

Technical Memorandum

To:	Kathy Arnold	From:	Mark Williamson
Company:	Rosemont Copper Company	Date:	November 16, 2010
Re:	Response to Comments on February 2010 Geochemical Pit Lake Predictive Model Report	Doc #:	266/10-320884-5.3
CC:	David Krizek, P.E.; Amy Hudson; Michael Gabora (Tetra Tech)		

1.0 Introduction

SRK Consulting (SRK, 2010) prepared a review of the February 2010 report titled *Geochemical Pit Lake Predictive Model* (Tetra Tech, 2010a). This pit lake modeling report was prepared for the proposed Rosemont Copper Project (Project) on behalf of the Rosemont Copper Company (Rosemont). This Technical Memorandum provides a response to SRK's comments. The responses address the specific comments either by:

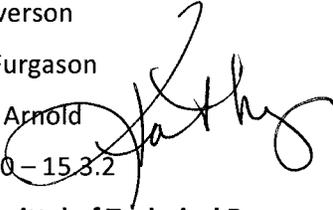
- Describing updates to the February 2010 *Geochemical Pit Lake Predictive Model* report (Tetra Tech, 2010a) made in the November 2010 *Geochemical Pit Lake Predictive Model – Revision 1* report (Tetra Tech, 2010b); or
- Providing reference material intended to provide clarity for reviewers, but not deemed necessary for inclusion in the updated report itself.

The material presented below attempts to follow the text sections provided in the SRK's review comments memo (SRK, 2010). SRK's review comment text is italicized and underlined for clarity, followed by Tetra Tech's response (non-italicized). SRK review comments are provided in Attachment 1.

2.0 Pit Lake Water Balance

The February 2010 *Geochemical Pit Lake Predictive Model* report (Tetra Tech, 2010a) used pit lake refill data derived from the 2009 Montgomery & Associates (M&A, 2009) regional groundwater flow model. The November 2010 *Geochemical Pit Lake Predictive Model – Revision 1* report (Tetra Tech, 2010b) used pit lake refill data based on the regional groundwater flow model developed by Tetra Tech (Tetra Tech, 2010c). Accordingly, specific review comments related to information derived from the 2009 M&A report were not included in the revised pit lake report (Tetra Tech, 2010b) or in this Technical Memorandum. However, comments regarding specific information requests, including clarifying any confusion regarding units or apparent data inconsistencies, have been addressed within the updated report (Tetra Tech, 2010b) or within this Technical Memorandum.

Memorandum

To: Bev Everson
Cc: Tom Furgason
From: Kathy Arnold 
Doc #: 045/10-15.3.2
Subject: **Transmittal of Technical Responses and Reports**
Date: November 18, 2010

Rosemont is pleased to transmit the following documents:

- *Response to SRK's Technical Review Comments to Tetra Tech's Groundwater Flow Model*, Technical Memorandum, Tetra Tech, November 17, 2010
- *Response to comments on February 2010 Geochemical Pit Lake Predictive Model Report*, Technical Memorandum, Tetra Tech, November 16, 2010
- *Geochemical Pit Lake Predictive Model – Revision 1 (includes DSM Input/Output Files in electronic format)*, Tetra Tech, November 2010

Rosemont is providing three hardcopies and two disk copies for the Forest and two hardcopies and one disk copy for SWCA of the technical memos. Copies of the reports are provided in a hardcopy format with the disk copies enclosed in the same number.

3.0 Dynamic Systems Model (DSM) Integration (Section 2 of the SRK review memo)

SRK is of the opinion that this approach of using precipitation, evaporation, and pit wall runoff as stochastic parameters and combining them with a deterministic relationship between groundwater inflow and pit lake stage ($QGW = f(HPL)$) is very approximate because both groundwater inflow and lake stage depend on these stochastic parameters. It is not clear from the Tetra Tech report how groundwater inflow to the pit lake was simulated (from previous time step based on used relationship $QGW = f(HPL)$, or not?) As mentioned above, it is SRK's opinion that the water-balance components can be evaluated precisely only by using a numerical groundwater model, by simulating pit-lake stage iteratively, and by considering and varying all components of the water balance for the same time period. (SRK)

Groundwater inflow to the pit lake in the Dynamic System Model (DSM) (Tetra Tech, 2010a) was taken directly from the regional groundwater model (M&A, 2009), from which an inflow was established as a function of the pit lake stage (basically head difference between lake surface and surrounding groundwater). The pit lake stage is calculated at each time step within the DSM based on the stochastic parameters of the water balance. The new lake stage determines the groundwater inflow for the next time step (i.e., groundwater inflow is based on the lake stage from the previous time step). The precipitation, evaporation, and pit wall runoff significantly affect the pit lake stage calculation, which in turn can significantly alter the groundwater inflow.

