FAX (613) 225–7337

RECORD DRAWING

DATE: _____

PROJECT NO: OTCD18881A

UPPER LAGOON
DRAINAGE AREA 2.16ha

UPPER LAGOON
EXT. CAPACITY
7,900 cu. m.

SITE BENCHMARK
RE-BAR ELE.=102.72m

UPPER LAGOON
BERM

EXISTING GULCH

IMPROVED ACCESS ROAD

LOWER LAGOON
EXT. CAPACITY
21,600 cu.m.

LOWER LAGOON
DRAINAGE AREA 9.51ha

LOWER LAGOON
BERM

SIGN

SIGN

SIGN

SIGN

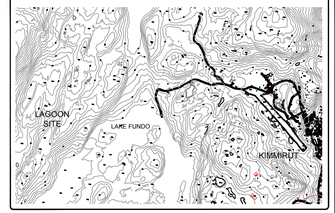
SIGN

LAKE FUNDO
ELEV +/- 33m

ELEV +/- 22m

WETLANDS
+/- 20 ha

KEY PLAN



LEGEND

PROPOSED LAGOON

SIGN
PROPOSED SIGN

PERMIT OF PRACTICE
TROW ASSOCIATES INC.

Signature _____

Date _____

PERMIT NUMBER: P184
The Association of Professional Engineers
Geologists and Geophysicists of the NWT/NU

BENCH MARK

BM 1 ELEV. = 102.72m

RE-BAR PLANTED EAST OF THE ACCESS ROAD ACROSS FROM THE EXISTING TRUCK DISCHARGE POINT AND 2.9m FROM THE FACE OF THE CHAIN LINK FENCE.

No.	DESCRIPTION	DATE	BY	APP'D
3	AS-CONSTRUCTED	18/11/11	MEB	SLB
2	ISSUED FOR TENDER	06/04/09	MMR	SLB
1	ISSUED FOR APPROVAL	17/01/08	MEB	SLB

R E V I S I O N S

HORIZONTAL 1:2500

S.L. BURDEN
LICENSEE
N.W.T.

Trow Associates Inc.
154 Colonnade Road South
Ottawa, Ont. K2E 7J5
Tel:(613)225-9940
Fax:(613)225-7337

CLIENT
GOVERNMENT OF NUNAVUT

PROJECT
KIMMIRUT WASTEWATER LAGOON

TITLE
LAGOONS AND WETLANDS
SITE PLAN

design by	SAD	project no.	OTCD000188814
drawn by	MEB	drawing no.	SP-1
checked by	SLB		
date	4/01/2008		
scale	HORIZ 1:2500		

