APPENDIX V-1: Nondegradation Analysis for the MPDES Outfalls

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TECHNICAL M E M O R A N D U M

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SUBJECT: Black Butte Copper - Nondegradation Analysis for MPDES Outfalls

At the request of Tintina, Hydrometrics has analyzed the nondegradation requirement for the discharge of treated water from the Black Butte Copper Project (Project) under an MPDES permit. The Project is a proposed underground copper mine which will generate water from mine dewatering, process water, and other minor sources that once treated will be reused or discharged to state waters. As a new discharge, the level of treatment required by the Project is determined by the nondegradation statute (75-5-303 Montana Code Annotated MCA) and rule (Administrative Rules of Montana (ARM) 17.30 Subchapter 7) for nonsignificant activities. The overarching purpose is to identify the water quality needed to prevent effects to all current and anticipated beneficial uses in groundwater and surface water. This technical memo presents the methods and rationale utilized in the nondegradation analysis to estimate the maximum allowable effluent concentrations for the discharge.

Purpose: In statute [75-5-303(1) MCA], the policy of the State of Montana is to protect existing and anticipated uses of state waters and to protect and maintain the level of water quality necessary to protect those uses. The Department of Environmental Quality (DEQ) is tasked to maintain the quality of high-quality waters [75-5-303(2) MCA]. High-quality waters are defined in 75-5-103(13)(a) & (b)(i) MCA as all state waters except class III and IV groundwater and "… surface waters that: are not capable of supporting any one of the designated uses for its classification."

All groundwater systems within the Project area are high-quality waters. Surface waters in the Project area (Big Butte Creek and Little Sheep Creek) are high-quality waters. We note that within the Project area, Sheep Creek is listed on the 2016 303(d) list of impaired waters because aquatic life and primary contact recreation uses are not supported due to water quality exceedances of dissolved aluminum and bacterial concentration. While Sheep Creek does not meet the above definition of a high-quality water for these parameters, it supports all other uses and meets the definition of high-quality waters for other beneficial uses.

Non-significance is defined in 75-5-317(2) MCA as a change in water quality that has low potential for harm to human health or the environment that also, based on 75-5-301(5)(c), considers the quantity, strength, duration of discharge, and character of the pollutant. In this evaluation, we approach Sheep Creek as a high-quality water and consider whether the Project discharge meets non-significance criteria.

Process: Subchapter 7 of ARM 17.30 Rule 715 identifies the process for application of non-significance criteria for new or increased sources. Dependent on how each discharged parameter is classified and the condition of the surface water, certain increases are not considered significant and may be allowed by statute and rule. The non-degradation rules to evaluate increases in the receiving waters are summarized below:

- For carcinogenic parameters and those with bioconcentration factors greater than 300 – no increases are allowed in the receiving water.
- For toxic parameters – increases are allowed up to the trigger value contained in Circular DEQ-7. If changes in water quality are greater than the trigger value, the change is not significant if the resulting concentration at the edge of a mixing zone does not exceed 15% of the lowest applicable standard.
- For harmful and nutrient parameters – changes in water quality at the edge of a mixing zone are allowed when the existing concentration in the receiving water is less than 40% of the applicable standard and the water quality change outside a mixing zone is less than 10% of the applicable water quality standard.
- For changes in the quantity of surface water – increases or decreases in surface water flows that are less than 15% of the mean monthly flow or less than 10% of the seven-day ten-year low flow (7Q10). Non-significance criteria are not applied to quantity of groundwater discharges.
- For nitrate – changes in the concentration of nitrate in groundwater will not exceed 7.5 mg/L.
- For narrative standards – changes in water quality will not have a measurable effect on beneficial uses or cause measurable changes in aquatic life or ecological integrity.

Receiving Waters: The Project is proposing to discharge water to three separate Underground Infiltration Galleries (UIGs), which include two Upland UIGs (Eastern and Central) and one alluvial (Sheep Creek Alluvial UIG). Four separate evaluations have been conducted to evaluate whether discharges from the Project will result in non-significant changes in water quality for each receiving water. The receiving waters and types of discharge that have been evaluated are as follows: discharge to the alluvial aquifer adjacent to Sheep Creek, discharge to the bedrock aquifer in the upland infiltration gallery (UIG) areas, discharge to Sheep Creek after mixing with alluvial groundwater, and discharge to Sheep Creek after mixing with Upland bedrock aquifer (Central UIG) and alluvial groundwater. These four analyses were conducted to assure the nondegradation criteria was evaluated for each receiving water from each outfall.

