LANL Legacy Cleanup Technical Working Group

Meeting Agenda
May 5, 2021
3:00 – 5:00 p.m.
Conference Call via Webex
Video Link:
https://n3b-la.webex.com/n3b-la/j.php?MTID=m8197c36660681a6372fc7e9a4dc41d14
Call-in number: 1-415-527-5035
Access code: 199 529 1938

3:00 p.m. Welcome and Introductions

- Safety and Ethics

3:10 p.m. Introduction to Agenda Topic

3:15 p.m. Chromium Project Overview: Setting the Stage

- Presentation by Dave Broxton:
  - Complex hydro-stratigraphy of the regional aquifer in the area of the hexavalent chromium plume
  - Influence on groundwater flow and contaminant movement

4:45 p.m. Open Discussion

- Time is allotted to address process questions or other items TWG members might have

5:00 p.m. Adjourn

Items not covered during this meeting will be carried over to the June 2, 2021 meeting

Future meeting(s) will focus on geochemistry of the regional aquifer and hexavalent chromium plume

U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

High-Resolution Stratigraphic Characterization of the Regional Aquifer at the Location of Hexavalent Chromium Plume at Los Alamos National Laboratory

Technical Working Group
May 5, 2021

David Broxton
Senior Geologist
N3B Los Alamos

ENVIRONMENTAL MANAGEMENT
SAFETY ◆ PERFORMANCE ◆ CLEANUP ◆ CLOSURE

N3B Los Alamos

PR001

Key Points

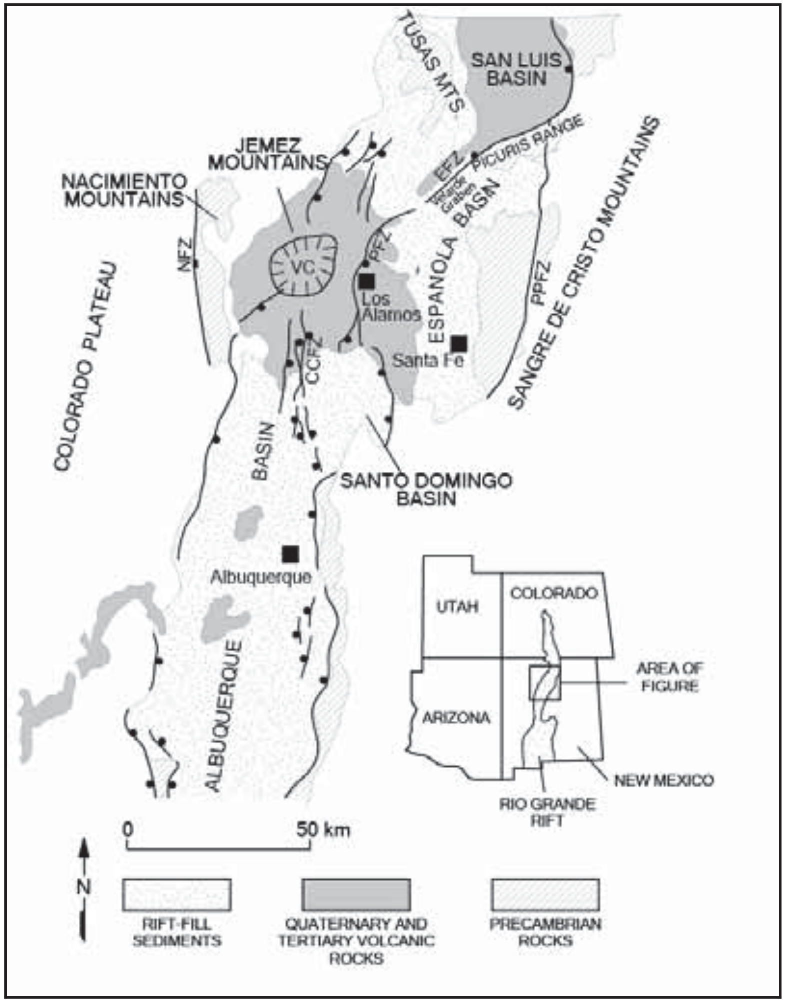
Objectives

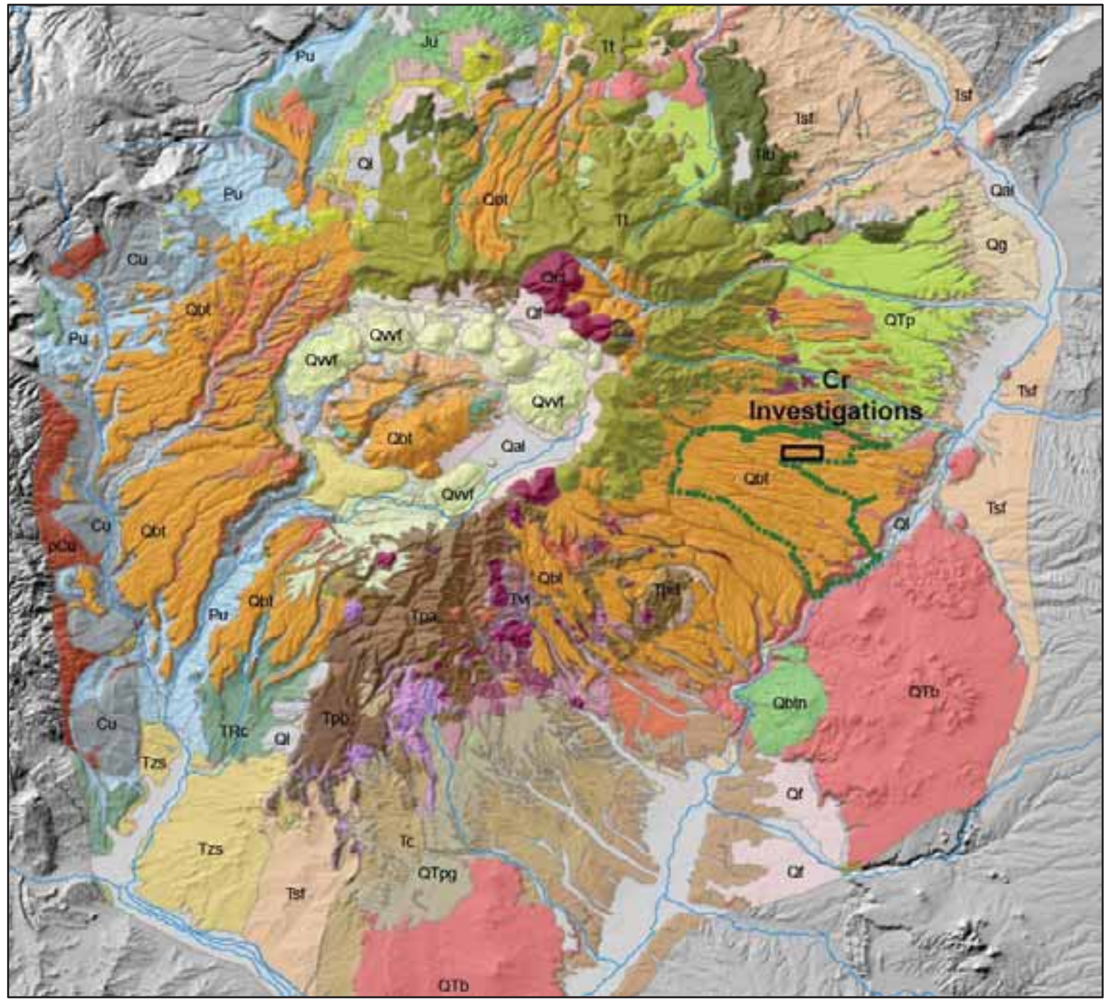
- Provide a high-resolution characterization of the lithologic and hydrologic structure of the regional aquifer
- Develop conceptual model that describes how chromium transport is occurring
- Support of design of remediation alternatives

Main Conclusions of This Analysis

- The regional aquifer in the Cr plume area consists of three primary stratigraphic units, but groundwater flow and chromium mass transport is effectively occurring through a single, highly heterogeneous, hydrostratigraphic unit
- The primary advective transport strata where groundwater and chromium flux is occurring are highly variable throughout the plume area
- Design of remediation strategies will need to consider that variability

Geologic Setting





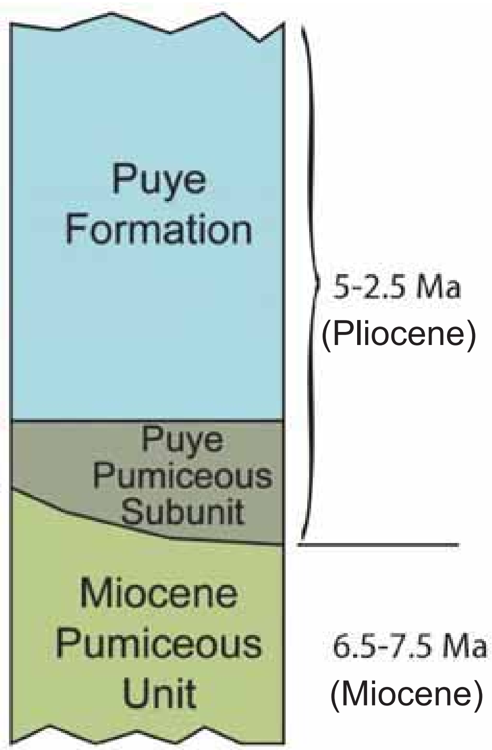
ENVIRONMENTAL MANAGEMENT
SAFETY ❖ PERFORMANCE ❖ CLEANUP ❖ CLOSURE

N3B Los Alamos

PR003

Geologic Units of the Regional Aquifer

Geologic units in regional aquifer are Miocene and Pliocene alluvial fan deposits



Puye Formation
Brown to gray dacitic gravels and lithic sandstones. Coarsest parts of the deposits contain boulders and cobbles of lava and tuff in a poorly sorted matrix of ash, silts, and sands.

