Groundwater Conceptual Flow and Transport Model at LANL

Joint Meeting
of the
Los Alamos National Laboratory Oversight Committee
and
Radioactive and Hazardous Materials Committee

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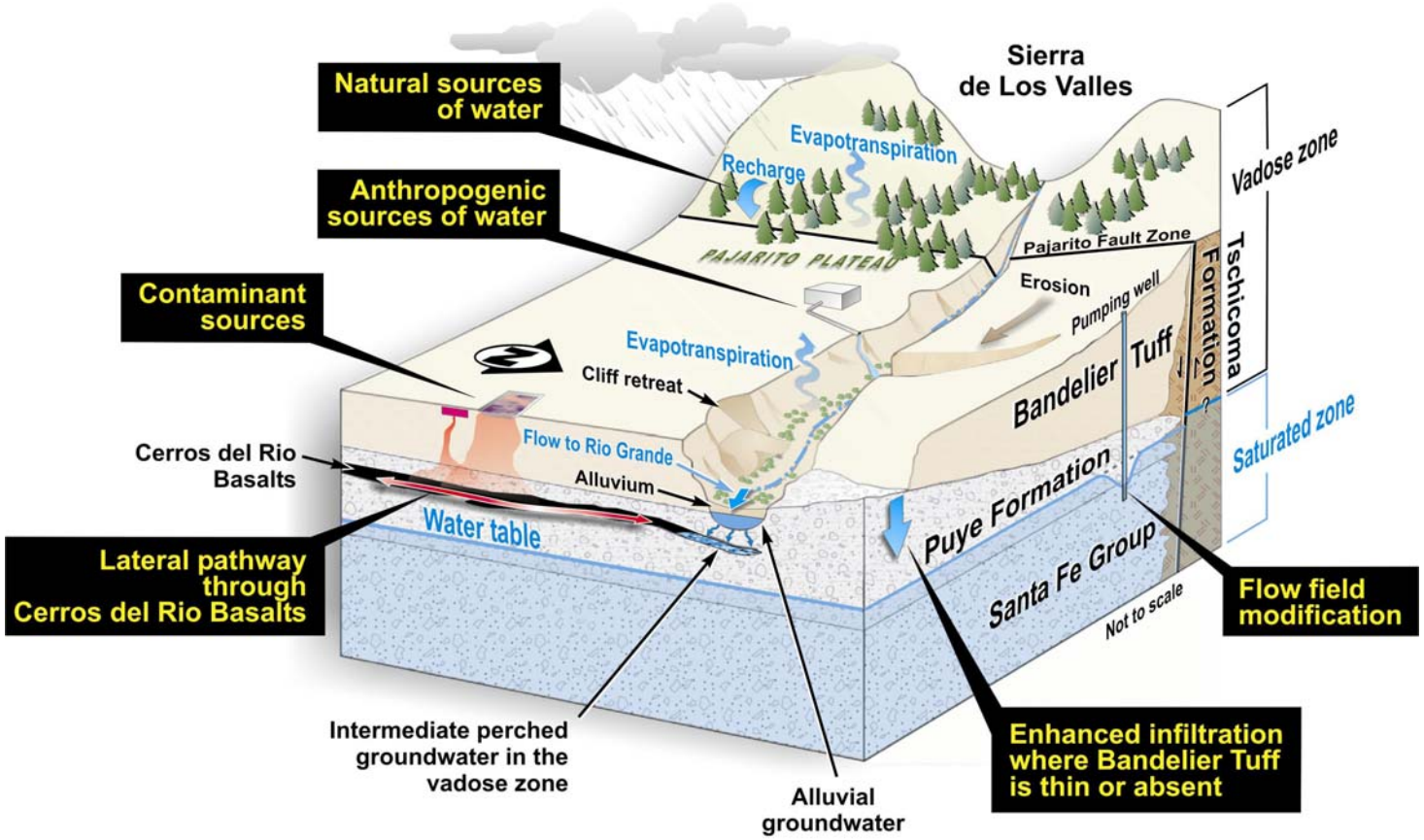
Purpose

- To provide a fundamental understanding of flow and transport on the Pajarito Plateau
- To describe the hydrologic conceptual model as determined from hydrologic studies.
  - Alluvial groundwater
  - Vadose zone
  - Regional aquifer
- To provide framework for specific contaminant transport investigations (to follow) for protection of human health and environment
- To demonstrate how groundwater flow and transport models provide technical assistance to communities

Technical Approach

- Deep well drilling
  - –Geologic characterization
  - –Geophysical logs
  - –Identification of perched water
  - –Geochemistry sampling
  - –Contaminant sampling
- Hydrologic Measurements
  - –Head measurements
  - –Hydrologic testing
- Analysis and Interpretation
  - –Identification of recharge zones
  - –Travel times
  - –Refinement of conceptual models
  - –Numerical modeling to quantify conclusions

