# Uranium Elemental and Isotopic Constraints on Groundwater Flow Beneath the Nopal I Uranium Deposit, Peña Blanca, Mexico

OCRWM Office of Science and Technology and International

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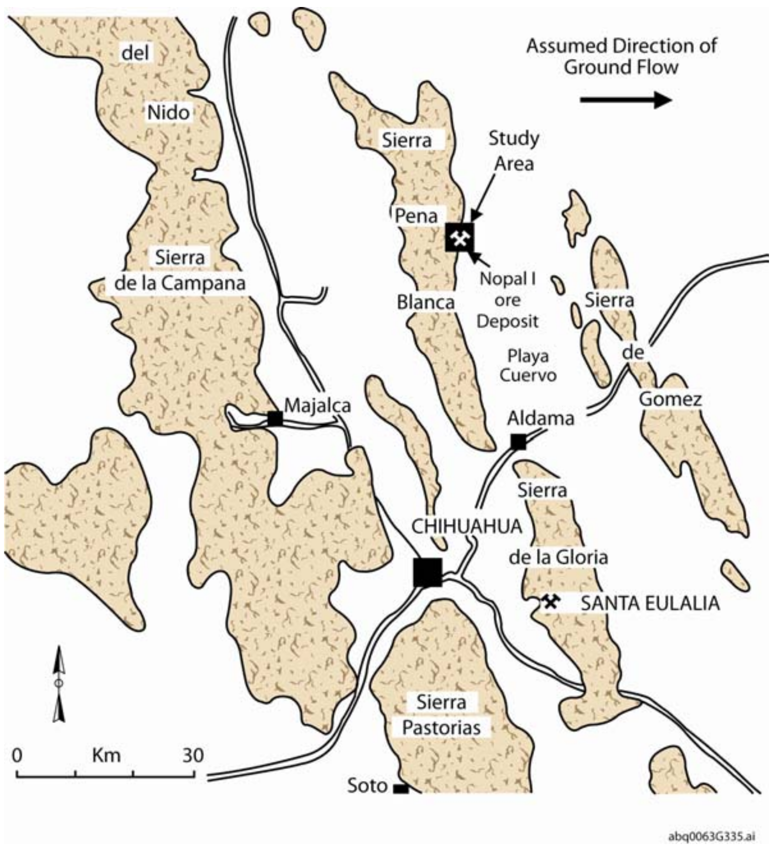
# Relationship to Yucca Mtn.

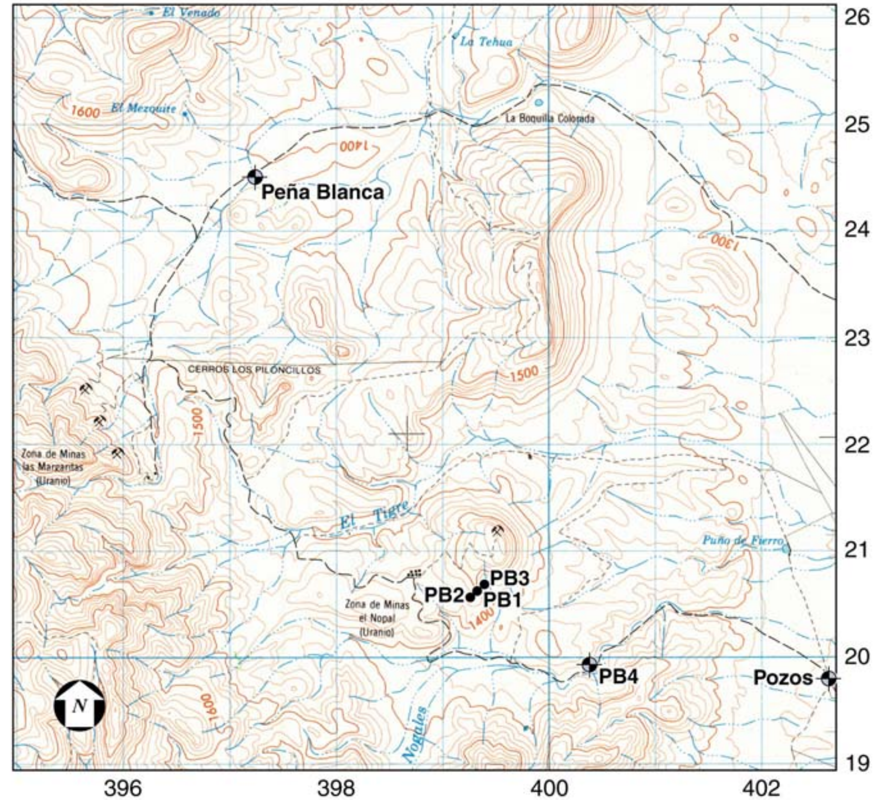
- Groundwater velocity is an important parameter influencing radionuclide transport at Peña Blanca and Yucca Mountain.
- Groundwater hydrology at Peña Blanca is poorly understood:  speed and direction.
- Specifically identified need: conduct artificial tracer studies at Peña Blanca to detect SZ groundwater flow and transport.
- This study uses natural U as a tracer of groundwater flow.
- SZ groundwater velocity information is directly used by models of radionuclide transport, including TSPA.

