



Tucson Office
3031 West Ina Road
Tucson, AZ 85741
Tel 520.297.7723 Fax 520.297.7724
www.tetrattech.com

Technical Memorandum

To:	Kathy Arnold	From:	Amy L. Hudson, REM
Company:	Rosemont Copper Company	Date:	November 23, 2010
Re:	Rosemont Infiltration, Seepage, Fate and Transport Response to Comments	Doc #:	268/10-320884-5.3
CC:	David Krizek. P.E.; Mark Williamson (Tetra Tech)		

1.0 Introduction

A technical review of the document titled *Infiltration, Seepage, Fate and Transport Modeling Report* (Tetra Tech, 2010a) prepared for Rosemont Copper Company (Rosemont) was presented in a Technical Memorandum prepared by SRK Consulting (SRK), dated April 30, 2010 (SRK, 2010). This technical review was conducted on behalf of the Coronado National Forest (CNF) and SWCA Environmental Consultants (SWCA) as part of the Environmental Impact Statement (EIS) process associated with the Rosemont Copper Project (Project).

Subsequent to the February report and SRK's comments (SRK, 2010), an updated version of the report was prepared titled *Infiltration, Seepage, Fate and Transport Modeling Report – Revision 1* (Tetra Tech, 2010b), dated August 2010. This Technical Memorandum presents responses to the specific comments by SRK and Tetra Tech's revisions included in the updated report.

The section numbers below correspond to the sections of the April 30, 2010 memo prepared by SRK (2010) and each issue raised is addressed separately. Questions/comments raised by SRK are italicized. SRK's review comments are provided in Attachment 1.

2.0 Infiltration and Seepage Modeling

The following sections present the responses to issues raised relating to the infiltration and seepage modeling portions of the report.

2.1 Input Data

This section addresses the issues raised regarding the climate data selected for the modeling and the saturated and unsaturated material properties.

2.1.1 Site Climate Data

1. *Why was the Nogales 6 N meteorological station chosen, when the Santa Rita station is closer to the site and is at a similar elevation to the site?*



In the Technical Memorandum titled *Rosemont Copper Design Storm Precipitation Data/Design Criteria* (Tetra Tech, 2009a), the average yearly rainfall of 17.37 inches, taken between the years 1952 and 2007 at the Nogales 6 N meteorological station, was selected for the Rosemont Project site based on the following:

- An on-site meteorological monitoring station was installed at the Project site in 2006. For the recorded years between 2006 and 2008, the average annual rainfall was 17.12 inches. This closely matched the average annual rainfall recorded at the Nogales 6 N station.
- The Nogales 6 N station is the closest meteorological station to the Project site that had recorded both precipitation and evaporation and had a large dataset (approximately 50 years). The next closest station having both data sets was the University of Arizona in Tucson. Selecting a station that provided both long-term rainfall and evaporation was deemed important for data consistency and correlation.
- The Santa Rita Experimental Range meteorological station, although closer to the Project site than the Nogales 6 N station, did not have evaporation data in addition to precipitation. Additionally, although precipitation was recorded at the Santa Rita station from 1950 to 2005, the calculated average annual precipitation of 22.19 inches was considered high. The average annual precipitation for the Rosemont area, estimated by Sellers (University of Arizona, 1977) for the period of 1931 to 1970, was approximately 16 inches. Also, based on available records from the Western Regional Climate Center (WRCC, 2009), the average annual precipitation for Helvetia, which was the closest recording station to Rosemont, was 19.72 inches for the period of 1916 to 1950.

2. *Provide more detail about the method used to extrapolate the Nogales 6 N pan evaporation data presented in Illustration 3.2 of the Appendix B memo. Explain the method used to translate the Nogales pan evaporation data to the Rosemont site (Section 4.1.4 of Appendix B memo).*

The average annual pan evaporation from both the University of Arizona and Nogales 6 N station were plotted against elevation with a straight line projection to the elevation of the existing Rosemont station. This projection gave an estimated average annual evaporation for the Project site of 71.52 inches. The monthly pan evaporation data set from the Nogales 6 N station was then compared to the Rosemont site based on this estimated average annual evaporation rate. In general, the limited pan evaporation measurements from the Rosemont meteorological station corroborated the Project data set.

No changes were made to the updated report (Tetra Tech, 2010b) with regard to the climate data.

3. *What method was used to determine the 7-day storm event used in the transient model evaluations?*

The data set used to represent the seven (7)-day storm event (worst case infiltration scenario) was a set of daily measurements for a storm that occurred from September 29 to

October 5, 1983. Additional text was added to the final paragraph of Section 5.5.1 of the updated report (Tetra Tech, 2010b) to provide information on the source of the multi-day and 24-hour, 100-year storm event data.

4. *Provide additional description of the temporal distribution of precipitation used in the modeling, and provide a hydrograph of the daily distribution.*

A hydrograph of the modeled daily precipitation distribution was added to Section 5.8.1 of the updated report (Tetra Tech, 2010b). In addition to the sinusoidal distribution pattern, the constant averaged and sloped averaged patterns were considered during the response to comments. It was determined that the sinusoidal pattern resulted in the most stable modeling calculations and that the other distribution patterns did not change the overall results. Further explanation of the distribution pattern, and why the sinusoidal distribution was chosen, was also added to Section 5.8.1 of the updated report.

2.1.2 Site Material-Soil Data

1. *Provide illustrations of the hydraulic conductivity and moisture content functions used in the modeling.*

Illustrations of the hydraulic conductivity and water content functions were added to the descriptions of input parameters provided in Sections 5.5.5.1 through 5.5.5.5 of the updated report (Tetra Tech, 2010b).

2. *In Section 5.5.5 of the report, provide more detail regarding the range of values and the source of the data used.*

Text was added to Sections 5.5.5.1 through 5.5.5.5 of the updated report (Tetra Tech, 2010b) to provide additional information related to the source of the data used and the ranges of values considered.

3. *For laboratory data, provide the laboratory name, the method used, and the resulting data set.*

Additional text was added to Sections 5.5.5.1 through 5.5.5.5 of the updated report (Tetra Tech, 2010b) to provide details of the laboratory data.

2.2 Heap Leach Facility Conceptual Model

1. *Consider the impacts of leaching the oxide material and its impact on the hydraulic conductivity and the use of a run of mine material property to model the heap.*

