Attachment 5

Mine Site Waste Rock Stockpile Water Treatment System Design Basis Memorandum

NOT FOR CONSTRUCTION

January 31, 2018

BAFFINLAND IRON MINES
MARY RIVER PROJECT WASTE ROCK PILE FACILITY

Design Basis Memorandum Waste Rock Pile Water Treatment Facility

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REPORT

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this Design Basis Memorandum (DBM) is to summarize conditions, assumptions, input data and treatment targets, to support procurement of a water treatment system (WTS) for Baffinland Iron Mines (BIM)'s Mary River Project waste rock pile facility. Additional work is required, to specify detailed engineering, procurement construction, commissioning and operations. This document is not intended for construction and the assumptions will be revised upon detailed engineering.

1.2 Project Objectives

The treatment goal of the project is pH adjustment and total suspended solids removal. In addition, removal of some heavy metals, in particular nickel, could be targeted if required in future. Details are provided in Section 2.4. The treatment goal is to ensure that all water discharged to the natural environment is in compliance with the criteria outlined in the Metal Mining Effluent Regulations (MMER) and BIM's Type A Water Licence 2AM_MRY1325 – Amendment No. 1.

1.3 Guiding Principles

The fundamental principles governing the project are:

- A short schedule is required to meet the needs to treat freshet in 2018.
- Safe design with health, safety and environment being the topmost priority.
- Reuse existing infrastructure where possible.
- Equipment to be air freighted to site, skid dimensions and weight constraints for air freight and selected to reduce shipping costs while meeting project objectives.
- Robust process design to allow limited variation in feed criteria while meeting permit targets for treated water.
- Reduce capital and operating costs with innovative design and process control.
- Partially automated system suitable for short term operations, with a focus on rapid equipment delivery. Additional automation to allow unattended operation may be provided at a later date.

1.4 Key Assumptions

The key assumptions for the plan are:

- The effluent targets shall be per Canadian Metal Mines Effluent Regulations (MMER).
- Drainage from the dump will be collected in the existing pond and pumped to the water treatment system.
- Geotechnical conditions for the selected area for installing the water treatment plant are suitable for siting with minimal site preparation, to be performed by BIM in advance. No specialized civil or geotechnical technique is required for construction.
- Hydrological conditions and assumptions, including input data provided by BIM.

- Lay-flat hose is suitable for the intake and discharge pipes to facilitate air freight and rapid installation. This assumption to be confirmed when more details including hydraulic profile, piping route, and site topography are available.
- Any overflow or spill from the water treatment plant or reagent systems will flow by gravity to the seepage collection system downstream of the Waste Rock pile pond. Any spill from the WTS or seepage from the pond is collected and pumped back to the pond. Hence, secondary containment tanks for the reactors and chemical solution tanks are not required.
- A temporary shelter is required, surrounding major equipment for protection against inclement weather, for the health and safety of the plant operators and protection of equipment. The housing shall be light in weight to minimize air freight, easy in installation and uninstallation, and easy to relocate and reuse when required.
- All equipment will be powered by either a direct-drive diesel engine (major pumps) or a continuous diesel powered generator.
- All lighting will be provided by temporary diesel powered lighting stations, provided by BIM (not included in the scope of the WTS).
- Transportation of workers from camp facilities to the site, communications, break room facilities, restrooms, first aid allowances and other common services shall be provided by BIM (not included in the scope of the WTS).
- Transportation of reagents and materials on site, including manipulation of pallets, shall be provided by BIM (forklift and trucks not included in the scope of the WTS).
- Fuel for pumps, gensets, and heaters as required shall be provided by BIM (not included in the scope of the WTS)
- Transportation of workers to and from the Mary River site from Montreal, Mirabel, shall be provided by BIM only as arranged and agreed in advance.

1.5 Risk Management

Risks and uncertainties related to process, electrical and controls, construction, and operation and maintenance will be identified and ranked in consultation with BIM. The risks will be mitigated by either updating the design or identifying management actions required. The risks and uncertainties will be resolved in the detailed design phase and during the operation phase.

1.6 Applicable Standards and Guidelines

Applicable standards and guidelines are:

- Metal Mining Effluent Regulations (MMER), SOR/2002-222, dated 22 September 2017;
- Water Licence No: "2AM_MRY1325 – Amendment No. 1", Nunavut Water Board (July 30, 2015);
- Canada Occupational Health and Safety Regulations, latest edition, Canadian Centre for Occupational Health and Safety;
- National Building Code;

- American National Standards Institute (ANSI) Standard Z358.1- 2009 “Emergency Eyewash and Shower Equipment”;
- CSA standard M421-11 “Use of Electricity in Mines” in conjunction with the Canadian Electrical Code; and
- NWT Fire Code.

2.0 DESIGN BASIS

2.1 Site

Location:	BIM, Mary River Project
Latitude:	79°16'33"W
Longitude:	71°18'37"N
Elevation:	570 m

2.2 Raw Water Quality

The summary of raw water quality data for period July 2017 to September 2017 is provided in Appendix A. Effluent discharge limits per MMER guidelines are also provided in the same table for comparison.

Analysis of raw water quality data indicates that the pH and TSS parameters have exceed the MMER effluent limits in the past year. Concentration of other deleterious substances such as arsenic, copper, cyanide, lead, nickel, zinc, and radium 226 were always within the discharge limits.

2.3 Target Effluent Limits

The target effluent limits per the MMER guidelines are shown in Table 1.

Table 1: MMER Effluent Limits

Parameter	Unit	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentrations in a Composite Sample	Maximum Authorized Concentrations in a Grab Sample
Arsenic	mg/L	0.50	0.75	1.00
Copper	mg/L	0.30	0.45	0.60
Cyanide	NTU	1.00	1.50	2.00
Lead	mg/L	0.20	0.30	0.40
Nickel	mg/L	0.50	0.75	1.00
Zinc	mg/L	0.50	0.75	1.00
Total Suspended Solids	mg/L	15.00	22.50	30.00
Radium 226	Bq/L	0.37	0.74	1.11
pH	SU	6 – 9.5	6 – 9.5	6 – 9.5

To provide a safety factor, an internal limit for grab samples for all parameters except pH will be set at a level below of the MMER grab sample limits. For pH the internal grab sample is set as 6.5 to 9. If the concentration in a grab sample exceeds the set limit or if the measured pH is outside the internal set range, then the water treatment system will be shut down or water recirculated back to the pond.

2.4 Water Treatment Objectives

The main objectives of water treatment are to adjust pH and remove suspended solids from raw water before discharge to the environment. In addition, removal of some heavy metals, in particular nickel, could be targeted if in future their concentrations exceed the MMER discharge limits.

2.5 Design Flow Rate

Golder prepared a hydrological analysis to support the selection of a treatment flow rate to limit the risk of an unauthorized discharge to the environment. The analysis included two steps:

1) A baseline hydrology analysis to estimate the waste rock pile runoff volumes for different return periods (2 years to 100 years) and different durations (1 day to 100 days); and

2) A pond water balance exercise to calculate the required treatment rate to manage a certain runoff event under consideration of the current pond conditions.

The analysis is described in detail in a separate document. A summary of the approach is provided in Appendix B.

The approach described in Appendix B supported the following results:

- For the current (January 2018) footprint of the waste rock pile and of the pond (0.23 km^2) and for an estimated Q1 2018 expansion to an approximate total of 0.32 km^2.
  - A treatment rate of 280 m^3/hr (or 6,720 m^3/day) is sufficient to avoid unauthorized discharge to the environment of waste rock pile runoff for an event with a return period of approximately 10 years.

The calculations assume that the treatment plant is fully operational from the beginning of the 2018 freshet and that BIM will return seepage collected at the berm's downstream toe to the pond as required as water will be stored temporarily in the pond. The calculations assume that the pond capacity (up to the liner top elevation) can be used temporarily with the understanding that any seepage will be collected in the existing seepage collection system and returned to the pond/ treatment system.

Assuming an approximately 100 days open season (high range value), the 280 m^3/hour is equivalent with a theoretical treatment volume of 672,000 m^3 water. However, Golder expects that the treatment plant would need to be operated continuously over several weeks only during the freshet (approximately two to three weeks) and for short durations after large rainfall events. The plant would also need to be operated occasionally after smaller rainfall events. The total treated volume would be significantly smaller than the theoretical maximum and would vary from year to year as a function of the hydrological conditions and the pile footprint.

Based on the considerations described above, Golder recommends a 280 m^3/hour treatment rate for the freshet with a contingency seepage pump-back system. It is also recommended that the pond lining system be inspected and repaired during the summer of 2018, in parallel to the increasing the pond's storage capacity for a larger waste pile footprint (and potentially a higher return period). The required design criteria and increase in capacity will be determined at a later date in conjunction with the update of the waste rock management plan. The plan may also include increasing the treatment capacity.