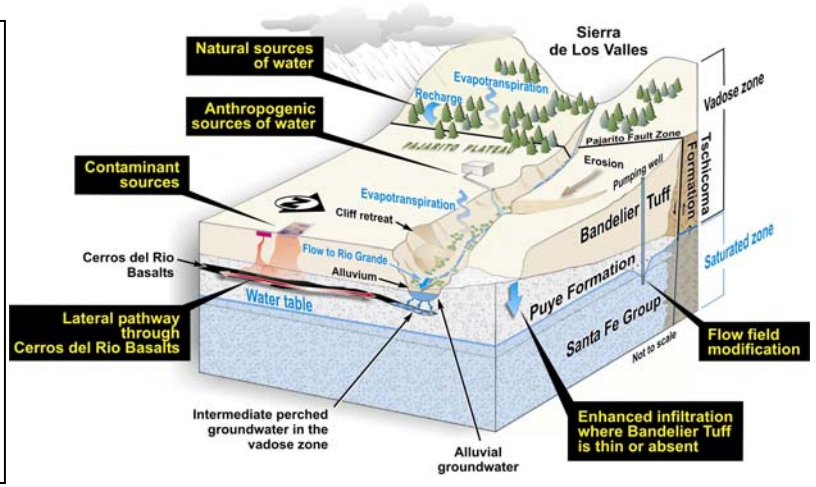
Hydrologic Conceptual Model



Hydrologic Conceptual Model

Alluvial Groundwater

- Alluvial groundwater is a significant lateral fast pathway
- Conservative contaminants are rapidly flushed from the alluvial groundwater into the deeper vadose zone
- Sorbing contaminants tend to remain close to the source in the alluvial system



Tritium and Chloride Tracer Test in Mortandad Canyon
Purtymun, 1974, LA-5716-MS

	Distance, m	Tritium		Chloride	
		Transit Time, days	Transport Velocity, m/y	Transit Time, days	Transport Velocity, m/y
MCO-5 to MCO-6	393	20	7300	25	5800
MCO-6 to MCO-7	320	77	1500	63	1900
MCO-7 to MCO-7.5	290	66	1600	52	2000
MCO-7.5 to MCO-8	183	109	620	79	840

Hydrologic Conceptual Model

Vadose Zone

Dry Canyons and Mesas

Downward percolation rates are low (<10 mm/y)

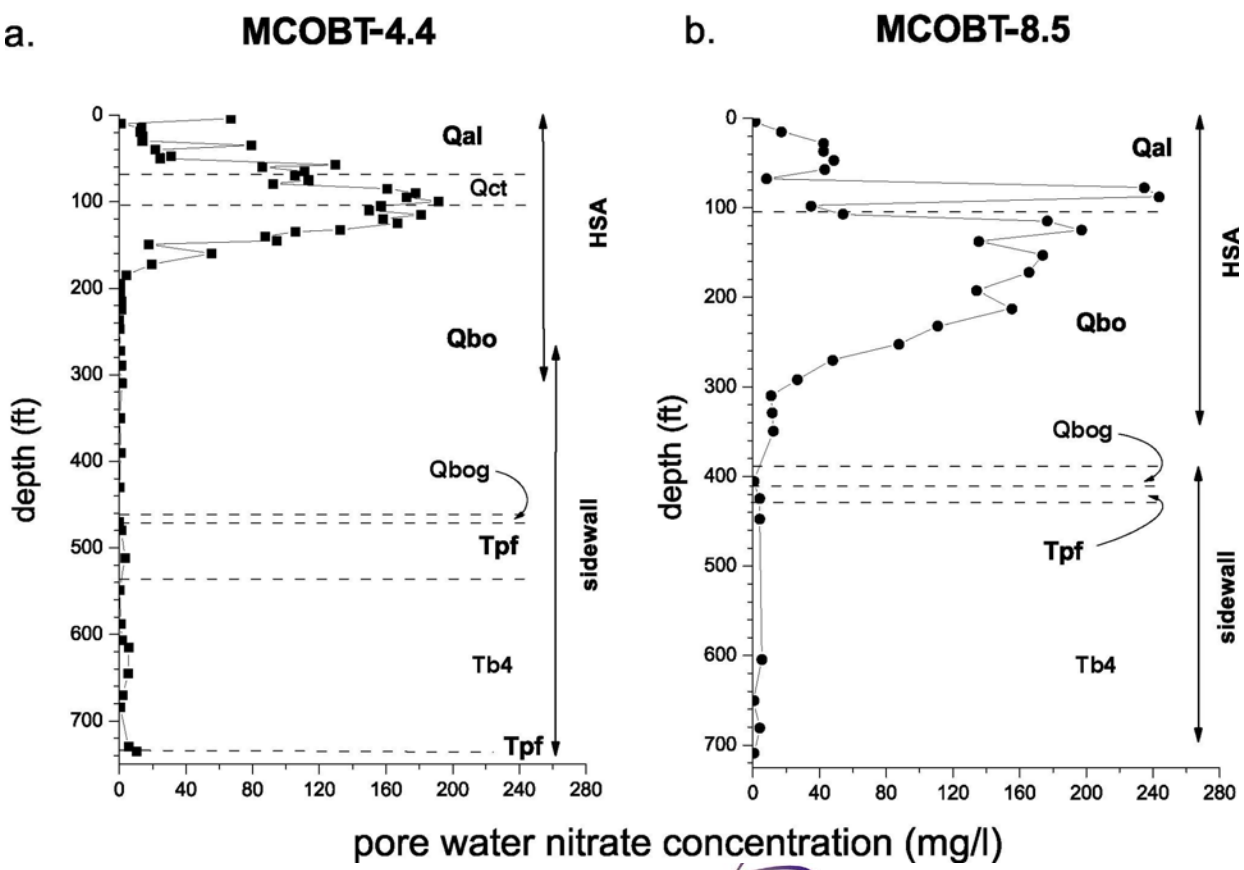
Wet Canyons

Downward percolation rates are high (1000 mm/y)