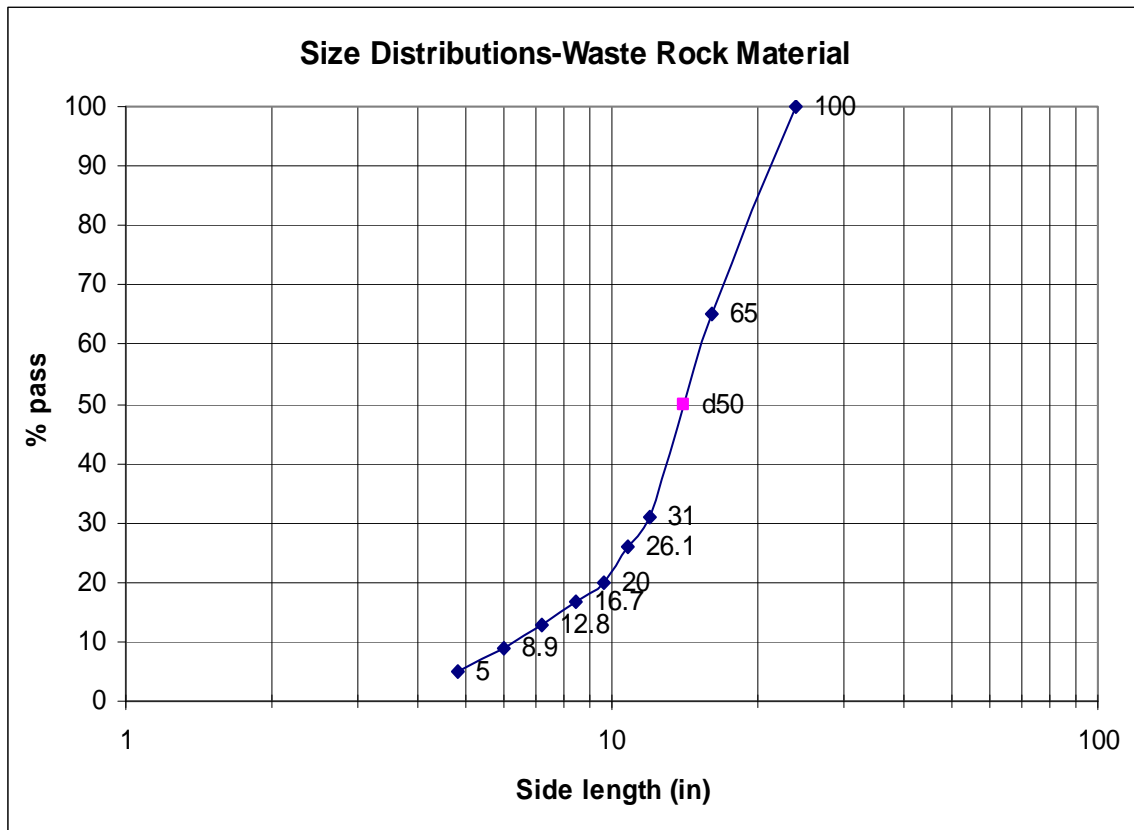
In May of 2009, the document titled *Rosemont Heap Leach Facility Permit Design Report* (Tetra Tech, 2009b) was submitted to the Arizona Department of Environmental Quality (ADEQ) as part of a submittal for the Aquifer Protection Permit (APP) application associated with the Rosemont Project. The design plans indicated two (2) pads, cumulatively able to accommodate



up to about 75 million tons (Mt) total: 40 Mt on the Phase 1 Pad and 35 MT on the Phase 2 Pad. Based on a 2008 in-fill drilling program conducted by Rosemont, and as presented in a 2009 Feasibility Update, approximately 69,000 Mt of oxide ore have been delineated. The ore density has an assumed density of 125 pounds per cubic foot (pcf).

Based on Appendix F of the May 2009 design report - Design Criteria (Tetra Tech, 2009b), run-of-mine (ROM) ore will be placed on the pad. Estimated ROM particle size distributions were determined for the Rosemont deposit by Call & Nicholas, Inc. (CNI, 2008). CNI calculated four (4) fragment size-distributions for the ore and waste rock materials in the Rosemont Open Pit. The fragment size-distributions included sulfide ore, oxide ore, and two (2) waste rock types. Subsequent analysis performed in conjunction with designing the flow-through drain structures (Technical Memorandum titled *Rosemont Flow-Through Drain Design* (Tetra Tech, 2010c) dated April 5, 2010) determined that the ROM waste rock is anticipated to have a D50 of about 14" with 80% of the rock materials under 24" in diameter (see Illustration 1.0 below). The oxide ore is anticipated to have a similar distribution.

Illustration 1.0 Modified Particle Size Distribution



The oxide ore material will generally be stacked in 30 foot lifts following two (2) 20-foot starter lifts on the down-gradient side of the Phase 1 Pad. A haul road will divide the Phase 1 Pad from the Phase 2 Pad.

- 2. The draindown rate seems to underestimate the time that will be required to reach a rate of ten gallons per minute and will require management during and after reclamation.*

As described in the response above, the material being placed on the heap leach pad will be ROM sized material. Based on the gradation presented in Illustration 1, the ROM material includes few fines and will generally have a high saturated hydraulic conductivity. The type of material anticipated to be placed in the heap is also not expected to breakdown and generate a significant amount of fines due to the chemical leaching. Because of the lack of fines and high saturated hydraulic conductivity, the heap leach will drain freely after leaching operations cease. A review of conditions at other heap leach pads currently in closure or post-closure in Arizona and Nevada support the conclusion of the draindown rate reaching approximately ten (10 gallons per minute within a three (3) year period.

2.3 Waste Rock Storage Area

- 1. The conceptual model text and low-resolution illustrations do not clearly represent the depth of the three simulations.*

Illustrations 5.1, 5.2, 5.3, 5.6, 5.7, and 5.8 were increased in size in the updated report (Tetra Tech, 2010b) to fit one figure per 8.5 by 11 inch page in landscape position.

2.4 Steady-State and Transient Solutions

- 1. Explain why the water balance graphs start at zero.*

The information presented in the water balance graphs is not the change in moisture content of the material, but the inflows and outflows of water due to the climactic conditions. Additional text was added to Section 5.9.1 of the updated report (Tetra Tech, 2010b) to better explain what the illustrations are presenting and the differences between the water balance fluxes and the material moisture content. A graph of moisture contents within the facilities over time was also added to the updated report to minimize the confusion between moisture content and water balance fluxes.

- 2. The averaging of the climate data is muting the impacts of individual rain events.*

The preferred datasets for this Project were only provided as average daily measurements for the period of record. However, a dataset from the University of Arizona was identified that contained actual daily measures which could be used in the transient modeling. A ten (10)-year portion of this daily measurement dataset was applied to the modeling for comparison to the results of the average conditions dataset. Because the evaporation measured at the University of Arizona meteorological station is higher than that at the

Project site, evaporation values from this ten (10)-year data set were not used in the comparison modeling. The model calculated the actual evaporation based on the location of the Project site and the other components of the climate file.

3. *The models should be run using the daily measures and for the 50-year period.*

The average conditions dataset is a conservative representation of the conditions that will exist at the Project site. Rarely would a condition exist where precipitation occurs every day. As indicated above, an actually daily measurement dataset was considered and was presented in the updated report (Tetra Tech, 2010b) for comparison with the average conditions results.

2.5 Illustrations and Tables

1. The figures of the model results are too small to read the detail and need to be presented in a larger format.

Illustrations 5.10, 5.12, 5.13, 5.15, 5.16, and 5.17 were increased in size in the updated report (Tetra Tech, 2010b) to fit one illustration per 8.5 by 11 inch page in landscape position.

3.0 Fate and Transport (Geochemical) Modeling

The following sections present the response to issues raised relating to the fate and transport modeling portions of the report.

3.1 General Comment

The general comments made regarding the geochemical modeling were positive. There are no specific issues to be addressed under this section that were not addressed in other sections.

3.2 Review of Modeling Steps

The following sections address the comments made regarding the data used to construct the geochemical models.

3.2.1 Waste Characteristics

1. *The bulk geochemical characteristics do not appear in this report.*

A bulk geochemical characterization is presented in the *Baseline Geochemical Characterization and Geochemical Characterization, Addendum 1* reports (Tetra Tech 2007a and Tetra Tech 2007b). Although explanation of the bulk characterization was not added to the updated report (Tetra Tech, 2010b), a reference to the appropriate sections of the geochemical characterization reports were added to Section 6.3.1.