Puye Pumiceous Subunit
Hybrid unit that has lithologic characteristics of overlying Puye Fm. And underlying Miocene Pumiceous Unit

Miocene Pumiceous Unit
Tan to light gray rhyolitic tuffaceous sands. Largely made up of medium- to coarse-grain pumiceous sands with minor gravels.

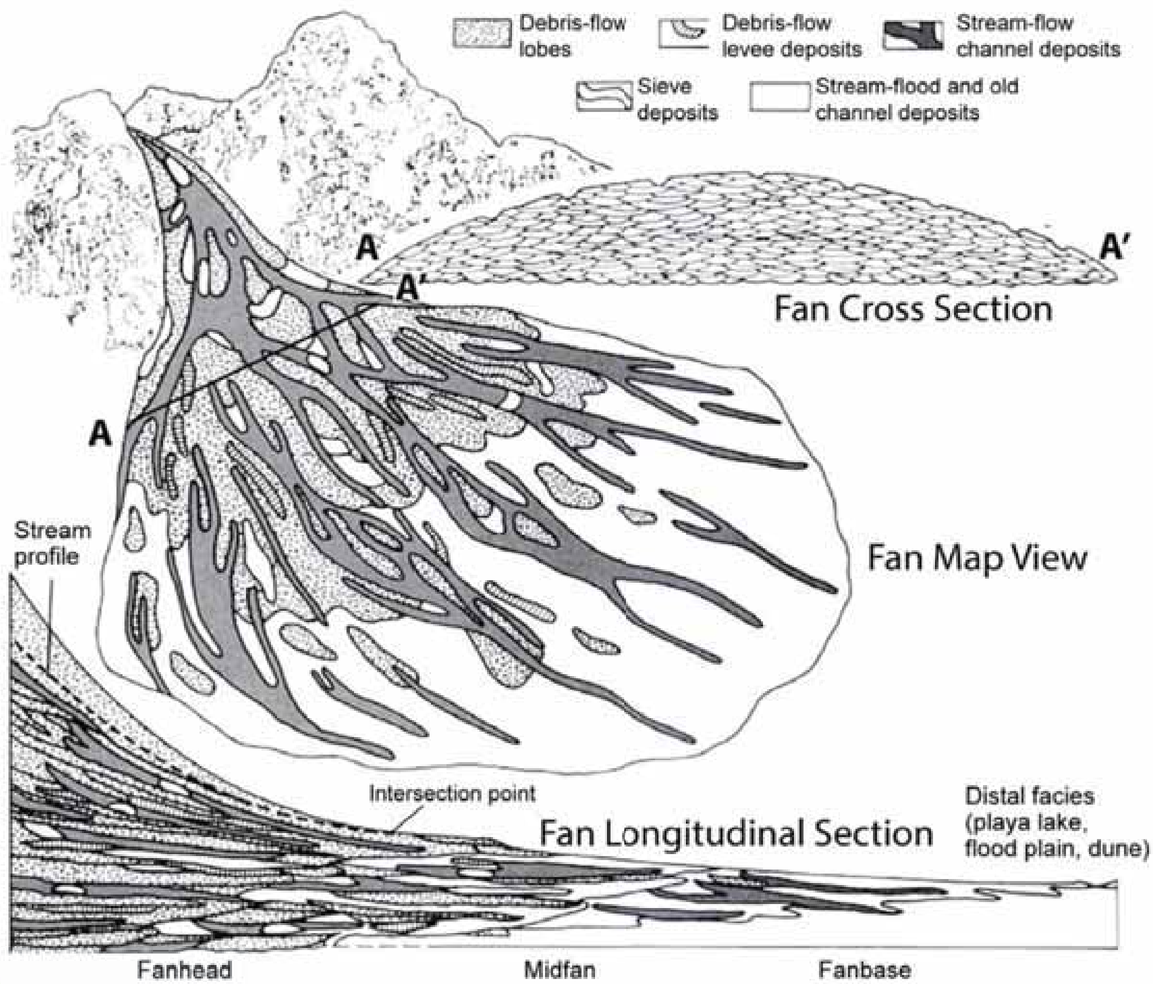
ENVIRONMENTAL MANAGEMENT
SAFETY ◆ PERFORMANCE ◆ CLEANUP ◆ CLOSURE

PR003

Alluvial Fans

Alluvial Fan Lithological Characteristics

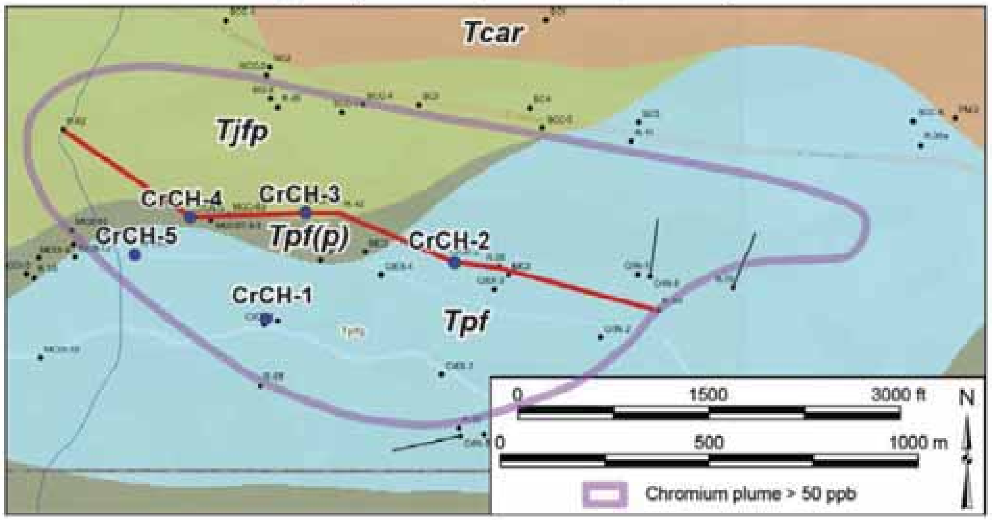
From Spearing, 1974



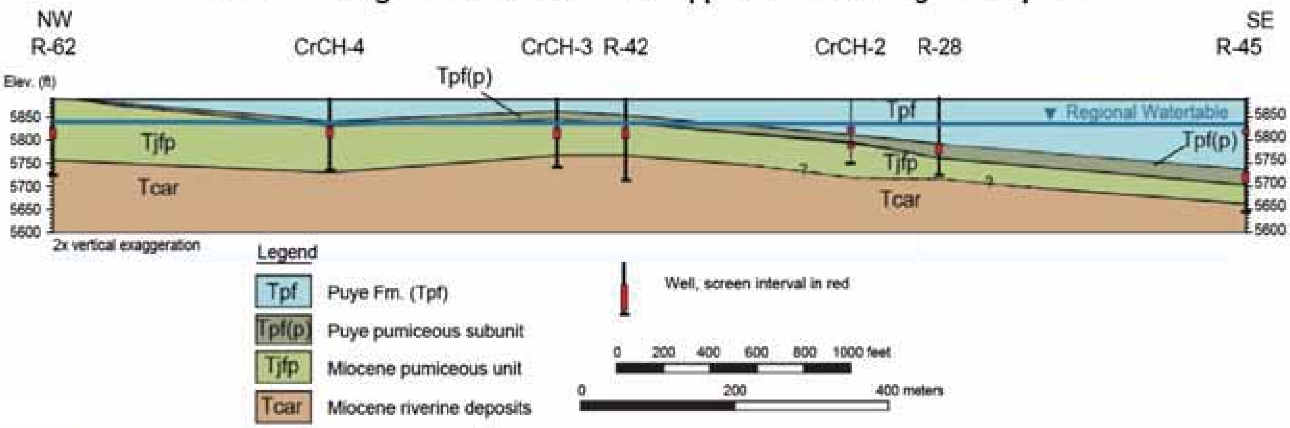
Aquifer Geology

- Chromium plume is largely confined to the upper 30 m (100 ft) of regional aquifer
- Three primary units:
  - *Puye Formation*
  - *Pumiceous Puye*
  - *Miocene Pumiceous Unit*
- Units dip gently towards the SE
- Groundwater flowing eastward across the plume area will encounter progressively younger rocks

