U.S. Department of Energy
Office of Civilian Radioactive Waste Management

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Percolation and Seepage at Nopal I, Peña Blanca

Presented to:
Appendix 7 Meeting on Peña Blanca Natural Analogue Studies

Presented by:
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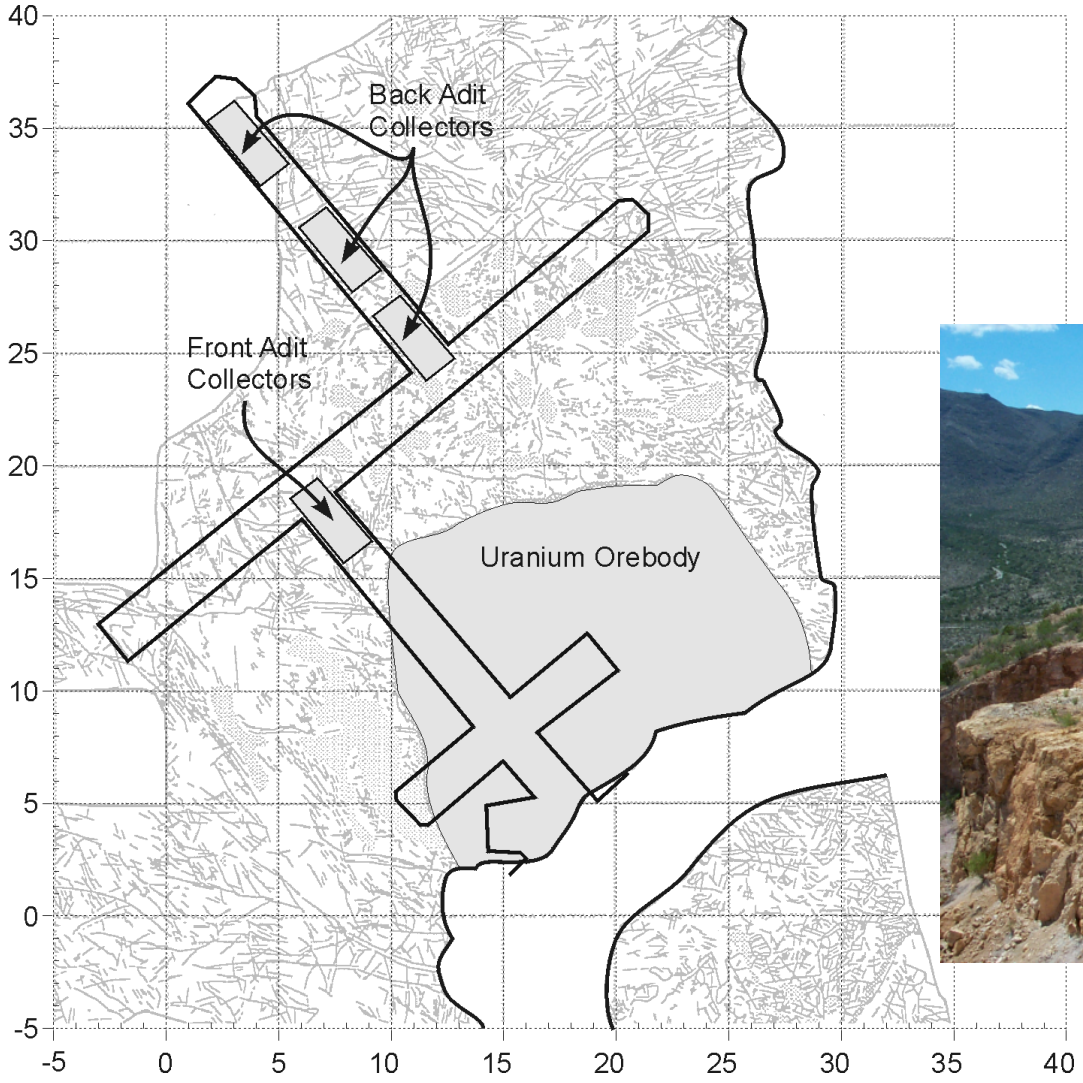
Lawrence Berkeley National Laboratory

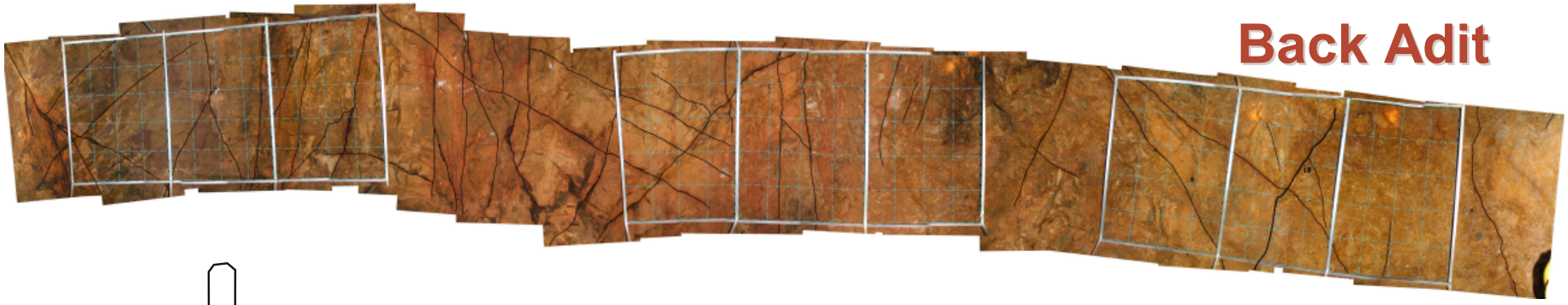
February 16, 2006
Las Vegas, Nevada

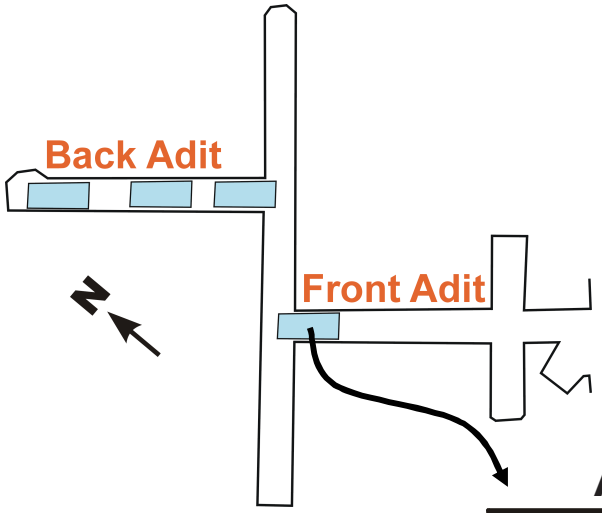
Adit and Seepage Collectors at Peña Blanca

