1.0 INTRODUCTION

This technical memorandum responds to the May 3, 2012, Coronado National Forest (Forest) request for additional information on the Rosemont Project groundwater flow models. Groundwater flow models and predictions have been submitted to support the Environmental Impact Statement process by Tetra Tech and Montgomery & Associates (M&A). This memorandum contains information relevant to the Tetra Tech flow model (Tetra Tech, 2010). M&A responses will be provided under separate cover. The original Forest request is provided as Attachment A for reference.

2.0 ADDITIONAL EXISTING SENSITIVITY ANALYSIS HYDROGRAPHS

The Forest requested additional drawdown hydrographs at 15 previously defined locations (Figure 2-1). Hydrographs for the calibrated model simulations were previously submitted for these locations (EA, 2012). This current request was for hydrographs related to results of sensitivity simulations. A large number of sensitivity simulations have been conducted and the results for the most sensitive model parameters are presented in Figures 2-2 to 2-16. These simulations provide the bounding information requested by the Forest.

The hydrographs indicate that there is a limited range in predicted drawdown regardless of the sensitivity simulation. The largest range in simulated drawdown occurs at locations closest to the proposed pit. For example, drawdown at Rosemont Spring 1,000 years after the end of mining was predicted to range between 77 and 97 feet (Figure 2-10).

A summary of drawdown results from the sensitivity simulations are presented in Tables 2-1, 2-2, and 2-3. The earliest and latest time predicted for drawdown to occur and the minimum and maximum drawdown after 1,000 years at each location are provided in Table 2-1. Locations nearest to the Open Pit have the earliest time and largest magnitude drawdown predicted. More
distant locations along Cienega Creek have a wide range of times when drawdown begins, but the drawdown magnitude is consistently small for all simulations.

The specific sensitivity simulations that resulted in the earliest and latest on-set for predicted drawdown at each location are provided in Table 2-2. The calibrated model results are provided for comparison to the sensitivity simulations. The predicted results are most sensitive to changes in aquifer storage and the absence of the Davidson Canyon Dike. Increases and decreases in aquifer storage influence how rapidly drawdown propagates through the groundwater system. The calibrated model used relatively low aquifer storage properties, which results in more rapid drawdown propagation. These results indicate that if aquifer storage is greater than simulated in the calibrated model it will take many more years for drawdown to reach the locations (Table 2-2).

The sensitivity simulations that resulted in the minimum and maximum predicted drawdown at each location are provided in Table 2-3. At most locations the calibrated model predicted the maximum drawdown, which also occurred for several of the sensitivity simulations. The minimum drawdown at each location usually occurred when pit-lake evaporation was decreased. At Empire Gulch Spring the minimum and maximum predicted drawdown were 4.37 feet and 5.95 feet, which is a range of 1.58 feet. The calibrated model resulted in the maximum predicted drawdown at Empire Gulch Spring.

3.0 ADDITIONAL DOCUMENTATION OF WESTERN MODEL BOUNDARY

The Forest request consisted of additional documentation of the western model boundary. The requests and responses are as follows:

- **Request:** “An explanation of why the distance of ½ mile was used to assign general head boundaries along the western boundary of the model.”

- **Response:** Responses to similar requests for additional information on the model boundaries was originally provided in Tetra Tech (2011a) and Tetra Tech (2011b). This response provides additional information that augments these previous technical memorandums.

In the calibrated Tetra Tech model constant-head cells were employed along the western boundary (Tetra Tech, 2010). However, a general head boundary (GHB) with a distance of ½-mile was used in the sensitivity analysis, which was documented in Tetra Tech (2010). These results indicated that there was no significant difference in drawdown predictions between the constant-head and general-head boundary conditions.

The western model boundary was located near the contact between the low permeability bedrock and the higher permeability basin-fill alluvium. Due to the different rock
permeabilities there is a significant change from the large hydraulic gradient in the bedrock to a small gradient in the basin fill (Figure 3-1).