Geologic Map at the Top of the Regional Aquifer



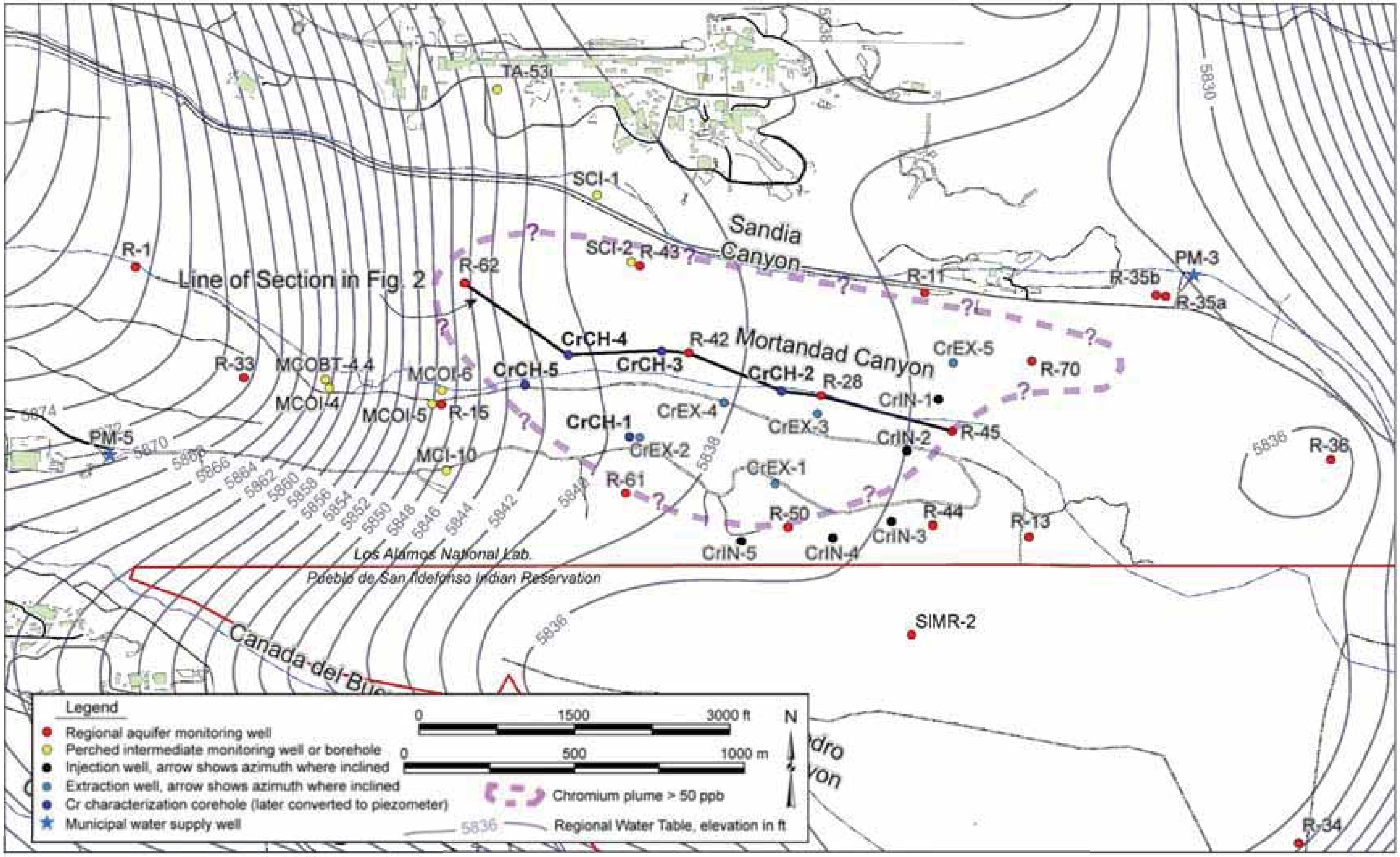
NW-SE Geologic Cross Section in the Upper Part of the Regional Aquifer



ENVIRONMENTAL MANAGEMENT
SAFETY ◆ PERFORMANCE ◆ CLEANUP ◆ CLOSURE

PR003

Core Holes CrCH-1 through CrCH-5 – drilled 2014



Cores

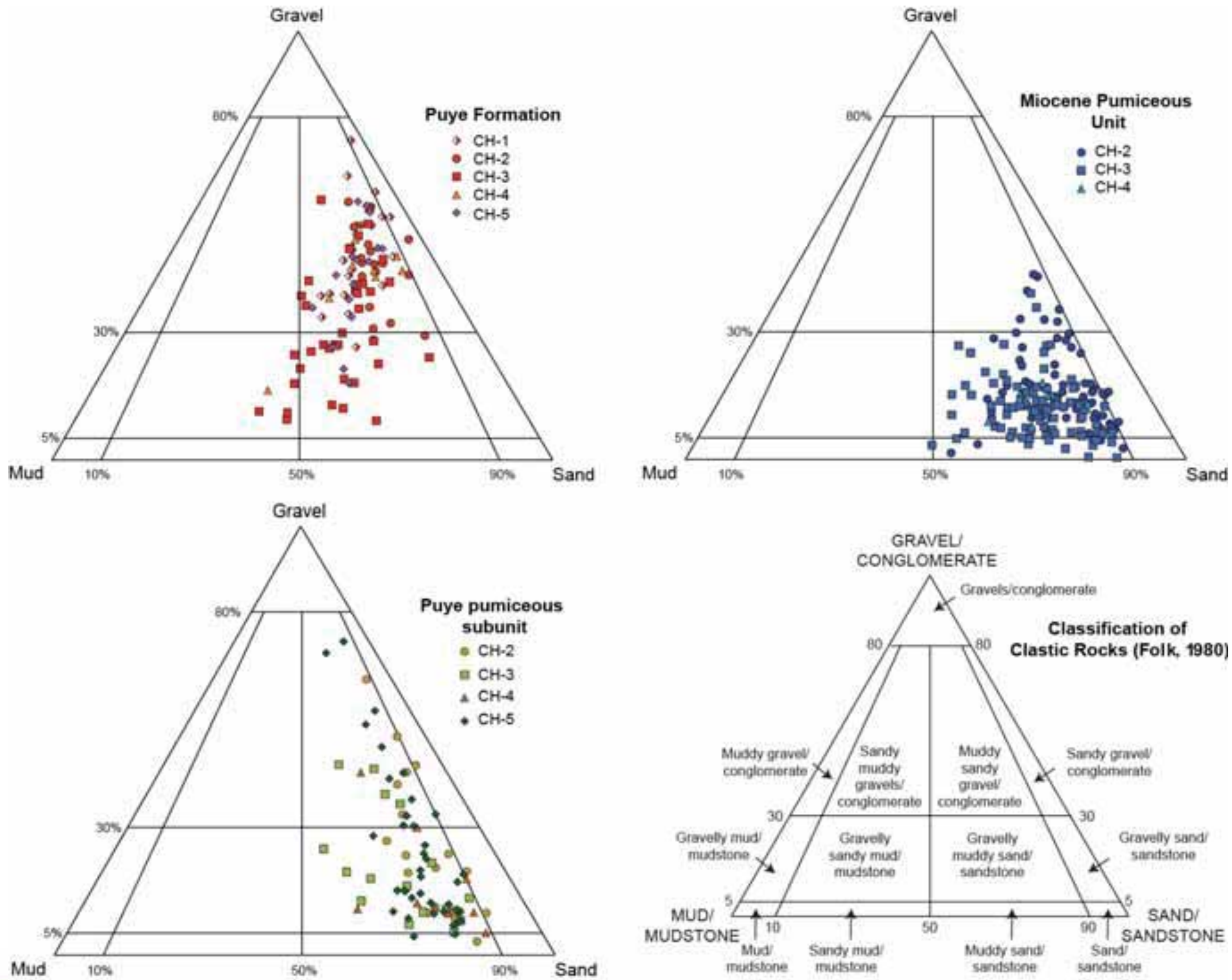
- Continuous core was collected by sonic drilling with nearly 100% recovery
- Strata were sampled from geologic formations that make up the regional aquifer
- Cores collected in lexan liners and plastic sleeves were cut open longitudinally and the core was described for color, grain size, clast composition, clast angularity, and bedding characteristics

