TECHNICAL MEMORANDUM

DATE: August 18, 2011

TO: Katherine Arnold
ROSEMONT COPPER

FROM: Hale Barter and Jonathan Whittier
MONTGOMERY & ASSOCIATES

SUBJECT: ROSEMONT PIT BACKFILL SIMULATION

SUMMARY

At the request of Rosemont Copper, Montgomery & Associates (M&A) evaluated waste rock backfilling of the Rosemont pit using the Rosemont pit-dewatering groundwater flow model. For this evaluation, the final backfill surface is assumed to not rise above the equilibrium pit lake elevation, which maintains the pit as a hydraulic sink due to lake evaporation. Backfill of the pit void reduces post-mining groundwater inflow to the pit. Projected results for the 1,000-year post-mining period indicate the decreased groundwater inflow due to pit backfilling resulted in negligibly less groundwater level drawdown compared to the base simulation without backfill.

MODEL MODIFICATION

The revised Rosemont pit-dewatering model (M&A, 2011), which simulated pit-lake development commencing immediately after cessation of mining, was modified to simulate pit backfilling during the first years after end of mining. The following assumptions were used to develop the backfill model simulation:

- The pit would be backfilled with waste rock to approximately 4,199 feet above mean sea level (msl), an elevation near the projected 4,208 feet msl equilibrium lake stage (determined from the base simulation without backfill; M&A, 2011).
- Volume of waste rock backfilled to the 4,199 feet msl pit elevation is approximately 3.58 billion cubic feet.
- Waste rock compressed porosity is estimated at 30 percent (provided by Rosemont Copper); therefore, backfill void space is approximately 1.07 billion cubic feet.
- Based on projected groundwater inflows from the base simulation without backfill, groundwater inflow is estimated to fully saturate backfill void space approximately 38 years after end of mining.
• Backfill rate will be sufficient to stay ahead of the rising groundwater level in the backfill; therefore, evaporation will not occur during the 38-year backfill saturation period (“pre-lake period”).
• Inflow to the backfill will be from groundwater and precipitation recharge. It is assumed 30 percent of precipitation falling on the pit watershed capture area will recharge the backfill during the pre-lake period.

The MODFLOW Lake Package, LAK2 (Council, 1999) was adapted to simulate the 38-year pre-lake period with the following input changes from the base simulation:

• An additional inflow source equivalent to 70 percent of the backfilled volume was added to the lake package for the 38-year pre-lake period. This volume is a surrogate for the solid portion of the pit backfill, resulting in groundwater inflow being reduced during the 38-year pre-lake period in the same manner as would occur during actual backfilling.
• Lake evaporation was set to zero during the pre-lake period.
• Thirty percent of precipitation falling on the pit watershed capture area is simulated as inflow in the lake package; this represents runoff recharge and direct recharge to the backfill.
• Post-mining years 39 through 1,000 are unchanged from the base simulation.

RESULTS

Results are presented for the pit backfill simulation in comparison to the revised 2011 model results (M&A, 2011).

**Pit Lake Formation**

Projected pit lake water balance for the 1,000 year post-closure simulation period is shown on Figure 1. A comparison of the projected backfill simulation lake water balance to the base simulation without backfill is tabulated below, for the end of the 1,000 year post-mining period.

<table>
<thead>
<tr>
<th></th>
<th>BACKFILL/PIT LAKE SIMULATION AT 1,000 YEARS</th>
<th>PIT LAKE BASE SIMULATION AT 1,000 YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater Inflow</td>
<td>95 gpm</td>
<td>95 gpm</td>
</tr>
<tr>
<td>Evaporation</td>
<td>489 gpm</td>
<td>489 gpm</td>
</tr>
<tr>
<td>Precipitation</td>
<td>217 gpm</td>
<td>217 gpm</td>
</tr>
<tr>
<td>Runoff</td>
<td>176 gpm</td>
<td>176 gpm</td>
</tr>
<tr>
<td>Lake Stage</td>
<td>4,208 feet msl</td>
<td>4,208 feet msl</td>
</tr>
</tbody>
</table>

gpm = gallons per minute

Lake balance results for the two simulations are the same at the end of the 1,000 year post-mining period and the backfilled pit will remain a hydraulic sink due to the existence of the
evaporative lake. Over the 1,000 year post-mining period the decrease in groundwater inflow to the backfilled pit compared to the base simulation is approximately 6,000 acre-feet. This represents a 4.6 percent decrease in groundwater inflow to the pit for the 1,000 year post-mining period compared to the base simulation.