Perturbation of these parameters (precipitation, evaporation, and pit wall runoff) in the regional groundwater flow model could result in changes to recharge and simulated aquifer heads. However, their effect on groundwater inflow would be comparatively minor. Therefore, the pit inflow curve is relatively invariant and the stochastic simulation of evaporation, precipitation, etc., in the DSM provides a useful means to gauge the effects of uncertainty.

The text of the updated pit lake report (Tetra Tech, 2010b) provides an amplified discussion of the integration of hydrologic parameters.

4.0 Geochemical Model (Section 3 of the SRK review memo)

Characterization of Pit Walls. The following questions refer to deposit type. (page 7 of 11)

The deposit type needs to be more fully described because the skarn and porphyry mineralization types have important different implications for geochemical performance. (SRK)

The Rosemont deposit was described in the February 2010 *Geochemical Pit Lake Predictive Model* report (Tetra Tech, 2010a) as a "wall rock porphyry system" in keeping with the description found in the Baseline Geochemical Characterization, Revision 1 report (Tetra Tech, 2007). This description differs from earlier documentation (trip report and sampling and analysis plan) prepared for the Project (Vector, 2006) which described the deposit as a skarn. The Rosemont deposit should be described as a skarn, as evidenced by its overall composition being dominated by alkaline (limestone) host rocks. Therefore, the terminology within the November 2010 *Geochemical Pit Lake Predictive Model – Revision 1* report (Tetra Tech, 2010b) was changed. Attachment 2 includes the Technical Memorandum titled *Preliminary Trip report and Phase 1 Sampling & Analysis Plan* (Vector, 2006).

It was not clear in the description whether classic porphyry hydrothermal alteration (e.g. potassic, argillic, propylitic) is present at Rosemont, which in some porphyry deposits can exert a control on the geochemical characteristics of the pit walls. Vector (2006, p. 2) indicated “most of the porphyry system including the pyrite shell is absent due to structural controls.” (SRK)

A discussion of the mineralogy and alteration types within the Rosemont deposit, as described by Rosemont geologists (Daffron, et al., 2007), does not indicate the presence of classic porphyry hydrothermal alteration. Although such alteration can occur on a very localized level, the distinct clay alteration associated with argillic conditions is not noted.

In addition, although propylitic alteration is not specifically noted (Daffron, et al., 2007), the observed presence of pyrite in the Willow Canyon andesite, along with acid neutralizing capacity (likely calcite), indicates that such alteration is present locally in that unit.

Rosemont geologists (Daffron, et al., 2007), indicate that approximately 50% of the andesite is barren of pyrite, suggesting it had either been oxidized or that propylitic alteration was absent to begin with. The portions of the andesite that were observed to contain pyrite indicated estimates in the borehole logs of 1-3% pyrite, with 2% pyrite being an average observation in these select locations. Additionally, some andesite samples tested (Daffron, et al., 2007) included up to 4% pyrite. It should be noted that andesite comprises approximately only 0.9% of the projected ultimate pit wall surface and 6% of projected waste rock. Attachment 3 includes the report titled *Geologic Report, ReLogging Program at the Rosemont Porphyry Skarn Copper Deposit* (Daffron, et al., 2007).

The Tetra Tech (2010) report lacks a mineralogical description of the supergene zone, which could have different geochemical characteristics from the hypogene zone. (SRK)

Rosemont geologists (Daffron, et al., 2007) describe chalcocite and covellite as potential supergene sulfides, although they also indicate that these minerals may also be associated with the hypogene environment. Supergene oxides are present and correspond to the wide range of such phases commonly associated with copper deposits (e.g., azurite, malachite). Chalcopyrite, sphalerite, and molybdenite predominate the hypogene ore mineralogy, with noted minor pyrite.

The distinction of supergene and hypogene is not currently expressly mapped in the deposit.

Characterization of Pit Walls (continued). These questions refer to sample coverage. (page 7 of 11)

Samples were dominantly collected from drilling focused on the core of the deposit. Depending on the type, intensity, and distribution of alteration, the assumption that the samples can be used to characterize the pit walls needs to be investigated. Should a “pyrite halo” be present, it is possible the pit walls have a different style of mineralization from the core of the deposit used to characterize the rock types. Conversely, mineralization intensity may decrease near the pit walls. (SRK)

Descriptions of the Rosemont deposit mineralogy and alteration by Rosemont geologists (Daffron, et al., 2007) do not indicate the presence of a pyrite halo. Limited occurrence of

pyrite in the Willow Canyon andesite is noted, and to a limited extent in some of the other principal rock types such. In general, the deposit is described as containing very low pyrite, suggesting the absence of a pyrite halo.

