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Giant Mine Remediation Project

Pilot Treatment Plant - Testing Summary

Public Services and Procurement Canada

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Quality information

Prepared by

Reviewed by

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[Handwritten signature of Marco Denee]

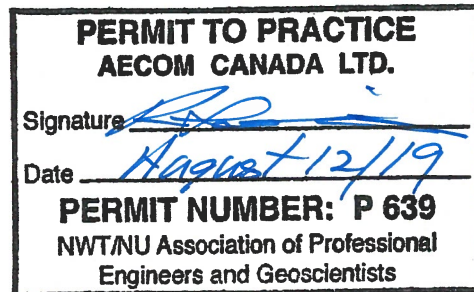
Marco Denee, E.I.T., M.A.Sc.
Process Engineer

[Handwritten signature of Brett deWynter]
August 12/19.

Brett deWynter, P.Eng.
Senior Water Treatment Specialist

[Handwritten signature of Rudy Schmidtke]

Rudy Schmidtke, M.Sc., P.Eng.
Project Principal



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Prepared for:

Public Services and Procurement Canada

Prepared by:

Marco Denee, E.I.T., M.A.Sc.
Process Engineer
T: +1 250 980 7102
E: marco.denee@aecom.com

AECOM Canada Ltd.
3275 Lakeshore Road
Suite 201
Kelowna, BC V1W 3S9
Canada

T: 250.762.3727
F: 250.762.7789
aecom.com

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Appendices

Appendix A. Giant Mine Rehabilitation Project – Arsenic and Antimony Ion Adsorption Pilot Test Plan

1. Introduction and Context

Giant Mine is an inactive gold mine that produced gold from 1948 to 2004 in the City of Yellowknife, Northwest Territories. A by-product of the mining process was arsenic trioxide, a hazardous and water soluble compound that is currently stored within man-made chambers and stopes in the underground mine. The existing Effluent Treatment Plant (ETP) was commissioned in 1981 to manage the contaminated mine pool water. The mine pool water is treated seasonally between June and September. Once treated, mine water effluent is discharged to Baker Creek.

In 2005, the Government of the Northwest Territories and the Government of Canada began plans to remediate, care for and maintain the site. The agreement is to remediate the site according to industry standards, while protecting the health and safety of the public and the environment. The long-term remediation and closure plan of the Giant Mine site is to infill the surface ponds currently used to seasonally store water, decommission the existing water treatment plant and construct a new water treatment plant (WTP) to treat constituents in the mine water.

At the time of this report, design of the WTP is on-going and process treatment efficacy requires confirmation. In 2012, a WTP Preliminary Design Report (PDR) was produced for a facility that meets the Metal and Diamond Mining Effluent Regulations (MDMER). However, an environmental assessment required more stringent discharge objectives for the WTP, including an objective to produce mine water effluent with an average arsenic concentration of 10 µg/L (MVEIRB, 2013). Treatment options to meet the mandated 10 µg-As/L discharge objective were conceptualized, but the unique characteristics of Giant Mine mine water made the efficacy of the proposed treatment solution uncertain. This report documents the pilot treatment testing completed to support the use of arsenic removal media to meet the mandated arsenic discharge criteria.

1.1 Previous Work

Mine water treatment has been reported on in the past. The relevant documents considered during the production of this report include the following:

1. AECOM Canada Ltd. (AECOM, 2012). Preliminary Design Report for Giant Mine Water Treatment Plant. November, 2012. This report provided a plan for the treatment of the water within the Giant Mine site. However, at the time this report was written, the focus was to produce treated water that was compliant with the Metal and Diamond Mining Effluent Regulations (MDMER).
2. Makenzie Basin Environmental Impact Review Board (MBWB, 2013). Report of Environmental Assessment and Reasons for Decision. This report mandated that the WTP effluent arsenic concentration meets 10 µg/L, significantly more stringent than the MDMER requirement.
3. AECOM Canada Ltd. (AECOM, 2013). Giant Mine Water Disposal – Information Request Response. March, 2013. The report assessed a variety of options to treat the water on the Giant Mine site to meet or exceed the more stringent arsenic effluent requirement mandated by the MBWB. This report concluded that Option 2 (arsenic treatment with adsorption/ion exchange) offered an appropriate balance of achieving water quality requirements and cost. The recommended option used filtration and adsorptive media for final treatment.
4. AECOM Canada Ltd. (AECOM, 2013). Giant Mine Water Disposal – Information Request Response, Further Technical Information for Arsenic Removal. June, 2013. The letter documents that adsorptive media has been used in other cold weather climates by AECOM for arsenic treatment to achieve drinking water standards. The recommendation was that pilot testing be completed to confirm the operating parameters and the efficiency of adsorptive media at the Giant Mine site.

5. AECOM Canada Ltd. (AECOM, 2014). Giant Mine Effluent Treatment Plant Assessment. January, 2014. The report assessed the ETP and determined the work required to support the continued operation of the existing facility until the long term treatment plant is constructed. It is assumed that the existing facility will have served the design life and will be completely replaced once the new WTP is constructed.
6. Golder Associates Ltd. (AECOM, 2017). Giant Mine Remediation Project, Outfall Location: Mixing and Water Quality Assessment. March, 2017. The report assessed several different locations for the discharge of the water from the mine site WTP.
7. AECOM Canada Ltd. (AECOM, 2018). Giant Mine Off-Site Pilot Testing Results Memo. The memo presented the results from an off-site testing experiment. An open procurement program was used to source adsorptive media vendors. The vendors completed preliminary testing to demonstrate their product performed sufficiently. Successful vendors were retained for on-site pilot testing.
8. AECOM Canada Ltd. (AECOM, 2018). Pilot Plant Options Analysis. The report details the need for pilot testing and outlines the alternative piloting options.
9. AECOM Canada Ltd. (AECOM, 2018). Pilot Testing Plan. This report describes the plan to complete pilot testing on arsenic removal media and the experimental methodology. The design documents for the pilot plant are included in this report. The document is included in this report as Appendix A.
10. AECOM Canada Ltd., and Golder Ltd. (2019). Giant Mine Remediation Project, Closure and Reclamation Plan. The plan is a major outline of the remediation activities planned for the entire Project. The report is not discipline-specific and includes all the activities planned for remediation.

1.2 Objectives of Testing

The objectives of the pilot test include the following:

- If arsenic removal media can be used for simultaneous arsenic and antimony treatment
- If treatment can reliably meet the Effluent Quality Criteria (EQC) and the Measure 14 of the Environmental Assessment (i.e., 0.01 mg-As/L)
- The projected material costs of using arsenic removal media
- If metal leachability from exhausted arsenic removal media will allow disposal within a non-hazardous landfill

The conclusions provided in this report will inform the design of the WTP and address assumptions made in the Closure and Reclamation Plan (AECOM & Golder, 2019) Specifically, there is a high level of concern if Measure 14 of the Environmental Assessment can actually be sustainably achieved given the various contaminants in the raw water diverted from the mine pool and the arsenic removal efficiency required. The raw water concentration of arsenic in the mine pool is predicted to vary, but is expected to be more than 1,000 times greater than the treatment objective. The pilot testing is being completed to provide demonstrated evidence that a conventional treatment process train followed with arsenic removal media can sustainably achieve the treated water arsenic concentration goal of less than 0.01 mg-As/L.

An additional key benefit of the pilot testing is operational data to identify potential challenges with the future full scale facility. The knowledge obtained from the pilot testing program will be utilized in the design process to improve the treatment facility robustness and reliability.

2. Pilot Testing Methodology, Materials, and Equipment

The following sections briefly describe the raw materials, equipment, and experimental methodology used to complete the pilot testing. Refer to Appendix A for a complete set of process drawings and the Pilot Testing Plan (AECOM, 2018) for further information on the experimental set up of the pilot plant.

2.1 Methodology

The plan to complete pilot testing was initiated when Measure 14 of the Environmental Assessment (Makenzie Basin Environmental Impact Review Board, 2012) mandated that treated water quality meets 0.01 mg-As/L. The WTP designed in 2012 (AECOM, 2012) did not have the process capability to meet the treated water quality objectives of Measure 14. Therefore, an additional step in the treatment plant was required to further treat arsenic. Several alternative unit processes were proposed as technologically practical options; however, arsenic removal using specialized arsenic removal media was proposed as the most financially feasible technological alternative (AECOM, 2018a).

Despite the recommendation to use arsenic removal media to meet Measure 14, there were uncertainties regarding the functionality of using arsenic removal media. The mine water at Giant Mine is a unique and not comparable to other typical raw water sources that are treated with arsenic removal media. A perceived risk was that elevated sulphate and other ion concentrations typically found in the Giant Mine mine water could compromise an arsenic removal media's ability to produce compliant treated water quality. Therefore, piloting was recommended to determine that the mandated treatment objective of Measure 14 could be achieved (AECOM, 2018a).

Prior to initiating pilot testing, an open procurement process was completed to survey the market for available arsenic removal medias. An off-site experiment was organized with interested media vendors in order to confirm that the proposed media products would effectively adsorb arsenic and antimony from the Giant Mine mine water. Giant Mine Polishing pond water (representative of water quality expected to be treated with arsenic removal media) was sampled and sent to media vendors whom expressed interest through the procurement process. The vendors mixed proposed media in an alliquote of Polishing Pond water for ten minutes and then sampled the water for arsenic and antimony. Media products capable of adsorbing arsenic and antimony were then considered for on-site pilot testing.

During the off-site testing, AECOM completed the plan for on-site testing (AECOM, 2018c). Although the off-site testing was completed on Polishing pond water, the on-site testing needed to be completed using a more representative feed water source similar to the feed water expected to enter the arsenic removal media at the full scale. Fortunately, the existing ETP utilizes the same chemical treatment process proposed for the WTP. Therefore, instead of piloting the chemical treatment process, the pilot plant was designed to draw chemically treated water from the ETP chemical reaction tanks. The chemically treated water requires physical solids separation before it can be treated with arsenic removal media, so the pilot plant was designed to include a pilot-scale clarifier and filter before the arsenic removal process. The treatment processes, piping requirements, pumping requirements and other construction requirements were designed and included in the Pilot Treatment Plan in Appendix A. A contractor, Pure Elements, was hired through the Mine Construction Manager, Parsons to construct the pilot plant designed for on-site testing. AECOM commissioned the pilot plant onsite when construction was completed.

Similar to construction, the operation and experimental plan for the pilot plant is outlined in the Pilot Testing Plan in Appendix A. A contractor, Pure Elements was hired through the acting Mine Construction Manager, Parsons to operate the pilot plant during on-site testing. During operation, the contractor maintained hourly records of the pilot plant unit processes and completed sampling and delivery of samples to Taiga Environmental Laboratory. Analytical results and operating data were retained by AECOM for quality control and reporting purposes.

2.2 Materials & Test Media (Arsenic Removal Media)

Consumable materials used in the pilot plant include polymer, citric acid, cartridge filters, and the arsenic removal media. Polymer was used to flocculate the ETP feed water and facilitate the settling of solids in the clarifier. Citric acid was used to acidify the feed water to a pH suitable for efficient adsorption. Cartridge filters with 5 µm pore sizes were used to remove residual solids that bypassed the clarifier; the pore size was selected to be representative of a typical deep bed granular filter planned for the WTP. A summary of the media products is provided below in **Table 2-1**:

Table 2-1: Arsenic Removal Media Products

		Media Products Tested		
Product Name	(Desc.)	Media Product 1	Media Product 2	Media Product 3
Product Type	(Desc.)	Titanium Oxide	Ferric Oxide	Polystyrene w/ Divinylbenzene
Appearance	(Desc.)	White, Sandy	Brown, Sandy	Brown, Beads
Bulk Density	(kg/L)	0.65	0.46 0.57	0.79 – 0.82
Description of Function	(Desc.)	Titanium oxide media manufactured for the adsorption of arsenic.	Iron oxide manufactured media designed for the adsorption arsenic. Hydroxide ions are released and targeted constituents such as arsenic ions are adsorbed.	Hybrid ion exchange resin designed for the selective removal of arsenic from water.

2.3 Equipment

The following sub-sections describe the process equipment used to complete pilot testing.

The general layout of the pilot plant is shown in Error! Not a valid bookmark self-reference.. A 100 millimetre (mm) tank coupling was drilled into the ETP B3 Tank below the operating water level. Chemically treated ETP process water flowed by gravity from the ETP chemical reaction tanks and into the clarifier tank through approximately 50 metre (m) of 100 mm PVC that was sloped by 2% to facilitate gravity flow. Solids settle in the clarifier tank and clarified water is pumped from the supernatant of the clarifier and into the cartridge filters using a rotary vane pump. A flowmeter is set to flow-pace citric acid into the filtered water for pH adjustment. The filtered water then discharges into equalization tanks, or “pH Tanks”. The equalization tanks are operated in batches so that the process water can be assessed for pH and turbidity before being pumped to the arsenic removal contactors. Once water quality is confirmed, water is pumped from the storage tanks and into the arsenic removal contactors using a rotary vane pump. Effluent from the contactors is discharged into a sump and pumped back to the headworks of the ETP chemical reaction tanks.

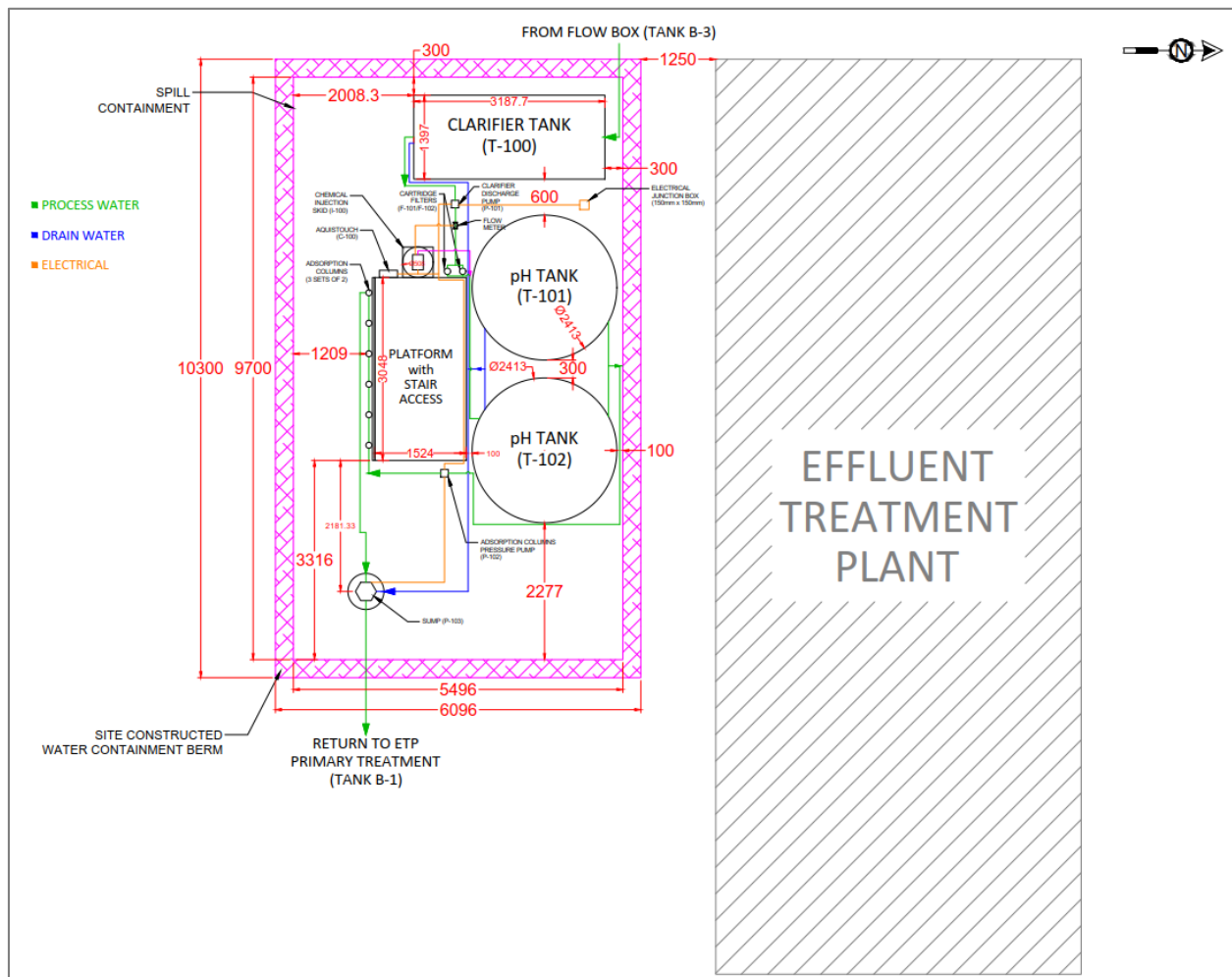


Figure 2-1: Pilot Plant Layout

2.3.1 Clarifier

Clarification was completed in a high-density polyethylene tank. An diaphragm inlet valve was utilized to control the flow entering the clarifier. The target inlet flow was always slightly higher than the pumped outlet flow so that an overflow would be surcharged. The overflow ensured that the pump would not draw air. Clarified water was decanted from the top of the tank and pumped through the cartridge filters. A drain valve and submersible pump were used to drain sludge that accumulated at the bottom of the tank. A peristaltic pump was used to dose polymer into the feed piping of the clarifier tank. The feed line from the ETP to the Clarifier, the Clarifier inlet piping, and the Clarifier outlet piping are shown in **Figure 2-2**.



Figure 2-2: Clarifier Photographs

2.3.2 Filtration

Cartridge filters were used to remove residual solids from the clarified water. A 5 µm pore size was utilized for the cartridge filters to target a particle size removal typical of a deep bed granular filter planned for the WTP. Two filters in series were used, the second cartridge filter was added as protection against solids breakthrough from the first filter. Pressure gauges allowed for observation of the differential pressure and assessment of the filter life. Turbidity was monitored on the filtered water to confirm solids were not entering the adsorption process. A variable speed rotary vane pump pressurized the filters. The filter bank, pump, and pump controller are shown below in **Figure 2-3**.