Hydrologic Conceptual Model

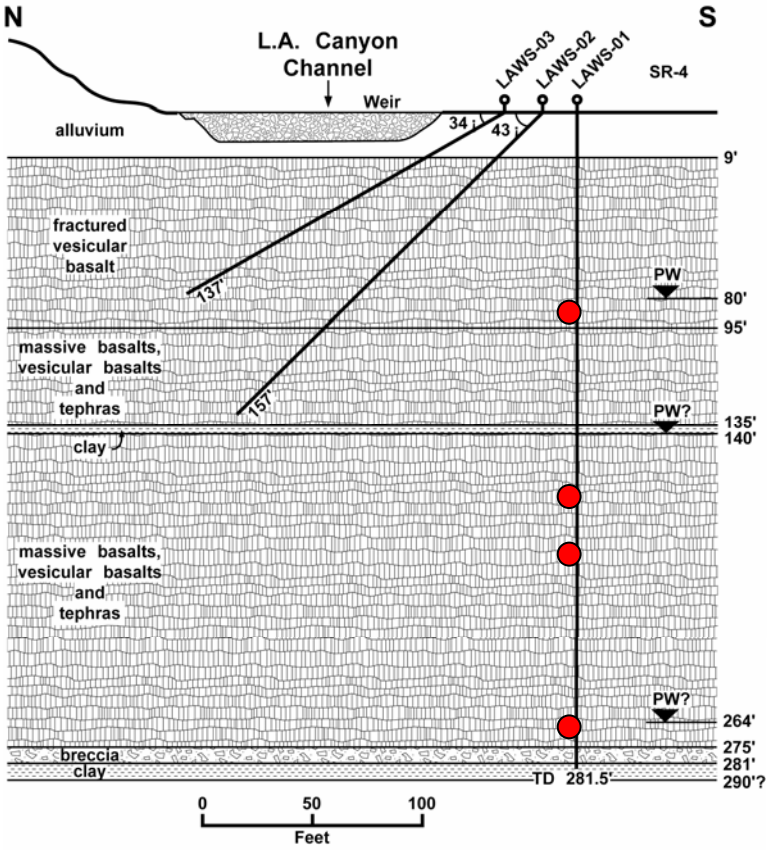
Vadose Zone – Transport through Bandelier Tuff

- Percolation occurs principally through the rock matrix
- Travel times are on the order of decades from the canyon bottoms, in excess of 1000 years from dry, undisturbed mesas



Hydrologic Conceptual Model

Vadose Zone – Transport through basalts

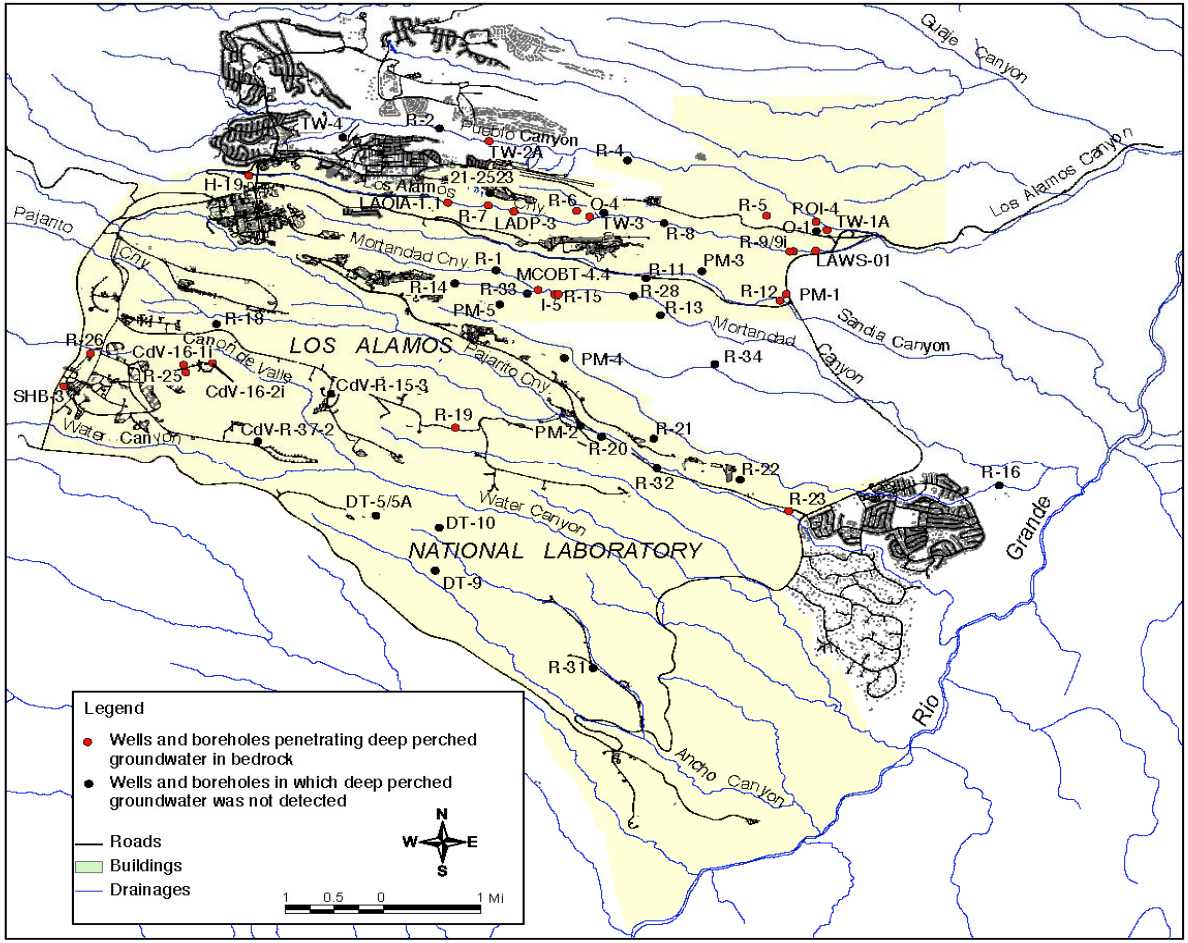


- For basalts, the measured transport times from the surface to significant depths are on the order of days to months
- Flow and transport occurs exclusively through fast paths

