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TECHNICAL MEMORANDUM

TO: Vicky Peacey, Resolution Copper

FROM: Ted Eary, Enchemica

DATE: July 18, 2018

SUBJECT: Common Inputs Common to All Operational Models of Tailings Circuit Solute Chemistry

1   INTRODUCTION

The draft environmental impact statement (DEIS) for the Resolution Copper mine includes assessment of the following tailings storage facility alternatives:

- Alternative 1: No Action
- Alternative 2: Near West Modified Proposed Action
- Alternative 3: Near West Modified Proposed Action – Thin Lift/Pag Cell
- Alternative 4: Silver King Filtered
- Alternative 5: Peg Leg
- Alternative 6: Skunk Camp

Water balance models have been created for Alternatives 2, 3, 4, and 6 by Klohn Crippen Berger (KCB). The Alternative 5 water balance model was developed by Golder Associates. These water balance models have been augmented by the addition of chemical balances for solutes, so that the models can be used to make predictions of water chemistries for the process water circuits for the operational period of the mine. The predictions of process circuit water chemistries include tailings pore water, reclaim ponds, water entering the West Plant, and seepages from tailings and storage ponds.

The chemical balance portions of the models share a set of common inputs for water chemistry. The purpose of this memo is to provide a description of those common inputs.

2   MODELING SEQUENCE

The sequence of models used for predicting water chemistries for the Resolution Project is shown Figure 2-1. The tailings circuit solute models discussed in this memo rely on data from the following models:

- Rates of groundwater flow into the block cave mining zones predicted by the WSP hydrologic model (WSP, 2018).
- Rates of water flow and water chemistry from the block cave geochemistry model to the West Plant where it will be used as makeup water for ore processing.

The tailings circuit solute models provide inputs to the following models:

- Embankment and Beaches Sulfide Oxidation Modeling: The predictions of the initial chemical compositions of pore water entrained in tailings in embankments and beaches are made with the

> tailings circuit solute models. The entrained water will be the initial water type that will drain to collection systems during operations and after closure.
- Seepage Transport Models: The predictions of the chemical compositions of lost seepages from deposited tailings and ponds for the mine operational period are made with the tailings circuit solute models. These predicted seepage chemical compositions represent the water that will initially exit the TSFs and enter transport paths after closure.

The initial tailings pore water and seepage chemistries will eventually evolve to different chemistries due to infiltration and drain-down and sulfide oxidation processes. The effects of sulfide oxidation on tailings pore water and seepage chemistry during mine operations and after closure are described in RT G&I (2018).
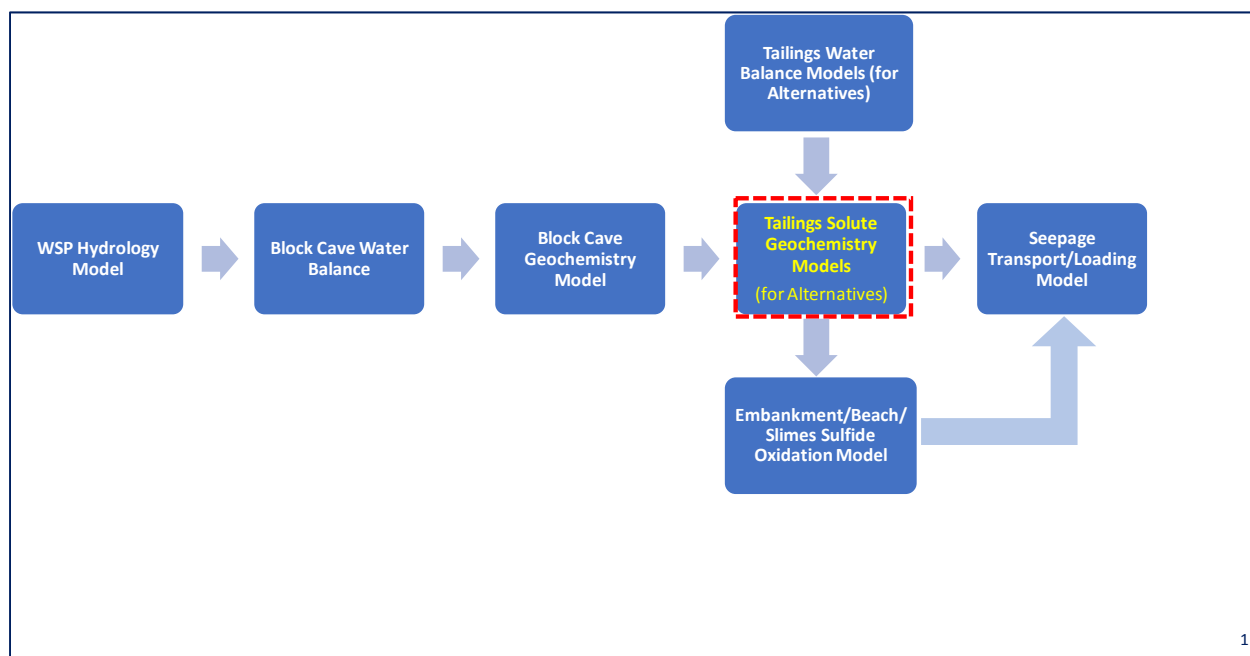

Figure 2-1. Modeling sequence for prediction of water chemistry during mining operations

3 COMMON INPUTS

Each source of water or chemical loading that will enter the process water circuit is assigned a chemical composition. These chemical compositions are the primary inputs to the tailings circuit solute models. In GoldSim, solute transport is expressed as chemical loads (mass/time); hence, the models are based on the water balances such that the input chemical compositions are multiplied by flow rates to calculate chemical loads being transported through the TSF water circuits. At points of mixing or storage, such as reclaim ponds or the West Plant, the chemical loads are converted to concentrations based on the storage volumes. PHREEQC is used to equilibrate the chemical concentrations at key mixing points. The equilibrated water chemistries are then converted back to chemical loads for transport to the next point in the circuit.