A GHB implementation assumes a linear hydraulic gradient between the physical model boundary (Figure 3-1, location A) and the assigned water-level location (Figure 3-1, location B). The ½-mile distance was selected because this was considered the maximum distance into the basin fill where the linear gradient would still be a reasonable approximation of the natural hydraulic gradient. Using a lower water level in the basin fill would represent a location further to the west (Figure 3-1, location C). Extending the projected boundary more than ½-mile to the west would create an unrealistic gradient between the physical model boundary and the projected boundary (Figure 3-1, location C).

- **Request:** “A map or table that shows simulated outflow from the western boundary of the model (i.e., potentiometric surface and flow vectors).”

**Response:** These results were previously provided to the Forest in a Technical Memorandum (Tetra Tech, 2011a). Attachment B contains relevant excerpts from the original memorandum documenting the requested flow vector and mass balance results. Potentiometric-surface maps for pre-mining, end of mining, and 20, 50, 150, and 1,000 years post closure are provided as Figures 3-2 to 3-7. These maps indicate that the flow directions and gradients at the model boundaries do not change significantly over time.

- **Request:** “The predicted passive inflow to the pit to demonstrate that all inflow would come from groundwater storage.”

**Response:** Groundwater inflows to the Open Pit under mining and post-closure conditions have been provided previously in Tetra Tech (2010) as Figure 8-3 and Figure 8-16. The model’s water balance for steady state, end of mining, and 1,000 years after the end of mining have also been provided previously in Tetra Tech (2010) as Table 8-3. Changes in external boundary flows under mining and post-closure conditions have also been previously provided in Tetra Tech (2011a).

It is assumed that the underlying issue for these requests is related to groundwater capture that occurs due to dewatering the Open Pit and due to the pit lake during post closure. Groundwater capture balances the loss due to dewatering or pit-lake evaporation. In the simulated Rosemont groundwater system capture occurs as decreases in stream flow, decreases in riparian vegetation groundwater use, removal of water from storage, and decreases in flow out of the region. Capture is occurring as a decrease in groundwater outflow through the western model boundary. The previously provided results demonstrate that these processes are occurring and quantify the magnitude of these changes.
The implication that all capture must come from groundwater storage is incorrect. Removing groundwater from storage produces drawdown. The distribution of drawdown has been previously provided for numerous scenarios and times. The volume of water removed from storage decreases with time and distance from the pit. Capture stops when water is no longer removed from storage and this prevents drawdown from further expansion away from the pit. The total capture is equal to the groundwater inflows and for the Tetra Tech model this is approximately 230 gpm at 1,000 years, which has been shown to be steady state.

- **Request:** “The groundwater budget at the end of the mine life and long-term post-mining conditions (1,000 years after mine closure) and changes compared to pre-mining steady state conditions.”

  **Response:** These results were previously provided in the Tetra Tech modeling report as Table 8.3 (Tetra Tech, 2010). The cumulative water balance for steady state, end of mining, and 1,000 years post closure are presented as Table 3-1.

### 4.0 ADDITIONAL SENSITIVITY ANALYSIS OF WESTERN MODEL BOUNDARY

A two-step request for additional simulations was made. Responses are provided for each step.

- **Request:** Step 1 was to “… add a well to the steady state simulation, simulating the maximum rate of pit dewatering… compare the two simulations and measure how much of the change to the water balance to accommodate the added stress comes from the artificial boundaries.”

  **Response:** Drain cells, with an elevation of the final predicted pit lake stage, were added to the steady-state model. Drain cells were employed to distribute the groundwater withdrawal over the entire pit area, rather than a few models cells at one location. The drain cell discharge, which is equivalent to groundwater inflow to the pit, was approximately 230 gallons per minute (gpm). This inflow rate was also predicted by the post-closure model that simulated the pit lake with the LAK2 package. This steady-state simulation test adequately replicates the post-closure simulation.

