Anthropogenic influences on groundwater in the vicinity of the Waste Isolation Pilot Plant, southeastern New Mexico, USA

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Waste Isolation Pilot Plant (WIPP)
Culebra Dolomite (Rustler Fm.)

Powers and Holt (1999)

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<th>PERMIAN</th>
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<td>Rustler</td>
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<td>Forty-niner</td>
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<td>Magenta Dolomite</td>
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<td>Tamarisk</td>
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<td>Culebra Dolomite</td>
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<td>Los Medaños</td>
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<td>(proposed formal name for &quot;unnamed lower member&quot;)</td>
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<td>Salado</td>
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<td>Castile</td>
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Beauhiem and Holt (1990)

Zones Prograde East Due to Progressive Unloading/Erosion and Dissolution

WIPP

West

East

Culebra hand sample

Beauhiem and Holt (1990)
Groundwater monitoring network

- Culebra is the most transmissive and laterally extensive saturated zone above the Salado.
- Flow is ~N-S inside Land Withdrawal Boundary.
- Long-term, high-frequency monitoring network
  -Began in 2003
  -40 Culebra wells
  -Recording fluid pressure
  -Collected at 15-minute intervals, downloaded monthly

Kuhlman (2014)
Pressure transducer data

Study objective(s)

- Within a preliminary, simulation-based framework:
  - Estimate a pumping rate for the well.
  - Simulate drawdown associated with the pumping.
  - Simulate and compare advective particle travel paths/times for cases with and without pumping.
  - Consider what the pumping tells us about the system in light of how it is has traditionally been modeled.
    - 100 base-case (calibrated) realizations
    - 2D, steady state, heterogeneous, and anisotropic
Culebra flow modeling, setup

- Code: PFLOTRAN
- Ensemble-averaged 2D realization; constant head and no-flow boundaries; initial conditions from steady-state simulation; sink term (pumping well); nine-month period
Culebra flow modeling, targets

- Iterate for sink term that minimizes Modeling Efficiency (EF).
- Two observation groups; strong vs. subdued response
- Best-fit pumping rate: $1.8\times10^{-3} \, \text{m}^3\text{s}^{-1}$ (28.5 gpm)
Qualitative similarities between observed and simulated drawdown field

- North-south lobe
- Drawdown opens to the south
Culebra particle tracking, setup

- Codes: PFLOTRAN, DTRKMF
  - PFLOTRAN:
    - Apply best-fit sink term from ensemble-averaged model to the 100 realizations that comprise the ensemble-average model.
      - Constant head and no-flow boundaries; initial conditions from steady-state simulation; sink term (pumping well); nine-month period
  - DTRKMF:
    - Calculate conservative (i.e., non-dispersive and non-reactive) particle track each realization.
Culebra particle tracking, results

**Particle tracks w/o pumping**
- Distance: 3134.1 m
- Time: 8254.2 yr
- Rate: 0.38 m/yr

**Particle tracks w/ pumping**
- Distance: 3295.3 m
- Time: 3981.9 yr
- Rate: 0.83 m/yr
Summary

Findings
- The Culebra-based pumping in the vicinity of the WIPP halves “snapshot based” estimates of particle travel time across the site.
- The effects (i.e., change in travel time and path) associated with the pumping period are unimportant relative to the WIPP performance period.

Food for thought
- What did we learn about the system?
- What could transient forcings looking like in the future?
- What is the best way to increase confidence in a transient simulation conducted on the geologic timescale when it is calibrated with observations made on the human timescale?
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