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Memorandum - DRAFT

To:	Dale Ortman, P.E.	**Date:**	August 2, 2010
cc:	Tom Furgason, SWCA Cori Hoag, SRK File	**From:**	Vladimir Ugorets, Ph.D. Larry Cope, M.S. Mike Sieber, P.E.
Subject:	Review of Tetra Tech (2010) *Hydraulic Property Estimates*	**Project #:**	183101/1800

This memorandum provides a technical review of the Technical Memorandum, *Hydraulic Property Estimates* (Tetra Tech, 2010) dated July 9, 2010, hereafter referred to as the "Technical Memorandum." This review was undertaken, and our Memorandum prepared by Vladimir Ugorets, Larry Cope, and Mike Sieber of SRK Consulting (U.S.), Inc. (SRK), at the request of SWCA and the Coronado National Forest, and in accordance with a Statement of Work and Request for Cost Estimated from Mr. Dale Ortman dated July 18, 2010.

The comments in the present review are grouped into three topics: (1) short-term aquifer test analysis, (2) long-term pumping test analysis, and (3) hydraulic parameters used in the regional groundwater flow model. The Technical Memorandum is well written and the thinking of the authors can be followed in a straight forward manner. The comments presented below are, in general, requests for clarifications and additional detail related to the data applied and the configuration of the radial flow models.

1 Short-Term Aquifer Test Analysis

Tetra Tech re-evaluated the short-term aquifer tests completed by Montgomery & Associates (M&A) in 2007 and 2008 (M&A, 2007, 2009a, 2009b) by using standard straight-line solutions: Copper-Jacob or Theis Recovery. The results of this re-evaluation produced an arithmetic mean of all K values that was 90.9 percent of the M&A values calculated for the same subset of wells. Although there are some significant differences (by factors of up to 5) for several analyses, SRK considers the brief explanations in Attachment 1 (Tetra Tech, 2010) provide adequate rationale for the differences. With the 10 values of greater than a factor of two removed from the mean calculation, the Tetra Tech mean is 94.1 percent of the M&A mean. Given that the large differences do not have much impact on the mean of all the values, further refinement of the some values is not viewed here as warranted. It may be noteworthy that four of the 10 values with large differences used data from the multiple-level vibrating wire piezometers, which can be very interpretive given the difficulty in quantifying how the point pressure measurements relate to the larger (thicker) flow field.

To demonstrate that the re-analysis by Tetra Tech can be compared to the M&A analysis, SRK recommends that Attachment 1 include a column that refers the reader to the figures in the M&A report to show the particular analytical plots. Further, to make the comparisons fully defensible, it is recommended that the Tetra Tech analysis be provided as an additional attachment to the Technical Memorandum.

2 Long-Term Pumping Test Analysis

Tetra Tech completed re-evaluation of three long-term pumping tests (from wells PC-5, HC-1B, and HC-5A) using detailed 2-D radial numerical groundwater models. Their results are shown in their report Tables 1 through 4.

SRK agrees that a 2-D radial model is an appropriate way to evaluate vertical hydraulic conductivity values when pumping from one tested interval, and water levels are monitored in the same interval and in intervals below or above. However, no discussion is provided on the intervals pumped relative to the piezometers being monitored. Though the configuration is implied in Attachment 1, SRK recommends that the text include a description of the configuration and some detail on how the isolation packers were deployed and monitored (given the 60 plus day deployment of the packer, if used).

Figures 3 though8 show reasonably good agreement between observed and modeled drawdowns in the grouted-in piezometer PZ5 and the stand-pipes in PC2, HC-1A, and HC-5B. SRK would like to see a figure for that test cell similar to the Figure 2 cross section. The elevations of the screened intervals and piezometers, and the pumping rates should be listed in a text box on all plots. Tetra Tech should consider adding a right-hand Y-axis showing pumping rates over the duration of pumping. Also, the units on the time axis are not clear. They appear to be in units of "year decimal year," which should be stated in the axis title. Actual dates may be a better presentation.