This steady-state simulation with drain cells is a simplified approximation of the physical processes that will occur due to the pit lake. The groundwater model with the more appropriate pit lake simulation is more reliable. The simplified steady-state simulation confirms the pit lake results and confirms that the flow system is at steady-state conditions 1,000 years after mining ends.
Even though the steady-state simulation is an approximation, the water balances are provided and compared as requested (Table 4-1). The pre-mining steady state simulation is compared to the pit-inflow steady state test and to the 1,000-year post-closure simulation. The magnitude and percent change to the various boundary conditions are provided. The steady-state test simulation closely approximates the post-closure simulation. These simulations differ in the amount of recharge applied because the post-closure model simulated the dry stack tailings drain down and recharge due to the flow-through drains.

The pit-inflow steady-state test resulted in a 10.1 percent decrease in outflow through the external model boundaries (Table 4-1). The model boundaries are therefore not significantly impacting the model predictions. At steady state, 374 AF/yr of groundwater capture is simulated. ET losses account for 12.3 percent of this capture. Decreased stream flow accounts for 42.9 percent of the capture. Reduction in outflow through the external model boundaries accounts for 44.8 percent of the capture, which is 168 AF/yr.

**Request:** “Step 2. If the solution to Step 1 indicates more than 10 percent of the added stress comes from the artificial boundaries, then conduct a transient simulation with the boundaries “fixed” or “isolated” with the steady state flow rates.”

**Response:** The results of Step 1 indicate that outflows through the boundaries change 10 percent relative to the pre-mining model. Step 2 is therefore not necessary, however, the request is discussed for completeness.

Changing the western model boundary to a specified constant flux does not result in a realistic simulation of the natural processes occurring due to the Open Pit. A constant-flux boundary would represent an additional hydrologic sink in the groundwater system and would grossly over predict impacts. Dewatering results in the groundwater divide moving to the west and lowering due to drawdown. This decreases the hydraulic gradients to the west, which naturally decreases the outflows through the western boundary. A constant flux boundary does not account for this change in hydraulic gradient and is an inappropriate model configuration. Step 2 was therefore not attempted as requested since the results would be misleading and inaccurate.

The Forest’s concern that the western model boundary is inappropriately influencing the model predictions has been shown to be unwarranted. However, an additional sensitivity run was completed to simulate lower bedrock permeability in the Santa Rita Mountains. This simulation further reduces the influence of the western boundary by further decreasing westerly flow. This configuration decreases groundwater capture from the western model boundary and forces additional groundwater capture from the Cienega Creek basin. Predicted drawdown at 1,000 years is shown in Figure 4-1 and it indicates a minor increase in drawdown relative to the post-closure model. The 5-foot drawdown
Response to May 3, 2012 Forest Service Request for Groundwater Model Information

contour was predicted to move a maximum of about 0.7 miles further down Davidson Canyon with the lower permeability simulation. These results further confirm that the western model boundary is not unduly influencing the model predictions.

5.0 REFERENCES


TABLES
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<tr>
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**NOTES:**

¹ Parameter used in base simulation was changed by a factor of 2.
² Parameter used in base simulation was changed by a factor of 10.
³ Pit evaporation used in base simulation was decreased by 20%.

Engineering Analytics, Inc.
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1. Specific Storage Decreased
2. Specific Yield Decreased
3. Specific Yield Increased
4. Specific Storage Decreased
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NOTES:
¹ Parameter used in base simulation was changed by a factor of 2.
² Parameter used in base simulation was changed by a factor of 10.
³ Pit evaporation used in base simulation was decreased by 20%.
### Table 3-1. Mass Balance for Predictive Simulations