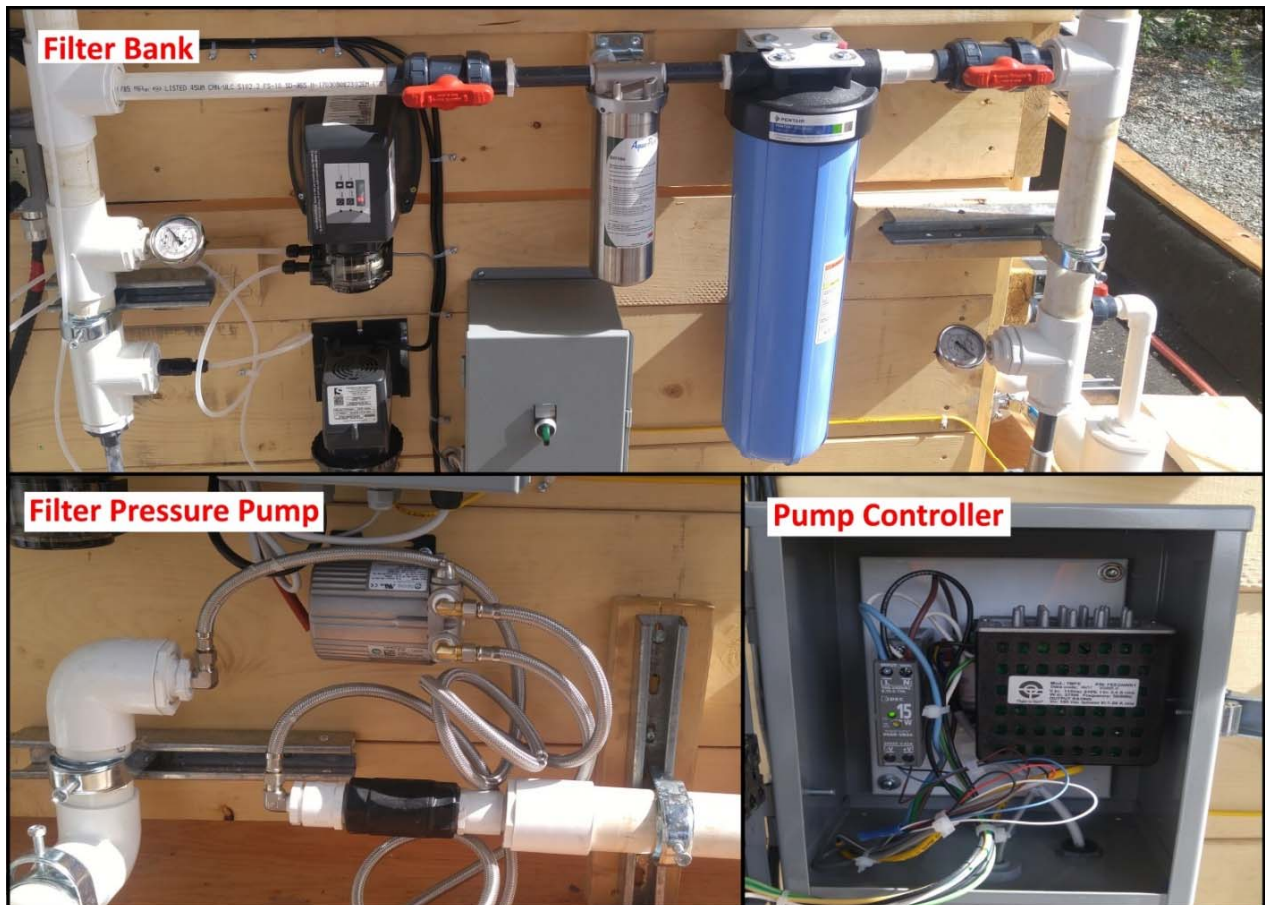


Figure 2-3: Filtration Photographs

2.3.3 Chemical Dosing –pH Adjustment

For all three medias tested, adsorption performance is expected to be more efficient at lower than neutral pH ranges (approximately 4.5 - 6.5). Therefore, the pH of the alkaline process water was adjusted prior to adsorption. Citric acid was dosed to target a pH of 6.5 to 7 so that the effluent from the adsorption process would satisfy the minimum EQC pH requirement of 6.5 while still optimizing the performance of the arsenic removal media. Citric acid was flow paced using a peristaltic pump and a digital flowmeter. The pH of the dosed water was manually checked every hour to confirm flow pacing was operating correctly and the pH of the water was not being compromised. The pH-adjusted water is stored in large equalization tanks. The citric acid day tank, dosing pump, and flowmeter used for flow-pacing are shown below in **Figure 2-4**.

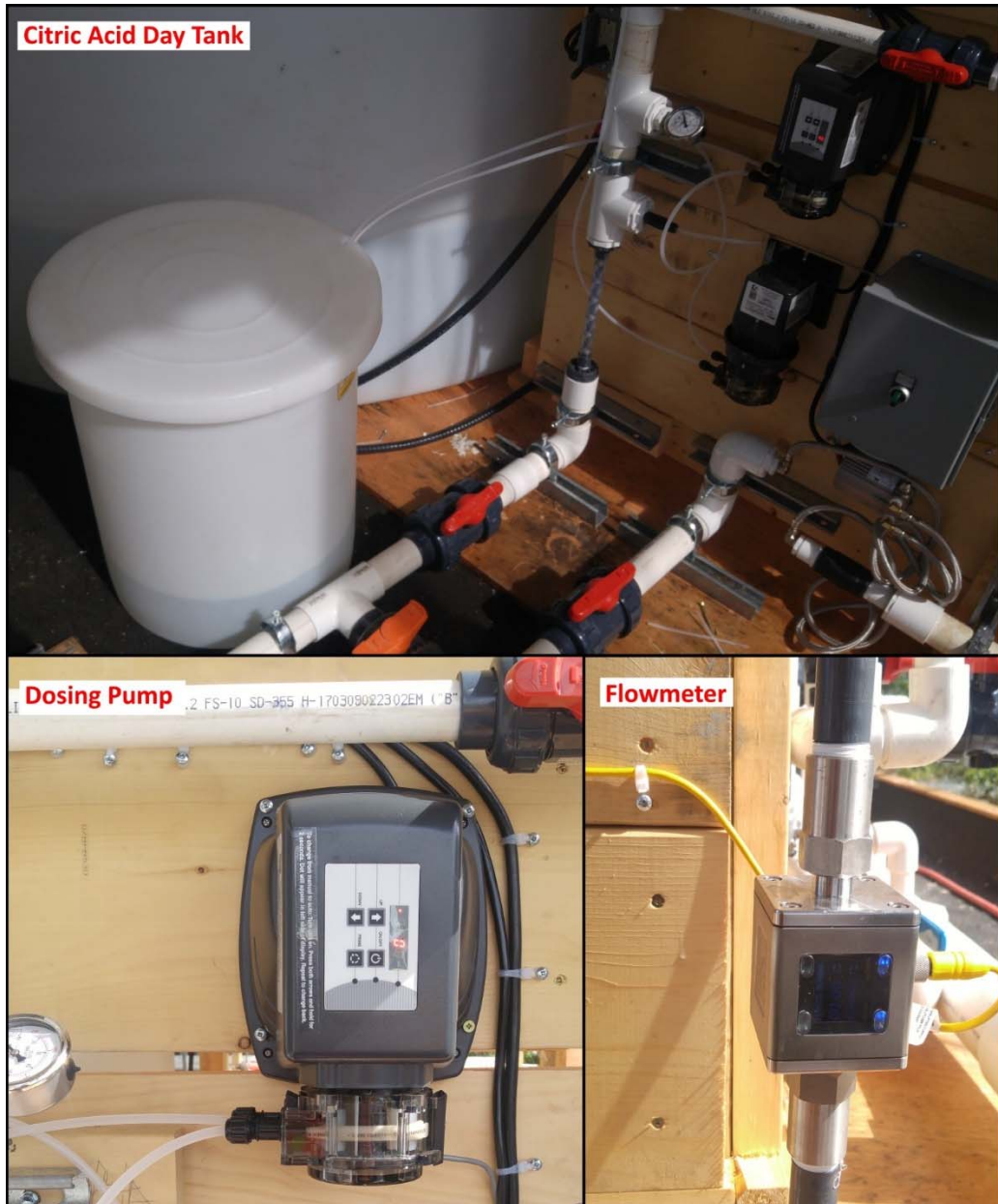


Figure 2-4: pH Adjustment Photographs

2.3.4 Arsenic Removal Contactor

Lead-lag configuration allows the full capacity of an adsorption media to be utilized. The lead-lag configuration employs two contactors in series, the duty contactor in the lead position acts as the main treatment vessel while the lag contactor acts as the polishing unit. In a single-column configuration, the media is swapped out at breakthrough, which is defined as the period where constituents in the treated water no longer meet water quality objectives. However, media still contains adsorption capacity after breakthrough. When the water quality entering the arsenic removal contactor is identical to the discharge water quality, the full capacity of the media is realized and the media is said to be exhausted. To minimize long term consumption costs, the WTP will be configured to fully exhaust the arsenic removal media. Therefore, the pilot is also configured to exhaust each media bed, meaning that the pilot assembly has been configured with a lead-lag configuration.

Figure 2-5 illustrates the arsenic removal media process and sampling locations for water quality and flow analysis. Water quality samples are taken on the feed water, lead-column effluent, and lag-column effluent to assess the arsenic and antimony treatment performance of the media. Rotameters monitor treated water production in order to assess the treated water production per unit of media, which can be used to project operating costs.

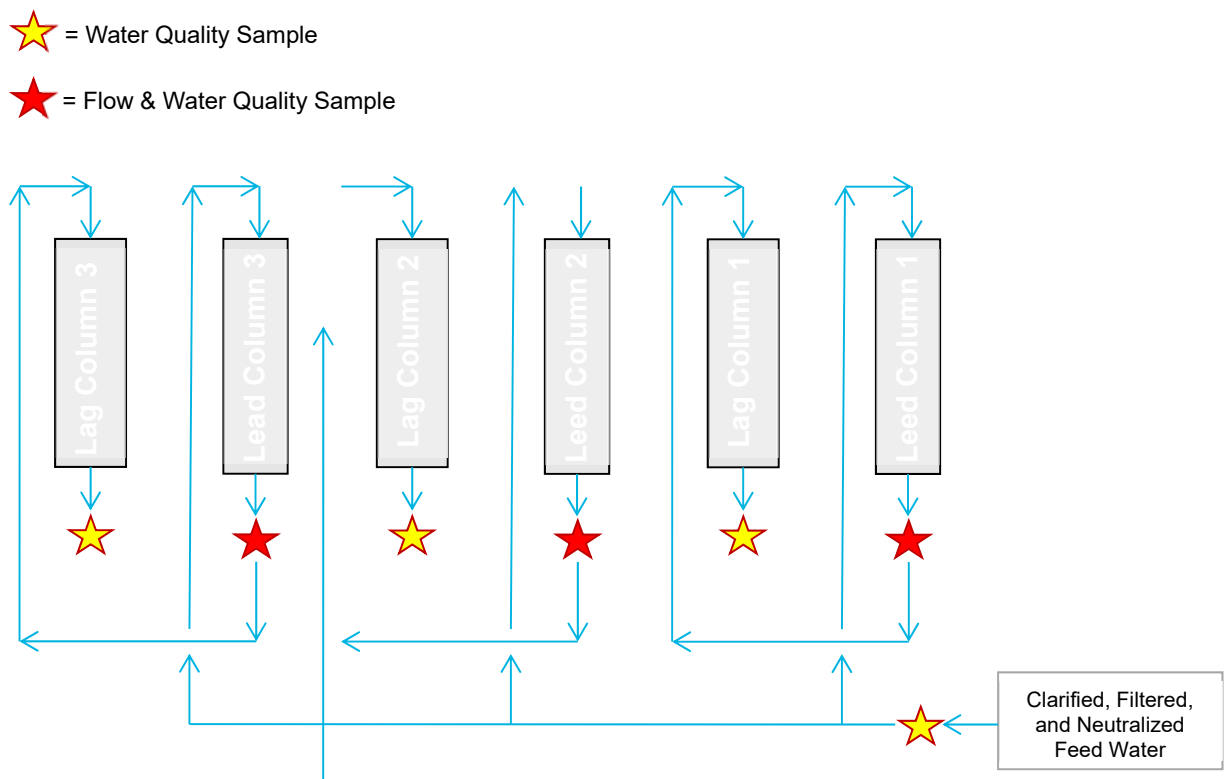


Figure 2-5: Basic Pilot Study Flow Diagram

Water was pumped into each of the arsenic removal contactors using a rotary vane pump and a common header. The water quality entering each of the different media trains was identical and evenly distributed through the duration of the piloting. Rotameters and inlet valves were used to manually modulate flow into each adsorption column. The flow was monitored hourly and adjusted to the target set-point as needed. Media was loaded into the 100 mm clear acrylic pipe to a depth of approximately 0.5 m. Three different medias were tested in the adsorption columns, each in lead-lag configuration. **Figure 2-6** shows a picture of the arsenic removal contactors.



Figure 2-6: Photograph of the Arsenic Removal Contactors

3. Experimental Results

The experimental results from the pilot testing are discussed in the following sections. The results include treated water quality, media antimony adsorption capacity, and metal leachability from exhausted media. The objectives of the pilot testing are to confirm the following:

1. The arsenic removal media can be used to reliably meet the Effluent Quality Criteria (EQC).
2. Which media is most cost effective for treatment of Giant Mine process water.
3. The exhausted media can be safely disposed in a non-hazardous waste landfill.

The sequence of pilot testing operational events includes the following:

- August 9 - pilot plant is commissioned.
- August 12 - the cartridge filter is over-loaded and suspended arsenic contaminated the arsenic removal media.
- August 19 - new media beds are installed and a second pilot run begins.
- August 19 - the adsorption column header is over pressurized and a by-pass line burst. The second pilot run is paused as repairs are made.
- August 22 - Pilot operation is resumed after repairs are made.
- August 29 - September 14: Clarifier performance reduces and causes excess suspended solids to load the cartridge filters. The pilot is intermittently turned off while the clarifier performance is addressed.
- October 5 - The ETP is shut down and feed water quality changes.
- November 9 - Media Product 1 is backwashed to relieve pressure.
- November 15 - Last sample is taken and pilot is shut off.
- November 17 - Decommissioning is completed.

With the exception of the backwashing completed on November 9, all operational events affected each media product. Backwashing can cause new flowpaths in the media bed and expose fresh media; it is standard operating procedure to backwash a media bed as it approaches exhaustion and prior to disposal. Unfortunately, there was insufficient piloting time to approach exhaustion and complete this step. Only one arsenic removal media was backwashed during the testing period, therefore a comparative assessment of the arsenic removal media will be biased toward the arsenic removal media that was backwashed. As discussed in Section 3.3, the antimony adsorption capacity was conservatively selected prior to the backwash step to avoid comparative bias.

3.1 Raw Water Quality

The pilot operated from August 22nd, 2018 to November 15, 2018. During this time, the raw water quality entering the ETP had higher arsenic concentration, but was otherwise typical of the Akaitcho dataset. A summary of the feed water quality to the ETP during pilot testing is provided in **Table 3-1** below.

Table 3-1: Mine Water Quality during Pilot Testing

Parameter	Unit	EQC		Water Quality at SNP 43-21 during Piloting		
		Average	Grab	Median	95 th Percentile	Sample Population
pH	-	6.5 to 8.0		8.01	8.14	13
Total Suspended Solids	mg/L	15	30	2.9	5.64	13
Total Ammonia	mg-N/L	-	-	0.22	0.95	13
Un-ionized Ammonia	mg-N/L	0.5	1.0	0.03	0.04	13
Total Antimony	mg/L	0.2	0.3	0.82	0.88	13
Total Arsenic	mg/L	0.01	0.02	44.4	75.6	13
Total Copper	mg/L	0.024	0.033	< 0.005	-	13
Total Lead	mg/L	0.003	0.008	0.0006	0.0007185	13
Total Nickel	mg/L	0.1	0.15	0.0298	0.0362	13
Total Zinc	mg/L	0.08	0.16	0.042	0.0501	3
Radium-226	Bq/l	0.37	1.11	n.m.	n.m.	-
Cyanide	mg/L	0.5	1	0.0098	0.01404	13
Total Petroleum Hydrocarbons	mg/L	3	5	n.m.	n.m.	-

The pilot feed water was taken from the ETP effluent. The ETP treats mine water using a coagulation process and is considered representative of the planned WTP process water. However, the ETP uses sedimentation ponds to separate coagulated solids from the process water. This is a considerable distinction from the planned mechanical solids separation processes planned for the WTP. Therefore, instead of drawing water from the settling ponds, pilot feed water obtained from the ETP chemical reaction tank and solids were removed from the feed water using a pilot-scale clarification and filtration processes. Furthermore, after solids separation, the feed water was acidified using citric acid to enhance the performance of the arsenic removal media. The feed water characteristics being fed into the arsenic removal contactors is presented below in **Table 3-2**. The arsenic and antimony concentration in the contactor feed water exceeds the EQC. From the feed water characterization, it is clear the total arsenic and total antimony are not meeting the EQC and require further treatment.

Table 3-2: Influent Water Quality Entering the Arsenic Removal Contactors

Parameter	Unit	EQC		Feed Water Quality		
		Average	Grab	Median	95th Percentile	Sample Count
pH	pH units	6.5 to 8.0		7.2	7.7	65
Total Suspended Solids	mg/L	15	30	4.0	6.5	30
Un-ionized Ammonia	mg-N/L	0.5	1.0	0.001	0.006	30
Total Antimony	mg/L	0.2	0.3	0.283	0.385	65
Total Arsenic	mg/L	0.01	0.02	0.255	0.596	65
Total Copper	mg/L	0.024	0.033	0.002	0.006	30
Total Lead	mg/L	0.003	0.008	0.000	0.166	30
Total Nickel	mg/L	0.1	0.15	0.02	0.02	30
Total Zinc	mg/L	0.08	0.16	0.003	0.007	30
Radium-226	Bq/L	0.37	1.11	n.m.	-	0
Cyanide	mg/L	0.5	1	<0.005	-	30
Total Petroleum Hydrocarbons	mg/L	3	5	n.m.	-	0

3.2 Treated Water Quality

The treated water quality produced from the arsenic removal contactors is presented in **Table 3-3**. It should be noted that the treated water quality presented is sampled from the lag column, therefore, the sampled water has passed through the lead and lag column. Refer to **Figure 2** for an illustration of the sampling point. This distinction is important to note because later in the report water quality samples from the lead column effluent are used to track exhaustion and adsorption capacity of the respective media. Treated water quality was sampled throughout the duration of the piloting period, however, throughout the pilot test, two of the lag column contactors showed evidence of antimony or arsenic breakthrough. Only water quality samples obtained prior to lag column breakthrough are incorporated into **Table 3-3**. The larger the sample population, the longer the respective media lasted before contaminant breakthrough. The treated water quality results and comparison to the EQC, all three media products can produce a treated water quality that meets the EQC.

Table 3-3: Treated Water Quality

Parameter	Unit	Effluent Quality Criteria		Media Product 1			Media Product 2			Media Product 3		
		Maximum Average	Maximum Grab	Average	Max	Count	Average	Max	Count	Average	Max	Count
pH	-	6.5-8.0		7.2	7.4	44	7.3	7.8	64	7.3	7.6	29
Total Suspended Solids	mg/L	15	30	3.7	8.0	21	4.0	20.0	29	4.2	12.0	12
Unionized Ammonia	mg-N/L	0.5	1	0.0002	0.0007	21	0.0006	0.0013	29	0.0002	0.0005	12
Total Antimony	mg/L	0.2	0.3	0.008	0.144	44	0.078	0.173	64	0.179	0.298	29
Total Arsenic	mg/L	0.01	0.02	0.004	0.016	44	0.003	0.017	64	0.004	0.013	29
Total Copper	mg/L	0.024	0.033	0.0023	0.0119	21	0.0029	0.0235	29	0.0004	0.0005	12
Total Lead	mg/L	0.003	0.008	0.001	0.0071	21	0.0024	0.043	29	0.0001	0.0001	12
Total Nickel	mg/L	0.1	0.15	0.011	0.023	21	0.006	0.016	29	0.005	0.008	12
Total Zinc	mg/L	0.08	0.16	0.002	0.0187	21	0.0074	0.057	29	0.0004	0.0009	12
Radium-226	Bq/L	0.37	1.11	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
Cyanide	mg/L	0.5	1	0.004	0.005	21	0.005	0.005	29	0.005	0.005	12
Total Petroleum Hydrocarbons	mg/L	3	5	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.

3.3 Adsorption Capacity

Based on the current ETP treatment efficiency, arsenic and antimony will both require treatment with arsenic removal media to meet EQC. However, antimony is only slightly above the EQC (see **Figure 3-1a**). Improvements in precipitation treatment may allow antimony to be compliant with the EQC without the use of arsenic removal media. In this case, only arsenic would require treatment by the arsenic removal media.

To be conservative, during pilot testing both arsenic and antimony were monitored and reported relative to the EQC requirements. The influent and effluent arsenic and antimony water quality are plotted on **Figure 3-1**. The time series in **Figure 3-1** has been converted to an adsorption capacity trend shown in **Figure 3-2**. Effluent data plotted in **Figure 3-1** and **Figure 3-2** represent water quality from the lead column. Refer to **Figure 2** for an illustration of the lead column sample location. Dissolved arsenic began to break through the Media Product 1 first, followed by Media Product 3, and then Media Product 2. Despite experiencing initial arsenic breakthrough, none of the media products were exhausted for arsenic due to time restrictions with the pilot. Therefore, the arsenic adsorption capacity of each media based on processing Giant Mine water has not been determined. The arsenic adsorption capacity is required to improve the accuracy of the operating cost estimate of the arsenic removal media.