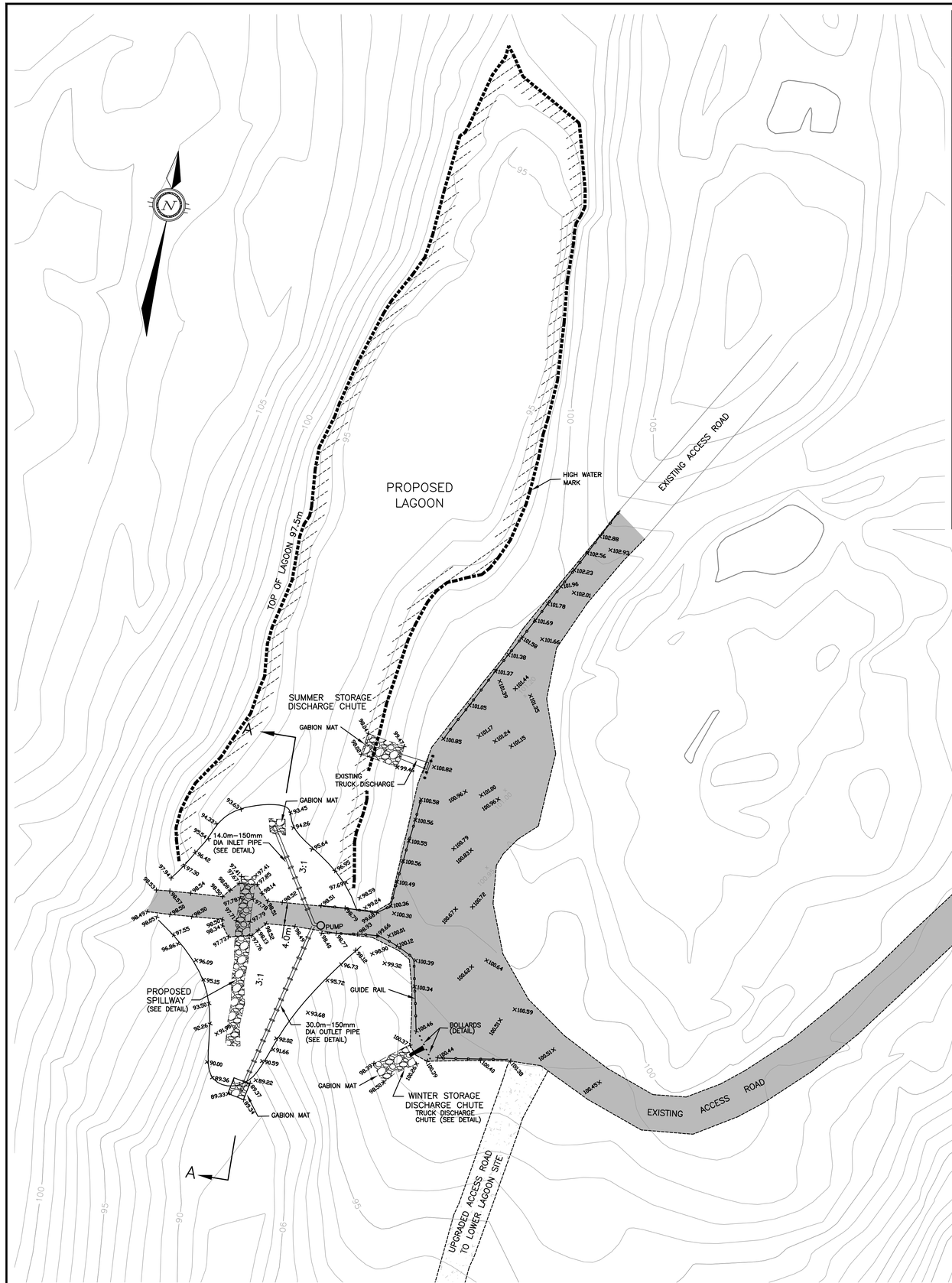
0.56m

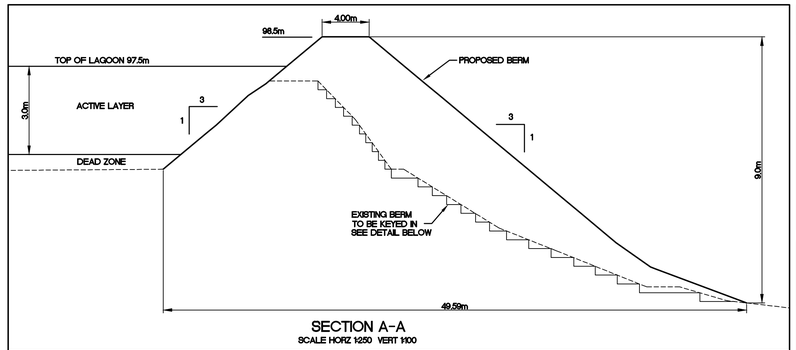
INUKTITUK TRANSLATION

SEWAGE TREATMENT
FACILITY
NO GATHERING
OR
HARVESTING

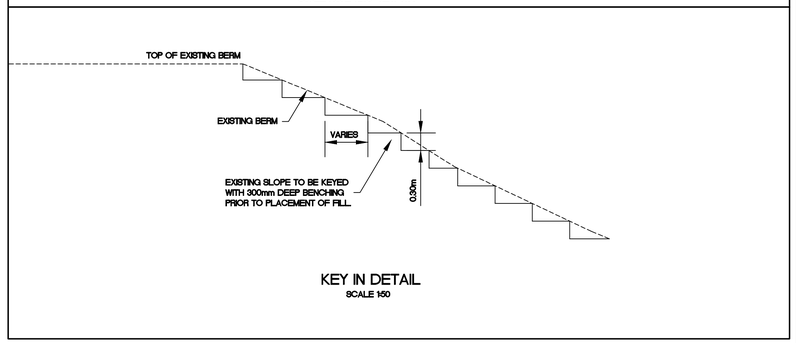
0.63m

SIGN DETAIL
SCALE 1:10



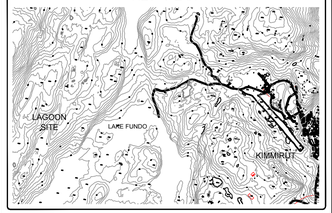


SECTION A-A
SCALE HORZ 1:250 VERT 1:100



KEY IN DETAIL
SCALE 1:50

KEY PLAN



LEGEND

PERMIT OF PRACTICE
TROW ASSOCIATES INC.
Signature _____
Date _____
PERMIT NUMBER: P184
The Association of Professional Engineers Geologists and Geophysicists of the NWT/NU

BENCH MARK

BM 1 ELEV. = 102.72m

RE–BAR PLANTED EAST OF THE ACCESS ROAD ACROSS FROM THE EXISTING TRUCK DISCHARGE POINT AND 2.9m FROM THE FACE OF THE CHAIN LINK FENCE.