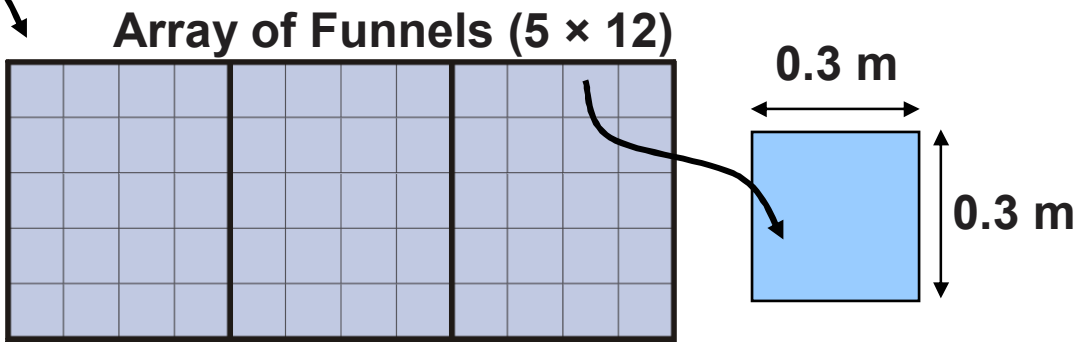


Top View of Nopal I
Peña Blanca, Mexico

Seepage Collection Frames at Peña Blanca





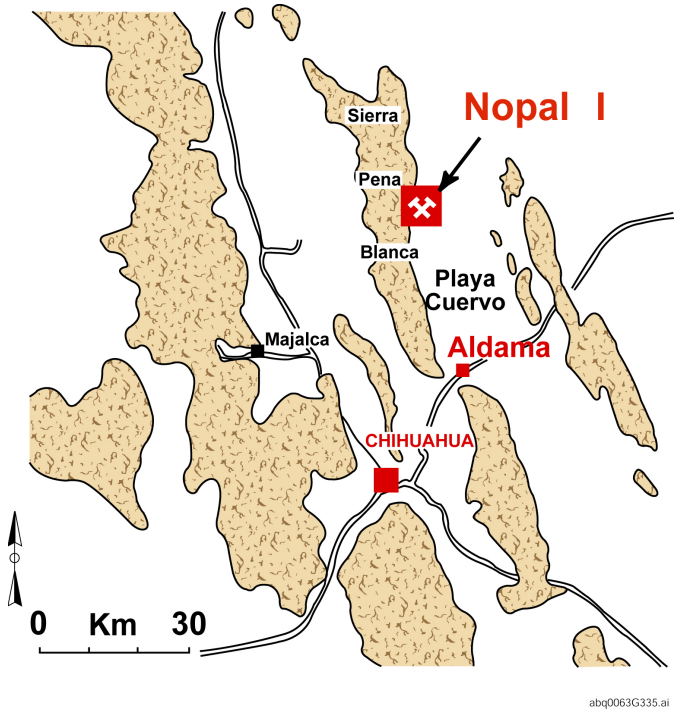


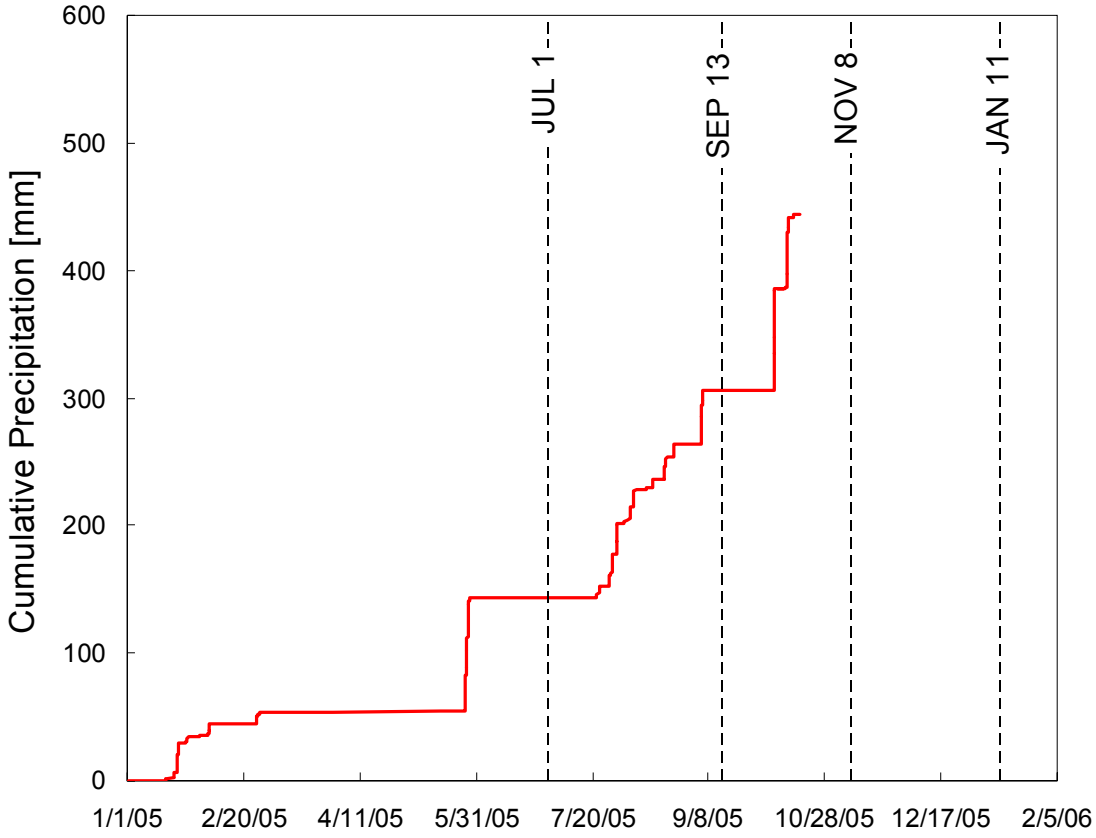
Seepage Collectors at Peña Blanca

Collection Bottles

Instrumented Column

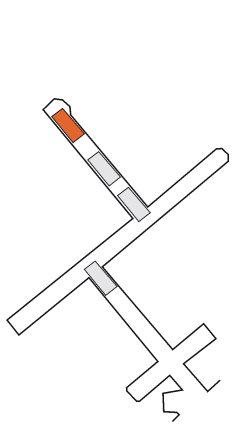
Precipitation at Aldama (Mexico)