Additional sampling has been completed since publication of the *Baseline Geochemical Characterization, Revision 1* report (Tetra Tech, 2007). The spatial extent of the waste rock and pit wall rock sampling is described in the Technical Memorandum titled *Rosemont Geochemical Sample Selection* (Tetra Tech, 2010d). The spatial distribution of the samples collected during the 2007 geochemical characterization program (Tetra Tech, 2007), and the samples collected in addition to the 2007 samples, indicate an adequate distribution of the samples selected to represent the ultimate pit wall rocks. Attachment 4 includes the Technical Memorandum titled *Rosemont Geochemical Sample Selection* (Tetra Tech, 2010d).

Since lead and zinc vein mineralization can be associated with distal propylitic porphyry alteration and skarn mineralization, the statistical characterization of metal distribution in the pit walls should be considered in addition to acid rock drainage (ARD) potential. (SRK)

Lead phases are not noted to be present in the Rosemont deposit. Although they may have the potential to occur on a local scale, their lack of description by Rosemont geologists (Daffron, et al., 2007) indicate they would not be considered a feature that could exert appreciable influence. Sphalerite mineralization is noted in the hypogene zone of the deposit.

Owing to the dominantly alkaline nature of the deposit, most metals are conceptually expected to have very limited mobility and solubility. Thus, a statistical characterization of their distribution in pit walls is unlikely to have a substantial positive contribution to characterization. The statistical evaluation of acid-base potential tends to address pH considerations, which is the dominant geochemical parameter influencing pit lake water quality (at Rosemont and elsewhere).

The statistical evaluation should be extended to consider hydrothermal alteration as a variable. (SRK)

Hydrothermal alteration is not expressly mapped in the deposit.

The characteristics of wall rock oxide materials should be provided. (SRK)

Characteristics of wall rock oxide minerals are not mapped.

Characterization of Pit Walls (continued). These questions refer to acid-base accounting. (page 7 of 11 and page 8 of 12)

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. (SRK)

As noted in SRK's review (SRK, 2010), "the water is expected to be basic" and not acidic. 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 preponderance of rock with uncertain ARD potential, is not deemed likely to have a useful impact in refining pit lake water quality predictions at the Rosemont site.

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. (SRK)

As described in the *Baseline Geochemical Characterization, Revision 1* report (Tetra Tech, 2007), acid potential (AP) was calculated using sulfide sulfur. To the extent that soluble sulfur may be present in the form of acid-producing water soluble salts, their potential effect was characterized in both long-term humidity cell tests (HCTs) and in short-term leaching tests (e.g., Synthetic Precipitation Leaching Procedure, SPLP). Thus, their possible (and likely) presence is characterized, as is their contribution to net AP, through initial humidity cell rinsates and in the SPLP results.

The geochemical characterization addendum report (Tetra Tech, 2007) discusses the stoichiometry of sulfate release in HCTs relative to the release of calcium and magnesium. That discussion notes that the 1:1 correspondence for release stoichiometry for the Rosemont tests is consistent with the dissolution of gypsum. The 2:1 correspondence is more consistent with the neutralization of the products of pyrite oxidation, which can be expected to include the family of acid generating sulfate salts. However, this 2:1 correspondence is lacking at Rosemont.

Gypsum is a water-soluble sulfate, although the rate of its dissolution is slow relative to that of acid-producing iron sulfates such as jarosite. Thus, the sustained low releases of sulfate, with the 1:1 release stoichiometry, are consistent with gypsum dissolution and inconsistent with rapidly dissolving acid sulfate salts. Therefore, any potential small contributions to AP from acid sulfate salts (to the extent that they exist) appear to be dwarfed by the abundant acid neutralizing capacity of the rocks at Rosemont.

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. (SRK)

The Sobek neutralization potential (NP) test was designed and is used to provide an empirical measurement of the neutralization capacity of rock. Although it is true that silicate minerals can react to neutralize acidity, this only adds to the capacity of any non-ferrous carbonate to do so. Silicate minerals most capable of neutralizing acidity during NP lab measurements will favor mafic, high temperature phases that are volcanogenic in origin (e.g., biotite, olivine). With the exception of andesite, these silicate minerals are not

associated with most of the rocks at Rosemont. For reference, andesite comprises 0.9% of the projected area of the ultimate pit walls and 6% of the waste rock tonnage.

Siderite, a ferrous carbonate, clearly does not contribute to acid neutralization due to its release of ferrous iron, which will commonly oxidize and hydrolyze (react with water) to generate acidity. Siderite is not reported in the Rosemont deposit and therefore is not expected to play a significant role in predicting the pit lake water quality at Rosemont.