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<td>Recharge - All Sub-basins</td>
<td>9,907</td>
<td>9,907</td>
<td>10,099</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td><strong>OUT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evapotranspiration</td>
<td>5,637</td>
<td>5,591</td>
<td>5,619</td>
<td>-46</td>
<td>-0.8%</td>
</tr>
<tr>
<td>Streams</td>
<td>2,618</td>
<td>2,457</td>
<td>2,558</td>
<td>-161</td>
<td>-6.1%</td>
</tr>
<tr>
<td>Boundary</td>
<td>1,652</td>
<td>1,485</td>
<td>1,548</td>
<td>-168</td>
<td>-10.1%</td>
</tr>
<tr>
<td>Groundwater Flow to Pit</td>
<td>0</td>
<td>374</td>
<td>371</td>
<td>374</td>
<td>--</td>
</tr>
<tr>
<td>Change in Storage</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td><strong>IN - OUT</strong></td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PERCENT DISCREPANCY</strong></td>
<td>0</td>
<td>0</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Positive indicates flow out of model domain is increasing, negative indicates flow out of model domain is decreasing.
FIGURES
Figure 2-1. Hydrograph Locations

<table>
<thead>
<tr>
<th>Hydrograph Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Empire Gulch Spring</td>
</tr>
<tr>
<td>2</td>
<td>Confluence of Gardner Canyon and Cienega Creek</td>
</tr>
<tr>
<td>3</td>
<td>Confluence of Davidson Canyon and Cienega Creek</td>
</tr>
<tr>
<td>4</td>
<td>Gaging Station #09484560</td>
</tr>
<tr>
<td>5</td>
<td>Gaging Station #09484550</td>
</tr>
<tr>
<td>6</td>
<td>Reach 2 Spring</td>
</tr>
<tr>
<td>7</td>
<td>Fig Tree Spring</td>
</tr>
<tr>
<td>8</td>
<td>Scholefield Spring</td>
</tr>
<tr>
<td>9</td>
<td>Rosemont Spring</td>
</tr>
<tr>
<td>10</td>
<td>Sycamore Spring</td>
</tr>
<tr>
<td>11</td>
<td>Ruelas Spring</td>
</tr>
<tr>
<td>12</td>
<td>Helvetia Spring</td>
</tr>
<tr>
<td>13</td>
<td>Corona De Tucson Residences</td>
</tr>
<tr>
<td>14</td>
<td>Singing Valley North Residences</td>
</tr>
<tr>
<td>15</td>
<td>Hilton Road Residences</td>
</tr>
</tbody>
</table>

Explanation

- ▲: Hydrograph Location and Identifier
- Model Boundary
- Extent of Ultimate Pit
- Dry Stack Tailings and Waste Rock Facilities
- Watershed Boundary
- Perennial Streams
- Ephemeral Streams
- Highway
- Secondary Road

File: T:\GIS\Projects\110130\Figures\HydrographLocations.mxd UTM NAD 83 Zone 12 N

June 28, 2012
FIGURE 2-2. SENSITIVITY OF PROJECTED DRAWDOWN AT EMPIRE GULCH SPRING (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-3. SENSITIVITY OF PROJECTED DRAWDOWN AT CONFLUENCE OF GARDNER CANYON AND CIENEGA CREEK (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-4. SENSITIVITY OF PROJECTED DRAWDOWN AT CONFLUENCE OF DAVIDSON CANYON AND CIENEGA CREEK (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-5. SENSITIVITY OF PROJECTED DRAWDOWN AT CIENEGA CREEK GAGING STATION #09484560 (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-6. SENSITIVITY OF PROJECTED DRAWDOWN AT CIENEGA CREEK GAGING STATION #09484550 (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-7. SENSITIVITY OF PROJECTED DRAWDOWN AT REACH 2 SPRING IN DAVIDSON CANYON (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.