Hydrologic Conceptual Model

Vadose Zone – wells encountering perched water

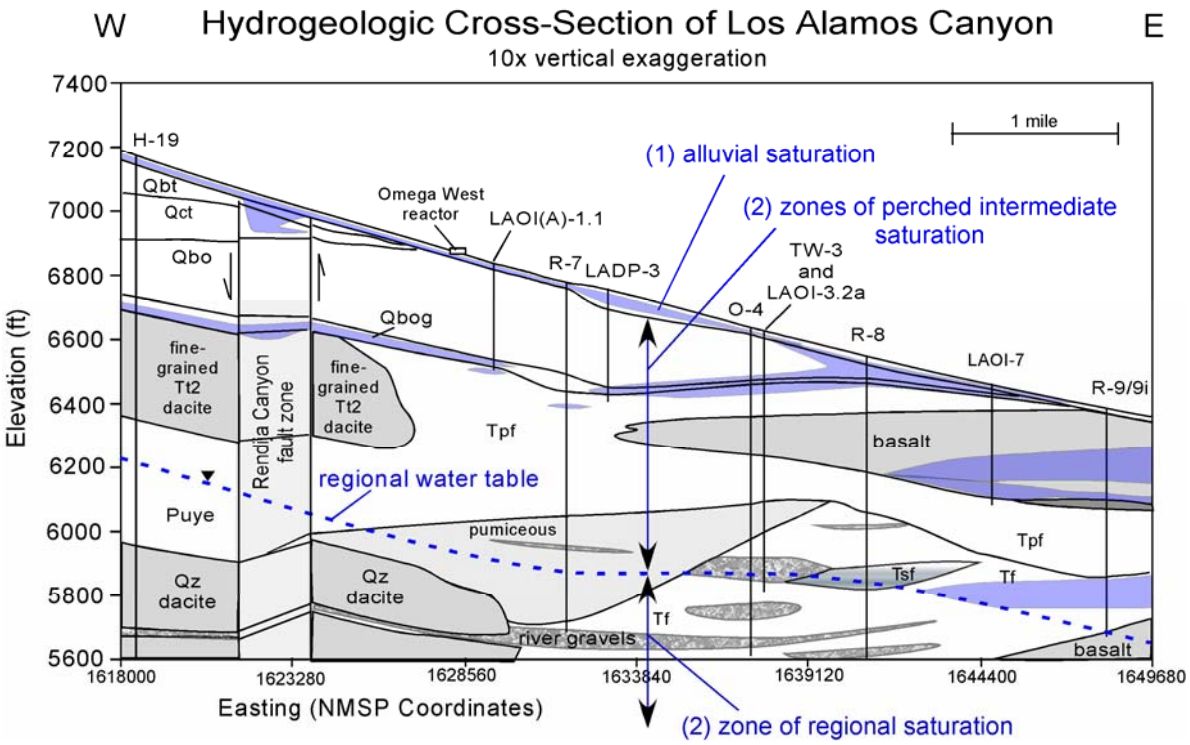
- Perched water often found beneath canyons where infiltration rates are highest
- Perched water much less often found beneath mesas
- Anthropogenic chemicals are typically found in perched water, indicating contaminant transport to significant depths



Hydrologic Conceptual Model

Vadose Zone – perched water conceptual model

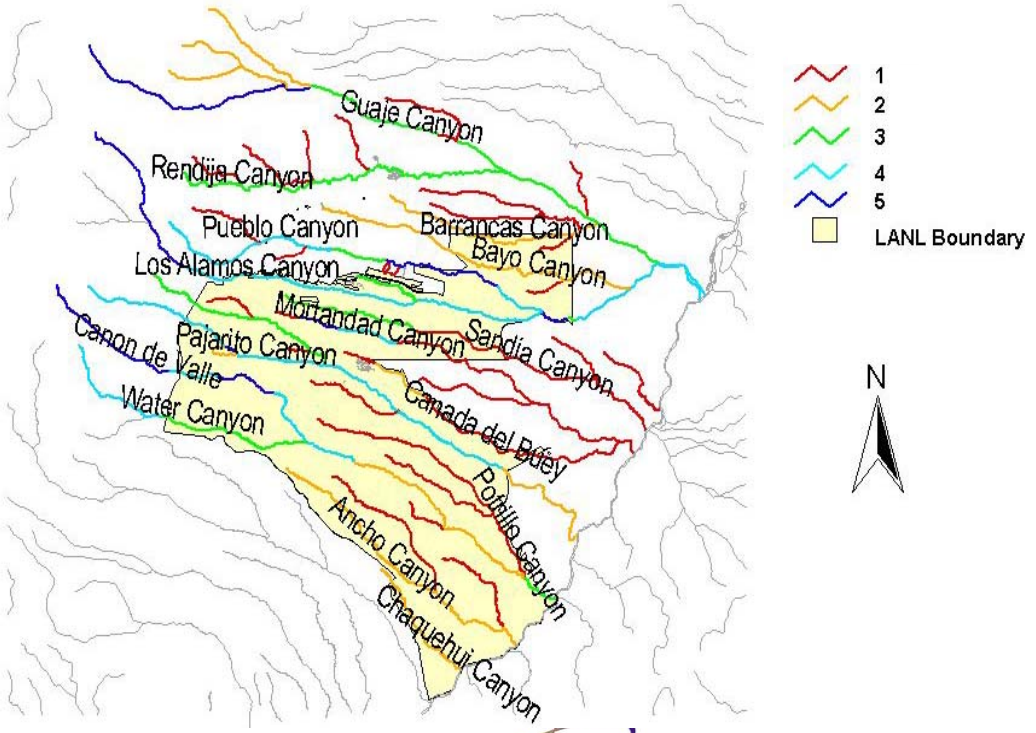
- Perched zones usually are controlled by local hydrostratigraphy – perching horizons include unfractured basalts, clay-rich interflow zones in basalts, buried soils, clay-altered tuffaceous sediments
- Flow conditions within perched zones are difficult to characterize. End-members are:
  - –Low-velocity, nearly stagnant water
  - –High-velocity, laterally migrating fluid