Methodology for Determining Particle Size Distribution

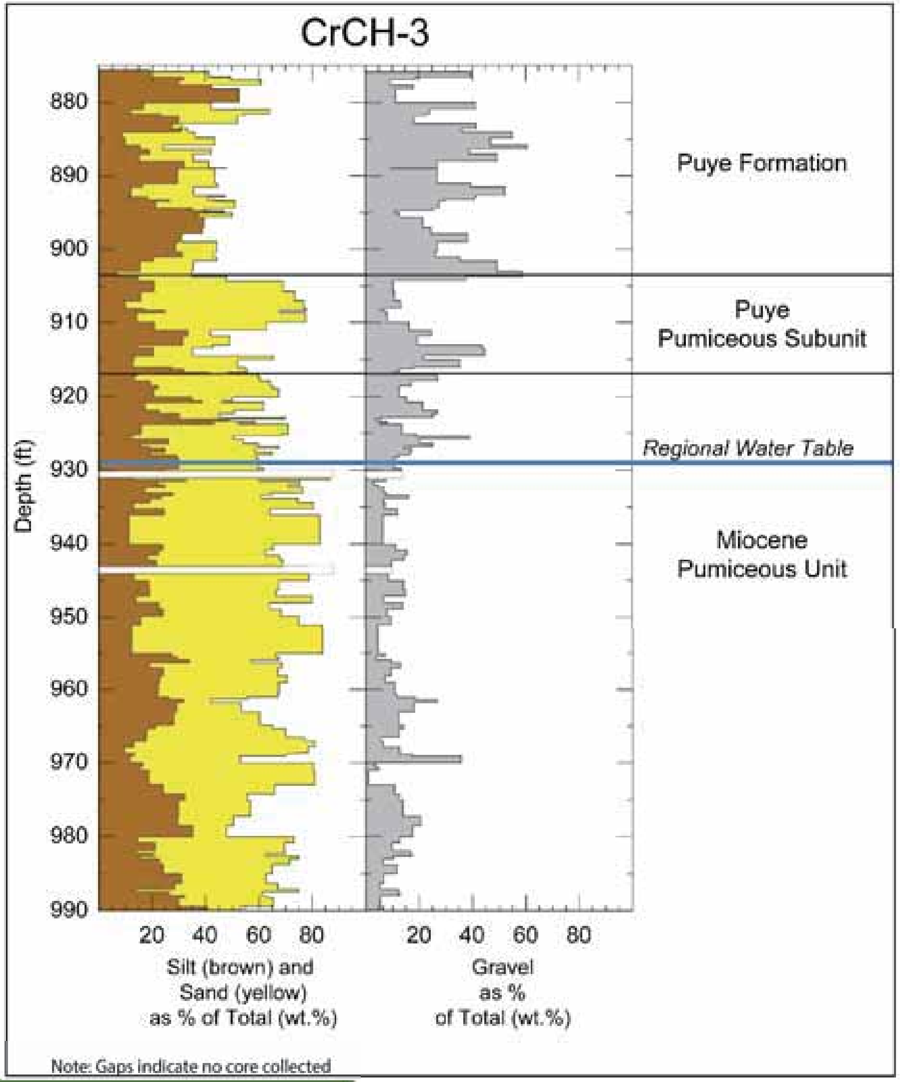
- Each bed or depositional unit was isolated and collected as an individual sample (371 samples collected over 5 core holes)
- Each sample was homogenized, and then a split was dry sieved into 6 size fractions ranging in size from gravel to silt
- Distilled water then used to wash the 6 size fractions and the wash water was collected in a container where suspended silt and clay was allowed to settle over a period of at least 24 hours; this yielded a seventh size fraction
- Each size fraction was dried and weighed
- Weights of the various sieve size classes were tabulated and then converted to weight percent

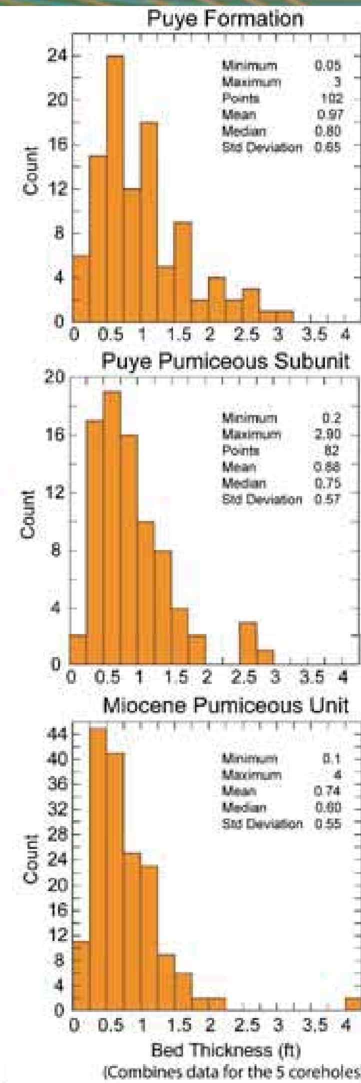
U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

Grain Size Characteristics by Geologic Formation



High Resolution Stratigraphy





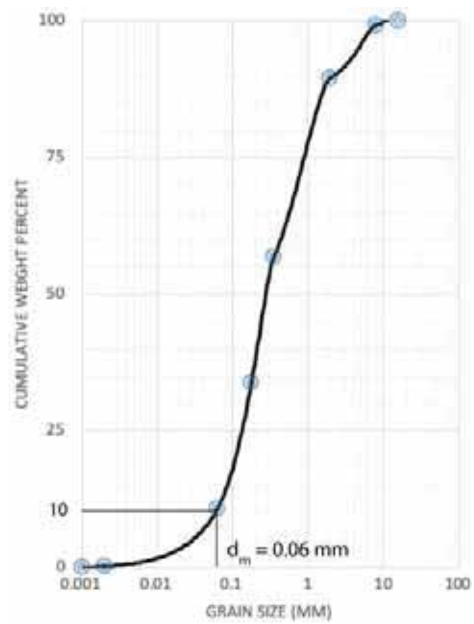
Calculation of Hydraulic Conductivity (K) from Particle Size Distribution

- Hydraulic Conductivity or K is a measure of the rate of flow of water in an aquifer
- A 2015 paper by Devlin in the journal Hydrogeology compared 15 published approaches for calculating hydraulic conductivity from particle size data
- Devlin's paper included an Excel spreadsheet called HydrogeoSieve that calculates hydraulic conductivity by the different methods
- The 15 methods use a form of the Kozeny Carmen equation, but variables such as effective grain diameter, porosity function, and grain roughness are derived differently each of the methods

Kozeny Carmen Equation
(works best for sands and gravels)

$$K = \frac{\partial g}{\mu} \times \frac{d^2_m}{180} \frac{\phi^3}{(1-\phi)^2}$$

K	=	Hydraulic Conductivity (cm/s)
∂	=	water density (g/m^3)
g	=	gravitational constant (cm/s^2)
μ	=	dynamic viscosity (g/cm s)
180^{-1}	=	medium constant (grain angularity)
d_m	=	grain diameter at d10 (cm)
ø	=	fractional porosity



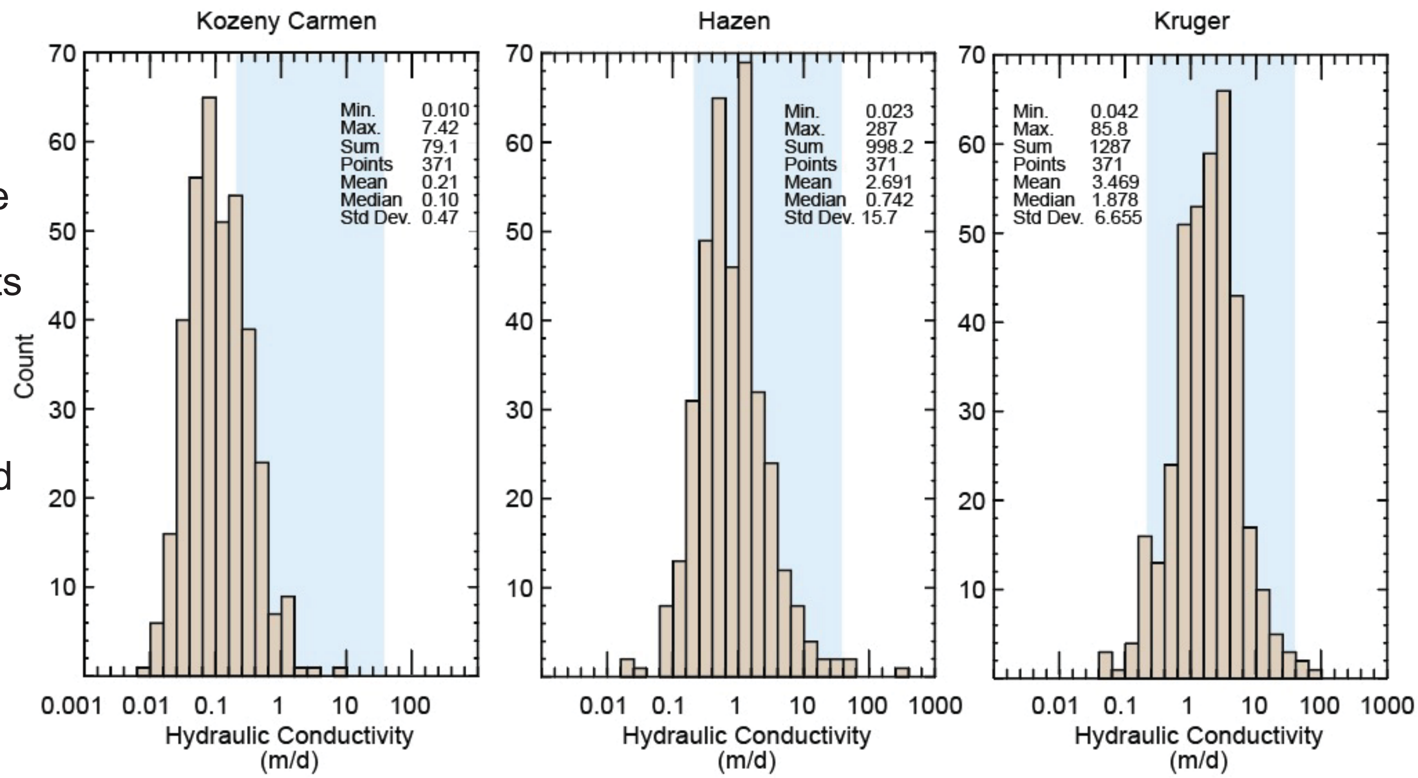
ENVIRONMENTAL MANAGEMENT
SAFETY ❖ PERFORMANCE ❖ CLEANUP ❖ CLOSURE