3.1 Water from the Block Cave Mine

Excess water from the block cave will be used for makeup water for ore processing. Enchemica (2018) provides a description of the model developed to predict flow rates and chemical compositions for block cave water.

3.1.1   Flow Rates

Flows from the block cave were split into two types in Enchemica (2018) because they have different chemical compositions. These two flows are:

- Ore moisture – water contained in ore is expressed as an equivalent flow rate based on the rate of ore production and gravimetric water content of 4%.
- Sump water – mixture of groundwater, excess mine service water, and blowdown water from cooling systems that will be pumped from underground sumps.

The predicted flow rates for ore moisture, sump water, and total water are shown in Figure 3-1.

An important distinction between ore moisture and sump water is that ore moisture will comprise a fraction of makeup water for all TSF alternatives because it cannot be separated from the ore entering the West Plant. The chemical composition of ore moisture will be affected by oxidation and leaching of sulfide minerals in the block cave and ore stockpile (Enchemica, 2018). The solute content of ore moisture is one of the largest chemical loads affecting the solute balances for all TSF alternatives.

A portion or all of sump water may be used for makeup for ore processing. The chemical composition is expected to be circumneutral pH but with elevated TDS due to the addition of cooling blowdown water (Enchemica, 2018).
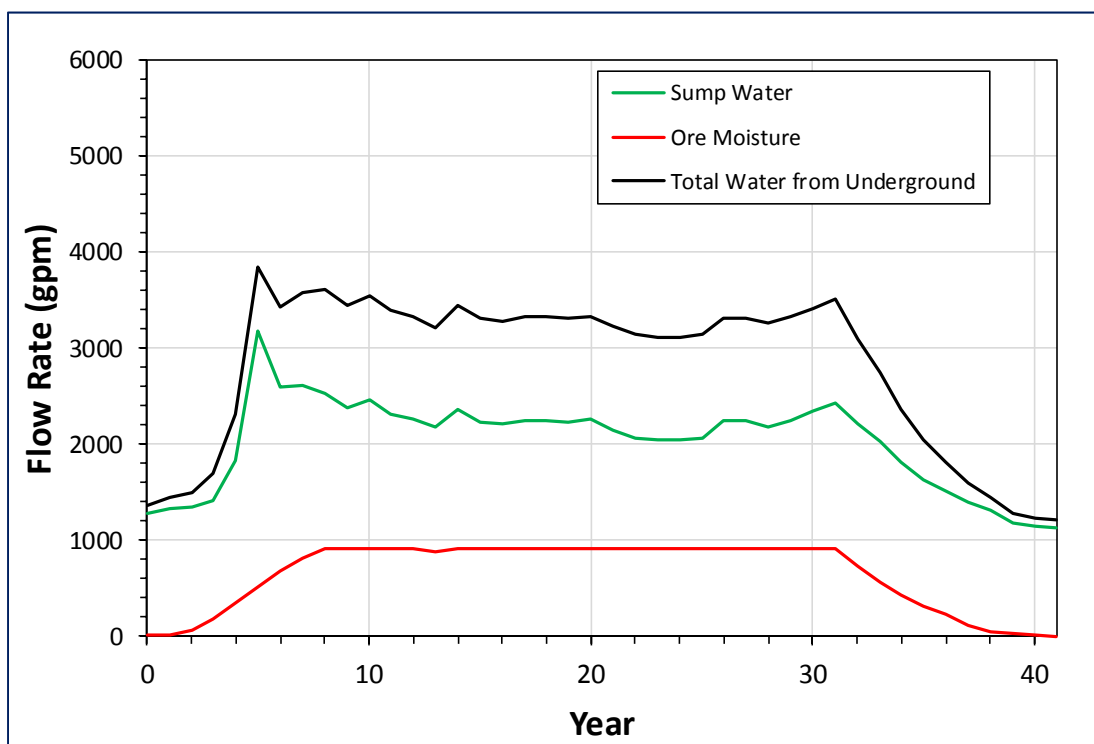

Figure 3-1. Predicted flows from the block cave for use as makeup water for ore processing