# Outline

- **Saturated Zone Uranium Data**
  - **Concentrations [U] and isotopics ($^{234}U/^{238}U$)**
- **Modeling**
  - **One-Dimensional (1-D) Dispersion/Advection**
- **Conclusions**
  - **Limited groundwater flow and mixing are apparent**

# Sample Locations




*Legend*

- Existing Wells
- New Peña Blanca Boreholes

0 1 Km

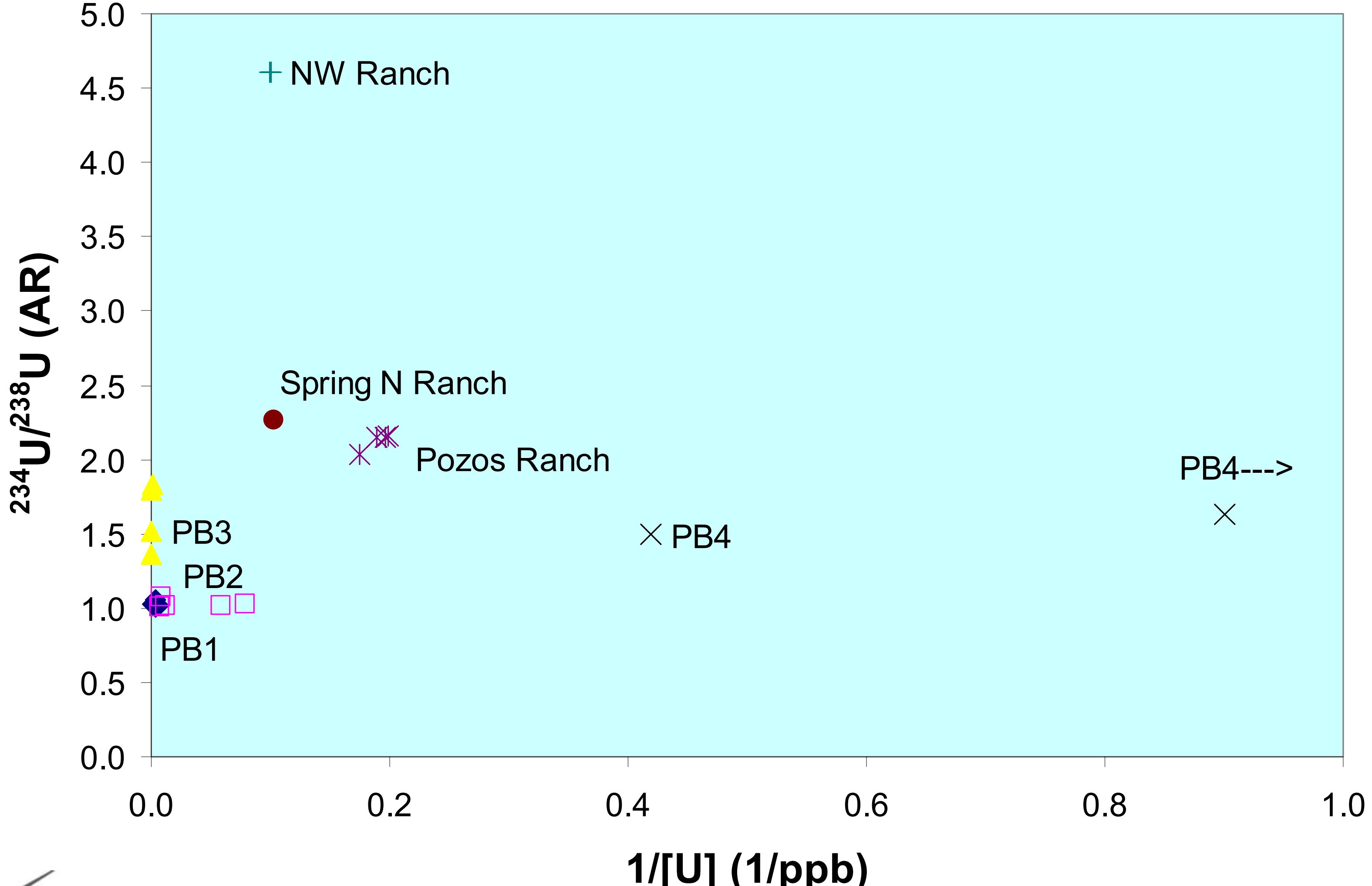
Contour Interval = 20 Meters

El Sauz 1:50,000 Topographic Map (H13C46)
North American 1927 datum

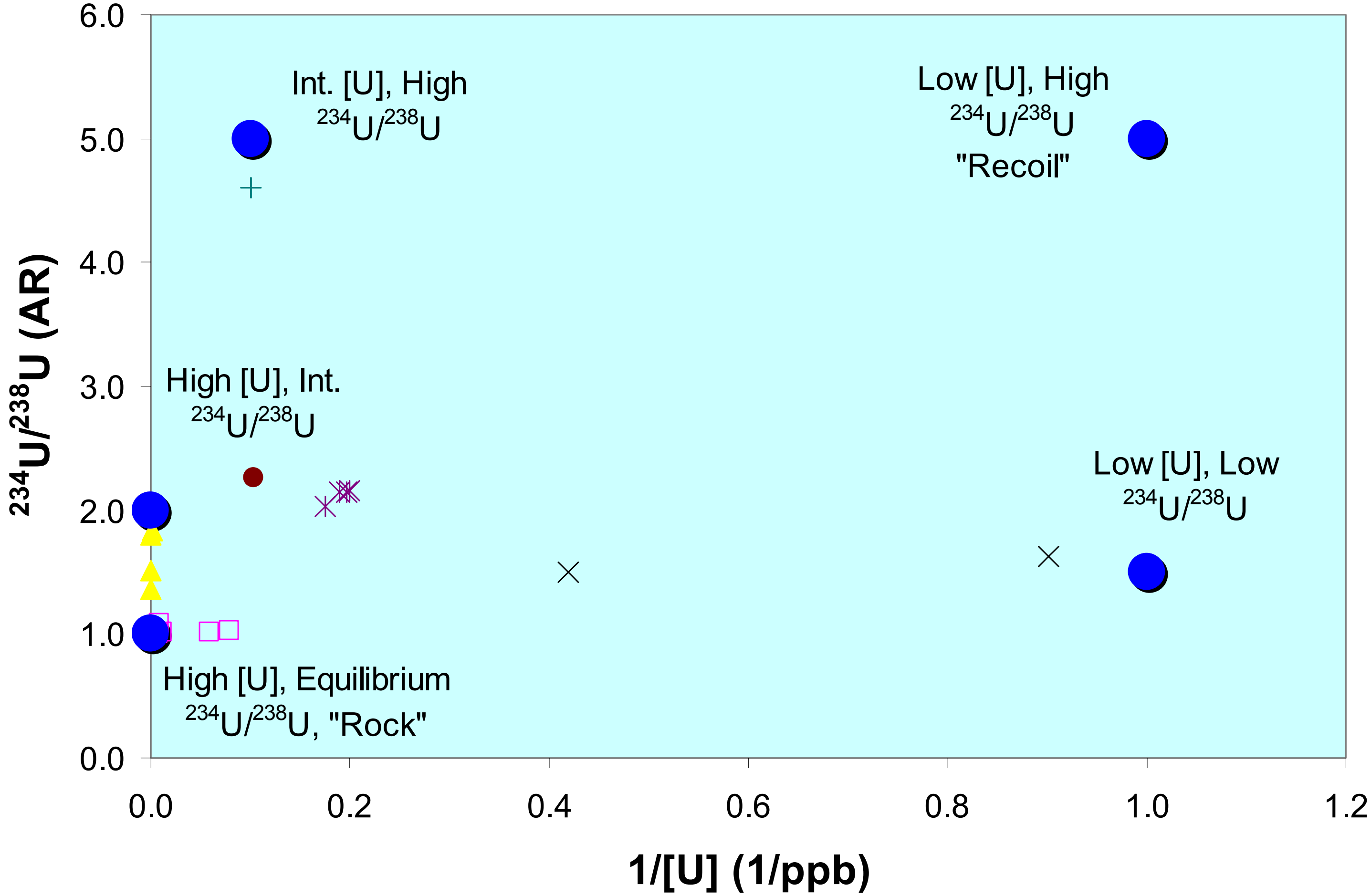
NA04-001

# Panoramic View of New PB Wells

# U Isotopic Results



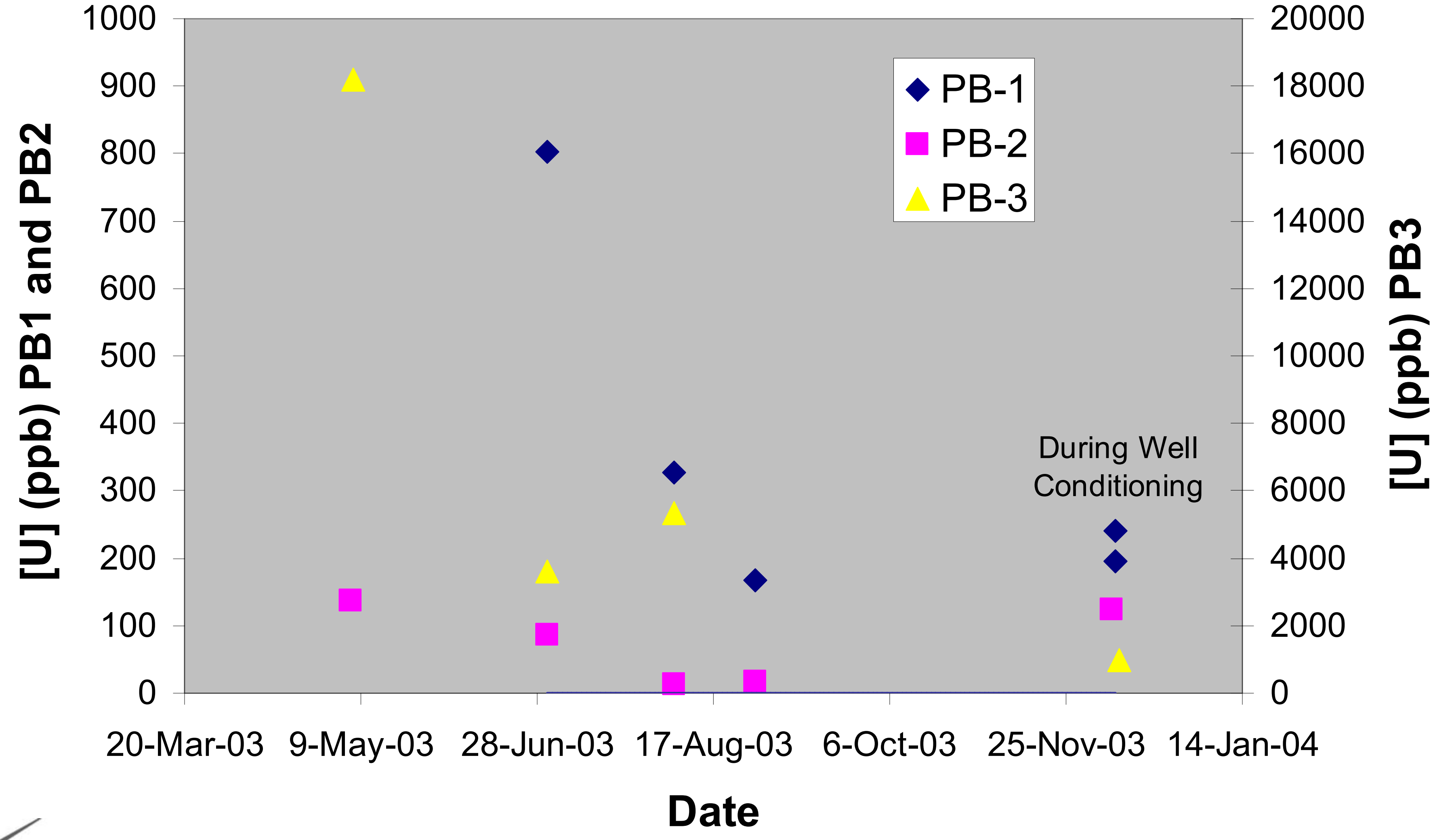