Dissolved antimony began to break through Media Product 3 first, followed by Media Product 2, and then Media Product 1. Media Product 2 and Media Product 3 were run to exhaustion for antimony. Media Product 1 was nearly exhausted near the end of the pilot test; however, antimony exhaustion was not completely achieved. For the purposes of comparison, antimony exhaustion for Media Product 1 is interpreted as the date where the antimony concentration exiting the lead column reached the highest concentration, November 7, 2018. For Media Product 2 and Media Product 3, exhaustion occurred when the antimony concentration reached or exceeded the influent antimony concentration.

During further advancement of the design improved antimony precipitation and removal through clarification and filtration to achieve compliance with the EQC is the recommended approach. It will simplify the design. This will allow the arsenic removal media to focus on arsenic removal only. It will simplify the design and reduce the expected operating cost by extending the life of the media.

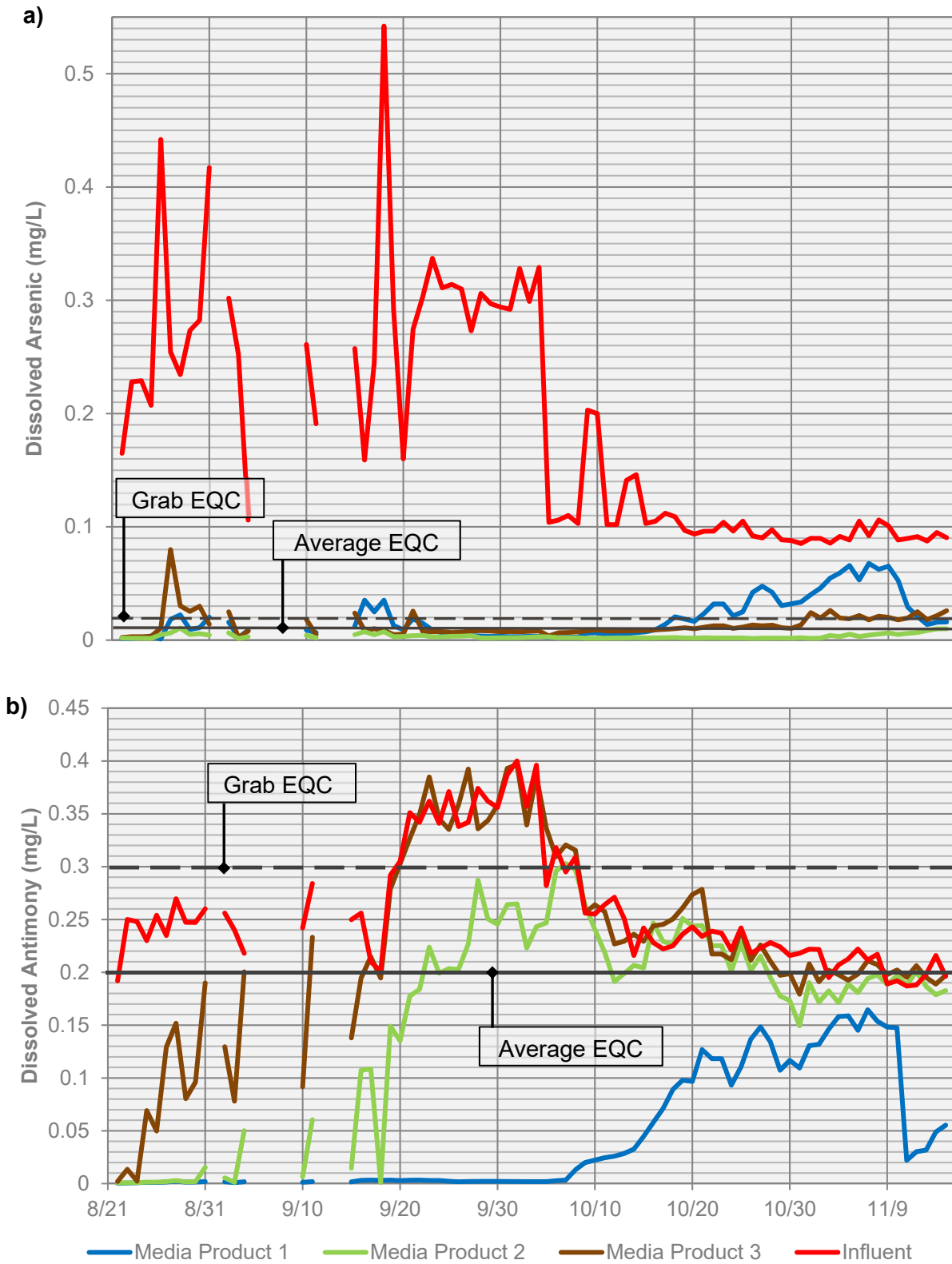


Figure 3-1: a) Dissolved Arsenic and b) Dissolved Antimony Concentration Time-Series

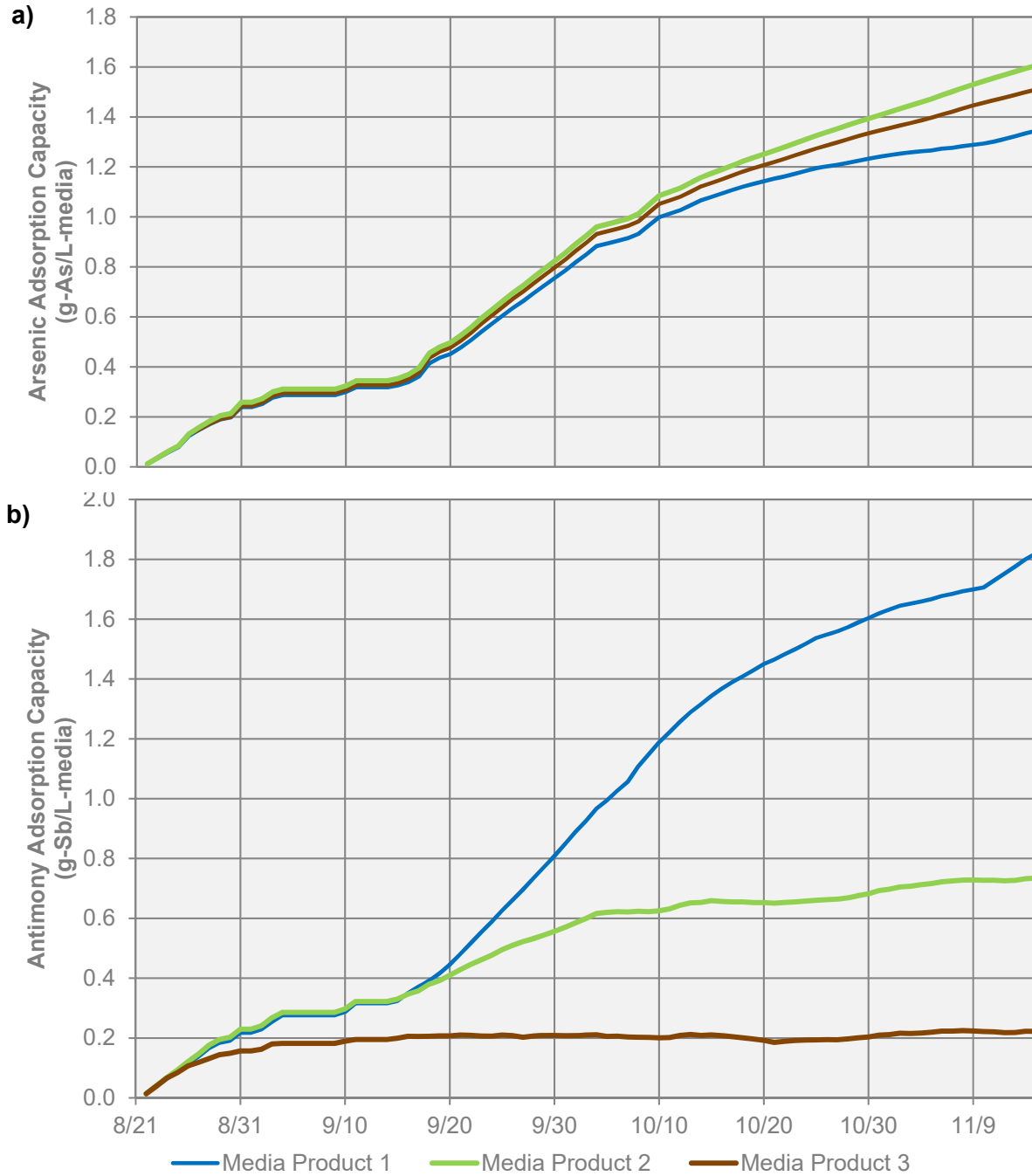


Figure 3-2: a) Dissolved Arsenic and b) Dissolved Antimony Adsorption Capacity

3.4 Metal Leachability

A critical design assumption for the remediation project is that exhausted media can be safely disposed of in a non-hazardous waste landfill. The key concern is confirmation that the exhausted media can be classified as a non-hazardous waste material. To determine if the media is non-hazardous, a toxicity characteristic leaching procedure (TCLP, SW-846 EPA test method 1311) was completed on the partially exhausted media from the pilot test.

The waste material is submerged in a synthetic acidic solution meant to simulate the characteristics of a landfill leachate. The waste and synthetic leachate are continuously mixed for a period of 20 hours. After mixing, the synthetic leachate is tested for metals. In the Northwest Territories, guidelines and regulations are in place that regulate the concentration of allowable metal leaching for hazardous waste classification. The results from the TCLP test and regulation criteria are presented in **Table 3-4**. All three exhausted media products passed the TCLP and are classified as non-hazardous waste.

Table 3-4: TCLP Results

Analyte	Units	BC Hazardous Waste Regulation (2017)	Guideline for Hazardous Waste Management (NWT; 2017)	Media Product 1	Media Product 3	Media Product 2
Antimony	mg/L	-	0.6	0.026	0.076	0.0915
Arsenic	mg/L	2.5	2.5	0.355	0.211	0.102
Barium	mg/L	100	100	<1.0	<1.0	<1.0
Beryllium	mg/L	-	5	<0.050	<0.050	<0.050
Boron	mg/L	-	500	<0.50	<0.50	<0.50
Cadmium	mg/L	0.5	0.5	<0.001	0.001	<0.001
Chromium	mg/L	5	5	<0.050	<0.050	<0.050
Cobalt	mg/L	-	100	0.24	0.105	0.05
Copper	mg/L	100	100	<0.10	<0.10	<0.10
Iron	mg/L	-	-	<1.0	<1.0	2
Lead	mg/L	5	5	<0.010	<0.010	<0.010
Mercury	mg/L	0.1	0.1	<0.002	<0.002	<0.002
Nickel	mg/L	-	-	0.21	0.235	0.2
Selenium	mg/L	1	1	<0.020	<0.020	<0.020
Silver	mg/L	5	5	<0.002	<0.002	<0.002
Thallium	mg/L	-	-	<0.010	<0.010	<0.010
Uranium	mg/L	10	2	<0.020	<0.020	<0.020
Vanadium	mg/L	-	-	<0.050	<0.050	<0.050
Zinc	mg/L	500	500	<0.50	<0.50	<0.50
Zirconium	mg/L	-	-	<0.050	<0.050	<0.050
Extraction Fluid pH	-	-	-	4.94	4.94	4.94
Final Extract pH	-	-	-	5.215	4.95	5.02

Notes:

1: Data represents average of two samples, no significant deviation was observed between sample replications

4. Conclusions and Recommendations

As described within previous sections of this report, a pilot test was completed in 2018 to demonstrate treatment of mine water using arsenic removal media. The pilot tested three media products installed downstream of a simulated version of the planned WTP. The simulated version of the WTP consisted of the ETP chemical reaction process, followed by pilot-scale gravity clarification, cartridge filtration, pH adjustment and arsenic contactors.

The pilot testing assembly was built at the ETP. Once the pilot treatment assembly was constructed, testing, commissioning and trial operating periods were completed. After the constructed assembly was demonstrated to be fully functional, the test period commenced. The goal prior to commencing the on-site testing was to fully exhaust the media twice to demonstrate the repeatability of the arsenic removal media performance. Due to challenges on-site during the construction and commissioning phase of the project, the treatment process period from August 22 to November 15, 2018 was not long enough to fully exhaust all the test media. The testing was terminated on November 15, 2018 due to the cold winter weather.

The desired data was not collected, but valuable information that will inform the design, construction and operation of the long term WTP was obtained. The key conclusions from the pilot testing program completed during the summer of 2018 are the following:

1. The use of conventional water treatment processes for the removal of particulate and contaminants prior to the arsenic removal contactors is a suitable approach. The discharge from the ETPs chemical reaction tanks was diverted to a gravity clarification basin followed with cartridge filtration. For ease of construction and operation simple clarification and filtration processes were built and both process functioned suitably. As a result, a properly designed clarification process downstream of a reaction basin for the addition of lime and coagulants, followed by granular media filtration is expected to provide sufficient pre-treatment to support the sustainable operation of the arsenic removal media.
2. Arsenic removal media may be used to treat arsenic and antimony to achieve the EQC target of less than 0.01 mg/L of arsenic and 0.2 mg/L of antimony. As noted previously, meeting the antimony treatment target is likely achievable prior to the final process polishing step meaning the arsenic removal media could be optimized for arsenic only.
3. The arsenic removal media does not interfere with or impede the other water quality parameters of the EQC.
4. It is recommended that arsenic removal media is incorporated into the WTP process to treat for arsenic and antimony in order to meet the EQC.
5. Three arsenic removal media products were tested. Media Product 1 is estimated to provide the most cost-effective treatment. However, all three media effectively removed both arsenic and antimony from the process stream. For development of the pre-design, Media Product 1 will be used; however, the specific selection of the arsenic removal media should be delayed until detailed design of the WTP is completed.
6. All three exhausted media products passed the TCLP for classification as non-hazardous waste. Disposal of the exhausted media produced during the long term operation of the WTP can occur at the on-site non-hazardous waste landfill.
7. All three media products were not run to exhaustion and the test was not repeated. It is anticipated that a future test would continue to demonstrate the ability to remove arsenic and antimony and achieve the treated water quality objectives identified in the EQC. However, without exhausting the media and repeating the test, providing accurate operating cost projections is not possible at this time.

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AECOM Canada Ltd. (AECOM, 2018b). Giant Mine Off-Site Pilot Testing Results Memo.

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Appendix A

Giant Mine Remediation Project – Arsenic and Antimony Ion Adsorption Pilot Test Plan

Indigenous and Northern Affairs Canada

Giant Mine Rehabilitation Project – Arsenic and Antimony Ion Adsorption Pilot Test Plan

Prepared by:

AECOM
201 – 3275 Lakeshore Road
Kelowna, BC, Canada V1W 3S9
www.aecom.com

Project Number:

60561021

Date:

March 23rd 2018

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1	02/21/2018	MD, BdW	Draft Issue to PSPC and TRC
2	09/04/2018	MD, BdW	Issue with Response to Review Comments

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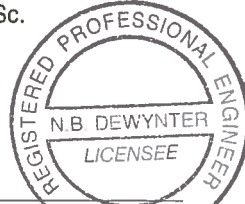
Quality Information

Report Prepared By:

Marco Denee, E.I.T., M.A.Sc.

Report Reviewed By:

Brett deWynter, P. Eng.



April 9/18.

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1. Introduction

A long term closure and reclamation plan is being developed for Giant Mine. The long term water management plan for the Giant Mine site includes the ongoing collection and treatment of contaminated water at the mine site. To facilitate a long term sustainable treatment plant that consistently achieves the treated water quality objectives, a treatment solution is needed that balances process risk against capital and operating cost.

Analysis of the treatment options has been completed in the past. Currently the coagulation, pH adjustment and sedimentation in earth ponds provide a reduction in the order of 98% for arsenic removal. However, even with this level of treatment the arsenic levels are still roughly 20 times greater than the treatment target. Previous analysis has indicated that mechanical sedimentation and filtration followed with ion exchange media for final polishing of the process flow offers a cost effective method to reliably remove arsenic and antimony to achieve the water quality objectives. Although this general approach has been successfully used at other facilities, some challenges specific to the characteristics of the Giant Mine site run-off water are:

- There are numerous other ions present that may compete with arsenic and antimony for affinity onto adsorption media.
- The concentrations of the arsenic entering the ion exchange process are in the order of the 0.298 mg/L. This is significantly higher than drinking water design target of 0.010 mg/L and higher than the arsenic concentrations typically found in raw drinking water sources. Therefore, there is a risk that ion exchange media will not function as designed.

Ion exchange media manufacturers and distributors have indicated interest in participating in the pilot testing and have proposed media options. An off-site bench test will be completed by each vendor to demonstrate the adsorption properties of each proposed media. Only media that has demonstrated the ability to achieve the performance with a water sample collected from the Giant Mine site will be considered for on-site pilot testing. The process of identifying media capable of achieving the treatment objectives is ongoing.

This plan describes the objectives and methodology of the on-site pilot test for the media selected through the initial screening process. The results of the initial screening followed with on-site pilot test will produce data which will inform the design and operation of the long term Giant Mine Effluent Treatment Plant (ETP).

1.1. Objectives

The following objectives of the pilot test have been used to design the experiment methodology:

- Identify the removal efficiency of arsenic and antimony for each media and confirm the media can produce treated water that meets water quality objectives outlined in **Table 1**.
- Rank media performance in terms of volumetric production of treated water per volume of media.
- Rank media performance in terms of volumetric production of treated water per dollar spent.
- Estimate operational cost for full-scale treatment using the most cost effective media.
- Develop full-scale design parameters based on the performance characteristics observed and measured.
- Quantify and characterize waste streams produced by the exhausted media and the volume of media that will require disposal in the on-site landfill. Additionally, the exhausted media will be tested to confirm that it complies with EPS's SW-846 Test Method 1311: Toxicity Characteristics Leaching Procedure.

Table 1 – Water Quality Objectives

Parameter	Value
Treated Water Antimony Concentration	< 0.006 mg/L
Treated Water Arsenic Concentration	< 0.010 mg/L

2. Experimental Plan

The pilot test will rank and compare the performance of three ion exchange adsorption media. Three media have been sourced through the Relative comparisons between the media will be completed based on the data collection from the pilot columns operated in parallel to each other. However, the feed water entering the adsorption process will need to represent conditions expected at a full-scale treatment plant to ensure data can be used to inform decisions that extend beyond relative comparisons between media vendors. The following paragraphs describe the testing plan to produce water for testing which will closely represent full scale water characteristics entering the ion exchange adsorption contactors.

Water is currently treated at the mine site with coagulation, pH adjustment, flocculation, and extended clarification in earth ponds. The sedimentation in the earth ponds occurs in 2-stages. The proposed full-scale treatment plant will use high-rate clarification, filtration and adsorption process downstream of the existing coagulation, pH adjustment and flocculation processes.

A low cost method is needed to produce feed water for testing which will closely represent full scale water characteristics entering the ion exchange adsorption contactors. The plan is to divert a sidestream flow from the ETP after flocculation and prior to discharge to the earth clarification ponds during the regular summer operation. For the pilot testing, simple equipment will be moved to site for clarification, filtration, and pH adjustment upstream of the pilot ion exchange adsorption test columns. The ion exchange adsorption process will be operated in lead-lag configuration to represent a full scale application.

Lead-lag configuration allows the full capacity of an ion exchange adsorption media to be utilized. The lead-lag configuration employs 2 contactors in series, the duty contactor in the lead position acts as the main treatment vessel while the lag contactor acts as the polishing unit. In a single-column configuration, the media is swapped out at breakthrough, which is defined as the period where constituents in the treated water no longer meet water quality objectives. However, media still contains adsorption capacity after breakthrough. When the water quality entering the ion exchange adsorption contactor is the same as the discharge for the targeted parameters, the full capacity of the media is realized and the media is said to be exhausted. The full scale ETP will be configured to allow the media to be exhausted. To mimic the full scale ETP and extrapolate the media operational costs with confidence, the pilot assembly will be configured with lead and lag contactors.

