REPORT

Interim Waste Rock Management Plan

Mary River Project

Submitted to:

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1.0 INTRODUCTION

Baffinland Iron Mines Corporation's (Baffinland) Mary River Project is an operational iron mine on Baffin Island in Nunavut, Canada. An estimated 640 Mt of waste rock and 32 Mt of overburden will require management from mining Deposit No. 1 (Baffinland, 2014). Baffinland has retained Golder Associates Ltd. (Golder) to assist with developing an updated waste rock management plan (WRMP) for deposition of potential acid generating (PAG) and non-PAG waste rock at their Waste Rock Facility (WRF). An updated WRMP is required to accommodate current operational constraints, address the occurrence of acid rock drainage (ARD) from the WRF, and improve the chemical stability of future PAG waste rock deposition.

This interim WRMP provides a waste rock deposition plan at the WRF through to May 2019. The deposition plan for June 2019 – December 2019 will be provided for end of March 2019 after the mining plan is finalized. Submission of the 1 to 5 Year WRMP has been deferred until sufficient site data has been collected to gain a more thorough understanding of the current state of the WRF. Instrumentation installed in December 2018 is expected to provide insight into the internal temperature at shallow borehole and trench locations on the WRF. Additional thermistors and oxygen sensors will be installed in deeper boreholes in 2019. The instrumentation results will allow for a better understanding of the mechanisms driving ARD production and allow for mitigation strategies to be better incorporated into the 1 – 5 Year WRMP.

This Interim WRMP is intended to provide an incremental update to the Interim WRMP submitted in March 2018 (Golder, 2018a). A revised interim waste rock placement strategy is provided through to May 2019, as well as an update on the current site conditions and progress made on the 2018 geochemical characterization and instrumentation program. This interim WRMP is intended to temporarily supersede the waste rock placement criteria approved under the Life of Mine WRMP (Baffinland, 2014). An updated 1 to 5 Year WRMP plan is anticipated for submission in December 2019.

2.0 WASTE ROCK CHARACTERIZATION

2.1 Deposit Geology

Deposit No.1 occurs at the nose of a syncline plunging steeply to the north-east (Aker Kvaerner, 2008). The iron formation occupies the nose and two limbs of this feature with a ~1,300 m long northern portion and a ~700 m long southern portion. The footwall to the iron formation mainly consists of gneiss with minor schist, psammitic gneiss (psammite) and amphibolite. The hanging wall is primarily composed of schist and volcanic tuff with lesser amphibolite and metasediment.

The hanging wall primarily encompasses chlorite–actinolite schist and garnetiferous amphibolites. Metavolcanic tuff is also a significant lithology identified in the hanging wall. The footwall mainly consists of quartz-feldspar-mica gneiss with lesser meta-sediment (greywacke) and quartz-mica schist. Microcline and albite are the predominant feldspars within the gneiss and biotite is generally more abundant than muscovite.

The iron ore deposits at the Mary River project represent high-grade examples of Algoma-type iron formation and are composed of hematite, magnetite and mixed hematite-magnetite-specular hematite varieties of ore (Aker Kvaerner, 2008). The iron deposits consist of a number of lensoidal bodies that vary in their proportions of the main iron oxide minerals and impurity content of sulphur and silica in the ore. The massive hematite ore is the highest grade ore and also has the fewest impurities, which may indicate it was derived from relatively pure magnetite or that chert, quartzite and sulphides were leached and oxidized during alteration of the iron formation.

Intense deformation and lack of outcrop limit the ability to subdivide by lithology on the basis of future mined tonnages.

2.2 Geochemistry Update

Metal leaching and acid rock drainage (ML/ARD) characterization studies in support of the LOM pit waste rock are provided in the report entitled "Mine Rock ML/ARD Characterization Report Deposit 1, Mary River Project", March 2014 as appended to the LOM Waste Rock Management Plan (Baffinland, 2014). Additional investigations have been completed specifically for the 5 year open pit and in response to observed acidic conditions within the current waste rock pile (AMEC, 2014 and AMEC, 2017).

A field program was undertaken in December 2018 to further characterize the waste rock deposited at the WRF. It is anticipated that preliminary data from the field program (lab results and site measurements) will be available in February 2019.

2.2.1 2018 Geochemistry Results

The following section provides a summary of the water quality and geochemistry testing results collected by Baffinland in 2018.

Water Quality (Waste Rock Facility Pond and nearby seepage)

Seepage water quality was monitored at 13 seepage locations around the WRF as shown in Figure 1. Two of the locations (MS-08-WEST-INFLOW and MS-08-EAST-INFLOW) were sampled between June and September for general field parameters. One sample from MS-08-WEST-INFLOW was submitted for trace metal analysis. The remaining 11 seepage locations were sampled between 1 September 2018 and 4 September 2018 for general field parameters and trace metal analysis. Seepage from all locations monitored is located within the current containment of the WRF and reports to MS-08.

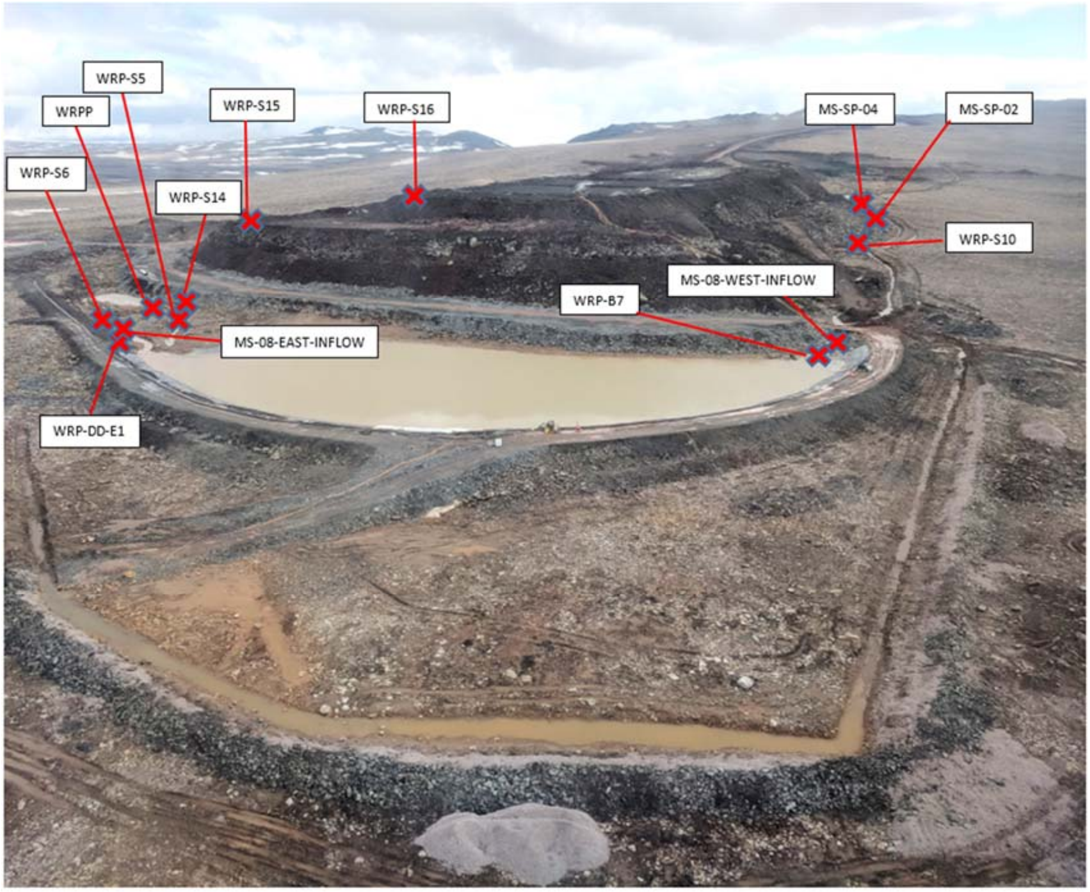

Figure 1: WRF Seepage Monitoring Locations

Seepage pH values ranged from 4.2 to 8.3 with three locations having moderately acidic conditions (4.5 > pH > 3.5, with minimum observed value of pH 4.2). Five locations had slightly acidic conditions (6 > pH > 4.5) and the remaining five locations had circumneutral conditions (9 > pH > 6). A total of 12 seepage samples were submitted for trace metal analysis. The results of key parameters are summarized as follows:

- Aluminum concentrations ranged from <0.05 to 165 mg/L with the highest concentrations observed at seepage location at MS-SP-02;
- Arsenic ranged from <0.0010 to 0.015 mg/L;
- Copper concentrations ranged from <0.010 to 1.0 mg/L with the highest concentrations observed at seepage location MS-SP-02 (1 mg/L) and WRPP (0.6 mg/L);
- Iron concentrations ranged from <0.10 to 6,870 mg/L;
- Nickel concentrations ranged from <0.0050 to 34.6 mg/L with the highest concentrations observed at seepage location MS-SP-02 (34.6 mg/L) and WRP-S10 (6.4 mg/L); and,
- Zinc concentrations ranged from ;<0.30 to 3.5 mg/L with the highest concentrations observed at seepage location MS-SP-02 (3.5 mg/L) and WRP-S10 (0.80 mg/L).

Water quality was monitored throughout 2018 at the WRF pond discharge (MS-08). Water required neutralization and settling at times during the summer and fall of 2018 prior to discharge. A total of 62 samples were collected from the discharge. The results of key parameters are summarized as follows:

- pH values ranged from 6.8 to 9.4;
- Total suspended solids in the discharge ranged from 2 to 29.2 mg/L;
- Sulphate concentrations ranged from 2,340 to 10,600 mg/L (six samples), and;
- Total concentrations of all key metals (e.g., arsenic, copper, lead, nickel and zinc) were below MDMER guidelines.

ABA and Total sulphur

Blast hole geochemical data from 2018 was reviewed for comparison to the original 5 year open pit characterization (AMEC, 2014). A total of 11,965 samples were submitted for total sulphur analysis with 13.5% of the samples classified as waste rock material (11.2% non-PAG and 2.3% PAG). PAG waste rock represented 17.2% of the waste rock material generated during 2018 which is greater than the assumed 10% for the five-year pit. Total sulphur content ranged from 0.003 to 0.2 wt% as S with an average of 0.039 wt% as S in the non-PAG waste rock. PAG waste rock had total sulphur content ranging from 0.21 to 10.3 wt% as S with an average of 0.92 wt% as S. Total sulphur was greater than 0.2% in 7.6% of the overall 2018 blast hole data (i.e., including waste rock and ore material) compared to 10% for the five-year pit. ABA analysis was completed on 260 samples of waste rock material (6 samples of non-PAG and 254 samples of PAG). Neutralization Potential (NP) ranged from -5 to 25 (tonnes $CaCO_3$/ 1000 tonnes) and Acid Potential (AP) ranged from 6.3 to 322 (t $CaCO_3$/ 1000 t). Neutralization Potential Ratio (NPR), expressed as the NP divided by the AP, ranged from 0.3 to 3.7 in the non-PAG samples and from -0.15 to 3.81 in the PAG samples. It should be noted that a direct comparison of blasthole data and the core sample results from the geochemical characterization is difficult, because NPR was determined mostly on blastholes samples of >0.2% sulfur (thus skewing the average to lower NPR values).

Soluble sulphates

Soluble sulphate minerals release stored acidity upon dissolution unlike sulphide minerals which release acidity based on their rate of oxidation. Soluble sulphate minerals provide an immediate source of acidity but typically over a shorter time frame when compared to the acidic generation from sulphide oxidation. The iron sulphate mineral melanterite has been observed within the WRF. Dissolution of soluble sulphate minerals may be a key source of the acidic drainage currently observed from the WRF. Geochemical samples have been collected during the 2018 geochemical evaluation program (Section 2.2.2) and will be submitted for geochemical analysis. Additional investigation into the presence of soluble sulphate minerals will also be a part of the planned 2019 geochemical program.

2.2.2 2018 Geochemical Evaluation

Given the differences between predicted geochemical conditions for the five year pit and observed acidity on site, a geochemical evaluation program was designed to characterize the waste rock deposited at the WRF and to monitor the thermal and chemical performance. A plan view of the planned instrument installation locations is provided as Figure 2. The program includes the following:

- Installation of thermistor strings at 5 boreholes (T1, T2, BH1, BH2, and BH3) and 3 horizontal installations (T3, T4, and T5).

- Three boreholes drilled through the WRF crest (BH1, BH2, and BH3), one borehole at the WRF north toe (T2), and one borehole within the WRF Pond berm expanded footprint (T1). Boreholes extend up to 6.5 m into native ground below the WRF.
- Three horizontal thermistor installations laid out on the current WRF crest (T3, T4, and T5).
- Typical thermistors sensor spacing from 0.5 m – 3.0 m. A total of 125 thermistor sensors will be installed.

- Installation of 9 oxygen sensors at BH1 (4 sensors) and BH2 (5 sensors). Sensors are located throughout the WRF profile.
- Drill cuttings from the proposed boreholes will be sampled and sent for geochemical characterization.
- Excavation of test pits within the WRF for waste rock grab sampling. Test pits to target locations of the WRF where acidic seepage has been identified (to be completed prior to winter 2019).