EXPLANATION
- Projected Drawdown, Base Simulation
- Earliest Projected Drawdown, No Davidson Canyon Dike
- Latest Projected Drawdown, Specific Storage Increased
- Minimum Projected Drawdown, Pit Evaporation Decreased
- Maximum Projected Drawdown, Base Simulation
- Projected Drawdown for Other Sensitivity Simulations
FIGURE 2-8. SENSITIVITY OF PROJECTED DRAWDOWN AT FIG TREE SPRING (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.

EXPLANATION
- Projected Drawdown, Base Simulation
- Earliest Projected Drawdown, Specific Storage Decreased
- Latest Projected Drawdown, Specific Storage Increased
- Minimum Projected Drawdown, Pit Evaporation Decreased
- Maximum Projected Drawdown, Specific Yield Decreased (Alluvium)
- Projected Drawdown for Other Sensitivity Simulations
FIGURE 2-9. SENSITIVITY OF PROJECTED DRAWDOWN AT SCHOLEFIELD SPRING (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-10. SENSITIVITY OF PROJECTED DRAWDOWN AT ROSEMONT SPRING (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-11. SENSITIVITY OF PROJECTED DRAWDOWN AT SYCAMORE SPRING (TETRA TECH, 2010)

EXPLANATION

- Projected Drawdown, Base Simulation
- Earliest Projected Drawdown, Specific Storage Decreased²
- Latest Projected Drawdown, Specific Storage Increased²
- Minimum Projected Drawdown, Pit Evaporation Decreased¹
- Maximum Projected Drawdown, Specific Yield Decreased¹ (Alluvium)
- Projected Drawdown for Other Sensitivity Simulations

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.

File: P:\projects\1101952.02.7\Sensitivity\Hydrograph_SycamoreSpring.grf
**FIGURE 2-12. SENSITIVITY OF PROJECTED DRAWDOWN AT RUELAS SPRING (TETRA TECH, 2010)**

**NOTES:**
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.

**EXPLANATION**
- Projected Drawdown, Base Simulation
- Earliest Projected Drawdown, Specific Storage Decreased
- Latest Projected Drawdown, Specific Storage Increased
- Minimum Projected Drawdown, Pit Evaporation Decreased
- Maximum Projected Drawdown, No Davidson Canyon Dike
- Projected Drawdown for Other Sensitivity Simulations
FIGURE 2-13. SENSITIVITY OF PROJECTED DRAWDOWN AT HELVETIA SPRING (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-14. SENSITIVITY OF PROJECTED DRAWDOWN AT CORONA DE TUCSON RESIDENCES (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-15. SENSITIVITY OF PROJECTED DRAWDOWN AT SINGING VALLEY NORTH RESIDENCES (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
FIGURE 2-16. SENSITIVITY OF PROJECTED DRAWDOWN AT HILTON ROAD RESIDENCES (TETRA TECH, 2010)

NOTES:
1) Parameter used in base simulation was changed by a factor of 2.
2) Parameter used in base simulation was changed by a factor of 10.
3) Pit evaporation used in base simulation was decreased by 20%.
Linear hydraulic gradient approximates natural observed gradient

Linear hydraulic gradient deviates from natural gradient

Figure 3-1. Section illustrating hydraulic gradients and GHB implementation along the western model boundary
Figure 3-2. Simulated Groundwater Level Contours, Pre-Mining Conditions
Minimum Groundwater Level = 3,017 feet

EXPLANATION
- Generalized Groundwater Flow Direction
- Simulated Groundwater Level Contour, in feet
- Model Boundary
- Extent of Ultimate Pit
- No Flow Cell
- Ephemeral Streams

Figure 3-3. Simulated Groundwater Level Contours at End of Mining Operations

File: T:\GIS\Projects\110195\Figures\FS\Request\SimulatedGW_L_EOM.mxd  UTM NAD 83 Zone 12 N
June 28, 2012
Figure 3-4. Simulated Groundwater Level Contours 20 Years After End of Mining Operations
Figure 3-5. Simulated Groundwater Level Contours 50 Years After End of Mining Operations