Vadose Zone Travel Times

- Infiltration is a function of the surface hydrologic conditions in individual canyons
  - –Origin of headwaters
  - –Human-induced water sources
  - –Surface disturbances
- Relative infiltration rates are set based on these criteria

Infiltration Index for Canyons

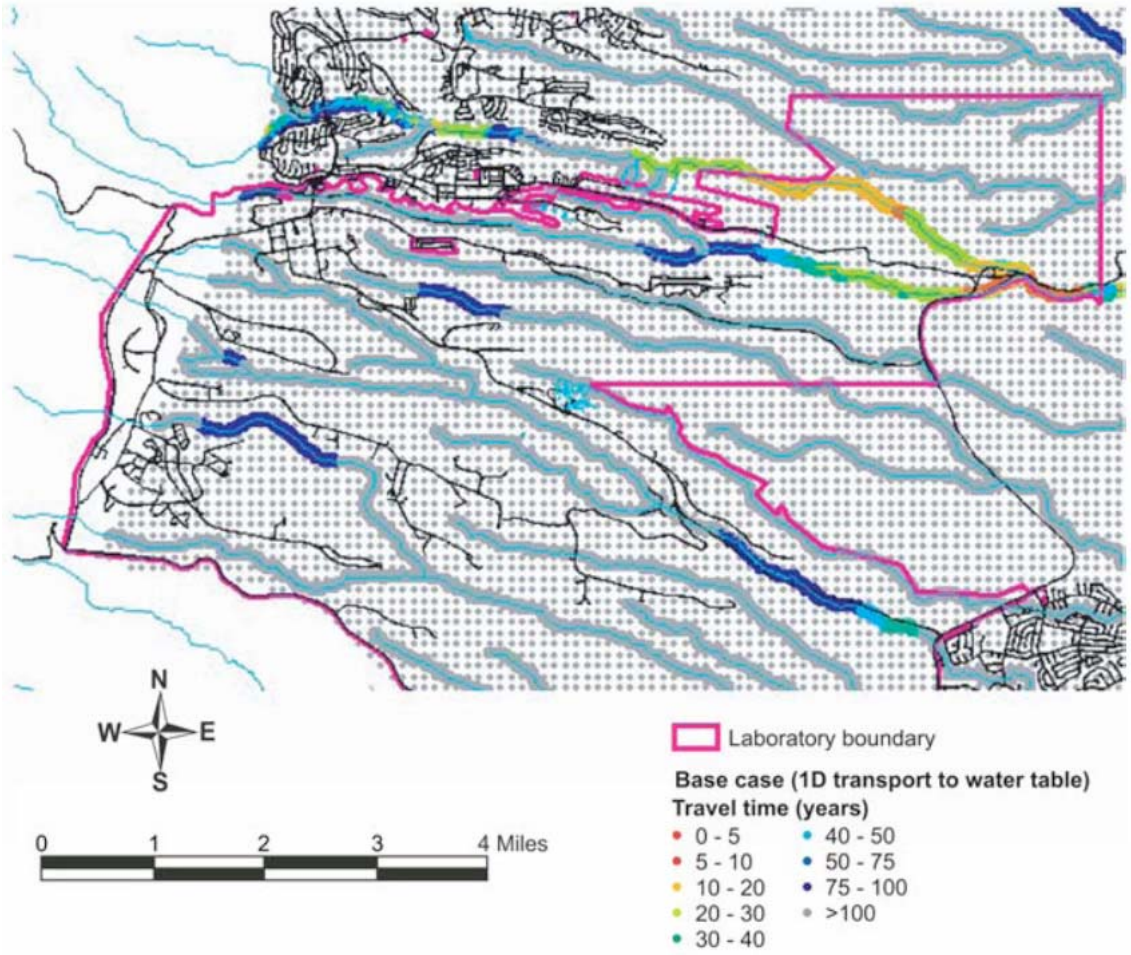


Vadose Zone Travel Times

Canyons

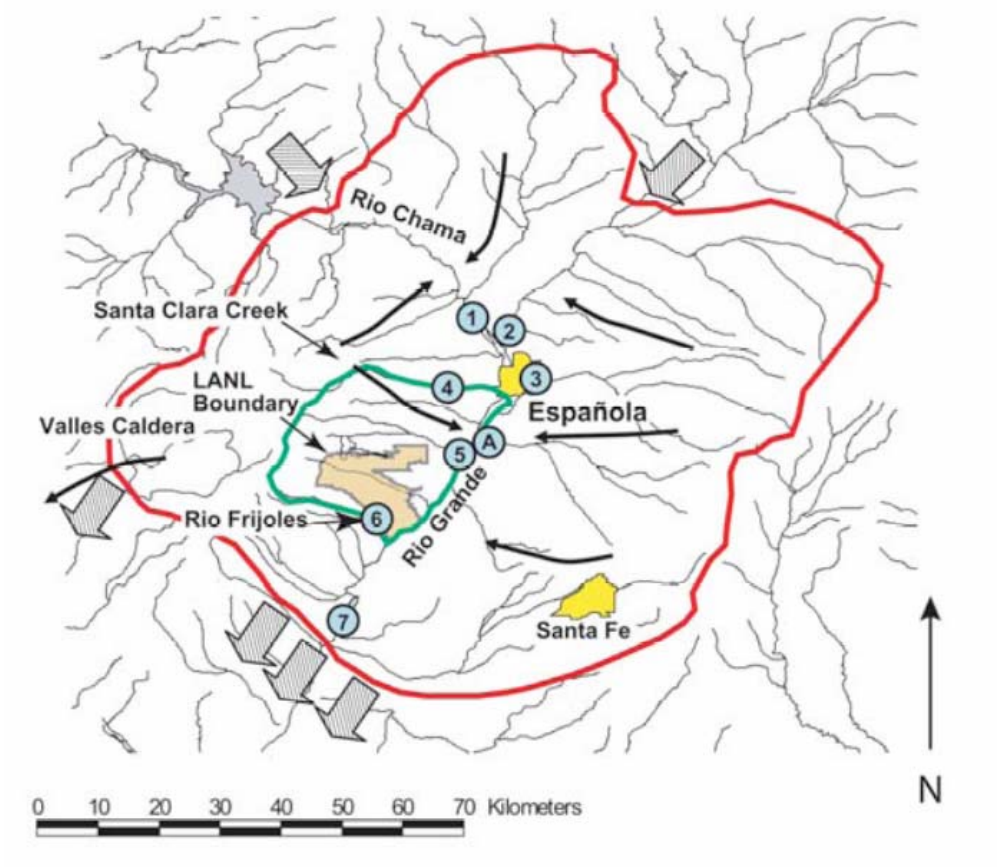
Vadose zone travel times to the regional aquifer water table are a function of:

- Infiltration rate
  - Long travel times from mesas
  - Short travel times from naturally wet canyons or canyons with large water inputs due to LANL or municipal water discharges