Given the relatively high concentration of the arsenic entering the ion exchange contactors, it is expected that breakthrough could begin early in the run cycle resulting in loading on the lag contactor. An item to demonstrate is that breakthrough of the lag contactor will not occur as the lead contactor reaches exhaustion. Achieving the arsenic treatment target of 0.010 mg/L is critical and given the high concentration of arsenic entering the system it is suspected that loading on the lag contactor could create a concern that impacts the operating costs. To quantify this issue the pilot assembly will be configured for lead-lag operation with sample points at the discharge of the lead and lag contactor.

Figure 1 illustrates the basic pilot test process. Although 5 media trains are listed, the results from the off-site testing will determine exactly how many media will be evaluated in the pilot test. A more detailed set of piping and process drawings is provided in Appendix B – Site and Process Drawings.

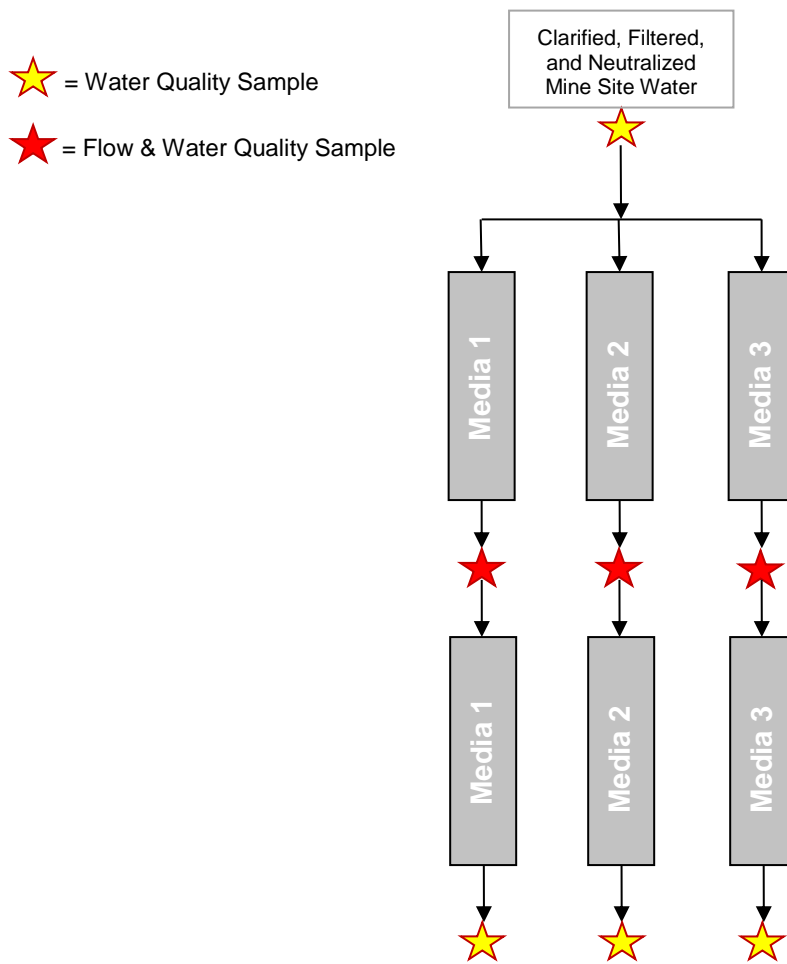


Figure 1 – Basic Pilot Study Flow Diagram Train

The overall pilot program is subdivided into stages as follows:

- **Stage I: Pilot Plant Setup and Diagnostics Testing.** The pilot assembly will be designed to be a simple assembly consisting of generic plumbing supplies configured in a manner to achieve the desired test results. Based on a pilot assembly schematic design, a local contractor will be hired to complete all wiring and piping to the pilot equipment. Once this is complete, hydrostatic testing, equipment setup and calibration will be completed, thereby bringing the unit processes to a state of readiness for the commencement of testing.
- **Stage II: Comparative Testing of Ion Exchange Adsorption Media.** This stage of pilot testing will assess the performance of each adsorption media and record the first iteration of the results for development of the Pilot Treatment Testing Program Report. Testing will be performed in a comparative manner, to support a recommendation for the most beneficial ion exchange media for the full scale Giant Mine ETP.
- **Stage III: Replication of Comparative Testing.** This stage of pilot testing will re-assess the performance of each adsorption media and record the second iteration of the results for development of the Pilot Treatment Testing Program Report. The results will be replicated to demonstrate repeatability and robustness of the

adsorption media. Practically, Stage II and Stage III of the testing procedure equate to running the media to exhaustion two consecutive times.

2.1. Schedule

It is important to accurately design the pilot test equipment according to the project schedule. The key time constraints for the pilot testing program is aligning with the seasonal operation of the existing ETP and providing enough time to run the ion exchange media to exhaustion two consecutive times.

For the purpose of planning it is assumed that there is a 2.5 month period for on-site testing. Based on this available time and a rough review of the media characteristics, a water flow rate for testing has been estimated. Using the flow passing through the media the reaction time for adsorption can be determined based on the media depth. Preliminary calculations based on vendor performance estimates have been completed to determine adsorption column size which will lead to media exhaustion twice within the available test schedule.

An estimate of the project schedule is presented in **Figure 2**. The schedule is intended to be used as a prediction for implementation of the pilot test, but the actual duration of each task and the overall schedule may be subject to change.

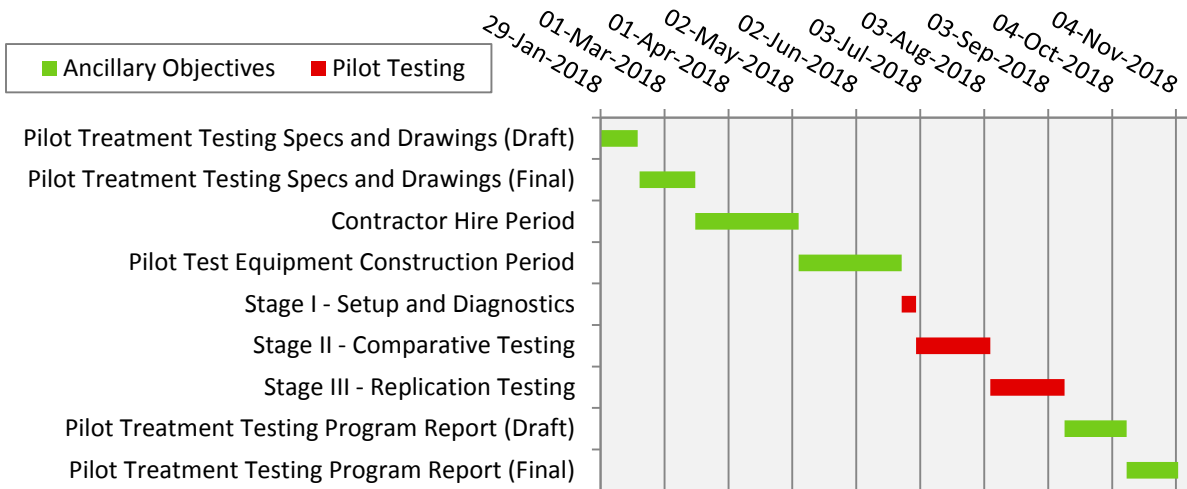


Figure 2 – Estimate of Pilot Testing Schedule

2.2. Stage I: Pilot Plant Setup and Diagnostics Testing

Once the pilot equipment is plumbed, the water supply to the pilot assembly will need to be tested to confirm the supply of process water is reliable. Additionally, water processed through the test assembly will need to be discharged. To minimize the water supply and disposal logistics it is assumed that the pilot testing assembly will be located at the location of the existing ETP.

To reduce the risk of interruption during testing, the pilot testing assembly will be trial tested with water to confirm the function of the equipment. Once the pilot test assembly is proven to function reliably, the next stage of testing will be completed.

2.3. Stage II: Comparative Testing of Adsorption Media

The Stage II test period will be the culmination of operational and performance data during the first iteration of the pilot test. Flowrate, arsenic, and antimony data will be monitored every other day for each media. Additional data will

be taken from the pilot test as described in Section 4 – Analytical Sampling Plan. Phase II will continue until the lead column for each media has been exhausted. Media columns have been sized to exhaust media within an estimated 15-20 day time period. However, column size is based on media water quality characteristics and vendor performance estimates of 4,500 - 5,500 bed volumes of treated water production, or 11 – 13 days of treated water production, before constituent breakthrough. An additional 2 – 7 days of run time is assumed to reach media exhaustion. The schedule is based on vendor performance estimates and will be subject to change depending on water characteristics and real media performance. Provision for a 36 day Stage II test period has been considered in the schedule as contingency in case media performance exceeds expectations and/or arsenic and antimony loading is lower than the considered media values. Upon completion of testing, the following will be known and/or achieved:

- capability of each media to produce treated water that meets the water quality objectives;
- dollar cost per volume of treated water for each media; and
- leaching properties of the exhausted media – this will be determined by analyzing the exhausted media in accordance with the EPA SW-846 Test Method 1311.

2.4. Stage III: Comparative Testing of Adsorption Media

The Stage III will repeat the pilot test completed in Stage II. Each media in the lead and lag adsorption columns will be replaced with fresh media. The goal of Stage III testing is to demonstrate that adsorption media will perform consistently.

3. Pilot Testing

On-site pilot testing will be completed at the mine site near the existing ETP. The general layout of equipment, ground conditions, feed water tie-in point, and treated water discharge will need to be finalized in the On-site Pilot Testing Specifications and Drawings.

The pilot equipment will require a power source, feed water source, and treated water disposal. Servicing of the pilot equipment will be required during the operation of the pilot study. The configuration of the pilot is designed to be simple allowing for consistent results with minimal operation input.

A power supply will be needed to power three pumps and instrumentation for the pilot testing equipment. The flowrate is small and the pump sizes are expected to require only single phase 120/240 volt power. It is assumed that a 1-phase power connection from the existing power supply within the ETP can be provided to the pilot testing site.

The pilot testing feed water source will be the chemically processed water from the existing ETP. The pilot testing media columns have been sized based on a feed water flowrate of 4.9 m³/d. The flowrates are specified so that 4 L of media is expected to run to exhaustion twice within the amount of time projected for pilot testing (see Figure 2 for schedule). The hydraulic profile of the pilot testing equipment will depend on the inlet pressure of the feed water source. Discharge tanks at the ETP are 10 ft (3 m) high and the grade at site is relatively level, so it is assumed that a minimum of 50-60 kPa of inlet pressure will be available to supply the clarification process under gravity flow conditions.

Process flow diagrams are provided in Appendix B. The chemically processed water from the existing ETP will be diverted through a clarification tank followed by pumping and filtration. A small pump is proposed for the clarified water to overcome the headloss through the cartridge filters. Once the water is filtered, the pH of the process stream will be lowered in pH adjustment tanks to work more effectively with the ion exchange adsorption media. All overflow and waste streams will be collected in a wet well and discharged to the surface of tank B-3 of the ETP with a submersible pump.

3.1. Pilot Testing Operation

In addition to the analytical sampling program outline in Section 4 – Analytical Sampling Plan, operation staff will be responsible for routine operating procedures at the pilot treatment plant. The operational labour demand is expected to be approximately 24 - 32 hours/week during the pilot test. Some of the tasks include:

- Weekly wasting (or as required) of settled sludge in the clarifier tank.
- Daily check the pressure differential across the duty cartridge, if the differential is 5 psi within the maximum allowable, the operator will manually adjust the valves so that the stand-by filter is in operation. Once the duty filter is isolated the filter can be replaced.
- Perform daily batch pH adjustment according to the procedure described in Section 3.2.3.
- Maintain a daily log of the activities;
- Collect samples and deliver to the selected laboratory for analysis;
- At the end of Stage II, the operator will need to replace spent adsorption media with fresh media.

3.2. Pilot Testing Equipment

3.2.1. Clarification

Clarification will be completed in a commercially available high-density polyethylene. Under the flow conditions mentioned (4.9 m³/d) above, a 5.8 m³ tank will allow for approximately 7 hours of settling. The clarified water will be decanted from the top of the tank and conveyed to the next process for further treatment. To address solids build-up in the bottom of the tank a drain valve will be provided. During the pilot testing period, the drain valve can be manually opened by the operator to waste the precipitated solids material from the bottom of the tank and into the discharge wet well. Additionally, a roof access will be provided so settled sludge can be pumped from the tank if required.

3.2.2. Filtration

Cartridge filtration will be used to polish feed water prior to media adsorption. Two cartridge filters will be operated in duty/stand-by configuration. A pressure gauge will be placed upstream of each filter to allow for the operator to monitor and replace duty cartridges as needed. A continuous pump will operate upstream of the cartridge filter to apply adequate pressure and maintain a constant flowrate.

3.2.3. Chemical Dosing – pH Adjustment

Media adsorption is expected to be more functional at roughly a neutral pH. Therefore, the pilot test will be operated at an optimal pH so that the results may be representative of the full-scale operational costs. Unfortunately, optimal pH varies for each media and the pH of the water diverted from the existing ETP will be elevated for the precipitation of metals. After filtration feed water pH for each media will be lowered to 6.0 – 6.5. This pH aligns with the requirements of the treated water objectives and will avoid the need for downstream alkalinity dosing. A batch pH adjustment tank that services all 5 media columns is proposed for the pilot testing equipment.

The chemical dosing system will operate in batch. Two tanks will be connected downstream of the filtration process. The tank will be sized to store water for two days of flow from the process stream and have an emergency overflow that ties into the effluent pond. Once full, an operator will sample 1 liter of water from the tank and determine the volumetric ratio of acid reagent required to adjust the entire tank volume to a pH value between 6 - 6.5 using a field pH probe. The operator will then dose the tank with reagent and use a mechanical mixer to equalize the tank pH. Once the tank has been sufficiently mixed, the valve system is manually configured so that the newly prepared tank is being drawn from and the previously operational tank will be filling up.

3.2.4. Adsorption

Water from the pH tanks will be pumped into a common header shared between each adsorption column. Rotameters and inlet valves will be used to control the flow into each ion exchange adsorption contactor. A contactor pipe diameter of 100 mm will provide slow flow-through velocity and sufficient reaction time between the media and the water constituents. Five trains of unique adsorption media will be tested in parallel. Each parallel train will run two columns of the media in a “lead-lag” configuration. The lead-lag configuration will be representative of a full-scale operation and is meant to capitalize on the full capacity of each respective media.

Each column will be equally sized to allow similar volumes of water and similar reaction times to interact with each respective media. At the inlet to the header, a sampling port will be available for influent arsenic and antimony monitoring. At the discharge of each of the first columns, a flow element and a sampling port will measure the volume of water treated and residual arsenic and antimony concentration. The columns have been sized to contain 4 L of media which is expected to be exhausted within 15 to 20 days based on preliminary performance quotations from various vendors. The objective is to run the media to exhaustion twice to demonstrate reproducible results.

Considering the 72 day pilot testing schedule, sizing for a 20 day exhaustion period allows for contingency in case of delays.

To capture the key adsorption performance metrics, arsenic, antimony, and volumetric output are recorded every day during pilot testing. Further, acidification and cartridge filtration have been designed for a daily operational service frequency.

4. Analytical Sampling Plan

4.1. Sampling Program

For the duration of the pilot testing program, water quality sampling will proceed on a continuous daily basis. **Table 2** lists the various water quality sampling and monitoring to be completed during each pilot stage. It is assumed that off-site laboratory testing will be coordinated by AECOM. AECOM will be responsible for QA/QC of laboratory data, tracking samples and managing data.

Table 2 – Summary of Sampling Plan During Pilot Test

Sample Location	Parameter	Frequency	Analytical Lab Turnaround
Influent Line	Full Parameter Sweep ²	Every 2 nd day	Regular
Influent Line	Total Arsenic + Antimony Dissolved Arsenic + Antimony pH Conductivity Chloride Sulphate	Every other 2 nd day (when full parameter sweep is not being sampled)	Regular ³
Lead Column Effluents ¹	Column Flow Rate Total Arsenic + Antimony Dissolved Arsenic + Antimony pH Conductivity Chloride Sulphate	Every day	Rush ⁴
Lag Column Effluents ¹	Full Parameter Sweep ²	Every 2 days	Regular ³
Lag Column Effluents ¹	Total Arsenic + Antimony Dissolved Arsenic + Antimony pH Conductivity Chloride Sulphate	Every other 2 nd day (when full parameter sweep is not being sampled)	Regular ³

1: Lead and lag column effluent samples will be taken for each of the three media adsorption columns

2: Full parameter list is provided in Appendix D

3: Regular delivery time means results are delivered within 10 days (including weekends) of sampling at the pilot test plant

4: Rush delivery time means results are delivered within 2 days (including weekends) of sampling at the pilot test plant

4.2. Sampling Protocol

Collect all organic and inorganic water quality samples as grab samples from the denoted sample points. Clean sample bottles of adequate volume should be obtained for all sampling. Prior to sampling, sample containers will be clearly marked and identified with a permanent ink marker and double checked that the sample ID matches the sampling port. As a minimum, sample ID shall contain: name of operator taking sample, date (accurate to the hour), and the tag ID of the sampling port used to take the sample. If sampling from a sample tap, one litre should be flushed from the sample port. Rinse water from the flushing activity should be used to rinse the sample container with brief washes at least three times before taking a permanent sample. During this rinsing and sampling period, care should be made to avoid causing the internal parts of the sample container and lid to touch any foreign surface.

After the sample has been taken, the sample container will be covered and immediately placed in a cooler. Once all the daily samples have been taken, the batch will be sent to the laboratory to be analyzed. Two record logs of all samples in each shipment will be completed. One copy of the log will be kept and filed by the pilot plant operator(s), and one copy will accompany the samples. Regular communication will be maintained with the off-site laboratory, AECOM staff, and operation staff to ensure that samples are received at the laboratory and that samples are analyzed within their allowable holding period.

At the end of Phase II and Phase III, the lead column for each tested media will be sampled and sent to an analytical laboratory for leaching characterization using EPA SW-846 Test Method 1311. Briefly, the SW-8846 Test Method 1311 exposes the spent media to an acidic solution. After an 18 hour extraction period, the extraction solution is measured for metals and compared to regulatory guidelines. The operator will complete sampling of the media and send the media to AECOM to coordinate testing.

4.3. On-Site Analysis

On-site analysis will be limited to the recording of the flow indicator readings. The flow indicator recordings will be completed daily by operation staff and will include the respective date, accurate to the hour. The timing when the flow indicator reading is recorded needs to coincide with the timing in which the respective lead column grab sample is taken for off-site laboratory analysis. An example of the on-site flowmeter data recording expectation is shown as a datasheet in **Appendix A**.

4.4. Sampling & Laboratory Analyses

All samples will be carefully collected according to the sampling protocol described above to minimize the risk of contamination and to ensure collection of a representative sample. Proper QA/QC will be conducted by the laboratories on all instruments used for analyses. All samples will be refrigerated and analyzed within the allowable holding time period of the parameter to be analyzed. A copy of the results of each analysis will be sent to and filed by the pilot plant operations staff.

4.5. Data Collection & Storage

AECOM will routinely collect and file data sheets from both the on-site operator and off-site laboratories. Data will be stored in the form of a Microsoft Excel spreadsheet database, allowing trending in the data to be readily analyzed.

A sample data collection sheet for on-site operator data collection is attached in **Appendix A**. The sheet is intended to be a guide and not to supersede the testing requirements identified in **Table 2**. Operation staff will email AECOM an updated copy of the On-Site Data Sheet every time on-site data is collected (refer to **Table 2**). Data analysis done by off-site analytical laboratory will be emailed to AECOM as analysis are completed and AECOM will compile both data sources into a spreadsheet on a continuous basis to monitor the performance of the media.