Data from Instituto de Ecología, Mexico

Cumulative Seepage at Peña Blanca: Frame 1



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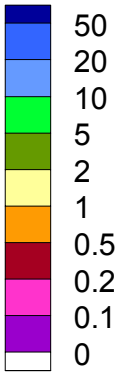
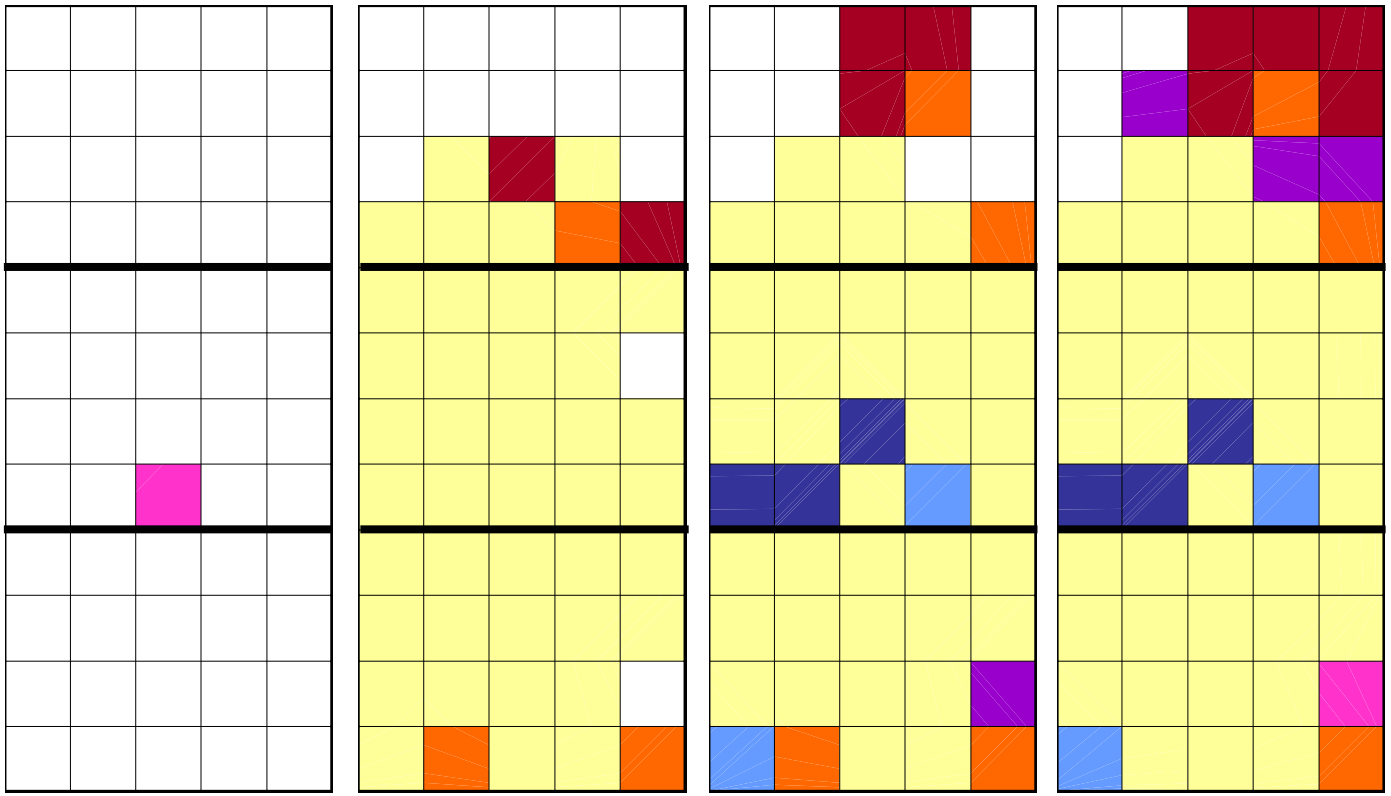
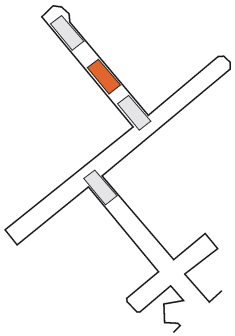


Jul 1, 2005 Sep 13, 2005 Nov 8, 2005 Jan 10, 2006



Cumulative Seepage at Peña Blanca: Frame 2



Seepage [mm]

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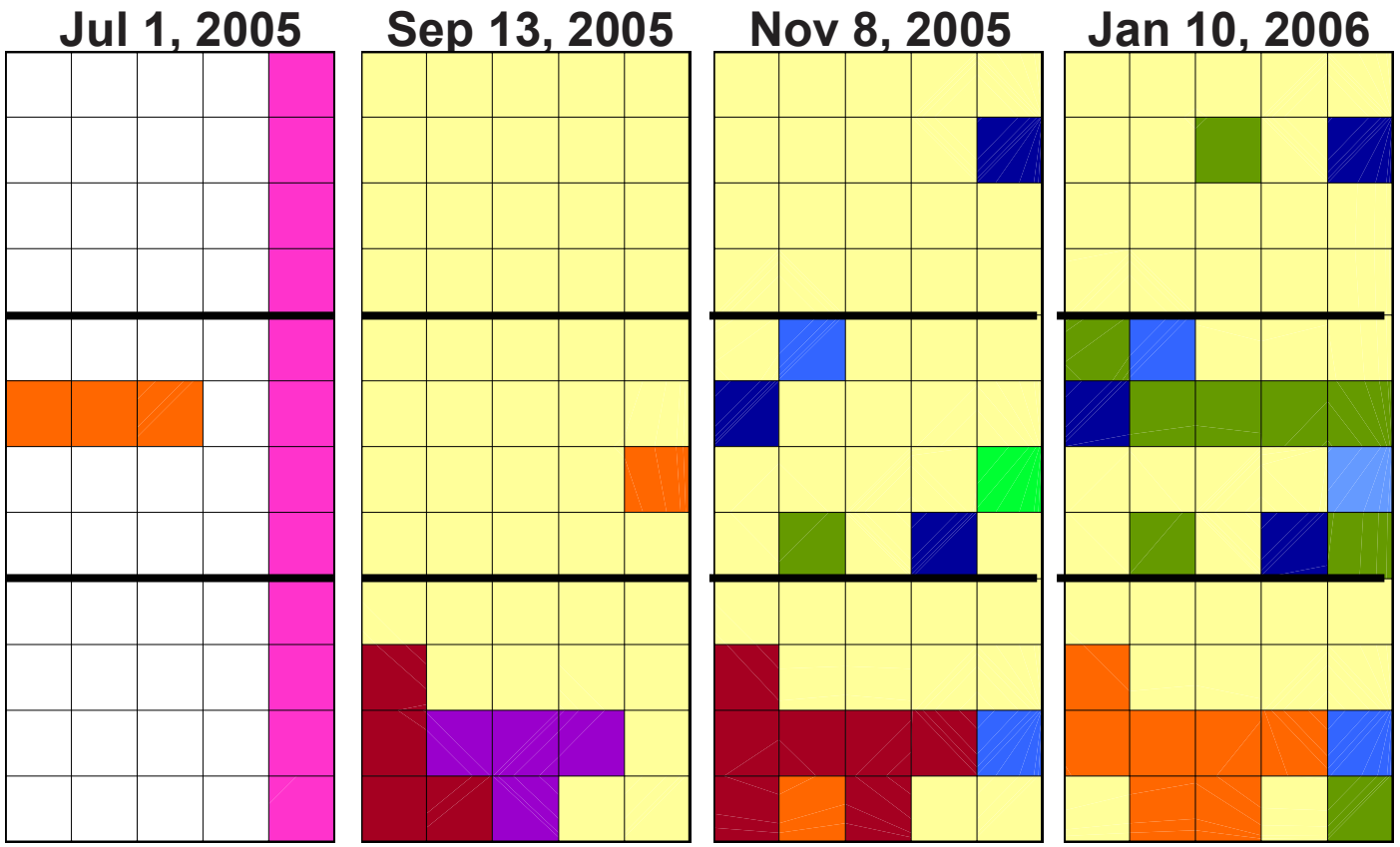
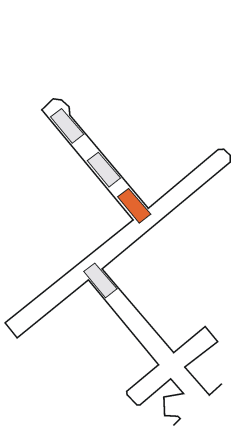