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.” (SRK)

Blast fines are finely divided mine rock. Rock, when tested for acid base accounting, SPLP, and humidity cell testing, is finely ground. When subjected to these standard tests, the effects of being finely ground are empirically incorporated by the procedure. Such finely ground material can contribute to the relatively higher chemical concentrations observed in the initial weeks of a humidity cell test. The data from initial week humidity cell tests (as available) were used in the updated geochemical pit lake model (Tetra Tech, 2010b) to address the contribution of chemical mass from the pit walls (and benches) due to fines and accumulated water soluble salts as they are inundated by the developing pit lake.

Based on these considerations, the application of conventional ARD criteria may need to be re-considered for the site. (SRK)

While the above considerations are largely consistent with fundamental geochemical principles applicable to almost any mining site, nothing has been observed with respect to the Rosemont deposit to suggest that the conventional and standard tools of ARD criteria should be abandoned and re-developed for site-specific application. As noted by reviewers, Rosemont pit water “is expected to be basic” due to the overwhelming mass of acid neutralizing material compared to the limited occurrence of potentially acid generating mine rock (e.g., andesite and miscellaneous limited pyrite occurrences), which comprises only a small proportion of the pit wall and waste rock.

Conceptual Geochemical Model. Suggested considerations (page 8 of 11).

The assumed configuration of broken rock in the pit walls; (SRK)

Modeling of the projected pit lake in the updated geochemical pit lake model (Tetra Tech, 2010b) was modified to incorporate the presence of a damaged rock zone associated with the ultimate pit wall surface. The zone of enhanced fracturing was established/estimated as six (6) feet in depth, with an average porosity of 9% (varied between 2% and 15%). These are relatively arbitrary selections as no formal quantitative geochemical assessments of this feature are available.

The processes leading to leaching of potential contaminants from the pit walls considering the roles of oxidation, dissolution, and water rock interactions; (SRK)

Processes leading to the potential leaching of chemical constituents from the pit walls were addressed in the updated geochemical pit lake model (Tetra Tech, 2010b) by using the results of laboratory testing. For pit walls, which weather with time but receive periodic

rinsing from rain, SPLP test results were used as these tests are consistent with long-term humidity cell test results (or often more concentrated; see Tetra Tech, 2010e). For initial rinsing of the blast affected (fractured) rock zone, i.e., as the developing pit lake inundates pit walls, average initial rinse data from the humidity cells were used.

Initial humidity cell rinse results typically have higher concentrations of chemical constituents and are used to simulate wall rock that has had a considerable time to weather, but without periodic rinsing. In cases where humidity cell data were not available (low to fundamentally absent sulfide sulfur), SPLP results were used. However, the SPLP results were increased 3-fold for major constituents and 2-fold for minor/trace constituents. Attachment 5 includes the Technical Memorandum titled *Rosemont SPLP Usage for Pit Wall Runoff* (Tetra Tech, 2010e).

Mechanisms for attenuation of acidity and metal loadings from pit walls: (SRK)

As an element of conservatism, the updated geochemical pit lake model (Tetra Tech, 2010b) model incorporated no provision for attenuation of either acidity or metals by the pit walls.

The effect of submergence of pit walls by the rising pit lake: (SRK)

The model calculation has been updated in the November 2010 *Geochemical Pit Lake Predictive Model – Revision 1* report (Tetra Tech, 2010b) to include a term for chemical loading due to submergence of pit walls. The updated model includes a damaged rock zone extending six (6) feet into the projected ultimate pit wall surface, with a fracture void space of 10%. This volume is assigned a chemical composition equivalent to the first humidity cell flush. If humidity cell data were not available for the given lithology, the SPLP composition was used and adjusted so that major chemical constituents were increased by a factor of three (3) and trace elements by a factor of two (2).

Geochemical reactions between pit lake and walls: (SRK)

Geochemical reactions between the pit lake and wall are not expected to produce significant effects. Along the same lines of reasoning as the water to rock ratio in laboratory testing, the water to rock ratio in the pit lake is very large, on the order of 500 to one (1) as a minimum. The chemical mass derived from such a large ratio is low relative to the mass derived from inflowing groundwater itself combined with rinsing of the pit walls by rain and the flushing of the damaged rock zone.

The potential role of limnological processes in pit lake development (e.g. meromixis); and (SRK)

Both the February 2010 (Tetra Tech, 2010a) and the November 2010 (Tetra Tech, 2010b) pit lake models assumed that the projected pit lake does not become stratified. The lake was modeled as an oxidized system, allowing the oxidation of iron, the formation of hydrous ferric oxides (HFO), and the attendant adsorption of arsenic (and other chemical species). Although the reports describe the relative depth of the projected pit lake to support stratification, the terminal hydrologic projection of the pit lake would appear to render the issue of stratification somewhat immaterial. Hence, the lake was fundamentally

modeled as fully oxidized. To the extent that the lower portion of the pit may become relatively reduced (relative to the uppermost portion) due to stratification, any HFO that is precipitated and drops into this zone is expected to be unstable and re-dissolve, releasing any adsorbed constituents (also see discussion below). This effect is not expressly modeled or tracked since the projected pit lake is anticipated to be a perpetual hydrologic sink, retaining all chemical mass in the lake (upper oxidized portion as well as the relatively reduced portion). Only the upper oxidized portion will be a point of exposure and therefore only the modeled chemical composition of the oxidized portion was considered.