- Hydrogeology
  - Bandelier Tuff leads to slow percolation
  - Basalts lead to fast pathways through the vadose zone



Hydrologic Conceptual Model

Regional Aquifer – Española Basin

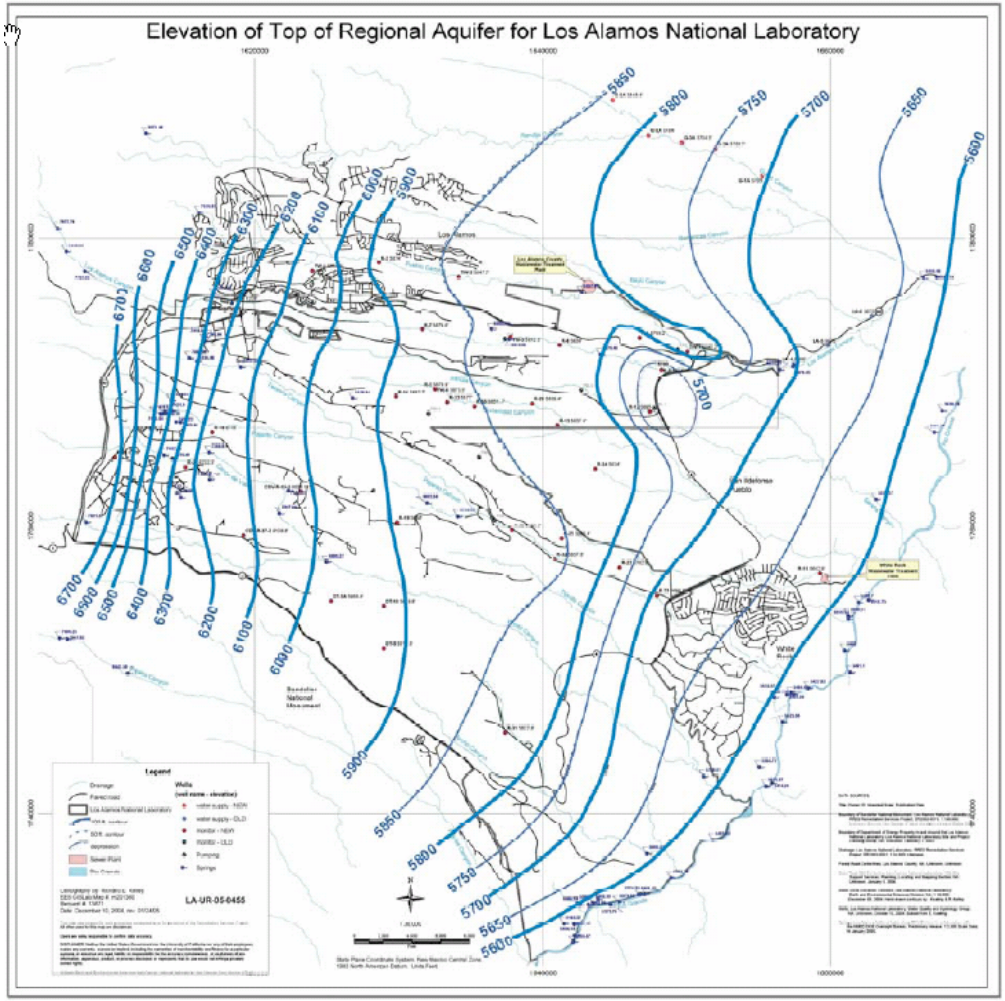


- Regional aquifer is a major source of municipal and agricultural water supply for Northern New Mexico
- Basin-scale flow paths are from Mountainous regions to the Rio Grande
- Regional water table is typically 0-60 m below ground surface, but is much deeper beneath the Pajarito Plateau (up to 350 m below ground surface)
- Aquifer consists primarily of weakly consolidated basin-fill sediments (Santa Fe Group rocks)