No.	DESCRIPTION	DATE	BY	APP'D
3	AS–CONSTRUCTED	18/11/11	MEB	SLB
2	ISSUED FOR TENDER	06/04/09	MMR	SLB
1	ISSUED FOR APPROVAL	17/01/08	MEB	SLB

R E V I S I O N S

REGISTERED PROFESSIONAL ENGINEER S.L. BURDEN LICENSEE N.W.T.

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154 Colonnade Road South
Ottawa, Ont. K2E 7J5
Tel:(613)225–9940
Fax:(613)225–7337

CLIENT
GOVERNMENT OF NUNAVUT

PROJECT
KIMMIRUT WASTEWATER LAGOON

TITLE
UPPER LAGOON SITE PLAN

design by	SAD	project no.	OTCD00018881A
drawn by	MEB	drawing no.	SP–2
checked by	SLB		
date	4/01/2008		
scale	HORIZ 1:400		

PROPOSED
LOWER LAGOON

TOP OF LAGOON 71.0m

UPGRADED ACCESS ROAD

GABION MAT

15.5m–150mm DIA INLET PIPE (SEE DETAIL)

GUIDE RAIL

PUMP

14.0m–150mm DIA OUTLET PIPE (SEE DETAIL)

GABION MAT

TOE OF SLOPE

3:1

TOP OF LAGOON 71.5m

TOP OF BERM

4.0m

TOE OF SLOPE

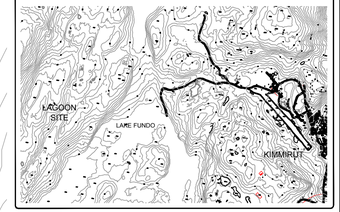
3:1

SPILLWAY (SEE DETAIL)