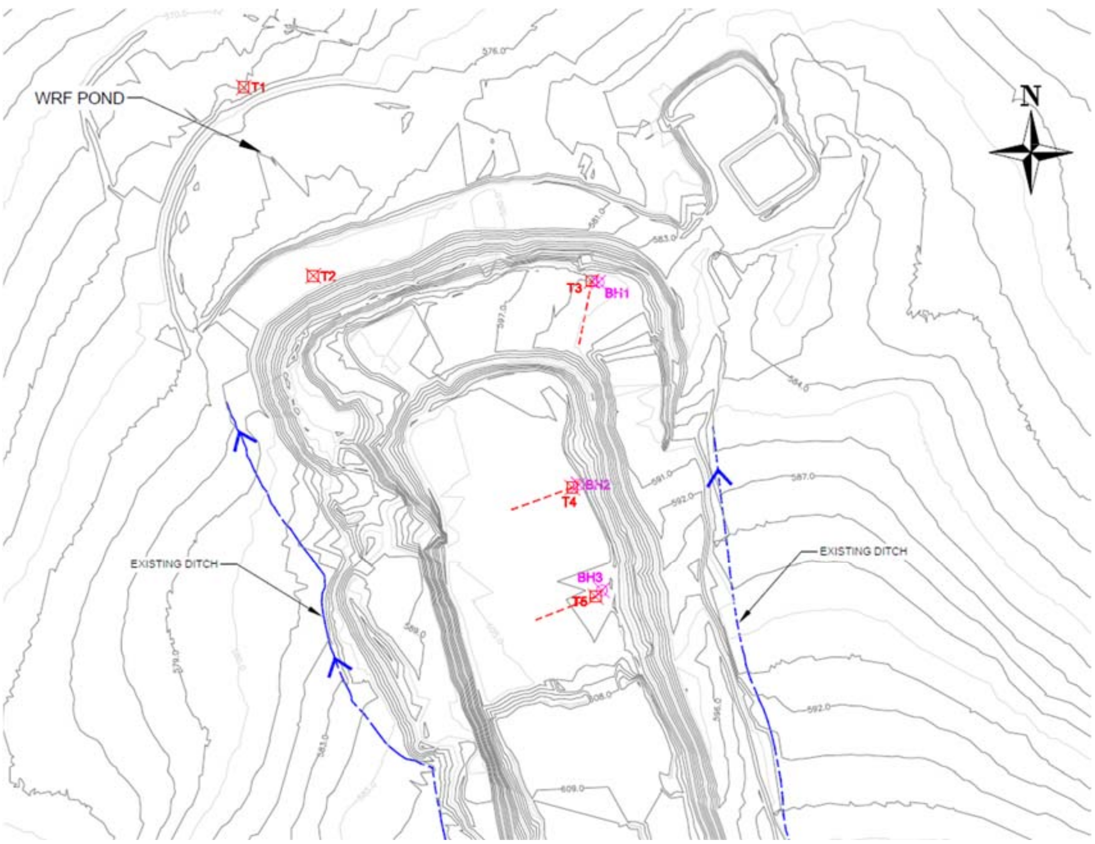

Figure 2: Instrumentation Plan

During the December 2018 program thermistors were installed at locations T1 through T5 and BH3, however, due to logistical challenges thermistors at locations BH1 and BH2 as well as oxygen sensors at these locations will be installed in 2019. All installed instruments are recording readings on 8h intervals. The instruments are currently equilibrating and therefore no data is currently available. The test pitting program has been deferred until summer 2019 when seepage locations can be identified.

2.2.3 Water Quality Modelling

An updated water quality model will be prepared following collection and analysis of the 2018 instrumentation data (thermistor, oxygen sensor, and geochemical samples) and 2019 test pitting data.

A mass-balance based model approach will be used to develop water quality predictions that take into consideration the waste rock deposition plan, water balance and geochemical data. Infiltration and runoff flow estimates will be assigned water quality source terms to predict seepage and runoff water quality corresponding to the 1-5 Year WRMP. Existing data and new results from laboratory-scale geochemical tests will be used to develop mass loading source terms for each of the main material types present in the WRF. The results of laboratory scale tests will be used to develop specific scenarios in terms of particle size distribution, water-to-rock ratios, temperature, and availability of atmospheric gases that could influence material reaction rates (e.g., oxygen and carbon dioxide).

The results of the water quality modelling will be included with the 1-5 Year WRMP submitted in December 2019.

2.2.4 Thermal Modelling

A thermal model of the WRF will be completed once sufficient site data has been collected for model calibration. The thermal model will consider the waste rock deposition plan, atmospheric conditions, and stockpile chemistry. The thermal model is expected to provide an estimate of the freeze-back time for the WRF and ability to maintain the WRF in a frozen state. The results of the available thermal modelling will be included in the 1 to 5 year WRMP submitted in December 2019.

For the current interim update preliminary thermal models were prepared to assess the time for waste rock to freeze under varying deposition and climatic conditions. The model results were used as a guideline for the waste rock deposition plan (Section 5.4). Transient one-dimensional thermal models were prepared using the finite element software TEMPW2018 (version 9), developed by Geoslope International Ltd. A description of the different model components are discussed in the sections below.

2.2.4.1 Model Scenarios and Geometry

A sequential model was prepared to assess the time for waste rock placed during fall and early winter to freeze. The model geometry consisted of an initial 2.5 m thick layer of thawed waste rock (permafrost active layer) assumed to have been deposited on top of a 5 m thick layer of frozen overburden underlain by 10 m of frozen bedrock. Subsequently, two additional 2 m thick thawed lifts of waste rock were assumed to be placed on top of the existing lift on September 1 and October 30, as shown in Figure 3.

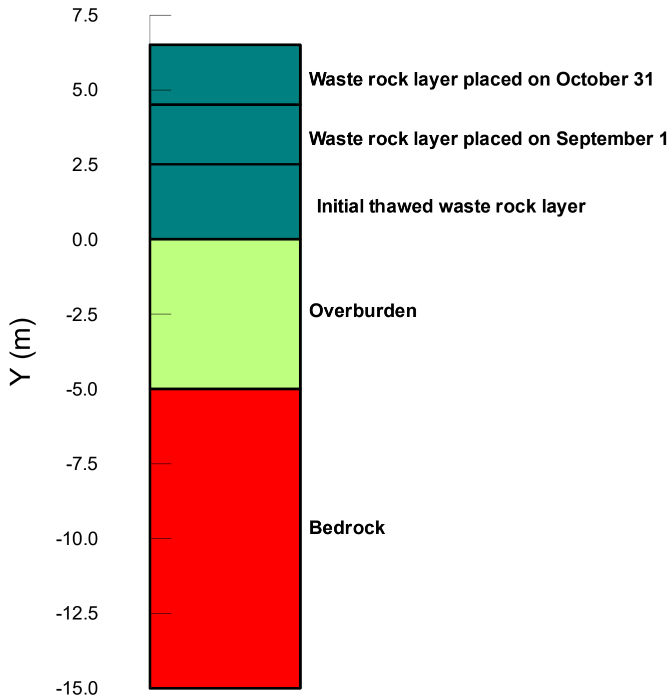

Figure 3: Sequential thermal model geometry

The model was run from September 1 to December 31 to compute time for freezing of the rockfill layers under two model scenarios as summarized in Table 1.

Table 1: Summary of sequential thermal model scenarios.

Model Scenario	Configuration (top to bottom)	Model Duration	Initial Temperatures
Initial Conditions	2.5 m waste rock 15 m foundation	Steady-state	Top of waste rock: 10°C Base of waste rock: 0°C Bedrock: -3°C
One additional waste rock lift placed on September 1	2 m waste rock 2.5 m waste rock 15 m foundation	September 1 to December 31	September 1 waste rock lift: 10°C. Previous lift and foundation: Temperature from initial conditions model.
Two additional waste rock lifts placed on September 1 and October 31	2 m waste rock 2 m waste rock 2.5 m waste rock 15 m foundation	October 31 to December 31	October 31 waste rock lift: 5°C Previous waste rock lifts and foundation: Temperature from previous models.

The initial temperature profiles presented in Table 1 are conservative estimates. The actual waste rock temperatures will be periodically measured at the time of haulage and the modelling correspondingly updated, as required.

In addition to the sequential model scenarios presented above, transient models were performed to estimate the duration of time required for a single 2 m thick waste rock layer at an initial temperature of +5°C to freeze under a range of constant surface temperatures from -5°C to -25°C. Additional initial rock temperatures will be reviewed during operations and the modelling updated, as required, to reflect field conditions.

Refer to Section 2.2.4.3 and 2.2.4.4 for the model results.

2.2.4.2 Material Properties and Model Boundary Conditions

Material properties adopted for the models were assumed based on professional judgement and experience with similar projects and are summarized in Table 2.

Table 2: Summary of Material Properties

Material	Volumetric Water Content (m^3/m^3)	Volumetric Heat Capacity ($MJ/m^3/°C$		Thermal Conductivity (W/m/°C)	
		Frozen	Unfrozen	Frozen	Unfrozen
Waste Rock	0.06	1.5	1.7	1.3	1.1
Overburden	0.20	1.6	2.1	2.0	1.5
Bedrock	0.05	2.4	2.4	3.0	3.0

A constant temperature of -3°C was assumed for the bedrock at the base of the model geometry (i.e. depth of 15 m).

For the sequential model scenarios described in Table 1, a ground surface temperature function was applied to the top of the model geometry. Ground temperatures are typically warmer than air temperature due to the process of energy absorption and radiation from the ground to the atmosphere. For this conceptual model, ground temperature was defined using multipliers of 0.7 for winter and 1.3 for summer applied to the average monthly air temperature. Table 3 summarizes the average monthly air temperatures obtained from the Mary River station between August 2014 and August 2017, as well as the ground temperatures defined for the models.

Table 3: Average air temperatures and ground temperatures defined for the thermal models.

Month	Average Air Temperature (°C) (Mary River Station from August 2014 to August 2017)	Defined Ground Temperature (°C)
January	-29.1	-20.4
February	-32.9	-23.0
March	-29.8	-20.9
April	-17.9	-12.5
May	-5.9	-4.1
June	4.2	5.5

Month	Average Air Temperature (°C) (Mary River Station from August 2014 to August 2017)	Defined Ground Temperature (ºC)
July	10.7	13.9
August	8.1	10.5
September	-1.5	-1.1
October	-10.1	-7.1
November	-22.1	-15.5
December	-30.6	-21.4
Average	-13.1	-8.0

For the model scenario aimed to assess the duration of time required for a single 2 m thick lift of waste rock at initial 5ºC to freeze, constant temperatures of -5, -10, -15, -20 and -25ºC were applied to the top of the model geometry. The purpose of this modelling was to gain a preliminary understanding of the time for waste rock to freeze under varying climatic conditions. Additional initial waste rock temperatures will be reviewed during operations and the modelling updated, as required, to reflect field conditions.

2.2.4.3 Thermal Model results – Sequential Deposition

Figure 4 presents the evolution of temperatures within the foundation, summer waste rock lift (permafrost active zone), and waste rock lift deposited on September 1 from the initial thawed conditions on September 1 to December 31.

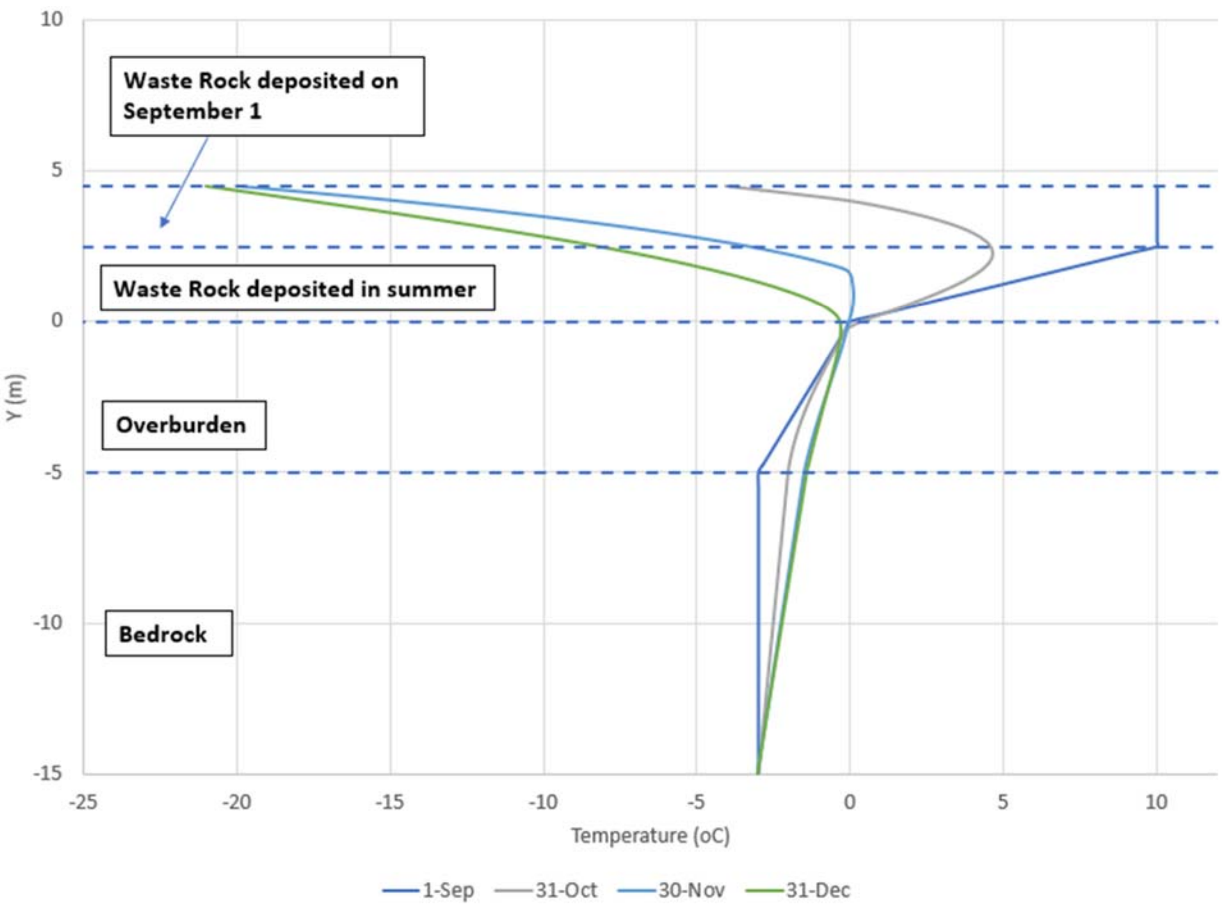

Figure 4: Evolution of temperatures within foundation and waste rock considering placement of one 2 m thick waste rock layer on top of the pile on September 1.