N3B Los Alamos

PR003

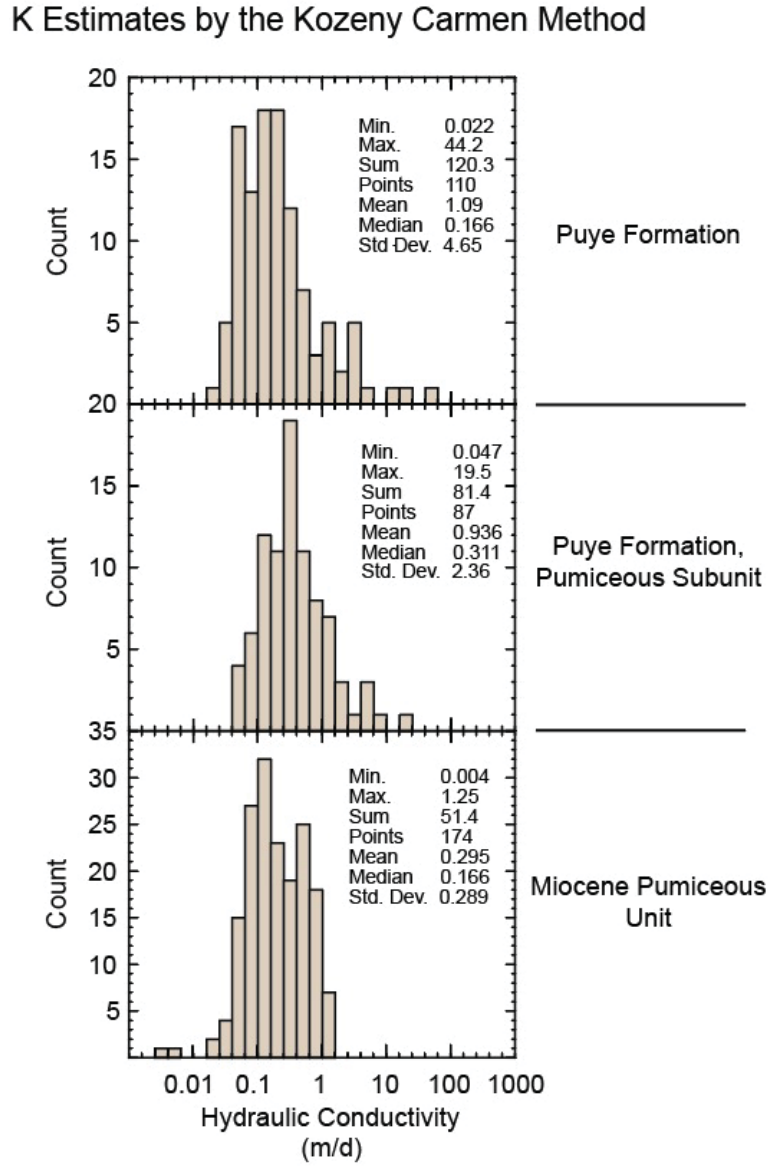
K Distributions by Different Estimation Methods

- K values by all methods have a log normal distribution
- For a given method, Ks span an order-of-magnitude
- Blue shading shows range of hydraulic conductivities determined by aquifer tests in the chromium plume area
- Order-of-magnitude differences in Ks produced by the different methods
- However, relative data for Ks is remarkably consistent among the 15 estimation methods



Hydraulic Conductivity by Geologic Unit

- Histograms of K distributions for the three geologic units strongly overlap for any given estimation method
- The overlap in Ks suggests there is little difference in the bulk hydraulic properties at the scale of geologic units