Appendix A – On-Site Data Sheet

Appendix B – Civil, Process, and Electrical Drawings



Indigenous and
Northern Affairs Canada



INDIGENOUS AND NORTHERN AFFAIRS CANADA

Giant Mine Rehabilitation Project

Arsenic and Antimony Ion Adsorption Pilot Testing

ISSUE FOR CONSTRUCTION

APRIL 2018

DRAWING LIST

CIVIL

C-100 SITE PIPING PLAN

PROCESS

P-100 LEGENDS & SYMBOLS (SHEET 1 OF 2)
P-101 LEGENDS & SYMBOLS (SHEET 2 OF 2)
P-102 ABBREVIATIONS
P-200 CLARIFICATION, FILTRATION, & pH ADJUSTMENT
P-201 ADSORPTION COLUMNS 1 & 2
P-202 ADSORPTION COLUMNS 3, 4, & 5

ELECTRICAL

E-100 THREE LINE DIAGRAM

AECOM Project No. 60561021

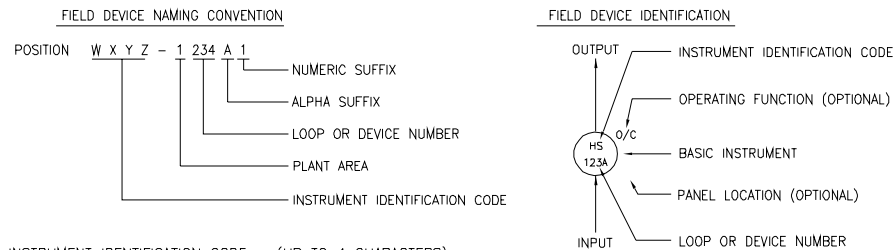
EQUIPMENT SYMBOLS		PIPE LINE DEVICES		VALVE SYMBOLS		PIPE IDENTIFICATION	
	BIN		AIR GAP		3 WAY VALVE		PIPE MATERIAL: SS STAINLESS STEEL STL BLACK STEEL GS GALVANIZED STEEL DI DUCTILE IRON PE POLYETHYLENE PVC POLYVINYL CHLORIDE
	BLOWER OR FAN		ANNUBAR		4 WAY VALVE		CHANNEL OR CHUTE IDENTIFICATION AAAxBBB-CCC COMMODITY CHANNEL OR CHUTE SIZE (WIDTH x HEIGHT)
	BOILER		BLIND FLANGE		ANGLE VALVE		EQUIPMENT IDENTIFICATION EQUIPMENT ABBREVIATION EQUIPMENT NUMBER NON-MOTORIZED EQUIPMENT EQUIPMENT ABBREVIATION EQUIPMENT NUMBER MOTORIZED EQUIPMENT
	BURNER, WASTE GAS		CALIBRATION CHAMBER		BACKFLOW PREVENTER		PROCESS LINE IDENTIFICATION XX1 COMMODITY XX2 COMMODITY LIN1 LIN2 DRAWING No. XX1 COMMODITY XX2 COMMODITY LIN1 LIN2 SOURCE OR DESTINATION
	CENTRIFUGE		CAP OR PLUG		BACK PRESSURE REGULATOR VALVE - EXTERNAL PRESSURE TAP		PROCESS LINE CODES PRIMARY PROCESS LINE SECONDARY PROCESS LINE FUTURE PROCESS LINE PRE-PURCHASE BOUNDARY VENDOR PACKAGE BOUNDARY EXISTING EQUIPMENT EXISTING PIPING AND EQUIPMENT ENCLOSURE BOUNDARY EXISTING PIPING AND EQUIPMENT TO BE REMOVED PROCESS FLOW ARROW AREA BOUNDARY
	CHILLER		CONNECTION, PURGE OR FLUSHING		BACK PRESSURE REGULATOR VALVE - SELF CONTAINED		GENERAL ABBREVIATIONS B.O.P. BOTTOM OF PUMP C/L CENTRE LINE EL. ELEVATION HWL HIGH WATER LEVEL INV. INVERT LWL LOW WATER LEVEL MAX. MAXIMUM MIN. MINIMUM N.T.S. NOT TO SCALE TOC TOP OF CONCRETE
	COMPRESSOR		CONNECTOR, QUICK		BALANCING DAMPER, CIRCULAR		PLANT AREA CODES 1 INLET WORKS 2 PRIMARY 3 SECONDARY 4 ADVANCED 5 SOLIDS 6 BIOGAS 7 ODOUR CONTROL 8 BUILDING SERVICES 9 GENERAL
	CYCLONE		DIFFUSER OR SPRAY NOZZLE		PRESSURE REDUCING REGULATOR VALVE - EXTERNAL PRESSURE TAP		GENERAL NOTES 1. THIS DRAWING IS GENERAL IN NATURE, SOME SYMBOLS SHOWN HERE MAY NOT BE USED ON THE CONTRACT DRAWINGS. 2. SEE DRAWING P-002 FOR PROCESS EQUIPMENT AND PIPE COMMODITY IDENTIFICATION ABBREVIATIONS. 3. SEE DRAWING P-003 FOR INSTRUMENTATION LEGEND, SYMBOLS AND IDENTIFICATION ABBREVIATIONS.
	DIFFUSER HEADER		DISCHARGE CONE		PRESSURE REDUCING REGULATOR VALVE - SELF CONTAINED		LEGENDS & SYMBOLS Giant Mine Rehabilitation Arsenic and Antimony Ion Adsorption Pilot Testing
	DISTILLATION TOWER		DRAIN		PRESSURE AND VACUUM RELIEF VALVE		PROJECT INFORMATION PROJECT START DATE (M/Y) MARCH 2018 PROJECT NO. 60561021 FILENAME 60561021-DW-ME-0001.dwg SHEET NO. 1 OF 2 DRAWING NO. P-100
	GENERATOR		EXPANSION JOINT		RUPTURE DISC PRESSURE RELIEF VALVE		Indigenous and Northern Affairs Canada
	GRINDER/MACERATOR		EYE WASH/SHOWER STATION		RUPTURE DISC VACUUM RELIEF VALVE		AECOM Suite 201, 3275 LAKESHORE ROAD, VILVOY, B.C. CANADA V1V 6S9 250-762-9727
	GRIT CLASSIFIER		FILTER		TELESCOPIC VALVE		Indigenous and Northern Affairs Canada
	HEAT EXCHANGER (SPIRAL)		FLAME ARRESTER		VACUUM RELIEF VALVE		Indigenous and Northern Affairs Canada
	MIXER, PROPELLER		FLEXIBLE CONNECTION		MANUAL AIR VENT		Indigenous and Northern Affairs Canada
	MIXER, INLINE		FLOW STRAIGHTENING VANES		AUTOMATIC AIR VENT		Indigenous and Northern Affairs Canada
	MOTOR		FLUME		BALANCING VALVE		Indigenous and Northern Affairs Canada
	ROTARY SCREEN		INSULATION AND HEAT TRACING		VALVE ACTUATORS/OPERATOR DIAPHRAGM (PRESSURE) DIAPHRAGM (SPRING) DIGITAL MOTOR PISTON SOLENOID		Indigenous and Northern Affairs Canada
	ROTARY SEPARATOR		LEVEL		GENERAL ABBREVIATIONS B.O.P. BOTTOM OF PUMP C/L CENTRE LINE EL. ELEVATION HWL HIGH WATER LEVEL INV. INVERT LWL LOW WATER LEVEL MAX. MAXIMUM MIN. MINIMUM N.T.S. NOT TO SCALE TOC TOP OF CONCRETE		Indigenous and Northern Affairs Canada
	SCREEN, BAR		ORIFACE PLATE		GENERAL ABBREVIATIONS B.O.P. BOTTOM OF PUMP C/L CENTRE LINE EL. ELEVATION HWL HIGH WATER LEVEL INV. INVERT LWL LOW WATER LEVEL MAX. MAXIMUM MIN. MINIMUM N.T.S. NOT TO SCALE TOC TOP OF CONCRETE		Indigenous and Northern Affairs Canada
	SCREEN, MANUAL		PUMP SYMBOLS PUMP, CENTRIFUGAL PUMP, DIAPHRAGM PUMP, GEAR PUMP, METERING PUMP, PLUNGER AS ADJUSTABLE SPEED CS-1 CONSTANT SPEED (SINGLE SPEED) CS-2 CONSTANT SPEED (TWO SPEED) CS-R CONSTANT SPEED (REVERSIBLE)		GATE SYMBOLS DIVERTER GATE FLAP GATE LEVEL CONTROL GATE SLIDE GATE SLUICE GATE STOP LOG WEIR GATE		Indigenous and Northern Affairs Canada
	SCREENING WASHER/COMPACTOR		PUMP, PROGRESSING CAVITY		PUMP, ROTARY LOBE		Indigenous and Northern Affairs Canada
	SCRUBBER		PUMP, SUBMERSIBLE		PUMP, SUBMERSIBLE PROPELLER		Indigenous and Northern Affairs Canada
	SLUDGE COLLECTOR		PUMP, VERTICAL		PUMP, SUBMERSIBLE PROPELLER		Indigenous and Northern Affairs Canada
	SLUDGE CONVEYOR		PUMP, SUBMERSIBLE PROPELLER		PUMP, SUBMERSIBLE PROPELLER		Indigenous and Northern Affairs Canada
	SLUDGE SKIMMER		PUMP, SUBMERSIBLE PROPELLER		PUMP, SUBMERSIBLE PROPELLER		Indigenous and Northern Affairs Canada
	TANK		PUMP, SUBMERSIBLE PROPELLER		PUMP, SUBMERSIBLE PROPELLER		Indigenous and Northern Affairs Canada
	VESSEL		PUMP, SUBMERSIBLE PROPELLER		PUMP, SUBMERSIBLE PROPELLER		Indigenous and Northern Affairs Canada
	VESSEL, JACKETED		PUMP, SUBMERSIBLE PROPELLER		PUMP, SUBMERSIBLE PROPELLER		Indigenous and Northern Affairs Canada
	VESSEL (PRESSURE)		PUMP, SUBMERSIBLE PROPELLER		PUMP, SUBMERSIBLE PROPELLER		Indigenous and Northern Affairs Canada
	WAS BOX		PUMP, SUBMERSIBLE PROPELLER		PUMP, SUBMERSIBLE PROPELLER		Indigenous and Northern Affairs Canada
		PROCESS LEGEND SHEET FOLLOWS ISA 5.1 (R1992) INSTRUMENTATION SYMBOLS AND IDENTIFICATION. ALL EQUIPMENT SHOWN ON THIS LEGEND SHEET ISN'T NECESSARILY USED FOR THIS PROJECT.					

LETTER	FIRST LETTER (4)		SUCCEEDING-LETTERS (3)		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
C	USER'S CHOICE (1)			CONTROL	
D	USER'S CHOICE (1)	DIFFERENTIAL			
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)			
G	USER CHOICE (1)		GLASS, VIEWING DEVICE		
H	HAND				H-HIGH-(ALARM) HH-HIGH-(SHUTDOWN)
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		L-LOW-(ALARM) LL-LOW-(SHUTDOWN) MIDDLE, INTERMEDIATE
M	USER'S CHOICE (1)	MOMENTARY			
N	USER'S CHOICE (1)		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
O	USER'S CHOICE (1)		ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD		
S	SPEED, FREQUENCY, SOLENOID	SAFETY		SWITCH, OR SAFETY	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION, MECHANICAL ANALYSIS		VALVE, DAMPER, LOUVRE		
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OR PRESENCE	Y AXIS		RELAY, COMPUTE, CONVERT	
Z	POSITION, DIMENSION	Z AXIS		DRIVER, ACTUATOR, UNCLASSIFIED - FINAL CONTROL ELEMENT	

NOTES:
 (1) USER'S CHOICE - INTENDED TO COVER UNLISTED MEANINGS SPECIFIC TO A PROJECT
 (2) INSTRUMENT SYMBOLS AND IDENTIFICATION STANDARD, ISA-S5.1-1984

TYPICAL INSTRUMENT FIELD DEVICE IDENTIFICATION

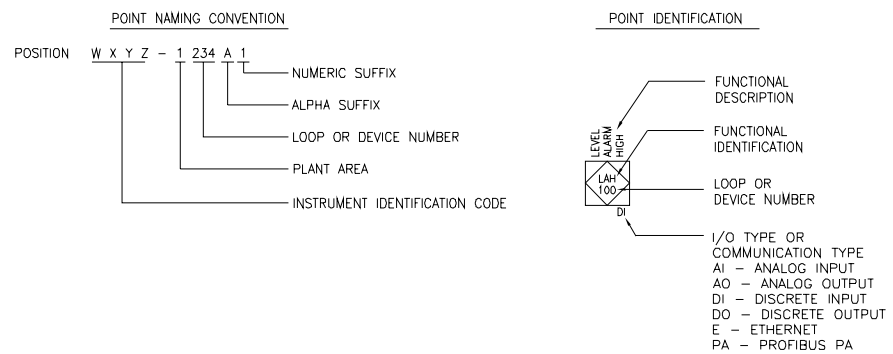
NOTE: IN ADDITION TO THE REQUIREMENTS DETAILED BELOW, REFER TO DIGITAL POINT NAMING CONVENTIONS WHEN INSTRUMENT INTERFACES TO SCADA



- INSTRUMENT IDENTIFICATION CODE - (UP TO 4 CHARACTERS) - REFER TO INSTRUMENT IDENTIFICATION TABLE
- LOOP OR DEVICE NUMBER - (3 NUMERALS AND 1 CHARACTER, 1 NUMBER (AS REQUIRED)) - TYPICALLY SIMILAR NUMBERS AS ASSOCIATED LINE OR EQUIPMENT. - CHARACTER SUFFIX IN POSITION IS INCREMENTED BY NUMERIC SUFFIX TO DIFFERENTIATE SIMILAR DEVICES.
- HYPHENS ARE OPTIONAL

DIGITAL POINT TAG NAMING CONVENTION

NOTE: ALL DEVICES INTERFACING WITH SCADA MUST FOLLOW THE DIGITAL POINT NAMING CONVENTION.



	DISCRETE INSTRUMENTS FIELD OR LOCALLY MOUNTED NOT PANEL OR CABINET MOUNTED NORMALLY ACCESSIBLE TO AN OPERATOR
	DISCRETE INSTRUMENTS SHARING COMMON HOUSING
	DISCRETE INSTRUMENTS SECONDARY OR LOCAL CONTROL ROOM FIELD OR LOCAL CONTROL PANEL MOUNTED NORMALLY ACCESSIBLE TO AN OPERATOR
	DISCRETE INSTRUMENTS CENTRAL OR MAIN CONTROL ROOM FRONT OF MAIN PANEL MOUNTED NORMALLY ACCESSIBLE TO AN OPERATOR
	ANNUNCIATOR POINT FIELD OR LOCALLY MOUNTED NOT PANEL OR CABINET MOUNTED (OPTIONAL ARROW TO INDICATE ROTATING BEACON)
	ANNUNCIATOR POINT FIELD OR LOCAL CONTROL PANEL PANEL MOUNTED
	ANNUNCIATOR POINT CENTRAL OR MAIN CONTROL ROOM MAIN PANEL MOUNTED
	INPUT, OUTPUT, OR FUNCTION. ACCESSIBLE EG. DCS OR SCADA
	SHARED DISPLAY OR CONTROL DEDICATED SINGLE FUNCTION DEVICE FIELD OR LOCALLY MOUNTED NORMALLY ACCESSIBLE TO THE OPERATOR AT DEVICE
	SHARED DISPLAY OR CONTROL SECONDARY OR LOCAL CONSOLE FIELD OR LOCAL CONTROL PANEL VISIBLE ON VIDEO DISPLAY NORMALLY ACCESSIBLE TO AN OPERATOR AT CONSOLE
	SHARED DISPLAY OR CONTROL CENTRAL OR MAIN CONSOLE VISIBLE ON VIDEO DISPLAY NORMALLY ACCESSIBLE TO AN OPERATOR AT CONSOLE
	PROGRAMMABLE LOGIC CONTROL FIELD OR LOCALLY MOUNTED NOT PANEL OR CABINET MOUNTED NORMALLY ACCESSIBLE TO AN OPERATOR AT DEVICE
	PROGRAMMABLE LOGIC CONTROL SECONDARY OR LOCAL CONSOLE FIELD OR LOCAL CONTROL PANEL VISIBLE ON VIDEO DISPLAY ACCESSIBLE TO AN OPERATOR AT CONSOLE
	PROGRAMMABLE LOGIC CONTROL CENTRAL OR MAIN CONSOLE VISIBLE ON VIDEO DISPLAY NORMALLY ACCESSIBLE TO AN OPERATOR AT CONSOLE
	COMPUTER FUNCTIONS FIELD OR LOCALLY MOUNTED
	COMPUTER FUNCTIONS SECONDARY OR LOCAL COMPUTER VISIBLE ON VIDEO DISPLAY NORMALLY ACCESSIBLE TO AN OPERATOR AT TERMINAL
	COMPUTER FUNCTIONS CENTRAL OR MAIN COMPUTER VISIBLE ON VIDEO DISPLAY NORMALLY ACCESSIBLE TO AN OPERATOR AT TERMINAL
	COMMUNICATION INTERFACE - COMMUNICATIONS TO AN ADDRESSABLE DEVICE (I.E. DB=DEVICEBUS, MB=MODBUS, E=ETHERNET IY=CURRENT-FIELDBUS, FB=FIELDBUS, PB=PROFIBUS)
	NOT NORMALLY ACCESSIBLE TO THE OPERATOR OR BEHIND-THE-PANEL DEVICES OR FUNCTIONS MAY BE DEPICTED BY USING THE SAME SYMBOLS BUT WITH DASHED HORIZONTAL BARS, I.E.