As seen in Figure 4, the model results indicate if a 2 m thick layer of waste rock initially at 10ºC is placed on top of 2.5 m of thawed waste rock, it would take about three months from September 1 to November 30 for the entire 4.5 m thick layer of thawed waste rock to freeze.

Figure 5 shows the evolution of temperatures within the foundation and waste rock considering placement of two 2 m thick waste rock lifts – one on September 1 (waste rock at 10ºC) and the other on October 30 (waste rock at 5ºC), on top of a 2.5 m waste rock layer of thawed waste rock.

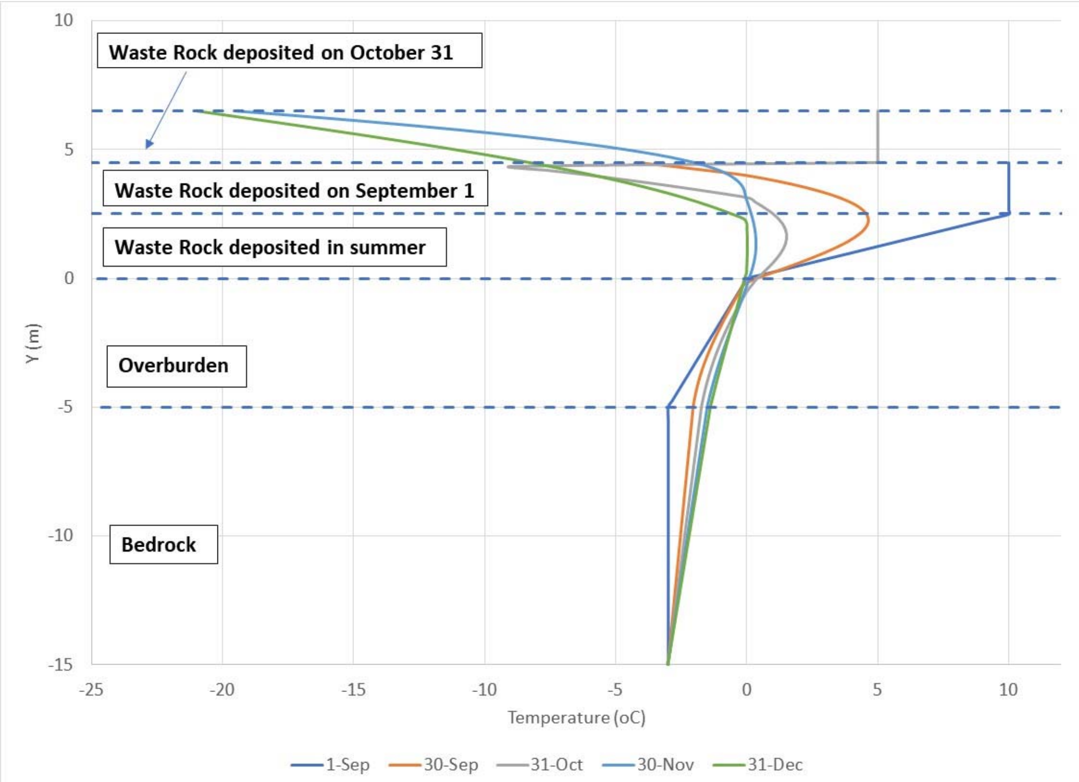

Figure 5: Evolution of temperatures within foundation and waste rock considering placement of two additional waste rock layers on top of thawed waste rock.

The models show that, with deposition of an additional 2 m layer of waste rock in Fall, the freezing time would increase and the entire 6.5 m of waste rock would be frozen by the end of the year on December 31.

2.2.4.4 Thermal Model results – Constant Surface Temperature

Figure 6 provides the relationship between the average ground temperature and time required for a 2 m thick layer of waste rock at initial temperature of +5°C to freeze. Separate models were run for each ground temperature value, and a fitting curve was obtained from the combined results.

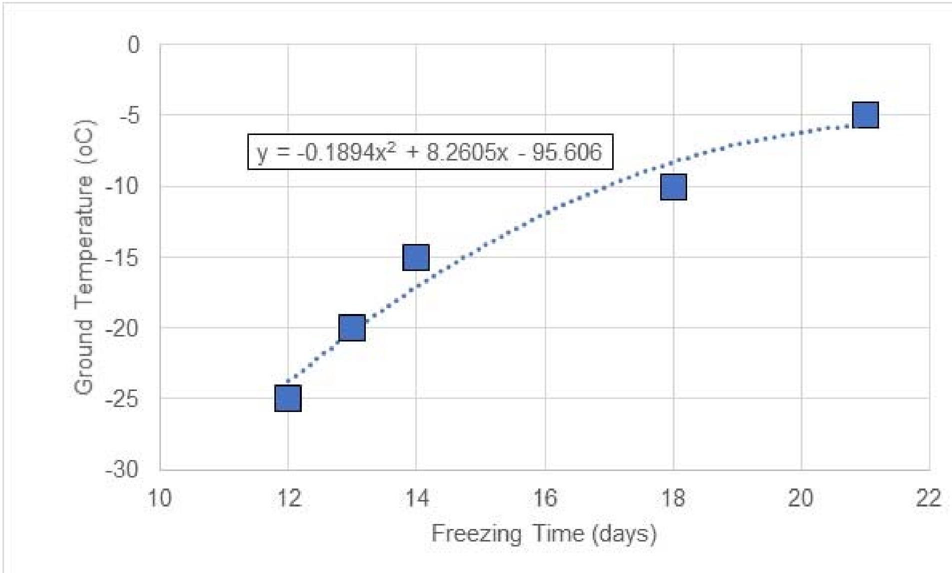

Figure 6: Conceptual relationship between ground temperature and freezing time for a 2 m thick waste rock placed at initial temperature of 5°C.

The models showed that it would take between 12 and 21 days for temperatures within a 2 m thick layer of waste rock to lower to 0°C or less, assuming an initial deposition temperature of 5°C. It is important to note that the existence of a thick snowpack on top of waste rock will have an insulation effect, causing ground temperature to be much warmer than air temperature and increasing freezing times.

2.3 Estimates of PAG and non-PAG rock (November 2018 through December 2019)

The projected quantities of waste rock to be stored at the WRF were provided by Baffinland on 21 December 2018, and are summarized in Table 4. Waste rock tonnages have been presented based on winter (November through May) and summer (June through October) deposition conditions. Waste rock tonnages may be revised as the mining plan from June 2019 – December 2019 has not yet been finalized.

Table 4: Estimated in-situ waste rock tonnages

Period	Tonnage of Non-PAG (t)	Tonnage of PAG (t)	Total Tonnage of Waste Rock (t)
December 2018 through May 2019	715,993	329,919	1,045,912
June through October 2019	989,359	321,164	1,310,523
November through December 2019	916,248	159,852	1,076,100
Total	2,621,600	810,935	3,432,535

For 2019, PAG waste rock will continue to be identified by processing on-site analytical data from blast hole drill cutting samples. Laboratory determination of PAG waste materials will be completed using total sulphur analysis by Leco sulphur analyser and guidance provided in the report on ML/ARD characterization for a five year pit (AMEC, 2014). Materials identified with total sulphur content greater than 0.20% will be considered PAG rock or subjected to standard ABA testing for confirmation as either PAG or non-PAG rock. Net Acid Generation (NAG) testing or short-term leach (STL) pH testing may also be used as a screening tool for this purpose. The on-site processing of blast hole samples in the on-site laboratory will allow timely development of the mine scheduling plan.

The blast hole results are used to divide the blast pattern up into minable units. A minable unit is considered to be anything greater than 125 m^2. If a continuous area of material can be isolated within a blast with a surface area that is 125 m^2 or greater, with a total sulfur content >0.2% and NPR <2, it is identified as PAG and this material is staked out in the field after the blast and then hauled to a specific PAG designated location at the WRF.

3.0 WRF WATER MANAGEMENT

The following section discusses water management at the WRF. All runoff from the WRF is currently collected in a series of perimeter ditches and directed towards the WRF Pond.

3.1 Runoff Management

The existing WRF footprint is located within the western watershed which drains into Camp Lake. A series of ditches excavated around the perimeter of the WRF direct runoff and seepage from the WRF to the WRF Pond which is located at the north toe of the WRF. Collected flows are passed through a water treatment plant (WTP) and discharged to the catchment of a Mary River tributary. Figure 7 provides the current WRF and runoff management ditch configuration.

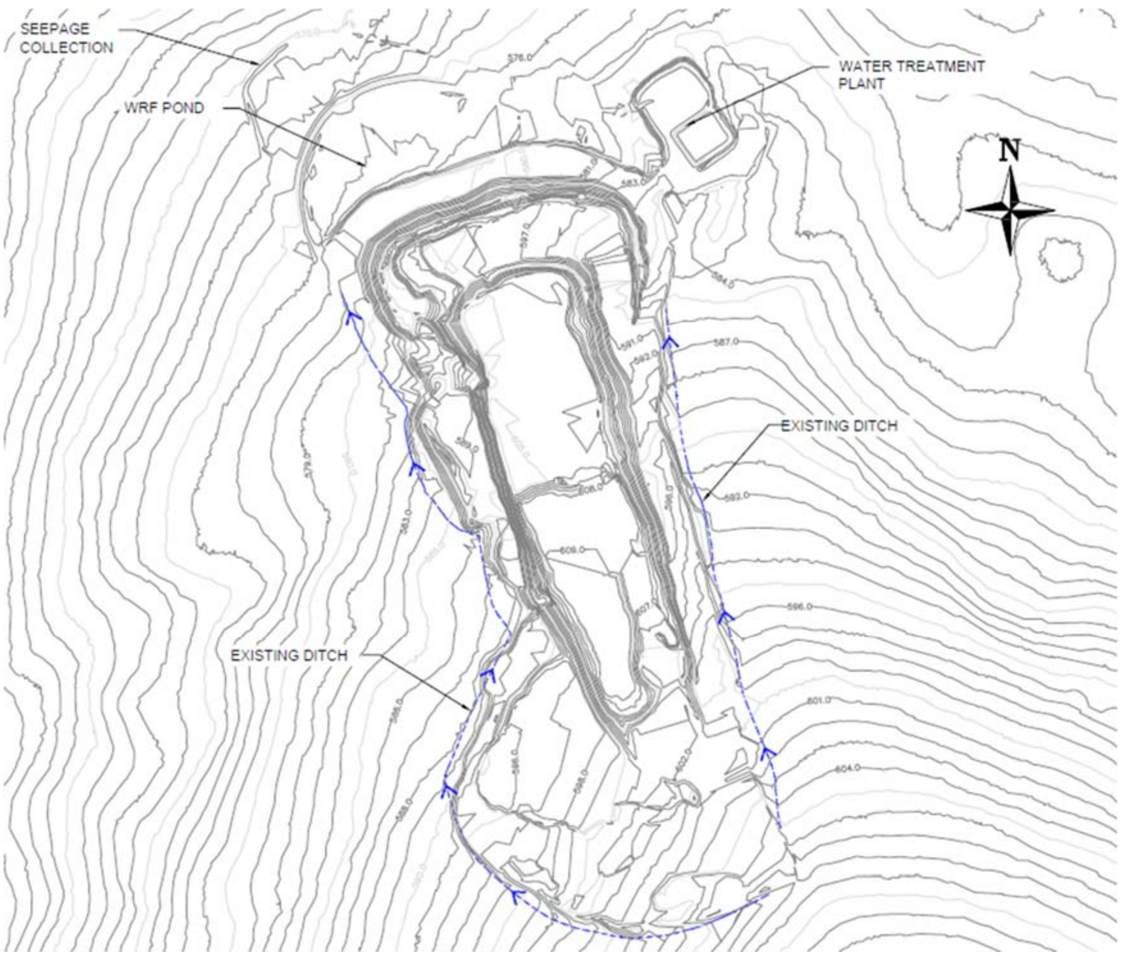

Figure 7: WRF Water Management

No updates to the perimeter ditches are proposed until the WRF Pond expansion (Section 3.3) has been constructed. Once the WRF Pond raise is nearing completion the new WRF perimeter ditches proposed under the WRF Pond Expansion report (Golder, 2018b) will be constructed.

3.2 Existing WRF Pond Capacity and Repair

The existing WRF Pond has a design capacity of approximately 9,000 m^3 at the maximum operating water level (MOWL) of 575.8 masl (Hatch, 2017a). The existing berm has a crest elevation of 577.0 masl and the geomembrane installed to elevation 575.8 masl. The emergency spillway is set at elevation 576.0 masl. The WRF Pond is currently sized to retain the 1:10 year 24 hour storm event (Hatch 2013). The existing pond has a surface area of approximately 9,900 m^2 at a water elevation of 575.8 masl.

Seepage through the existing WRF Pond Berm has been identified. An inspection was carried out in September 2017 to identify the seepage source (Hatch 2017b). No damage to the existing WRF Pond geomembrane was noted during the inspection and the seepage source was not conclusively determined.

An inspection of the existing WRF Pond was carried out by Golder and Layfield (liner installer) in mid-August 2018 for the purpose of identifying the source of seepage. The WRF Pond elevation at the time of the inspection was approximately 574.0 m (approximately 60% of liner visible). The results of the liner inspection is currently under review.

Seepage from the WRF Pond continues to be collected in a ditch immediately downstream of the WRF Pond berm and is pumped back to the WRF Pond.