3.0 TREATMENT PLANT DETAILS

3.1 Process

The design consists of physical-chemical treatment for converting dissolved metals into precipitates and removing the solids by physical barrier. The water treatment processes include coagulation, pH adjustment and precipitation, flocculation and filtration.

The treatment plant process, flow rate, and equipment are analogous to facilities successfully installed and operated at other mines in Canada.

Water from the feed pond will be pumped to the first reactor tank and will be mixed by an aeration system. Lime and coagulant (ferric sulfate) solutions will be added and pH adjusted to 8.5 to assist precipitate heavy metals. The intent of coagulation is to neutralize the electric charge on colloidal particles, and also assist with precipitation of some heavy metals. The coagulated water will flow to the second reactor tank to provide additional mixing and retention time for reactions to occur. The pH adjusted water will flow to the third reactor in which polymer will be added for flocculation. Flocculation will create flocs to assist with the separation of solids and liquids in subsequent stages. The overflow from the third reactor tank will be pumped to geotube and solids filters via the membrane. The filtered final effluent from the geotubes will collect in sumps and will be pumped for discharge to environment (if meeting permit targets) or recycled to the feed pond (if not meeting the internal limits as discussed in Section 2.3).

For each train, the water flow rate and pH in Reactor tanks 1 and 2 will be continuously monitored and the data sent to a central programmable logic controller (PLC). Ferric sulfate and polymer will be added based on flow rate, while lime dose will be based on pH at the reactor tank 1. The chemical dose rate can be adjusted by the plant operator in the PLC to meet the targets. The plant operator will periodically monitor the turbidity of the geotube effluent.

3.2 Plant Design

The treatment plant will consist of two trains, each designed to treat maximum flow rate of 140 m^3/h. Hence, the total treatment capacity of the treatment plant will be 280 m^3/h. The two train design provides option of operating only one train or both trains simultaneously. Also, in case one train is out of service for any reason, the second train is still available for water treatment.

Raw water from the existing storage pond will be pumped to the treatment plant with two diesel trash pumps, each rated for 140 m^3/h. Suction intake piping to the pumps will consist of floating intake pipe with screen, located in the feed collection pond. The pumps will be located to keep the suction piping as short as practically possible. Pump speed will be adjusted with the throttle to achieve the required flow rate, and monitored using flow meters and totalizers. Fine flow control, if required, will be done with manual butterfly valves provided upstream of Reactor #1 of each treatment train. Pipeline from the raw water transfer pumps to the water treatment plant will be heavy-duty, polyurethane layflat hose.

Each train will consist of three reactor onion tanks. These tanks will be self-supporting type with heavy duty air or foam collar for self-rising. The tanks will be installed on a protective laydown PVC or plywood matt. Inlet and outlet connection will be flanged ends and supported to the plywood base to protect the collars. Coarse bubble aeration system will be installed in each tank to provide necessary energy for mixing, supported by a simple frame. A goose neck in piping downstream of the reactors will maintain the water level in the tanks at a minimum level regardless of flow. A butterfly valve will be provided to by-pass the goose neck and drain all the tanks when required.

Three chemical dosing systems will be provided, one each for ferric sulfate, hydrated lime, and polymer. The chemical makeup system for ferric sulfate will be manually-operated to simplify construction. Automation may be provided at a later date. An operator will add ferric sulfate granules from 23 kg bags, delivered to site by pallet, to the solution makeup tank filled with water. Mixers will provide necessary mixing energy. Two chemical metering pumps, one for each train, will dose the ferric sulfate solution based on the raw water flow rate.

The lime makeup system will also be manual, with operator adding hydrated lime from bags to solution makeup tank filled with water. Lime makeup tank will either be circular HDPE type or onion tank design. Mixing will be provided by coarse bubble aeration system and/or a mechanical mixer. One lime slurry pump will continuously pump lime slurry in the recirculation loop to the addition points and back to the tank at sufficient velocity to prevent any settling of lime in the pipeline. Based on pH signals, two modulating actuated valves in the loop, one in each train, will open to add lime solution to reaction tank based on feedback from a pH controller.

Polymer makeup system will consist of polymer mixing/wetting and activation system, and maturation tank with mixer. Two chemical metering pumps, one for each train, will dose the polymer solution based on the raw water flow rate and a dosage setpoint.

Chemically conditioned water from the last reactor tank of each train will flow by gravity in rigid suction hose or heavy-duty, polyurethane layflat hose to the geotextile tube laydown area. The flow will be pressurized inline by a diesel powered trash pump (total two, one for each train) and sent to the geotubes. Supplemental or alternate polymer injections will be provided at the pump. Flow will be adjusted with the pump throttle, combined with a fine flow adjustment will be with a modulating valve, programmed to maintain the water level in the last reactor tank in a set limit. A distribution manifold in each train (2 total) with isolation valves will divert flow to geotube ports. The geotubes will be installed in bermed laydown area complete with a geomembrane liner. The berm will be designed to storage at least 110% volume of one geotube. The geotube material and dimensions will be properly selected to ensure optimum solids removal by filtration.

Clarified effluent from the geotubes will flow by gravity to an effluent sump. Two diesel trash pumps, each rated for 140 m^3/h, will pump the effluent from the sump to the final discharge point. If water quality does not meet the effluent limits, the treated water will be pumped back to the raw water holding pond for retreatment. Necessary piping and valves will be provided to divert the flow to either the discharge point or the raw water pond. All piping downstream of the discharge pumps will be heavy-duty, polyurethane layflat hose.

A submersible pump will be installed in the sump to transfer filtered water to the water treatment system for chemical solution make-up and for flushing lime line. The submersible pump discharge piping will be heavy duty fire hose.

The reactor tanks, chemical dosing system, air blowers, and electrical control panel will be housed in an industrial grade "air shelter", suitable for the site conditions, for protection from wind and precipitation. In addition to protecting the equipment, the air shelter will also provide safe working condition to plant operators. The treatment plant flooring will consist of plywood to provide even surface for plant installation and operation. A modular self-supporting piping support system will be installed to carry and support all chemical dose piping, air piping, instrumentation cables, and electric cables. The piping support system will minimize the amount of piping and wiring on ground, and will reduce tripping hazards.

The fuel level of the diesel trash pumps will be periodically monitored and filled up by plant operators. The power supply to treatment plant equipment including air blowers, chemical makeup and dosing systems, and control panel will be supplied by a diesel generator (supplied by BIM).

Design details of the water treatment plant components are presented in the following sections.

4.0 RAW WATER TRANSFER SYSTEM

4.1 Water Intake Screen

Quantity:	02
Design:	Floating intake with screen
Design Flow Rate:	43 L/s (154 m^3/h)
Make/Model:	By Contractor

4.2 Diesel Trash Pump (by Baffinland)

Quantity:	02
Design:	Trailer mounted diesel trash pump with fuel storage tank, auto on/off based on water level, dry run ability,
Design Flow Rate:	140 m^3/h (600 US gpm)
Head at minimum flow:	TBD
Make/Model:	To use existing pumps

4.3 Piping

Length:	TBD
Design:	Heavy-duty, polyurethane layflat hose
Design Flow Rate:	Variable flow from 140 m3/h to 280 m3/h (600 to 1250 US gpm)
Design Working Pressure:	7.1 kg/cm^2 (g) (100 psig)
Diameter:	200 mm (8”) nominal diameter
Make/Model:	By Contractor

5.0 WATER TREATMENT SYSTEM

5.1 Coagulant (Ferric Sulfate) Addition System

5.1.1 Chemical Dose

Chemical:	Ferric Sulfate, Ferix-3 or approved equivalent
Dose:	20 mg/L Fe equivalent
Makeup Solution Concentration	10%

5.1.2 Makeup System

Chemical Addition to Tank:	Manual by plant operator
Number of Makeup Tank:	02
Makeup Tank Volume:	800 L
Tank Dimensions:	By Contractor
Number of Tank Mixer:	02 (one per tank)
Tank Mixer Design/Sizing:	By Contractor (minimum 0.5 HP)

5.1.3 Dosing Pump

Number of pump:	02
Configuration:	02 operating + 0 stand-by
Type:	Variable speed peristaltic pump or piston diaphragm pump
Turn-down Ratio:	10 (minimum)
Design Flow Rate:	By Contractor
Pump Accessories:	Intake piping with screen and check valve; minimum other accessories as required for safe pump operation
Pump Calibration:	Manual with calibrated graduated cylinder
Pump Mounting:	On modular piping support structure (pump skid not required)
Minimum Required Automation:	Auto adjustable dosing rate based on flow signal
Make:	Blue-White / Pulsafeeder / LMI / approved equivalent

5.2 Lime Addition System

5.2.1 Chemical Dose

Chemical:	Hydrated lime ($Ca(OH)_2$)
Dose:	50 to 300 mg/L (max)