3.2.1.1 Waste Rock

1. *A more detailed characterization of the site mineralogy is required to calibrate the ABA method results.*

Although sulfide minerals are present in rocks comprising the Rosemont pit, the system is dominated by acid neutralizing materials (limestone). Calibration of conventional ABA methodology, while potentially very useful at project sites where there is a significant level of uncertainty related to acid generating potential, will have limited useful impact in refining waste rock leachate quality estimates at the Rosemont site.

2. *Evaluate the soluble form of sulfur should be done to determine if it is acid-generating.*

Static testing performed to characterize the waste rock material included sulfur speciation analysis in addition to the Acid Base Accounting (ABA) method. This provided information on the types and quantities of sulfur that could be present in the waste rock, as well as providing an indication of behavior (e.g., acid generating potential) of the material. A summary of the testing completed and the resulting characterization of the waste rock was provided in the *Baseline Geochemical Characterization* report (Tetra Tech, 2007a) and the *Geochemical Characterization, Addendum 1* report (Tetra Tech, 2007b). A brief summary of the waste rock characterization, including discussion of the types and quantities of sulfur present, were added to Section 6.3 of the updated report (Tetra Tech, 2010b). However, for a more detailed discussion, the geochemical characterization reports should be referenced.

3. *Evaluate the carbonate to neutralization potential and possible effects of silicates on the neutralization potential.*

The ore deposit at the Rosemont site is part of a skarn deposit. This type of formation is defined by a high percentage of carbonate materials. Testing of the different rock types present at the Rosemont site support this conclusion. During core logging, a significant amount of carbonate material was noted and very little silica mineralogy was identified. Based on these observations, the oxidation of silicates is not expected to have an impact on the overall site water chemistry, which is expected to be controlled by the dissolution of carbonate minerals. Since this issue was addressed in detail in the geochemical characterization report, no further explanation or text was added to the updated report (Tetra Tech, 2010b).

4. *Evaluate the effects of blasting on release of minerals.*

Very little nitrate is present in the rocks at the Rosemont site and predicted concentrations have generally been at or below detection limits. Some residual nitrate could be present on the rocks due to blasting. However, because of the high solubility and mobility of nitrate, it is not anticipated that it will build up in the system, but rather be flushed from the pit walls and waste rock by precipitation or dust suppression activities, keeping the concentrations low.

5. *Evaluate Acid Rock Drainage (ARD) criteria for this site.*

A draft guidance criteria for the determination of ARD characteristics was inadvertently used. This reference has been removed from the updated report (Tetra Tech, 2010b). Instead, guidance provided in the Best Available Demonstrated Control Technology (BADCT) document from the Arizona Department of Environmental Quality (ADEQ, 2004) was used. This issue was more related to the geochemical characterization of the site materials than predictive modeling. Therefore, no additional information was added to the updated report except to correct the reference.

6. *Include an explanation of how the waste rock proportions were developed.*

The waste rock proportions used to develop the fate and transport modeling were supplied by Rosemont, and were the result of the mine planning activities also taking place during the design of the mine.

7. *Include an explanation of the waste characterization and overall ABA results.*

A brief explanation of the waste rock characterization has been added to the infiltration, seepage, fate and transport modeling report, but a full description of the characterization has not been added. A reference has been added to this report to reference the more detailed characterization description in the *Baseline Geochemical Characterization* report (Tetra Tech, 2007a) and the *Geochemical Characterization, Addendum 1* report (Tetra Tech, 2007b) for the location of the detailed characterization information.

8. Evaluate the timing of the release of PAG materials and its consideration during the staged construction of the storage area.

In general, the plan to segregate acid generating waste rock will be activated based on observations, sampling, and characterization of samples completed during mining operations.

During the mining operations, drilling will be completed on 50-foot benches and overseen by a Rosemont geologist. Variations in lithology and mineralogy/geology, as well as degree and extent of fracturing, will be evaluated by the geologist. Composites from the drill holes will be assayed as needed to characterize the material. If however, the presence or layer of one of the units (i.e., Andesite, Arkose, etc.) is identified as potentially being acid generating based on past characterization work, the individual layer will be discretely sampled and characterized.

Characterization of these samples could include Acid Base Accounting (ABA) or net acid generation pH test (NAG pH). The degree of sulfide and oxide mineralization would be determined as part of the aforementioned characterization.

Decisions for segregation, particularly of any potentially acid generating waste rock, will be based on the results of the characterization. Non-acid generating waste rock will be preferentially placed on the east and south haul roads and buttresses, the dry stack tailings buttresses and exterior haul roads, screening berms, drain fills, permanent diversion

crossings, the crusher haul road, and the leach pad. Acid generating waste rock will be placed to the interior of the waste rock pile and possibly mixed (comingled) with non-acid generating waste rock. Additionally, potentially acid generating waste rock will not be placed beneath areas designated for water management ponds as part of the final landform.

A geologist or trained technician will inspect each pile of blasted and broken rock before removal from the active mining face. A fizz test will be conducted at the active heading with dilute hydrochloric acid (HCl). The visual inspection and fizz test will guide the preferential placement of waste rock as described. If the results are questionable, or if there is the presence of potentially acid generating material as defined in the preliminary characterizations work, additional testing may be necessary or material may be preferentially treated as acid generating and placed appropriately. Specific waste rock segregation requirements will be detailed in operating plans that will be modified as appropriate.

Mine staff shall maintain records that indicates the personnel involved in the decision, the testing or review involved, and if the rock was determined to be acid generating or not. Placement of the material should also be verified. The records shall be maintained on site and available for inspection.

In addition to the determination of testing as described above, ABA tests shall be completed on at least two (2) random samples per week up to a maximum of ten (10) samples during a month. ABA testing includes a measurement of the Acid Neutralization Potential (ANP) and the Acid Generating Potential (AGP) of the waste rock. SPLP (Synthetic Precipitation Leaching Potential EPA Method 1312), shall be completed quarterly on samples used as buttress or drain materials. These records should also be maintained on site.

3.2.1.2 *Heap Leach Facility*

1. *Add discussion of the geochemical data.*

A brief explanation of the heap material characterization was added to the updated report (Tetra Tech, 2010b). A reference was also added to the updated report to reference the more detailed characterization descriptions in the *Baseline Geochemical Characterization* (Tetra Tech, 2007a) and the *Geochemical Characterization, Addendum 1* report (Tetra Tech, 2007b).

3.2.1.3 *Dry Stack Tailings*

1. *Add discussion of the geochemical data and how the tailings characteristics could change overtime.*

Additional tailings material has been generated to ensure characterization of the tailings over time. This material was submitted for testing using a variety of static testing methods. A Technical Memorandum titled *Rosemont Tailings Geochemistry Sample Sources* dated



August 30, 2010 (Tetra Tech, 2010d). was prepared to summarize all of the tailings material that has been used in the geochemical characterization and the results of the testing. A brief explanation of the tailings characterization and the material anticipated over time has been added to the revised report (Tetra Tech, 2010b).

3.2.2 Conceptual Geochemical Models

1. *Add discussion in this section of the report related to geochemical processes.*

A basic discussion of the applicable geochemical processes was added to the updated report (Tetra Tech, 2010b). Text was also added to the updated report to reference the *Baseline Geochemical Characterization* report (Tetra Tech, 2007a) and the *Geochemical Characterization, Addendum 1* report (Tetra Tech, 2007b) for a more detailed discussion. A complete geochemical process description was not added to the updated report.