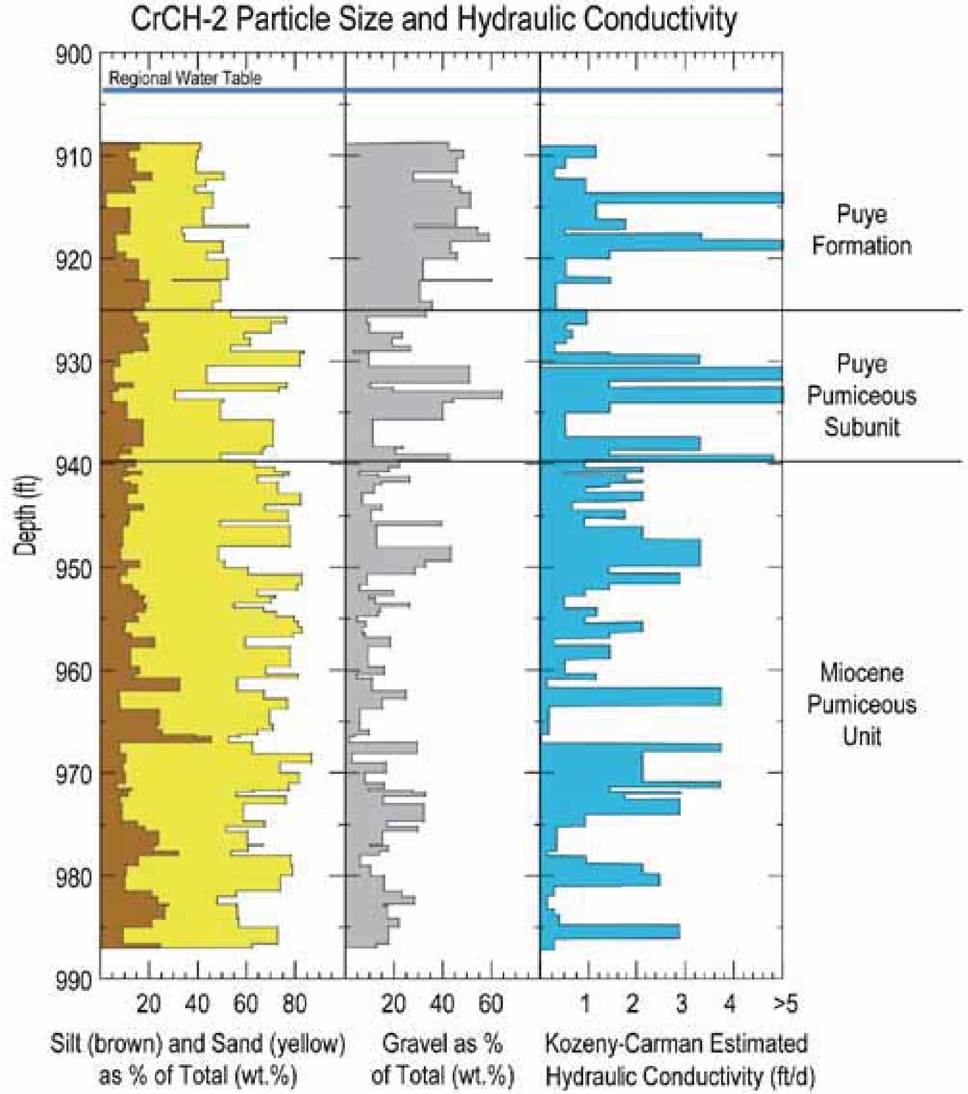


ENVIRONMENTAL MANAGEMENT
SAFETY ❖ PERFORMANCE ❖ CLEANUP ❖ CLOSURE

PR003

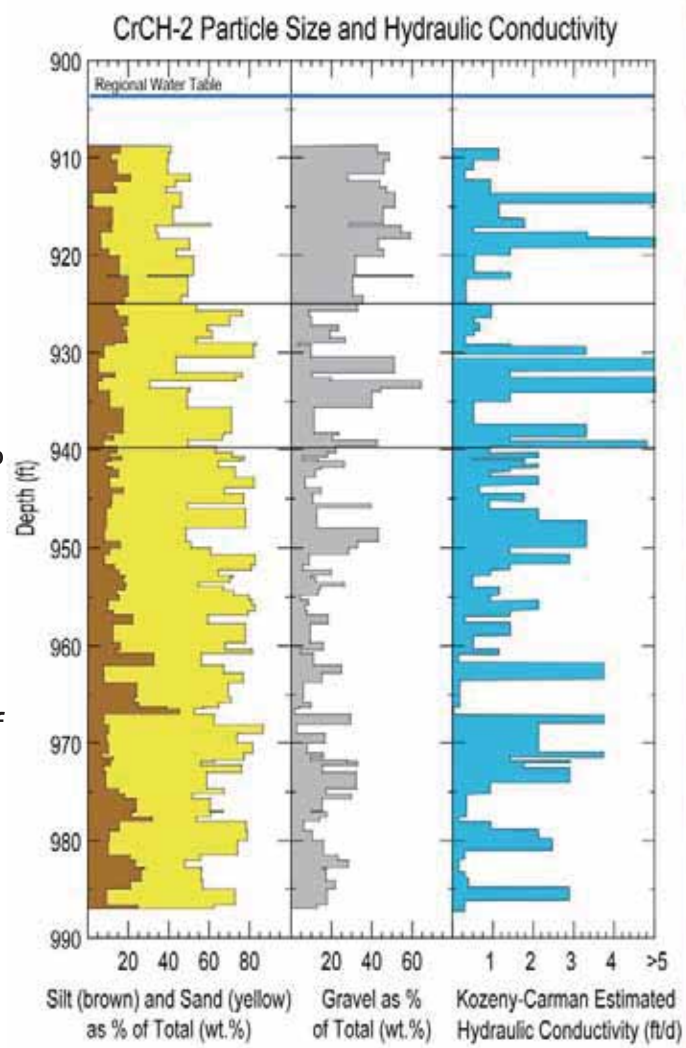
High Resolution Stratigraphy with Ks in Core Hole CrCH-2

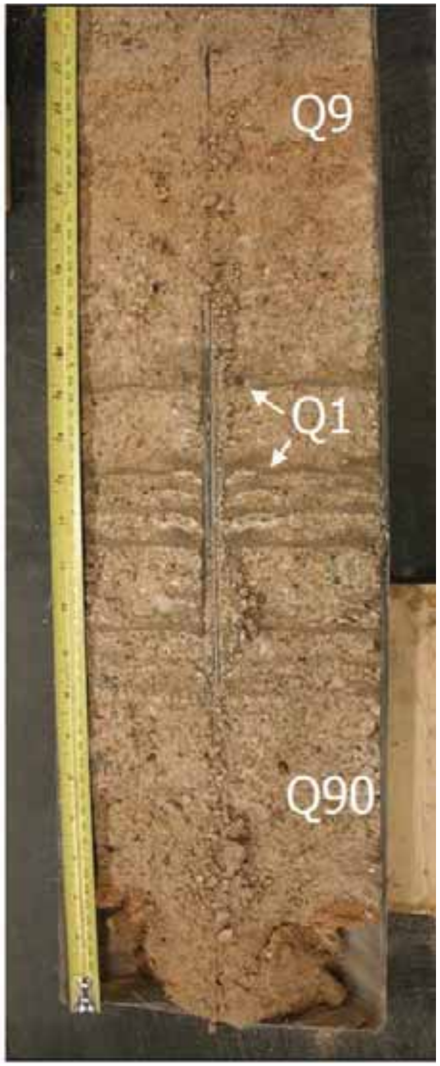
- High-resolution stratigraphy combined with estimated Ks provide a detailed characterization of the hydraulic structure of the regional aquifer
- Permeable strata are found in all geologic units making up the regional aquifer
- All three geologic units are characterized by lithologic and hydraulic heterogeneity – something we'd expect to see in alluvial fans
- When comparing the five core holes, the stratigraphic position of high-K beds varies and is unpredictable, and the lateral extent of individual beds is uncertain



Groundwater Flux Distribution

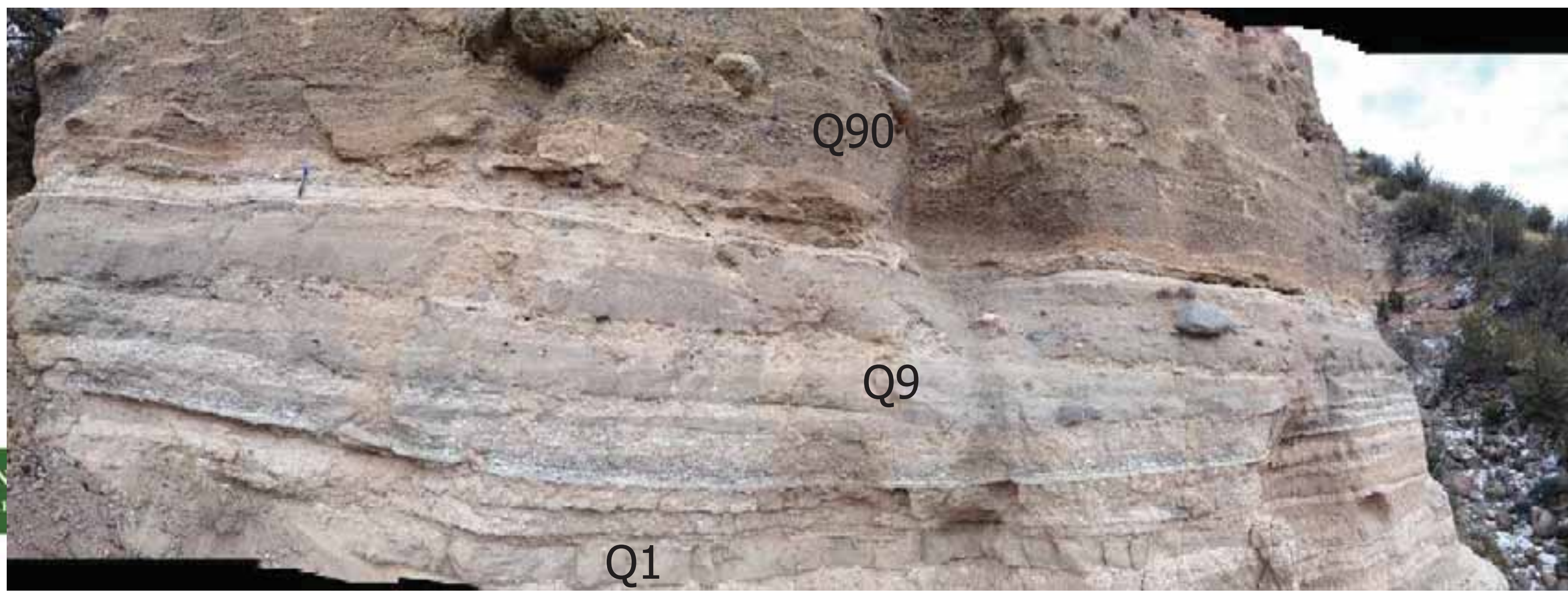
- (Horst et al 2017) present a method for using cumulative flow distribution plots to identify flow regimes in an aquifer
- This approach emphasizes the importance of order-of-magnitude differences in K rather than absolute values of K to differentiate high, medium, and low flow regimes
- “Q90” is used to describe the most permeable aquifer materials that carry 90% of the groundwater and chromium flux – these are advective zones in which water flows freely through the available pore space
- “Q9” are less permeable strata and carry 9% of the groundwater flux – these parts of the aquifer are characterized by slow advection and diffusion
- “Q1” are tight zones (silts and clays) and have 1% of the groundwater flux – water is static in these zones