Makeup Solution Concentration: Approximately 10%

5.2.2 Makeup System

Chemical Addition to Tank:	Manual by plant operator
Number of Makeup Tank:	01
Makeup Tank Volume:	3,000 L
Tank Material:	HDPE/Polyurethane/ approved equivalent
Tank Dimensions:	By Contractor
Tank Outlet Connection:	50 mm (2”) nominal diameter
Aeration Mixing Design/Sizing:	By Contractor

5.2.3 Dosing Pump

Number of pump:	01
Configuration:	01 operating + 0 stand-by
Type:	Slurry pump
Design Flow Rate:	By Contractor
Accessories:	50 mm (2”) nominal dia recirculation pipe with two 25 mm (1”) nominal dia actuated valves for automated chemical dosing, one for each train
Pump Calibration:	Manual with calibrated graduated cylinder
Pump Mounting:	On modular piping support structure (pump skid not required)
Minimum Required Automation:	Automated on/off valve for adjustable dosing rate based on pH and flow signals
Make:	By Contractor

5.3 Polymer Addition System

5.3.1 Chemical Dose

Chemical:	Polymer for flocculation and assist for dewatering
Polymer Type and Make:	By Contractor
Dose:	0.5 mg/L to 3 mg/L. Dose to be set based on bench scale test by the Contractor
Makeup Solution Concentration:	By Contractor, not to exceed 0.5%

Note: Raw water sample will be provided to the successful Contractor for bench scale testing to select polymer and dose

5.3.2 Makeup System

Polymer Makeup System:	By Contractor
Number of Makeup Tank:	01
Makeup Tank Volume:	By Contractor
Tank Dimensions:	By Contractor
Number of Tank Mixer:	01
Tank Mixer Design/Sizing:	By Contractor

5.3.3 Dosing Pump

Number of pump:	02
Configuration:	02 operating + 0 stand-by
Type:	Progressive cavity dosing pump, variable speed peristaltic pump, or piston diaphragm pump
Turn-down Ration	10 (minimum)
Design Flow Rate:	By Contractor
Pump Accessories:	Intake piping with screen and check valve; minimum other accessories as required for safe pump operation
Pump Calibration:	Manual with calibrated graduated cylinder
Pump Mounting:	On modular piping support structure (pump skid not required)
Minimum Required Automation:	Auto adjustable dosing rate based on flow signal
Make:	Seepex / Blue-White / Pulsafeeder / LMI / approved equivalent

5.4 Reactor Tanks

5.4.1 Coagulant (Ferric Sulfate)

Tank type:	Onion tank, collapsible and foldable
Number of tanks:	02 (one per train)
Configuration:	02 operating + 0 stand-by
Reactor Volume:	23 m^3 (6,100 US gallon)
Maximum Tank Diameter	5.8 m (at bottom)
Tank Material:	Polyurethane or approved equivalent
Accessories:	200 mm (8”) diameter flanged inlet and outlet connection; ground sheet for tank protection

Spare Part/Repair Kit:	Per manufacturer's recommendation
Aeration Mixing System	One or two per tank based on configuration. Air supply per tank not less than 0.3 scfm/ft^2

5.4.2 pH Adjustment Reagent (Lime)

Tank type:	Onion tank, collapsible and foldable
Number of tanks:	02 (one per train)
Configuration:	02 operating + 0 stand-by
Reactor Volume:	23 m^3 (6,100 US gallon)
Maximum Tank Diameter	5.8 m (at bottom)
Tank Material:	Polyurethane or approved equivalent
Accessories:	200 mm (8") diameter flanged inlet and outlet connection; ground sheet for tank protection
Spare Part/Repair Kit:	Per manufacturer's recommendation
Aeration Mixing System	One or two per tank based on configuration. Air supply per tank not less than 0.3 scfm/ft^2

5.4.3 Polymer

Tank type:	Onion tank, collapsible and foldable
Number of tanks:	02 (one per train)
Configuration:	02 operating + 0 stand-by
Reactor Volume:	23 m^3 (6,100 US gallon)
Maximum Tank Diameter	5.8 m (at bottom)
Tank Material:	Polyurethane or approved equivalent
Accessories:	200 mm (8") diameter flanged inlet and outlet connection; ground sheet for tank protection
Spare Part/Repair Kit:	Per manufacturer's recommendation
Aeration Mixing System	One or two per tank based on configuration. Air supply per tank not less than 0.3 scfm/ft^2

5.5 Aeration/Mixing System

5.5.1 Air Blower

Quantity:	02 (one per train)
Configuration:	02 operating + 0 stand-by
Blower Type:	By Contractor
Blower Capacity:	By Contractor
Make and Model:	By Contractor
Accessories:	Minimum accessories as required for safe blower operation; based on blower type could include inlet filter, inlet silence, pressure relief valve, pressure gauge, outlet silencer

5.5.2 Aeration System

Quantity:	06 (one per reactor tank)
Diffuser Type:	By Contractor
Piping:	Air hose / PVC
Make and Model:	By Contractor
Accessories:	

Note: (a) Aeration system to be supported from the modular piping support system. (b) Aeration system to be designed to properly mix the whole reactor and not create any dead zone. (c) The system should be installable and removable in parts such that the onion reactor tanks do not get damaged.

5.6 Plant Water Piping

Piping Material:	PVC
Pipe Size:	200 mm (8”) nominal diameter, Sch 80 thickness
Isolation Valve:	200 mm (8”) nominal diameter manual actuated butterfly valves (see P&ID)
Make and Model:	By Contractor

5.7 Plant Air Piping

Piping Material:	Reinforced synthetic rubber hose
Pipe Size:	By Contractor
Isolation/Throttling Valve Size:	By Contractor
Make and Model:	By Contractor

5.8 Modular Pipe Support

Purpose:	Carry and support all chemical dose piping, air piping, instrumentation cables, electric wiring
Design:	Self-supported, modular pipe support system
Material:	Carbon steel galvanized
Size:	By Contractor
Make:	Hilti / Sikla / Approved equivalent
Isolation/Throttling Valve Size:	By Contractor

5.9 Plant Floor

Size:	18.3m (60’) wide x 24.4 (80’) long (To be confirmed by the Contractor)
Flooring Material:	Plywood
Sheet Dimensions:	By Contractor

5.10 Industrial Air Shelter

Quantity:	01
Internal Dimensions:	18.3m (60’) wide x 24.4 (80’) long (To be confirmed by the Contractor from final layout)
Side Wall Height:	3.1 m (10 ft) minimum
Cover Material:	High density/high quality material suitable for site conditions
Accessories:	(a) all material required for installation and normal operation including interior insulation curtain, exterior skirt, fly cables, HVAC inlets, inflation system, anchoring system, equipment and man doors, lighting, installation tools (b) Spares and repair kit as required

5.11 Artic Heater (By BIM)

Quantity:	01
Capacity/Rating:	Suitable to heat the Industrial Air Shelter to minimum 5 deg C

5.12 Emergency Eyewash (By BIM)

Quantity:	01
Design:	Suitable for remote location without running water supply.

Note: The emergency eyewash shall comply with the latest edition of the following guidelines/standards:

- Canada Occupational Health and Safety Regulations

- Canadian Centre for Occupational Health and Safety

5.13 Geotextile Filtration System

5.13.1 Diesel Trash Pump for Geotube Feed

Quantity:	02
Type:	Trailer mounted diesel trash pump with fuel storage tank, auto on/off based on water level, dry run ability
Design Flow Rate:	140 m^3/h (600 US gpm)
Design Head:	TBD
Make/Model:	Tsurumi/Gorman-Rupp/Approved equivalent
Accessories:	

5.13.2 Geotextile Tube

Quantity:	04
Configuration:	02 operating + 02 stand-by
Geotube Make/Model:	Tencate GT500D with internal non-woven textile lining to improve filtration efficiency
Dimensions:	60’ circumference x 100’ long (to be confirmed by Geotube manufacturer)
Accessories:	(a) Impermeable geo-membrane (to cover geotube lay down area, berms, and trenches of the dewatering cells); (b) Non-woven geo-synthetic (to protect geo-membrane); (c) Geotube Filtration Fabric (to be installed over the non-woven geosynthetic material to promote drainage from the bottom of the Geotube units) (d) Layflat hose as required (e) Distribution manifold with isolation valve

6.0 EFFLUENT TRANSFER SYSTEM

6.1 Water Intake Pipe

Quantity:	02
Pipe Size:	By Contractor
Design Flow Rate:	43 L/s (154 m^3/h)

6.2 Diesel Trash Pump

Quantity:	02
Design:	Trailer mounted diesel trash pump with fuel storage tank, auto on/off based on water level, dry run ability

Design Flow Rate:	140 m^3/h (600 US gpm)
Head at minimum flow:	TBD
Make/Model:	Tsurumi/Gorman-Rupp/Approved equivalent

6.3 Submersible Pump

Purpose:	Supply water for chemical solution makeup, and to lime feed flushing line.
Quantity:	01
Design:	Submersible pump
Design Flow Rate:	By Contractor
Head at minimum flow:	TBD
Make/Model:	By Contractor

7.0 AUTOMATION AND CONTROL SYSTEM

A summary of the plant controls system is provided in Table 2. The control system will be provided by either a distributed control system (DCS) or a central process logic and control (PLC) system.