ANALYTICAL FUNCTIONS	
	EXPOSED PROBE OR GAS DETECTOR
	TAPPED OR SAMPLED
	IN-LINE
NOTE XX	
CH4	METHANE
Cl2	CHLORINE
CO	CARBON MONOXIDE
COMB	COMBUSTIBLE GAS
DO	DISSOLVED OXYGEN
HC	HYDROCARBONS
H2S	HYDROGEN SULFIDE
HUM	HUMIDITY
LEL	LOWER EXPLOSIVE LIMIT
MLSS	MIXED LIQUOR SUSPENDED SOLIDS
NH4	AMMONIA GAS
NO	NITRIC OXIDE
NO2	NITROGEN DIOXIDE
NO3	NITRATE
O2	OXYGEN
ORP	OXIDATION REDUCTION POTENTIAL
OUR	OXYGEN UPTAKE RATE
pH	pH
PO4	PHOSPHORUS
SO2	SULPHUR DIOXIDE
SS	SUSPENDED SOLIDS (DENSITY)
TSS	TOTAL SUSPENDED SOLIDS
TURB	TURBIDITY
VIB	VIBRATION
SWITCHING FUNCTIONS	
ACK	ACKNOWLEDGE (ALARM)
ALOH	AUTO-LOCAL-OFF-HAND
A/M	AUTO/MANUAL
CLS	CLOSE
COB	COMPUTER-OFF-BYPASS
COH	COMPUTER-OFF-HAND
ESD	EMERGENCY SHUTDOWN DEVICE
FO	FAIL-OPEN
FC	FAIL-CLOSED
FIP	FAIL-IN-PLACE
F/S	FAST-SLOW SELECTION
FOR	FORWARD-OFF-REVERSE
FVNR	FULL VOLTAGE NON-REVERSING
FVR	FULL VOLTAGE REVERSING
FWD	FORWARD SELECTION
HA	HAND-AUTO SELECTION
HOA	HAND-OFF-AUTO SELECTION
JOA	JOG-OFF-AUTO SELECTION
L/L	LEAD-LAG SELECTION
LOR	LOCAL-OFF-REMOTE
LOS	LOCK-OFF-STOP
L/R	LOCAL-REMOTE SELECTION
M/A	MANUAL-AUTO SELECTION
MAN	MANUAL REG.
O/A	OPEN/AUTO
O/C	OPEN/CLOSE
O/O	ON-OFF SELECTION
OCA	OPEN-CLOSE-AUTO SELECTION
OPN	OPEN
OSC	OPEN-STOP-CLOSE SELECTION
OVR	INTERLOCK OVERRIDE SWITCH
P/M	POSITIONER/MANUAL
POT	POTENTIOMETER
R/B	RUN/BYPASS
R/L	RAISE-LOWER
REV	REVERSE SELECTION
RST	RESET
SEL	SELECTOR SWITCH
S/S	START-STOP
SP	SET POINT
VFD	VARIABLE FREQUENCY DRIVE

	ANNUBAR		CORIOLIS MASS FLOWMETER
	DENSITY METER		FLOW ELEMENT INTEGRAL WITH TRANSMITTER (MASS FLOW, ETC)
	IN-LINE CAPACITANCE FLOW ELEMENT		ANNULAR PRESSURE ISOLATOR
	MAGNETIC FLOWMETER		PITOT TUBE
	POSITIVE DISPLACEMENT METER		PROPELLER OR TURBINE METER
	SONIC FLOWMETER (DOPPLER OR TRANSIT TIME)		THERMAL MASS FLOW ELEMENT
	VARIABLE AREA FLOW INDICATOR (ROTAMETER)		VORTEX FLOW SENSOR
	DIAPHRAGM SEAL		
	CAPACITANCE/POINT LEVEL ELEMENT		GUIDED WAVE RADAR LEVEL ELEMENT
	UNGUIDED WAVE ULTRASONIC/MICROWAVE LEVEL ELEMENT		FLOAT LEVEL ELEMENT
	VIBRATING TUNING FORK LEVEL SWITCH		HYDROSTATIC LEVEL ELEMENT
	THERMAL ELEMENT WITH WELL		THERMAL SENSING RTD STRIP
	BUBBLER LEVEL TUBE		DISPLACEMENT LEVEL ELEMENT

INSTRUMENT SIGNAL TYPES	ABBREVIATIONS
	DCS DISTRIBUTED CONTROL SYSTEM
	I/I CURRENT TO CURRENT
	I/O INPUT/OUTPUT
	I/P CURRENT TO PRESSURE
	IBD INBOARD BEARING
	LEAK LEAKAGE
	LCP LOCAL CONTROL PANEL
	OBOD OUTBOARD BEARING
	O/L OVERLOAD
	PLC PROGRAMMABLE LOGIC CONTROLLER
	ROS REMOTE OPERATOR STATION
	RTD RESISTIVE THERMAL DEVICE
	SOL SOLENOID
	T/C THERMOCOUPLE
	TOR TORQUE
	WDG WINDING
	XJB JUNCTION BOX

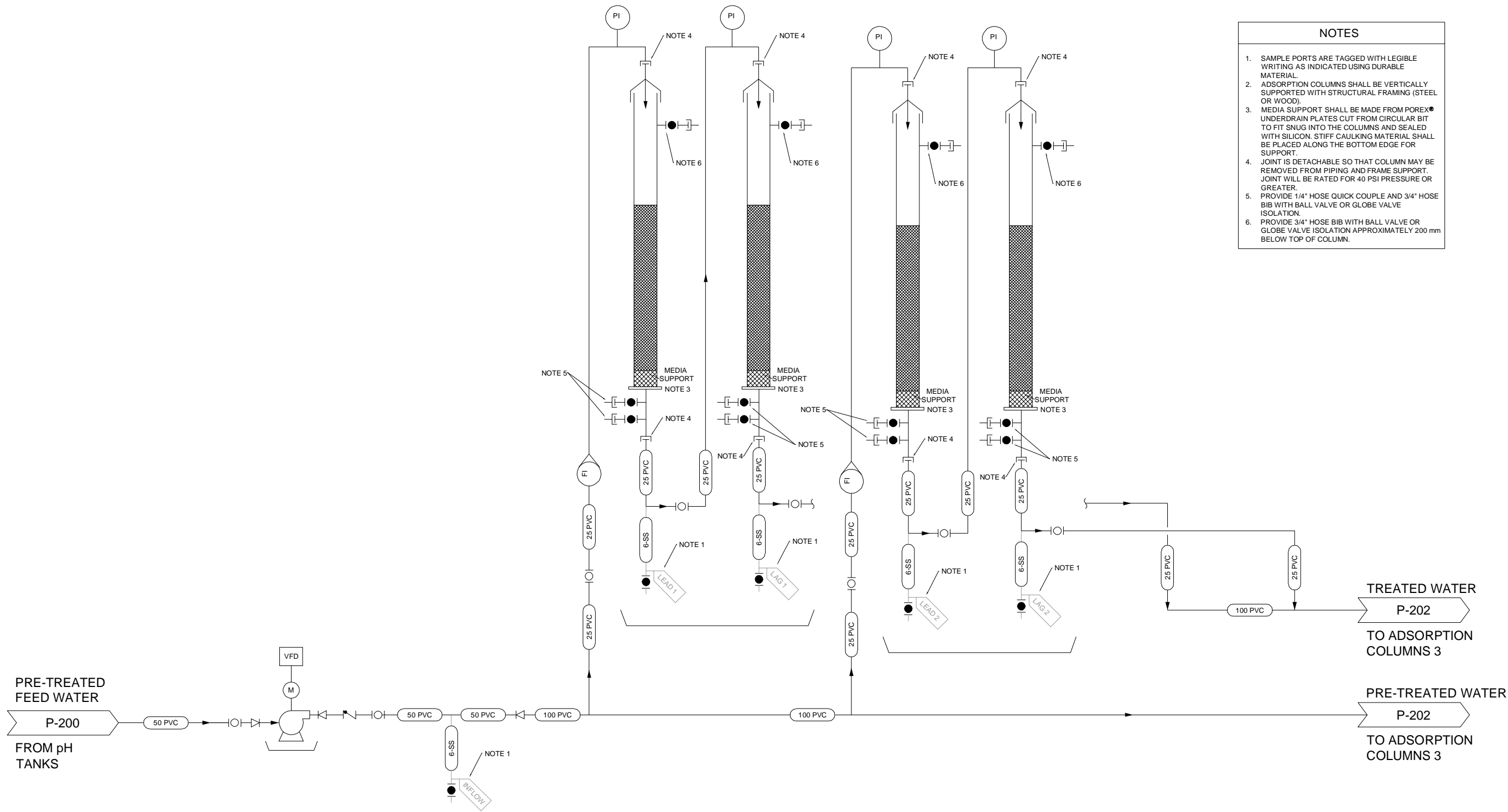
MISCELLANEOUS SYMBOLS	
	ANNUNCIATOR HORN
	VARIABLE FREQUENCY DRIVE
	DOOR SWITCH
	SMOKE DETECTOR
	ELECTRICAL SUPPLY 120VAC UNLESS OTHERWISE NOTED

DRN BY:	CF	DES BY:	MD	CHK BY:	BfW	2018/04/09	2018/02/23
APP BY:	A	ISSUE FOR CONSTRUCTION	CF	ISSUE FOR CONSTRUCTION	CF	DRN	DATE (Y/M/D)
 Suite 201, 3275 LAKESHORE ROAD, KILGORE, BC, CANADA V1V 6S9 250-762-9727							
Indigenous and Northern Affairs Canada							
Giant Mine Rehabilitation Arsenic and Antimony Ion Adsorption Pilot Testing							
LEGENDS & SYMBOLS							
PROJECT START DATE (M/Y)							
MARCH 2018							
PROJECT NO.							
60561021							
FILENAME							
60561021-DW-ME-0001.dwg							
SHEET NO.							
2 OF 2							
DRAWING NO.							
P-101							

COMMODITY ABBREVIATIONS		COMMODITY ABBREVIATIONS		EQUIPMENT ABBREVIATIONS		EQUIPMENT ABBREVIATIONS		GENERAL NOTES			
SYMBOL	COMMODITY	SYMBOL	COMMODITY	AC	AIR COMPRESSOR	P	PUMP	1. THIS DRAWING IS GENERAL IN NATURE, SOME ABBREVIATIONS SHOWN HERE MAY NOT BE USED ON THE CONTRACT DRAWINGS. 2. SEE DRAWING P001 FOR PROCESS EQUIPMENT LEGEND AND SYMBOLS. 3. SEE DRAWING P003 FOR INSTRUMENTATION LEGEND, SYMBOLS AND IDENTIFICATION ABBREVIATIONS. 4. VENDOR TO VERIFY COMPONENTS OF PACKAGED SYSTEMS AS OUTLINED BY THE VENDOR PACKAGE BOUNDARY SHOWN ON P&ID DRAWINGS.			
AA	AQUEOUS AMMONIA	PA	PROCESS AIR	AD	AIR DRYER	PBF	PALMER BOWLES FLUME				
AAS	AERATION AIR SUPPLY	PE	PRIMARY EFFLUENT	AER	AERATOR, SURFACE	PBP	PERFORATED BAFFLE PLATE				
ACS	ACTIVATED CARBON SOLUTION (SLURRY)	PET	GASOLINE (PETROLEUM)	AF	AIR FILTER	PCN	PARTICLE COUNTER				
AL	ALUM LIQUID	PHWR	POTABLE HOT WATER RECIRCULATION	AFK	AFTERCooler	PDC	POWER DISTRIBUTION CENTRE				
AMG	AMMONIA GAS (ANHYDROUS)	PHWS	POTABLE HOT WATER SUPPLY	AR	AIR RECEIVER	PFL	PARSHALL FLUME				
AML	AMMONIA LIQUID (ANHYDROUS)	PI	PRIMARY INFLENT	AS	AIR SEPARATOR	PLT	PELLETIZER				
AMS	AMMONIA SOLUTION	PLS	PRIMARY LIME SLUDGE	AST	AIR STRIPPER	PRV	PRESSURE REGULATING/REDUCING VALVE				
AP	ALUM POWDER (DRY)	PLY	POLYELECTROLYTE	AWH	AIR WASH	PSE	PLATE SETTLER				
ARL	AIR RELIEF LINE	PLYS	POLYELECTROLYTE SOLUTION	BA	BIN ACTIVATOR	PSU	POWER SUPPLY UNIT				
AS	ALUM SOLUTION	PPS	POTASSIUM PERMANGANATE SOLUTION	BPV	BACKFLOW PREVENTOR	PSV	PRESSURE/VACUUM SAFETY VALVE				
ASL	ALUM SLUDGE	PRL	PRESSURE RELIEF LINE	BPS	BELT FILTER PRESS	PT	PRESSURE TANK				
AWS	AIR WASH SUPPLY	PS	PRIMARY SLUDGE	BIN	BIN (Container, Process, Grit, Screenings)	PTO	POWER TAKE OFF/REDUCER				
BWR	BACKWASH RECIRCULATION WATER	PSW	PLANT SERVICE WATER	BIF	BIOFILTER	PV	PRESSURE VESSEL RELIEF VALVE				
BWS	BACKWASH SUPPLY WATER	PTW	(NOT SAFE FOR HUMAN CONSUMPTION)	BLO	BLOWER	RBC	ROTATING BIOLOGICAL CONTACTOR				
BWW	BACKWASH WASTE WATER	PW	PRE-TREATED WATER	BR	BRUSH	RCO	RESIDUAL COLLECTOR				
CD	CENTRIFUGE DECATATE	PWD	POTABLE WATER	BRM	BARMINUTOR	RDT	ROTARY DRUM THICKENER				
CDG	CHLORINE DIOXIDE GAS	PY	(SAFE FOR HUMAN CONSUMPTION)	CBA	COMPOST BAY (Compost Tunnel, Compost Bunker)	RM	ROTAMETER				
CDS	CHLORINE DIOXIDE SOLUTION	QL	PROCESS WASTE DRAIN (PUMP)	CBD	COMPOST BAY (Compost Tunnel, Compost Bunker)	RV	RELIEF VALVE				
CG	CARBON DIOXIDE GAS	PY	PRIMARY SCUM	CDF	COARSE BUBBLE DIFFUSER	SC	SLUDGE COLLECTOR MECHANISM				
CHW	CHEMICAL WASTE (LAB WASTE)	QL	QUICK LIME (DRY)	CDR	CLARIFIER DRIVE - PRIMARY	SCB	SCRUBBER				
CLG	CHLORINE GAS	RAG	RECARBONATION AIR GAS SUPPLY	CFG	CENTRIFUGE	SCL	SCALE				
CLL	CHLORINE LIQUID	RAS	RETURN ACTIVATED SLUDGE	CFL	CUT THROAT FLUME	SCN	PERFORATED PLATE SCREEN				
CLS	CHLORINE SOLUTION	RCD	RECARBONATOR DECATATE	CGS	CHLORINE GAS SCRUBBER	SCP	SCUM COLLECTION MECHANISM				
CLW	CHLORINATED WATER	RS	RAW SLUDGE	CHF	CHEMICAL FEEDER (Polymer, Lime Slaker, Chlorinator)	SCR	BAR SCREEN - AUTOMATIC AND MANUAL				
CON	CONDENSATE	RSD	RECLAIM SERVICE WATER	CHL	CHLORINATOR	SCW	SCUM WEIR - ROTATING				
CWR	COOLING WATER RETURN	RSW	(NOT SAFE FOR HUMAN CONSUMPTION)	CMM	COMMINUTOR	SDR	SECONDARY CLARIFIER				
CWS	COOLING WATER SUPPLY	RWD	REWASH DRAIN	CMP	COMPACTOR	SEP	SEPARATOR				
CWW	COOLING WATER WASTE	RWC	RAW WATER COOLING RETURN	COL	COLLECTOR	SG	SLIDE GATE				
DCW	DOMESTIC COLD WATER	RWS	RAW WATER COOLING SUPPLY	CON	CONVEYOR	SL	STOP LOG				
DHW	DOMESTIC HOT WATER	RWW	RAW WASTE WATER	COV	COVER (Tank Cover, Digester Cover, Gas Holder)	SLC	SLUDGE COLLECTOR				
DHWR	DOMESTIC HOT WATER RECIRCULATION	SA	SERVICE AIR	CP	COMPRESSOR	SLG	SILUICE GATE				
DR	DRAIN	SAM	SAMPLE LINE	CPW	CIPOLETTI WEIR	SLR	SILENCER				
DS	DIGESTED SLUDGE	SAN	SANITARY WASTE	CRN	CRANE	SM	STATIC MIXER				
DTW	DOMESTIC TEMPERED WATER	SAS	SODA ASH SOLUTION	CY	CYCLONE	SMP	SAMPLER				
DUF	DISSOLVED AIR FLOTATION UNDERFLOW	SCR	SCREENINGS	CYL	CYLINDER (Gas)	SRC	SURGE CHAMBER				
EE	ENGINE EXHAUST	SD	STORM DRAIN	DAF	DISSOLVED AIR FLOTATION THICKENER EQUIPMENT	STR	STRAINER				
F	FLUORIDE (FLUORINE)	SDG	SULFUR DIOXIDE GAS	DDR	DAF DRIVE	T	TANK				
FA	FLUOSILICIC ACID	SDS	SULFUR DIOXIDE SOLUTION	DIF	DIFFUSER	TB	TURBIDITY METER				
FE	FINAL EFFLUENT	SE	SECONDARY EFFLUENT	DIG	DIGESTER FLOATING ROOF COVER	TCP	TEMPERATURE CONTROL PANEL				
FLO	FLUSHING OIL	SEL	SENSING LINE	DPS	DIAPHRAGM SEAL	THK	GRAVITY THICKENER				
FLW	FLOCCULATED WATER	SHC	SODIUM HYPOCHLORITE	DR	DRIVE	TRP	TRAP, DRIP, SEDIMENT				
FOA	FOUL AIR	SLS	SECONDARY LIME SLUDGE	DST	ROTARY DISTRIBUTOR	TSV	TELESCOPIC GATE				
FOR	FUEL OIL RETURN	SLR	SURGE RELIEF LINE	DSC	DRUM SCREEN	UV	ULTRA VIOLET LAMP BANK				
FOS	FUEL OIL SUPPLY	SO	SUPERNATANT OVERFLOW	DUF	DAF THICKENER UNDERFLOW	V	VALVE				
FW	FILTERED WATER	SRS	SCREENED RAW SEWAGE	DWS	DEWATERING SCREW	VAP	VAPORIZER				
GRE	GREASE	SSS	SODIUM SILICATE SOLUTION	EF	EXHAUST FAN	VDR	VORTEX DRIVE				
GR	GRIT	SW	STORM WATER	EV	EVAPORATOR	VFD	VARIABLE FREQUENCY DRIVE				
HL	HYDRATED LIME (DRY)	SY	SECONDARY SCUM	EXT	EXPANSION TANK	VNT	VENT EQUIPMENT				
HPA	HIGH PRESSURE AIR	TO	THICKENER OVERFLOW	F	FAN	VSD	VARIABLE SPEED DRIVE				
HPW	HEATED POTABLE WATER	TPS	THICKENED PRIMARY SLUDGE	FAR	FLAME ARRESTER	VW	V-NOTCH WEIR				
HRR	HOT WATER RETURN	TW	TREATED WATER	FBD	FINE BUBBLE DIFFUSER	W	WEIR				
HRS	HOT WATER SUPPLY	TWAS	(PRIMARY TREATMENT, NOT SAFE FOR HUMAN CONSUMPTION)	FCH	FLAME CHECK	WG	WEIR GATE, (Rectangular - Straight Weir)				
HRWR	HEATED RAW WATER RETURN	UD	THICKENED WASTE ACTIVATE SLUDGE	FCV	FLOW CONTROL VALVE (MODULATING)						
HRWS	HEATED RAW WATER SUPPLY	UFE	UTILITY FINAL EFFLUENT (CHLORINATED)	FDR	FERMENTER DRIVE						
HSG	HIGH PRESSURE SLUDGE GAS	VA	VACUUM LINE	FIS	FILTER SEPARATOR						
IA	INSTRUMENT AIR (FILTERED & DRIED)	VE	VENT	FLC	FLOCCULATOR						
LO	LUBRICATING OIL	WAS	WASTE ACTIVATED SLUDGE	FLG	FLAP GATE						
LPG	LIQUID PROPANE GAS	WLS	WASTE LIME SLUDGE	FLT	FLTR						
LS	LIME SOLUTION (LIME SLURRY)	ZW	ZEOLITE SOFTENED WATER	FOS	FOAM SEPARATOR						
LSG	LOW PRESSURE SLUDGE GAS			FY	FLOW VALVE (OPEN/CLOSE)						
MS	MIXED SLUDGE			GBT	GRAVITY BELT THICKENER						
MSG	MEDIUM PRESSURE SLUDGE GAS			GCL	GRIT CLASSIFIER						
NGH	NATURAL GAS HIGH PRESSURE			GCY	GRIT CYCLONE						
NGL	NATURAL GAS LOW PRESSURE			GDR	GRINDER						
NGM	NATURAL GAS MEDIUM PRESSURE			HEX	HEAT EXCHANGER (SPIRAL)						
OA	OUTSIDE AIR			HPG	HAND PULL GATE						
OF	PLANT OUTFALL			HSS	HAULED SEPTAGE SCREEN						
OV	PLANT OVERFLOW			HST	HOIST						
				HTR	HEATER						
				HX	HEAT EXCHANGER (SHELL & TUBE)						
				INC	INCINERATOR						
				INJ	INJECTOR, CHEMICAL						
				LAG	LAGOONS						
				LCG	LEVEL CONTROL GATE						
				LCP	LOCAL CONTROL PANEL						
				LG	LEVEL SIGHT GLASS (Calibration Column)						
				LGR	LINEAR GRILLE						
				MB	MEMBRANE						
				MCP	MASTER CONTROL PANEL						
				ME	MECHANISM						
				MLW	MIXED LIQUOR WASTING CHAMBER						
				MUA	MAKE-UP AIR UNIT						
				MWA	MICROWAVE ANALYZER						
				MXR	MIXER						
				ODU	OZONE DESTRUCT UNIT						

2018/04/09	2018/02/23	DATE (Y/M/D)
BW	BW	CHK
CF	CF	DRN
B	A	REV
DESCRIPTION		
DRN BY: CF DES BY: MD CHK BY: B&W APP BY: A		
Indigenous and Northern Affairs Canada  AECOM Suite 201, 3275 LAKESHORE ROAD, KILGONIA, BC, CANADA V1W 1S9 250-762-3727		
GIANT MINE REHABILITATION ARSENIC AND ANTIMONY ION ADSORPTION PILOT TESTING ABBREVIATIONS		
PROJECT START DATE (M / Y)		
MARCH 2018		
PROJECT NO.		
60561021		
FILENAME		
60561021-DW-ME-0001.dwg		
SHEET NO.		
DRAWING NO.		
P-102		

Plotted By: charlie.frenol
 Plot File Date Created: Apr/09/2018 10:31 AM
 Layout-Sheet Name: P-201
 Filename: P:\60561021\400-TECHNICAL\431 PILOT TESTING DOCUMENTS\ON-SITE TESTING\PILOT TESTING PLAN\60561021-DW-ME-0001.DWG



- NOTES**
1. SAMPLE PORTS ARE TAGGED WITH LEGIBLE WRITING AS INDICATED USING DURABLE MATERIAL.
 2. ADSORPTION COLUMNS SHALL BE VERTICALLY SUPPORTED WITH STRUCTURAL FRAMING (STEEL OR WOOD).
 3. MEDIA SUPPORT SHALL BE MADE FROM POREX® UNDERDRAIN PLATES CUT FROM CIRCULAR BIT TO FIT SNUG INTO THE COLUMNS AND SEALED WITH SILICON. STIFF CAULKING MATERIAL SHALL BE PLACED ALONG THE BOTTOM EDGE FOR SUPPORT.
 4. JOINT IS DETACHABLE SO THAT COLUMN MAY BE REMOVED FROM PIPING AND FRAME SUPPORT. JOINT WILL BE RATED FOR 40 PSI PRESSURE OR GREATER.
 5. PROVIDE 1/4" HOSE QUICK COUPLE AND 3/4" HOSE BIB WITH BALL VALVE OR GLOBE VALVE ISOLATION.
 6. PROVIDE 3/4" HOSE BIB WITH BALL VALVE OR GLOBE VALVE ISOLATION APPROXIMATELY 200 mm BELOW TOP OF COLUMN.