3.3 WRF Pond Expansion

Expansion of the WRF Pond is required in support of the planned WRF expansion. A design for the WRF Pond expansion to approximately 50,000 m^3 capacity was submitted in June 2018 for approval (Golder, 2018b). Expansion of the WRF Pond is expected to be completed by October 2019.

3.4 Water Treatment

Baffinland constructed a WTP in 2018 to treat surface runoff collected at the WRF Pond. The WTP has a design treatment rate of 280 m^3/hr and employs a process of coagulation, pH adjustment, flocculation, and filtration to treat water to within the parameters outlined in the Metal and Diamond Mining Effluent Regulations (MDMER) and Type A Water Licence. Refer to Appendix A for the WTP conceptual process. Detailed engineering and verification of the treatment process was carried out by McCue Engineering Contractors.

Appendix A provides the WTP Operating Manual which includes the operating instructions as well as an overview of the treatment process, General Arrangement Drawings and Process and Instrumentation Diagrams.

Baffinland may revise the water treatment process, as required, to accommodate variability in the WTP intake chemistry to maintain compliance with the MDMER and Type A Water Licence effluent discharge requirements.

4.0 QUALITY CONTROL AND QUALITY ASSURANCE (QC/QA)

Baffinland's waste rock management plan focuses on reducing the potential for development and environmental release of ARD from the WRF through defined waste rock placement methods, collection of the WRF contact water, and treatment of collected flows to comply with MDMER and the Type A Water Licence effluent discharge requirements.

A construction quality control (QC) and quality assurance (QA) plan has been developed to assist with implementing the waste rock management plan. The QC/QA plan specifies the operational and documentation requirements that are to be followed in order to implement and verify that the waste rock deposition plan has been followed. Accurate documentation of the WRF construction will assist with further understanding and managing ARD.

A draft QC/QA plan for implementation throughout the WRF development has been submitted by Golder to Baffinland for review. Golder is currently working with Baffinland to update this document and implement the QA/QC plan in 2019.

5.0 WRF DEVELOPMENT STRATEGY

The primary objectives for the WRF development are safety of personnel/environment and long-term physical and chemical stability. Thin lift deposition of waste rock is expected to create a more homogenous stockpile and reduce segregation that may create preferential air flow paths throughout the stockpile (i.e. reduce potential for oxygen supply to PAG materials). Waste rock placement locations and lift thickness also focus on the continuous development and raising of permafrost within the WRF. It is expected that permafrost aggradation will provide an effective barrier to acid-forming reactions as absence of oxygen and water limits potential for sulphide oxidation and ARD transport.

The following WRF development strategies have been established:

- **Footprint expansion:** The first lift of the WRF on native ground shall be non-PAG waste rock. Waste rock placement over native ground shall be carried out in the winter to the extent practicable. As a minimum, placement within 10 m of the stockpile edge should be completed in winter, and/or the lift should be allowed to freeze prior to layering activities. Maintaining a frozen base and perimeter is expected to reduce potential for seepage.
- **Stockpile expansion construction**: Waste rock placed over an area of new WRF expansion shall be carried out in a manner conducive to aggrading permafrost, to limit potential for further development of ARD.
- **Material separation:** PAG waste rock shall be separated from non-PAG waste rock placement (i.e. non-PAG and PAG waste rock shall have defined placement locations). Deposition locations of the PAG waste rock shall be documented by survey.
- **Stockpile exterior face**: PAG waste rock shall be placed 10 m (minimum) interior from the ultimate stockpile face, and 2.5 m interior from an interior or temporary face. The final or temporary outer face of the stockpile shall be non-PAG waste rock. This criteria has been established to maintain the PAG materials interior from the permafrost active zone which is estimated at 2.5 m thickness. A larger 10 m buffer has been established for ultimate stockpile faces until the permafrost active zone has been better defined through thermal modelling and site measurements. Note that in this current WRMP, a 10 m buffer has been chosen due to operational considerations.
- **Lift thickness:** Waste rock placement to target 3 m maximum lift thickness. This lift thickness has been established to reduce potential for waste rock segregation during placement while remaining operationally feasible with the available equipment. Reducing segregation of deposited waste rock is expected to reduce the potential for development of preferential air flow paths that can delivery oxygen to PAG waste rock.
- **Successive lift placement:** Placement of successive waste rock lifts shall give consideration to the waste rock and environmental conditions as described below. These placement strategies may be revised as the thermal performance of the WRF becomes better understood.

- When the waste rock temperature at the time of placement is <0ºC successive lifts may be continuously placed over a given footprint.
- When the waste rock temperature is above 0ºC and the air temperature below 0ºC, the surface of the waste rock shall be kept clear of snow for the length of time specified in Figure 6 to promote permafrost aggradation prior to placement of the subsequent lift.

- **Capping winter PAG placement before summer:** To the extent practicable, PAG waste rock placed during winter shall be covered with a 2.5 m thick (minimum) layer of non-PAG waste rock prior to summer. The intention of this criteria is to maintain the permafrost active zone within the non-PAG waste rock during the summer months (i.e. maintain the PAG waste rock in a frozen state).

These development strategies will be followed to the extent practical. Modified placement strategies shall be documented, and potential issues mitigated during future pile expansion.

5.1 WRF Design Criteria

The following design criteria have been developed giving consideration the criteria established under the LOM WRMP (Baffinland, 2014):

- The WRF footprint will not be expanded beyond the limits of ditching as shown in Figure 8 until the WRF Pond has been repaired. This interim WRMP does allow for minor relocation of ditching along the SW edge of the pile to allow for construction of berms that will promote freezing of existing PAG waste rock to help limit release of ARD. This change does not materially affect the catchment area of the WRF Pond;
- Runoff and seepage from the WRF will be collected at the WRF Pond. Collected flows will be treated to comply with requirements of the Type A Water License 2AM-MRY1325 and MDMER;
- The WRF will be developed in a manner conducive to permafrost aggradation
- The following conditions define the WRF geometry (Baffinland, 2014):
  - Overall external side slopes of 2H:1V. Exterior slopes will be benched with inter bench slopes of 1.5H:1V;
  - Minimum crest width of 25 m; and,
  - The perimeter of the WRF will be a minimum of 31 m from any water body.

5.2 2018 Waste Rock Placement

Figure 8 below presents the 28 November 2018 WRF as-built survey. The colour banding shows the fill placement locations relative to the 26 January 2018 as-built survey. Waste rock placement locations differ from that presented in the March 2018 Interim WRMP (Golder, 2018a) because the WRF Pond was not expanded or repaired in 2018 and therefore the WRF footprint was not significantly increased.

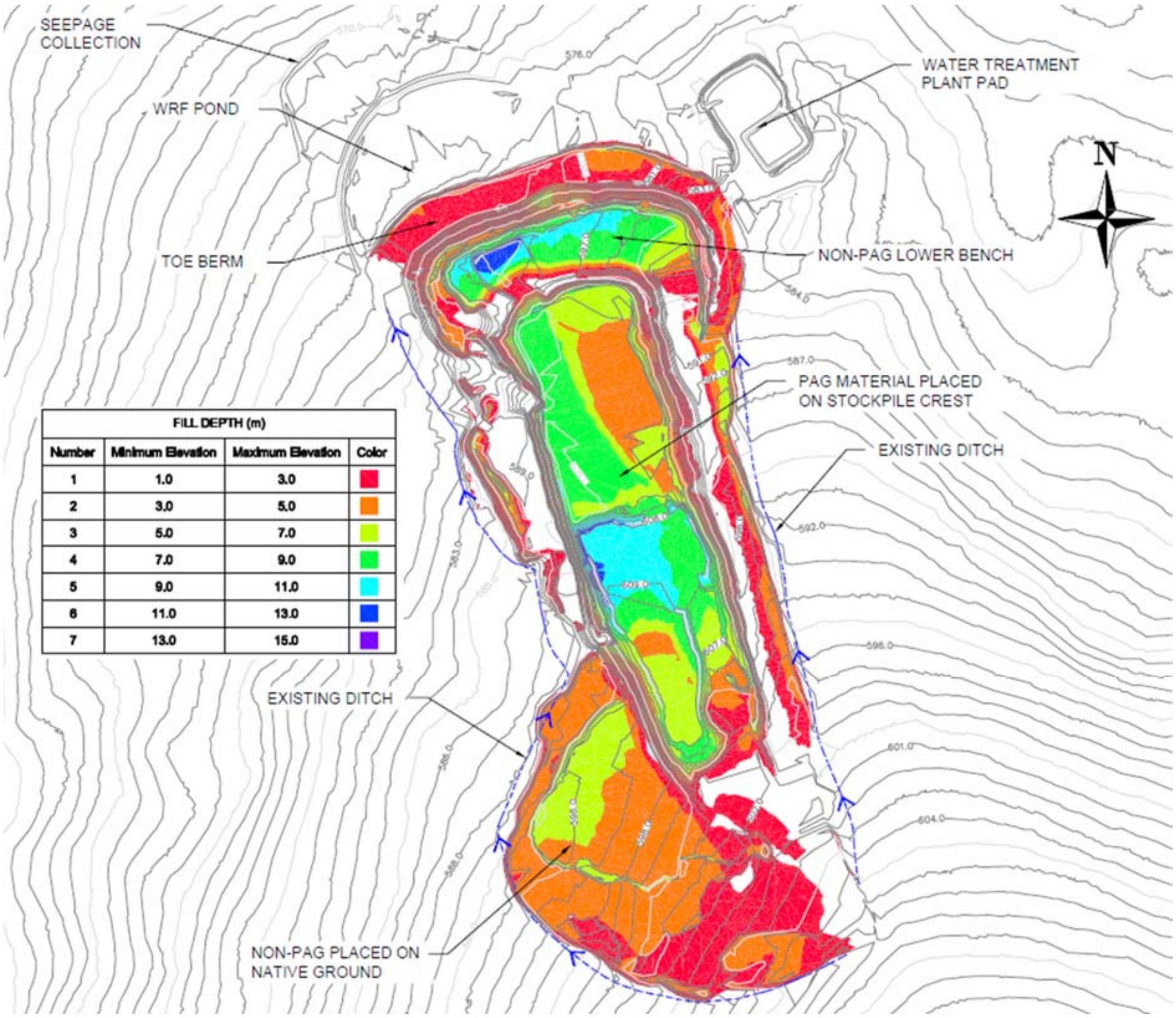

Figure 8: 2018 Waste Rock Placement Locations

A non-PAG waste rock toe berm was constructed at the north toe of the WRF. The purpose of the toe berm was to provide a more fine-grained rock fill barrier to reduce potential for airflow through the potentially coarse base layer of the WRF. The toe berm also forms the south boundary of the WRF Pond expansion. Winter construction of the toe berm was intended to raise the permafrost active layer to within the waste rock. At the time of the WRF Pond expansion, a trench will be excavated through the toe berm and the pond low permeability liner anchored into the frozen overburden.

Non-PAG waste rock was placed at the southwest expansion area over native ground. The lower bench at the north of the WRF was also raised with non-PAG material.

The central area of the stockpile was raised approximately 5.0 – 11.0 m with PAG waste rock.

5.3 Waste Rock Volume

An updated waste rock deposition plan has been developed for the interim period ending May 2019.

The projected quantities of waste rock to be stored at the WRF provided by Baffinland on 21 December 2018 are summarized in Table 5.

Table 5: Estimated Waste Rock Volumes

Year	Time Period	Non-PAG Volume (m^3)	PAG Volume (m^3)	Total Waste Rock (m^3)
2018	November	40,155	51,164	91,319
	December	19,093	3,553	22,646
2019	January	44,541	27,438	71,979
	February	35,175	10,820	45,995
	March	25,269	17,952	43,221
	April	99,346	38,167	137,513
	May	61,089	38,846	99,935
	June	45,716	12,981	58,697
	July	58,797	39,739	98,537
	August	58,216	16,594	74,809
	September	138,933	47,721	186,654
	October	127,488	23,336	150,825
	November	162,257	30,411	192,668
	December	238,813	36,414	275,226
	Total	**1,154,887**	**395,137**	**1,550,024**

Baffinland converted the waste rock tonnages (Section 2.3) to volumes by applying a swell factor of 1.3 to the in-situ pit volumes.

5.4 Waste Rock Deposition Plan

The WRF development considers winter (November through May) deposition. These climatic periods have been assessed based on climatic records at the Mary River meteorological station (Table 3). The estimated waste rock volumes for each deposition season are summarized below in Table 6.

Table 6: Waste Rock Volumes by Deposition Season

Period	Non-PAG Volume (m^3)	PAG Volume (m^3)	Total Volume (m^3)
December 2018 through May 2019	284,513	136,776	421,289

As-built survey dated November 27, 2018 provided by Baffinland was used as the base surface to model the WRF development discussed below.

The following sections provide discussion on the planned locations for waste rock placement for December 2018 through to May 2019. Table 6 includes water rock quantities through to December 2019 to provide a preliminary review of the upcoming waste rock quantities. The mining plan for June – December 2019 is currently under review by Baffinland. Accordingly, the waste rock deposition plan for June – December 2019 will be provided in March 2019 once the mining plan is finalized.