B

B

KEY PLAN



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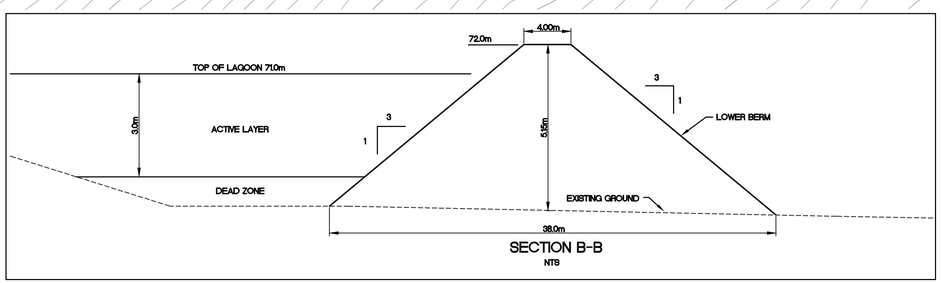
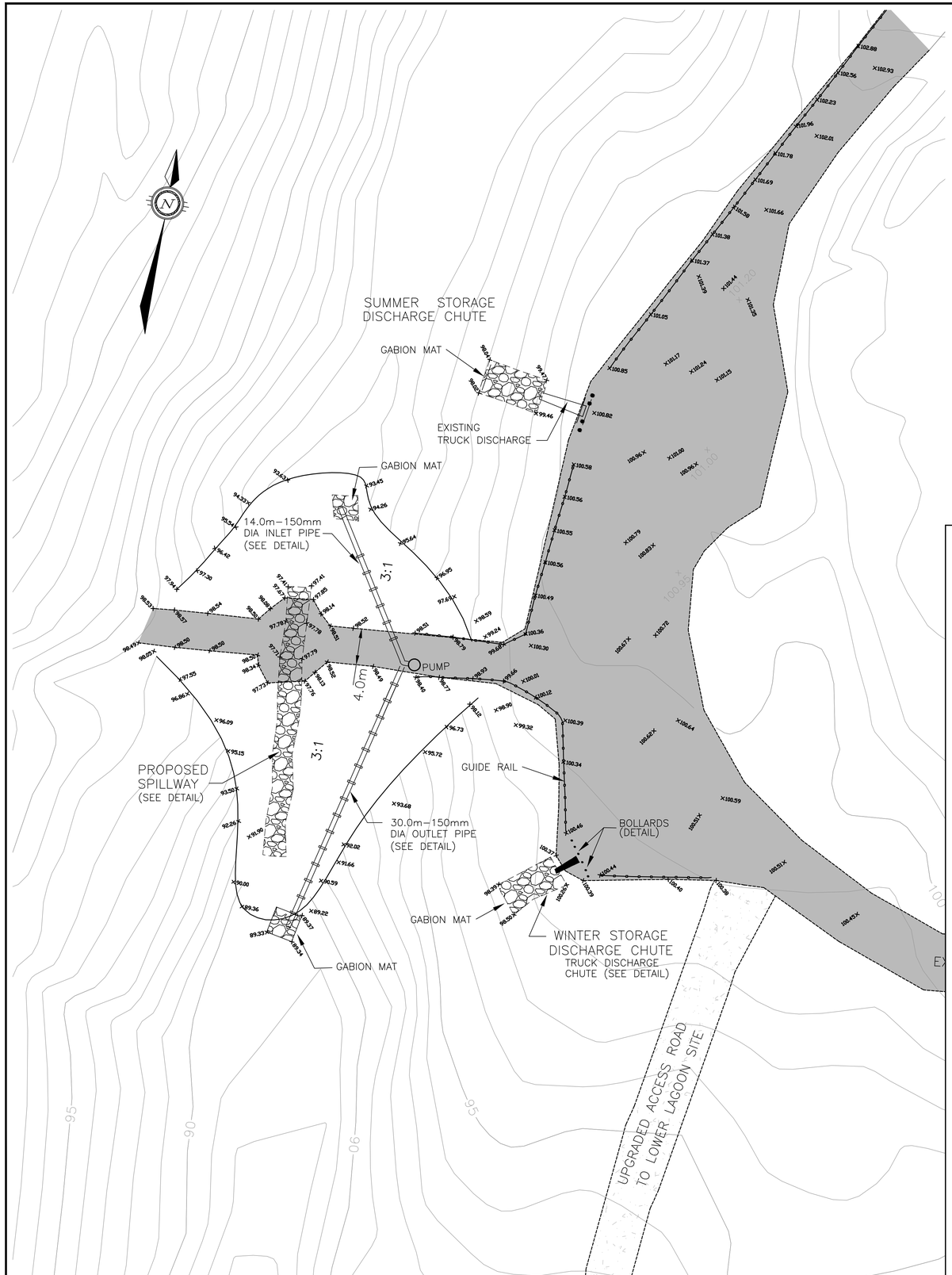
KIMMIRUT WASTEWATER LAGOON