ADSORPTION COLUMNS PRESSURE PUMP

EQUIP. NO.: P-102
 MANUFACTURER: FLUID-O-TECH
 MODEL: TMFRSS-201
 TYPE: ROTARY VANE
 CAPACITY: 240 L/hr
 HEAD: 8 bar
 POWER: 330 W
 MOTOR: 110 V AC, 50/60 Hz
 FLOW: 5 m³/d

ADSORPTION COLUMN 1

DIAMETER: 0.1 METER
 HEIGHT: 1.0 METER
 MATERIAL: CLEAR PVC
 BED DEPTH: 0.5 METER

ADSORPTION COLUMN 2

DIAMETER: 0.1 METER
 HEIGHT: 1.0 METER
 MATERIAL: CLEAR PVC
 BED DEPTH: 0.5 METER

DRN BY:	DES BY:	CHK BY:	APP BY:	REV	DESCRIPTION
CF	MD	BfW	BfW	A	ISSUE FOR CONSTRUCTION
				B	ISSUE FOR CONSTRUCTION
				CF	DRN
				BfW	CHK
					DATE (Y/M/D)
					2018/04/09
					2018/02/23

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Suite 201, 3275 LAKESHORE ROAD,
 KILGORE, BC, CANADA
 V1W 1S9
 250-762-3727

GIANT MINE REHABILITATION ARSENIC AND ANTIMONY ION ADSORPTION PILOT TESTING

ADSORPTION COLUMNS 1 & 2

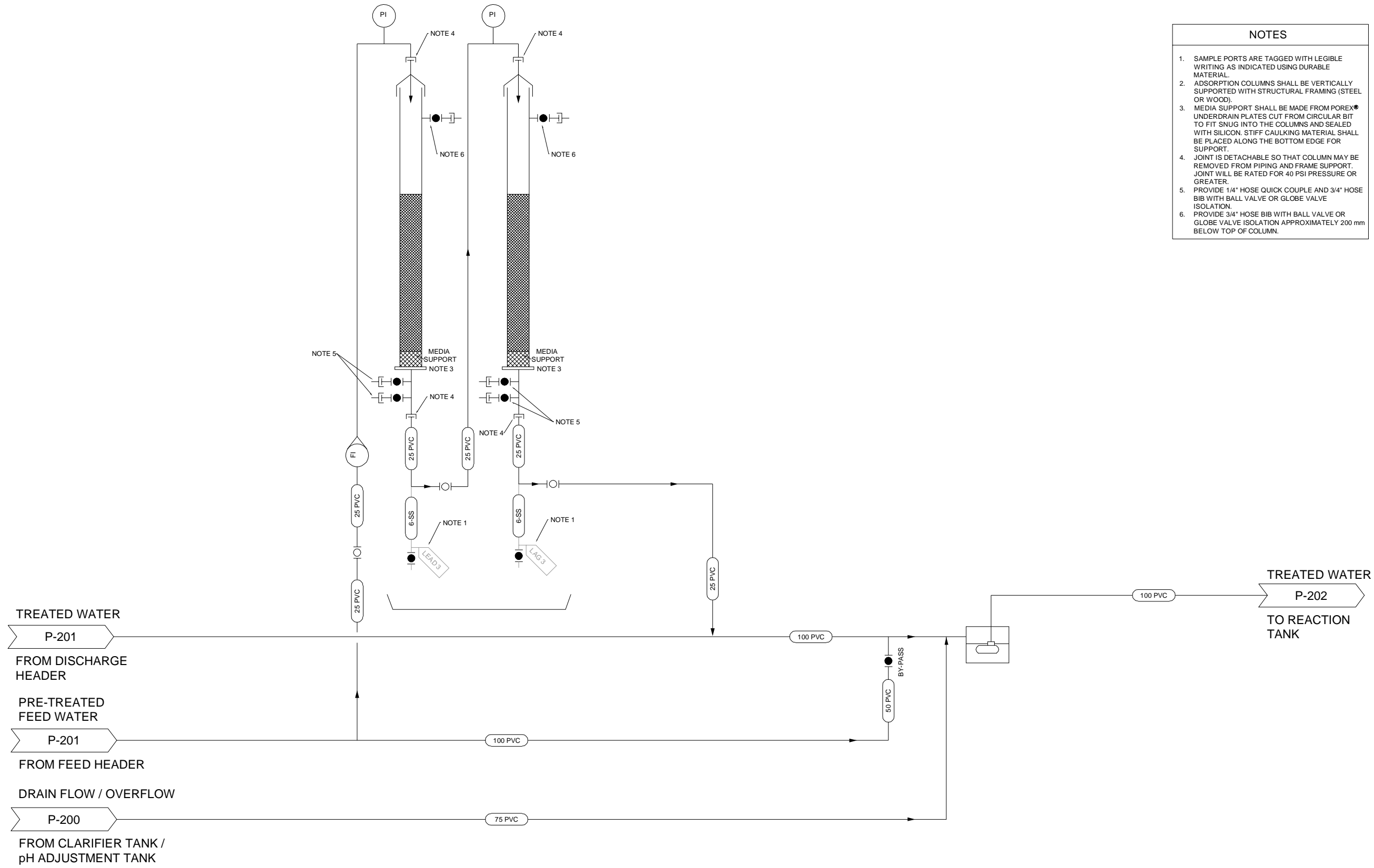
PROJECT START DATE (M / Y)
 MARCH 2018

PROJECT NO.
 60561021

FILENAME
 60561021-DW-ME-0001.dwg

SHEET NO.

DRAWING NO.
P-201



- NOTES**
1. SAMPLE PORTS ARE TAGGED WITH LEGIBLE WRITING AS INDICATED USING DURABLE MATERIAL.
 2. ADSORPTION COLUMNS SHALL BE VERTICALLY SUPPORTED WITH STRUCTURAL FRAMING (STEEL OR WOOD).
 3. MEDIA SUPPORT SHALL BE MADE FROM POREX® UNDERDRAIN PLATES CUT FROM CIRCULAR BIT TO FIT SNUG INTO THE COLUMNS AND SEALED WITH SILICON. STIFF CAULKING MATERIAL SHALL BE PLACED ALONG THE BOTTOM EDGE FOR SUPPORT.
 4. JOINT IS DETACHABLE SO THAT COLUMN MAY BE REMOVED FROM PIPING AND FRAME SUPPORT. JOINT WILL BE RATED FOR 40 PSI PRESSURE OR GREATER.
 5. PROVIDE 1 1/4" HOSE QUICK COUPLE AND 3/4" HOSE BIB WITH BALL VALVE OR GLOBE VALVE ISOLATION.
 6. PROVIDE 3/4" HOSE BIB WITH BALL VALVE OR GLOBE VALVE ISOLATION APPROXIMATELY 200 mm BELOW TOP OF COLUMN.

ADSORPTION COLUMNS 3

DIAMETER: 0.1 METER
 HEIGHT: 1.0 METER
 MATERIAL: CLEAR PVC
 BED DEPTH: 0.5 METER

SUBMERSIBLE PUMP / SUMP

EQUIP. NO.: P-103
 MANUFACTURER: LIBERTY PUMPS
 MODEL: 405
 TYPE: CENTRIFUGAL
 CAPACITY: 2280 L/hr
 HEAD: 9.1 m
 POWER: 375 W
 MOTOR: 120 V AC, 60 Hz

REV	DESCRIPTION	DRN	CHK	DATE (Y/M/D)
B	ISSUE FOR CONSTRUCTION	CF	B4W	2018/04/09
A	ISSUE FOR CONSTRUCTION	CF	B4W	2018/02/23

Indigenous and Northern Affairs Canada

Suite 201, 3275 LAKESHORE ROAD,
 K10 0N6, BC, CANADA
 V1V 8S9
 250-762-3727

**GIANT MINE REHABILITATION
 ARSENIC AND ANTIMONY ION
 ADSORPTION PILOT TESTING**

ADSORPTION COLUMNS 3, 4, & 5

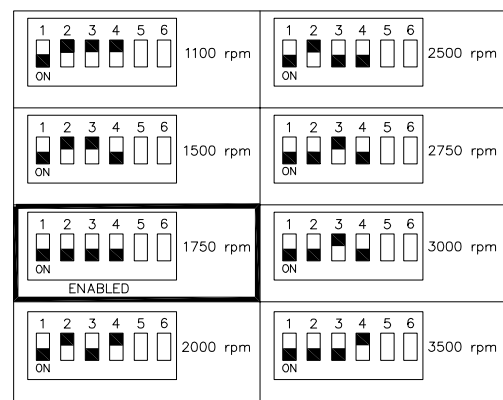
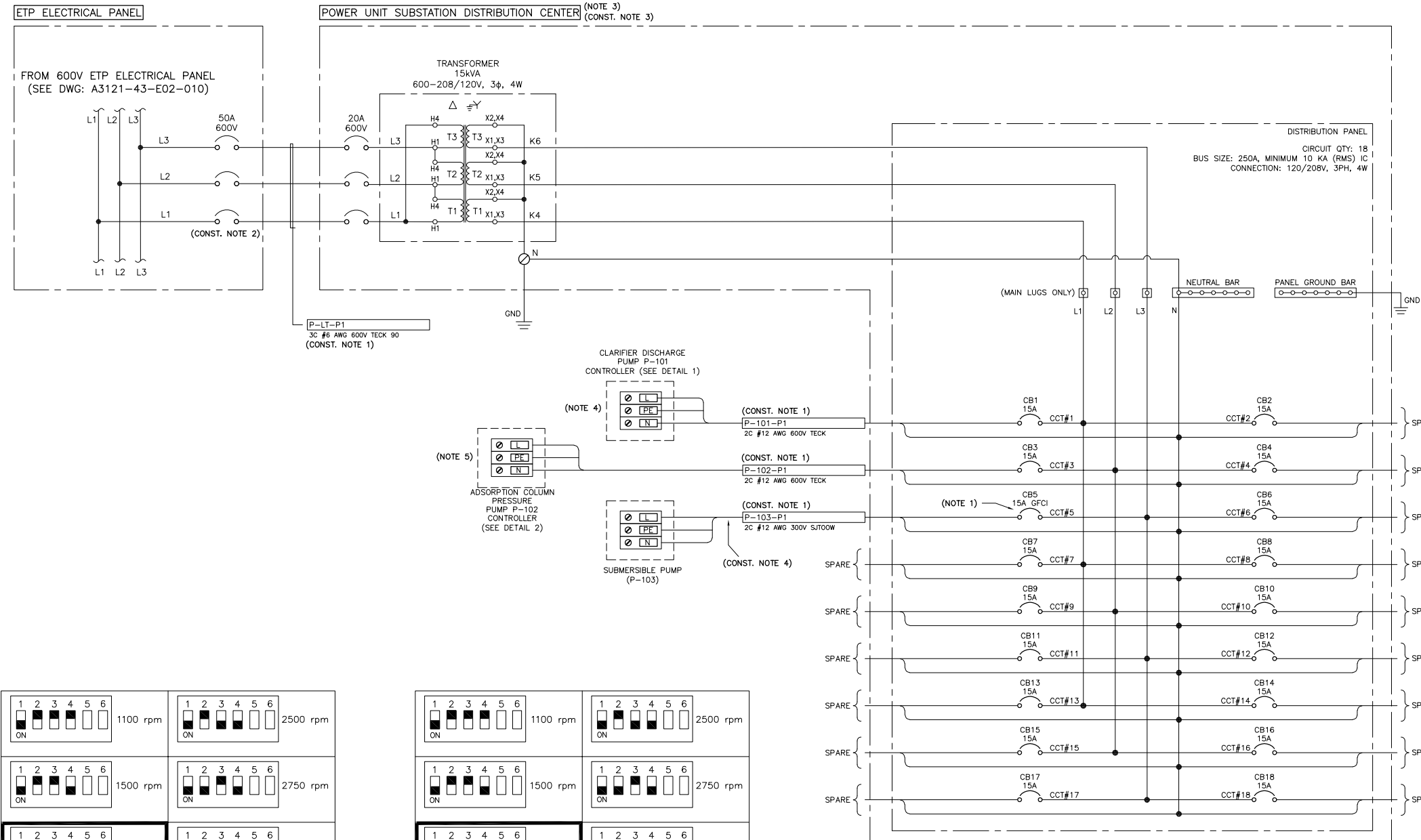
PROJECT START DATE (M / Y)	MARCH 2018
PROJECT NO.	60561021
FILENAME	60561021-DW-ME-0001.dwg
SHEET NO.	
DRAWING NO.	P-202

NOTES

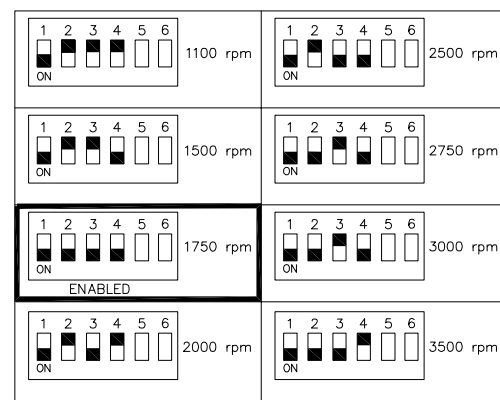
1. CLASS A GFCI BREAKER FOR SUBMERSIBLE PUMP.
2. VERIFY TERMINATION DETAIL IN PUMP CONTROLLER PACKAGE.
3. 'DUS-C1-15' POWER UNIT SUBSTATION DISTRIBUTION CENTER BY AC DANDY OR EQUIVALENT. INCLUDE OPTIONAL SIDE SUPPLY TERMINAL BOX, LOAD EXIT BOX AND TRANSFORMER PRIMARY CIRCUIT BREAKER.
4. CONTRACTOR TO CONFIGURE DIP SWITCH SETTINGS AS SHOWN IN DETAIL 1. ACTUAL PRESENT SPEED SETTINGS TO BE CALIBRATED DURING COMMISSIONING. DIP SWITCH #5, #6 DO NOT AFFECT SPEED: NOT USED.
5. CONTRACTOR TO CONFIGURE DIP SWITCH SETTINGS AS SHOWN IN DETAIL 2. ACTUAL PRESENT SPEED SETTINGS TO BE CALIBRATED DURING COMMISSIONING. DIP SWITCH #5, #6 DO NOT AFFECT SPEED: NOT USED.

CONSTRUCTION NOTES

1. CONTRACTORS TO SUPPLY AND INSTALL ALL NEW CABLING.
2. CONTRACTORS TO CONFIRM 50A 600V SPARE BREAKER ON ETP ELECTRICAL PANEL.
3. CONTRACTOR TO SUPPLY THE POWER UNIT SUBSTATION PER NOTE 3.
4. IF SUBMERSIBLE PUMP CORD HAS SUFFICIENT LENGTH, CONTRACTOR TO CUT THE PLUG AND TERMINATE CONDUCTORS TO GFCI BREAKER IN THE DIST. PANEL. IF CORD HAS INSUFFICIENT LENGTH, CONTRACTOR TO MAKE A CONNECTION TO A FEMALE PLUG END AS REQUIRED.



DETAIL 1 - PUMP P-101 CONTROLLER DIP SWITCH SETTINGS



DETAIL 2 - PUMP P-102 CONTROLLER DIP SWITCH SETTINGS

USER :		DATE :		FILE INFO :		TIME :		PLOT SCALE :		PERMIT STAMP:		ENGINEERING STAMP:		CLIENT:		SCALE: N.T.S.		DATE		LOCATION: --- SITE: GIANT MINE	
																				PROJECT NAME: PILOT PLANT TREATMENT TESTING PROGRAM	
																				DRAWING TITLE: ETP PILOT PROJECT THREE LINE DIAGRAM	
																				PROJECT No. A3121-54	
																				DRAWING No. A3121-54-E03-001	
																				SHEET NO. 1 OF SHEET 1 REV. B	



DRAWING No.	DRAWING TITLE	No.	DESCRIPTION	DATE	BY
A3121-43-E02-010	GIANT MINE ELECTRICAL DISTRIBUTION SYSTEM SINGLE LINE DIAGRAM	B	ISSUED FOR TENDER	03/APR/18	XH
		A	ISSUED FOR REVIEW	23/MAR/18	XH

REFERENCE DRAWING

REVISION

Appendix C – Contractor Statement of Work Specification



PILOT TREATMENT PLANT STATEMENT OF WORK

1. GENERAL

The Pilot Treatment Plant Statement of Work references the Arsenic and Antimony Ion Adsorption Pilot Testing Drawing Package. The drawing package should be reviewed in conjunction with this document.

1.1 Equipment

1. The Contractor is responsible for supply of the equipment specified in this Section and in the On-site Pilot Treatment Testing Drawings.
 - (a) If the equipment specified is unavailable within the required time-frame, the Contractor may propose an alternative to be approved by the Engineer.
2. Equipment will be owned by the Contractor and it will be the responsibility of the Contractor to remove the equipment from site after completion of the pilot test.