3.2.3 Source Terms

Several comments were made regarding the source terms selected to represent the materials that will be placed in the facilities. Revision of the source terms required modification of the geochemical models and corresponding results discussion in the updated report (Tetra Tech, 2010b). The following sections present the specific issues with each facilities' source term for the geochemical modeling.

3.2.3.1 Waste Rock

1. *Discuss the potential for local areas of acidification or the process that will ensure complete mixing of PAG material with non-PAG material.*

In general, the plan to segregate acid generating waste rock will be activated based on observations, sampling, and characterization of samples completed during mining operations.

During the mining operations, drilling will be completed on 50-foot benches and overseen by a Rosemont geologist. Variations in lithology and mineralogy/geology, as well as degree and extent of fracturing, will be evaluated by the geologist. Composites from the drill holes will be assayed as needed to characterize the material. If however, the presence or layer of one of the units (i.e., Andesite, Arkose, etc.) is identified as potentially being acid generating based on past characterization work, the individual layer will be discretely sampled and characterized.

Characterization of these samples could include Acid Base Accounting (ABA) or net acid generation pH test (NAG pH). The degree of sulfide and oxide mineralization would be determined as part of the aforementioned characterization.

Decisions for segregation, particularly of any potentially acid generating waste rock, will be based on the results of the characterization. Non-acid generating waste rock will be preferentially placed on the east and south haul roads and buttresses, the dry stack tailings buttresses and exterior haul roads, screening berms, drain fills, permanent diversion crossings, the crusher haul road, and the leach pad. Acid generating waste rock will be placed to the interior of the waste rock pile and possibly mixed (comingled) with non-acid generating waste rock. Additionally, potentially acid generating waste rock will not be placed beneath areas designated for water management ponds as part of the final landform.

A geologist or trained technician will inspect each pile of blasted and broken rock before removal from the active mining face. A fizz test will be conducted at the active heading with dilute hydrochloric acid (HCl). The visual inspection and fizz test will guide the preferential placement of waste rock as described. If the results are questionable, or if there is the presence of potentially acid generating material as defined in the preliminary characterizations work, additional testing may be necessary or material may be preferentially treated as acid generating and placed appropriately. Specific waste rock segregation requirements will be detailed in operating plans that will be modified as appropriate.

Mine staff shall maintain records that indicates the personnel involved in the decision, the testing or review involved, and if the rock was determined to be acid generating or not. Placement of the material should also be verified. The records shall be maintained on site and available for inspection.

In addition to the determination of testing as described above, ABA tests shall completed on at least two (2) random samples per week up to a maximum of ten (10) samples during a month. ABA testing includes a measurement of the Acid Neutralization Potential (ANP) and the Acid Generating Potential (AGP) of the waste rock. SPLP (Synthetic Precipitation Leaching Potential EPA Method 1312), shall be completed quarterly on samples used as buttress or drain materials. These records should also be maintained on site.

2. Explain the data presented in the tables in more detail and considering rewording the table footnotes to make it more clear.

The explanation associated with the tables in the fate and transport sections were updated and the footnotes revised to clarify the information being presented (Tetra Tech, 2010b).

3. Describe the methodology used to mix the source terms.

The source terms were mixed using the MIX function in the model PHREEQC. This is equivalent to mixing solutions in a beaker to determine the resulting chemistry. The proportion information presented was used to determine the amount of each source term that would be contributing to the mix.

4. *Describe how the data presented as source terms was developed and minerals used.*

The sources terms were developed from the short-term leaching tests performed during the geochemical characterization activities. Two (2) short-term leaching tests were used: the Synthetic Precipitation Leaching Procedure (SPLP) and the Meteoric Water Mobility Procedure (MWMP). The available SPLP and/or MWMP data were gathered for each rock type to determine which test method provided the most complete data set. Each of the short-term leaching results for a particular rock type were then averaged to represent the average overall characteristics of the specific rock type. The averaged solution was then used directly in the modeling as the starting solutions in PHREEQC.

5. *Describe how the nitrate value was developed and how it will be impacted by residuals from the explosives.*

The nitrate values present in the report are those measured during the short-term leaching tests. Blasting could impact the concentrations of nitrogen compounds, such as nitrate, present on the rock. However, very little nitrate is present in the rocks at the Rosemont site so predicted concentrations have generally been at or below the detection limit. Some residual nitrate could be present on the rocks due to blasting. Because of the high solubility and mobility of nitrate, it is not anticipated that it will build up in the system, but rather be flushed from the pit walls and waste rock by precipitation or dust suppression activities, keeping the concentrations low.

6. *Describe how the dilute SPLP and MWMP tests were scaled up and adjusted for the much drier conditions of the storage facility.*

No adjustments were made to the Synthetic Precipitation Leaching Procedure (SPLP) and Meteoric Water Mobility Procedure (MWMP) data prior to using the information in the modeling. There is much debate about the proper scale up methods applied to this type of data, and there is currently not enough information to implement any type of adjustment. As a consideration for this issue, where possible the MWMP data was used since this method uses a 1:1 water to rock ratio and the SPLP uses a 20:1 ratio.

3.2.3.2 *Heap Leach Facility*

Comments made regarding the Heap Leach Facility source terms are similar to those made for the waste rock. In addition to the issues described for the waste rock, the heap leach geochemical model revision also included a reassessment of the proposed treatment systems. The section in the updated report (Tetra Tech, 2010b) was revised to describe the treatment system in more detail and possible adjustments that would be required should the conditions or drain-down rate change.



3.2.3.3 *Dry Stack Tailings*

Comments made regarding the source terms for the dry stack tailings material were limited to providing more text in the updated report (Tetra Tech, 2010b) to describe the source terms and modeling method in more detail.



REFERENCES

- Arizona Department of Environmental Quality (ADEQ) (2004). *Arizona Mining Best Available Demonstrated Control Technology (BADCT) Guidance Manual: Aquifer Protection Program*. Publication # TB-04-01.
- Call & Nicholas, Inc. (CNI) (2008). *Feasibility-Level Geotechnical Study for the Rosemont Deposit*. Prepared for Augusta Resources. Report Dated February 2008.
- SRK Consulting, Sieber, M., Day, S. and Ugorets, V. (SRK, 2010). *Technical Review of Infiltration, Seepage, Fate and Transport Modeling Report, Tetra Tech, 2010, Prepared for Rosemont Copper Company*. Technical Memorandum to Dale Ortman (SWCA). Technical Memorandum Dated April 30, 2010.
- Tetra Tech (2007a). *Baseline Geochemical Characterization*. Prepared for Rosemont Copper Company. Report Dated June 2007.
- Tetra Tech (2007b). *Geochemical Characterization, Addendum 1*. Prepared for Rosemont Copper Company. Report Dated October 2007.
- Tetra Tech (2009a). *Rosemont Copper Design Storm Precipitation Data/Design Criteria*. Technical Memorandum to Daniel Roth (M3). Technical Memorandum Dated April 7, 2009.
- Tetra Tech (2009b). *Rosemont Heap Leach Facility Permit Design Report*. Prepared for Rosemont Copper Company. Report Dated May 2009).
- Tetra Tech (2010a). *Infiltration, Seepage, Fate and Transport Modeling Report*. Prepared for Rosemont Copper Company. Report Dated March 2010.
- Tetra Tech (2010b). *Infiltration, Seepage, Fate and Transport Modeling Report – Revision 1*. Prepared for Rosemont Copper Company. Report Dated August 2010.
- Tetra Tech (2010c). *Rosemont Flow-Through Drain Design*. Technical Memorandum to Kathy Arnold (Rosemont Copper Company). Technical Memorandum Dated April 5, 2010.
- Tetra Tech (2010d). *Rosemont Tailings Geochemistry Sample Sources*. Technical Memorandum to Kathy Arnold (Rosemont Copper Company). Technical Memorandum Dated August 30, 2010.
- University of Arizona, (1977). *An environmental inventory of the Rosemont area in southern Arizona, Volume I: The present environment*. Edited by Davis, R., and Callahan, J.R.
- Western Regional Climate Center (2009). <http://www.wrcc.dri.edu/summary/Climsmaz.html> Arizona. Visited January 7, 2009.