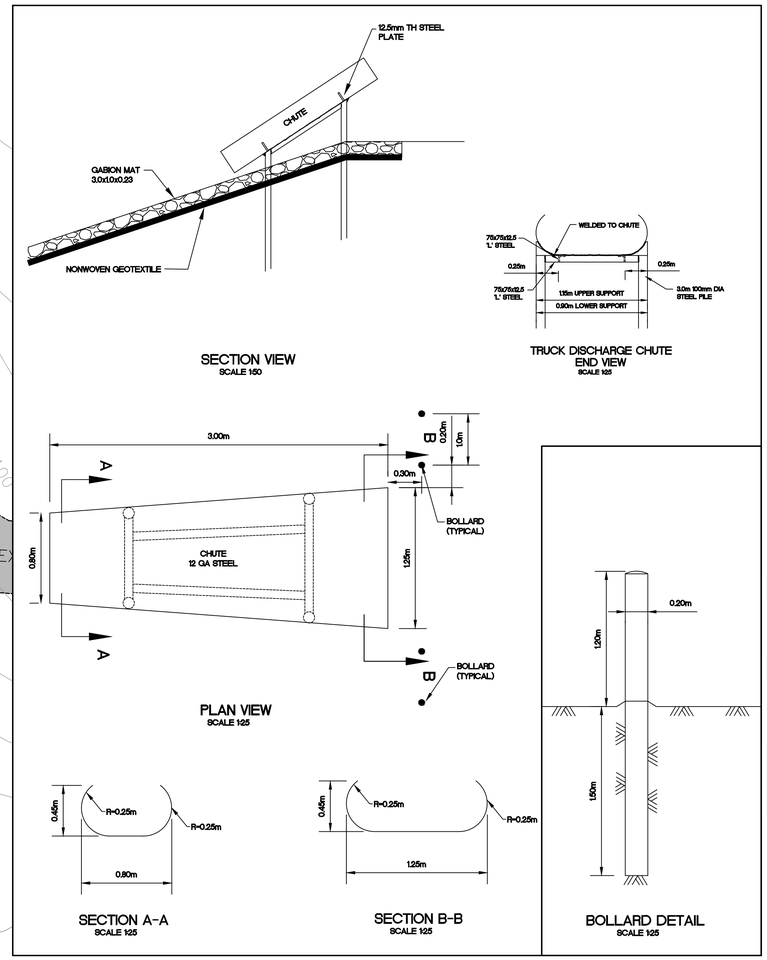
TITLE
LOWER LAGOON
SITE PLAN

design by	SAD	project no.	OTCD00018881A
drawn by	MEB	drawing no.	SP–3
checked by	SLB		
date	4/01/2008		
scale	HORIZ 1:400		



SECTION B–B
NTS





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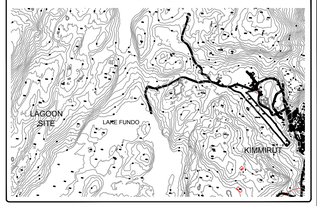

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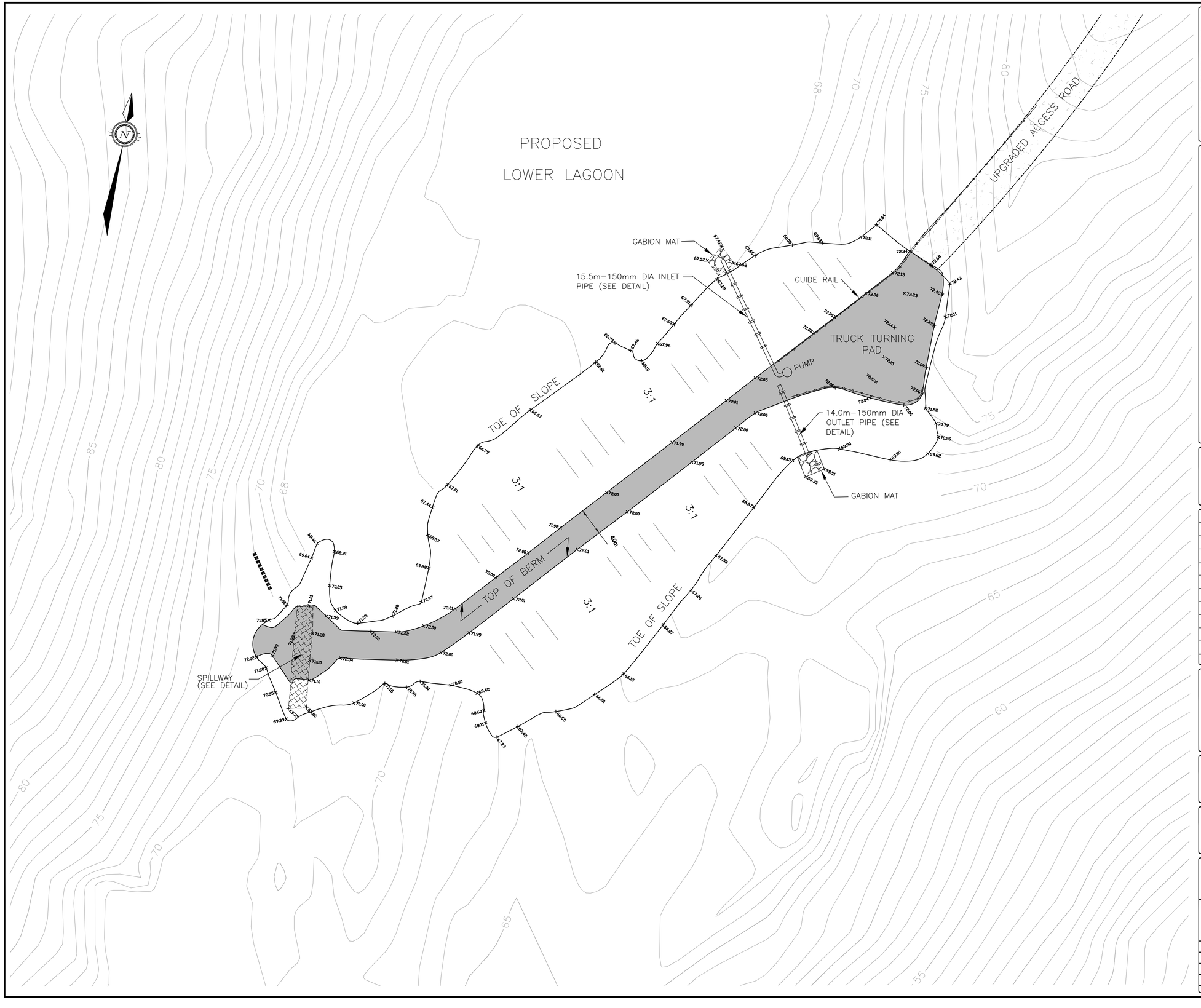
CLIENT
GOVERNMENT OF NUNAVUT

