APPENDIX G

Technical Memorandum 7

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To: Montana Department of Environmental Quality

From: Environmental Resources Management

Date: December 29, 2017

Subject: Black Butte Copper Project - Whether there is an advantage to requiring alternative water treatment technologies rather than the proposed reverse osmosis treatment

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BACKGROUND

Groundwater collected during the dewatering of the underground workings starting in year 2 of construction through closure would be collected and treated in a water treatment system that includes a dual pass Reverse Osmosis (RO) system. Approximately 60 percent of the groundwater would be treated to non-degradation standards and discharged under the conditions of a Montana Pollutant Discharge Elimination System (MPDES) permit through upland underground infiltration galleries (UIGs) to shallow bedrock, or into an infiltration gallery located in the Sheep Creek alluvial aquifer system. There are concerns with the ability of the water treatment system to effectively treat the water in all phases of mine operation to non-degradation standards, particularly for nitrates, and the disposition of the large volume of waste brine generated from the RO system.

CURRENT MOP

There are three phases of water management: Construction, Operation, and Closure. During construction, no water would be treated in the first year, and an estimated 250 gallons per minute (gpm) is anticipated in the second year. RO with pretreatment would be used to treat dewatering flow. Pretreatment prior to RO for all three phases includes ferric chloride precipitation/ coagulation of metals and solids and settling, followed by multimedia and cartridge filtration. The pretreatment and RO system treats the water to non-degradation standards. Following the RO system, treated water would be discharged primarily to the alluvial UIG (if needed) under the conditions of the MPDES permit. Treatment residuals would be stored in the Contact Water Pond (CWP). RO blowdown (brine) would be further treated in a Vibratory Shear Enhanced Process (VSEP) system to reduce its volume prior to storage in the brine cell or the CWP. The VSEP is a membrane system that uses vibrational shear forces to reduce membrane fouling, resulting in the ability to treat brine streams and recover water while reducing the brine volume (Johnson 2002). Constituents of concern for treatment during the Construction phase include arsenic, lead, strontium, thallium, total suspended solids (TSS), and nitrogen (nitrate, nitrite, etc.) species. Nitrogen species that originate from blasting operations are predicted to be removed in the RO system. An estimated 48.1 million gallons of RO blowdown would be generated during the 2-year Mine Construction Phase and stored in the CWP brine cell or hauled offsite, if necessary.

In the Operations phase, the treatment capacity would be increased to 588 gpm, with only 497 gpm treated with RO. The remaining water would be used in the Mill. During Operations, water would be a mixture of underground, process, and contact water. Constituents of concern would include pH, dissolved metals (antimony, arsenic, copper, lead, nickel, strontium, and thallium), nitrogen species (nitrate, nitrite, and precursors), and TSS.

The VSEP would not be used during the Operations phase as there are multiple onsite disposal options for the brine, and volume reduction is not needed. One brine disposal option is to pump the brine to the Process Water Pond (PWP). A second option is to pump the brine to the mill thickener. Both options would involve the incorporation of the brine into the cemented tailings paste for permanent disposal.

In the Closure phase, the RO system would be used at full capacity (500 gpm) to produce water to rinse the underground workings. RO blowdown would be volume reduced with the VSEP and shipped offsite. Water treatment would have the same effluent goals of not exceeding the Estimated Maximum Allowable Effluent Concentrations (EMAEC) throughout the three phases; however, the influent quality would vary.

Tintina maintains that the anticipated nitrate concentration from the water treatment facility would be below the groundwater non-degradation level. For the surface water alluvium (Little Sheep Creek), the non-degradation criteria for Nitrate + Nitrite (as N) is 11.29 milligrams per liter (mg/L), and Total Nitrogen at 0.61 mg/L. The predicted quality from the water treatment facility is estimated for Nitrate + Nitrite (as N) at 0.22 mg/L and Total Nitrogen at 0.32 mg/L. If these systems function as predicted, there should be no issues with meeting the non-degradation standards.

EIS ENVIRONMENTAL ISSUES

The potential environmental impacts would be with the water treatment system not consistently meeting non-degradation standards, particularly for nitrates and the disposition of the brine from water treatment from Construction through the Closure phases.

