Assessing Potential Impacts from Underground Mine Dewatering in the Gallup, Dakota, and Westwater Canyon Aquifers with a Basin-Wide Groundwater Flow Model

Dr. John Sigda, Dr. Cheng Cheng, Cynthia Ardito, P.Hg
National Conference on Mining-Influenced Waters
14 August 2014
Acknowledgements

- Michael Neumann and Dan Kapostasy, Energy Fuels Resources, Inc.
- Maryann Wasiolek, Hydroscience Associates, Inc.
- John DeJoia and Juan Velasquez, Roca Honda Resources, LLC
- EIS hydrology technical group
Problem Statement

- Proposed Roca Honda uranium mine required modeling tools to assess dewatering impacts on operations, costs, and scarce water resources
  - Can the Westwater be mined safely and cost-effectively?
  - How much water must be removed?
  - How will proposed dewatering affect rivers, springs, and wells?
Background

- Regional basin
  - 21,000 square miles
  - Spans 4 states
- Intensive historical uranium mining
  - Grants Uranium Mineral Belt
  - 340 million pounds produced 1948-2002
- Dewatering removed 100 billion gallons
San Juan Basin Stratigraphy
SW-NE Cross-Section

Stone et al., 1983; Kernodle, 1996
San Juan Basin Stratigraphy
SW-NE Cross-Section

Stone et al., 1983; Kernodle, 1996
Approach

1. Estimate mine inflows analytically
2. Construct and calibrate 3D numerical groundwater flow modeling tool
3. Confirm mine inflow estimates
4. Construct predictive simulations for scenarios without and with mine dewatering
5. Assess impacts by comparing changes in heads and groundwater discharges to surface water bodies
• Refined geologic framework (Leapfrog modeling)
  – Stone et al. (1983) maps, USGS HA 720, bore logs, site data
• Created MODFLOW-SURFACT modeling tool
• Calibrated to pre-mining steady state and 1930 to 2012 transient conditions
  – 69 pre-mining targets, 27 transient targets
  – Incorporated 50 years of historical mine dewatering
• Constructed predictive simulations for 13-year mining period and additional 100 years
Model Grid and Layers

<table>
<thead>
<tr>
<th>Model Layer</th>
<th>Hydrostratigraphic Unit</th>
<th>Thickness Range (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>San Jose Formation</td>
<td>200 – 2,700\textsuperscript{a}</td>
</tr>
<tr>
<td>2</td>
<td>Animas Fm and Nacimiento Fm</td>
<td>230\textsuperscript{d} – 2,700\textsuperscript{e}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500 – 1,300\textsuperscript{f}</td>
</tr>
<tr>
<td>3</td>
<td>Ojo Alamo Sandstone</td>
<td>20 – 400\textsuperscript{e}</td>
</tr>
<tr>
<td>4</td>
<td>Kirtland Shale and Fruitland Fm</td>
<td>0 – 1,500\textsuperscript{e}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 – 500\textsuperscript{g}</td>
</tr>
<tr>
<td>5</td>
<td>Pictured Cliffs Sandstone</td>
<td>0 – 400\textsuperscript{e}</td>
</tr>
<tr>
<td>4</td>
<td>Lewis Shale</td>
<td>0 – 2,400</td>
</tr>
<tr>
<td>5</td>
<td>Cliff House Sandstone</td>
<td>20 – 500</td>
</tr>
<tr>
<td>6</td>
<td>Menefee Formation</td>
<td>0 – 2,000\textsuperscript{g}</td>
</tr>
<tr>
<td></td>
<td>Point Lookout Sandstone</td>
<td>40 – 415\textsuperscript{a}</td>
</tr>
<tr>
<td>6</td>
<td>Mancos Shale (NE only)</td>
<td>1,000 – 2,300</td>
</tr>
<tr>
<td>7</td>
<td>Gallup Sandstone (SW only)</td>
<td>0 – 600\textsuperscript{d}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 – 700\textsuperscript{a}</td>
</tr>
<tr>
<td>7</td>
<td>Mancos Shale</td>
<td>1,000 – 2,300</td>
</tr>
<tr>
<td>8</td>
<td>Dakota Sandstone</td>
<td>50 – 350\textsuperscript{a}</td>
</tr>
<tr>
<td>9</td>
<td>Brushy Basin Member of Morrison Formation</td>
<td>80 – 250</td>
</tr>
<tr>
<td>10</td>
<td>Westwater Canyon Member of Morrison Formation</td>
<td>100 – 300</td>
</tr>
</tbody>
</table>
Steady-State Calibration

- Total inflow for RHR model: **58 ft³/s**
- Falls within the range of **30** and **195 ft³/s** from Frenzel and Lyford (1982) and Kernodle (1996), respectively
- Matches **60 ft³/s** estimated by Lyford and Stone (1978)
Steady State Westwater Heads
Transient Calibration:
Historical Mine Dewatering

Chenoweth (1989)
Compare Historical and Simulated Dewatering Stresses

Ambrosia Lake Area Mines
Transient Calibration Plots

Dakota Aquifer

Westwater Aquifer

Groundwater Level Elevation (ft)

- Observed Groundwater Levels
- Simulated Groundwater Levels


Impact Assessment

- Scenario 1: no Roca Honda pumping
- Scenario 2: Roca Honda pumping at maximum rate for entire mining period
- Impacts defined by differences between scenarios
  - Differences in groundwater discharge to surface water bodies for rivers and Horace Spring
  - Drawdown for wells and springs
Springs
Results

- Negligible impacts at springs
  - 0.7 ft max drawdown
- 1 Westwater well affected
- Westwater head recovers to 97% within 100 years after end of mining
- Negligible changes in groundwater discharges
  - << 1% for San Juan, Rio San Jose, and Rio Puerco Rivers and Horace Springs
  - < 2% for Puerco River
Conclusions

• Constructed and calibrated a new groundwater flow modeling tool for the San Juan Basin
  – First to incorporate historical mine dewatering
• Predictive model used to evaluate potential impacts to water resources from mine dewatering
  – No impacts to rivers, springs, and all but 1 well
• US Forest Service accepted model for EIS analysis
• NM State Engineer awarded Roca Honda the first mine dewatering permit since NM’s Mine Dewatering Act was passed in 1980