PROJECT
KIMMIRUT WASTEWATER LAGOON

TITLE
UPPER LAGOON
TRUCK DISCHARGE PLAN

design by	SAD
drawn by	MEB
checked by	SLB
date	4/01/2008
scale	HORIZ 1:250
project no.	OTCD000188814
drawing no.	TD-1



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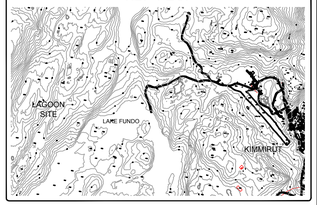

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CLIENT

GOVERNMENT OF NUNAVUT

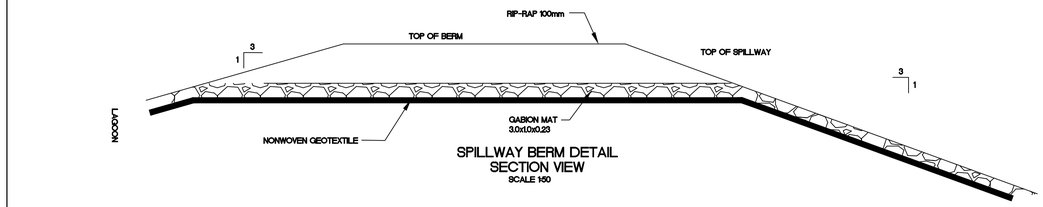
PROJECT

KIMMIRUT WASTEWATER LAGOON

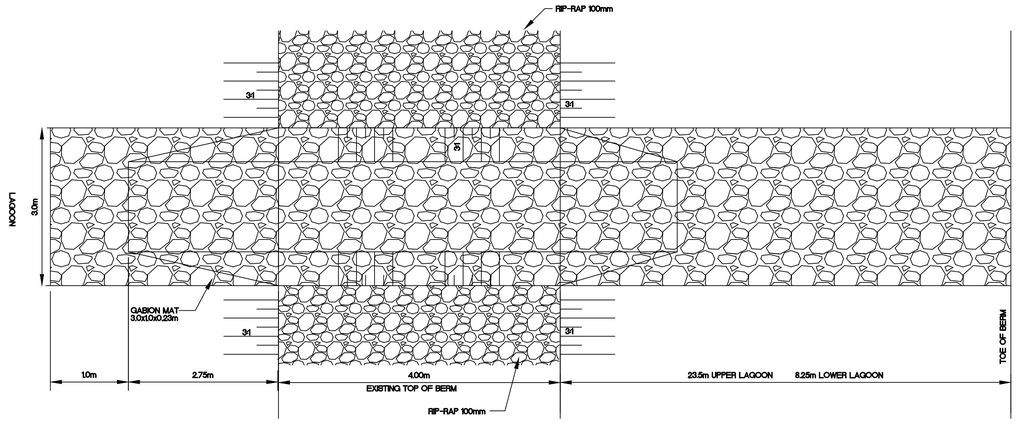
TITLE

LOWER LAGOON
TRUCK ACCESS PLAN

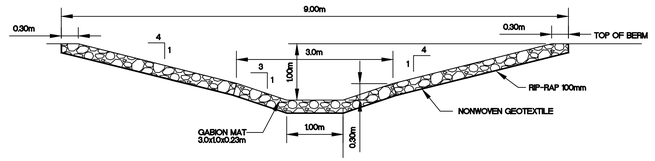
design by	SAD
drawn by	MEB
checked by	SLB
date	4/01/2008
scale	HORIZ 1:250
project no.	OTCD000188814
drawing no.	TA–1



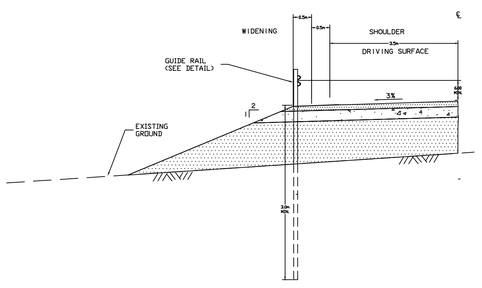
SPILLWAY BERM DETAIL
SECTION VIEW
SCALE 1:50