Cumulative Seepage at Peña Blanca: Frame 3



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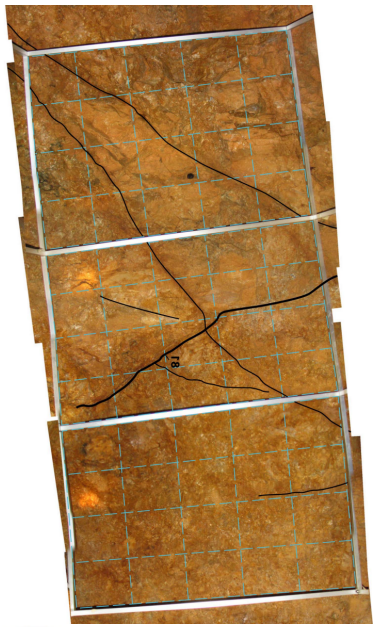
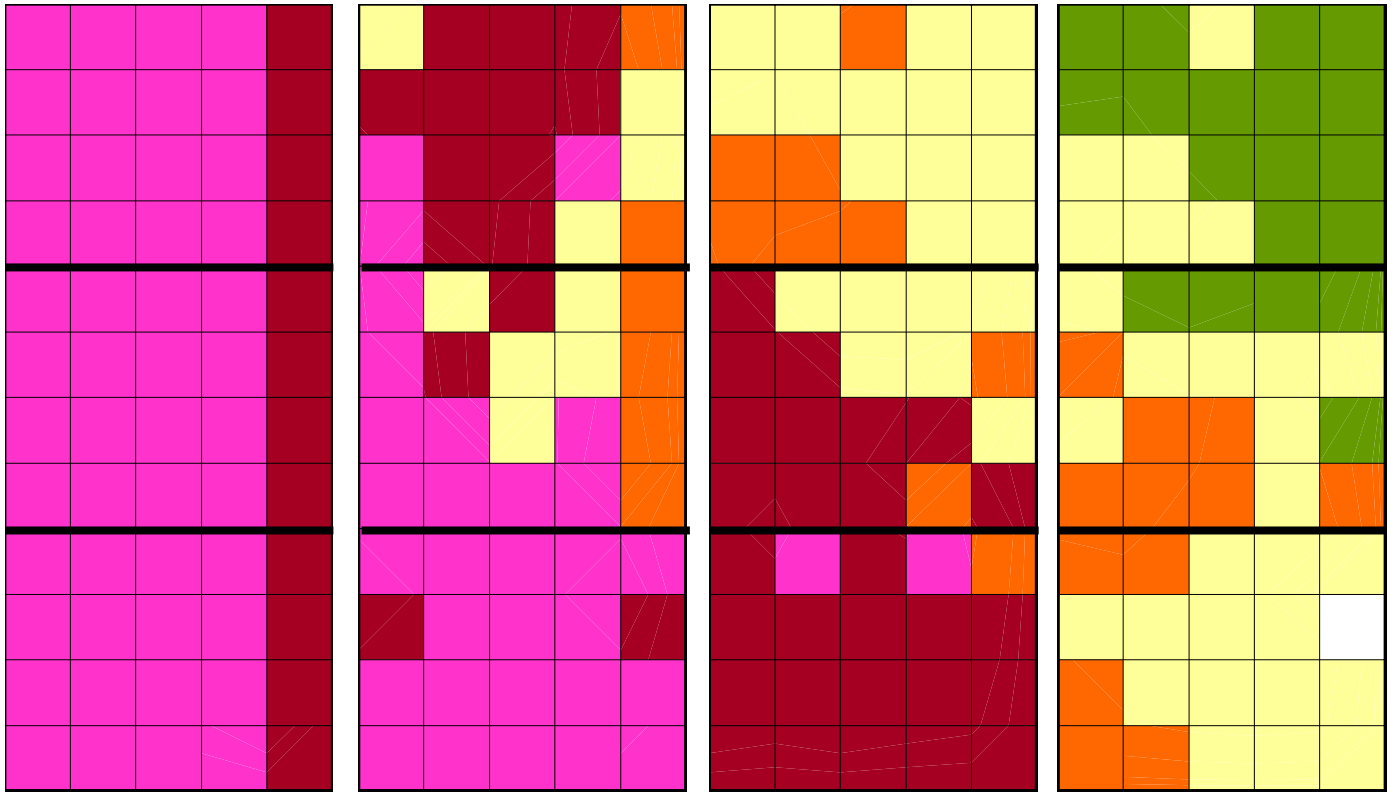
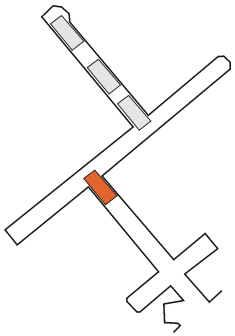


Jul 1, 2005 Sep 13, 2005 Nov 8, 2005 Jan 10, 2006



Cumulative Seepage at Peña Blanca: Frame 4



Seepage [mm]

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0.2
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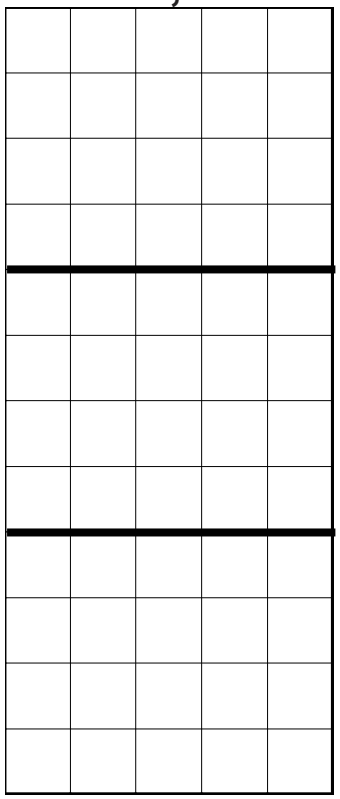
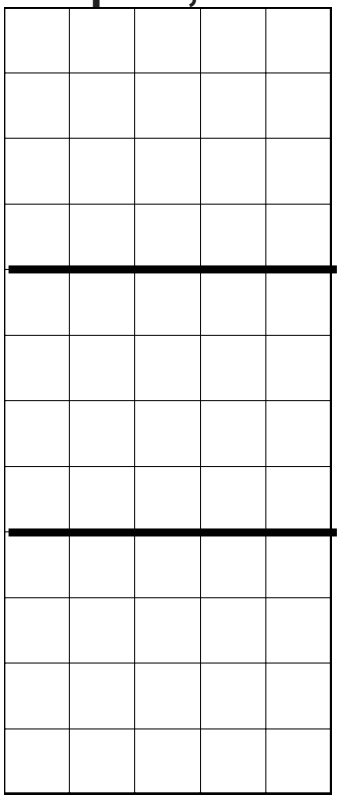
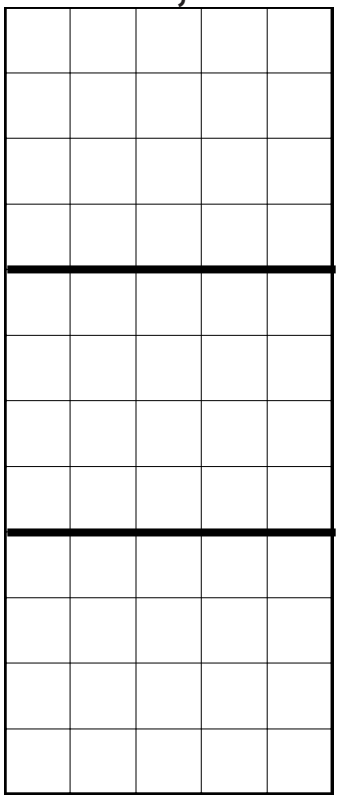
Jul 1, 2005