EXPLANATION
- Generalized Groundwater Flow Direction
- Simulated Groundwater Level Contour, in feet
- Model Boundary
- Extent of Ultimate Pit
- No Flow Cell
- Ephemeral Streams

Pit Lake Elevation = 3,828 feet

File: T:\GIS\Projects\110195\Figures\FSRequest\SimulatedGWL_50YrsPC.mxd

June 28, 2012
Figure 3-6. Simulated Groundwater Level Contours 150 Years After End of Mining Operations

EXPLANATION
- Generalized Groundwater Flow Direction
- Simulated Groundwater Level Contour, in feet
- Model Boundary
- Extent of Ultimate Pit
- No Flow Cell
- Ephemeral Streams

Pit Lake Elevation = 4,093 feet
Figure 3-7. Simulated Groundwater Level Contours 1,000 Years After End of Mining Operations
Figure 4-1. Predicted Groundwater Level Drawdown 1,000 Years After End of Operations (Model Layer 17) With Lower Conductivity Zone
Attachment A –

Forest Service May 3, 2012 Request for Additional Information
Katherine A. Arnold, P. E.
Vice President, Environmental and Regulatory Affairs
Rosemont Copper Company
P. O. Box 35130
Tucson, AZ 85740-3510

Dear Ms. Arnold:

The Coronado National Forest has reviewed the Montgomery and Tetra Tech groundwater flow models commissioned by Rosemont in light of public comments, and in light of further technical review recently conducted by SRK on behalf of the Forest. The Forest has determined that some additional documentation is needed in order to either better describe model results in the EIS, or to ensure that the Forest fully understands the limitations of the models.

Additional Existing Sensitivity Analysis Hydrographs
The Forest is considering revising the presentation of model results in the EIS in order to better describe the uncertainty associated with the groundwater flow models. Specifically, the Forest is considering presenting the upper and lower bounds of the sensitivity analyses as part of the model results.

For instance, instead of stating “Drawdown at Empire Gulch is modeled to be 3.2 feet after 1,000 years, with drawdown beginning approximately 90 years after start of mining,” the Forest is considering stating the following: “Drawdown at Empire Gulch is modeled to be 3.2 feet after 1,000 years; sensitivity analysis shows this drawdown could range from non-existent to XX feet. Drawdown is modeled to begin approximately 90 years after start of mining; sensitivity analysis shows that drawdown could begin from 60 to 120 years after start of mining.”

In a data request to Rosemont on December 20, 2012, the Forest had requested hydrographs for 15 selected monitoring locations. These hydrographs were subsequently provided by Rosemont. In order to better describe the model uncertainty, the Forest requests that additional hydrographs be provided for these same 15 locations, representing the upper and lower bounds of the sensitivity analyses.

Additional Documentation of Western Model Boundary
In the most recent review conducted for the Forest, SRK found that “the use of general head (Montgomery) and constant head (Tetra Tech) boundary conditions along the western model boundary do not invalidate the model and reasonably predict the impacts...” However, SRK also indicated that “the defensibility of the models would be advanced by evaluating in more detail the boundary flux through the western boundary...”

The Forest requests that Rosemont provide for each of the models the following documentation:
• An explanation as to why the distance of ½ mile was used to assign general head boundaries along the western boundary of the model;
• A map or table that shows simulated outflow from the western boundary of the model (i.e., potentiometric surface and flow vectors);
• The predicted passive inflow to the pit to demonstrate that all inflow would come from groundwater storage; and,
• The groundwater budget at the end of the mine life and long-term post-mining conditions (1,000 years after mine closure) and changes compared to pre-mining steady state condition.