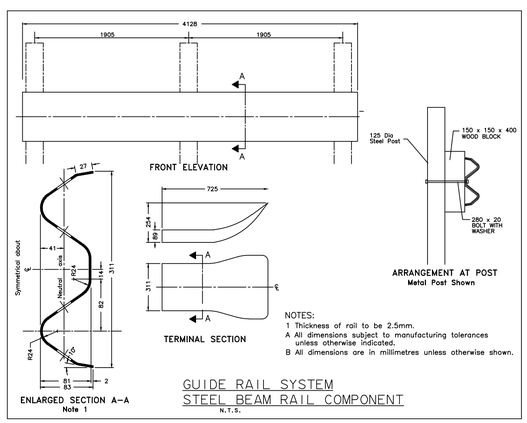
SPILLWAY BERM DETAIL
PLAN VIEW
SCALE 1:50



SPILLWAY DETAIL
SECTION VIEW
SCALE 1:50



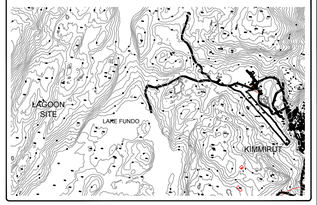
LOCAL ROAD WIDENING AT GUIDE RAIL LOCATIONS
N.T.S.



NOTES:
1 Thickness of rail to be 2.5mm.
A All dimensions subject to manufacturing tolerances unless otherwise indicated.
B All dimensions are in millimetres unless otherwise shown.

GUIDE RAIL SYSTEM
STEEL BEAM RAIL COMPONENT
N.T.S.

KEY PLAN



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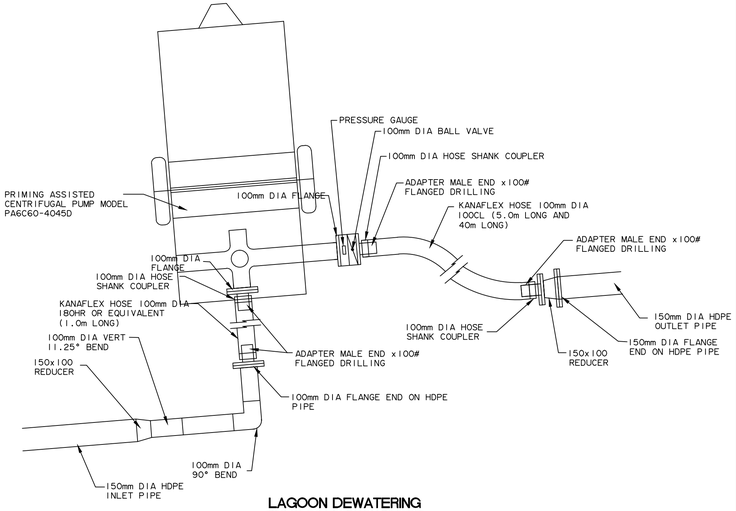
CLIENT
GOVERNMENT OF NUNAVUT

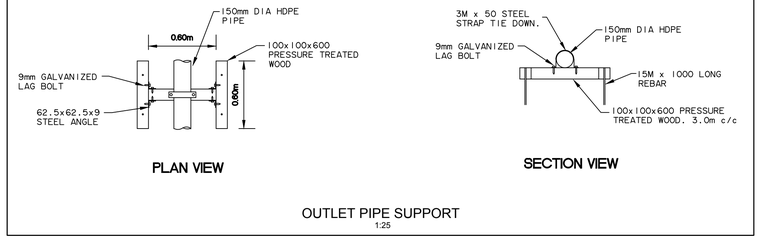
PROJECT
KIMMIRUT WASTEWATER LAGOON

TITLE
DETAILS

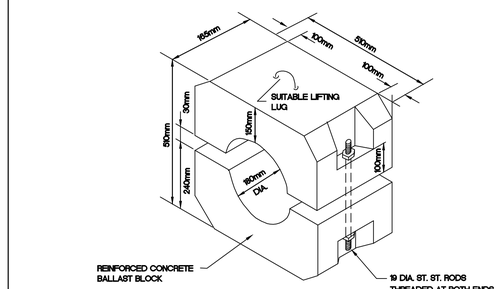
design by	SAD
drawn by	MEB
checked by	SLB
date	4/01/2008
scale	AS SHOWN
project no.	OTCD000188814
drawing no.	DE-2