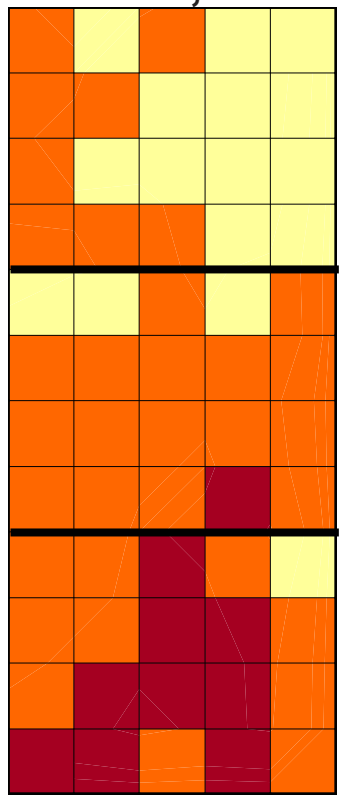
Sep 13, 2005



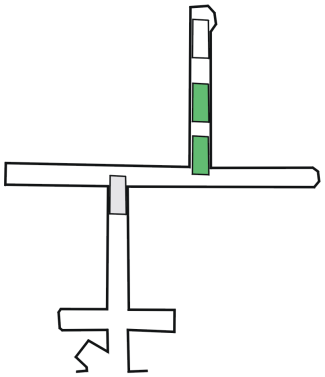
Nov 8, 2005

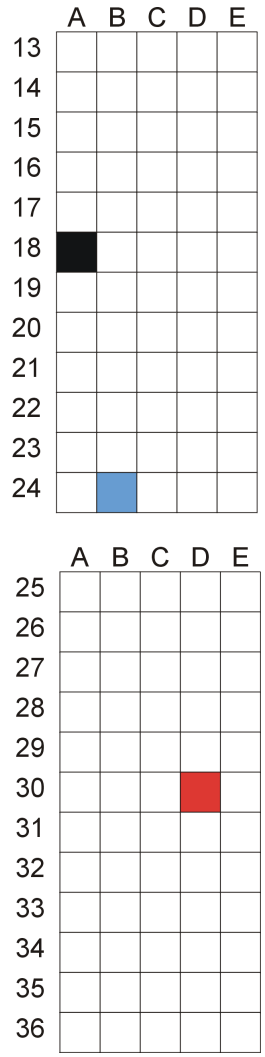


Jan 10, 2006

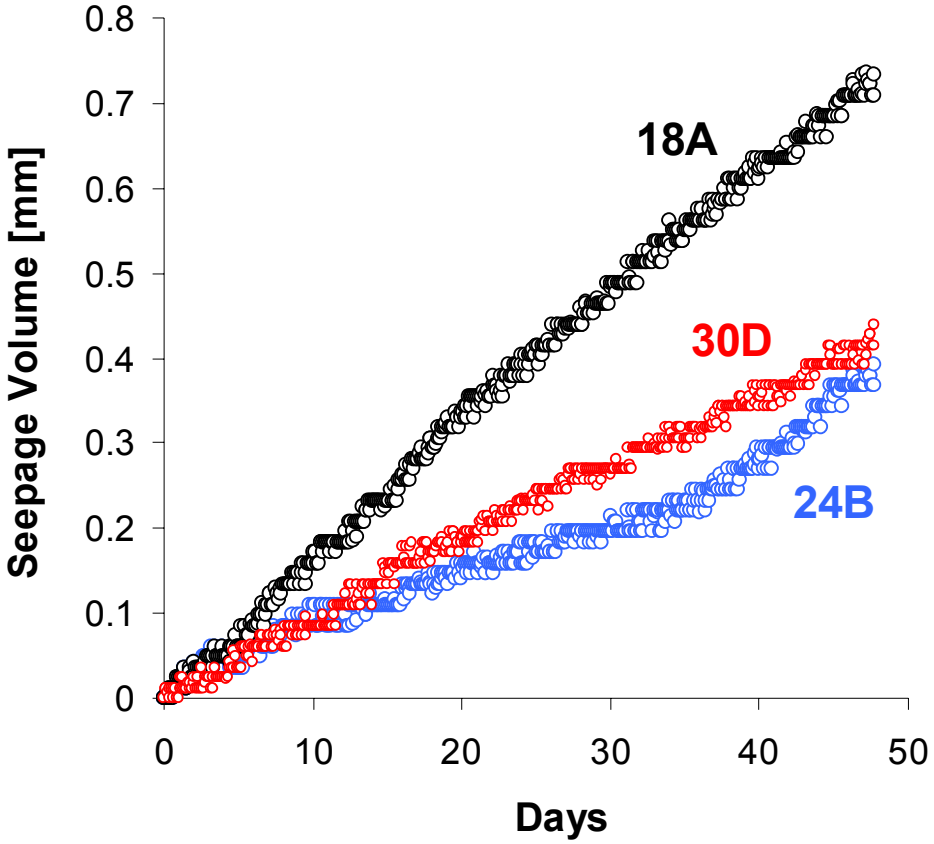


Cumulative Seepage at Peña Blanca: Instrumented Funnels





Seepage recorded between Nov 8'05 and Jan 10'06 visits to Nopal I

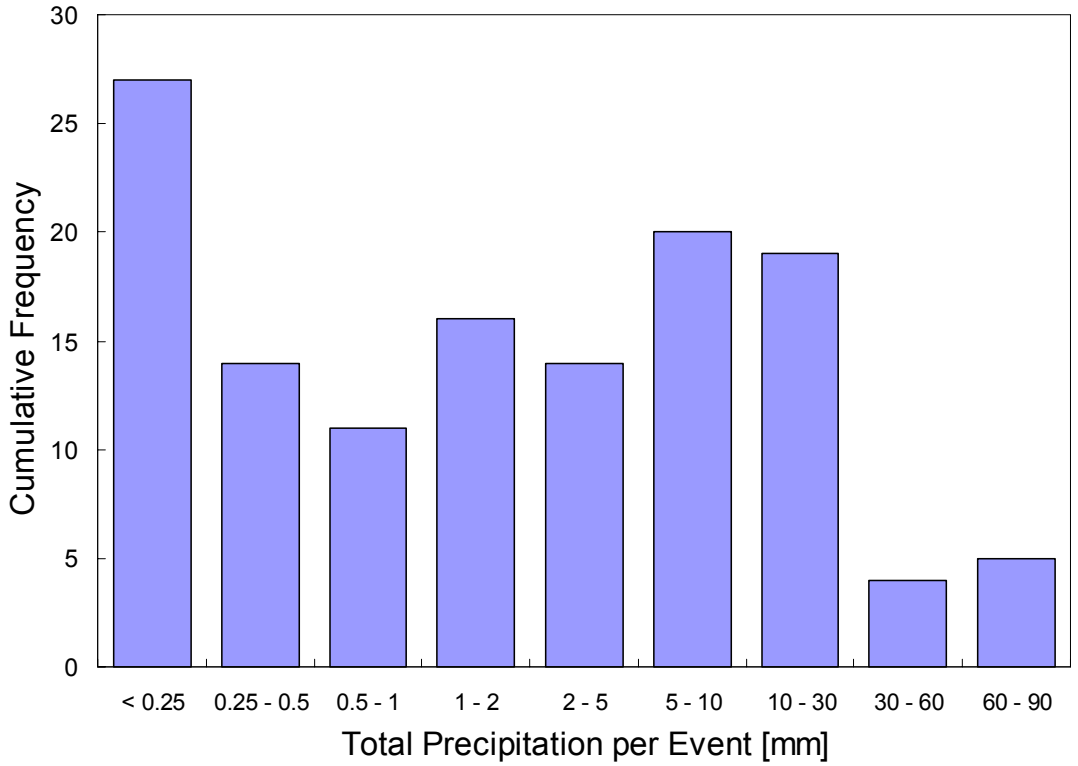


Preliminary Observations (Peña Blanca)

- Observed seepage volumes and arrival times were highly heterogeneous
- A few fast flow paths in the back adit carry large volumes of water, with large volumes of seepage occurring between September and November 2005
- Most of the remaining parts of the front and back adit exhibit slow steady seepage
- Onset of seepage began in the front adit earlier than in the back adit