ATTACHMENT 1
TECHNICAL REVIEW OF INFILTRATION, SEEPAGE,
FATE AND TRANSPORT MODELING REPORT, TETRA
TECH, 2010, PREPARED FOR ROSEMONT COPPER
COMPANY (SRK, 2010)

Technical Memorandum

To:	Dale Ortman, P.E.	Date:	April 30, 2010
cc:	Tom Furgason, SWCA File, SRK	From:	Mike Sieber, P.E, SRK Stephen Day, P.Geo. SRK Vladimir Ugorets, PhD, SRK
Subject:	Technical Review of <i>Infiltration, Seepage, Fate and Transport Modeling Report</i> , Tetra Tech, 2010, Prepared for Rosemont Copper Company	Project #:	183101

A technical review has been undertaken, and this Technical Memorandum prepared at the request of SWCA and the Coronado National Forest, in accordance with a request for a Statement of Work dated February 17, 2010. Provided here are comments related to the review of the, *Infiltration Seepage, Fate and Transport Modeling Report*, prepared for the Rosemont Copper Company by Tetra Tech (2010b). These comments were prepared by Mike Sieber, Stephen Day, and Vladimir Ugorets of SRK Consulting, Inc. (SRK). Editorial review was completed by Cori Hoag and Larry Cope, also of SRK.

The seepage, fate and transport modeling report and supporting documents from Tetra Tech regarding the 2007 geochemical characterization (Tetra Tech, 2007a and Tetra Tech, 2007b) and the *Dry Stack Tailings Storage Facility Design Report* (AMEC, 2009, Appendix D) and the *Mine Plan of Operations* (WestLand Resources, 2007) were reviewed as part of this effort.

This memorandum is organized into two sections, corresponding to the two topics under review:

- Section 1 - Infiltration and seepage modeling; and,
- Section 2 - Fate and transport (geochemical) modeling.

The 2010 Tetra Tech report is well presented and well written, and as supported by the appendices, is in general comprehensive in scope. The GEO-SLOPE VADOSE/W code is industry standard infiltration-seepage modeling software. However, SRK requests clarifications and additional supporting data, as well as an explanation for several methodologies not clearly understood by the reviewers. The requests are indicated below in relevant sections. The models cannot be adequately judged as suitable and defensible without the requested information.

1 INFILTRATION AND SEEPAGE MODELING

1.1 Input Data

This section summarizes the review of the climatic data and the saturated and unsaturated material properties used for the infiltration models.

1.1.1 Site Climatic Data

The Nogales 6 N weather station was selected for the Waste Rock Storage Area and Heap Leach Facility infiltration models. The precipitation and maximum and minimum temperature data appear reasonable. However, the Santa Rita weather station is closer to the Rosemont Project area and is at an elevation

closer to that of the project elevation than is the Nogales 6 N weather station. It is stated in Appendix B of the report that the Nogales 6 N pan evaporation data were adjusted to the Rosemont project site based on a linear extrapolation with each station's elevation. However, illustration 3.2 in the text does not appear to be a simple linear extrapolation. Section 4.1.4 states that a correlation was performed to translate the Nogales pan evaporation data to the Rosemont Project, please explain the method used. Three climate conditions were used for the transient model, average climate conditions, 24-hour, 100 year storm event, and multi-storm (approximately six inches of rain in seven days). What statistical method used to determine the 7-day storm event, it is not clear and cannot be understood from the description provided.

The report states that precipitation was applied in a "sinusoidal function that peaks at noon. The distribution pattern in the model allows for peak rainfall over a short period around noon." The transient log header in Appendix C states that average annual conditions are sinusoidal; however, the precipitation appears to be applied from 0 to 24 hours and nearly every day of the year. This does not appear to be average conditions in southern Arizona. A hydrograph of the simulated precipitation would aid in understanding the temporal distribution of precipitation.

1.1.2 Site Material-Soil Data

Section 5.3 of the report provides an explanation of unsaturated flow theory. Illustration 5.5 shows a generic soil water characteristic curve (SWCC) for two soils, however, an illustration of hydraulic conductivity as a function of capillary function or moisture content is not presented or discussed. Section 5.5.5 presents saturated hydraulic conductivity values for three waste rock materials, alluvium, and bedrock without providing either a range of values, or a source for the saturated hydraulic conductivity data.

The conceptual model for the Waste Rock Storage Area shows three layers of waste rock, benches-buttrass, alluvial deposit, and bedrock, each with different properties. The model logs in Appendix C give a brief description of the material—Andesite—for unconsolidated waste rock and list the unsaturated properties. Section 5.5 state that laboratory and library parameters were used for unsaturated flow parameters. The laboratory work that was completed should include the data, laboratory name, and the ASTM methods that were used. The GEO-SLOPE library data should also be presented. SWCC and unsaturated hydraulic conductivity charts for the materials modeled should be presented in either the report or appendices. The charts in Figure 1 and Figure 2 below are examples of what is necessary to present a defensible infiltration-seepage model. In Appendix A, AMEC presented the SWCCs and a hydraulic conductivity function for the Dry Stack Tailings Storage Facility infiltration and seepage model.