Projected Groundwater Level Drawdown

Projected changes in groundwater level drawdown due to pit backfilling are as follows:

- 20 years after mine closure (2052), projected 5, 10, and 100-foot groundwater level drawdown contours for the backfilled pit are essentially unchanged from the base simulation, as shown on Figure 2.

- 150 years after mine closure (2202), projected extents of groundwater level drawdown contours for the backfilled pit compared to the base simulation decrease slightly, as shown on Figure 3. Projected maximum extent of the backfilled pit 5-foot groundwater level drawdown contour decreases from approximately 9.6 miles (base simulation) to 9.2 miles east-northeast from the proposed pit along Davidson Canyon. Extents of the 10- and 100-foot drawdown contours decrease by smaller distances.

- 1,000 years after mine closure (3032), projected 5, 10, and 100-foot groundwater level drawdown contours for the backfilled pit are essentially unchanged from the base simulation, as shown on Figure 4.

SUMMARY

Over the 1,000 year post-mining period model projections indicate backfilling of the pit will result in a negligible decrease in groundwater level drawdown, compared to the base simulation without backfilling. This small decrease can be attributed to the relatively small decrease in groundwater inflow which will occur due to backfilling. These projected results would change negligibly if the porosity of the waste rock or pre-lake backfill recharge rate were varied from what is simulated.

REFERENCES


During first 38 years of the backfill simulation a pit lake does not exist. "Runoff" during this period represents total recharge from precipitation to pit catchment area; "Lake Stage" represents groundwater level in backfill; Direct "Precipitation" to lake surface is zero; and "Evaporation" from lake surface is zero.

**FIGURE 1.** GRAPH OF PROJECTED PIT INFLOW AND OUTFLOW RATES, AND LAKE STAGE, AFTER CESSATION OF MINING OPERATIONS, PIT BACKFILL SIMULATION, ROSEMONT PROJECT
EXPLANATION

- Hydrograph Location
- Contour of Projected Drawdown for Backfill Simulation, in feet
- Contour of Projected Drawdown for Baseline Simulation, in feet
- Ephemeral Drainage Channel
- Perennial Stream Reach
- Perennial Spring or Seep
- Cienega Creek Watershed
- Proposed Rosemont Open Pt
- Extent of Model Domain
- Tailings Impoundment
- Waste Rock Impoundment

PROJECTED GROUNDWATER LEVEL DRAWDOWN 20 YEARS AFTER THE END OF MINING OPERATIONS, WITH PIT BACKFILL

2011

FIGURE 2
FIGURE 3

EXPLANATION

- Hydrograph Location
- Contour of Projected Drawdown for Backfill Simulation, in feet
- Its Contour of Projected Drawdown for Baseline Simulation, in feet
- Ephemeral Drainage Channel
- Perennial Stream Reach
- Perennial Spring or Seep
- Cienega Creek Watershed
- Proposed Rosemont Open Pit
- Extent of Model Domain
- Tailings Impoundment
- Waste Rock Impoundment

PROJECTED GROUNDWATER LEVEL DRAWDOWN 150 YEARS AFTER THE END OF MINING OPERATIONS, WITH PIT BACKFILL

2011

MONTGOMERY & ASSOCIATES
Water Resource Consultants
EXPLANATION

- ▲ Hydrograph Location
- 100 Contour of Projected Drawdown for Backfill Simulation, in feet
- 100 Contour of Projected Drawdown for Baseline Simulation, in feet
- ♦ Ephemeral Drainage Channel
- Perennial Stream Reach
- Perennial Spring or Seep
- Cienega Creek Watershed
- Proposed Rosemont Open Pit
- Extent of Model Domain
- Tailings Impoundment
- Waste Rock Impoundment