In the event that chemically reducing conditions develop in the pit lake, the effect on attenuation and mobilization of potential contaminants (e.g. arsenic). (SRK)

Chemically reducing conditions may develop in the pit lake, on a local scale, at depth where the solution is isolated from contact with atmospheric oxygen. However, such a condition is reducing only relative to the upper, exposed portion of the lake. Due to a general lack of organic matter available for introduction into the projected pit lake, truly chemically reducing conditions are not expected and were not incorporated into the February 2010 (Tetra Tech, 2010a) or the November 2010 (Tetra Tech, 2010b) pit lake models.

Under chemically reducing conditions, any hydrous ferric oxides (HFO) forming in the oxidized (upper) portion of the pit lake, that falls to the reducing zone is anticipated to re-dissolve. This would release any associated arsenic onto the surface of HFO. Section 6.0 of the updated pit lake model report (Tetra Tech, 2010b) illustrates both the conservative and adsorption controlled concentrations of arsenic. Under reducing conditions, the conservative representation of arsenic provides an appropriate estimate of concentration.

Pit Wall Source Terms (page 8 of 11 and page 9 of 11)

To address this concern, the pit wall source terms should be re-calculated using an approach that considers scale-up from laboratory to site conditions. The approach could consider differences in solution ratios for extraction tests, or scale-up of kinetic test results. Both approaches should ensure that secondary mineral dissolution controls are incorporated. (SRK)

The Synthetic Precipitation Leaching Procedure (SPLP) results used to represent pit wall runoff are more often than not consistent with, or have higher constituent concentrations than, the long-term humidity cell test (HCT) results and the Meteoric Water Mobility Procedure (MWMP) results (see Tetra Tech, 2010e). These three (3) tests represent water:rock ratios of 20:1 for SPLP, about 1.5:1 for HCT, and 1:1 for MWMP. The results suggest that the leaching behavior of the rock at Rosemont, as tested, is not particularly sensitive to the water rock ratio and that any factor used to scale the leaching test results upward would be arbitrary and inconsistent with the observed results.

However, in general the first flush associated with the humidity cell tests for most, but not all, chemical constituents is elevated relative to the long-term results. These initial flush results were incorporated into the updated pit lake model (Tetra Tech, 2010b) as a loading term to represent leaching of the damaged wall rock zone of the ultimate pit walls and of the blast fines that may be present on the pit benches.

It is not clear what specific geochemical mechanism is responsible for the first flush results as constituents such as calcium and sulfate are observed to be released at a 1:1 ratio in the HCTs, which is consistent with gypsum dissolution. This is opposed to the 2:1 ratio that might be associated with sulfide mineral oxidation (also see discussion above). It is speculated that very finely divided minerals may be responsible (which would be interpreted as a surface area, water:rock ratio control on simple mineral dissolution under the 1:1 release). However, their mass in the ultimate system would be dwarfed relative to the more persistent massive features.

This argues for the use of long-term humidity cell results, which are consistent with the SPLP results. Information provided in the Technical Memorandum titled *Rosemont SPLP Usage for Pit Wall Runoff* (Tetra Tech, 2010e) presents laboratory testing data that suggests scaling approaches that take into account water:rock ratios may not be appropriate at Rosemont. The use of SPLP data appears to scale up the chemical loading observed in the long-term HCT results by at least a factor of two (2) on average, despite the test having a significantly higher water:rock ratio.

The revised source terms should include the potential effect of acidification. It is understood that one of the model runs considered acidification of the Bolsa Quartzite (Tetra Tech, 2010, page 26), but the use of humidity cell data may not be appropriate with scaling of the results to site conditions. (SRK)

To the extent that pronounced acidification has not been observed in any of the laboratory tests, and in agreement with SRK's comment that the ultimate pit lake is anticipated to be alkaline (SRK, 2010), the consideration of a hypothetical acidification would seem arbitrary and inappropriate for the conditions at Rosemont.