5.4.1 Waste Rock Placement - December 2018 through May 2019

The waste rock deposition locations for the period of December 2018 through May 2019 are provided in Figure 9 below:

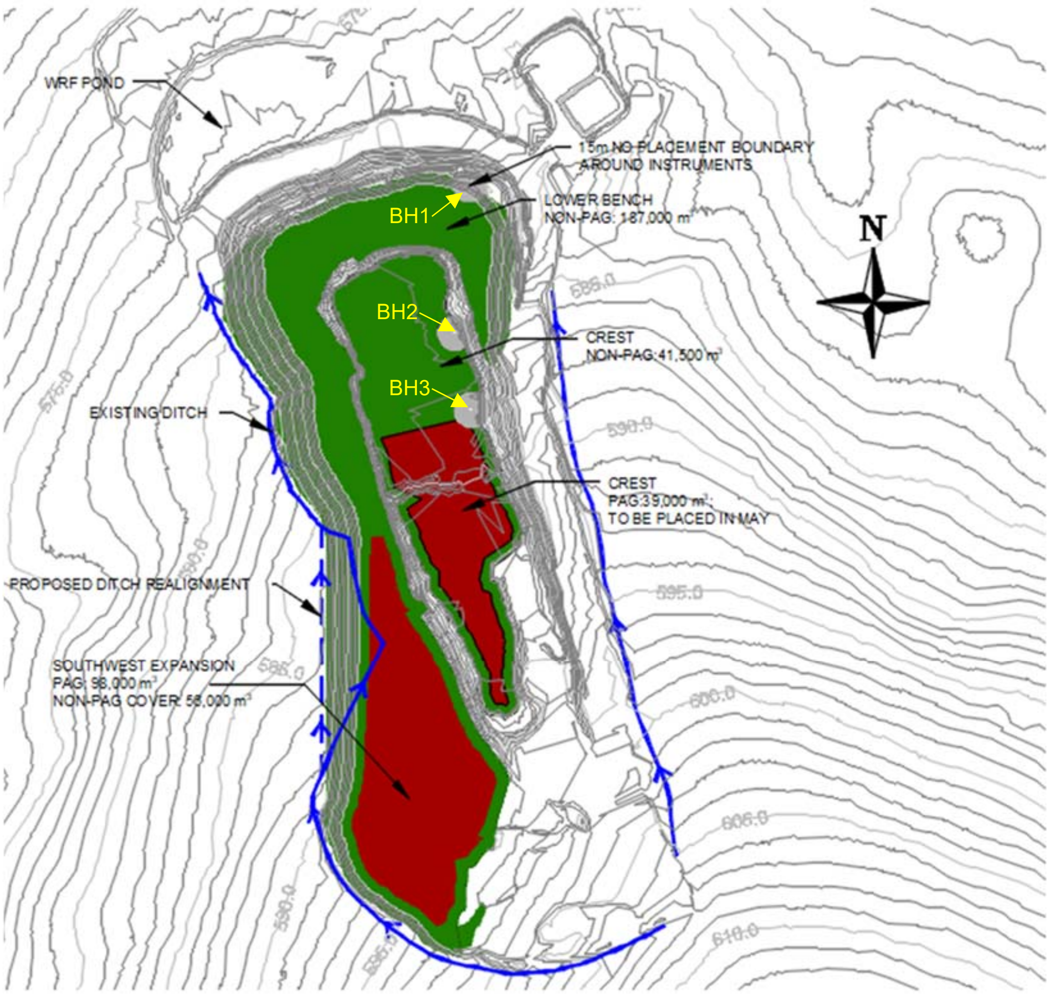

Figure 9: Waste Rock Deposition - December 2018 through May 2019

From December 2018 through April 2019 PAG waste rock (98,000 m^3) will be placed at the southwest expansion area that was constructed in 2018. PAG waste rock will be placed in 1 to 6 successive <3 m thick lifts to level off the area and raise to a uniform crest elevation of approximately 600 m. Lifts will be left exposed as recommended in Figure 6, based on the atmospheric temperature at the time of placement, prior to covering over with the subsequent lift. Where waste rock placed is below zero a successive lift may be placed immediately. A minimum

10 m wide berm of non-PAG waste rock will be placed at the exterior of the lift to protect the PAG waste rock from thaw during summer. By end of May 2019 the PAG waste rock will be covered with a 2.5 m thick lift of non-PAG waste rock (56,000 m^3), raising the stockpile crest to elevation 602.5 m.

A 2.5 m thick lift of waste rock will be placed over the stockpile crest (non-PAG over the northern half and PAG over the southern half). The purpose of this layer is to reduce potential for thawing of the existing PAG waste rock (placed on the stockpile crest in 2018) during summer 2019 by maintaining the permafrost active layer within the freshly placed waste rock. Waste rock will not be spread within 15 m of the instrumentation installed during December 2018 to reduce potential for influence on the instrumentation readings, specifically with respect to the shallow instruments that measure the depth of the permafrost active zone. The total volume of non-PAG waste rock required is 41,500 m^3 and the volume of PAG waste rock is 39,000 m^3. PAG waste rock placed on the stockpile crest will be covered in winter 2019/2020 once frozen.

The remaining volume of non-PAG waste rock (187,000 m^3) will be utilized to raise the existing lower bench around the stockpile perimeter to approximate elevation 597 m. The maximum total thickness of material placed is estimated at 12 m.

As shown in Figure 9, an approximately 200 m long section of the existing perimeter ditch on the west side of the WRF is proposed to be re-aligned. The ditch re-alignment is required to provide sufficient width for raising of the non-PAG waste rock berms through this area. Without the ditch re-alignment it will not be possible to maintain a 10 m width of non-PAG waste rock around the PAG waste rock placed through this area (i.e. the ditch re-alignment is required to promote chemical stability). The ditch re-alignment increases the WRF Pond catchment area by 0.65 ha. The resulting marginal increase in surface runoff does not have a material impact on the WRF Pond operation. The ditch re-alignment is expected to be carried out prior to the 2019 spring freshet.

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APPENDIX A

Water Treatment Plant

Standard Operating Procedure

OPERATIONS & MAINTENANCE MANUAL FOR MARY RIVER MINE WASTE ROCK PILE WATER TREATMENT PLANT 20180817_v02

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Project No. 137-0001

TABLE OF CONTENTS

1.0 INTRODUCTION

This documents outlines the Operations Manual for Baffinland Iron Mine Corporation's (BIM) Mary River Mine Waste Rock Pile water treatment plant (WTP).

2.0 PLANT OVERVIEW

2.1 General Process Description

The WTP employs a process of coagulation, pH adjustment, flocculation, and filtration to treat acid rock surface runoff collected in the pond at the base of the waste rock pile. The objective of the system operation is to treat water to within the parameters outlined in the Metal Mining Effluent Regulations (MMER), as specified to McCue by BIM, and summarized in Table 1.

Table 1: MMER Effluent Limits

Parameter	Unit	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentrations in a Composite Sample	Maximum Authorized Concentration in a Grab Sample
Arsenic	mg/L	0.5	0.75	1.00
Copper	mg/L	0.3	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

The treatment steps are described in Section 2.2. Refer to drawings in Appendix A:

2.2 Brief Process Overview

2.2.1 *System Inlet*

Water is collected at an inlet storage pond (P-001) where it is held for treatment. Two diesel powered centrifugal trash pumps (PU-100A/B) are used to transfer water from the storage pond to an equipment enclosure where the WTP is housed.

At the WTP, the flow can be divided into two separate treatment trains (1 and 2), with each train having a flow meter on the inlet line to monitor flow.

Water is directed into two reactor tanks (TA-110 and TA-210) for processing.

2.2.2 *Step 1 – Iron Precipitation*

Ferric sulphate solution is injected into TA-110 and TA-210 to promote coagulation and precipitation of some heavy metals.

As of system commissioning in June 2018, ferric sulphate liquid solution (12% Fe) is used and injected directly into the process. Each process train utilizes an independent chemical pump to introduce chemical into the system.

The WTS also includes a ferric sulphate make down system, including a holding tank and mixer to allow for makeup of solution using dry ferric sulphate.

Each reactor tank includes a pH sensor to provide continuous monitoring of pH.

Each reactor tank is equipped with four air diffusers which supply air to the process and provide continuous mixing so that solids are kept suspended. Each train is supplied air by a dedicated blower.

2.2.3 *Step 2 – Hydroxide Precipitation and pH Adjustment*

Water flows by gravity from TA-110 and TA-210 to TA-120 and TA-220 respectively. Here, hydrated lime is injected into the process to increase pH and aid in further precipitation of some metals through hydroxide precipitation.

Hydrated lime solution is made manually by adding dry hydrated lime and raw influent water to a mixing tank (TA-020). A mixer is run continuously to ensure the hydrated lime slurry does not solidify.

One hydrated lime chemical pump is utilized to dose each reactor tank with chemical. Two motorized valves (MV-120 and MV-220) are used to control the flow of lime to each reactor tank. Each reactor tank includes a pH sensor to provide continuous monitoring of pH.

Each reactor tank is equipped with four air diffusers which supply air to the process and provide continuous mixing so that solids are kept suspended. Each train is supplied air by a dedicated blower.

2.2.4 *Step 3 – Flocculation*

Water flows by gravity from TA-120 and TA-220 to TA-130 and TA-230 respectively. Here, polymer is injected into the process to aid in flocculation of suspended solids prior to filtration.
Polymer solution is made manually by adding dry polymer and raw influent water to a mixing tank (TA-030). A mixer is run continuously to ensure uniformity of the polymer solution.

Two polymer chemical pumps are utilized to provide polymer dosing to each train. Polymer can be dosed directly into each reactor tank, or inline through a static mixer located directly downstream of the reactor tank.

2.2.5 *Step 4 – Filtration*

Water from TA-130 and TA-230 is pumped to a geotube pond via two diesel powered centrifugal trash pumps (PU-200A/B).

Water is directed to a manifold where it can be distributed to two geotube bags for solids filtration. Two additional geotube bags can be deployed in the pond once the currently operating geotube bags have reached capacity. These spare geotubes are currently stored in a warehouse for future use.

Filtered water leaves the geotube bags and is directed to a collection point at the North West corner of the pond. From here, water is pumped via one diesel trash pump (PU-300) to the Mary River discharge point, or recycled back to the inlet pond. A flow meter is installed on the discharge line to Mary River to allow for data logging of flow.

2.3 Major Equipment List

The WTP layout is provided in appendix A. A list of major equipment is provided in Table 2.

Table 2: Major WTP Equipment

Equipment	Description	Qty	Drawing Reference (If Available)
Pond Transfer Pump	Model: Prime Aire PA4A60-404ST Power: Diesel Driven Capacity: 140m3/hr	2	PU-100 A / PU-100 B
Inlet Flow Meter	Model: GF Signet 3-2551-P1-42	2	FT-100 / FT-200
Ferric Reaction Tank	Material: Polyurethane Size: 5.9m W x 1.5 H Capacity: 24,820 Liters	2	TA-110 / TA-210
Lime Reaction Tank	Material: Polyurethane Size: 5.9m W x 1.5 H Capacity: 24,820 Liters	2	TA-120 / TA-220
Polymer Reaction Tank	Material: Polyurethane Size: 5.9m W x 1.5 H Capacity: 24,820 Liters	2	TA-130 / TA-230
Aeration Blowers	Gast R7100A-3 Blower • 208 V / 3 HP / 60 Hz	2	BL-100A / BL-100B
pH Controller and Sensors	Model: Walchem W900 (Controller) Model: Walchem WEL-PHF-NN (Sensors)	1	pH-110/120/210/220
Motorized Ball Valve	Hayward 1" Ball Valve Model: HRSN2	2	MV-120 and MV-220
Level Transmitter	Model: Echosonic 11 LU27	2	LT-130 / LT-230
Bag Filter	Model: FTI830-2P-150-CS-BS-P13-DP Bag Size: 5 Micron	1	FIL-100
Ferric Chemical Pump	Model: Walchem EHE31E1-VC Power: 115 VAC/1hp/60Hz Capacity: 1 LPM @ 105m TDH	2	PU-010A / PU-010B
Lime Chemical Pump	Model: Flowmotion FR25-HR30HR Power: 230V/3hp/60Hz Capacity: 9.5 LPM @ 105 m TDH	1	PU-020
Polymer Chemical Pump	Model: Flowmotion FR25-HR30HR Power: 230V/3hp/60Hz Capacity: 16.5 LPM @ 105 m TDH	2	PU-030A / PU-030B
Ferric Mixing Tank	Material: Polyurethane Size: Ø 1.2m x 1.3m Height	1	TA-010
Lime Mixing Tank	Material: Polyurethane Size: Ø 1.8m x 1.7m Height	1	TA-020
Polymer Mixing Tank	Material: Polyurethane Size: Ø 1.6m x 1.6m Height	1	TA-030
Coarse Bubble Diffusers	Model: Maxair 24" SS	24	-

2.4 System Automation

The system is automated through a main control panel located in the system enclosure. The system P&ID is provided in Appendix A. Operation is outlined in Table 3.