The flow of each receiving water was quantified for this nondegradation analysis to evaluate different mixing analyses. The nondegradation analysis uses three flows for Sheep Creek; the annual 7Q10 for mixing of all constituents except nutrients, seasonal (July through October) 14Q5 for nutrients mixing analysis, and mean monthly flows for evaluation of nondegradation

for flow. These flows were calculated based on data from the USGS gaging station on Sheep Creek (#06077000) and applying a multiplier (1.75) based on a watershed analysis to adjust for the larger watershed for the SW-1 surface water site as documented in Sheep Creek 7Q10 Low Flow Estimation Technical Memorandum (Hydrometrics, 2013). The calculated 7Q10 and seasonal 14Q5 for site SW-1 are 8.6 cfs and 21 cfs, respectively. The mean monthly flow ranges between 9.1 cfs and 115 cfs. Groundwater flux was calculated based on Darcy's Law for the Eastern UIG, Central UIG, and Sheep Creek Alluvial UIG. The aquifer parameters and resultant flow for each groundwater system is summarized in Table 1. Since the Central UIG has the lower groundwater flux and the water quality beneath the Eastern and Central UIGs is similar, the Central UIG was only evaluated in the bedrock analysis.

TABLE 1. GROUNDWATER FLUX CALCULATIONS

Parameter	Central UIG	Eastern UIG	Sheep Creek Alluvium UIG
Hydraulic Conductivity (ft/d)	3	5	200
Thickness (ft)	15	15	15
Width (ft)	2150	2615	1420
Gradient	0.04	0.04	0.008
Groundwater Flux (gpm)	23	40	177

Baseline monitoring has been conducted quarterly (monthly at select sites) at the project since 2011 at reporting levels required by Circular DEQ-7. The extended dataset shows the unique water chemistry and natural variation of each receiving water. DEQ promotes the use of the 75th percentile statistic to represent the upper bound interquartile range of the mean water quality. Water quality data were therefore summarized at the 75th percentile value to represent conditions of each receiving water for this nondegradation analysis. The monitoring sites used for each receiving water include SW-1 for Sheep Creek, MW-4A for Sheep Creek alluvium, and MW-7 and MW-8 for the Central UIG. The Central UIG was used for the Upland UIGs as the estimated groundwater flux is lowest in this area, making in the more conservative analysis. The 75th percentile for each water quality parameter used in the nondegradation analysis for the receiving waters is shown in Table 2.

TABLE 2. SUMMARY OF WATER QUALITY 75TH PERCENTILE

Parameter	Units	Central UIG	Sheep Creek Alluvium UIG	Sheep Creek
Field Parameters				
Dissolved Oxygen	mg/L	1.23	1.44	12.20
pH - Field	s.u.	7.89	7.35	8.32
Specific Conductance	uhoms/cm	535	523	323
Water Temperature	deg F	45.3	45.6	48.3
Common Constituents				
Total Dissolved Solids	mg/L	315	296	187
Total Suspended Solids	mg/L	189	10	10
Alkalinity as CACO3	mg/L	237.5	280	180
Calcium	mg/L	58	78	49
Magnesium	mg/L	37	22	13
Potassium	mg/L	1	2	1
Sodium	mg/L	3.5	3	2
Chloride	mg/L	4	2.25	2
Fluoride	mg/L	0.3	0.2	0.1
Sulfate	mg/L	62	18.25	6.5
Total Hardness as CACO3	mg/L	164	274	113
Nutrients				
Nitrate + Nitrite as N	mg/L	0.01	0.01	0.03
Total Persulfate Nitrogen (seasonal)	mg/L	NM	NM	0.085
Total Phosphorus	mg/L	NM	NM	0.018
Trace Constituents (GW - Dissolved; SW - Total Recoverable except Aluminum Dissolved)				
Aluminum	mg/L	0.017	0.009	0.032
Antimony	mg/L	0.0006	0.0005	0.0005
Arsenic	mg/L	0.003	0.001	0.001
Barium	mg/L	0.075	0.188	0.110
Beryllium	mg/L	0.0008	0.0008	0.0008
Cadmium	mg/L	0.00003	0.00003	0.00003
Chromium	mg/L	0.01	0.01	0.01
Cobalt	mg/L	0.01	0.01	0.01
Copper	mg/L	0.002	0.002	0.002
Iron	mg/L	0.08	0.04	0.46
Lead	mg/L	0.0003	0.0003	0.0005
Manganese	mg/L	0.09	0.20	0.02
Mercury	mg/L	0.000005	0.000005	0.000007
Molybdenum	mg/L	0.003	0.002	0.002
Nickel	mg/L	0.001	0.001	0.002
Selenium	mg/L	0.0002	0.0002	0.0002
Silver	mg/L	0.0005	0.0005	0.0005
Strontium	mg/L	0.163	0.173	0.127
Thallium	mg/L	0.0002	0.0002	0.0002
Uranium	mg/L	0.008	0.008	0.008
Zinc	mg/L	0.002	0.002	0.006