- Long residence time in the front adit is consistent with higher U concentration and U isotope disequilibrium observed at this location

Statistics of Rainfall Intensity

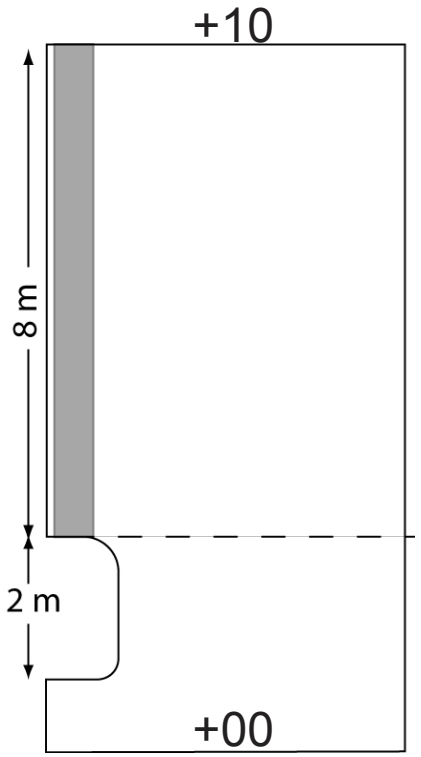
Aldama, Mexico
March 2004 – October 2005



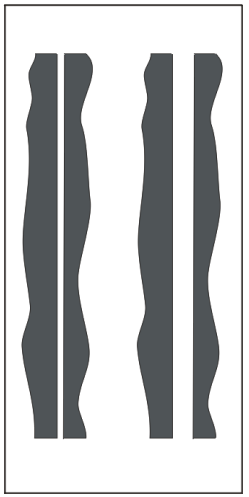
Data from Instituto de Ecología, Mexico

Conceptual Model of Fracture Flow

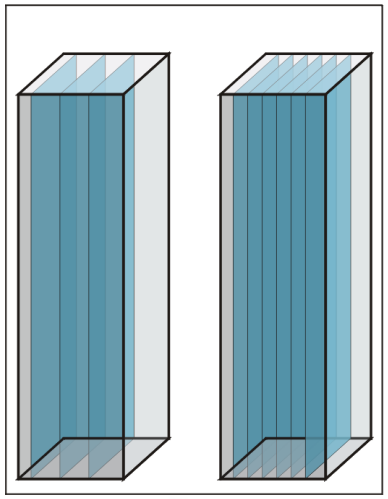
- **Fractures that connect the +10 level and the adit are modeled as 1D column**
- **The columns are made of parallel vertical fractures of uniform aperture**
- **Several fracture spacing (densities) and apertures are considered**
- **Hydrologic properties of the composite were calculated using theoretical models (e.g., cubic law)**