Table 3: Control Panel Automation

Equipment ID	Equipment Description	Control Logic	PID Control Reference	Controls	Panel Indication
PU – 100 A/B	Inlet Pond Pump	Units can be controlled in Hand or in Auto. Pump will turn on in Hand in Auto or in Hand.	-	-	Pump icon will indicate run status
		Pump will turn off if high level is measured in TA-110 or TA-210	LSH-110 / LSH-210	Auto	High level alarm at panel
		Pump will turn off if high level measured in TA-130 or TA-230	LIT-130 / LIT-230	Auto - High level settable at panel	High level alarm at panel
BL-100 A/B	Blower	Units can be controlled in Hand or in Auto Blower will turn on in Auto or in Hand	-	-	Blower icon will indicate run status
		BL-100 A will turn off if low level is measured by LIT-130	LIT-130	Auto – Low level settable at panel	Low level alarm
		BL-100 B will turn off if low level is measured by LIT-230	LIT-230	Auto – Low level settable at panel	Low level alarm
pH-110	pH Sensor	Continuous monitoring of pH	-	-	Display pH on PLC
pH-210	pH Sensor	Continuous monitoring of pH	-	-	Display pH on PLC

pH-210	pH Sensor	If pH>9.5, close MV-120 - Alarm	MV-120	Auto – pH set point settable at panel	Display pH on PLC
pH-220	pH Dosage	If pH>9, close MV-220 - Alarm	MV-220	Auto – pH set point settable at panel	Display pH on PLC
PU-010A	Ferric Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		If FIT-100 measures flow, PU-010A energizes.	FIT-100	Auto	Display run status on PLC
PU-010B	Ferric Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		If FIT-200 measures flow, PU-010B energizes.	FIT-100	Auto	Display run status on PLC
PU-020	Lime Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		Speed Control (1 train only) If pH-120> 8.5, PU-020 will reduce speed. If pH < 8, pump will increase pump speed. If pH is between 8 to 8.5, pump will maintain pump speed.	pH-110 / pH-120	Auto – pH set point adjustable at panel	Display run status on PLC
		Speed Control Disabled If flow is detected by both trains, speed control is disabled.	FIT-100 / FIT-200	Auto	Display run status on PLC
PU-030 A	Polymer Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status

		Polymer pump energizes if PU-200 A is on	PU-200A	-	Display run status on PLC
PU-030 B	Polymer Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		Polymer pump energizes if PU-200 B is on	PU-200B	-	Display run status on PLC
PU-200 A	Transfer Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		If LT-130 measures < 3', PU-200A off. If LT-130 measures >3', PU-200A on.	LT-130	Auto – Set points adjustable at panel	Pump icon will indicate run status
		If LT-130 measures >4.5', PU-200A off. If LT-130<4.5', PU-200A on.	LT-130	Auto – Set points adjustable at panel	Pump icon will indicate run status
PU-200 B	Transfer Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		If LT-230 measures < 3', PU-200B off. If LT-230 measures >3', PU-200B on.	LT-130	Auto – Set points adjustable at panel	Pump icon will indicate run status
		If LT-230 measures >4.5', PU-200B off. If LT-230<4.5', PU-200B on.	LT-130	Auto – Set points adjustable at panel	Pump icon will indicate run status
PU-300	Discharge Pump	Units can be controlled in Hand or in Auto	-	-	Pump icon will indicate run status
		Pump off at LSL-200	LSL-200	-	Level indicator on panel

		Pump on at LSH-200	LSH-200	-	Level indicator on panel
		High Level Alarm at LSHH-200	LSHH-200	-	High Level Alarm
MX-010 /020/030	Mixer	Units can be controlled on/off manually	-	-	-

3.0 GENERAL STARTUP PROCEDURE

3.1 After Dormancy Pre-start-up Procedures

The following steps shall be taken after extended periods of dormancy, prior to general startup of the WTP.

Task	Check
Perform a visual inspection of the system enclosure for signs of water/snow ingress.	☐
Inspect hose and pipe for signs of leaks, abrasion, or other physical damage.	☐
Inspect Reactor tanks as follows: • Signs of leaks, abrasion, or other physical damage. • Tank connections for signs of strain or stress. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Blowers as follows: • Signs of abrasion, or other physical damage on all external accessories such as relief valves, gauges and filters. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Diesel Pumps as follows: • Signs of leaks, abrasion, or other physical damage. • Check for and tighten loose attaching hardware. • Make sure that valves at the inlet and outlet are opened. • Check oil levels and lubricate as necessary.	☐
Inspect Ferric Sulphate pump as follows • Signs of leaks, abrasion, or other physical damage. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Hydrated Lime pumps as follows • Signs of leaks, abrasion, or other physical damage. • Inspect condition of internal pump hose. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Polymer pump as follows: • Signs of leaks, abrasion, or other physical damage. • Inspect condition of internal pump hose. • Make sure that valves at the inlet and outlet are opened.	☐
Inspect Level Transmitter as follows: • Monitor debris and ensure the sensor is level and mounted perpendicular to water level. • Check and roughly compare measurement on the PLC with the real on the field.	☐
Inspect pH sensors as follows: • Monitor debris and deposition of scaling on the transmitter. Perform a cleaning of the sensors as necessary.	☐

Insect Bag Filter vessel as follows: • Signs of leaks, abrasion, or other physical damage. • Inspect filter bag and replace as necessary	☐
Inspect Inlet Flow Meter as follows: • Signs of leaks, abrasion, or other physical damage. • Inspect flow sensor for scaling. Clean as necessary.	☐
Inspect Geotube Bag as follows: • Ensure inlet connection points are securely attached. • Ensure height of bag does not exceed recommended limits. If so, decommission geotube bag. • Clean geotube surface of sediment and scaling to prevent fouling using a push broom, or gentle pressure washing.	☐

3.2 Commissioning

After pre-start-up procedures are completed, the system can be energized. The following procedure reflects a high level overview of equipment checks to be performed. Detailed instructions can be found in the product specific manuals. Before any mechanical intervention, disconnect the electrical supply.

3.2.1 *Hydrated Lime Pump / Polymer Pump*

Task	Check
Ensure that all protections (cover, cover window, ventilator hood, coupling protection) are in place before operating the pump.	☐
Check the direction of rotation of the pump.	☐
Make sure that valves at the inlet and outlet are opened.	☐
Start the pump by checking its direction of rotation through the cover window.	☐
Check the flow and discharge pressure and adjust rollers if these figures don’t match the pump specifications.	☐

IMPORTANT: Ensure lime pump valves remains open during operation. Should valves be left in the closed position, the process line can over pressurize, leading to a rupture of the chemical hose.

3.2.2 *Blowers*

Task	Check
Ensure impeller rotation is correct.	☐
Check filters and inspect for signs of fouling. Replace if necessary.	☐

Ambient temperature – Check room and discharge air temperatures. Exhaust air should not exceed 135ºC.	☐
Working pressure and vacuum values – Adjust relief valve pressure or vacuum setting, if needed.	☐
Motor current – Check that the supply current matches recommended current rating on product nameplate.	☐
Electrical overload cutout – Check that the current matches the rating on product nameplate.	☐

3.2.3 *Ferric Pump*

Task	Check
Ensure pump is energized.	☐
Make sure that valves at the inlet and outlet are opened.	☐
Start the pump manually, in order to prime and adjust dosing rates.	☐
Prime the pump. See manual for details.	☐
Adjust dosing according to inlet water flow rate. See below.	☐
Check dosing rate with calibration cylinder.	☐

3.2.4 *Motorized Valve*

Task	Check
Ensure valve is energized.	☐
Ensure valve opens/closes reliably in manual mode:	☐

3.2.5 *Diesel Pumps*

Task	Check
Check fuel level and oil levels in the engine, air compressor, pump bearings and seal housing.	☐
Consult engine operations manual before attempting to start the unit.	☐
Allow pump to prime.	☐
Adjust engine speed to desired output.	☐

3.2.6 *pH Sensors*

Task	Check
Ensure sensor is calibrated.	☐
Ensure the pH reading displayed locally at the Walchem panel is transmitted correctly to PLC.	☐

3.2.7 *Geotube*

Task	Check
Ensure surface is clean of sediment and debris.	☐
Ensure all inlet valve are open.	☐
Ensure height of geotube does not exceed manufacturer recommended limit.	☐

4.0 OPERATION

4.1 General Operating Instructions

Operation of the WTP will consist of ensuring major equipment (blowers, dosing pumps, motorized valves, level transmitters) is running correctly, and ensuring influent/effluent monitoring and sampling are conducted on schedule.

The drivers for pH adjustment and TSS treatment are operation of the Ferric Sulfate, Hydrated Lime and Polymer Pump, along with the proper performance of the aeration blowers and diffusers equipment.

The unit will run manually. During short term dormancy, the unit can be operated in a “Sleep Mode” where the system is run in a re-cycle status using two submersible pumps inside TA-130 and TA-230 to recirculate water from the end of each train to the beginning of each train. Chemical injection is disabled during dormancy, however, the lime mixer should remain on to maintain suspension of the hydrated lime slurry. Blowers will also remain on to ensure suspension of solids within the reactor tanks.

Parameters to be measured and recorded daily include temperature, pH (typical values are between 6.5 and 9), and TSS. The system must be monitored regularly to ensure pH does not drop below the low level set point or raise above the level set point.

The pH reading should be recorded daily. The pH should be cross referenced regularly with a hand held device. Should the pH differ from the hand held reading, the operator should clean the pH electrodes using a 2-5% solution of hydrochloric acid.

System data can be recorded in the spreadsheet provided in Appendix B. Regular daily monitoring of parameters such as pH, temperature, TSS, and Geotube height must be recorded to ensure proper operation.

4.2 Operating Procedure

The following section will outline the step-by-step procedures for operating the treatment system.

4.2.1 *Standard Operation*

Inlet

The inlet pond level should be checked and recorded prior to start up. Two pond pumps can be utilized to transfer raw water to the treatment system. Usage will depend on the volume of treatment required. At low pond levels, one pond pump and one process train can be utilized. At high levels, both pumps can be utilized to increase the treatment volume.

All pump discharge valves must be opened. The pumps (PU-100 A/B) shall be placed in "Hand" at the PLC. This will energize the pumps and begin transfer of water to the treatment system. The pumps will only turn on if a high level is measured by LSH-110/210 or LT-130/230.

Operators must ensure the inlet pond level is monitored, as the pumps do not include a low level shut off.

Ferric Pumps (PU-010 A/B)

Water is transferred from the inlet pond to two reactor tanks (TA-110 and TA-210) where ferric sulphate is injected. The dosage rate of the ferric pumps is determined by the inlet quality of the raw water and can range from 0 to 20 mg/l. The dosage rate is to be determined by the operator.

The dosage rate must be set manually at the pump. Once set, the pump can be set to "Auto" at the control panel. The ferric pumps, PU-010 A and PU-010 B, will energize when flow is detected by FIT-100 and FIT-200 respectively.

Before starting the pumps, all discharge valves must be opened.

Lime Pump (PU-020)

After coagulant addition, water flows by gravity to TA-120 and TA-220 where hydrated lime is injected into the process. The dosage rate of the Lime pump is determined by the inlet quality of raw water and the pH required, and can range from 0 to 300 mg/l. The dosage rate is to be determined by the operator.

In manual mode, the speed of the pump can be set at the pump VFD, located on the lime pump stand.

Pump speed will be dependent on the pH measured by pH-120, and the pH set point entered into the panel (adjustable by an operator). At a setpoint of 8.5, the pump will increase speed if pH-120 measures a pH below 8. If pH-120 measures a pH above 9, pump speed will decrease. If pH is measured between 8 to 8.5, the dosage rate will remain the same.

-

At a pH above 9.5, MV-120 and MV-220 will close.

The lime pump will operate continuously, with chemical consistently recirculated to the lime mixing tank (TA-020). This is done to ensure the lime slurry does not settle and solidify in the piping system. At the end of every shift, clean water must be flushed through the piping in order to prevent fouling. Flushing may be required more frequently depending on operational conditions.

Due to the possibility of fouling, the lime pump system must be monitored for pressure consistently.

Lime Solution Make Up

Hydrated lime solution is made manually, with the solution concentration ranging from 5-10% depending on volume of raw water to be treated. A concentration of 5% is recommended to minimize line fouling caused by the lime slurry. Higher concentrations can be made, but more frequent line flushing will be required.

The lime tank mixer is operated from the panel, and should be operated continuously to prevent the slurry from solidifying.

Polymer Pumps (PU-030 A/B)

The dosage rate of the ferric pumps is determined by the inlet quality and can range from 0 to 3 mg/l.

The dosage rate must be set manually at the pump. Once set, the pump can be set to "Auto" at the control panel. The polymer pumps, PU-020 A and PU-020 B, will energize when the transfer pumps, PU-200 A and PU-200 B are energized.

Before starting the pumps, all discharge valves must be opened.

Polymer Solution Make Up

Polymer solution is made manually, with concentration ranging from 0.1 to 0.25% depending on volume to be treated.

The polymer tank mixer is operated from the panel, and should be kept on at all times to maintain uniformity of the solution.

Blowers

The blowers are operated from the panel, and should be energized at all times when raw water is being processed in the reactor tanks.

Both blowers (BL-100A and BL-100B) can be set in "Auto" at the panel, at which point they will run continuously until the water level in TA-130 and TA-230 is measured to be less than 6". This level is settable at the panel.

Raw Water Bag Filter

The bag filter provides filtration of water required for chemical makeup. The filter bags should be replaced periodically when differential pressure across the filter exceeds approximately 20 psi.

Geotube Bags

Water is transferred from the final reactor tanks (TA-130 and TA-230) by diesel generated trash pumps (PU-200 A and PU-200 B) to the geotube pond. The transfer pumps, PU-200A and PU-200B are operated based on the level measured by the reactor tank level transmitters, LT-130 and LT-230 respectively. These set points are adjustable at the panel.

The height of the geotube bags must be monitored regularly.

4.3 Daily Operator Checklist

The following steps outline day-to-day operational procedures for the WTS.

