Water Use in Geothermal Exploration and Development

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What I’m going to tell you:

• Where water is consumed in exploration and development
• Who might care about your water use
• What these people may be concerned about
• Proactively managing their concerns
• Typical sources of water for your project
• Typical water consumption for exploration and development
• Geothermal fluid for drilling and cementing
• Case studies
Where is water consumed?

- **Exploration:**
  - Dust Suppression
  - Drilling
  - Flow Testing
  - Injection Testing

- **Development**
  - Dust Suppression
  - Construction
  - Cooling
  - Workover
  - Fire Suppression
  - Potable water
  - Reclamation
Who might care about your water use?

- BLM and Others with Environmental Oversight (Think NEPA – CEQA)
- Native Americans
- U.S. Bureau of Reclamation
- State Water Regulatory Agencies
- Farmers and Ranchers
- Non-Governmental Organizations (NGOs)
- Counties and Municipalities
What are their concerns?

• Environmental:
  • Impacts to (depletion or contamination of) fresh surface or ground water
    • Wildlife
    • Streams, springs, meadows, groundwater
    • Municipal supplies
    • Agricultural supplies

• Leverage Point:
  • Project opponents
  • Competitors
  • Speculators
Proactively managing concerns

- Project descriptions for purposes of environmental analysis should include water consumption estimates, sources or water, and water delivery methods
- Discuss alternatives with regulators, water brokers, ranchers, NGOs
- Be prepared to demonstrate that impacts will not be significant, or how impacts will be mitigated
  - Hydrologic studies
  - Baseline monitoring
  - Farm fallowing
  - Spring flow supplementation
Where will I get my water?

- Obtain temporary or permanent water rights and drill wells or create points of diversion (will require regulatory approvals)
- Ranchers (may require regulatory approvals)
- Commercial sources
- Municipal supplies
- Treated municipal waste water
For drilling and construction, consider Temporary Change in Manner of Use or Point of Diversion

• Using agricultural or stock water for other purposes
• Often necessary if purchasing water from rancher or other water rights holder for uses other than those originally permitted
  • Drilling
  • Construction dust suppression
  • Road maintenance
• Intra-basin change in point of diversion – from one well to another
• May not exceed one year
• May be denied if interferes with another water right
• Lender-Borrower or sale agreement required
How Much Water Will I Need?

**Exploration**
- Well pad and access road construction: 30,000 gpd
- Drilling, full sized wells: 50,000 gpd

**Construction**
- Plant construction, grading: 50,000 gpd

**Typical Project Totals**
- Exploration & drilling (assume 7 wells): 40.0 Acre-feet
- Construction & development: 17.6 Acre-feet
- Reclamation: 13.6 Acre-feet

1 Acre-foot = 325,851 gallons
Can I use geothermal fluid for drilling and testing?

- The simple answer: yes
  - If drilling with brine from the same reservoir, it can be argued that it is not consumed, just recirculated
  - Transporting water from another reservoir for drilling adds complications and invites intervention
    - Water quality issues – UIC
    - Consumptive use and water rights
    - NEPA-CEQA
  - Flow testing generally acceptable within the same reservoir
  - Injection testing may require additional authorizations
Can I use geothermal fluid for cementing?

- The simple answer: with care
  - Without knowing exactly what the fluid constituents are, it can be risky. Work with an experienced cementer
  - Temperature, pH, CA, Cl-, TDS can all affect cure time, either accelerating or retarding

<table>
<thead>
<tr>
<th>Property</th>
<th>Sample</th>
<th>Unit</th>
<th>Low</th>
<th>High</th>
<th>Affects on cement slurry</th>
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<td>Temperature (°F):</td>
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<td>°F</td>
<td>40</td>
<td>90</td>
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<tr>
<td>pH</td>
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<td>Potassium (K⁺):</td>
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<td>Hardness (Ca⁺²⁺):</td>
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<td>600</td>
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<td>Iron (Fe⁺²⁺):</td>
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<tr>
<td>Chlorides (Cl⁻):</td>
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<td>3000</td>
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<tr>
<td>Sulfates (SO₄⁻²⁻):</td>
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<td>1000</td>
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<td>Total Dissolved Solids:</td>
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<td>ppm</td>
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<td>2000</td>
<td>High TDS will accelerate</td>
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What about evaporative cooling?

• No simple answer, each project varies with:
  • Technology; flash or binary
  • Thermal efficiency
  • Geothermal fluid temperature
  • Ambient temperature
  • Ambient humidity
  • Makeup water quality
  • Cooling water chemical treatment plan
  • Cooling tower efficiency and cleanliness
Case Study: Fresh water for cooling

- Ormat’s Galena 1 project; a 20 MW net, air-cooled, binary power plant located in Reno, Nevada
Hybrid cooling:

- Air-cooled technology with evaporative assist during hottest hours of day
- Much lower water consumption than conventional wet cooling
- Can be retrofitted to existing air-cooled power plants
- Can be switched on and off quickly to help balance grid
Fogging System at Work
Water Sources

• Ormat considered using geothermal condensate, tertiary treated effluent, agricultural (surface) water from the Steamboat Ditch
• Economic evaluation of capital and operational costs drove the selection of ditch water
• Ormat purchased water rights in the secondary market; existing water rights holders
• Converting from agricultural to industrial requires additional rights for return flows
• In low water years, water allocation may be restricted
Case Study: Geothermal condensate for cooling
Water source:

- Condensate from flashed geothermal fluid
- Submit application for appropriation of maximum estimated condensate evaporation
- Unlikely to be required to obtain existing water rights, assuming a completely different reservoir/aquifer from fresh water users
- Be prepared to defend appropriation: hydrologic and reservoir models to show no impact to other water rights holders, wildlife, or the environment
- Once granted, project must show consumptive beneficial use by metering production and injection, calculating evaporation
- Extensions for additional time to demonstrate beneficial use often granted
For more information:

- Check recent NEPA – CEQA documents for discussions on water sources and consumption
- Nevada Division of Water Resources: http://water.nv.gov/index.cfm
- California Department of Water Resources: http://www.water.ca.gov/
- Geothermal Energy Association http://geo-energy.org/ search: “cooling water consumption”