Fracture Aperture

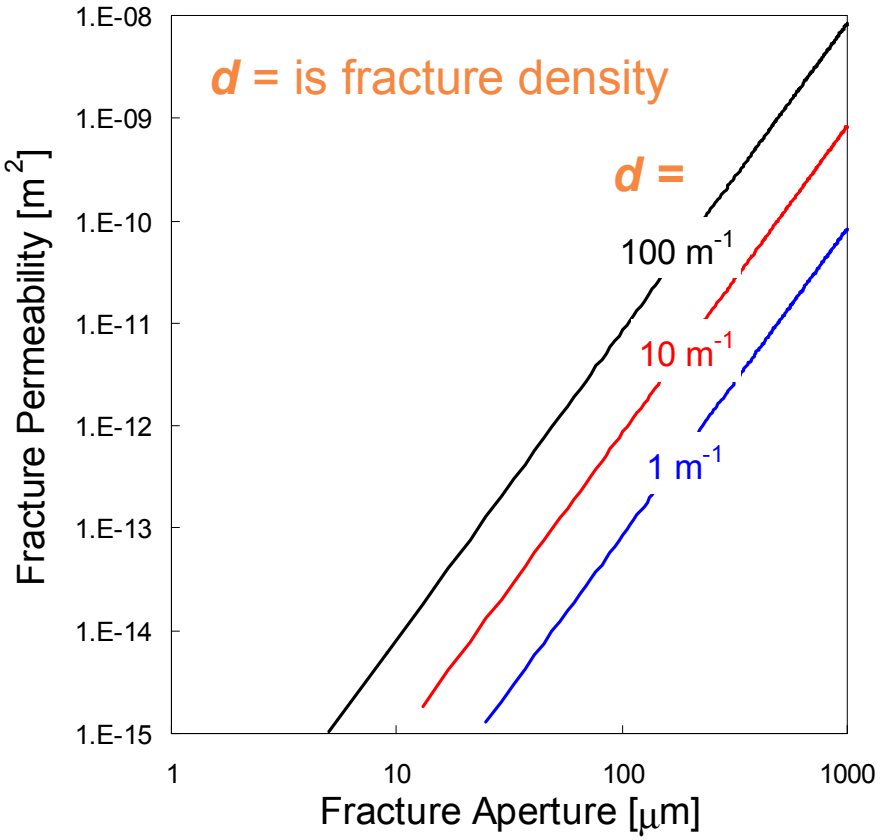


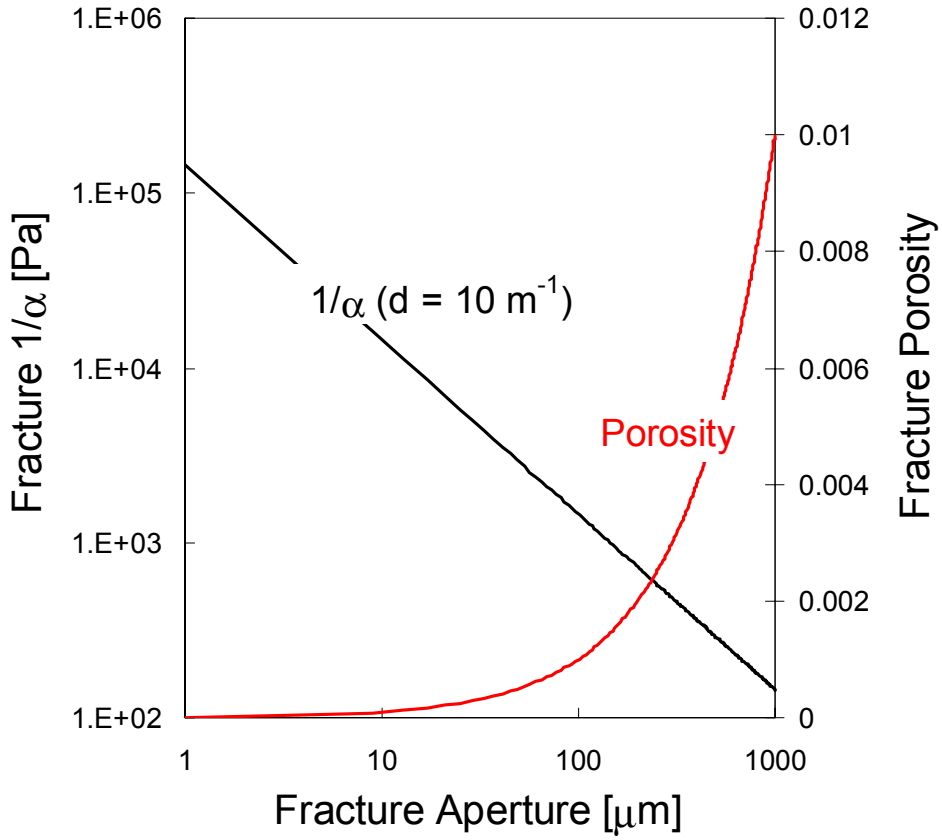
Fracture Spacing



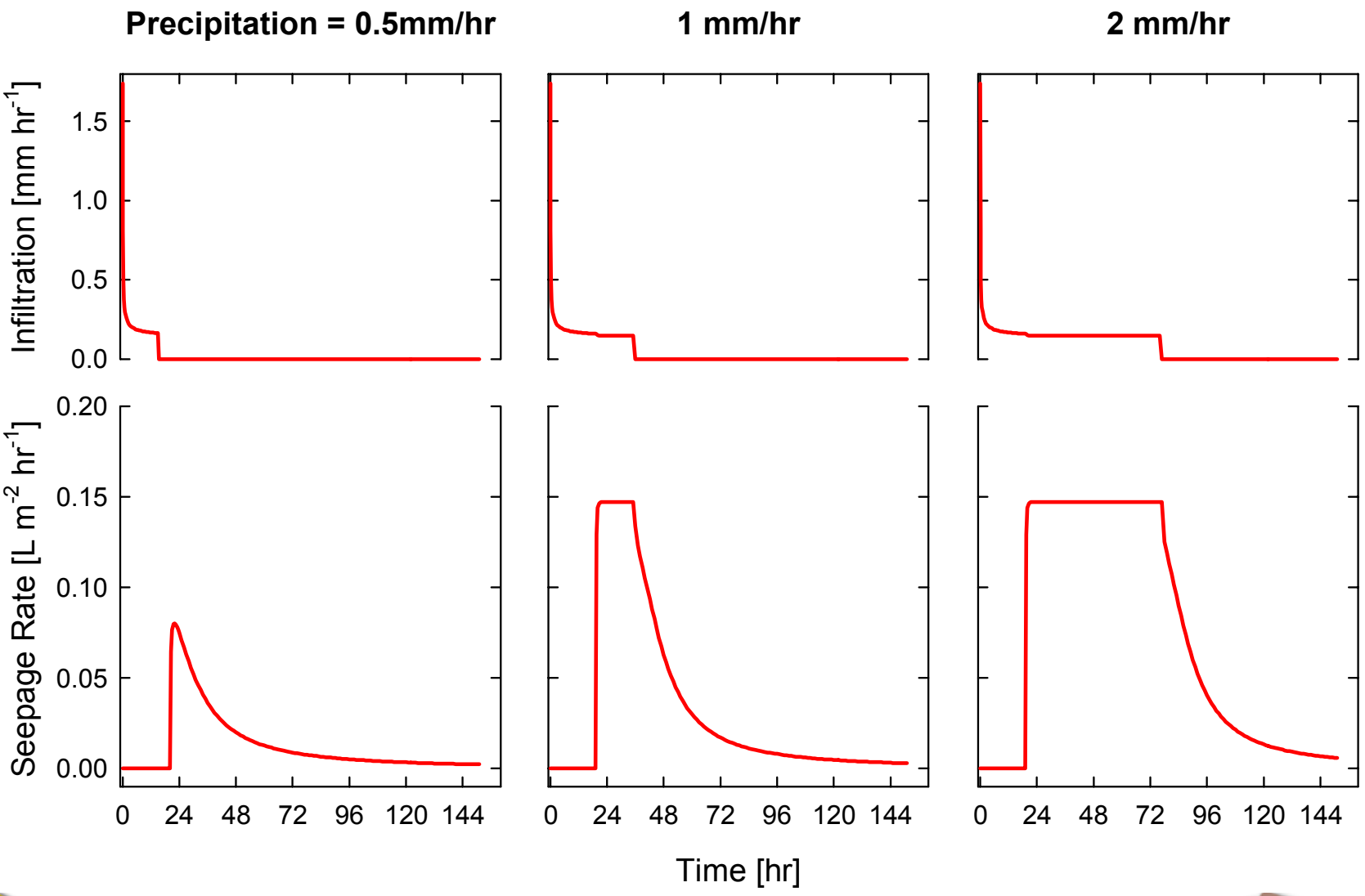
Calculated Hydrologic Properties

- **Composite hydrologic properties of 1D columns calculated using fracture density and aperture**