Hydrologic Conceptual Model

Regional Aquifer – Site Scale

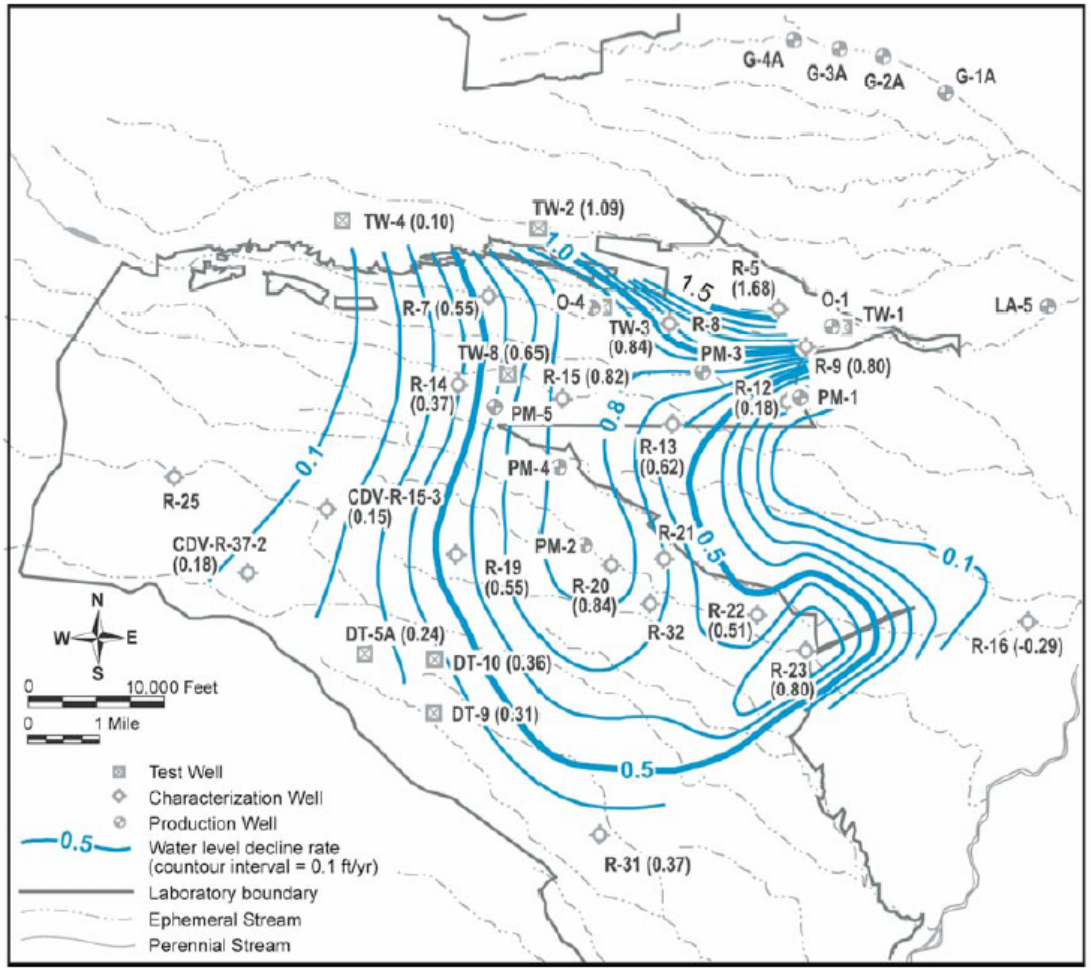
- Gradients are from west to east, toward the Rio Grande
- Steep gradients in the western portion of LANL are caused by the Pajarito Fault zone
- Municipal water supply well pumping has had an impact on the potentiometric surface



