Fractured Rock Hydrology Project – Assessing the Ground Water Supply Reliability of the Sierra Foothill Fractured Hydrogeologic Terrain

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(1) Coastal Range: Mesozoic Franciscan metamorphic complex (65-250 Ma)

(2) Central Valley: Cenozoic (<65 Ma) marine and terrestrial sediments and alluvium. (Tertiary & Quaternary age)

(3) Sierra Nevada: Mesozoic granitic rocks

Annual mean precipitation: approx. 60 cm in north; 15 cm in south; 75-250 cm in the mountains.
Source: USGS
NON-DARCIAN FLOW
i.e. flow through fractures
not following Darcy’s Law

Source: Colorado Geological Survey
EXFOLIATION
(Decompression)

TECTONIC FRACTURES
(Tectonic stress)
Foothill Communities

- Development pressure, resource conservation
- Planning policy concern
- Anecdotal incidents
- Need for scientific data and systematic analyses
Pilot Study Example (eastern Fresno County)

Watershed hydrology using $\delta^{2}H$ and $\delta^{18}O$ of surface water, ground water, and precipitations (“Forensic hydrology”, “fingerprinting”)

- What is the source of the current ground water supply? Is it from precipitation (meteoric water) or is it from geologic deposits, i.e. water from the last ice age more than 10,000 years old (fossil water)?

- What could be the implications on sustainability?
Big Sandy Watershed Isotope Hydrology

- High Elevation Ground water
- Low elevation ground and surface waters
- Big Sandy Creek Surface water
- Expected Fossil ground water
- Snow
- Rain water 1
- Rain water 2
- Evaporation trend

- Weldon pond
- Pond BSSW9
- Prather pond
- S. Joaquin R.-Big Sandy Junction
Outcrop mapping and air photos

δ¹⁸O
Conclusions of Fracture Hydrology Study

- **Source area** can be **readily identified.** The area of high elevations to the northeast is the main recharge area.

- **No evidence of fossil water.** The source of ground water is from active recharge through the interconnecting fracture networks.

- **Freshly recharged water** is found in deeper crystalline rocks **along a fracture zone.**

- Stable isotope ratios can provide independent **confirmation** of fracture-controlled ground water flow. They can be used as an indicator of connectivity to the recharge area. **A tool for development planning.**
Crucial Questions Remaining

- Sustainable?
- How much water is in the fracture network?
- Hydrogeologic characterization of fractures.
Needs for more scientific information and technical expertise (Lawrence Berkeley National Laboratory)

- Fracture types, fracture density, function of depth
- Porosity, length, connectivity
- Orientation, anisotropy
- Fracture zones and distribution
- Recharge rate
- Geologic mapping and evaluation
High-Level Radioactive Waste Repository at Yucca Mountain, Nevada

Nevada Test Site: 1,350 square miles
Nellis Air Force Range: 12,000 square miles
Fracture Hydrology and conceptual models of YM unsaturated fractured formation

1. Climate
2. Infiltration and percolation
3. Lateral flow diversion
4. Roles played by faults
5. Fracture-matrix interaction
6. Perched water
7. Matrix diffusion
8. Adsorption
Surface and Subsurface Investigations of fractured rock at Yucca Mountain

- Geophysical Surveys
- Tunnel Excavations
- 80 Boreholes
- Seepage/Tracer monitoring
- Field Test
- Laboratory Studies
- Modeling

MAGNETOTELLURIC - Filtered Apparent Resistivity

Berkeley Lab
A perspective view of all the possible connections between intervals in the seven nearest wells.

Tests:
• Pumping
• Geophysics
• Tracer
Radar (left) and seismic (right) tomography results. Darker pixels indicate low velocity, and therefore, possible permeable fracture zones. The radar survey was conducted between SW-1 and SW-3, whereas the seismic survey was conducted from SW-2 to SW-1 and SW-2 to SW-3. The depth for the two surveys were offset by 1 m.
1. Identify interested stakeholders
2. Partnership formation
   (Technical partners are: Lawrence Berkeley National Laboratory and CSU Fresno)
3. Gather support from agencies and elected officials
4. Obtain funding
5. Implement project
PURPOSE OF THE PARTNERSHIP

• Create a broader base for funding and legislative support

• Coordinate regional planning efforts and share water and landuse information

• Maximize the benefit of new technical knowledge gained by increasing its application to all affected area

• Promote a broad based collaboration to establish common water resource and prudent landuse policies based on strong scientific results and data.
Support and Sources of Funds

- Broad base community support
- Sierra Resource Conservation District – CALFED Funded Program
- Sierra and Foothill Citizens Alliance
- Fresno County Board of Supervisors resolution
- Fresno County Water Advisory Committee
- California State University, Fresno
- Interested parties include: El Dorado Irrigation District, El Dorado County Water Agency, CABY, Upper Merced River Watershed, Mariposa County Resource Conservation District, and the Endangered Species Coalition.

- State and Federal funds (CalFed, water bonds, etc.)
- State and U.S. legislators
Invitation to joint Partnership

R.S.V.P.

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