# Multiple Components for U



# U Isotopic Summary

- PB-1 and PB-2 isotopically similar, suggesting interconnectivity.
- PB-3 has distinct composition and therefore may be located on a different flow path.
- Generally, regional wells have distinct isotopic characteristics indicating limited mixing over larger length scales (km).
- Newly drilled wells PB-1, PB-2, and PB-3 have elevated U concentrations which are decreasing over time (next slides).

# U Time Series



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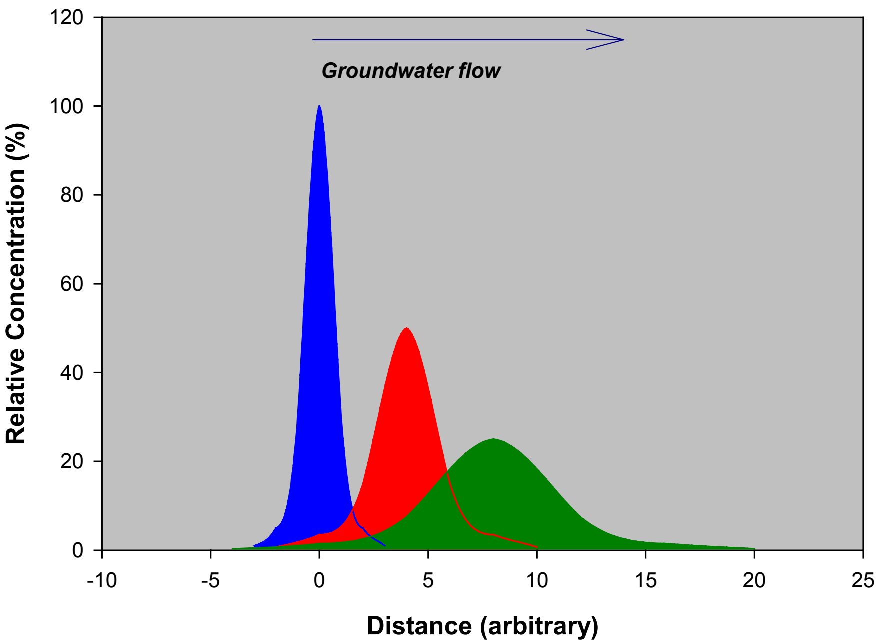
# 1-D Advection-Dispersion Model