Table 2 - Control Summary

Instrument	Quantity	Location	Function
Ultrasonic Clamp-on Flow Meter and Transmitter	02	Upstream of Reactor Tank #1 of both trains	Measure flow for chemical dosing, record for volume treated and discharged to environment.
pH Sensor and Transmitter	04	In Reactor Tank 1 and Reactor Tank 2 of both trains	Lime addition for pH adjustment to meet discharge pH limit.
Ferric Sulfate Dosing Pump	02	-	Auto adjustment of chemical addition rate based on flow signal.
Polymer Dosing Pump	02	-	Auto adjustment of chemical addition rate based on flow signal.
Actuated Valves in Lime Recirculation Loop	02	Reactor Tank 1 of both trains	Auto adjustment of chemical addition rate based on flow and pH signals.
Ultrasonic Level Sensor and Transmitter	02	In Reactor Tank 3 of both trains	Control actuated valves in geotube feed pump line to adjust flow rate within a set range.
Automatic Actuated Valve	02	Geotube feed pump piping	Control actuated valves in geotube feed pump line to adjust flow rate within a set range.
Level Switch	02	Raw Water Feed Pond	Auto turn ON and OFF the pump at set water levels.
Level Switch	02	Geotube Effluent Feed Sump	Auto turn ON and OFF the pump at set water levels.
Central Control Panel	1	-	Control of automated equipment, record keeping

8.0 LABORATORY INSTRUMENT AND EQUIPMENT

Benchtop Turbidimeter: Hach TL2310 LED Turbidimeter, ISO, 0 to 1000 NTU; Quantity: 01

Benchtop pH meter: Hach pH HQ440D Meter Package with PHC281 Ultra Electrode; Quantity: 01

Spectrophotometer: Hach DR1900 Portable Water Spectrophometer

Reagents: Hach Reagents; Type and quantity: TBD

Glassware: Laboratory glassware; Type and quantity: TBD

9.0 DIESEL POWER GENERATOR (BY BIM)

Quantity:	01
Capacity:	40 kW minimum (to be confirmed by the Contractor)

10.0 ELECTRICALS (BY BIM)

Design/Approval	Electrical Protection Act, Government of Northwest Territories
Design features:	(a) Temperature rise within electrical enclosures must not exceed the maximum temperature specified by the manufacturer for components inside those enclosures. (b) Live equipment and terminals shall be located behind removable covers or locked door to prevent accidental contact and accident. (c) All electrical equipment shall be protected from surge, and designed for automatic restart. A minimum 2 hour battery backup uninterrupted power supply (UPS) will be provided to operate PLC. (d) All electrical works will be by BIM or their approved electrical contractor.

11.0 SHIPPING

Length x Width x Height	3.07 m x 2.23 m x 2.13 m (121” x 88” x 84”) (Pallet or skid size not to exceed these dimensions)
Weight:	2,954 kg (6,500 lbs) maximum per pallet or skid
Shipping:	To Yellowknife, NWT (from here goods air-freighted to Baffin Island)
Shipping Address:	Will be provided later

Note: Refer to BIM document number: BAF-PH1-310-P25-0003 Rev 0 Dated 9 May 2017, Shipping and Packing Instruction Guide, for additional details.

12.0 INSTALLATION

Water Treatment System:	By the Contractor. Local general labour to be used where possible.
Industrial Air Shelter:	By the air shelter manufacturer. Local general labour to be used where possible.
Geotube Filtration System:	By the Contractor. Local general labour to be used where possible.
Geotube Civil and Berm:	BIM
Civil Works:	BIM
Electrical Works	BIM

13.0 DESIGN LIFE

The plant design life shall be minimum 10 years, with regular maintenance.

14.0 PLANT OPERATION AND MAINTENANCE

14.1 Operation and Maintenance Provisions

The following provisions shall be provided:

- In the industrial air shelter, a 12’ x 12’ access door or flap with two man doors for exit in emergency, c/w illuminated exit signs.
- HVAC opening in the air shelter to supply fresh air.
- Lighting and heating in the air shelter c/w venting of diesel exhaust to outdoors
- Automation only where required to minimize plant construction and operation complexity. As the plant would typically only be operated for a couple of days per season, easy to operate plant with manual labour would be more robust and reliable.
- All water quality and process monitoring instruments, chemical dosing systems, and central control panel to be located inside the air shelter for ease of access, operation, and maintenance.
- Quick disconnect fittings and true union connections shall be provided where possible for ease of maintenance and replacement of valves and fittings.
- Only reliable and proven products to be used in the water treatment plant given the remote site location.
- Dosing pump suction intake shall be designed for removal and installation in makeup tanks, without disconnecting any piping or instrumentation wiring connections.

14.2 Operation and Maintenance Requirements

Typical regular operation and maintenance activities and frequency are shown in Table 3.

Table 3: Operation and Maintenance Activities and Frequency

Parameter	Frequency	Type/Remark
Visual check of raw water intake screens	Once a day	Check the intake is free of debris, or any other obstructions. Clean the intake screen if required.
Visual check of diesel thrash pumps - raw water transfer pumps; geotube feed pumps, effluent transfer pumps; monitor fuel levels	Based on required fuel refilling rate	Check fuel level and refill diesel as required; record the fuel used to check whether the fuel consumption rate is normal or not; listen to the engine sound for any abnormal operation

Table 3: Operation and Maintenance Activities and Frequency

Parameter	Frequency	Type/Remark
Visual check of the Water Treatment Plant central controls system, in the air shelter	Every hour	Check system is in operation, raw water flow rate, chemical dosing rates, and reagent levels in makeup tanks. Check against target flow rate and dosing rate. Make adjustment if required.
Visual check of pressure in water piping	Every four hour	Note reading in the piping sections and compare to design/normal pressure. If pressure is high, check for source of blockage. If pressure is low, check for leakage, breakage, or failed valve.
Visual check of chemical makeup tanks	Every four hour	Note reading of chemical level in the tanks. Initiate manual makeup of chemical solution if level drops below a set level. Estimated chemical consumption at 280 m^3/h and 24 h operation: hydrated lime 1 to 2 tonnes/d; ferric sulfate granules 700 kg/d, polymer 20 kg/d
Flush lime recirculation line	Every eight hour	Preventive maintenance
Visual check of physical condition of the treatment plant	Daily	Visual inspection, check for any abnormal operation and pipe leakage; tripping hazards, spills
Calibration of instruments	Annually / As recommended by manufacturers	Magnetic or clamp-on flow meter, level sensors, inline pH sensors.
Preventive maintenance of equipment	As recommended by manufacturers	Diesel thrash pumps, chemical makeup system and dosing pumps, submersible pump, piping, air mixing system including air blowers
Manual measurement of chemical dosing rate	Once a day	With a graduated cylinder, measure the chemical dosing rate. Make adjustment if required.
Visual check of geotube laydown area	Daily	Visual inspection for any abnormal operation, damage to geotube, sludge leakage.
Visual check of geotubes	Daily	Activities as per geotube manufacturer
Emergency Eyewash	Monthly	Check operability, and that it water container is full.
Draining of all reactor tanks and pipelines in the Water Treatment Plant	After every operation cycle	During continuous operation there is very low risk of freezing in heated air shelter. When treatment system is expected not be operated for a long period of time, it is advisable to drain all the reactor tanks and chemical makeup and solution tanks, and piping, specifically PVC, to prevent breakage from freezing and expansion.

Table 3: Operation and Maintenance Activities and Frequency

Parameter	Frequency	Type/Remark
Visual inspection of air shelter and air pressure	Per manufacturer recommendation	Check for any damage or air leak that would require repairs.

15.0 DESIGN DRAWINGS

The following preliminary design drawing and figures are included in Appendix C.

- Figure 1: Process Flow Diagram

16.0 CLOSURE

The reader is referred to the Study Limitations, which follows the text and forms an integral part of this report.

Golder trusts that this design brief provides summary of all design criteria for the proposed Water Treatment System, and meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.