The use of sub-detection limit values should be explained. For example, the detection limits for selenium in the SPLPs is 0.04 mg/L, which is well above the water quality standard. The modeling inputs (Tetra Tech, 2010, Appendix D) show a large number of parameters as "0" mg/L. (SRK)

Analytical laboratory reporting limits are practical quantitation limits (PQL) – not method detection limits (MDL), which are indeed occasionally above certain water quality standards that may or may not have application to interpretation of pit lake model results. Inputs to the February 2010 pit lake model (Tetra Tech, 2010a) were assigned a value of zero for concentration values consistently falling below laboratory reporting limits. This was done to specifically avoid the potential effect of evapo-concentration that could result when increasing the concentration of constituents which were “apparently” below detection to detectable model levels. The intention was to avoid producing artificial results that could have commanded more influence on the model results than were supported by the fundamental data. However, in the updated pit lake model runs (Tetra Tech, 2010b), concentration values reported at below laboratory reporting limits were set to ½ the associated values.

The source terms presented are for pit wall runoff. Should that not already be included, additional source terms are needed for: (SRK)

Leaching of oxidized walls that occurs as the pit lake water-level rises; and (SRK)

As previously described, the November 2010 pit lake model (Tetra Tech, 2010b) was updated to include a term for chemical loading from the damaged rock zone as the pit lake develops.

Possible reactions of pit lake water with wall rock due to chemically reducing conditions, should these develop. (SRK)

Aside from sulfide mineral phases, minerals that comprise the bulk of the pit walls (e.g., calcite, silicates) are unresponsive to changing redox conditions, including reducing conditions. Sulfide phases are unstable in oxidizing, wet conditions. Prior to disturbance by mining, most rock, including that which ultimately will comprise the ultimate pit walls at Rosemont, exists in a relatively reduced environment, preserving any sulfide minerals (ore or waste). Development of a pit exposes these materials to oxidizing conditions that can lead to the decomposition of the sulfide phases. Subsequently exposing pit wall rock to reducing conditions would have the anticipated effect of returning them to pre-mining, background conditions, thus stabilizing the sulfides. Other major minerals comprising the anticipated wall rock (e.g., calcite and framework silicates) have very limited reactivity with respect to either oxidizing or reducing conditions.

Pit Lake Water Chemistry (page 9 of 11)

Minerals like barium arsenate, huntite, and magnesite may form theoretically but they rarely form from natural surface waters. Other components may co-precipitate rather than form discrete minerals (e.g. radium sulfate). (SRK)

Although the above statement is true, no mineral phases, other than ferrihydrite and calcite, were calculated to exceed saturation limits as indicated in the February report (Tetra Tech, 2001a). In the updated report (Tetra Tech, 2010b), similar phases were included in the PHREEQC calculations, with the same result. Only ferrihydrite and calcite were calculated to precipitate.

The modeling also incorporated the effect of adsorption by iron oxides. This latter effect may be limited because most of the walls are predicted to be non-acidic and iron solubility will be limited. (SRK)

The limited solubility of iron, due to the non-acidic conditions, is precisely why ferrihydrite precipitates. Thus, this phase becomes available as a phase for adsorption.

Additional clarification is suggested to improve understanding of the model:

- Provide sample calculation of mass balance.
- Update Table 6.02 (Tetra Tech, 2010) to compare mass balance chemistry and chemistry calculated by PHREEQC, to allow the effect of modeling assumptions to be evaluated.
- Provide graphs to illustrate the progress of concentrations as the pit lake fills.
- Provide a culpability analysis to illustrate sources of loading for each parameter in addition to TDS (Tetra Tech, 2010, Illustration 5.05). (SRK)

The updated report (Tetra Tech 2010b) includes graphs of predominate major species to illustrate their increase in concentration over the model timeframe. Arsenic and selenium, as trace elements, are similarly illustrated. These figures show the conservative mass balance of the illustrated chemical constituent. They also show the result of PHREEQC calculations for model years 75, 200, 500, and 1,000, for the highest chemical loading scenario when no attenuation resulted, and for all three (3) chemical loading scenarios when attenuation did result (low, average, and high).

The updated report (Tetra Tech 2010b) also includes an additional table to show the contribution of pit lake chemical constituents from the various loading sources.

For review purposes, it is useful to consider whether the modeled calculations can be reproduced using a simple scoping level calculation. SRK used the various graphical (Illustration 5.03) and tabulated (Table 4.01, 4.02, 4.03) input models in Tetra Tech (2010) and was able to calculate within 5 percent the predicted concentrations of sulfate and chloride in the pit lake at year 200. The calculation confirmed the significance of groundwater in terms of loading contribution. Using the scoping level calculation, it was determined that re-evaluation of source terms to reflect scale-up could lead to pit walls having a greater influence on pit lake chemistry including elements mobile under non-acidic conditions and with limited sorption capacity. For example, sulfate concentrations could be four times those predicted, and based on experience, selenium concentrations will likely be greater than predicted. (SRK)

When source terms are increased the chemical loading to the pit lake would increase. However, the data presented in Tetra Tech (2010e) suggest that leaching characteristics of mine rock at Rosemont do not systematically vary as the water:rock ratio in testing procedures. Therefore, factors commonly used to scale lab tests to alternate field water:rock conditions appear problematic for the Rosemont site. In the absence of a defensible and objective means to scale laboratory results, the model has endeavored to use the widest range of observed test results as were measured in order to provide a sense of variability.