3.1.2   Water Chemistry

The chemical compositions for ore moisture and sump water are taken directly from Enchemica (2018). Examples outputs of time trends for pH and TDS are shown in Figure 3-2 and divalent metals in Figure 3-3. The sump water is predicted to be neutral and TDS from 1100 to 1700 mg/L in comparison to the ore moisture that is predicted to be acidic with high TDS (Figure 3-2). The ore moisture is also predicted to contain much higher metal concentrations than the sump water (Figure 3-3). The chemical compositions for ore moisture and sump water are used to represent makeup to ore processing for all TSF alternatives.
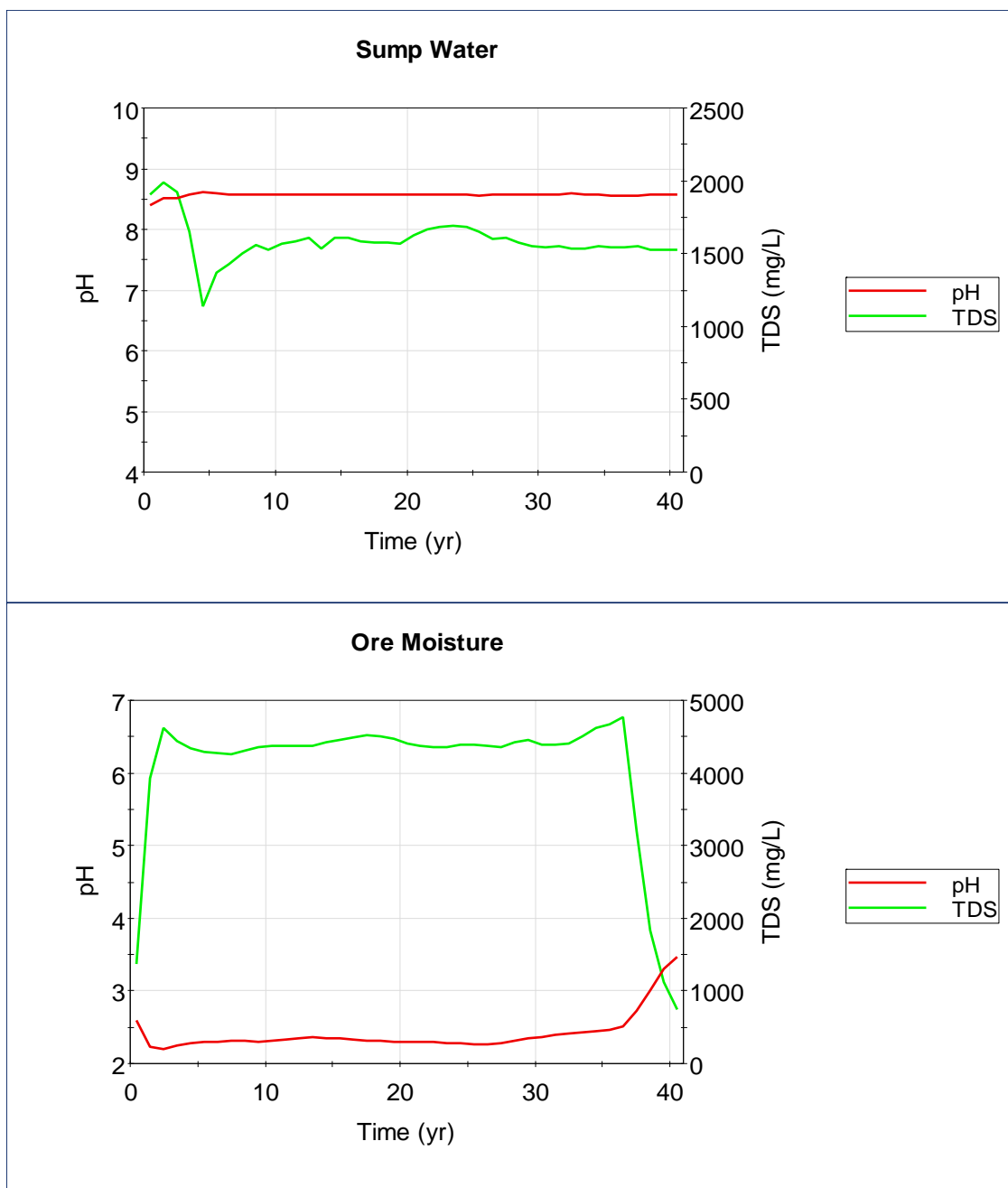

