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TECHNICAL MEMORANDUM

DATE: December 21, 2018 **PROJECT #**: 605.1602

TO: Vicky Peacey and Greg Ghidotti, Resolution Copper

FROM: Chris Gregory and Tim Bayley

PROJECT: Proposed Near West Tailing Storage Facility, Resolution Copper

SUBJECT: Estimated Preliminary Allowable Seepage from TSF Alternative Sites for Comparative Analysis

Introduction

Montgomery and Associates (M&A) has prepared this technical memorandum to document a preliminary analysis of allowable seepage from the tailings storage facility (TSF) alternatives currently being considered by Resolution Copper (RC). The analysis covers life of mine (LOM) and post-closure periods to a reasonable predictive duration of 245 years after the start of mining. The five TSF alternatives considered in this analysis are listed below:

- Alternative 2: Near West Modified Proposed Action (Modified Centerline Embankment – "Wet")
- Alternative 3: Near West Modified Proposed Action (High-density Thickened NPAG Scavenger Tailings and Segregated PAG Pyrite Tailings Cell – "Dry")
- Alternative 4: Silver King Filtered
- Alternative 5: Peg Leg
- Alternative 6: Skunk Camp

The analysis was conducted using seepage transport models previously developed with Goldsim's Contaminant Transport module (M&A, 2018a-d). The seepage transport models simulate conservatively over-predicted transport of chemical constituents from the locations of the proposed TSF alternatives to downgradient aquifers, creeks, and rivers. The models are useful predictive tools for comparative analysis of the TSF alternatives with regards to degree of Best Available Demonstrated Control Technology (BADCT) and seepage control measures possibly needed to meet regulatory compliance, but include many simplifications and assumptions; therefore, model results should be regarded as preliminary estimates for the purpose of alternative comparisons.

It is important to note that the GoldSim modeling provides a basis for comparison among the alternatives, but may not be adequate for water quality permitting. The TSF will be required to obtain an Aquifer Protection Permit (APP) from the Arizona Department of Environmental Quality. By regulation, every permitted facility must utilize Best Available Demonstrated Control Technology (BADCT) and demonstrate that Aquifer Water Quality Standards (AWQS) will not be exceeded in the aquifer at the point of compliance as a result of discharge from the facility. Although these requirements are currently being addressed by the GoldSim model for comparative analysis, modeled impacts will be refined by the final EIS after a final TSF and optimized design is selected.

The objective of this analysis is to develop preliminary estimates of allowable seepage rates from the TSF alternative sites. The results of the analysis are expected to demonstrate the environmental sensitivity of each alternative location and provide a basis for assessing the ease of meeting the allowable seepage rates for different TSF alternative designs.

Methods

The chemistry of tailings seepage was estimated using a combination of tailings circuit solute models (Enchemica, 2018a-d) and embankment chemistry models (Rio Tinto, 2018) for LOM and post-closure periods.

The analysis was conducted by adjusting the TSF seepage rates used in the Goldsim seepage transport models for each alternative. The model results were compared to applicable water quality standards at downgradient groundwater and surface water monitoring locations. Allowable seepage rates were determined for the first two chemical constituents with the lowest threshold compared to applicable water quality standards at each location.

For downgradient groundwater monitoring locations, preliminary allowable seepage rates were determined based on the available assimilative capacity between background concentrations and Arizona Department of Environmental Quality (ADEQ) Numeric Aquifer Water Quality Standards (Arizona Administrative Code - Title 18, Ch. 11, Art. 4, Sup. 16-4, 2016). Background concentrations were assigned based on laboratory results of water quality samples collected from wells downstream or in the vicinity of the TSF footprints.