ENVIRONMENTAL MANAGEMENT
SAFETY ❖ PERFORMANCE ❖ CLEANUP ❖ CLOSURE

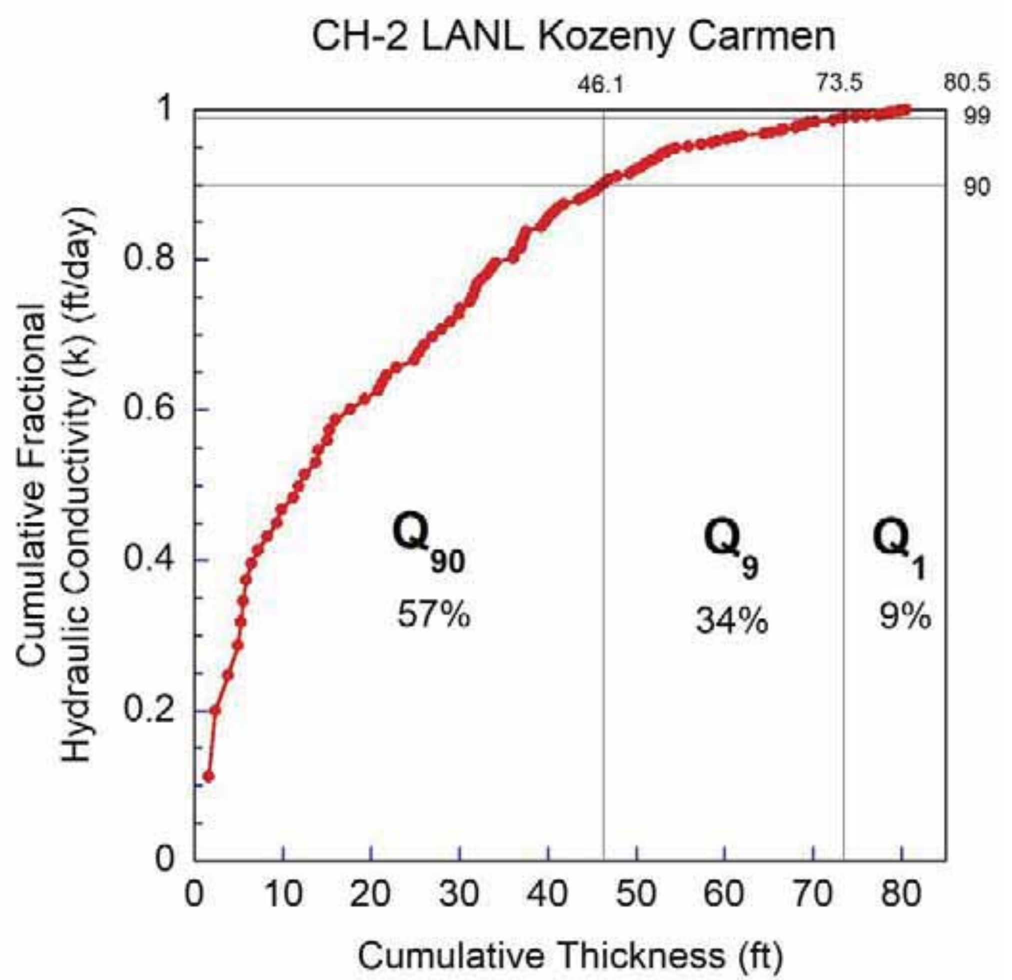
Outcrop Scale Flow Variations



R003

Groundwater Flux Example

- Using an Excel spreadsheet, the estimated K data are sorted from high to low values
- Starting with the highest K values, cumulative Ks and bedding thicknesses are tabulated sequentially on a bed-by-bed basis
- The cumulative Ks are converted to cumulative fractional hydraulic conductivities and plotted against the cumulative bed thickness

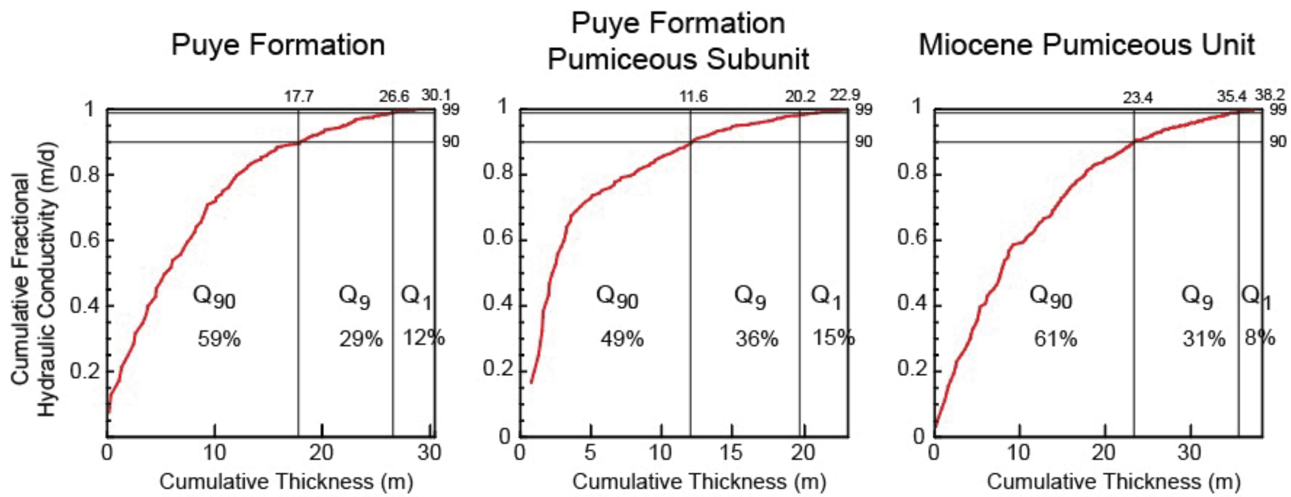


ENVIRONMENTAL MANAGEMENT
SAFETY ❖ PERFORMANCE ❖ CLEANUP ❖ CLOSURE

PR003

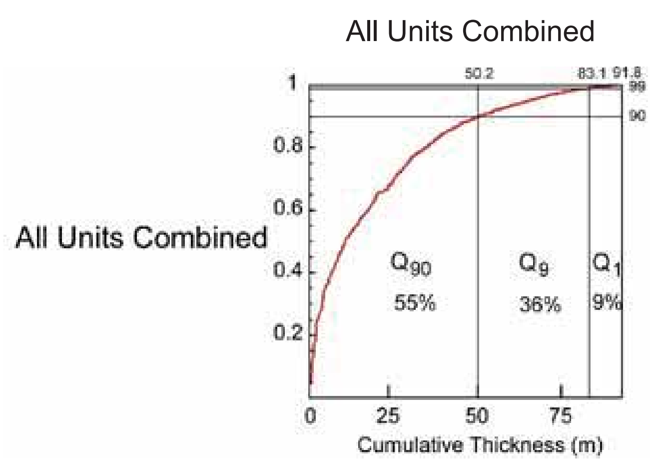
Comparing Groundwater Flux in the Geologic Units

- The distribution of groundwater flux is similar in each of the geologic units making up the regional aquifer
- 90% of groundwater flux in the regional aquifer occurs in about 49–61% of the aquifer profile
- Large portions of the aquifer are characterized by advective flow and are available for treatment



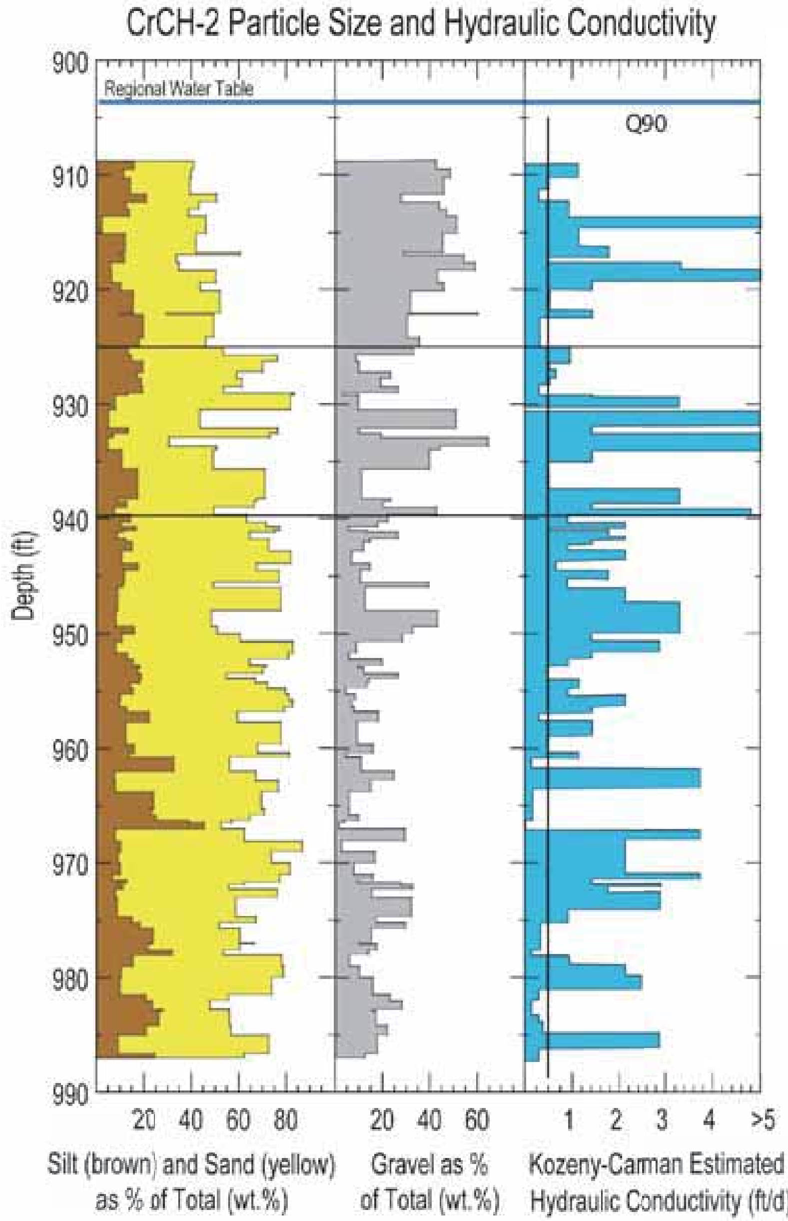
Plots include data for all five core holes