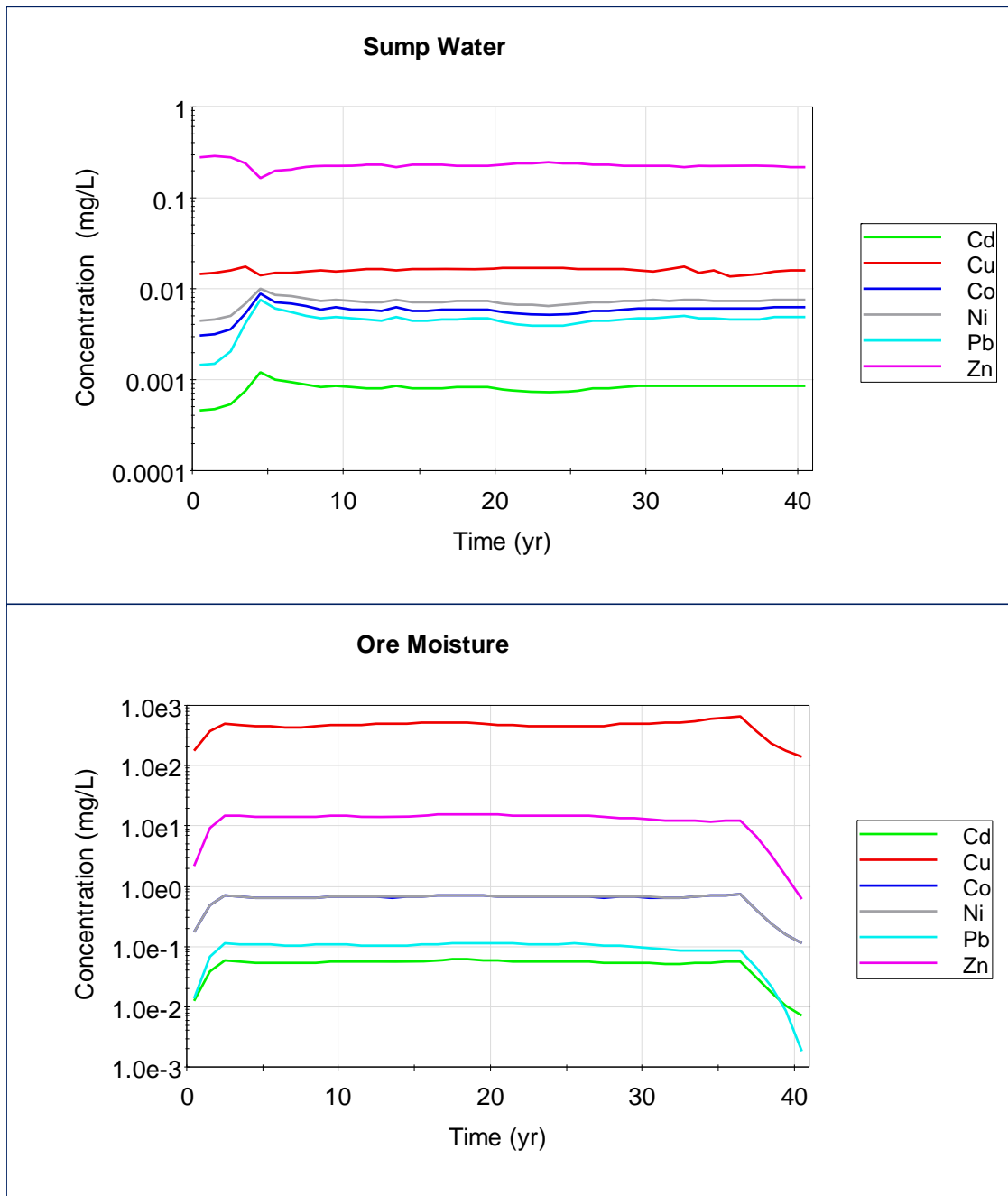**Figure 3-2. Predictions for pH and TDS for water from the block cave (Enchemica, 2018)**

Figure 3-3. Predictions for divalent metals for water from the block cave (Enchemica, 2018)

3.2   TSF Chemical Inputs from External Sources

The chemical compositions of all external water types that transport chemical loads into the tailings circuits for all TSF alternatives are described in the following sections.

3.2.1   Freshwater Makeup

The primary sources of renewable makeup water are the Central Arizona Project (CAP) canal and banked Recovery Wells. Based on guidance from Resolution Copper, 25% of makeup water is expected to be obtained from the CAP canal and 75% from the Recovery Wells.   The chemical composition for the 25%, 75% mixture was used to represent freshwater makeup for these alternatives.

3.2.1.1   CAP Water

The chemistry of the CAP canal water used in the model is from an analysis of a sample collected in March 2018 (**Error! Reference source not found.**Table 4-1). Table 3-1 gives the chemical composition for the average CAP canal water.

3.2.1.2   Recovery Well Water

The chemical composition for the Recovery Wells in the model is based on data from the 2016 water quality report for Superior, Arizona obtained from the Arizona Water Company (AZ, 2016) (**Error! Reference source not found.**Table 4-1). The report contained concentrations for As, Ba, Cr, Cu, Pb, F, NO_3, Cl, and Na. Concentrations for all other unreported parameters were assumed to be to be same as CAP water.

3.2.1.3   Mixture

The chemical composition for the mixture of 25% CAP canal and 75% from the Recovery Wells is given in Table 3-1. This chemical composition was obtained using the solution mixing function in PHREEQC (Parkhurst and Appelo, 2013) with the ionic charges balance by adjustment of the SO_4 concentration and assuming equilibrium with atmospheric O_2 and CO_2.