TECHNICAL APPROACH

RO membranes have a pore size of less than 0.002 micron and are susceptible to fouling by particulates, gas bubbles, and other fouling contaminants, requiring pretreatment of the influent beforehand. Constituents found in mine dewatering than could cause problems with RO membrane are iron salts, silica, calcium sulfate, and calcium carbonate (Chambers 2014). These constituents can reach saturation and cause scaling due to precipitate solids on the membrane. This causes reduced permeate flux and downtime of the treatment system to de-scale the membranes. Removal of cations through softening is a common RO pretreatment to increase the permeate recovery and reduce maintenance. Calcium, magnesium, and iron can be removed through hydroxide or sulfide precipitation, softening, or ion exchange. Precipitation produces a metal sludge that has to be disposed. Softeners and ion exchange processes require regeneration, which also produces a brine or concentrated waste that needs disposal. RO systems produce a significant amount of concentrated blowdown or brine for disposal. The permeate recovery and success of mine water treatment would depend on how well the pretreatment removes the scaling (calcium, iron) constituents in the water (USEPA 2003).

RO is a technically feasible treatment to remove nitrates. Rejection rates for sodium chloride and sodium nitrate can be as high as 98 percent and 93 percent, respectively (Jensen et al. 2012). RO membranes theoretically can reject as much as 99.5 percent of all dissolved ions including sodium, nitrate, and chloride (Dahm 2014).

While the most common application for RO is drinking and high-purity water treatment, RO has been considered in mining operations. In a report on water management in mines across the globe, RO was mostly used to desalinate sea water for mine operations. Only one mine – the closed Homestake gold mine in South Dakota – used RO to treat mine seepage (ICMM 2012). A large zinc-copper ore body near Crandon, Wisconsin, proposed to use RO and Evaporation for treatment of contaminated groundwater from the mine before reusing the water in the mine (Leopold et al. 2001).

ALTERNATIVE TECHNOLOGY

Other technologies considered for mining operations include ion exchange, electrodialysis, and mechanical (vapor compression) evaporators.

Ion Exchange has been used in mining applications to remove heavy metals and other divalent metal cations. Ion exchange resins for nitrate removal depend on the quality of the incoming water. There are three types of ion exchange systems: anionic, cationic, and chelating ion. Potable water influent can be treated for nitrate removal with strong base anion exchange and weak base anion exchange (Jensen 2012). Anions or cations are removed with the resins, producing treated water removed from the resin bed by regeneration with either acid or caustic. Regeneration of ion exchange beds produces a waste stream that has to be disposed of. Regeneration requires the storage of concentrated acids and bases and knowledgeable operators (Chambers 2014). Ion Exchange is generally not feasible or cost effective for treating large volumes of water as would be encountered in the Black Butte Copper Mine Project.

Electrodialysis uses direct electrical current across a stack of alternating cation and anion selective membranes to collect either anions or cations. Electrodialysis Reversal (EDR) units operate under lower pressures and are more tolerant of temperature and pH than RO. However, like RO, EDR units are susceptible to calcium sulfate scaling if pretreatment is inadequate. EDR treatment efficiency in removing dissolved ions does not compare favorably with RO. The amount of water recovered is lower, and a waste brine solution is also produced for disposal (Bowell 2004).

Mechanical vapor recompression evaporators can significantly reduce the waste brine volume; however, they have high maintenance requirements and high capital and operating costs. Mechanical and solar evaporation was considered by Tintina, but rejected based on inefficiency and costs.

The VSEP is a viable technology for volume reduction of the brine. It is not susceptible to calcium sulfate scaling and is more cost effective than mechanical evaporation.

CONCLUSIONS AND RECOMMENDATIONS

In theory, RO can remove 90+ percent of dissolved ions, including nitrate. In reality, the influent water quality and pretreatment determine the actual water recovery. The quality of the treated water modeled by the membrane manufacturer predicts that the proposed RO treatment system would produce water quality for injection below the non-degradation standards. However, the presence of calcium sulfate in the mine water is expected to play a significant role in reducing the water recovery rates and treatment efficiency. Selection and use of a calcium sulfate specific antiscalant would mitigate the impact of calcium sulfate and improve water recovery. The ability of the pretreatment would be critical to achieving the predicted quality of the RO treated water. There are not many technically feasible and non-cost prohibitive methods to reduce water treatment residuals. The VSEP system has been used for treatment of acid mine drainage and appears to be an appropriate method of reducing brine. In conclusion, there are no better alternatives to those proposed in the MOP for treating groundwater inflow and reducing brine volumes.

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