As a further check on the model, the report might consider adding regional comparisons of actual pit lake chemistry, such as that of the ASARCO Mission mine, which has similar pit wall formations and deposit chemistry. (SRK)

Such data for comparable settings could indeed provide a useful perspective for the Rosemont project. However, data for the ASARCO Mission Mine, as well as other regional operations, were not available to Tetra Tech at the time of the initial or revised report.



REFERENCES

Daffron, W.J., Metz, R.A., Parks, S.W. and Sandel-Weiss, K.L. (2007), *Geologic Report, Relogging Program at the Rosemont Porphyry Skarn Copper Deposit*, Augusta Resource Corporation, March 2007.

Montgomery & Associates (M&A) (2009). *Groundwater Flow Modeling Conducted for Simulation of Proposed Rosemont Pit Dewatering and Post-Closure Rosemont Project Pima County, Arizona*. Prepared for Rosemont Copper Company. Report Dated October 28, 2009.

SRK Consulting, Ugorets V. and Day, S. (SRK, 2010). *Technical Review of (Tetra Tech, 2010) Geochemical Pit Lake Predictive Model, Rosemont Copper Project*. Technical Memorandum to Dale Ortman (SWCA). Technical Memorandum Dated May 3, 2010.

Tetra Tech (2007). *Baseline Geochemical Characterization, Revision 1*. Prepared for Rosemont Copper Company. Report Dated September 2007.

Tetra Tech (2010a). *Geochemical Pit Lake Predictive Model*. Prepared for Rosemont Copper Company. Report Dated February 2010.

Tetra Tech (2010b). *Geochemical Pit Lake Predictive Model – Revision 1*. Prepared for Rosemont Copper Company. Report Dated November 2010.

Tetra Tech (2010c). *Regional Groundwater Flow Model*. Prepared for Rosemont Copper Company. Report Dated November 2010.

Tetra Tech, Hudson, A., (2010d). *Rosemont Geochemical Sample Selection*. Technical Memorandum to K. Arnold, Rosemont Copper Company. Technical Memorandum Dated October 26, 2010.

Tetra Tech, Williamson, M., (2010e). *Rosemont SPLP Usage for Pit Wall Runoff*. Technical Memorandum to K. Arnold, Rosemont Copper Company. Technical Memorandum Dated October 26, 2010.

Vector, Arnold, K., (2006). *Preliminary Trip Report and Phase 1 Sampling & Analysis Plan*. Technical Memorandum to J. Sturgis, Augusta Resource Corporation. Dated July 26, 2006.

ATTACHMENT 1

Rosemont Copper Project

Locator Sheet

Record # 013426

Document Date 2010 0503

Document Title: Technical Review of (Tetra Tech, 2010) Geochemical Pit Lake Predictive Model, Rosemont Copper Project

Author/Recipient V. Ugorets, S. Day SRK / Tom Furgason, SWCA

Description Comments are requests for information + recommendations that will clarify the use of output from the groundwater model.

Other Notes Attachment 1 of 013786

This document is located in the following: [CIRCLE THE CATEGORY (from the list below) IN WHICH THIS ITEM IS FILED]

1. **Project Management**
 - a. Formal recommendations & Directions
 - b. Formal meeting minutes & memos
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 - e. Other
2. **Public Involvement**
 - a. Announcements & Public Meetings
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 - g. AZ Dept of Environmental Quality (APP)
4. **Communication**
 - a. Congressional
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 - f. Internal
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5. **Proposed Action**
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 - c. Detailed Designs
 - d. References
6. **Alternatives**
- a. Cumulative Effects Catalog
- b. Connected Actions
- c. Dismissed from Detailed Analysis
- d. Analyzed in Detail
 - i. Barrel McCleary
 - ii. Barrel Only
 - iii. Scholefield McCleary
7. **Resources**
 - a. Air Quality & Climate Change
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 - i. Noise & Vibration
 - j. Public Health & Safety
 - k. Recreation & Wilderness
 - l. Riparian
 - m. Socioeconomics & Environmental Justice
 - n. Soils & Geology
 - o. Transportation & Access
 - p. Visual
 - q. Water
8. **Reclamation**
 - a. Plans & Reports
 - b. Notes & Correspondence
 - c. References
 - d. Other
9. **DEIS**
 - a. DEIS
 - b. References
10. **FEIS**
11. **Geospatial Analysis (GIS Data)**
12. **FOIA Exempt Documents**
13. **ROD (including BLM & ACOE)**

ATTACHMENT 2

Rosemont Copper Project
Locator Sheet

Record # 011908

Document Date 2006 07 26

Document Title: Preliminary Trip Report + Phase I Sampling + Analysis Plan

Author/Recipient Kathy Arnold, Tetra Tech / Jamie Sturgess

Description Objectives of the field trip were to gain familiarity w/site characteristics, including topography, surface water features + geology.