PROJECTED GROUNDWATER LEVEL DRAWDOWN 1,000 YEARS AFTER THE END OF MINING OPERATIONS, WITH PIT BACKFILL

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FIGURE 4

GIS/1232.32/Followup_Aug2011/ProjectedDrawdown_1000yr/EnvMine_rev2.mxd/18Aug2011
Memorandum

To: Bev Everson
Cc: Chris Garrett
From: Kathy Arnold
Doc #: 090/11:352
Subject: Transmittal of Technical Data in Hard Copy and CD Format
Date: 6 September 2011

Rosemont Copper Company is having delivered by courier, the following materials in hard copy and cd format as were previously submitted electronically:

- Equipment Emissions, Summary, Empire CAT, June 27, 2011
- Rosemont Pit Backfill Simulation, Montgomery & Associates, August 18, 2011
- Pit Backfill Simulation, Engineering Analytics, Inc., Technical Memorandum, August 17, 2011
- Predicted Groundwater Level Drawdown 20 Years after End of Operations (Layer 17), Engineering Analytics, Inc., Maps, August 2011
- Comments Regarding Memorandum Safety Bench Alternatives for Rosemont Pit Walls on Face of Santa Rita Mountains, Call & Nicholas, Inc., Memorandum, July 8, 2011
- Response to Golder Comments on Drop Chutes – Site Water Management Update Report, Rosemont Copper Company, Memorandum, June 8, 2011
- Response to SRK Pit Lake Comments, Rosemont Copper Company, Memorandum, May 13, 2011
- Predicted Regulatory (100-Yr) Hydrology and Average-Annual Runoff Downstream of the Rosemont Copper Project, Tetra Tech, Technical Memorandum, July 21, 2011
- Rosemont Facility Infiltration and Seepage Response to Comments, Tetra Tech, Technical Memorandum, April 22, 2011
- Response to Comments – Infiltration, Seepage, Fate and Transport Modeling, Tetra Tech, Technical Memorandum, June 9, 2011
- Additional Rosemont Response to FS/BLM Comments ES-1 on Tetra Tech Groundwater Model, Tetra Tech Technical Memorandum, May 18, 2011
- Response to PCRFC Comments Regarding Hydrology, Tetra Tech, Technical Memorandum, August 18, 2011
• Rosemont Facility Fate and Transport Modeling Response to Comments, Tetra Tech, Technical Memorandum, May 16, 2011
• AERMOD Modeling Analyses for the Alternatives to the Proposed Action for the Rosemont Copper Project, Applied Environmental Consultants, August 15, 2011
• Response to Golder Comments, Rosemont Copper Company, Technical Memorandum, May 6, 2011
• Misc. Docs. Submitted via Email, Rosemont, September 2011 CD

Please do not hesitate to contact me should you require anything further.
August 18, 2011

Mr. Jim Upchurch
Forest Supervisor
Coronado National Forest
300 West Congress
Tucson, Arizona 85701

Re: Analysis of Backfill on Impact on Groundwater

Dear Mr. Upchurch:

During a regularly scheduled status meeting, you requested that Rosemont Copper Company (Rosemont) have the groundwater models run to determine the impact that partial backfill would have on groundwater elevations. Rosemont requested that both models be run to give you a full view of the potential.

Both of these reports are included in this email:
- *Pit Backfill Simulation*, Engineering Analytics, August 17, 2011 (this is the Tetra Tech model)

You will note that in both cases the impact on the groundwater elevations is minimal to nonexistent.

Also included with this transmittal is a replacement figure for the 50-year post closure drawdown. There was an error discovered in the figure when the backfill memo was being completed.

Regards,

Katherine Ann Arnold
Vice President, Environmental and Regulatory Affairs

Cc: Jamie Sturgess, Augusta Resource Corporation
Chris Garrett, SWCA
File

*Doc. No. 80/11-15.3.1*