For downgradient surface water monitoring locations, preliminary allowable seepage values were determined based on half of the available assimilative capacities between background water quality concentrations and ADEQ Water Quality Standards for "Aquatic and wildlife warm" (A&ww) water with chronic exposure (Arizona Administrative Code - Title 18, Ch. 11, Sup. 16-4, 2016), which is considered the applicable surface water standard category at both Whitlow Ranch Dam and along the Gila River. Application of

ADEQ surface water standards may be revised following RC's APP pre-application with ADEQ and selection of a TSF site and refined design by the final EIS. Results

The results from the analysis are shown in **Table 1**. For each TSF alternative, the first two constituents to exceed water quality standards at the groundwater and surface water monitoring locations are identified. The most stringent (lowest) allowable seepage rate for each alternative is highlighted in blue.

The results indicate that during the first 245 years after the start of mining, the preliminary allowable seepage rate varies from 3 acre-feet per year (af/yr) for Alternatives 2 and 3 to 329 af/yr for Alternative 6. For Alternatives 2, 3, 4 and 6, allowable seepage is driven by aquifer standards, while for Alternative 5, allowable seepage is driven by surface water standards. In all cases, selenium is the threshold constituent for all TSF alternatives for comparative analysis of groundwater and surface water monitoring locations. The preliminary estimates of allowable seepage presented in this analysis may not be definitive and remain subject to change.

While this analysis provides a tool for preliminary comparison between alternative TSFs, once a final alternative has been selected analysis of allowable seepage will be updated based on additional baseline information, site characterization, understanding of applicable ADEQ regulations, refined engineering designs, and refined hydrogeologic modeling consistent with ADEQ requirements under the APP program.

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References

Enchemica, LLC, 2018a, Alternative 7 – Peg Leg Optimized: Prediction of Tailings Circuit Solute Chemistry: Technical Memorandum Draft prepared for Resolution Copper Mining LLC, June 16, 2018.

_____, 2018b, Near West Alternative 2 - Prediction of Tailings Circuit Solute Chemistry: Technical Memorandum Draft prepared for Resolution Copper Mining LLC, July, 2018.

_____, 2018c, Near West Alternative 3 - Prediction of Tailings Circuit Solute Chemistry: Technical Memorandum Draft prepared for Resolution Copper Mining LLC, July, 2018.

_____, 2018d, Silver King Alternative 4 - Prediction of Tailings Circuit Solute Chemistry: Technical Memorandum Draft prepared for Resolution Copper Mining LLC, July, 2018.

Montgomery & Associates, 2018, TSF Alternatives 2 and 3 - Near West: Life of Mine and Post-Closure Seepage Transport Modeling: Technical Memorandum prepared for Resolution Copper Mining LLC, September 14, 2018.

_____, 2018b, TSF Alternative 4 - Silver King: Life of Mine and Post-Closure Seepage Transport Modeling: Technical Memorandum prepared for Resolution Copper Mining LLC, September 14, 2018.

_____, 2018c, TSF Alternative 5 - Peg Leg: Life of Mine and Post-Closure Seepage Transport Modeling: Technical Memorandum prepared for Resolution Copper Mining LLC, September 14, 2018.

_____, 2018d, TSF Alternative 6 - Skunk Camp: Life of Mine and Post-Closure Seepage Transport Modeling: Technical Memorandum prepared for Resolution Copper Mining LLC, September 14, 2018.

Rio Tinto, 2018, Prediction of Tailings Seepage Water Chemistry Influenced by Tailings Weathering Processes: Technical Memorandum Draft prepared for Resolution Copper Mining LLC, July 29, 2018.

Table 1. Preliminary Estimates of Allowable Uncollected TSF Seepage: Years 0 - 245 after Start of Mine [1,2]

Limiting Constituent	Alternative 2 Near West (af/yr[3])		Alternative 3 Near West (af/yr)		Alternative 4 Silver King (af/yr)		Alternative 5 Peg Leg (af/yr)		Alternative 6 Skunk Camp (af/yr)	
	Groundwater	Surface Water	Groundwater	Surface Water	Groundwater	Surface Water	Groundwater	Surface Water	Groundwater	Surface Water
First	160 (Se)	3 (Se)	133 (Se)	3 (Se)	146 (Se)	6 (Se)	261 (Se)	370 (Se)	413 (Se)	329 (Se)
Second	413 (Cd)	66 (Cu)	394 (Tl)	71 (Cu)	270 (Sb)	83 (Zn)	355 (Ni)	682 (Cu)	873 (Tl)	1643 (Cu)