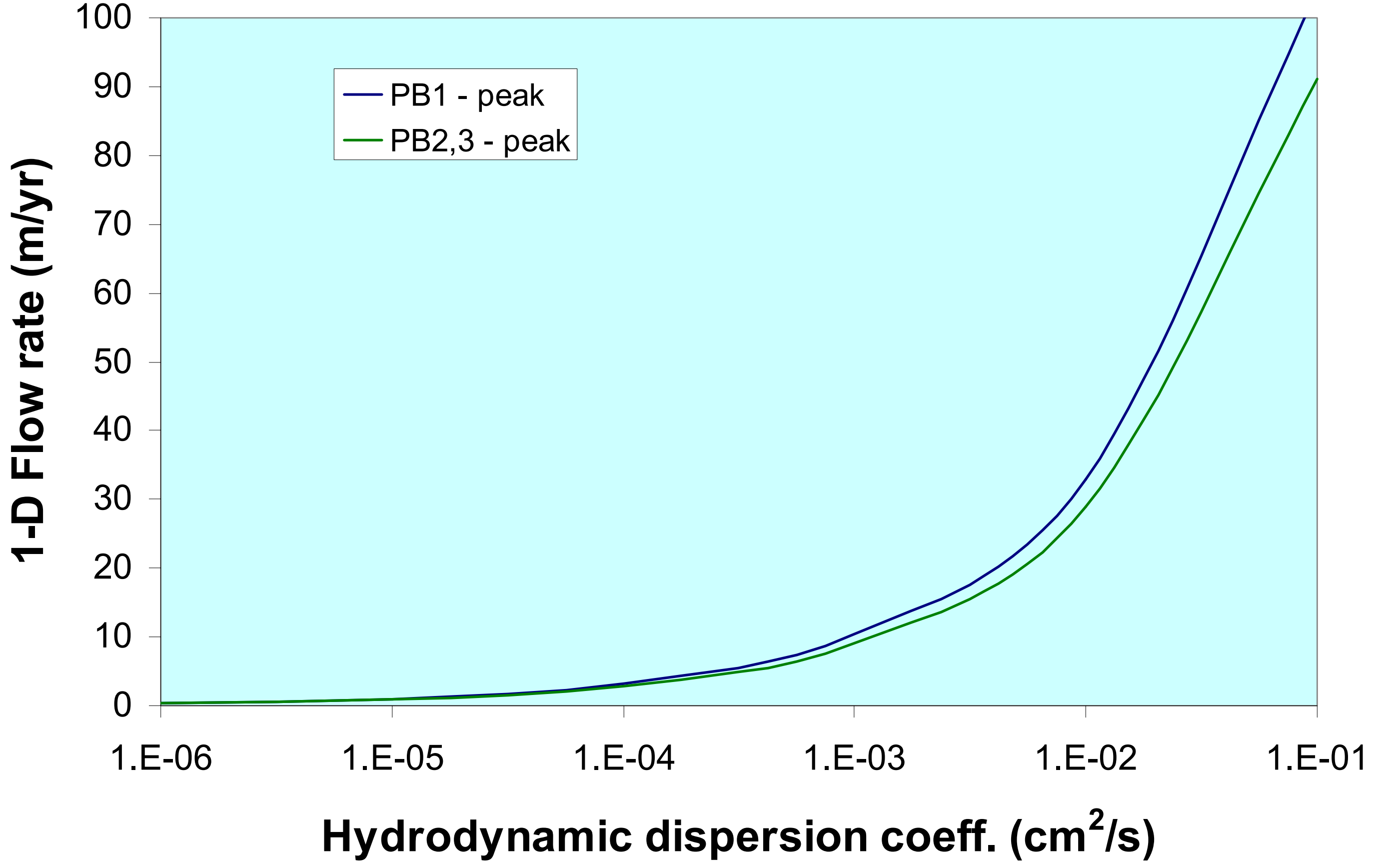

- Model Assumptions
  - U introduced as a slug at t=0, x=0
  - U is a conservative tracer over short timescales (months-year)
  - Analytical solution in Bear (1979)
- Relative U concentration (C) controlled by position (x), time (t), groundwater velocity (V), and dispersion ($D_h$)
- At point of U introduction (x=0),