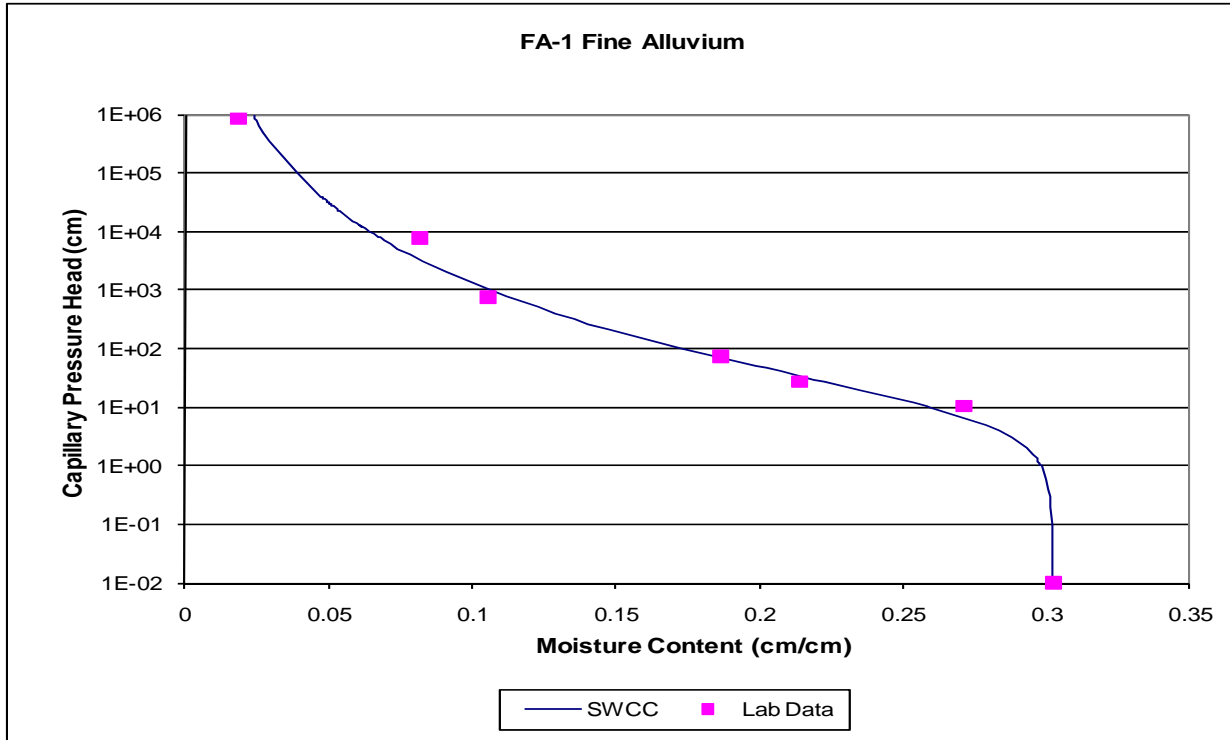


Figure 1 Example of soil water characteristic curve (SWCC)

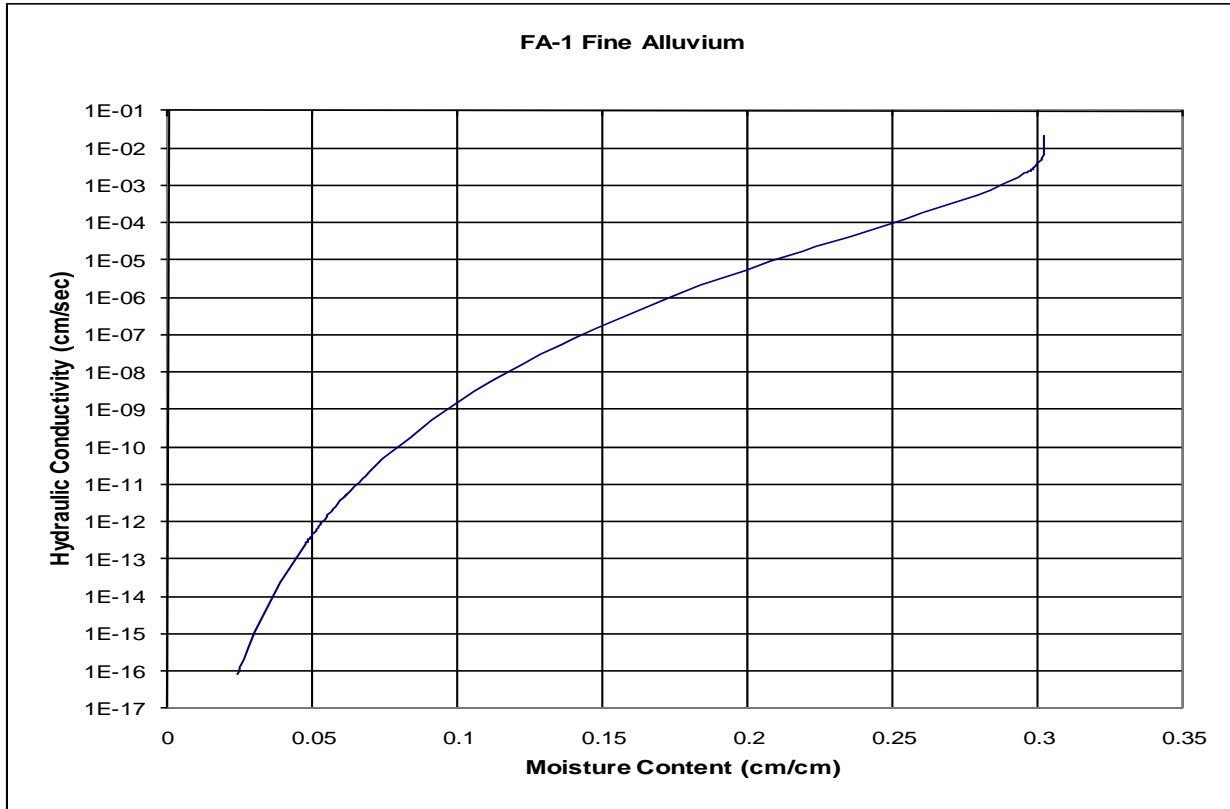


Figure 2 Example of unsaturated hydraulic conductivity function

1.2 Heap Leach Facility Conceptual Model

Infiltration-seepage modeling was completed to estimate the time required for draindown of the Heap Leach Facility (Heap) to drop to about 10 gpm. Appendix E describes the draindown modeling. Page 4 paragraph 4 of the report states, “The primary difference between the spent ore and the waste rock is the moisture content of the materials.” Oxide ore placed on the heap is not the same material as waste rock in terms of mineral concentrations of copper-bearing minerals (oxide/carbonate/silicate/sulfide), associated gangue minerals like iron oxides/silicates/sulfides, clay, and calcite, and secondary minerals that will form in response to leaching. Although both the oxide ore and waste rock (bedrock) have been hydrothermally altered, the materials on the Heap will likely break into smaller size fractions owing to the intensity of alteration, and disaggregation that will occur during placement, exposure to raffinate, and ripping in the upper layer of each lift; the lifts within the Heap will also compact with burial depth. Raffinate leaching will cause the Heap material to break down to smaller particles and the leaching of the calcitic material will cause the formation of secondary sulfate minerals and gypsum. These reactions will likely significantly decrease saturated hydraulic conductivity. In addition, simulating the Heap Leach Facility materials as run-of-mine material may significantly under-estimate the duration for draindown. SRK experience with draindown of an 89 MT heap in Arizona (larger than the estimated 60 MT Rosemont heap) indicates a decrease in draindown to 20 gpm in 8 years. An estimate for the Rosemont Heap is that a decrease in draindown to about 10 gpm probably will take 8 to 10 years. During and after reclamation, the continued drainage from the Heap will have to be managed.

1.3 Waste Rock Storage Area

Based on the conceptual model text and the low-resolution figures SRK cannot ascertain the depth of the three simulated stages.

1.4 Steady-State and Transient Solutions

Section 5.7 states that the sequence of steady-state simulations were to “offer non-zero starting values for the subsequent transient modeling scenarios.” We assume the non-zero refers to the moisture content of the material. The water balance illustrations presented in the report begin with the water content at zero. Can this be explained.

It is stated on Section 5.8, page 26 that, “Transient modeling provides a reasonable simulation of flow conditions within the Waste Rock Storage area, Heap Leach area, and the Dry Stack tailings facility.” The transient simulations reported in this report are one in year duration using average climatic conditions. However, movement of moisture through such materials often takes many years, a reasonable approach would be to conduct the 50-year transient simulations utilizing the entire 50-year climatic data set from the Nogales 6 N weather station.

In addition, the averaging of daily climatic conditions into a single year likely miss-represents measured daily climate conditions. The apparent miss-representation may be evidenced in the simulated daily climate input data presented in Appendix C. Those data indicate that precipitation fell virtually every day of the year, the ranges in values for relative humidity are shown as broad and relatively invariable, and precipitation is shown to occur at all hours of the day for all days. Because of the muting of the data by the process of averaging, small amounts of precipitation (0.001 inch to 0.248 inches with a mean of 0.048) falls on 255 days of the year. With evaporation exceeding precipitation on most days, such small precipitation values might be evaporated before infiltrating to depth, resulting in an under-estimate of the flux of water through the material. In reality, a few heavy rains can fall on humid days producing a significant source of water for infiltration.