Additional Sensitivity Analysis of Western Model Boundary
The Forest also requires an additional sensitivity analysis for the western model boundary, with the intent to ensure that this boundary is not unduly influencing model results. The Forest requests that the following test be conducted:

Step 1. Run a steady state simulation. Then add a well to the steady state simulation, simulating the maximum rate of pit dewatering and run it again. After the second run compare the two simulations and measure how much of the change to the water balance to accommodate the added stress comes from the artificial boundaries. If results are less than 10 percent, no further testing is needed.

Step 2. If the solution to Step 1 indicates that more than 10 percent of the added stress comes from the artificial boundaries, then conduct a transient simulation with the boundaries "fixed" or "isolated" with the steady state flow rates. In other words, change every constant head and general head boundary cell to a specified flux boundary, with the flux rate identical to the boundary fluxes in the original steady state scenario, so that no additional water can be introduced through the external boundaries. A cone of depression not influenced by an artificial influx of water may be produced in this manner.

Please provide the Forest with the following documentation:
• The water balances from the two steady state simulations conducted under Step 1.
• If the transient simulation is conducted under Step 2, provide 1) contour maps similar to those produced for the previous modeling reports for various time steps (end of mining, 20, 50, 150, 1,000 years), and 2) hydrographs for the 15 monitoring locations previously requested.

Thank you for your continued assistance in providing information needed for the analysis of your proposal. I would like to ask that you keep me apprised of the anticipated timeframes for completion of these tasks. If you have questions, contact Mindee Roth, who will coordinate with specialists from the Forest and/or SWCA to provide any clarification that may be required. Ms. Roth can be reached at (520) 388-8319 or mroth@fs.fed.us.

Sincerely,

JIM UPCHURCH
Forest Supervisor
Attachment B –

Excerpts from Technical Memorandum to Kathy Arnold from Grady O'Brien (EA) and Paul Ridlen (Tt), titled "Rosemont Response to FS/BLM Comments on Tetra Tech Groundwater Model" Dated May 6, 2011.
Legend

- **Perennial Stream**
- **Ephemeral Drainage**
- **Railroad**
- **Towns**
- **Quartz Porphyry Dike**
- **Roads**

Groundwater Flow Direction and Velocity (ft/d)

- 0.0001
- 0.0001 - 0.001
- 0.001 - 0.01
- 0.01 - 0.1
- 0.1 - 1
- > 1

**ROSEMONT COPPER**

FIGURE ES-2 A
SIMULATED STEADY-STATE FLOW DIRECTION AND VELOCITY

Project No: 114-320874

April 2011
Corona de Tucson

Legend

- Perennial Stream
- Ephemeral Drainage
- Railroad
- Towns
- Quartz Porphyry Dike

Groundwater Flow Direction and Velocity (ft/d)

- 0.001
- 0.001 - 0.01
- 0.01 - 0.1
- 0.1 - 1
- >1

FIGURE ES-2 B
SIMULATED FLOW DIRECTION AND VELOCITY DURING MINING

TETRA TECH
ROSEMONT COPPER

Project No: 114-320874

April 2011
Groundwater Flow Direction and Velocity (ft/d)

- < 0.0001
- 0.0001 - 0.001
- 0.001 - 0.01
- 0.01 - 0.1
- 0.1 - 1
- > 1

Legend

Perennial Stream
Ephemeral Drainage
Railroad
Towns
Quartz Perphyry Dike

FIGURE ES-2 C
SIMULATED FLOW DIRECTION AND VELOCITY
20 YEARS POST-MINING
**Legend**

- **Perennial Stream**
- **Ephemeral Drainage**
- **Railroad**
- **Quartz Porphyry Dike**
- **Proposed Rosemont Open Pit**
- **Towers**

**Groundwater Flow Direction and Velocity (ft/d)**

- > 0.0001
- 0.0001 - 0.001
- 0.001 - 0.01
- 0.01 - 0.1
- 0.1 - 1
- > 1

**FIGURE ES-2 D**

SIMULATED FLOW DIRECTION AND VELOCITY

1000 YEARS POST-MINING

April 2011