As directed in Circular DEQ-7 for groundwater quality characterization, laboratory analyses utilized the dissolved fraction for metals. We recognize that DEQ has not implemented a translator to convert dissolved fraction metals concentrations to total recoverable metals concentrations, so we assume that in groundwater and for groundwater that would discharge to the alluvial aquifer, the dissolved fraction metals concentration represents the total recoverable metals concentration that would discharge to surface water. The final effluent concentrations are expressed as total metals values.

Water Quality Standards: Several water quality standards are used in this analysis to calculate nondegradation criteria. These standards include:

- The most stringent applicable water quality standard found in the October 2012 Circular DEQ-7 (between the acute and chronic aquatic life and/or human health standards). Hardness-based aquatic life standards for metals are calculated using the 25th percentile value for hardness of the receiving water.
- Additional EPA secondary maximum drinking water criteria for total dissolved solids, chloride, and sulfate. EPA's aesthetic criteria were excluded for iron and manganese.
- Surface water quality standards for a B-1 water classification have been incorporated into the analysis (ARM 17.30.623).
- Nutrient standards are provided by the December 2013 DEQ-12A circular and correspond to Middle Rockies Ecoregion Big Snowy-Little Belt Carbonate Mountains (17q).
- Groundwater classification is based on monitoring data for aquifers in the Project area and correspond to Class I groundwater.

Nondegradation Criteria Development: For each parameter evaluated, the nondegradation criterion has been calculated as follows:

- The maximum effluent discharge proposed for the project (575 gpm) was used for the effluent flow rate, the average discharge is estimated at 398 gpm.
- No increases are allowed for carcinogens or parameters with a bio-concentration factor greater than 300.
- Depending on the parameter classification, the allowable increase is either the trigger value, or the corresponding portion (e.g., 15% of standard for toxics, etc.) of the lowest applicable water quality standard.
- Due to the impaired status of Sheep Creek, the water quality standard for dissolved aluminum will be used as the nondegradation criterion.

Based on the information summarized in the sections above, the nondegradation criterial for each relevant parameters was developed for each receiving water as summarized in Table 3.

TABLE 3. NONDEGRADATION CRITERIA FOR RECEIVING WATERS

Parameter	Units	Nondegradation Criteria		
		Central UIG Bedrock Aquifer	Sheep Creek Alluvial Aquifer	Sheep Creek Surface Water
Flow*	gpm	NA	NA	1072
Dissolved Oxygen	mg/L	NA	NA	8
pH	s.u.	6.5-8.5	6.5-8.5	6.5 - 8.5
Specific Conductance	uhoms/cm	635	623	408
Total Dissolved Solids	mg/L	365	346	237
Total Suspended Solids	mg/L	NA	NA	10
Chloride	mg/L	29	27	27
Fluoride	mg/L	0.6	0.6	0.6
Sulfate	mg/L	87	43	32
Nitrate + Nitrite as N	mg/L	7.5	7.5	1.5
Total Nitrogen (Persulfate Method)	mg/L	NA	NA	0.115
Total Phosphorus	mg/L	NA	NA	0.019
Aluminum	mg/L	0.013	0.013	0.087
Antimony	mg/L	0.0009	0.0009	0.00084
Arsenic	mg/L	0.003	0.001	0.001
Barium	mg/L	0.15	0.15	0.15
Beryllium	mg/L	0.0008	0.0008	0.0008
Cadmium	mg/L	0.000075	0.000075	0.000044
Chromium	mg/L	0.015	0.015	0.015
Copper	mg/L	0.195	0.195	0.0025
Iron	mg/L	0.11	0.03	0.48
Lead	mg/L	0.0023	0.0075	0.0006
Mercury	mg/L	0.000005	0.000005	0.000007
Nickel	mg/L	0.015	0.015	0.00855
Selenium	mg/L	0.0075	0.0075	0.00075
Silver	mg/L	0.015	0.015	0.00078
Strontium	mg/L	0.6	0.6	0.6
Thallium	mg/L	0.0003	0.0003	0.0005
Uranium	mg/L	0.008	0.008	0.008
Zinc	mg/L	0.30	0.30	0.02