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Water Treatment Engineer

Michael Bratty, M.Eng., P.Eng. (BC)
Associate, Senior Water Treatment Engineer

SS/MPB/sv

https://golderassociates.sharepoint.com/sites/21576g/technical work/phase 8000- wt design/dbm/rev. 0/1665556 doc001_baffinland iron mine wts_rev0_31jan2018.docx

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APPENDIX A

Raw Water Quality

Appendix A: Raw Water Quality Data of Water Discharged from Existing Raw Water Storage Pond

Parameter	Unit	MMER Limits	At MS-08 Sampling Point			
			Minimum	Maximum	Average	Median
General Parameters						
pH	SU	6 – 9.5	4.8	7.76	6.54	6.86
Total Suspended Solids	mg/L	15	1	240	22.35	12.45
Total Dissolved Solids	mg/L		36	3830	2210	2800
Turbidity	NTU		1	210	49	30
Hardness	mg/L		26	1990	778	318
Alkalinity	mg/L		3	82	25	8
Aluminum	mg/L		0.0067	0.816	0.23	0.10165
Cadmium (Cd)-Total	mg/L		0.000005	0.00038	0.00016	0.0001535
Iron (Fe)-Total	mg/L		0.2	34.8	9.31	4.005
Mercury (Hg)- Total	mg/L		0.000005	0.000005	0.00001	0.000005
Molybdenum (Mo)-Total	mg/L		0.000025	0.00025	0.00015	0.0001585
Ammonia	mg/L		0.028	1.67	0.71	0.431
Nitrate	mg/L		0.15	7.98	3.53	2.46
Electrical Conductivity	μmhos/cm		67.3	3330	1502	656
Arsenic (As)-Total	mg/L	0.5	0.00005	0.0005	0.0003	0.000275
Copper (Cu)-Total	mg/L	0.3	0.0026	0.029	0.010	0.006
Lead (Pb)-Total	mg/L	0.2	0.00025	0.00764	0.0016	0.000407
Nickel (Ni)-Total	mg/L	0.5	0.00175	0.317	0.14	0.12165
Zinc (Zn)-Total	mg/L	0.5	0.0015	0.042	0.02	0.0125
Ra 226	Bq/L	0.37	0.00255	0.03	0.01	0.012
Chloride (Cl)	mg/L		0.52	9.1	4.07	2.59
Fluoride (F)	mg/L		0.01	0.1	0.04	0.024

Appendix A: Raw Water Quality Data of Water Discharged from Existing Raw Water Storage Pond

Parameter	Unit	MMER Limits	At MS-08 Sampling Point			
			Minimum	Maximum	Average	Median
Total Kjeldahl Nitrogen	mg/L		0.075	2.08	0.93	0.62
Phosphorus, Total	mg/L		0.0015	0.0075	0.005	0.0061
Sulfate (SO4)	mg/L		20.9	2040	789.63	308
Dissolved Organic Carbon	mg/L		0.25	1.4	0.88	1
Total Organic Carbon	mg/L		0.73	1.5	1.08	1
Acidity (as CaCO3)	mg/L		2.4	14	8.20	8.2
Metals			0.00005	0.0005	0.000	0.000275
Antimony (Sb)-Total	mg/L		0.00276	0.0295	0.017	0.01525
Barium (Ba)-Total	mg/L		0.00005	0.0005	0.000	0.000275
Beryllium (Be)-Total	mg/L		0.000025	0.00025	0.0001	0.00015
Bismuth (Bi)-Total	mg/L		0.005	0.05	0.03	0.0325
Boron (B)-Total	mg/L		2.88	88.6	45.80	38.1
Calcium (Ca)-Total	mg/L		0.000005	0.00005	0.0000	0.000039
Cesium (Cs)-Total	mg/L		0.00025	0.0025	0.001	0.001545
Chromium (Cr)-Total	mg/L		0.0013	0.283	0.13	0.10545
Cobalt (Co)-Total	mg/L		0.0011	0.024	0.01	0.0093
Lithium (Li)-Total	mg/L		4.68	423	196.65	145.25
Magnesium (Mg)-Total	mg/L		0.119	18.1	8.08	5.86
Manganese (Mn)-Total	mg/L		0.025	0.25	0.14	0.1375
Phosphorus (P)-Total	mg/L		0.341	3.45	1.94	1.77
Potassium (K)-Total	mg/L		0.00069	0.0061	0.004	0.00355
Rubidium (Rb)-Total	mg/L		0.000087	0.00474	0.002	0.002145
Selenium (Se)-Total	mg/L		0.075	2.08	0.93	0.62

Appendix A: Raw Water Quality Data of Water Discharged from Existing Raw Water Storage Pond

Parameter	Unit	MMER Limits	At MS-08 Sampling Point			
			Minimum	Maximum	Average	Median
Silicon (Si)-Total	mg/L		0.24	1.5	0.89	0.925
Silver (Ag)-Total	mg/L		0.000025	0.00025	0.0001	0.0001375
Sodium (Na)-Total	mg/L		0.25	95.1	27.56	1.735
Strontium (Sr)-Total	mg/L		0.0021	0.06	0.03	0.02675
Sulfur (S)-Total	mg/L		6.79	762	332.40	240.5
Tellurium (Te)-Total	mg/L		0.0001	0.001	0.001	0.00055
Thallium (Tl)-Total	mg/L		0.000005	0.0002	0.000	0.00008
Thorium (Th)-Total	mg/L		0.00005	0.0005	0.000	0.00035
Tin (Sn)-Total	mg/L		0.00005	0.0005	0.000	0.00049
Titanium (Ti)-Total	mg/L		0.001	0.00963	0.004	0.0025
Tungsten (W)-Total	mg/L		0.00005	0.0005	0.000	0.0005
Uranium (U)-Total	mg/L		0.00005	0.00151	0.001	0.0001145
Vanadium (V)-Total	mg/L		0.00025	0.0025	0.001	0.001375
Zirconium (Zr)-Total	mg/L		0.00015	0.0015	0.001	0.000825
Cyanide, Total	mg/L	1.0	0.001	0.2	0.05	0.0067

Notes:

1) Cells with values exceeding the MMER guidelines are highlighted.
2) Data Source: Baffinland Iron Mills, spreadsheet file: “MS-08 Daily Discharge Results.xlsx”, by email dated 29-Jan-2018. Period:01-July-2017 to 06-Sep-2017.

APPENDIX B

Overview of Hydrological Review

Appendix B: Overview of the Baseline Hydrology Analysis

The baseline hydrology analysis included:

- A review of previously completed work (Knight Piésold 2012; Story Environmental Inc. 2016). Previous studies provided guidance to calculate instantaneous peak flows and 24-hour runoff volumes. Approaches to calculating runoff volumes for longer durations, for example for an entire freshet event, were not identified.
- An analysis of long-term climate records from Environment Canada climate stations at Clyde River and Pond Inlet and a comparison of these records with the short-term climate records from the Mary River climate station:
  - The short-term Mary River climate records do not include snowfall or snowpack monitoring. The comparison of rainfall records indicate larger rainfall depths at the Mary River project site than at the climate stations at the coast. This is very likely due to the large elevation gradient.
  - Golder completed an extensive analysis and modelling of freshet volumes based on the snowfall records at the Clyde River climate station. Golder acknowledges that the applicability of these estimates to the Mary River mine site is questionable because of likely differences between snowfall quantities at the site and on the coast. These estimates were used as an initial approach to analyse required treatment rates to manage waste rock pile runoff.
- An analysis of stream flow records from BIM Mary River mine environmental monitoring program and from Environment Canada neighbouring stream flow station:
  - Golder selected the monitoring station H07 as the most representative for the waste rock pile hydrology. The drainage area of the station is largely composed of high-elevation, well graded terrain without ponding.
  - Data from other monitoring stations were correlated to H07 records to allow extending the length of the H07 stream flow time series. 11 years of nearly complete values were thus constructed; they form the basis of the subsequent analysis.
  - Statistical analysis was used to extract runoff volumes from the 11 year time series for 1:2 year to 1:100 year frequencies and for durations of 1 day to 100 days. This allowed developing 1:2 year to 1:100 year design events.
  - The comparison of these runoff volumes, which are based on local streamflow records, with the runoff volumes, which are based on Clyde River snowfall records, pointed to relatively close values. Golder considers the streamflow based volumes to be more reliable and recommends their adoption for the current design.

The main uncertainties associated with the proposed approach of using streamflow based runoff estimates for the design of the waste rock pile water management system are:

- 11 years of data would be sufficient typically to provide robust estimates of design events for return periods of up to 25 years. There is significant uncertainty in extrapolating the frequency analysis to 100 year return periods.

- Variation of snowfall and rainfall volumes with elevation within the H07 drainage area can be significant. Wind redistribution of snow volumes can also be significant. Both aspects may impact the representability of the H07 records for waste rock pile runoffs.
- Golder assumed, based on discussions with BIM staff, that the waste rock pile will have similar hydrological properties to the natural surrounding landscape. Large differences, for example a higher infiltration capacity combined with a pile runoff attenuating effect, would render this assumption invalid.

To account for these uncertainties, Golder recommends applying a 1.2 safety factor to the estimated runoff volumes for design purposes going beyond short-term considerations. The value of the safety factor is based on professional judgement, but it does not imply that Golder is able to fully quantify the potential impact of these uncertainties.