LAGOON DEWATERING PUMP INFRASTRUCTURE PLAN VIEW
NTS



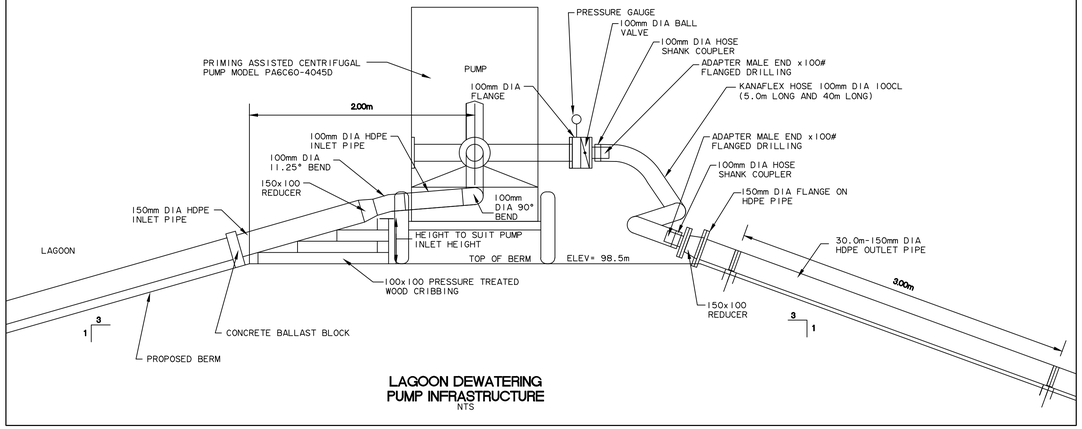
OUTLET PIPE SUPPORT
1:25



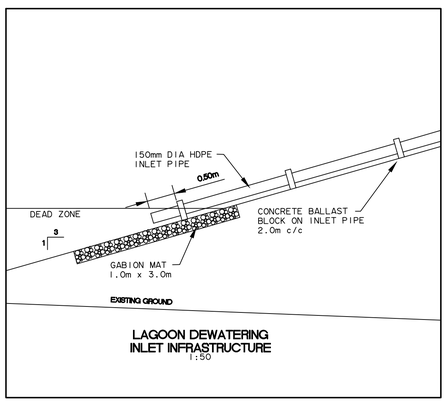
NOTE:

1. CONTRACTOR TO USE 6.25mm THICK NEOPRENE SPONGE PADDING BETWEEN PIPE AND BLOCKS TO PREVENT CONTACT. WIDTH TO BE 180mm.
2. BALLAST BLOCKS TO BE PLACED ON PIPE WHEN IT IS FLOATED IN THE WATER, SPACED AT 2.25m O.C.

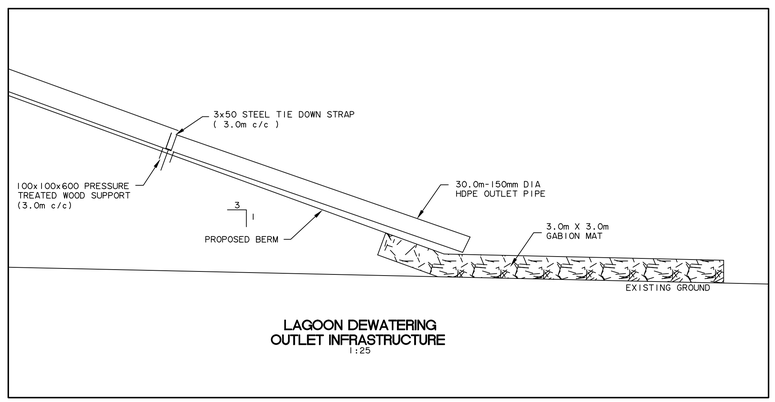
CONCRETE BALLAST BLOCK
SCALE 1:10



LAGOON DEWATERING PUMP INFRASTRUCTURE
NTS

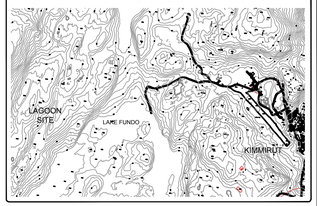


LAGOON DEWATERING INLET INFRASTRUCTURE
1:50



LAGOON DEWATERING OUTLET INFRASTRUCTURE
1:25

KEY PLAN



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TITLE
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