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# Memo

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| **To:** | Dale Ortman, P.E. | **Date:** | April 6, 2011 |
| **From:** | Mike Sieber, P.E. | | |
| **Copy to:** | Tom Furgason, SWCA<br>Cori Hoag, SRK<br>File | **Project #:** | 183101/2500 |
| **Subject:** | Technical Consistency Review of Tetra Tech and Montgomery & Associates Groundwater Models | | |

This memorandum reviews the internal technical consistency of the:

- Tetra Tech numerical groundwater models (Steady-State, Mining Phase, and Post Closure models) and the Tetra Tech report Regional Groundwater Flow Model Rosemont Copper Project dated November 2010 (Tetra Tech, 2010); and the
- Montgomery & Associates (M&A) numerical groundwater model (Steady-State, Transient DRN, and Transient LAK models) and the M&A report Revised Groundwater Flow Modeling Conducted for Simulation of Proposed Rosemont Pit Dewatering and Post-Closure Rosemont Project, dated August 30, 2010 (M&A, 2010).

The purpose for the review is to confirm that the digital input and output files created during the building of the models are consistent with the results of the steady-state and transient models presented by Tetra Tech (Tetra Tech, 2010) and M&A (M&A, 2010).

This review was undertaken and the Technical Memorandum prepared at the request of SWCA and the Coronado National Forest, in accordance with a Technical Review Scope of Work, Request for Cost Estimate and Schedule from Mr. Dale Ortman dated January 10, 2011. This memorandum was prepared by Mike Sieber, P.E. and reviewed by Vladimir Ugorets, Ph.D. Larry Cope of SRK Consulting (U.S.), Inc. (SRK).

## 1 Consistency Review of Tetra Tech Models and Tetra Tech (2010)

Tetra Tech provided SRK their final steady-state, mining phase, and post-closure numerical model files for SRK to review with Groundwater Vistas version 5.51 software, (Rumbaugh and Rumbaugh 2007). SRK opened the three models and checked the consistency with what was described in Tetra Tech (2010).

The steady-state model was checked for consistency of discretization; values for hydraulic conductivity on various layers, boundary conditions, recharge, evapotranspiration, groundwater/stream flow interaction parameters, the horizontal flow barrier hydraulic properties, and mass balance. The initial and calibrated groundwater elevation contours were compared to figures in the report (Tetra Tech, 2010). SRK's review of the steady-state model established that the steady-state model was consistent with what was presented in the report (Tetra Tech, 2010).

The transient mining phase model was checked for consistency for values of hydraulic conductivity, storage parameters (specific storage and specific yield), drain cell elevation and conductance values (used to simulate pit excavation), stress period set-up, passive inflow to the pit, and mass balance. SRK's review of the mining phase model established that it was consistent with what was presented the report (Tetra Tech, 2010).

The transient post-closure model was checked for consistency for hydraulic conductivity values, storage parameters (specific storage and specific yield), LAK2 package (Council, 1999) inputs (stage-area relationship) and output (precipitation to and evaporation from the pit lake, pit wall runoff, groundwater inflow, and pit lake elevation), stress period set-up, and mass balance. The post-closure model was consistent with the report (Tetra Tech, 2010). The LAK2 package was not incorporated into the post-closure model but was completed outside of the model. The drawdown contours presented in the report figures (Tetra Tech, 2010) were therefore not available to check for consistency. The figures showing the simulated drawdown shown on Figures 8-5, and 8-10 through 8-13 (Tetra Tech, 2010) were created with GIS using output from two models (personal communication with Grady O'Brien, Tetra Tech, March 16, 2011).

One additional comment on consistency is that Tetra Tech formulated their model using units of meters and days, whereas the report (Tetra Tech, 2010) was in feet and days. SRK checked the values and the unit conversions presented in the report were correct.

## 2 Consistency Review of M&A Models and M&A (2010)

M&A provided SRK with their final steady-state, mining, and closure numerical model files for SRK to review with Groundwater Vistas version 5.51 software (Rumbaugh and Rumbaugh 2007). SRK opened the three simulations and checked for consistency with what was described in the report (M&A, 2010).

The steady-state model was checked for consistency for discretization, values for hydraulic conductivity on various layers, boundary conditions, recharge, evapotranspiration, stream flow parameters and results, and mass balance. M&A utilized an inverse parameter estimation (PEST, Doherty, 2005) subroutine for evaluation of hydraulic conductivity and recharge during the steady-state calibration. The model files are much more complex than the equivalent figures in the report (M&A, 2010). However, the report figures have a range of values for each hydrogeologic unit that are consistent with the steady-state model input files for hydraulic conductivity values. The figure showing the simulated distribution of recharge has a range of recharge values for each recharge zone (M&A, 2010, Figure 93). This was consistent with the model recharge distribution that was generated using PEST. The steady-state model discretization and mass balance are also consistent with M&A (2010). The initial and calibrated groundwater elevation contours were consistent with the figures in the report (M&A, 2010).

It should be noted that the transient model used for calibration to the 30-day pumping test data was not available to SRK and was not reviewed.

The transient mining phase model was checked for consistency for values of hydraulic conductivity, storage parameters (specific storage and specific yield), drain cells parameters and fluxes (simulated pit inflows), and stress periods. SRK's review of the mining phase model established that it was consistent with the report (M&A, 2010). The mining phase model water level contours for the end of mining were consistent with the figure in the report (M&A, 2010).

The transient post closure model was checked for consistency for values of hydraulic conductivity, storage parameters (specific storage and specific yield), LAK2 setup (stage-area relationship) and output (precipitation to and evaporation from the pit lake, pit wall runoff, groundwater inflow, and pit lake elevation), and stress period set-up. The projected groundwater level drawdown for end of mining and at 1,000 years was reviewed. The M&A post-closure simulation is consistent with the report (M&A, 2010). M&A did not present mass balances in the report for their transient simulations, so these were not reviewed by SRK.

## 3 SRK Conclusions

SRK finds the Tetra Tech steady-state, mining phase, and post-closure numerical groundwater models to be consistent with their report (Tetra Tech, 2010).

SRK finds the M&A steady-state, mining phase, and post-closure numerical groundwater models to be consistent with their report (M&A, 2010).

# 4 References

Council, Gregory W. (1999), A Lake Package for MODFLOW (LAK2), Documentation and user's manual Version 2.2: software manual, 137 p.

Doherty, J. (2010), PEST: Model-Independent Parameter Estimation, version 12, Watermark Numerical Computing.

Montgomery & Associates, 2010, Groundwater flow modeling conducted for simulation of proposed Rosemont pit dewatering and post-closure: unpublished report prepared for Rosemont Copper, August 30, 2 vol., 123 p.

Rumbaugh, J.O., and Rumbaugh, D.B., 2007, Groundwater Vistas (Version 5.16): software published by Environmental Simulations Inc., Reinholds, Pennsylvania.

Tetra Tech, 2010, Davidson Canyon hydrogeologic conceptual model and assessment of spring impacts: unpublished report prepared for Rosemont Copper, Tetra Tech Project No. 114-320869, April 2010, 72 p., 1 appendix.

# 5 Reviewer Qualifications

The reviewer for hydrogeology, Mike Sieber, P.E., is a Hydrogeologist with SRK Consulting in Tucson. Mr. Sieber is a professional engineer with more than 17 years of hydrogeology experience including 15 years preparing infiltration and seepage models to estimate infiltration through tailings impoundments, waste rock storage and heap leach facilities, and landfill covers. He has more than 10 years experience in the preparation of numerical groundwater flow models to predict the formation of pit lakes and potential loss of containment at open pit and under-ground mining operations.