References:

Knight Piésold 2012. Baseline Hydrology Report. Prepared for: Baffinland Iron Mine Corporation. 4 January 2012.

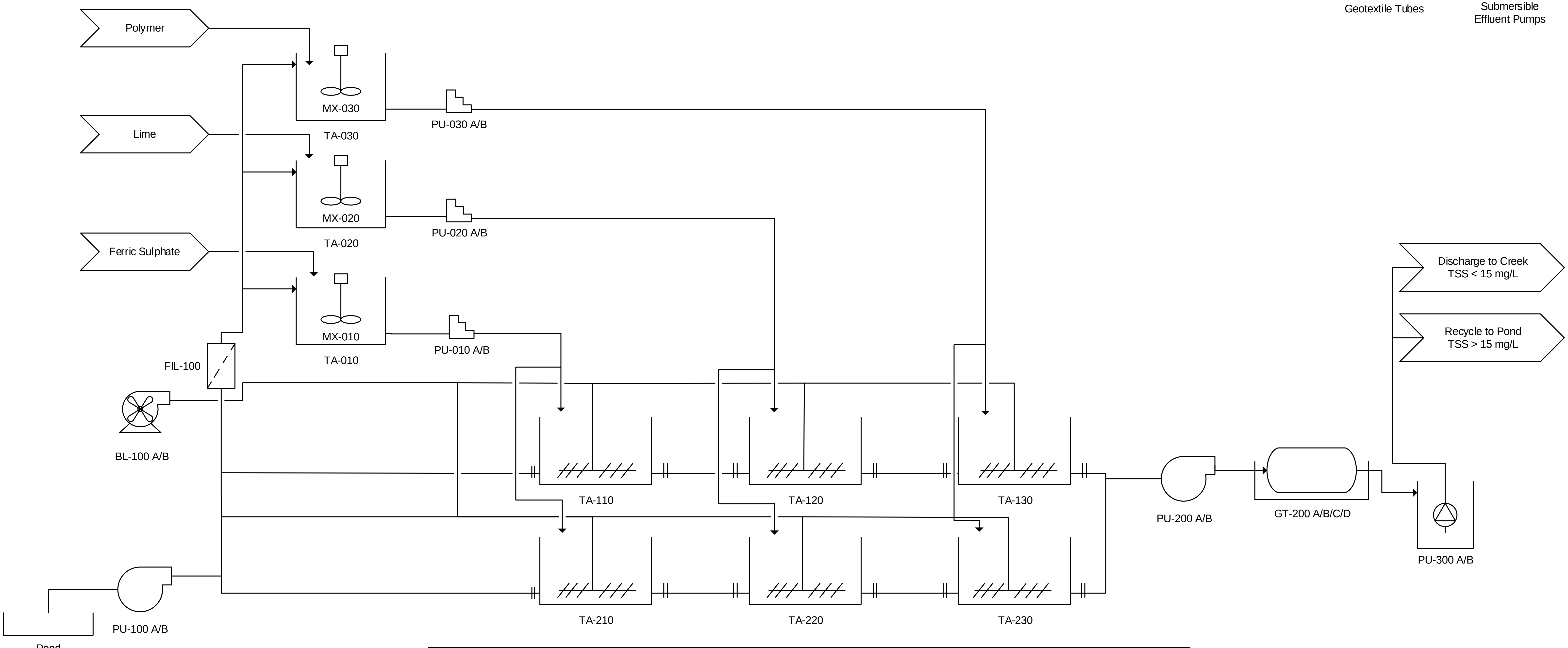
Story Environmental 2017. 2016 Hydrometric Monitoring Program. Prepared for Baffinland Iron Mines Corporation. 28 February 2017.

APPENDIX C

Process Flow Diagram

TA-010	MX-010	PU-010 A/B	TA-020	MX-020	PU-020 A/B	TA-030	MX-030	PU-030 A/B	TA-110/TA-210	TA-130/TA-230	TA-120/TA-220	FIL-100	PU-100 A/B	BL-100 A/B	PU-200 A/B
Ferric Sulphate Make-up Tank	Ferric Sulphate Tank Mixer	Ferric Sulphate Dosing Pumps	Lime Make-up Tank	Lime Tank Mixer	Lime Dosing Pumps	Polymer Tank	Polymer Tank Mixer	Polymer Dosing Pumps	Ferric Reaction Tanks	Flocculation Tanks	Lime Reaction Tanks	Bag Filter	Feed Pumps	Air Blowers	Geotextile Tube Feed Pumps

GT-200 A/B/C/D	PU-300 A/B
Geotextile Tubes	Submersible Effluent Pumps



Stream	11	12	13	14	15	16	17	18	19	20	21
Description	Feed Water	Ferric Dilution Water	Lime Dilution Water	Polymer Dilution Water	Train 1 Raw Water Feed	Train 2 Raw Water Feed	Ferric Solution Feed	Lime Solution Feed	Polymer Solution Feed	Influent to Geotubes	Final Effluent
Design Flowrate, m^3/d	6,720	1.21	12.78	40.30	3,333	3,333	1.23	13.89	40.32	6,721	6,717
Solids % w/w	0.010	0.010	0.010	0.010	0.010	0.010	10	13.6	0.05	0.015	0.001
SG	1.00	1.00	1.00	1.00	1.00	1.00	1.40	1.07	1.00	1.00	1.00

Maximum Chemical Consumption

Lime (CaO)	kg/d	2016
Ferix-3 (ferric sulphate)	kg/d	667.2
Polymer	kg/d	20.16

DRAFT

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Title

PROCESS FLOW DIAGRAM

Project Name	Project No.	FIGURE
WASTE ROCK PILE WATER TREATMENT	1665556	P1
Client Name	Date	
BAFFINLAND IRON MINES	15-DEC-17	

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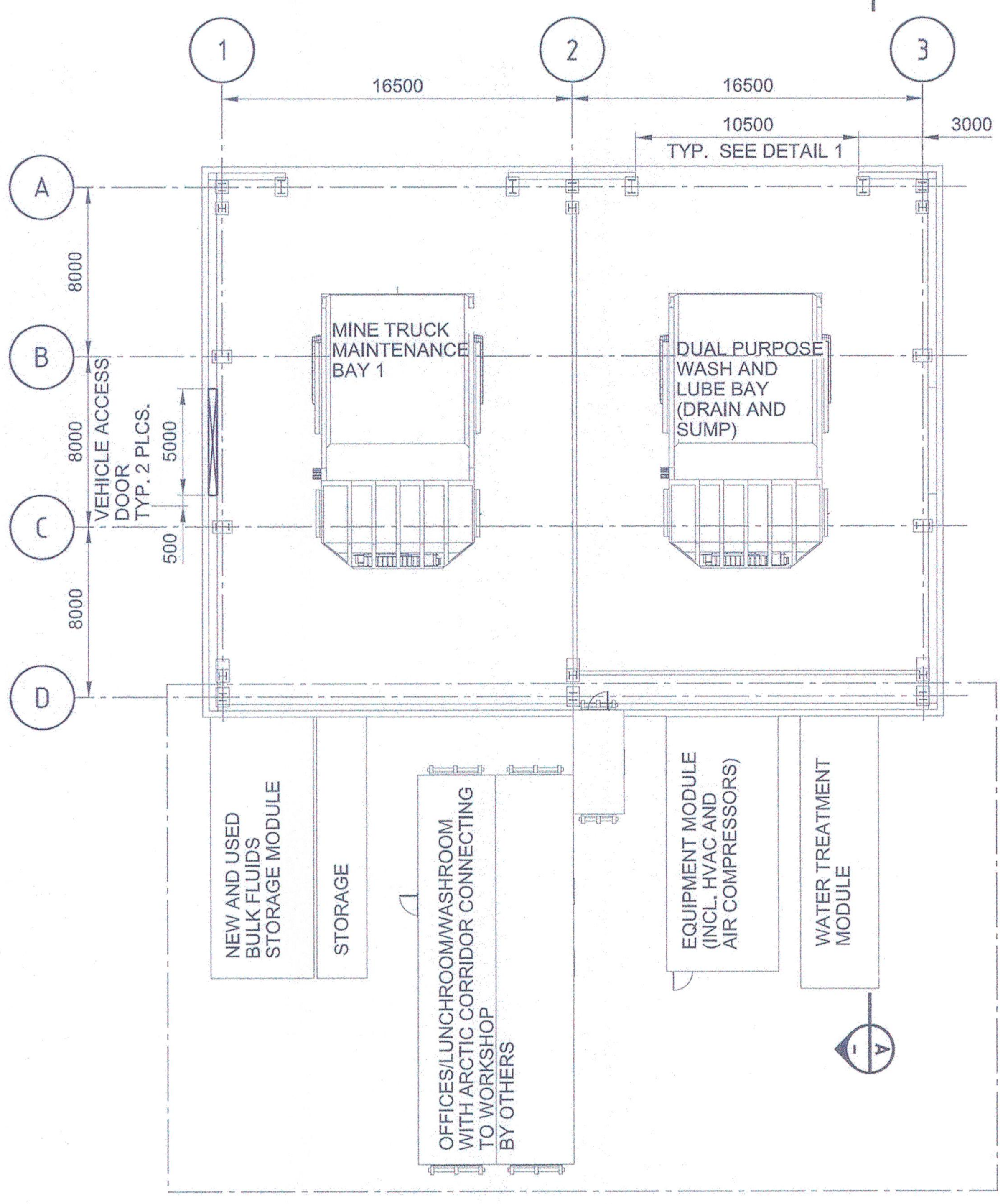
Golder Associates

Attachment 6

Mine Truck Shop General Arrangement

NOTES:
1. PERSONNEL DOORS NOT SHOWN.
2. ALL DIMENSIONS IN mm UNLESS NOTED OTHERWISE.
3. ALL ELEVATIONS ARE SHOWN IN m.