Other Notes Attachment 2 of 013786.

This document is located in the following: [CIRCLE THE CATEGORY (from the list below) IN WHICH THIS ITEM IS FILED]

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|--|--|
| <p>1. Project Management</p> <ul style="list-style-type: none">a. Formal recommendations & Directionsb. Formal meeting minutes & memosc. General Correspondenced. Contracts, Agreements, & MOUs (Rosemont, Udall, SWCA)e. Other <p>2. Public Involvement</p> <ul style="list-style-type: none">a. Announcements & Public Meetingsb. Mailing Listsc. Scoping Period Commentsd. Udall Foundation Working Groupe. Scoping Reportsf. Comments after Scoping Periodg. DEIS Public Comments <p>3. Agency Consultation & Permits</p> <ul style="list-style-type: none">a. Army Corps of Engineers (404 permit)b. US Fish & Wildlife Service (Sec. 7 T&E)c. State Historic Preservation Office (Sec. 106)d. Tribes (Sec. 106)e. Advisory Council on Historic Preservation (Sec. 106)f. Otherg. AZ Dept of Environmental Quality (APP) <p>4. Communication</p> <ul style="list-style-type: none">a. Congressionalb. Cooperating Agenciesc. Organizationsd. Individualse. FOIAf. Internalg. Proponent <p>5. Proposed Action</p> <ul style="list-style-type: none">a. Mine Plan (including compilation)b. Supporting Documentsc. Detailed Designsd. References <p>6. Alternatives</p> | <ul style="list-style-type: none">a. Cumulative Effects Catalogb. Connected Actionsc. Dismissed from Detailed Analysisd. Analyzed in Detail<ul style="list-style-type: none">i. Barrel McClearyii. Barrel Onlyiii. Scholefield McCleary <p>7. Resources</p> <ul style="list-style-type: none">a. Air Quality & Climate Changeb. Biologicalc. Dark Skiesd. Fuels & Fire Managemente. Hazardous Materialsf. Heritageg. Land Useh. Livestock Grazingi. Noise & Vibrationj. Public Health & Safetyk. Recreation & Wildernessl. Riparianm. Socioeconomics & Environmental Justicen. Soils & Geologyo. Transportation & Accessp. Visualq. Water <p>8. Reclamation</p> <ul style="list-style-type: none">a. Plans & Reportsb. Notes & Correspondencec. Referencesd. Other <p>9. DEIS</p> <ul style="list-style-type: none">a. DEISb. References <p>10. FEIS</p> <p>11. Geospatial Analysis (GIS Data)</p> <p>12. FOIA Exempt Documents</p> <p>13. ROD (including BLM & ACOE)</p> |
|--|--|

ATTACHMENT 3

Rosemont Copper Project

Locator Sheet

Record # 012695

Document Date 2007 03

Document Title: Geologic Report, Relogging Program at the Rosemont Porphyry Skarn Copper Deposit, Augusta Resource Corporation

Author/Recipient W.J. Daffron, R.A. Metz, S.W. Parks, K.L. Sandoll-Weiss

Description Cited by Tetra Tech & Montgomery & Associates

Other Notes Attachment 3 of 013786

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 - n. Soils & Geology
 - o. Transportation & Access
 - p. Visual
 - q. Water *ij*
8. **Reclamation**
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9. **DEIS**
 - a. DEIS
 - b. References
10. **FEIS**
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ATTACHMENT 4

Rosemont Copper Project

Locator Sheet

Record # 013838

Document Date 2010 10 26

Document Title: Rosemont Geochemical Sample Selection

Author/Recipient Amy L. Hudson, Tetra Tech

Description Provides additional detail & clarity regarding the approach to sampling and the spatial distribution of the waste rock & pit wall samples. App. 4 of 013786.

Other Notes

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ATTACHMENT 5

Rosemont Copper Project

Locator Sheet

Record # 013839

Document Date 2010 10 26

Document Title: Rosemont SPLP Usage for Pit Wall Runoff

Author/Recipient Mark A. Williamson, Tetra Tech

Description Response to review comments from SRK Consulting regarding Geochemical Pit Lake Predictive Model

Other Notes Attachment 5 of 013786

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