Notes:

[1] Allowable groundwater seepage assumes groundwater concentrations at downgradient aquifer monitoring location will not exceed Arizona Department of Environmental Quality Numeric Aquifer Water Quality Standards (Arizona Administrative Code - Title 18, Ch. 11, Art. 4, Sup. 16-4, 2016)

[2] Allowable surface water seepage assumes surface water concentrations at downgradient surface water monitoring location will not exceed half of available concentration between current background concentrations and Arizona Department of Environmental Quality Water Quality Standard for "Aquatic and wildlife warm" (A&ww) water with chronic exposure (Arizona Administrative Code - Title 18, Ch. 11, Sup. 16-4, 2016)

[3] af/yr = acre-feet per year

Estimated threshold preliminary allowable seepage to comply with Arizona Department of Environmental Quality (ADEQ) water quality standards

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December 21, 2018

Ms. Mary Rasmussen
US Forest Service
Supervisor's Office
2324 East McDowell Road
Phoenix, AZ 85006-2496

Subject: Response to Actions from November 13, 2018 Geochemistry Meeting

Dear Ms. Rasmussen,

In response to the action items from the Geochemistry meeting held on November 13, 2018 please find attached the following for your review and consideration:

- USFS Request: Sensitivity for seepage / back of envelope calculation
  - *RC Response: See Attachment 1 – Seepage Analysis by KCB*

- USFS Request: Calculate for each site the capacity of allowable seepage and assess the ability to meet that seepage rate at each site.
  - *RC Response: See Attachment 2 – M&A, December 2018 Technical Memorandum "Estimated Preliminary Allowable Seepage from TSF Alternative Sites for Comparative Analysis."*
    - *Additional modeling is underway to assess additional design features and seepage controls needed to meet those rates*

- USFS Request: RCM to complete the SWCA draft graphics on full build out and post closure for each alternative
  - *RC Response: See Attachment 3 – RC comments on SWCA graphics are in yellow highlighted red text*
  - *Attachment 4 – Response Table addressing Mark Williamson review comments and updated reports for Alternatives 2 and 3:*
    - *M&A, December 2018 "Alternatives 2 and 3 Steady-State Modeling"*
    - *M&A, December 2018 "TSF Alternatives 2 and 3 – Near West: Life of Mine and Post-Closure Seepage Transport Modeling"*

- USFS Request: Annotate Kate's graphic with information on all alternatives
  - *RC Response: See Attachment 3*

- USFS Request: RCM to provide additional analog examples of PAG within NPAG sub-aqueously in desert environment if current memo is not enough after review
    - *RC Response: See Attachment 5 – Case Studies for Resolution TSF Technologies*

Sincerely,

Vicky Peacey,

Senior Manager, Environment, Permitting and Approvals; Resolution Copper Company, as Manager of Resolution Copper Mining, LLC

Cc: Ms. Mary Morissette; Senior Environmental Specialist; Resolution Copper Company

Enclosure(s):

Attachment 1 – Seepage Analysis by KCB
Attachment 2 – M&A, December 2018 Technical Memorandum "*Estimated Preliminary Allowable Seepage from TSF Alternative Sites for Comparative Analysis*."
Attachment 3 – RC comments on SWCA graphics (yellow highlighted red text)
Attachment 4 – M&A, December 2018 "*Alternatives 2 and 3 Steady-State Modeling*" and M&A, December 2018 "*TSF Alternatives 2 and 3 – Near West: Life of Mine and Post-Closure Seepage Transport Modeling.*"
Attachment 5 - Case Studies for Resolution TSF Technologies