Table 3-1. Chemical compositions for freshwater makeup

Parameter	CAP Water	Recovery Well Water	Mixture (25% CAP + 75% Recovery Well)
Ca (mg/L)	74	74**	74
Mg (mg/L)	26	26**	26
Na (mg/L)	94	74	79
K (mg/L)	4.9	4.9**	4.9
Cl (mg/L)	98	98**	98
HCO_3 (mg/L)	130	130**	139
SO_4 (mg/L)	250	250**	189‡
Si (mg/L)	2.7	5.2**	2.7
F (mg/L)	0.4[†]	0.4	0.4
NO_3-N (mg/L)	0.28	1.4	1.12
Al (mg/L)	0.013*	0.05	0.013
Sb (mg/L)	0.00002*	0.00002**	0.00002
As (mg/L)	0.002	0.0076‡	0.006
Ba (mg/L)	0.13	0.01	0.040
Be (mg/L)	0.0001*	0.0001**	0.00010004
B (mg/L)	0.13	0.13**	0.13
Cd (mg/L)	0.00001*	0.00002**	0.00002
Cr (mg/L)	0.00022*	0.004	0.003
Co (mg/L)	0.00003*	0.00003**	0.00003
Cu (mg/L)	0.001	0.05††	0.038
Fe (mg/L)	0.0055*	0.055**	0.043
Pb (mg/L)	0.0001*	0.0025††	0.0019
Mn (mg/L)	0.0004*	0.0004*	0.00040027
Mo (mg/L)	0.0004*	0.0004**	0.00040027
Ni (mg/L)	0.00092	0.00092**	0.00092031
Se (mg/L)	0.0017	0.0017**	0.0017
Ag (mg/L)	0.000006*	0.000006**	0.000006
Tl (mg/L)	0.000007*	0.0000065**	0.000007
Zn (mg/L)	0.00165*	0.00165**	0.00165
pH (s.u.)	8.5	8.5	8.5
TDS (mg/L)	592***	530***	544**

*One-half of the analytical detection level
**Not analyzed, assumed the same as CAP
***TDS = Ca + Mg + Na + K + Cl + SO_4 + 0.4917*HCO_3 + SiO_2 + F + Al + Fe + Mn + Ba + Co + Ni + Cu + Zn (Hem, 1989)
†Not analyzed, assumed the same as Recovery Well wáter
††One-half of reported 90th percentile concentration
‡Average of mínimum and máximum of reported range
‡‡SO4 used to charge-balance solutions

3.2.2   Precipitation

The chemistry of precipitation was obtained from the National Atmospheric Deposition Program for Site AZ99 (Oliver Knoll) (http://nadp.sws.uiuc.edu/data/ntndata.aspx) as the average of 5 years of mean annual concentrations (Table 3-2). This average was used to represent precipitation chemistry for all TSF alternatives.

3.2.3   Natural Catchment Surface Water Runoff

The chemical composition of natural catchment surface runoff was determined from the average of three samples collected during a rainstorm in February 15, 2018 in an area above the location of the Near West

TSF. The average was calculated by equal mixing of the analytical results for the three samples in PHREEQC (Parkhurst and Appelo, 2013), with ionic charges balance by adjustment of the HCO_3 concentration, and assuming equilibrium with atmospheric O_2 and CO_2 (Table 3-2). This average was used to represent the chemical composition of natural catchment surface runoff for all TSF alternatives.

3.2.4   Groundwater

The water balances have input terms for groundwater flow to the TSFs. The chemical composition of groundwater is represented by analytical data from a well sample completed in the Pinal Schist (Table 3-2).

Table 3-2. Chemical compositions for precipitation, natural catchment surface water runoff, and groundwater

Parameter	Precipitation	Natural catchment surface water runoff	Pinal Schist Well DS16-06
Ca (mg/L)	1.53	10	124
Mg (mg/L)	0.0222	3.9	47
Na (mg/L)	0.0706	2.5	129
K (mg/L)	0.0234	3.9	3.3
Cl (mg/L)	0.12	2.4	82.6
HCO_3 (mg/L)	0	35.7	397
SO_4 (mg/L)	0.684	6.8	320
Si (mg/L)	0	6.6	44.1
F (mg/L)	0	0.13	0.62
NO_3-N (mg/L)	0.963	3.1	2.47
Al (mg/L)	0	0.05	0.400
Sb (mg/L)	0	0.00027	0.0008
As (mg/L)	0	0.0052	0.0015
Ba (mg/L)	0	0.0128	0.0198
Be (mg/L)	0	0.0005	0.0005
B (mg/L)	0	0.030	0.088
Cd (mg/L)	0	0.000019	0.000025
Cr (mg/L)	0	0.00095	0.00075
Co (mg/L)	0	0.00065	0.0005
Cu (mg/L)	0	0.012	0.0010
Fe (mg/L)	0	0.0225	0.395
Pb (mg/L)	0	0.0001	0.00089
Mn (mg/L)	0	0.017	0.0227
Mo (mg/L)	0	0.0015	0.0015
Ni (mg/L)	0	0.0013	0.0013
Se (mg/L)	0	0.00027	0.0028
Ag (mg/L)	0	0.000018	0.000018
Tl (mg/L)	0	0.000015	0.000015
Zn (mg/L)	0	0.0015	0.011
pH (s.u.)	4.57	7.59	6.94

3.3   TSF Chemical Inputs from Internal Sources

Internal sources of solutes that generate chemical loads in the TSF water circuits include embankment runoff, embankment seepage, and ore processing. The inputs for these sources are described below.

3.3.1   Embankment Runoff

The TSF alternatives 2, 3, 5, and 6 have embankments constructed of compacted scavenger tailings that have been thickened or cycloned to concentrate the sand portion with pyrite tailings placed in water to prevent oxidation. Alternative 4 at Silver King will involve stacking of filtered scavenger and pyrite tailings in separate facilities. The approach used to represent runoff chemistry from scavenger tailings and pyrite tailings are described in the following sections.