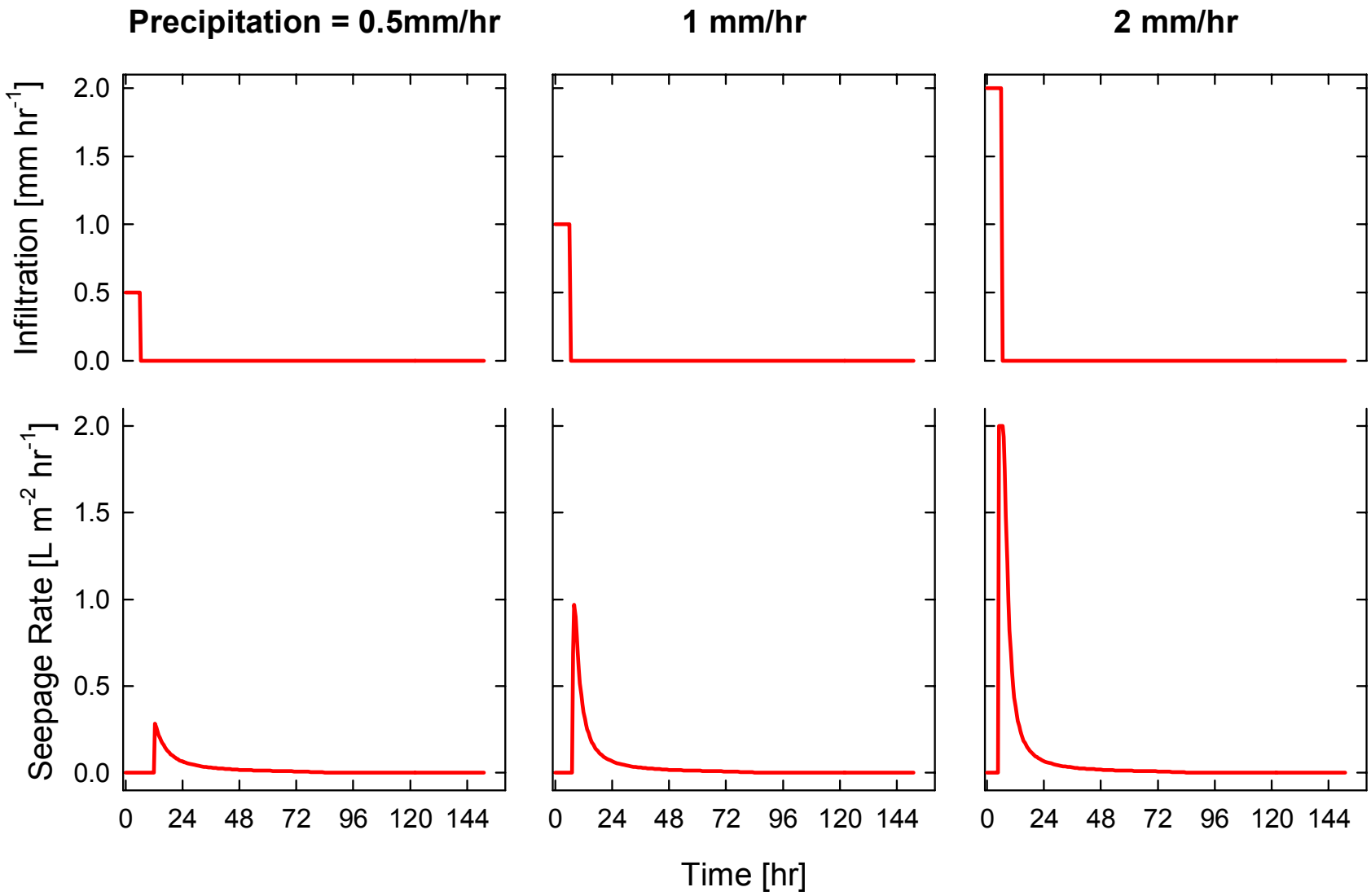




Seepage Predictions: 10 μm, 50 m^{-1}



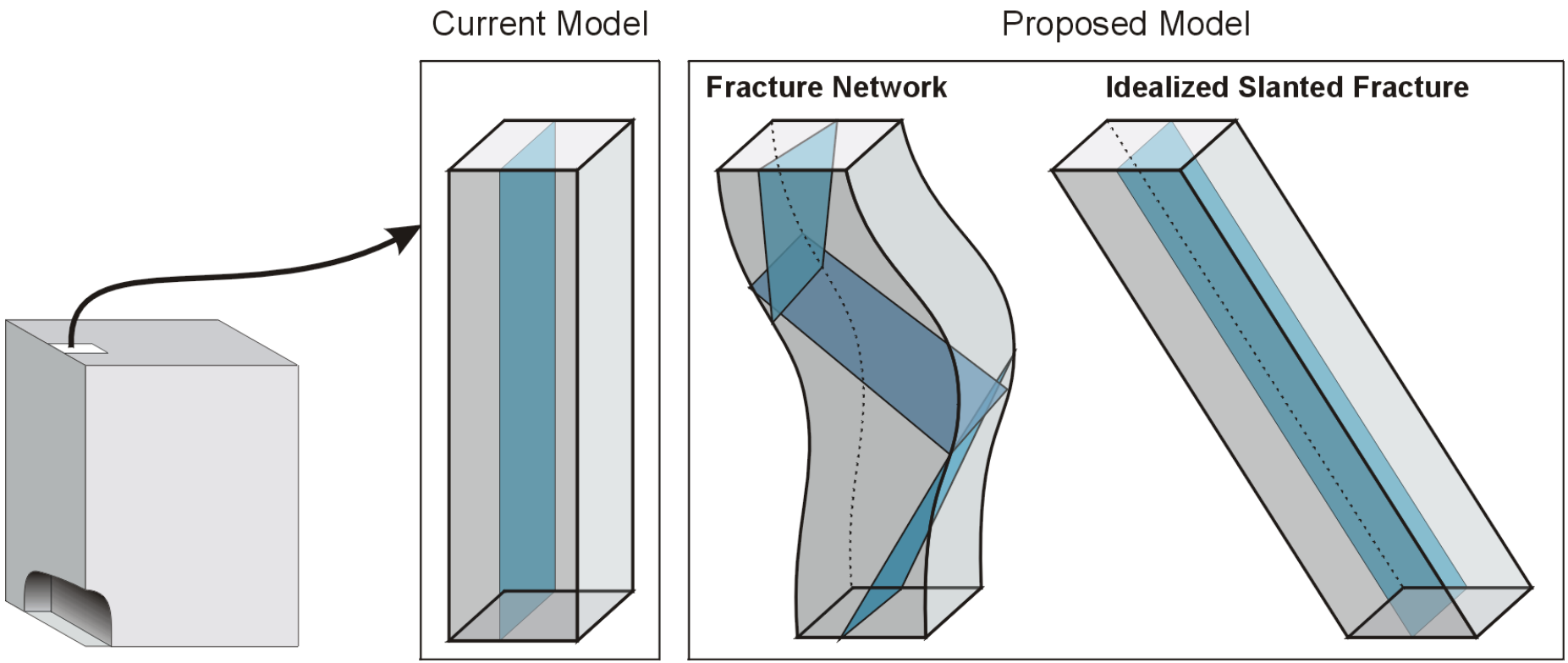
Seepage Predictions: 100 μm, 50 m^{-1}



Potential Uses of Fracture Map

- Fracture density and dip can be used in estimation of percolation pattern and bulk permeability
- Permeability estimates will provide better constraints on predictions of seepage arrival time
- Fracture density and connectivity patterns can potentially decrease uncertainties in site characterization through inverse modeling

Proposed Revision of Conceptual Model



Ongoing & Future Lab/Field Work

- **LABORATORY WORK**
  - Hydrologic characterization of cored samples
  - Analyses of seepage water (in progress at LANL)

- **FIELD DATA COLLECTION**
  - Collection of continuous seepage data to enable calculation of *seepage rate*
  - Installation of meteorological station to get better estimates of infiltration rate and precipitation pattern

Ongoing & Future Modeling Work

- **Improved seepage prediction that accounts for:**
  - **Routing of surface water**
  - **Evaporative losses**
  - **2D and 3D interaction between fracture sets (heterogeneity and flow focusing)**
- **Modeling radionuclide transport**
- **Calibration of flow and transport models against field observations**