  $$C_2/C_1 = (t_1/t_2)^{0.5}\exp\{V^2(t_1-t_2)/4D_h\}$$

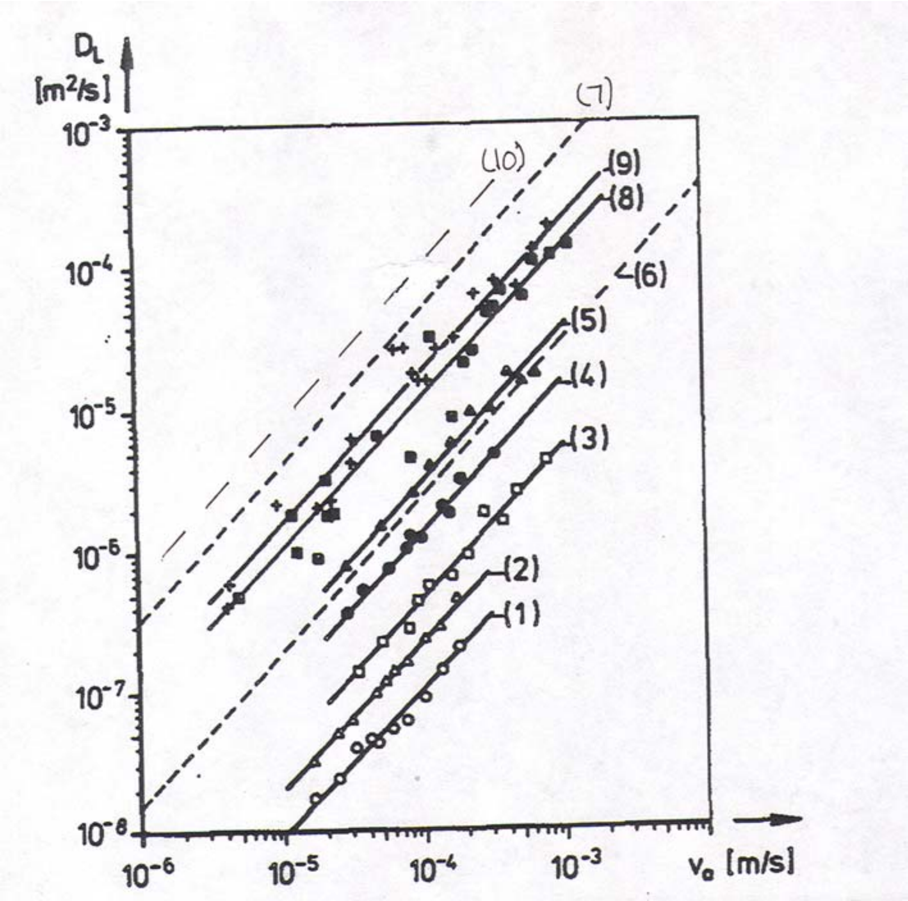
- Knowing $C_2$, $C_1$, $t_2$, and $t_1$, one can obtain a relationship between velocity and dispersion for each of the three wells:

  $$V = \{\ln[(C_2/C_1)(t_2/t_1)^{0.5}]4D_h/(t_1-t_2)\}^{0.5}$$

# Velocity-Dispersivity Relationship

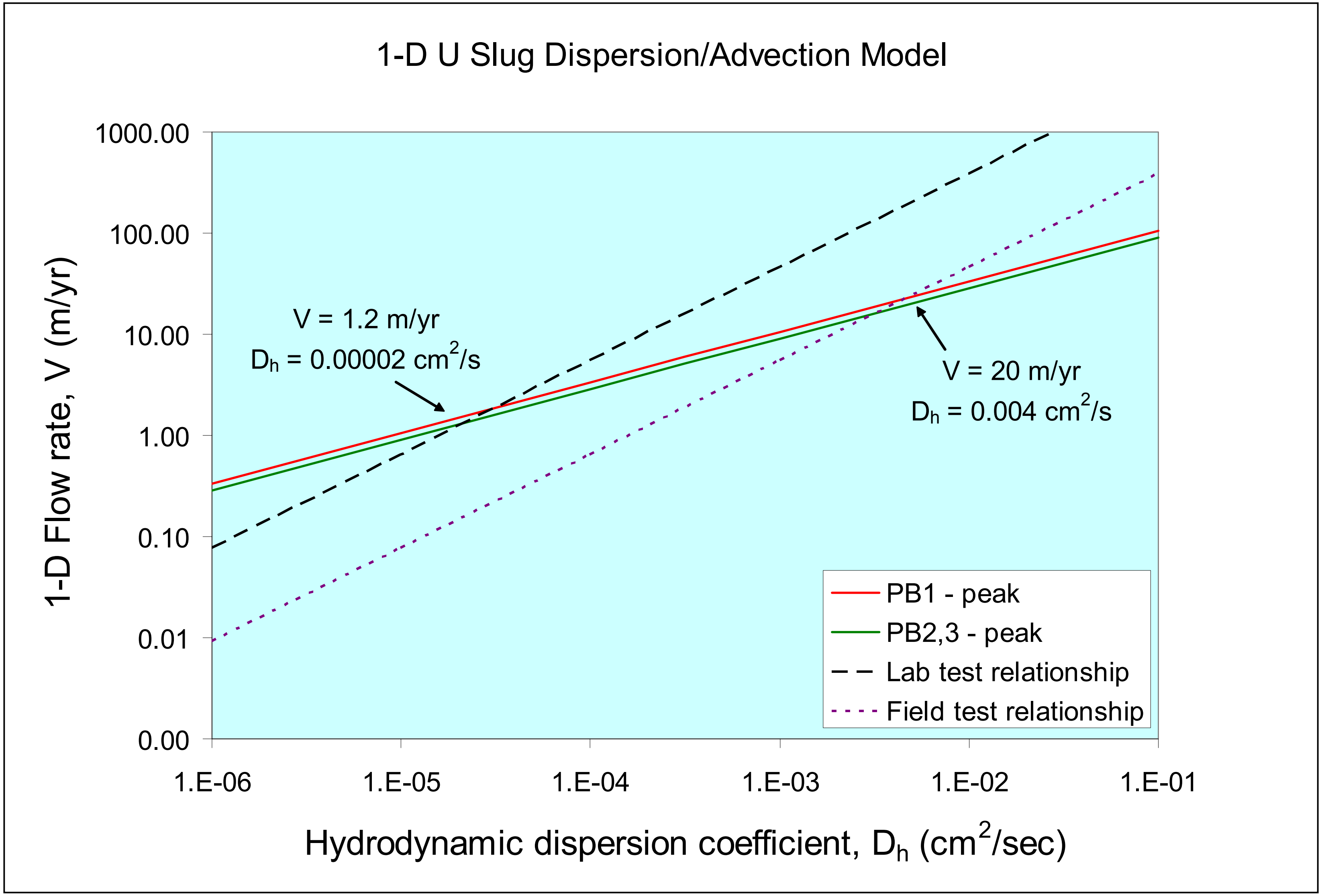


# Velocity-Dispersion Correlations from Lab and Field Studies




- Field and laboratory data from Klotz et al. (1980).
- Field site (Upper Bavaria, Germany) is composed of gravels with mean grain size of ~5 mm.
  - Lines 1-5: Lab tests based on natural mixtures of more homogeneous sands with grain size of 0.1 to 1 mm.
  - Lines 6-9: Lab tests based on natural mixtures of gravels from Bavaria
  - Line 10: Field tests in Bavaria

# Velocity Constraints



# Modeling Uncertainties

- **Field relationship between velocity and dispersion at Peña Blanca**
  - **German site is fairly typical of most aquifers (Gelhar et al. 1992).**
  - **Limestone aquifer data would provide a better approximation.**

- **Non-conservative behavior for U**
  - **U removal from solution would lower required flow velocity.**
  - **U addition to solution from rock-water interaction (aside from U slug) would increase required flow velocity.**

# Summary

- U isotopic data indicate multiple (4 or more) components for U in saturated zone water over various length scales (50 m to km).
  - Limited subsurface mixing apparent
- Decreasing U concentrations in the wells require limited flow and dispersion.
  - V ~ 20 m/yr
  - $D_h \sim 4 \times 10^{-3}$ cm$^2$/s
- Additional work with artificial tracers would better establish flow velocity and direction at this site.

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