Standard Operation

Task	**Check**
Check inlet pond and record water level	☐
Check lime and polymer solutions, make up additional solution as required.	☐
Place PU-100 A (and PU-100 B if necessary) in Hand mode at the control panel.	☐
Set Ferric Sulphate pump (PU-010 A / B) dose rate and place pump in Auto at control panel. Ensure pump energizes when flow is detected by FIT-100 or FIT-200.	☐
Turn on hydrated lime pump (PU-020 A) manually. Adjust dose rate based on flow measured by inlet flow meters.	☐
Monitor hydrated lime pump pressure gauge. If pressure gauge is showing a pressure greater than 15 psi, flush line with water.	☐
Set polymer pump dose rate at panel. Set in "remote" mode. Set pump to auto at panel. Pump will turn on when PU-200A/B energize.	☐
Set Blowers (BL-100 A / BL-100B) to Hand.	☐
Once onion tanks are full, set PU-200A/B to Auto (if using both trains). Ensure downstream valves to geotube bags are open.	☐

Observe reactor tank water levels to ensure inlet and outlet flows are balanced.	☐
Observe and record height of geotube bags. Height must not exceed 6 feet.	☐
Set PU-300 to auto in the panel. Once the water in the pond reaches the operating float switch, the pump will be energized.	☐
Discharge vales must be set manually to allow for discharge to the creek, or recycle back to the inlet pond. Set valves in correct position.	☐

Daily Shutdown

Task	**Check**
Set inlet pump to Off position	
Allow reactor tanks to be pumped down to ¼ volume.	☐
Turn off chemical pumps.	☐
Flush lime line with water	☐
Keep lime mixer (Mix-020) on to ensure hydrated lime slurry remains in liquid form.	☐
If tanks are lowered, blowers can be turned off. If tanks are kept full, energize recirculation pumps.	☐
Check lime and polymer solutions, make up additional solution if required.	☐
Turn transfer pumps (PU-200 A/B) and discharge diesel pump (PU-300) off.	☐

APPENDIX A –DRAWINGS

NOTES:

PU-200A/B- Transfer Pump
PU-300- Discharge Pump
FT-300- Flow Meter
LS- Level Switch
-LSHH 200
-LSH 200
-LSL 200

Process lines
Instrumentation lines

Process based on conceptual desgin by Golder Associates

REVISION TABLE		
No.	DESCRIPTION	DATE
0	Original Issue	2018/04/30
1	Record Drawing	2018/07/31

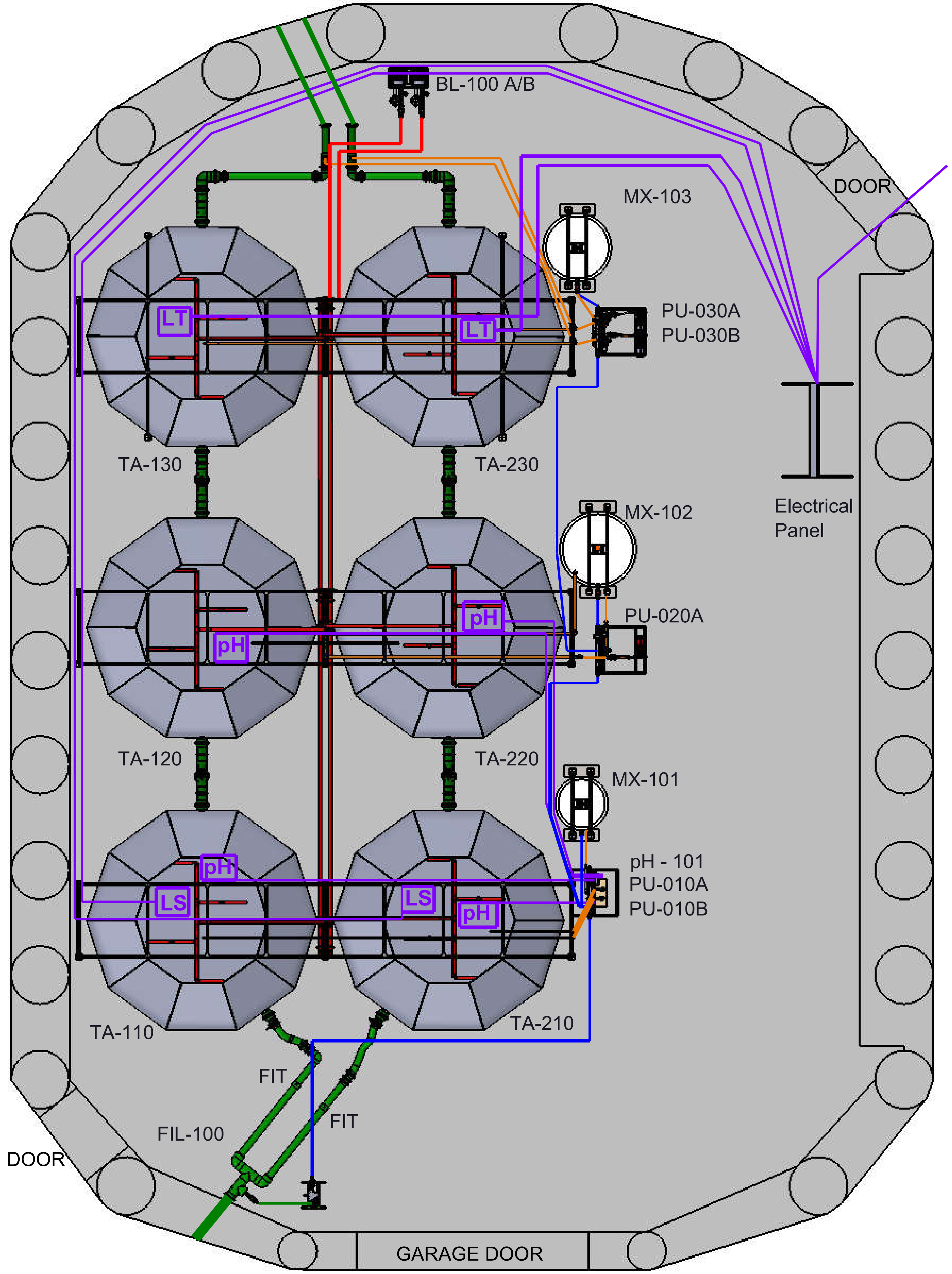
McCUE ENGINEERING CONTRACTORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

FULL SITE LAYOUT
GENERAL ARRANGEMENT DRAWING
Waste Rock Pile Water Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO: 137-0001
DRAWN BY: L.S	FIG: GA-001



LEGEND

BL-100 A/B - Blower
FIL-100 - Bag Filter
MX-101 - Ferric Mixing Station
MX-102 - Lime Mixing Station
MX-103 - Polymer Mixing Station
PU-010 A/B - Ferric Pump
PU-020 - Lime Pump
PU-030 A/B - Polymer Pump
TA-110 - Ferric Process Tank (Train 1)
TA-210 - Ferric Process Tank (Train 2)
TA-120 - Lime Process Tank (Train 1)
TA-220 - Lime Process Tank (Train 2)
TA-130 - Polymer Process Tank (Train 1)
TA-230 - Polymer Process Tank (Train 2)
pH-101 - pH Controller
FIT - Flow Meter
pH - pH Sensor
LS - Level Switch
LT - Level Transmiter

Notes:

Process Lines
Water Make-up Lines
Chemical Lines
Air Lines
Instrumentation Line

Process based on conceptual design by Golder Associates

REVISION TABLE

No.	DESCRIPTION	DATE
0	Original Issue	2018/05/01
1	Record Drawing	2018/08/17

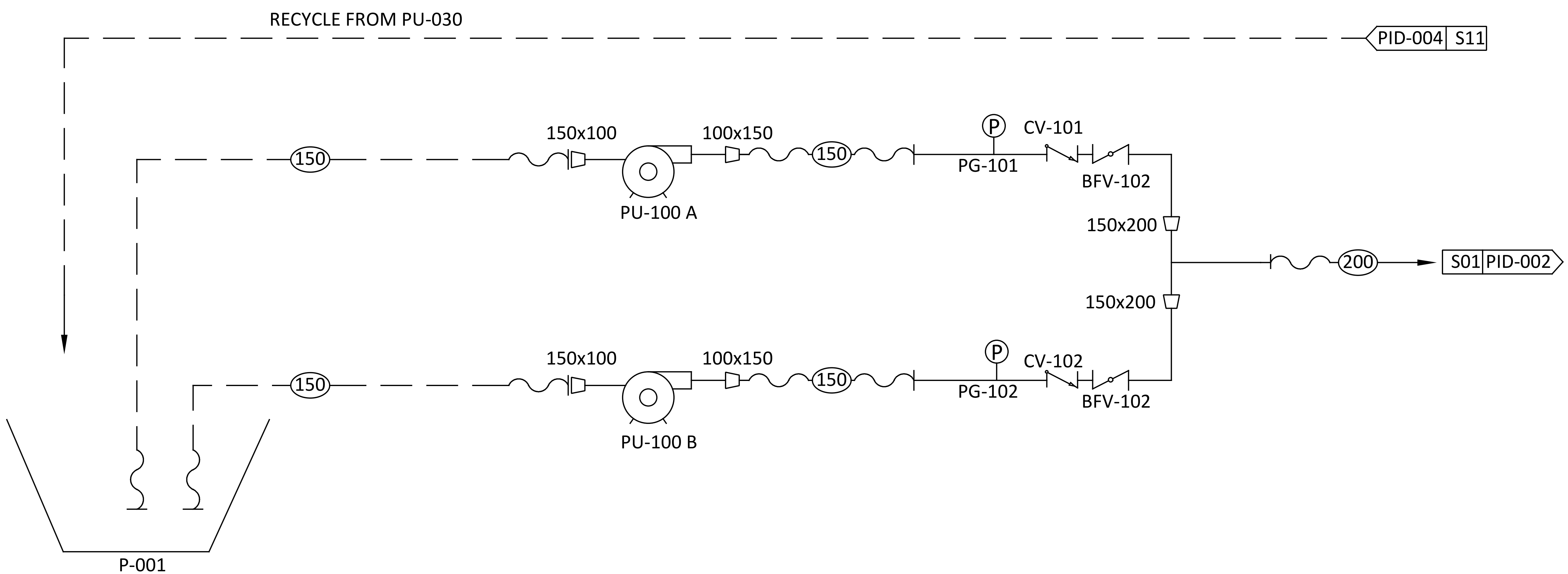
McCUE ENGINEERING CONTRATORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

BUILDING LAYOUT
GENERAL ARRANGEMENT DRAWING
Waste Rock Pile Water Treatment Plant

DATE: August 17, 2018	SCALE: AS SHOWN
DATA BY: R.B	JOB NO: 137-0001
DRAWN BY: L.S	FIG: GA-002



P-001
Inlet Storage Pond

PU-100 A/B
Pond Transfer Pump
Model: Prime Aire PA4A60-404ST
Power: Diesel Driven
Capacity: 140m³/hr

LEGEND :

- Hose
- Sch. 80 PVC Pipe
- Butterfly Valve
- Check Valve
- Reducer
- Pressure Gauge

Process based on conceptual design by Golder Associates

NO.	REVISION TABLE	DATE
0	Original Issue	April 30, 2018
1	Record Drawing	July 31, 2018

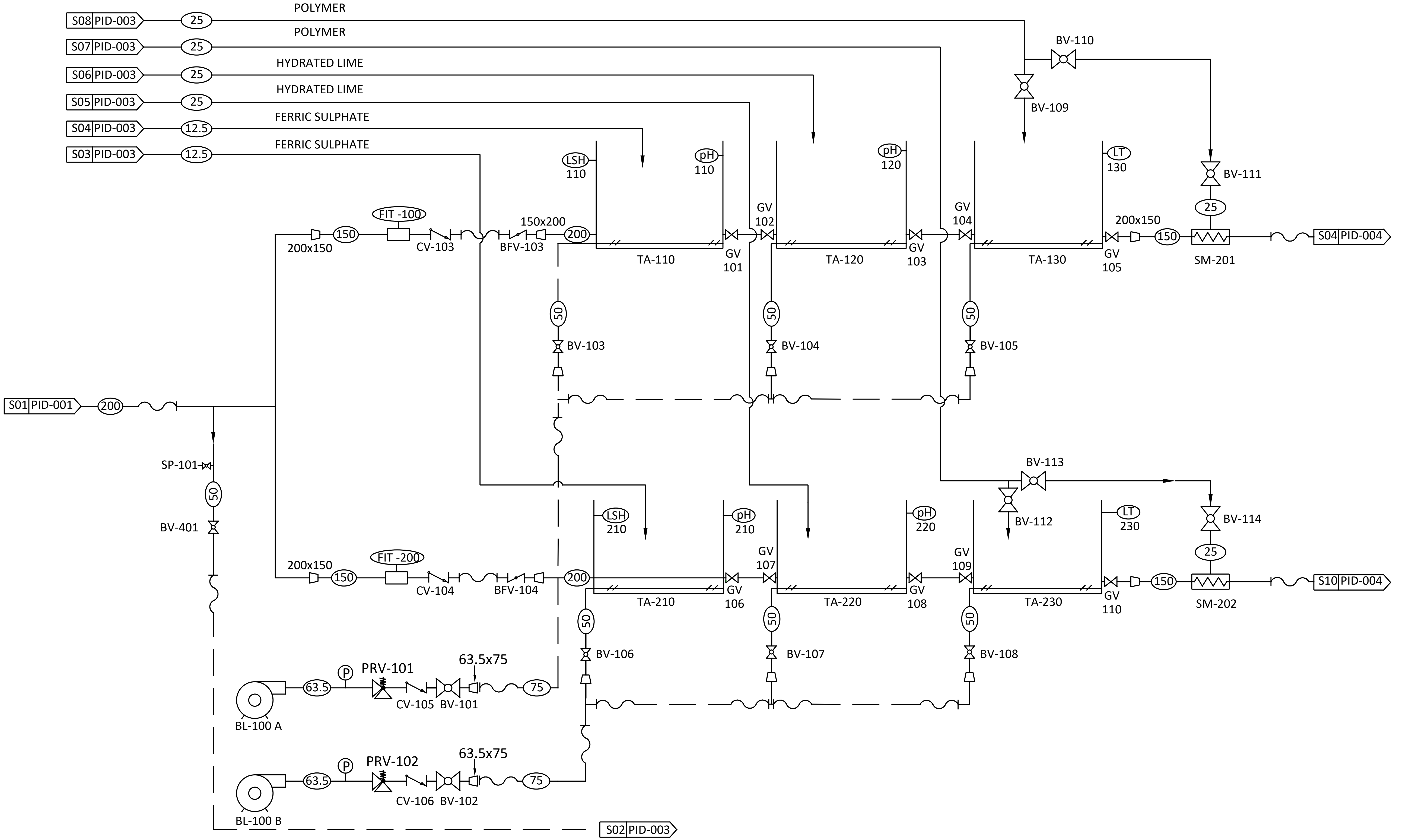
McCUE ENGINEERING CONTRACTORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