1.2 Shop Drawings

- .1 "Shop Drawings" mean custom drawings, specific product data, diagrams, illustrations, schedules, performance charts, brochures and other data, which are to be provided to illustrate details of a portion of the Work. Provide a complete installation schematic for all the works required for the pilot testing assembly. This is required to ensure there is no confusion with the scope of work or installation requirements. The shop drawing shall be submitted and approved by the Engineer prior to starting the installation.
- .2 Arrange for the preparation of clearly identified shop drawings as specified or as the Engineer may reasonably request. Shop drawings are to clearly indicate materials, methods of construction and attachment or anchorage, erection diagrams, connections, explanatory notes and other information necessary for completion of the Work. Where articles or equipment attach or connect to other articles or equipment, clearly indicate that all such attachments and connections have been properly coordinated, regardless of the trade under which the adjacent articles or equipment will be supplied and installed. Shop drawings must be submitted with the appropriate Specification Sections attached. Notify the Engineer in writing of any deviations in shop drawings from the requirements of the Contract Documents.
- .3 Examine all shop drawings prior to submission to the Engineer to ensure that all necessary requirements have been determined and verified and that each shop drawing has been checked and coordinated with the requirements of the Work and the Contract Documents. Examination of each shop drawing shall be indicated by stamp, date and signature of a responsible person of the Subcontractor for supplied items and of the General Contractor for fabricated items. Shop drawings not stamped, signed and dated will be returned without being reviewed and stamped "Resubmit".



PILOT TREATMENT PLANT STATEMENT OF WORK

- .4 Submit shop drawings with reasonable promptness and in an orderly sequence so as to cause no delay in the Work. Failure to submit shop drawings in ample time is not to be considered sufficient reason for an extension of Contract Time and no claim for extension by reason of such default will be allowed. Jointly prepare a schedule fixing the dates for submission and return of shop drawings.
- .5 The Engineer will review and return shop drawings in accordance with the schedule agreed upon or otherwise with reasonable promptness so as to cause no delay in the Work. Allow sufficient time for review and consideration by the Engineer. Claims for costs or contract extensions due to such review time will not be allowed.

1.3 Installation

1. The Contractor is responsible for any groundwork required to functionally support the installed equipment. The existing surface at the Overhead Shelter Laydown Area appears to be compact well-graded base and the ground work is expected to be limited to raking course gravel from underneath the tank laydown areas. Reference Appendix A for a picture of the Overhead Shelter Laydown Area.
2. Equipment that is not part of the pilot treatment plant will be removed from the Overhead Shelter Laydown Area by others before construction of the pilot treatment plant begins.
3. The Contractor is responsible for the installation of the pilot treatment plant within the Overhead Shelter Laydown Area and surrounding tie-in easements. The installation work will generally require the following items:
 - .1 Tie-in of the 100 mm PVC Supply Pipe into the bottom of an existing elevated stainless steel main shown in C-100. This connection should be made prior to the operation of the Effluent Treatment Plant (July) so that the pipe will be empty. Pictures of the tie-in point are available upon request. Coordinate tie-in with Engineer and Owner.
 - (a) Alternative tie-in approaches may be proposed by the Contractor, to be approved by the Engineer.
 - .2 PVC pipe and bends as indicated on the Civil and Process Drawings.
 - (a) Pilot plant to be as shown in the Process Drawings. The Civil Drawing presents a general pilot plant layout. The Contractor may propose modifications to the layout with detailed shop drawings for approval by the Engineer.
 - (b) Contractor can use all the space available in the Overhead Shelter Laydown Area.



PILOT TREATMENT PLANT STATEMENT OF WORK

- .3 Construct temporary structural framing to support the vertical adsorption columns against lateral wind loads and a vertical service load of 20 kN per pair of adsorption columns.
- .4 Construct temporary elevated scaffold adjacent to the pH adjustment tanks. The proposed schematic in drawing C-100 is a proposed structure for height requirements. The Contractor will be responsible for building the temporary elevated scaffold to conform to applicable standards.
- .5 Install a temporary electrical control panel within the Overhead Shelter Laydown Area and service the control panel with power from the existing control panel in the Effluent Treatment Plant located adjacent to the Overhead Shelter Laydown Area. See E-100 for details. Coordinate connection with Engineer and Owner.
 - (a) Pumping equipment to be energized through the newly installed electrical control panel.
4. All equipment and parts shall be installed as per the manufacturers' recommendations, unless otherwise indicated in the drawings and specifications.

1.4 Commission

1. The Contractor will be responsible for demonstration of the pilot treatment plant operation. The Contractor will be required to complete a successful leak test of the pilot treatment plant as per item 3.1 below. The leak test will demonstrate proper operation of the pumps.

1.5 Operation

1. Operation tasks are described in this Section.
 - .1 Operation of the pilot treatment plant will be completed by others under a separate contract.

2. PRODUCTS

1. Storage
 - .1 The Contractor will provide a lockable toolbox with at least 1 cubic meter of storage space to house spare equipment, sampling bottles, and consumable reagents.
2. Compressed Air



PILOT TREATMENT PLANT STATEMENT OF WORK

- .1 The Contractor shall provide an air compressor capable of providing at least 3 cubic feet per minute of air flow at a 20 psi pressure. The compressor will be compatible with 120 V power from the control panel (see electrical drawing).
3. Drip Trays
 - .1 All major wetted equipment will be placed in Drip Trays. Drip trays will be made of durable material capable of resisting the equipment operational service weight. Drip trays will capture leaks and are not intended to be full containment vessels.
4. Pipe
 - .1 All piping shall be solvent welded Schedule 40 PVC pipe unless otherwise indicated on the drawings. PVC pipe will be certified to CSA Standard B137.3 NSF Standard and certified to ASTM D1785 Standard.
 - .2 Temporary tubing will be provided for backwash sequences:
 - (a) Air hose with quick couple connections that are compatible with the air compressor provided as per 2.2.1 and adsorption column couplings specified in the process drawings (1/4" hose quick couple).
 - (b) Two 5/8" diameter 25 meter long water hoses with compatibility to connect to the service water at the Effluent Treatment Plant and adsorption column connections specified in the process drawings (3/4" garden bib)
5. Valves
 - .1 Valves shall be PVC socket ends complete with unions for all mainlines and sampling ports. Valves 75 mm or smaller will be Chemline Type 21 ball valves. Valves 100 mm or greater will be Chemline Type 21 ball valves or globe valves.
6. Flow Indicators
 - .1 Flow indicators shall be rotameter type and be of the same manufacturer and model for all three adsorption column trains. The rotameters shall be rated to service a flowrate of 40 – 80 L/hr.
7. Pressure Indicators
 - .1 Pressure indicators shall be pressure gauges with 0-60 psi pressure ranges.
8. Pumps



PILOT TREATMENT PLANT STATEMENT OF WORK

- .1 Clarifier Discharge Pump (P-101) will be a Fluid-o-Tech TMFRSS-201 rotary vane pump. The pump will be connected to a Fluid-o-Tech FEE2AWR1 controller. The controller will allow for manual modulation of the pump motor rpm between 1500 and 2000 rpm.
 - (a) The Contractor will provide a spare pump and controller for P-101.
 - .2 Adsorption Column Pressure Pump (P-102) will be Fluid-o-Tech TMFRSS-201 rotary vane pump. The pump will be connected to a Fluid-o-Tech FEE2AWR1 controller. The controller will allow for manual modulation of the pump motor rpm between 1100 and 1500 rpm.
 - .3 The Submersible Pump/Sump (P-103) will be a Liberty Pumps model 405 centrifugal pump/sump. The pump will provide at least 2,000 Litre/hour of flow at a discharge pressure of 9 meter. The sump tank capacity will be 19 Litre.
 - (a) The Contractor will provide a spare pump and sump for P-103.
9. Tanks
- .1 Clarifier Tank (T-100) will be made from HDPE material. T-100 will have a length at least 3.5 times greater than the width and the inlet and outlet will need to be at opposite ends respective to each other. The outlet will be offset from the inlet so that process water naturally flows to the outlet by gravity. The minimum liquid depth in T-100 is 1 meter. Minimum volumetric capacity of T-100 is 5 cubic meter. Large septic tanks are commonly available and suitable for the T-100 equipment specification.
 - .2 pH Adjustment Tanks (T-101/T-102) will be manufactured by Equinox and be model E-2000V with a 9 cubic meter capacity. T-101/T102 will be placed so that the lids are accessible from the mixing platform as possible.
10. Cartridge Filters
- .1 The cartridge filter (F-101/F-102) will be manufactured by HART model HWP005A10P. The filter will retain a nominal particle size of 5 µm. The housing material will be suitable for the specified cartridge filters and a 350 kPa internal pressure.
 - (a) The Contractor will provide 60 Hart, HWP005A10P cartridge filters (sold in boxes of 30).
11. Adsorption Columns
- .1 Adsorption columns will be made from 100 mm clear transparent PVC pipe. Columns need to be clear to measure media bed depth.



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- .2 Media support will be made from POREX Underdrain Plates. The plate material will be cored from rectangular plants using a circular bit and fit snug into the clear PVC columns. The edge of contact between the POREX Underdrain Plates and the PVC column will be sealed with silicon to prevent water from running through the edges. The bottom edge of the media support will be supported with rigid setting caulking. The media support will be placed at the bottom of the adsorption columns.
- .3 Contractor will provide connections at the outlet of each lead and lag column:
 - (a) 1/4" hose quick couple for compression hose connection with isolation ball valve or globe valve.
 - (b) 3/4" hose bib for service water connection complete with isolation ball valve or globe valve.
- .4 The Owner will purchase the media directly from the different vendors. The media will be provided to the contractor for their installation.

12. Electrical

- .1 See drawing E-100 for details.

3. EXECUTION

1. Commissioning

- .1 The Contractor will demonstrate that the equipment will operate without leaking by filling the clarifier tank and both pH adjustment tanks with potable water supplied by the Owner.
- .2 All tanks will each be flooded using the potable water source for 5 minutes to ensure the overflow lines drain to the discharge sump.
- .3 P-102 will be turned on to begin filling the adsorption columns; draining from both T-101 and T-102 for 5 minutes each.
- .4 While P-102 is operating and the clarifier tank is being flooded with potable water, P-101 will be turned on to test filter joints and discharge into T-101 and T-102. Ball valves downstream of F-101 and F-102 will be modulated during operation of P-101 to simulate 35 psi discharge pressure through the filters for 5 minutes each.
- .5 Finally, the influent line will be commissioned by opening the ball valve near the tie in point and closing the ball valve near the clarifier tank. The influent line will then be fed with potable water until the pipe is filled up to the



PILOT TREATMENT PLANT STATEMENT OF WORK

elevation of the upstream ball valve. After the influent main has been filled, the influent main will be left to sit under pressure for 30 minutes.

(a) If at any point the pilot treatment plant shows a sign of leaking, the commission test will be stopped and the source of the leak will be fixed promptly. Once the leak has been fixed, the leak test will be re-started.

.6 The contractor shall provide a complete, fully functional pilot assembly that functions to the satisfaction of the Engineer.

2. Operation

.1 Operation of the pilot treatment plant will be completed by others under a separate contract.

.2 The operator of the pilot treatment plant will be required to supply the following resources and consumable reagents:

(a) An operator with WHIMS training and the appropriate Personal Protective Equipment to avoid exposure to hazards associated with citric acid powder.

(b) A suitable supply of food-grade citric acid powder. Consumption rate is not certain until operation; assume a requirement of 100 kg.

(c) A 120 V AC powered drill with suitable mixing capabilities to disperse acid solution into T-101 or T-102.

(d) A 120 V AC powered field pH probe, accurate to 0.1.

(e) Suitable standards for field pH probe calibration, as a minimum 4, 7, and 10 pH standards will be supplied.

(f) Sampling containers.

(g) Shipping of sample containers to the Owner-approved Analytical Laboratory.

.3 The operator of the pilot treatment plant will be required to complete the following routine tasks.

(a) Weekly wasting (or as required) of settled sludge in the clarifier tank by partially draining clarifier tank contents into the sump.

(b) Check daily the pressure differential across the duty cartridge filter. Swap out the duty filter if the pressure differential is 5 psi within the manufacturers recommended change-out specification.



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- (c) Perform daily batch pH adjustment procedure.
 - (i) Sample 1 litre of process water from T-101 or T-102, whichever has been most recently filled.
 - (ii) Measure the pH of the sampled process water using a field pH probe, accurate to one decimal place.
 - (iii) Combine 908 grams (2 lb) (or more if required; solubility limit is 1,170 g/L) of citric acid powder into a 20 liter bucket with 10 liter of potable service water to produce the acidic solution.
 - (iv) Add 50 mL volumes of acidic solution to the 1 litre sample of process water, mix and measure pH with pH probe.
 - (v) Continue step (iv) until the process water pH reaches 6 – 6.5. Note the volume of acid solution required to adjust 1 litre of process water as X (mL of acidic solution/L of process water).
 - (vi) Calculate the volume of the water in T-101 or T-102, whichever the sample process water was drawn from. Calculate the volume by measuring the water level with a measuring tape and multiplying it by the area of the tank. Report the volume as Y (litre of process water)
 - (vii) Calculate the dose of acid solution required to lower the pH of T-101 or T-102 to 6 – 6.5 as X multiplied by Y.
 - (viii) Measure out the acid solution dose volume and pour it into T-101 or T-102.
 - (ix) Mix T-101 or T-102 with an electrically powered hand mixer until the pH has stabilized. Check pH with pH probe every minute to ensure pH has stabilized.
 - (x) Switch the newly prepared acidified process water into duty configuration.

- (d) Daily recording of rotameter readings entering each adsorption column train on the On-site Data Sheet. Flowrates should be recorded before the operator manually adjusts flows. Daily, the operator will control the flow rate entering the adsorption columns so that:
 - (i) the difference in flowrates between any of the adsorption column trains is less than 5 L/hr,
 - (ii) the indicated flow for all of the adsorption column trains is less than 70 L/hr, and
 - (iii) the indicated flow for all of the adsorption column trains is greater than 60 L/hr.
 - (iv) It may be necessary to use the by-pass to control flow within the specified range.

- (e) Update a data sheet with flow indicator readings and send to the Engineer, daily.



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- (f) Collect daily samples and organize for the samples to be delivered to an analytical laboratory approved by the Engineer for water quality analysis.
 - (i) Water quality analysis required is presented in Table 1 below:

Table 1 – Water Quality Sampling Details

Sample Location	Parameter	Frequency	Analytical Lab Turnaround
Influent Line	Full Parameter Sweep ²	Every 2 nd day	Regular
Influent Line	Total Arsenic + Antimony Dissolved Arsenic + Antimony pH Conductivity Chloride Sulphate	Every other 2 nd day (when full parameter sweep is not being sampled)	Regular ³
Lead Column Effluents ¹	Column Flow Rate Total Arsenic + Antimony Dissolved Arsenic + Antimony pH Conductivity Chloride Sulphate	Every day	Rush ⁴
Lag Column Effluents ¹	Full Parameter Sweep ²	Every 2 days	Regular ³
Lag Column Effluents ¹	Total Arsenic + Antimony Dissolved Arsenic + Antimony pH Conductivity Chloride Sulphate	Every other 2 nd day (when full parameter sweep is not being sampled)	Regular ³

1: Lead and lag column effluent samples will be taken for each of the three media adsorption columns

2: Full parameter list is provided in Appendix B

3: Regular delivery time means results are delivered within 10 days (including weekends) of sampling at the pilot test plant; includes shipping time to analytical laboratory.

4: Rush delivery time means results are delivered within 2 days (including weekends) of sampling at the pilot test plant; includes shipping time to analytical laboratory.

- (g) Sample and replace exhausted media in adsorption columns. Ship exhausted adsorption media to an analytical laboratory selected by the Engineer.
 - (i) Allow for cost to ship six 2 kg samples via standard international shipping to Austin, Texas, USA.

END OF SECTION



**PILOT TREATMENT PLANT STATEMENT
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APPENDIX A – OVERHEAD SHELTER LAYDOWN AREA





**PILOT TREATMENT PLANT STATEMENT
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APPENDIX B – WATER QUALITY PARAMETER LIST

Field Parameters	Conventional (Routine) Parameters	Major Ions	Nutrients	Total Metals	Dissolved Metals	Other
Temperature	pH	Bicarbonate, as CaCO ₃	Nitrate	Aluminum	Aluminum	Total cyanide
Dissolved Oxygen	Specific Conductivity	Bromide	Nitrite	Antimony	Antimony	
Dissolved Oxygen Saturation	Hardness, as CaCO ₃	Calcium	Nitrate + nitrite	Arsenic	Arsenic	
pH	Total Alkalinity, as CaCO ₃	Carbonate, as CaCO ₃	Total Ammonia	Barium	Barium	
Oxygen Reduction Potential	Total Dissolved Solids	Chloride	Total Kjeldahl nitrogen	Beryllium	Beryllium	
Turbidity	Total Suspended Solids	Fluoride	Total phosphorus (a)	Bismuth	Bismuth	
Specific Conductivity	Total Organic Carbon	Hydroxide, CaCO ₃	Total phosphorus (b)	Boron	Boron	
	Dissolved Organic Carbon	Magnesium	Dissolved phosphorus (a)	Cadmium	Cadmium	
	Turbidity	Potassium	Dissolved phosphorus (b)	Chromium	Chromium	
		Sodium	Orthophosphate	Cobalt	Cobalt	
		Sulphate		Copper	Copper	
		Silica		Iron	Iron	
				Lead	Lead	
				Lithium	Lithium	
				Manganese	Manganese	
				Mercury	Mercury	
				Molybdenum	Molybdenum	
				Nickel	Nickel	
				Selenium	Selenium	
				Silicon	Silicon	
				Silver	Silver	
				Strontium	Strontium	
				Sulphur	Sulphur	
				Thallium	Thallium	
				Tin	Tin	
				Titanium	Titanium	
				Uranium	Uranium	
				Vanadium	Vanadium	
				Zinc	Zinc	
				Zirconium	Zirconium	
					Cesium	
					Rubidium	

(a) - Phosphorus concentration obtained from the nutrient analysis method (colourimetric).
 (b) - Phosphorus concentration obtained from the metals analysis method (collision-cell mass spectrometry).

Appendix D – Water Quality Parameter List

Pilot Treatment - Water Testing - Expanded Parameter List

Field Parameters	Conventional (Routine) Parameters	Major Ions	Nutrients	Total Metals	Disolved Metals	Other
Temperature	pH	Bicarbonate, as CaCO ₃	Nitrate	Aluminum	Aluminum	Total cyanide
Disolved Oxygen	Specific Conductivity	Bromide	Nitrite	Antimony	Antimony	
Disolved Oxygen Saturation	Hardness, as CaCO ₃	Calcium	Nitrate + nitrite	Arsenic	Arsenic	
pH	Total Alkalinity, as CaCO ₃	Carbonate, as CaCO ₃	Total Ammonia	Barium	Barium	
Oxygen Reduction Potential	Total Disolved Solids	Chloride	Total Kjeldahl nitrogen	Beryllium	Beryllium	
Turbidity	Total Suspended Solids	Fluoride	Total phosphorus (a)	Bismuth	Bismuth	
Specific Conductivity	Total Organic Carbon	Hydroxide, CaCO ₃	Total phosphorus (b)	Boron	Boron	
	Disolved Organic Carbon	Magnesium	Dissolved phosphorus (a)	Cadmium	Cadmium	
	Turbidity	Potassium	Dissolved phosphorus (b)	Chromium	Chromium	
		Sodium	Orthophosphate	Cobalt	Cobalt	
		Sulphate		Copper	Copper	
		Silica		Iron	Iron	
				Lead	Lead	
				Lithium	Lithium	
				Manganese	Manganese	
				Mercury	Mercury	
				Molybdenum	Molybdenum	
				Nickel	Nickel	
				Selenium	Selenium	
				Silicon	Silicon	
				Silver	Silver	
				Strontium	Strontium	
				Sulphur	Sulphur	
				Thallium	Thallium	
				Tin	Tin	
				Titanium	Titanium	
				Uranium	Uranium	
				Vanadium	Vanadium	
				Zinc	Zinc	
				Zirconium	Zirconium	
					Cesium	
					Rubidium	

(a) - Phosphorus concentration obtained from the nutrient analysis method (colourimetric).

(b) - Phosphorus concentration obtained from the metals analysis method (collision-cell mass spectrometry).