DWG. No. H353004-18000-220-272-0001-0001



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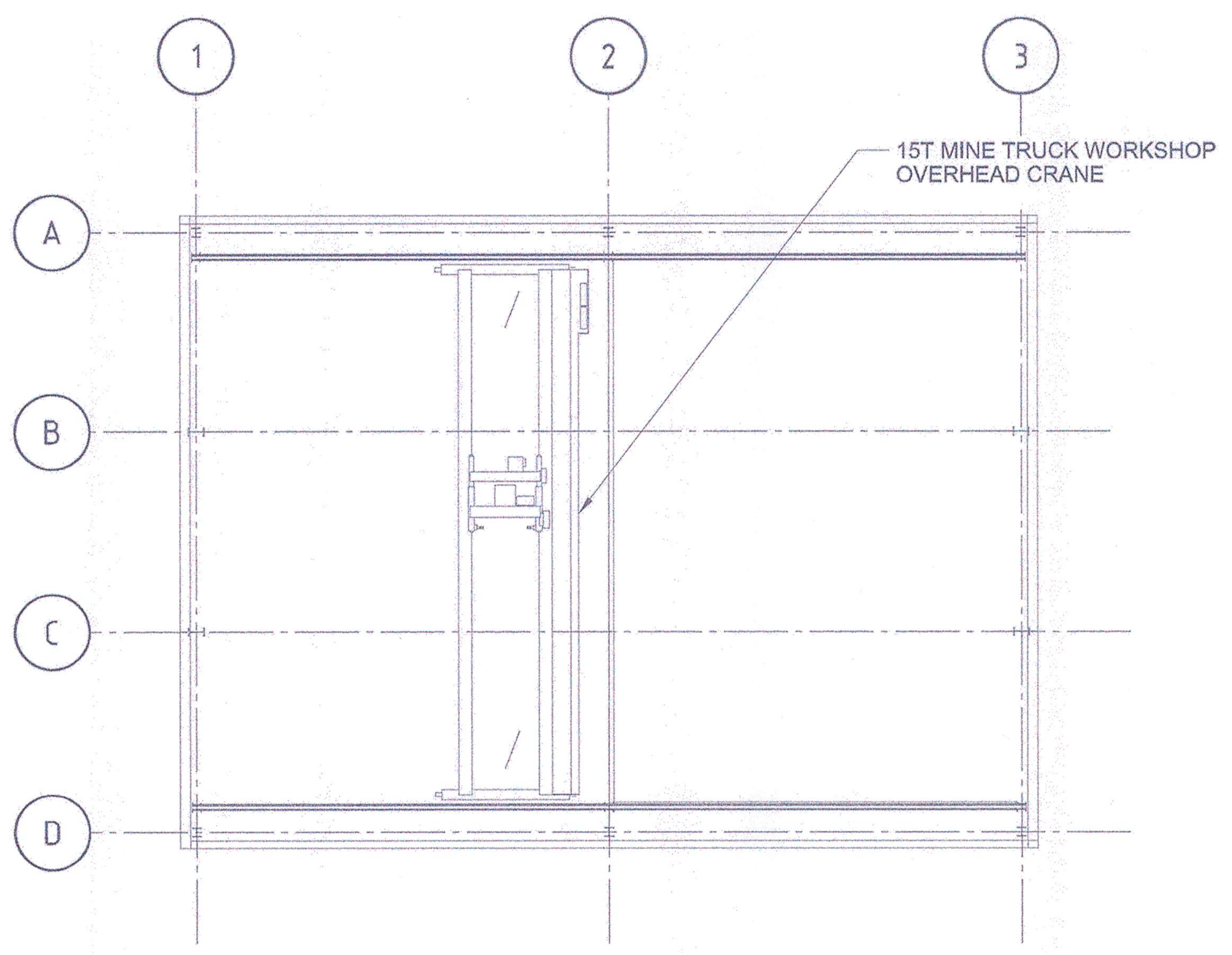
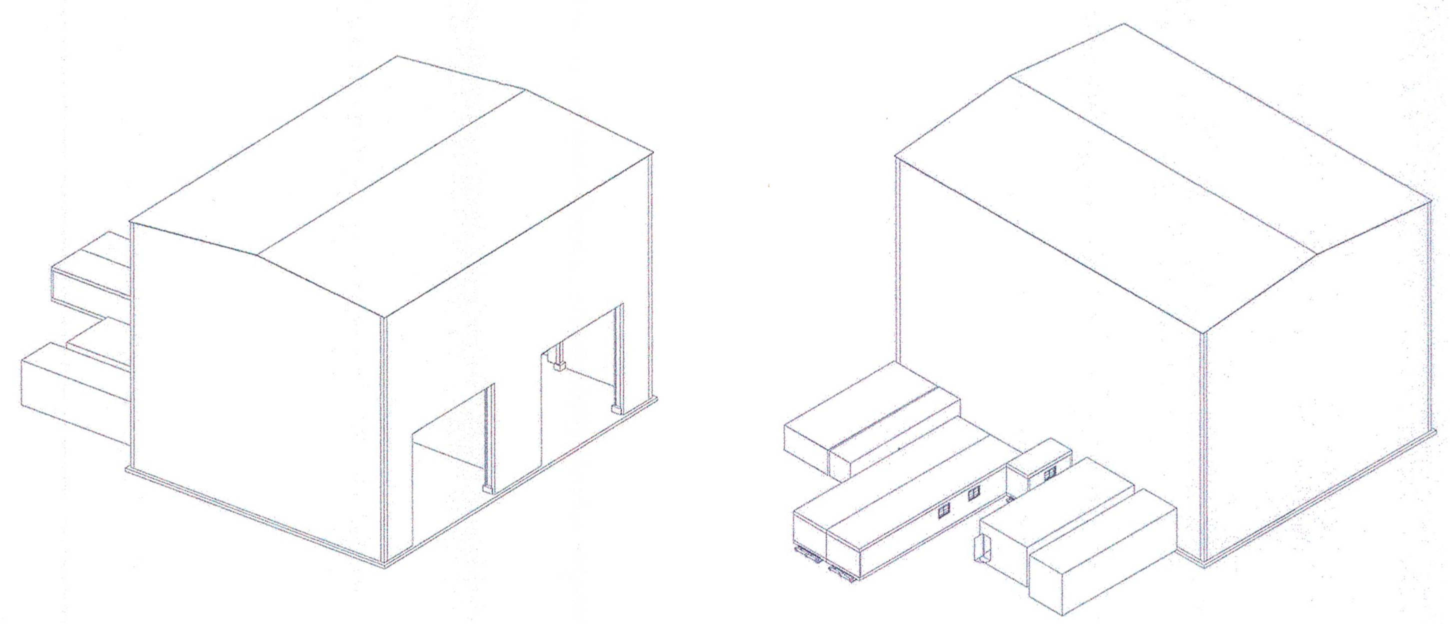
T.O.C.