1.5 Illustrations and Tables

Illustrations 5.6, 5.7, 5.10, 5.12, and 5.13 of the waste rock and heap leach conceptual models and numerical model results are too small to read annotations and the horizontal and vertical scales. The

values for moisture content and flux are often not legible. Illustration 5.22, presents the simulated volumetric moisture content distribution within the closed Heap, indicates upward flux from the base of the Heap. It is not clear to us how such a condition can exist, and we request that it be explained in text.

2 FATE AND TRANSPORT (GEOCHEMICAL) MODELING

2.1 General Comment

The overall approach to modeling the water chemistry for each facility (waste rock, heap leach, dry stack) is similar. The models combine understanding about the composition of the waste facilities with data on leaching behavior and water flow to predict pore water chemistry. Geochemical modeling was used in some cases to predict final water chemistry. The overall approach is consistent with general practice and the data used as a basis for the model are suitable for the intended purpose.

Details of each step in the geochemical method are reviewed below. SRK has identified concerns with the approach that are similar to those with the pit lake predictions (SRK, 2010b). The main factor that does not appear to have been addressed, however, is the degree to which the onset of acidic conditions in some components of the waste rock could affect overall water quality. In the following sections, a pre-amble review is provided, followed by specific bulleted items for follow-up.

2.2 Review of Modeling Steps

2.2.1 Waste Characteristics

Waste Rock

SRK (2010a) previously reviewed the overall geochemical database. Additional comments were provided by SRK (2010b). Acid-base accounting is used to acid rock drainage (ARD) potential while leachability was characterized using SPLP and MWMP. SRK (2010b) provided the following recommendations for the use of acid-base accounting data at the site:

- Calibration of the conventional ABA method to site mineralogy needs to be considered. A more detailed description of the relevant mineralogy including acid generating, acid neutralizing, and water-soluble minerals should be provided.
- The calculation of acid potential (AP) appears to have been based on sulfide sulfur though description of the method used to calculate this could not be located. It appears that soluble sulfur is an important component of the rock (Tetra Tech, 2007b, Illustration 3.1). The mineralogical form of soluble sulfur is important as it may be acid generating (e.g. jarosite) or non-acid generating (e.g. gypsum) and should be evaluated for its contribution to AP.
- The Sobek Neutralization Potential (NP) method can lead to over-statement of site-available NP if silicate minerals react in the test. To address this concern, the carbonate mineralogy of the site should be described (e.g. presence of iron carbonates), carbonate analytical data should be presented and compared with NP, and the effect of silicates on NP should be investigated by comparing carbonate and NP determinations.
- The possible effect of blasting on the release of mineral components to blast fines in the pit walls should be considered because the mineralization is described as “vein controlled.”
- Based on these considerations, the application of conventional ARD criteria may need to be re-considered for the site.

The bulk waste rock geochemical characteristics did not appear to be presented in the report. Table 6.2 provided the lithological composition of the waste rock while Tables 3.3 and 3.4 of Tetra Tech (2007) indicate the distribution of the ARD potential in waste rock. ARD potential is very low on the whole, but SRK notes that arkose is a major unit (44%) and 15% of samples from this unit were classified as

potentially ARD generating (PAG) by ABA. This indicates that at least 7% of the rock could be composed of PAG rock.

To complement this work and support the subsequent development of source terms, the following additional information should be presented:

- Explanation of how the waste rock proportions were calculated.
- Presentation of the overall acid-base account of the waste rock (sulfur content, neutralization potential) based on the rock type characteristics and proportion of rock types.
- An evaluation of the timing of release of PAG materials because if the PAG materials are released at certain stages of the mine rather than being continuously mixed in with the non-PAG materials local acidification could occur.

Heap Leach Facility

No geochemical description of the heap leach materials could be located.

- Geochemical data for the heap leach materials should be presented.

Dry Stack Tailings

Tetra Tech (2007) provided geochemical data for the tailings. These data indicate that tailings have very low potential for ARD due to mostly low sulfide content. SRK noted that like waste rock, sulfate content was variable. It is assumed that sulfate occurs as gypsum rather than acidic salts.

- Discussion of how the tailings characteristics might change as mining progresses because some tailings have ARD potential.

2.2.2 Conceptual Geochemical Models

Section 6.1 of the report provided the “Conceptual Fate and Transport Model”; however, the description did not include geochemical processes.

- This section should be updated to include geochemical processes, for example, the role of sulfide mineral oxidation, gas partial pressures, temperature variations, and the precipitation and dissolution of secondary minerals.

2.2.3 Source Terms

Waste Rock

It is understood the waste rock source term was developed by developing source terms for individual waste rock types, combining the source terms according to the rock type proportions, and then equilibrating the resulting chemistry using PHREEQC. The details of the method were not provided and should include:

- Further discussion of the role of local acidification and the need for a source term to reflect acidic conditions. This may be unnecessary if it can be demonstrated that PAG rock becomes intimately mixed with non-PAG rock during mining.
- Explanation and discussion of justification for use of zero concentration in the source term for rocks with undetectable solid phase concentration (NA in Table 6.1). The description “not part of the rock’s composition” should be re-worded to indicate undetected. It is noted that arkose is shown as NA but in Illustration 3.4 in Tetra Tech (2007) arkose is shown as having an enrichment ratio of 10, which seems to indicate detection (as shown in Illustration 3.5).
- The methodology used to mix the waters.

- Which minerals were used to model the waste rock source term resulting in the concentrations in Table 6.6. This table indicates very high sulfur concentrations and extreme ion imbalance. It is assumed that this sulfate not sulfur.
- How the nitrate concentration was calculated. The concentrations seem very low given that explosives residuals will be present.

To perform a reality check on the concentrations, SRK compared them to compiled seepage chemistry data for calc-alkalic and alkalic porphyry deposits in British Columbia, Canada (Day and Rees 2006; Red Chris Development Company 2004) (Table 1). While it is acknowledged that Rosemont has some skarn characteristics, predictions for cadmium, copper, selenium and zinc seemed atypical. These elements are associated with sulphides which can occur in skarn deposits.

- Further discussion is needed about how the very dilute concentrations obtained from SPLP and MWMPs are scaled up to the much drier conditions at the site. A similar concern was raised for the pit wall source term during review of the geochemical pit lake model report (SRK 2010b).