3.3.1.1   Scavenger Tailings Runoff

Scavenger tailings will be low in sulfide-sulfur content due to the separation of sulfide minerals into pyrite tailings during ore processing. About 84% of total tailings are predicted to be scavenger tailings. Acid base accounting data for scavenger tailings indicate a range from 0.01 to 1.09% sulfide sulfur content with a lognormal distribution (Duke, 2016). The geometric mean is 0.07% sulfide sulfur with 80% of samples containing less than 0.2% sulfide sulfur (Duke, 2016).

Humidity cell tests were conducted on 12 samples of scavenger tailings that represent the major ore lithologies (Duke, 2016) (Table 3-3). The leachates from the first three weeks (weeks 0, 1, and 2) of the HCTs were mixed in equal proportions with PHREEQC (Parkhurst and Appelo, 2013) to get an average leachate composition from each HCT. The average leachates were mixed again according to the lumped major ore lithologies given in Table 3-3 to obtain a leachate composition for each major lithology. Then, to represent scavenger tailings overall, the leachate compositions were combined according to the percentages of each major ore lithology given in the right-hand column in Table 3-3. All mixing calculations were made with PHREEQC, assuming equilibrium with atmospheric O_2 and CO_2, and with adjustment of SO_4 concentrations by PHREEQC to achieve ionic charge balances.   The resulting chemical composition for embankment and beach runoff for scavenger tailings is given in Table 3-4. The weighted average sulfide content for composite leachate chemistry developed by this approach is 0.15%.

Table 3-3. HCT samples and lithologies

HCT Sample	Acid Generation Potential	Sulfide-S (%)	HCT Lithologies	Lumped Major Lithologies	Projected Percent of Major Ore Lithology*
MC-1 LCT 23 (Hole 27C)	Uncertain	0.09	Kvs	KVS	9.2%
MC-1 LCT 35 (Hole 29A)	PAG	1.15	Kvs; Kqs		
MC-1 LCT 24 (Hole 29B)	PAG	0.36	Kvs		
MC-3 LCT 27 (Hole 27C)	NPAG	0.07	Breccia	Diabase	53.3%
MC-2 LCT 37 (Hole 29A)	PAG	0.37	pCbas; pCdiab		
MC-3 LCT 38 (Hole 29A)	NPAG	0.2	Breccia		
MC-5 LCT 42 (Hole 29A)	NPAG	0.06	pCDiab		
MC-3 LCT 28 (Hole 29B)	NPAG	0.04	pCDiab		
MC-7 LCT 46 (Hole 29A)	NPAG	0.02	Breccia; QEP	QEP	14.2%
LCT-4 Comb Py Sc Tls (Hole 31)	Uncertain	0.06	QEP; Kvs		
MC-4 LCT 30 (Hole 29B)	NPAG	0.01	Quartzite; pCDiab	Quartzite	16.3%
LCT-6 Comb Py Sc Tls (Hole 31)	NPAG	0.13	pCdiab; pCmls; Quartzite	Dm+Skn	7.0%

*Projected percentages from the 2016 block model

3.3.1.2   Pyrite Tailings Runoff

Pyrite tailings are expected to comprise about 16% of total tailings. Samples of pyrite tailings described in Duke (2016) have sulfide-sulfur contents from 12.4 to 22.9%. Pyrite tailings are fast to react and produce highly acidic leachates according to results from field barrel tests (Golder, 2013). Silver King, Alternative 4 is the only alternative where pyrite tailings will be placed in direct contact with air and water, such that runoff from exposed pyrite tailings can be expected to be affected by sulfide oxidation and metal leaching. The other alternatives include deposition of pyrite tailings underwater to prevent oxidation.

The results of a field barrel test conducted with a sample of filter cake pyrite tailings (Barrel #3 in Golder, 2013) were used to create a leachate chemical composition to represent runoff from pyrite tailings for Alternative 4. The Barrel #3 test yielded three leachate samples with relatively complete analyte concentrations. These three samples were mixed in equal proportions to obtain an average chemical composition using the mixing function in PHREEQC (Parkhurst and Appelo, 2013) with sulfate concentrations adjusted to produce an ionic charge balance. Equilibrium with atmospheric O_2 and CO_2 was assumed for these mixing calculations.

Barrel #3 was not artificially irrigated so that leachates were generated only by incident precipitation. As a result, the leachate volumes were low and not all analyte concentrations could be determined. Concentrations for the missing analytes were estimated by using the maximum concentrations measured in the Barrel #1 field test (paste pyrite tailings). The resulting leachate chemistry is given in Table 3-4.