PLAN AT EL. 14.0



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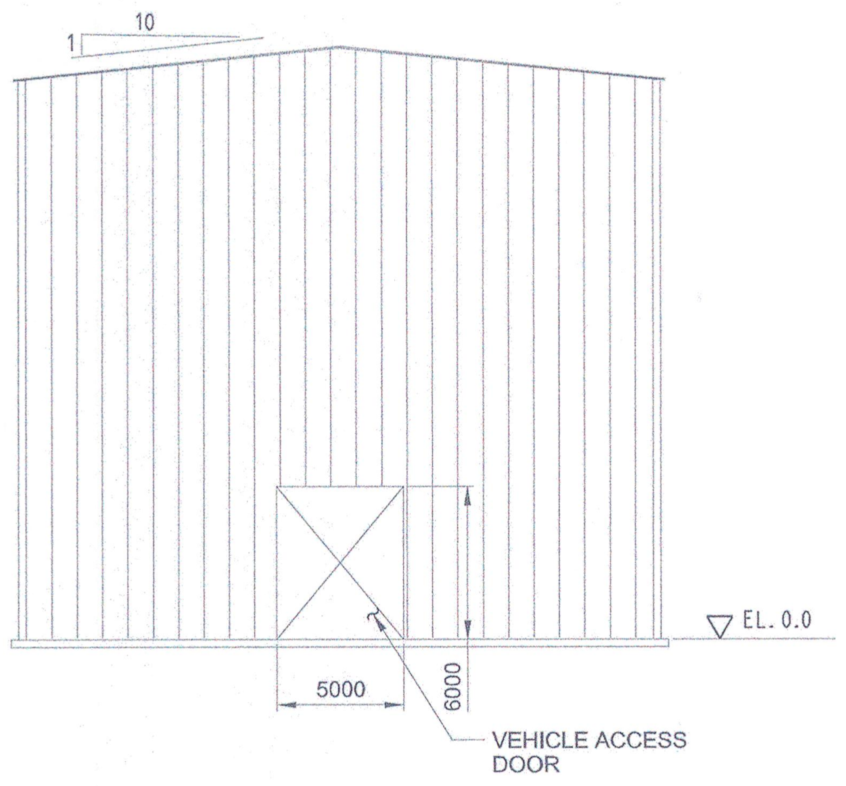
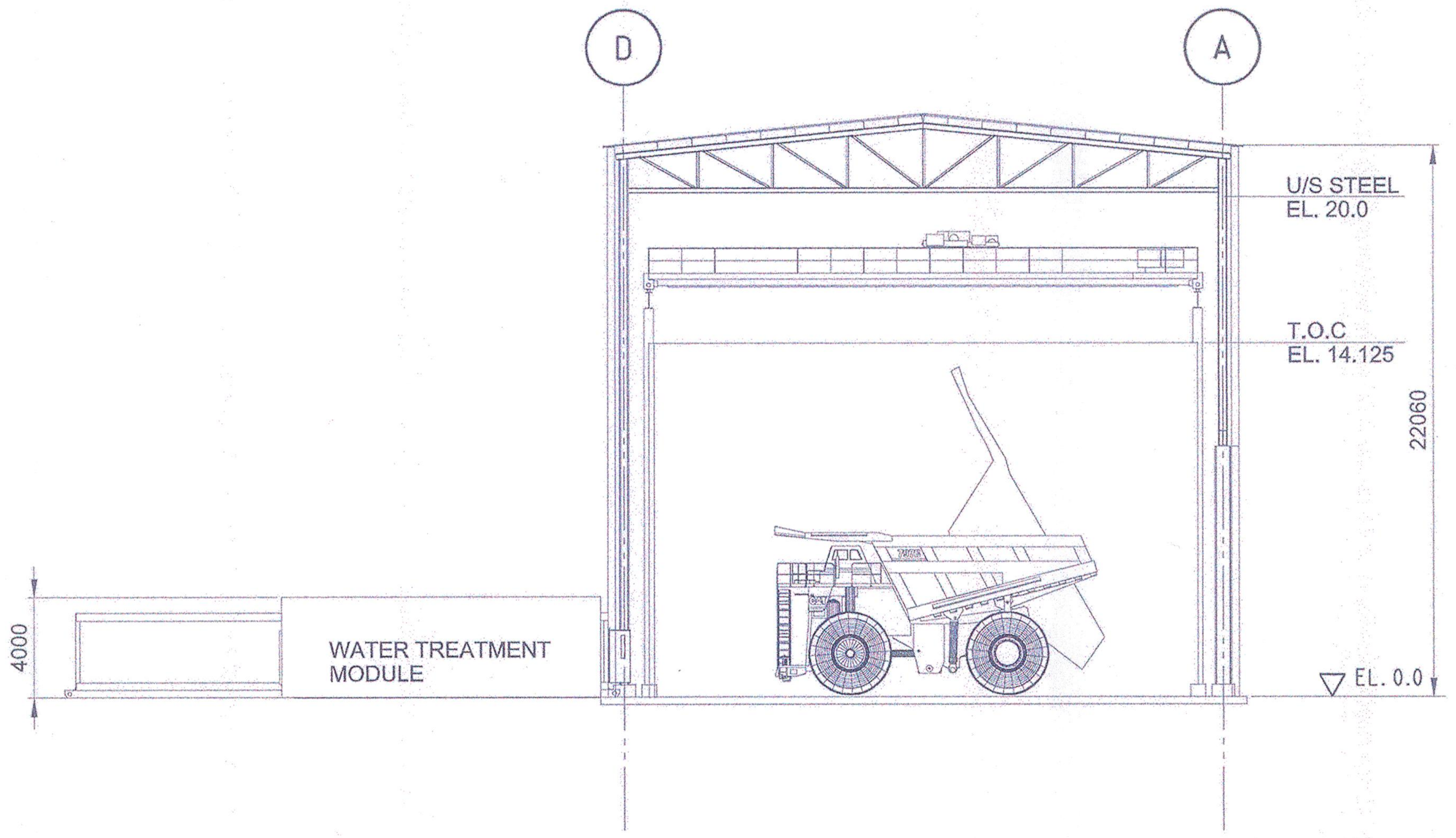
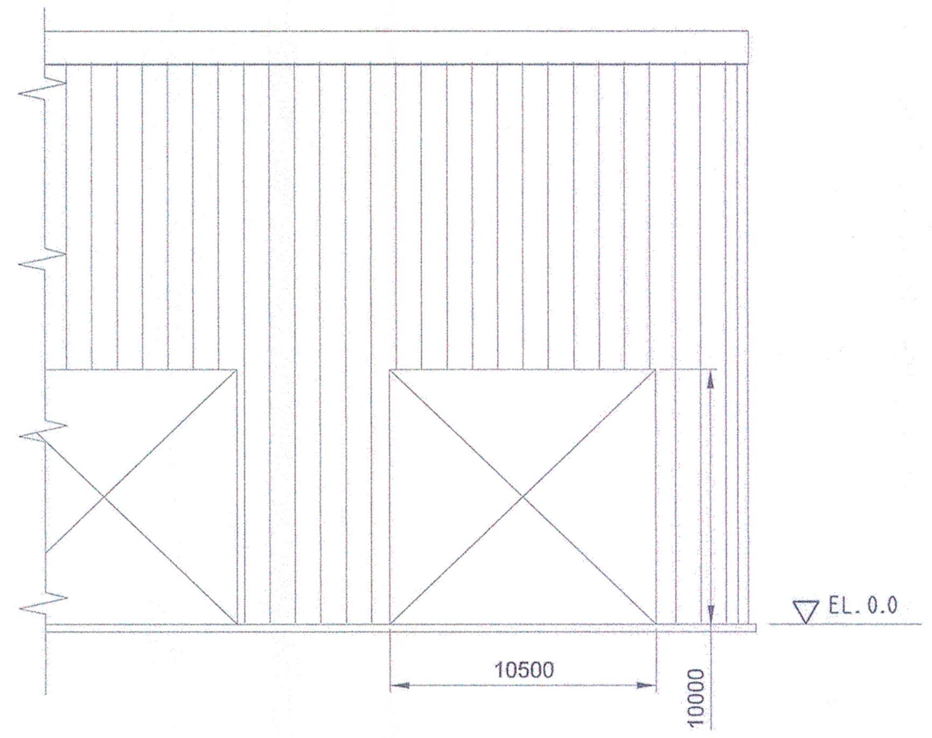


ELEVATION ON GRID 1
GRIDLINE 1 SIMILAR



SECTION A



DETAIL 1
TYPICAL TRUCK ACCESS DOOR

DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	

REG. PROFESSIONAL

HATCH

No.	DESCRIPTION	BY	CHK'D	DATE
0	APPROVED FOR BID	P.B.	J.C.	
B	APPROVED FOR BID	P.B.	J.C.	
A	CLIENT REVIEW	P.B.	J.C.	

REVISIONS

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	G. HOLM	NR	
DESIGNER	G. HOLM	NR	
CHECKER	L. DOS SANTOS		17/2/2017
DESIGN COORD.	R. GOOSEN		17/2/2017
RESP. ENG.	P. BHULLA		17/02/2017
LEAD DISC. ENG.	P. BHULLA		17/02/2017
ENG. MANAGER	J. CLELAND		17/2/2017
PROJ. MANAGER	N. MASON		17/2/2017
CLIENT	T. Atiba		14/2/17

DRAWING APPROVAL STATUS:

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION STAGE 3

MINE SITE
MINE TRUCK WORKSHOP
GENRAL ARRANGEMENT

SCALE NTS OR AS NOTED

DWG. No. H353004-18000-220-272-0001-0001

REV 0

SHEET SIZE: A1

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