*15% of minimum mean monthly flow

Mixing Zone Development: Dilution allowances in this analysis are based on source-specific mixing zones in groundwater (ARM 17.30.518 and ARM 17.30.508(3)) and a nearly-instantaneous mixing zone in Sheep Creek (ARM 17.30.516(1)). As the nondegradation criteria are based on only a portion of the chronic standard, 100% of the available dilution is used in the analysis. To provide a conservative analysis, it is assumed that treated effluent will eventually reach Sheep Creek. To ensure adherence to the nondegradation policy, groundwater discharges are evaluated stepwise to safeguard the quality of Sheep Creek and groundwater aquifer(s).

A mass balance approach was used to evaluate the resultant concentrations after mixing and to develop the maximum allowable effluent concentration that would be allowed under the most restrictive nondegradation criterion. The maximum allowable effluent concentration was evaluated based on the minimum nondegradation criterion of the receiving waters. Table 4 presents the nondegradation criterion for each receiving water and the maximum allowable effluent concentrations for each constituent considered in the analysis.

TABLE 4. MAXIMUM EFFLUENT CONCENTRATIONS ALLOWABLE UNDER NONDEGRADATION

Parameter	Units	Receiving Waters				Maximum Allowable Effluent
		Alluvium	Bedrock	Alluvium/ Surface Water	Bedrock/ Alluvium/ Surface Water	
Dissolved Oxygen	mg/L	NA	NA	8.0	8.0	**8.0**
pH - Field	s.us	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	**6.5 - 8.5**
Specific Conductance	uhoms/cm	654	639	915	910	**639**
Total Dissolved Solids	mg/L	361	367	535	532	**361**
Alkalinity as CACO3	mg/L	752	598			**598**
Chloride	mg/L	35	30	193	194	**30**
Fluoride	mg/L	0.72	0.61	3.90	3.91	**0.61**
Sulfate	mg/L	51	88	194	193	**51**
Nitrate + Nitrite as N	mg/L	9.81	7.80	11.29	11.35	**7.80**
Total Nitrogen (Persulfate Method)	mg/L	NA	NA	0.61	0.61	**0.61**
Total Phosphorus	mg/L	NA	NA	0.035	0.035	**0.035**
Aluminum	mg/L	0.014	0.013	0.463	0.466	**0.013**
Antimony	mg/L	0.0010	0.0009	0.0031	0.0031	**0.0009**
Arsenic	mg/L	0.001	0.003	0.001	0.001	**0.001**
Barium	mg/L	0.138	0.153	0.392	0.395	**0.138**
Beryllium	mg/L	0.001	0.001	0.001	0.001	**0.001**
Cadmium	mg/L	0.00009	0.00008	0.00013	0.00013	**0.00008**
Chromium	mg/L	0.017	0.015	0.048	0.048	**0.015**
Copper	mg/L	0.254	0.203	0.006	0.006	**0.006**
Iron	mg/L	0.03	0.11	0.74	0.76	**0.03**
Lead	mg/L	0.010	0.002	0.001	0.001	**0.001**
Mercury	mg/L	0.000005	0.000005	0.000007	0.000007	**0.000005**
Nickel	mg/L	0.019	0.016	0.052	0.053	**0.016**
Selenium	mg/L	0.0097	0.0078	0.0044	0.0044	**0.0044**
Silver	mg/L	0.0195	0.0156	0.0026	0.0027	**0.0026**
Strontium	mg/L	0.73	0.62	3.73	3.75	**0.62**
Thallium	mg/L	0.0003	0.0003	0.0025	0.0025	**0.0003**
Uranium	mg/L	0.008	0.008	0.008	0.008	**0.008**
Zinc	mg/L	0.39	0.31	0.11	0.11	**0.11**