Table 1. Statistics for Waste Rock Seepage from Porphyry Deposits

Parameter	Unit	pH<4				4<pH<6				pH>6			
		n	Max ¹	P ₉₅ ¹	P ₅₀	n	Max ¹	P ₉₅ ¹	P ₅₀	n	Max ¹	P ₉₅ ¹	P ₅₀
Acidity	mgCaCO ₃ /L	58	25400	6412	1822	24	560	544	151	63	214	36	15
Alkalinity ¹	mgCaCO ₃ /L	4	0	0.15	1	32	1.2	2	5	262	1	7.525	43.6
SO ₄ ²⁻	mg/L	93	30910	7969	3220	46	2930	2440	1260	299	1896	1531	464
Al	mg/L	42	766	436	239	25	47	40	5	66	0.6	0.2	0
Sb	mg/L	8	0.13	0.09	0.020	0	-	-	-	40	0.09	0.08	0.010
As	mg/L	0	-	-	-	2	0.0006	0.0006	0.00	26	0.04	0.03	0.01
Cd ³	mg/L	19	0.02	0.02	0.007	1	0.04	0.04	0.040	27	0.03	0.007	0.000
Ca	mg/L	54	804	748	532	39	832	793	361	147	964	727	247
Cu ⁴	mg/L	42	655	512	249	25	370	340	66	107	1	0.14	0.02
Fe ⁵	mg/L	42	1310	480	14	24	5	3	0.2	81	0.3	0.2	0
Hg ⁶	mg/L	3	0.00110	0.0011	0.00070	1	0.0006	0.0006	0.00060	24	0.002	0.00043	0.00005
Pb ⁷	mg/L	12	0.04	0.04	0.0155	7	0.02	0.02	0.012	27	0.01	0.0036	0.00007
Mg	mg/L	54	213	163	61	39	201	180	39	147	115	101	24
Mn	mg/L	37	56	41	4	26	31	26	9	113	6	4	1
Mo ⁸	mg/L	3	0.009	0.009	0.006	15	0.03	0.03	0.0068	114	0.4	0.3	0.03
Ni	mg/L	31	2	2	0.8	12	1	1	0.4	48	0.4	0.21	0.006
K	mg/L	47	148	134	67	16	112	87	3	77	58	39	4
Se	mg/L	29	0.2	0.2	0.09	7	0.09	0.08	0.07	34	0.3	0.3	0.06
Ag ⁹	mg/L	0	-	-	-	1	0.01	0.010	0.01	19	0.00001	0.00001	0.00001
Na	mg/L	54	204	91	20	35	64	49	14	127	126	54	11
Zn ³	mg/L	35	6	5	2	18	4	4	2	84	1	0.8	0.03
pH ¹	s.u.	99	2.1	2.5	3.1	46	4.0	4.1	5.3	311	6.0	6.4	7.5

Annotations refer to footnotes about data sources for each of five sites in the compilation.

Heap Leach

The methodology used to develop the heap leach source term was unclear.

- Description of the input data and methodology is requested following the same format as the waste rock.

Comparison of the sources terms in Table 6.7 of the report with Table 1 (above) leads to similar observations as for waste rock. Concentrations of many parameters seem very low. For example, an iron concentration of 0.3 mg/L is predicted at pH 3.23. As iron is highly soluble at this pH, much higher iron concentrations would be expected from dissolution of silicates. In addition, the biological system is

predicted to produce water with low Eh but this is not reflected in elevated iron concentrations in ferrous form.

- SRK recommends the source terms be re-visited and then used to re-assess the water treatment systems. The iron source term in particular will affect the performance of the water treatment systems.

Dry Stack Tailings

As with the other source terms:

- Further explanation of the modeling method and inputs is needed to address the scale-up of dilute leach tests to the full scale facility.
- The possible effect of timing of production of PAG tailings should be considered in the source term.

Concentrations reported in Table 6.8 do not appear to be consistent with equilibration with major minerals in the tailings, which would presumably include gypsum and calcite. Both minerals are probably present according to the acid-base accounting data. Concentrations of sulfate, alkalinity, and calcium would be expected to be comparable to the waste rock source term (Table 6.6).

3 Conclusions

For the infiltration and seepage component of the model report, SRK has the following recommendations:

- Results from the transient simulations do not indicate that a long-term solution has been reached at the end on one year. The transient simulations should be performed over the 50-year climatic data period of record, or at a minimum until the transient analysis demonstrates an asymptotic stabilization of results.
- Given the apparent need to extend the length of transient runs, the one year of averaged daily climate data may become mute. Actual climate data over the length of transient simulations should be applied as input.
- Present SWCC and unsaturated hydraulic conductivity functions on charts for all of the waste material and the alluvial deposit and bedrock.
- The Heap Leach Facility draindown model should use material typical of leached oxide ore. Alternatively, a review of actual draindown data from similar closed heap leach facilities could be considered.
- Several figures are difficult to read
- For the geochemical component of the model, SRK has recommended further explanation and/or re-visiting of source terms to address potential for local acidification in waste rock and tailings, and scale-up of laboratory leach tests to full scale.

4 REFERENCES

AMEC, 2009, Rosemont Copper Company, Dry stack tailings storage facility, Final design report: unpublished report prepared for Rosemont Copper Company, AMEC Project 842-1191, 54 p, 7 appendices.

Day, S. and Rees, B., 2006, *Geochemical controls on waste-rock dump seepage chemistry at several porphyry mines in the Canadian cordilleran*: paper presented at the 7th International Conference on Acid Rock Drainage (ICARD), March 26-30, 2006, St. Louis MO. R.I. Barnhisel (ed.) Published by the American Society of Mining and Reclamation (ASMR), 3134 Montavesta Road, Lexington, KY 40502.

- Red Chris Development Company Limited, 2004, *Application for Environmental Assessment Certificate for the Red Chris Porphyry Project* (October 2004). Volumes 1 to IV: unpublished report submitted to the British Columbia Environmental Assessment Office, October 2004.
- SRK Consulting, 2010a, Technical review of *Baseline geochemical characterization and Geochemical characterization, Addendum*: unpublished technical memorandum prepared for SWCA reviewing a report prepared by Tetra Tech (2007) for Rosemont Copper Company, February 10, 2010, 12 p.
- _____ 2010b, Technical review of *Geochemical pit lake predictive model, Rosemont Copper Project*: unpublished technical memorandum prepared for SWCA reviewing a report prepared by Tetra Tech (2010) for Rosemont Copper Company, April 16, 2010, 11 p.
- Tetra Tech, 2007a, Baseline geochemical characterization, Rosemont Copper: Report prepared for Augusta Resource Corporation, Tetra Tech Project No. 320614, June 2007, 41 p., 2 appendices.
- _____ 2007b, Geochemical characterization, Addendum I, Rosemont Copper: Report prepared for Rosemont Copper Company, Tetra Tech Project No. 320614.100.07, November 2007, 23 p., 2 appendices.
- _____ 2010a, *Geochemical pit lake predictive model, Rosemont Copper Project*: unpublished report prepared for Rosemont Copper, Tetra Tech Project No. 114-320777, February 2010, 33 p., 6 appendices.
- _____ 2010b, *Infiltration, seepage, fate and transport modeling report, Rosemont Copper*: unpublished report prepared for Augusta Resource Corporation, Tetra Tech Project No. 114-320794, February 2010, 68 p., 6 appendices.

5 REVIEWER QUALIFICATIONS

The Reviewer for hydrogeology, Mike Sieber, P.E. is a Hydrogeologist with SRK Consulting in Tucson, Arizona (resume attached). Mr. Sieber is a professional engineer with more than 20 years of experience in the preparing infiltration models to estimate infiltration through tailings impoundments and landfill covers, and numerical groundwater flow models to predict the formation of open pit lake loss of containment pit lake and underground workings. Mr. Sieber's review was under the supervision of Vladimir Ugorets, Ph.D., Principal Hydrogeologist with SRK Consulting in Denver, Colorado.

The Senior Reviewer for geochemistry, Stephen Day, P. Geol., is a Principal Geochemist with SRK Consulting in Vancouver, Canada (résumé attached). Mr. Day has more than 30 years of experience in geochemistry; in particular, he has more than 10 years of experience in the development of waste management plans to address acid rock drainage and leaching of mine wastes in general, as related to hard rock mining. One area of Mr. Day's expertise relevant to the present review is in the development of prediction methods for mine planning and modeling of leachate chemistry. Mr. Day was directly responsible for reviewing the geochemistry of the pit lake predictive model.