Table 3-4. Chemical compositions for tailings runoff water

Parameter	Scavenger Tailings Runoff	Pyrite Tailings Runoff
Ca (mg/L)	70.9	562.5
Mg (mg/L)	11.2	1213
Na (mg/L)	4.4	7.3*
K (mg/L)	10.1	7.8
Cl (mg/L)	0	20.8*
HCO$_3$ (mg/L)	1.4	0
SO$_4$ (mg/L)	264	28452
Si (mg/L)	2.4	66.9
F (mg/L)	0	424.6
NO$_3$-N (mg/L)	0	0
Al (mg/L)	3.44	1383.7
Sb (mg/L)	0.00073	0.00062
As (mg/L)	0.00016	0.576*
Ba (mg/L)	0.0128	0.208
Be (mg/L)	0.0022	0.192
B (mg/L)	0.0028	0.104
Cd (mg/L)	0.00097	0.106
Cr (mg/L)	0.00036	9.107
Co (mg/L)	0.059	14.6
Cu (mg/L)	9.81	3294
Fe (mg/L)	0.177	5353.8
Pb (mg/L)	0.00026	0.0095
Mn (mg/L)	0.693	43.0
Mo (mg/L)	0.0182	0.728*
Ni (mg/L)	0.112	26.39
Se (mg/L)	0.0088	0.322
Ag (mg/L)	0.000006	1.78
Tl (mg/L)	0.00008	0.0177
Zn (mg/L)	0.171	17.29
pH (s.u.)	5.48	2.13

*Estimated from maximum concentrations measured in Barrel #1

3.3.2   Embankment Seepage

Results from sulfide oxidation and transport modeling of embankment tailings indicates that oxidation fronts and reaction products are unlikely to affect the chemical composition of seepages entering collection ponds during mine operation (41 years) due to very slow infiltration rates (RT G&I, 2018). During the period of mine operation, embankment seepage chemistry is expected to be dominated by process water deposited with tailings slurries.

3.3.3   Chemical Releases during Ore Processing

Two lock-cycle hydrometallurgical tests were conducted to determine rates of chemical releases occurring during ore processing. The results from those two tests were averaged to obtain values for inputs to the TSF solute models (Table 3-5). The release rates are applied as a chemical load to the water portion of tailings slurry as a function of the kg of ore processed.

Table 3-5. Chemical release rates during ore processing

Parameter	Release Rate mg/kg ore
Ca	36.13
Mg	0*
Na	4.60
K	35.08
Cl	11.98
HCO_3	0*
SO_4	0*
Si	1.67
F	1.93
NO_3-N	0.21
Al	0.17
Sb	0.0003
As	0*
Ba	0.15
Be	0*
B	0.02
Cd	0*
Cr	0.001
Co	0*
Cu	0.03
Fe	0*
Pb	0*
Mn	0*
Mo	0.15
Ni	0*
Se	0.013
Ag	0*
Tl	0.0001
Zn	0*
NH4-N	0.02
pH	0*

*Concentrations for these parameters decreased during testing indicating possible retention rather than releases. Their release rates were set to 0 mg/kg.

3.4   Chemical Equilibria

The processes of solution mixing and evaporation result in conditions of oversaturation with some secondary minerals in the TSF solute models. The TSF solute models contain functions to equilibrate the solutions with secondary solids expected to form under the expected conditions. The effects of solubility equilibration are made with the equilibrium phases function in PHREEQC (Parkhurst and Appelo, 2013).

Table 3-6Table 3-6 gives the list of solubility controls used in the models. A different set of secondary minerals was used for the Pyrite Pond for Alternative 4 because of the acidic and high sulfate concentrations that are predicted to occur for that system due to runoff from exposed pyrite tailings.

Surface adsorption was included in the PHREEQC calculations of solution equilibria only for the West Plant where acidic ore moisture water is mixed with alkaline water from other water sources. The dissolved Fe in the ore moisture will precipitate at $Fe(OH)_3$ due to neutralization of the pH, creating new surfaces for ion adsorption. Adsorption was not included in the PHREEQC calculations for other mixing points because solutions at these locations are neutral to alkaline in pH and not expected to have high enough dissolved Fe to produce appreciable $Fe(OH)_3$.

Table 3-6. Parameters used for equilibrium chemical processes simulated with PHREEQC

Parameter	Alternatives 2, 3, 5, and 6	Alternative 4 (Pyrite Pond)
Temperature	30°C	30°C
Partial pressure $O_2(g)$ Partial pressure $CO_2(g)$	$10^{-0.7}$ atm (constant) $10^{-3.5}$ atm (upper limit)	$10^{-0.7}$ atm (constant) $10^{-3.5}$ atm (upper limit)
Secondary minerals specified as solubility controls (Only allowed to precipitate if oversaturation conditions exist)	Malachite, $Cu_2(OH)_2CO_3$ $Al(OH)_3$(am) Alunite, $KAl_3(SO_4)_2(OH)_6$ Barite, $BaSO_4$ $Be(OH)_2$(am) Calcite, $CaCO_3$ Chalcedony, SiO_2 Ferrihydrite, $Fe(OH)_{3(a)}$ Fluorite, CaF_2 Gypsum, $CaSO_4 \cdot 2H_2O$ Calcite, $CaCO_3$ Rhodochrosite(d), $MnCO_3$	Anglesite, $PbSO_4$ Antlerite, $Cu_3(OH)_4SO_4$ Brochantite, $Cu_4(OH)_6SO_4$ Langite, $Cu_4(OH)_6SO_4{:}H_2O$ Cerargyrite, $AgCl$ $Cu(OH)_2$ $Al(OH)_3$(am) Alunite, $KAl_3(SO_4)_2(OH)_6$ Barite, $BaSO_4$ Celestite, $SrSO_4$ $Be(OH)_2$(am) Chalcedony, SiO_2 Ferrihydrite, $Fe(OH)_{3(a)}$ Melanterite, $FeSO_4{:}7H_2O$ Fluorite, CaF_2 Gypsum, $CaSO_4 \cdot 2H_2O$ Calcite, $CaCO_3$ Manganite, $MnOOH$ Goslarite, $ZnSO_4{:}7H_2O$ ZnO(a)
Adsorption/Desorption (applied only to solution mixing at the West Plant; not applied to mixing in tailings ponds)	Surface Adsorption (mass determined from simulated amount of precipitant formed at each time step due to iron sulfide oxidation; surface area equal to 600 m^2/g; molecular weight of 89 g/mol) Hfo_wOH (week binding sites) 0.2 bindings sites (mol/mol Fe) Hfo_sOH (strong binding sites) 0.005 bindings sites (mol/mol Fe)	None