Hydraulic conductivity used in these plots is the geometric mean of the 15 estimation methods



Distribution of Q90 Beds

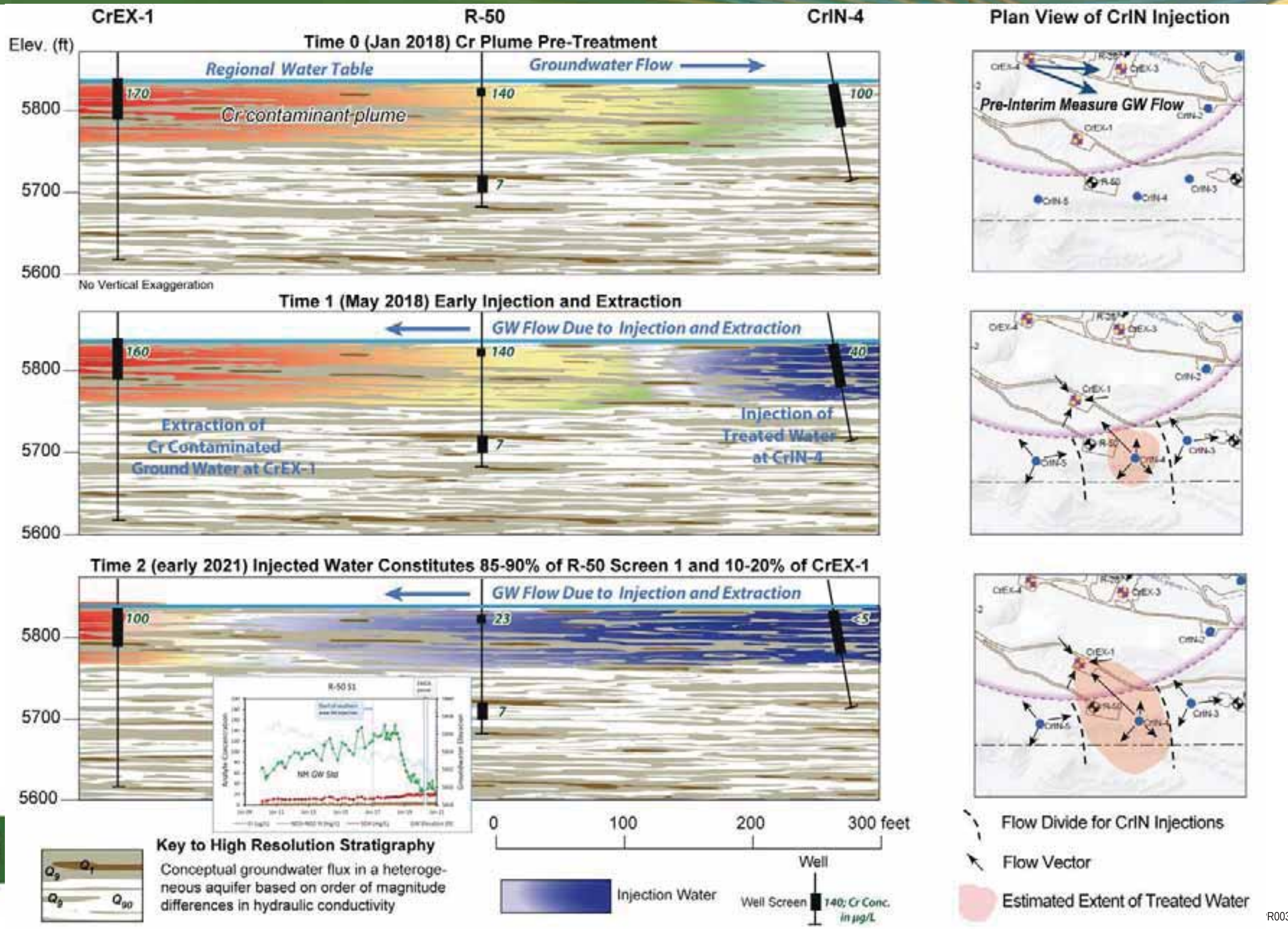
- Q90 beds are distributed throughout the aquifer
- There is a wide range of hydraulic conductivities within the set of Q90 beds
- A relatively small subset of beds may be responsible for a significant fraction of the advective flow
- Targeting the highest flow beds for remediation is probably impractical because of their widespread distribution in the aquifer, the thin nature of the beds, and the uncertain lateral continuity of any individual bed



ENVIRONMENTAL MANAGEMENT
SAFETY ◆ PERFORMANCE ◆ CLEANUP ◆ CLOSURE

PR003

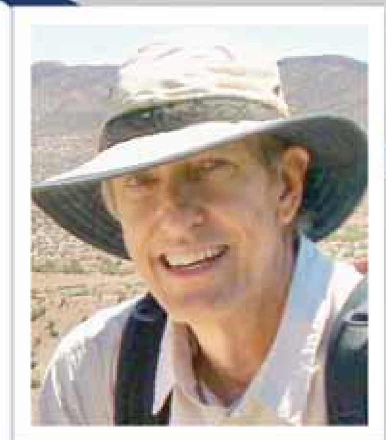
Conceptualization of Groundwater Hydraulics Related to IM Performance



R003

Summary and Conclusions

- High-resolution stratigraphy combined with estimated Ks from particle-size distributions provide a detailed characterization of the hydraulic structure of the regional aquifer
- These data provide a framework that supports remediation design by identifying aquifer heterogeneities that control where chromium mass transport is occurring
- Permeable beds are distributed throughout the stratigraphic sequence regardless of geologic unit, and the regional aquifer where the plume is located is effectively a single, highly heterogeneous, hydrogeologic unit
- Large portions of the aquifer are characterized by advective flow and therefore are available for treatment and remediation
- A relatively small subset of beds may be responsible for a significant fraction of the advective flow, but it would be impractical to target them for remediation



Dave Broxton

Groundwater Investigations
Senior Geologist

During his 35-year career as a research scientist at Los Alamos National Laboratory, Dave Broxton was involved in a variety of projects, including exploration for strategic minerals, research on the evolution of large silicic volcanic fields, siting nuclear waste repositories, and environmental groundwater investigations at Los Alamos. He is currently employed by Tech2 Solutions/Newport News Nuclear BWXT (N3B) as a senior geologist for groundwater investigations as part of the Legacy Cleanup Program at Los Alamos National Laboratory. His stated goal is to apply geologic research to address important national issues such as environmental protection, nuclear waste disposal, and mineral resource independence. He enjoys working with multidisciplinary teams to solve complex problems.

N3B Los Alamos

Paul W. Reimus, Ph.D

Chromium Remediation Project Scientist

Dr. Paul Reimus has B.S., M.S. and Ph.D. degrees in Chemical Engineering. He worked as a staff member at Los Alamos National Laboratory (LANL) from 1989 to 2018, and prior to that he was a research engineer at Battelle Pacific Northwest Laboratories from 1983 to 1989. He retired from LANL/TRIAD in 2018, but he has worked as a part-time scientist with T2S (under N3B) on the LANL Chromium Remediation project since January 2019. During his 29 years at LANL, Dr. Reimus worked on numerous projects related to nuclear safety analysis, contaminant and tracer transport in groundwater systems, and environmental restoration.

Dr. Reimus has been involved in the LANL Cr remediation project since 2013, and his responsibilities have included designing, conducting and interpreting numerous laboratory and field experiments to better understand Cr(VI) migration in the regional aquifer and to evaluate in-situ remediation technologies for Cr(VI) reduction. The field experiments have included 10 borehole-dilution tracer tests, 2 single-well push-drift-pull tracer tests, one cross-hole tracer test, and several planned observations in monitoring wells of water that was treated at the surface to remove Cr(VI) and then re-injected into the aquifer as part of the pump-and-treat interim measure (using both tracers and geochemical signatures to identify the treated water). He was also principal investigator for two field pilot tests to evaluate chemical and bio-stimulation amendments (sodium dithionite and molasses, respectively) that promoted in-situ reduction of Cr(VI) in the regional aquifer. His responsibilities in this role included overseeing numerous laboratory experiments that supported the design, and interpretation of the field amendment tests.