Hydrologic Conceptual Model

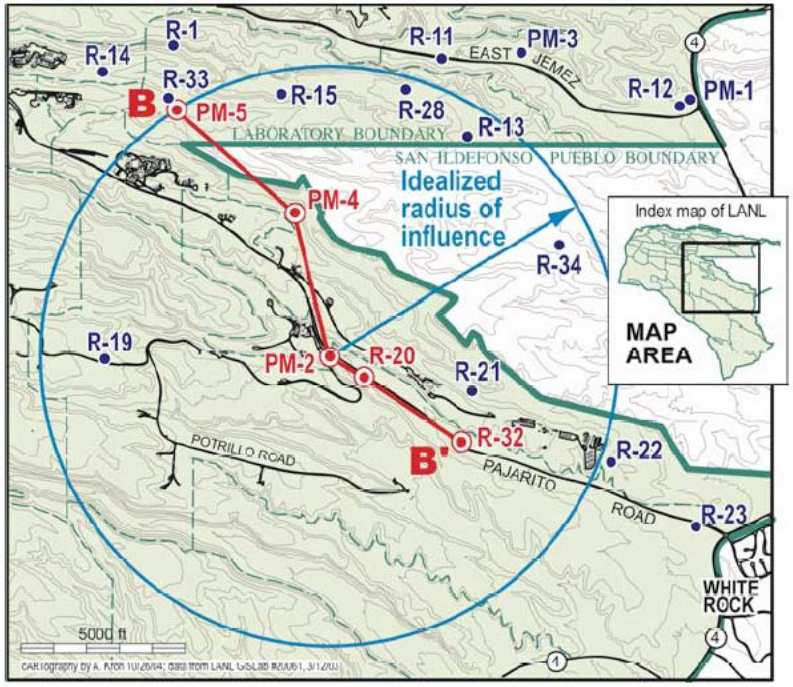
Regional Aquifer – Site Scale

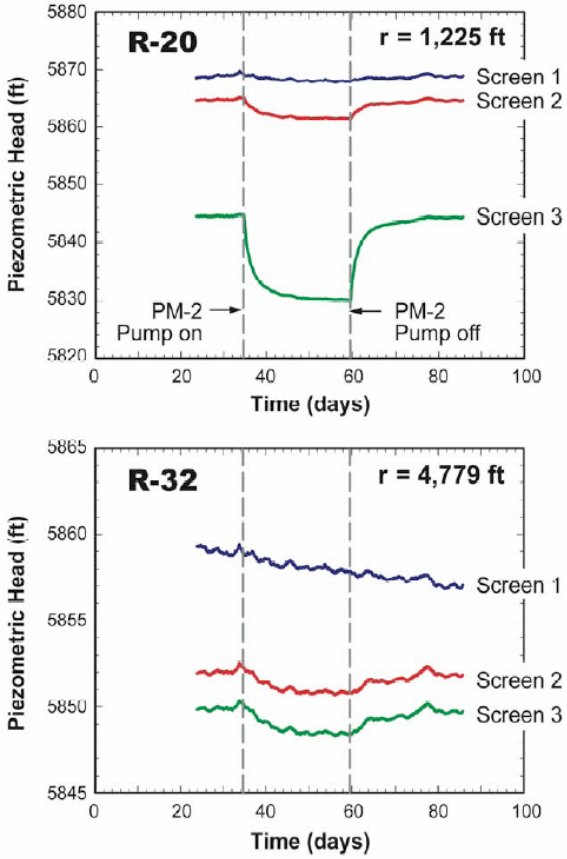
- Pumping of municipal water supply wells has led to measurable water level declines around LANL
- Declines at the depth of the pumping well screens are the largest
- Vertical anisotropy results in a more muted response at the water table



Hydrologic Conceptual Model

Regional Aquifer – Influence of Pumping



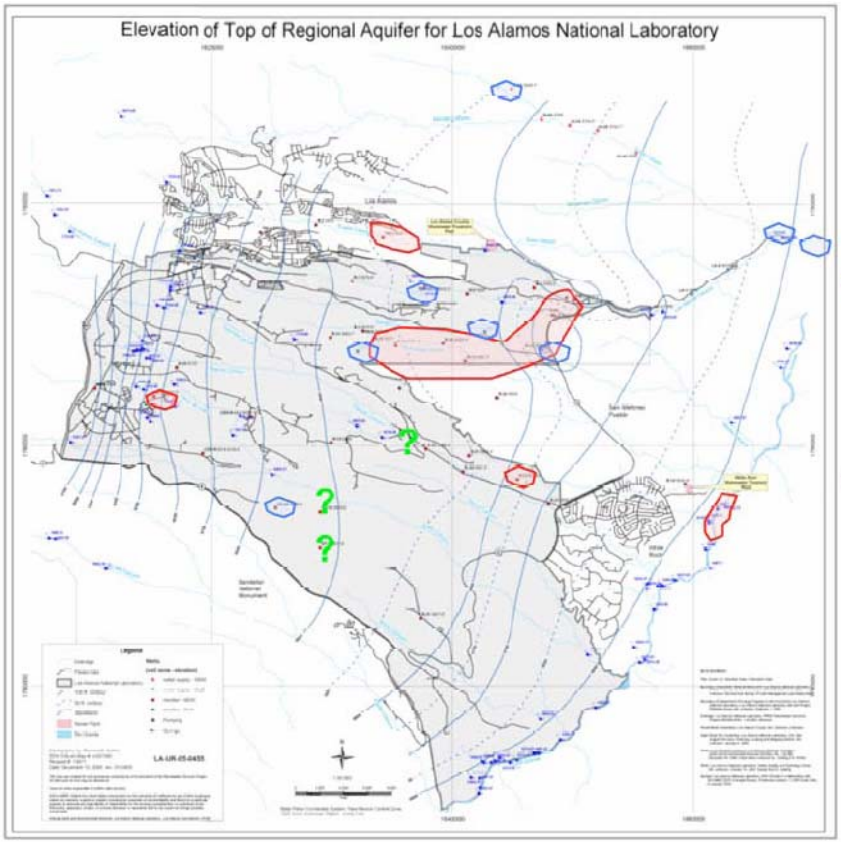


- Pumping tests show the large radius of influence for municipal water supply wells, and large vertical anisotropy in the regional aquifer (kv << kh)

Hydrologic Conceptual Model

Regional Aquifer – Hydrochemical information

- Different age indicators yield vastly different fluid ages in the regional aquifer
- Fluids are generally a mixture of very young and old waters
- Deep groundwater generally increases in age from west to east
- Groundwater from the greatest depths typically shows no indication of anthropogenic influence



Based on ^{14}C dating, groundwater has a component of very old water (> 1000 years)

Based on ^{3}H data, groundwater has a component of very young water (< 45 years)

Summary

- Alluvial groundwater represents a rapid lateral transport pathway for conservative contaminants
- Vadose zone transport is controlled by basic hydrogeolologic characteristics such as:
  - –Canyon vs. Mesa setting
  - –Bandelier Tuff vs. Basalt
  - –LANL and municipal water discharges
- Perched water is caused by a variety of complex, local hydrogeologic heterogeneities, and adds uncertainty to the characterization of subsurface pathways
- Regional aquifer pathways are well understood at the basin and Plateau scales
- Predictions at the scale of individual contaminant sources is complicated by heterogeneities, anisotropy, and the influence of municipal water supply well pumping