Waste Rock Water Storage Pond
PROCESS & INSTRUMENTATION DIAGRAM
Waste Rock Pile Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO: 137-0001
DRAWN BY: M.T.	FIG: PID-0001



BL-100 A/B
Blower
Model: Gast R7100A-3
Power: 208V/3hp/60Hz
Capacity: 500m³/hr @ 1.9m TDH

TA-110/210
Ferric Reaction Tank
Material: Polyurethane
Size: 5.9m W x 1.5 H
Capacity: 24,820 Liters

TA-120/220
Lime Reaction Tank
Material: Polyurethane
Size: 5.9m W x 1.5 H
Capacity: 24,820 Liters

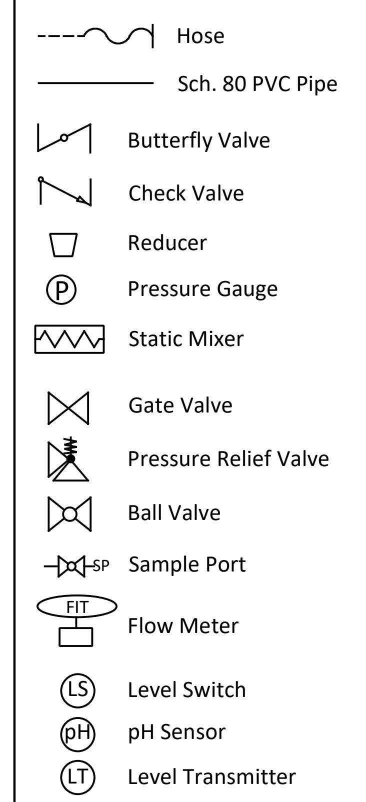
TA-130/230
Polymer Reaction Tank
Material: Polyurethane
Size: 5.9m W x 1.5 H
Capacity: 24,820 Liters

FT-100/200
Influent Flow Meter
Model: GF Signet 3-2551-P1-41

LT-130/230
Level Transmitter
Model: Echosonic 11 LU27

pH-110/120/210/220
pH Meter
Model: Walchem WEL-PHF-NN

LEGEND:



Process based on conceptual design by Golder Associates

NO.	REVISION TABLE	DATE
0	Original Issue	April 30, 2018
1	Record Drawing	July 31, 2018

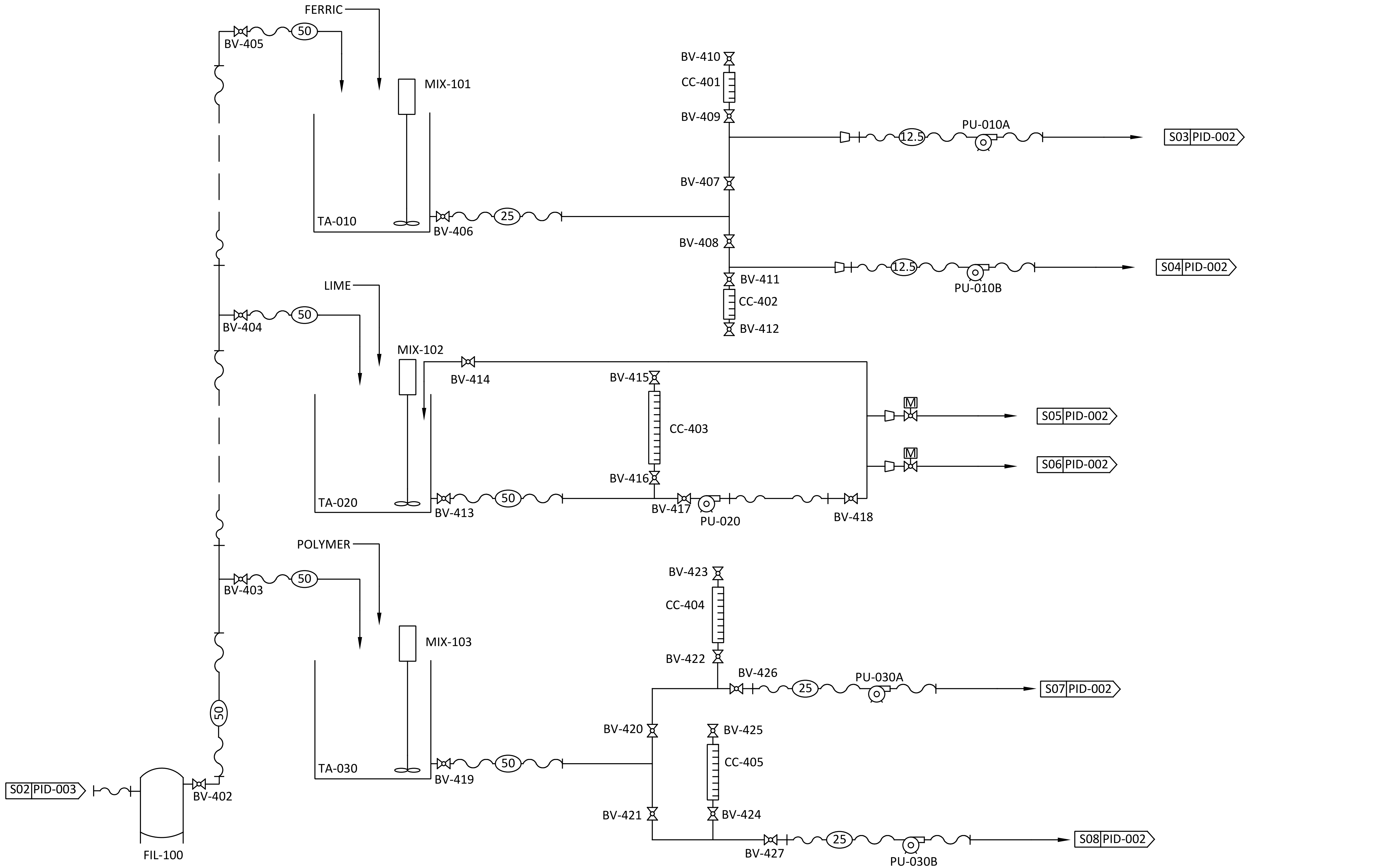
McCUE ENGINEERING CONTRACTORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

REACTION TANKS
PROCESS & INSTRUMENTATION DIAGRAM
Waste Rock Pile Water Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO: 137-0001
DRAWN BY: M.T.	FIG: PID-0002



FIL-100
Bag Filter
Model: FTI 830-2P-150-CS-BS-P13-DP
Bag Size: 5 Micron

PU-010A/B
Ferric Chemical Pump
Model: Welchmen EHE31E1-VC
Power: 115 VAC/1hp/60Hz
Capacity: 21 LPM @ 106m TDH

PU-020
Lime Chemical Pump
Model: Flowmotion FR25-HR30HR
Power: 230V/3hp/60Hz
Capacity: 570 LPM @ 42m TDH

PU-030
Polymer Chemical Pump
Model: Flowmotion FR25-HR30HR
Power: 230V/3hp/60Hz
Capacity: 990 LPM @ 42m TDH

MIX-101
Ferric Mixer
Model: Dynamix DMX-5505K-1
Power: 0.5 HP, 230V/1Ph/60Hz
Shaft: 1" Diameter x 41" Long

MIX-102
Lime Mixer
Model: Dynamix DMX-5505K-2
Power: 0.5 HP, 230V/1Ph/60Hz
Shaft: 1" Diameter x 52" Long

MIX-103
Polymer Mixer
Model: Dynamix DMX-5505K-1
Power: 0.5 HP, 230V/1Ph/60Hz
Shaft: 1" Diameter x 49" Long

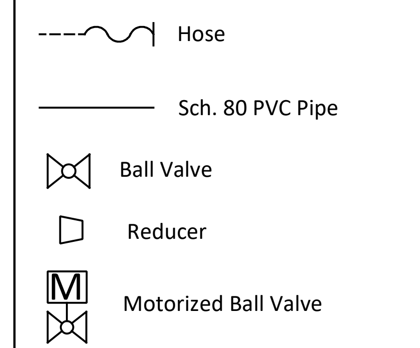
TA-010
Ferric Mixing Tank
Material: Polyurethane
Size: Ø 1.2m x 1.3m Height

TA-020
Lime Mixing Tank
Material: Polyurethane
Size: Ø 1.8m x 1.7m Height

TA-030
Polymer Mixing Tank
Material: Polyurethane
Size: Ø 1.6m x 1.6m Height

CC-401/402/403/404/405
Calibration Column

LEGEND:



Process based on conceptual design by Golder Associates

NO.	REVISION TABLE	DATE
0	Original Issue	April 30, 2018
1	Record Drawing	July 31, 2018

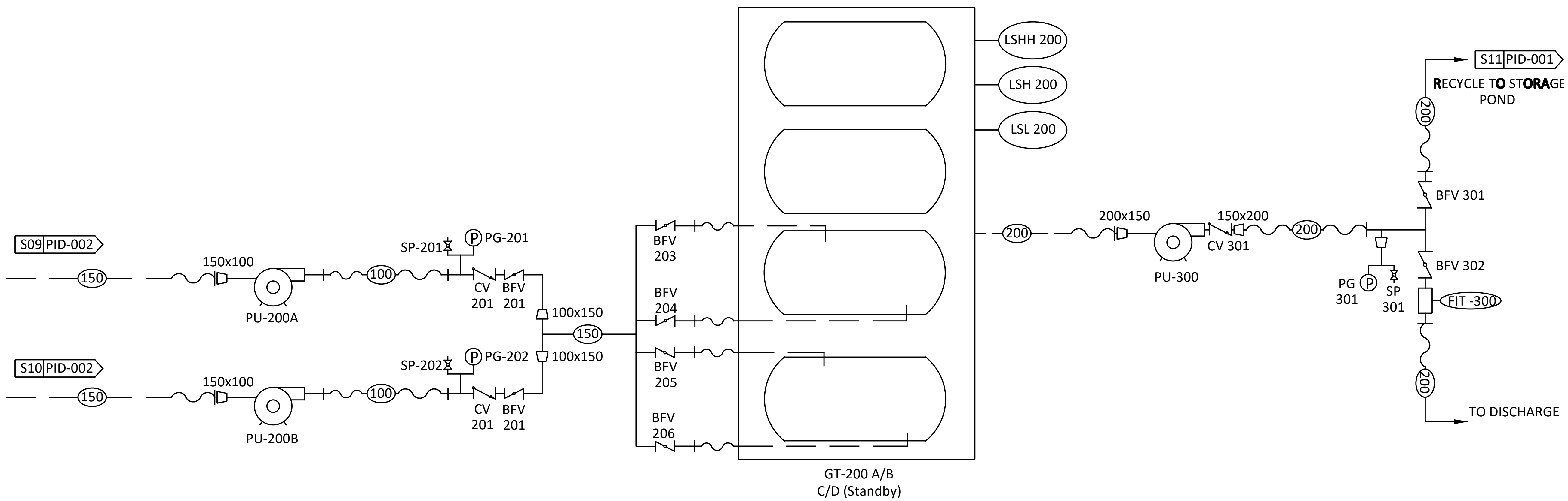
McCUE ENGINEERING CONTRACTORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

CHEMICAL MAKEUP
PROCESS & INSTRUMENTATION DIAGRAM
Waste Rock Pile Water Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO: 137-0001
DRAWN BY: M.T.	FIG: PID-003



LEGEND:

- Hose
- Sch. 80 PVC Pipe
- Butterfly Valve
- Check Valve
- Reducer
- Pressure Gauge
- Sample Port
- Level Switch

PU-200A/B
Transfer Pump
Model: Prime Aire PA4A60-404ST
Power: Diesel Driven
Capacity: 140m³/hr

GT-200 A/B/C/D
Geotube
Model: Tencare GT500
Dimensions: 60' Circumference x 100' Long

PU-300
Discharge Pump
Model: Prime Aire PA4A60-404ST
Power: Diesel Driven
Capacity: 280m³/hr

FT-300
Flow Meter
Model: Toshiba GFG32

Process based on conceptual design by Golder Associates

NO.	REVISION TABLE	DATE
0	Original Issue	April 30, 2018
1	Record Drawing	July 31, 2018

McCUE ENGINEERING CONTRACTORS

CLIENT:

BAFFINLAND IRON MINES CORPORATION

GEOTUBE FIELD
PROCESS & INSTRUMENTATION DIAGRAM
Waste Rock Pile Water Treatment Plant

DATE: July 31, 2018	SCALE: NTS
DATA BY: R.B.	MCCUE JOB NO: 137-0001
DRAWN BY: M.T.	FIG: PID-004

APPENDIX B - MONITORING

McCUE ENGINEERING CONTRACTORS EST. 2000

BROWNFIELDS TO GOLD MINES

Monitoring Spreadsheet

Project Name: BaffinLand Iron Mine
Waste Pile Water Treatment

			Inlet Quality			Train 1						Train 2						Discharge							
Date	Time	OP	Temp ºC	Inlet pH	Inlet TSS mg/L	FIT-100 (L/s)	pH-110	pH-120	Ferric Dosage Stroke/Speed	Lime Dosage Hz	Polymer Dosage Hz	FIT-200 (L/s)	pH-210	pH-220	Ferric Dosage Stroke/Speed	Lime Dosage Hz	Polymer Dosage Hz	FIT-300 (gpm)	FIT-300 Totalizer (gpm)	Geotube Pond pH	Geobag 1 Height (m)	Geobag 2 Height (m)	Discharge pH	Discharge Turbidity NTU	Discharge TSS (mg/L)

Observations

Chemical Availability	Week #1 Date:	Week #2 Date:	Week #3 Date:	Week #4 Date:
Ferric Sulphate				
Hydrated Lime				
Polymer				

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