4   REFERENCES

Duke (2016) Geochemical Characterization of Resolution Tailings Update: 2014 – 2016. Final Report prepared for Resolution Copper Mining; prepared by Duke Hydrochem, June 8, 2016.

Enchemica (2018) Block Cave Geochemical Model – 2018 Update on Calculation Approach and Results. Technical Memo from T. Eary (Enchemica) to V. Peacey (Resolution Copper), June 26, 2018.

Golder (2013) Field Testing Program: Resolution Copper Project – 2012-2013 Geochemical Annual Evaluation and Final Assessment. Final Report (073-92548-01.005) prepared for Resolution Copper; prepared by Golder Associates, April 2013.

Parkhurst, D.L. and Appelo, C.A.J. (2013) Description of Input and Examples for PHREEQC Version 3 – A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations. U.S. Geological Survey Techniques and Methods, Book 6, Chapter A43, 497 p, available only at http://pubs.usgs.gov/tm/06/a43.

Rio Tinto Growth & Innovation 2018. Prediction of seepage water chemistry influenced by tailings weathering processes. Technical Memorandum to: Victoria Peacey (RCML) from: Matt Wickham (RT G&I).

RESOLUTION
C O P P E R

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Tel.: 520.689.9374
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July 20, 2018

Ms. Mary Rasmussen
US Forest Service
Supervisor's Office
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Subject: Response to Analysis Data Request #1 – Request for Analysis of Tailings Seepage – Item #2 Tailings Solute Modeling.

Dear Ms. Rasmussen,

In partial response to your letter dated March 8, 2018, the following documents are attached as requested:

2. **Tailings Solute Modeling**: It is our understanding that the water balance and geochemical modeling for tailings solute is being updated, specific to each alternative tailings storage facility, and including specific analysis of oxidation potential of the embankment. There is an expectation that modeling would cover both operational and post-closure time frames.

Request: RCM to provide USFS with block cave geochemical modeling.

RCM Response: As requested, please see the attached technical memorandums by Enchemica dated July 17, 2018 for the following tailing storage facilities (TSF):

- *Alternative 2 - Near West Modified Proposed Action: Prediction of Operational Tailings Circuit Solute Chemistry*
- *Alternative 3 - Near West Modified Proposed Action – Thin Lift/PAG Cell: Prediction of Operational Tailings Circuit Solute Chemistry*
- *Alternative 4 - Silver King Filtered: Prediction of Operational Tailings Circuit Solute Chemistry*
- *Alternative 5 - Peg Leg: Prediction of Operational Tailings Circuit Solute Chemistry*
- *Alternative 6 - Skunk Camp: Prediction of Operational Tailings Circuit Solute Chemistry*
- *Common Inputs Common to All Operational Models of Tailings Circuit Solute Chemistry*

Overall, there are no substantive differences in predictive solute chemistry for the alternative TSF sites with the exception of Alternative 4 (Silver King). The solute balances are useful tools for TSF

alternatives comparison, but it is also worth noting that the model likely over predicts solute chemistry due to several conservative assumptions:

1. No mitigations have been applied to the water chemistry
2. Water from the block cave mine, which has the poorest water quality and highest solute load, has first priority to meet the water demand at the West Plant (concentrator).
3. Makeup water needed at the end of the operational period are sourced from the Pyrite Pond and water from the block cave. The decrease in the amount of freshwater makeup results in less dilution of the combined effects of evaporation and inflow of chemical loads from the block cave.

Once a selected TSF has been identified, additional mitigation approaches may be incorporated as needed.

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)

Technical Memorandum by Enchemica (2018), *Alternative 2 - Near West Modified Proposed Action: Prediction of Operational Tailings Circuit Solute Chemistry*

Technical Memorandum by Enchemica (2018), *Alternative 3 - Near West Modified Proposed Action – Thin Lift/PAG Cell: Prediction of Operational Tailings Circuit Solute Chemistry*

Technical Memorandum by Enchemica (2018), *Alternative 4 - Silver King Filtered: Prediction of Operational Tailings Circuit Solute Chemistry*

Technical Memorandum by Enchemica (2018), *Alternative 5 - Peg Leg: Prediction of Operational Tailings Circuit Solute Chemistry*

Technical Memorandum by Enchemica (2018), *Alternative 6 - Skunk Camp: Prediction of Operational Tailings Circuit Solute Chemistry*

Technical Memorandum by Enchemica (2018), *Common Inputs Common to All Operational Models of Tailings Circuit Solute Chemistry*