As pointed out in the Technical Memorandum, faults and discrete linear features are often difficult to represent in a radial model due to the possibility of their incorporation by using a cylindrical shape. It should be noted that such features as a fault and fault-truncated strata are present in the area of pumping well PC-5 and the contact with low permeable pre-Cambrian rocks is present in the vicinity of pumping well HC-1B. To present geological variation between PZ-5 and PC-2 (shown in Figure 2), it appears the model was run for scenarios with and without the Permian formations (Concha, Scherrer, and Epitaph/Colina). The estimated hydraulic parameters for both models are shown in Tables 1 and 2 (by using water level data from piezometers PZ-5 and PC-2, respectively). The results of the estimates for the Willow Canyon Formation (Ksd) are very different (K_h=0.16 feet per day (ft/day) and K_v=2.8 ft/day for piezometer PZ-5, and K_h=0.1 ft/day and K_v=0.006 ft/day for piezometer PC-2). The differences likely indicate the inapplicability of a 2-D radial flow analysis to simulate responses at PC-2 from the pumping of PC-5. To test the viability of the approach taken by Tetra Tech, SRK recommends a simplistic 3-D model (for the pumping area only) to re-evaluate the effects on the hydraulic parameters of the fault and truncated units for pumping test PC-5 and low permeable pre-Cambrian rock in pumping well HC-1B.

From the foregoing discussion, SRK's specific requests are summarized as follows:

1. Include details to show how values for K_v and K_h varied with the placement of packers in pumping well PC-5.
2. List test parameters on Figures 3 through 8 (Q, packer/tested interval).
3. Include figures showing the numerical model grid used to simulate the cross section shown on Figure 2 and the pumping test from well HC-1B.
4. Complete an analysis of the pumping tests from wells PZ-5 and HC-1B by using a simplified 3-D numerical groundwater flow model.

3 Hydraulic Parameters Used in the Regional Groundwater Flow Model

The results of the interpretation of long-term pumping tests by using 2-D radial models indicate that:

a) Horizontal hydraulic conductivity varies from 0.00017 ft/day to 761 ft/day,

b) Vertical hydraulic conductivity varies from 0.0005 ft/day to 0.28 ft/day, and
c) Specific storage was estimated to range from $7x10^{-7}$ 1/ft to 0.0004 1/ft, with a geometric mean of 9x10-6 1/ft (this number was recommended to be applied to all bedrock units within a regional groundwater model).

It should be noted that no values for hydraulic conductivity were recommended as initial input to the regional groundwater model. Given that Tables 1 and 2 provide very different values for K_h and K_v, SRK is uncertain as to how the values will be applied. Part of our uncertainty comes from not clearly understanding the placement of the packer in PC-5, and the manner in which values for both the Concha Limestone and Scherrer Formation are provided in Table 1, even though they may have been producing at the same time from the same packer setting. Thus we are uncertain how vertical conductivities were calculated. Due to these uncertainties, SRK is not able to judge the applicability of a 2-D radial model to serve as input to, and provide transient calibration for a 3-D regional groundwater flow model.

4 References

Errol L. Montgomery & Associates, Inc. (M&A), 2007, Results of drilling, construction, and testing of four pit characterization wells, Rosemont Project, Rosemont Copper Company, Pima County, Arizona: report prepared for Rosemont Copper Company, September 6, 2007, 108 p., 2 appendices.

_____ 2009a, Results of Phase 2 hydrogeologic investigations and monitoring program, Rosemont Project, Pima County, Arizona, Volume 2: Appendices: unpublished report prepared for Rosemont Copper Company, February 26, 2009, variously paginated.

_____ 2009b, Analysis of long-term, multi-well aquifer test, November 2008 through January 2009, Rosemont Project, Pima County, Arizona: unpublished report prepared for Rosemont Copper Company, May 21, 2009, 59 p, 2 appendices.

Tetra Tech, 2010, Technical Memorandum, Hydraulic property estimates, July 9, 2010, 12 p., 1 attachment.

5 Reviewer Qualifications

The Senior Reviewer, Vladimir Ugorets, Ph.D., is a Principal Hydrogeologist with SRK Consulting in Denver, Colorado. Dr. Ugorets has more than 31 years of professional experience in hydrogeology, developing and implementing groundwater flow and solute-transport models related to mine dewatering, groundwater contamination, and water resource development. Dr. Ugorets' areas of expertise are in design and optimization of extraction-injection well fields, development of conceptual and numerical groundwater flow and solute-transport models, and dewatering optimization for open-pit, underground and in-situ recovery mines. Dr. Ugorets was directly responsible for preparation of this memorandum. His resume has been provided to SWCA in prior submissions.