Geochemical and Biogeochemical Mechanisms of Contaminant Attenuation in a Multi-Layered Permeable Reactive Barrier

Betty A. Strietelmeier

John P. Kaszuba

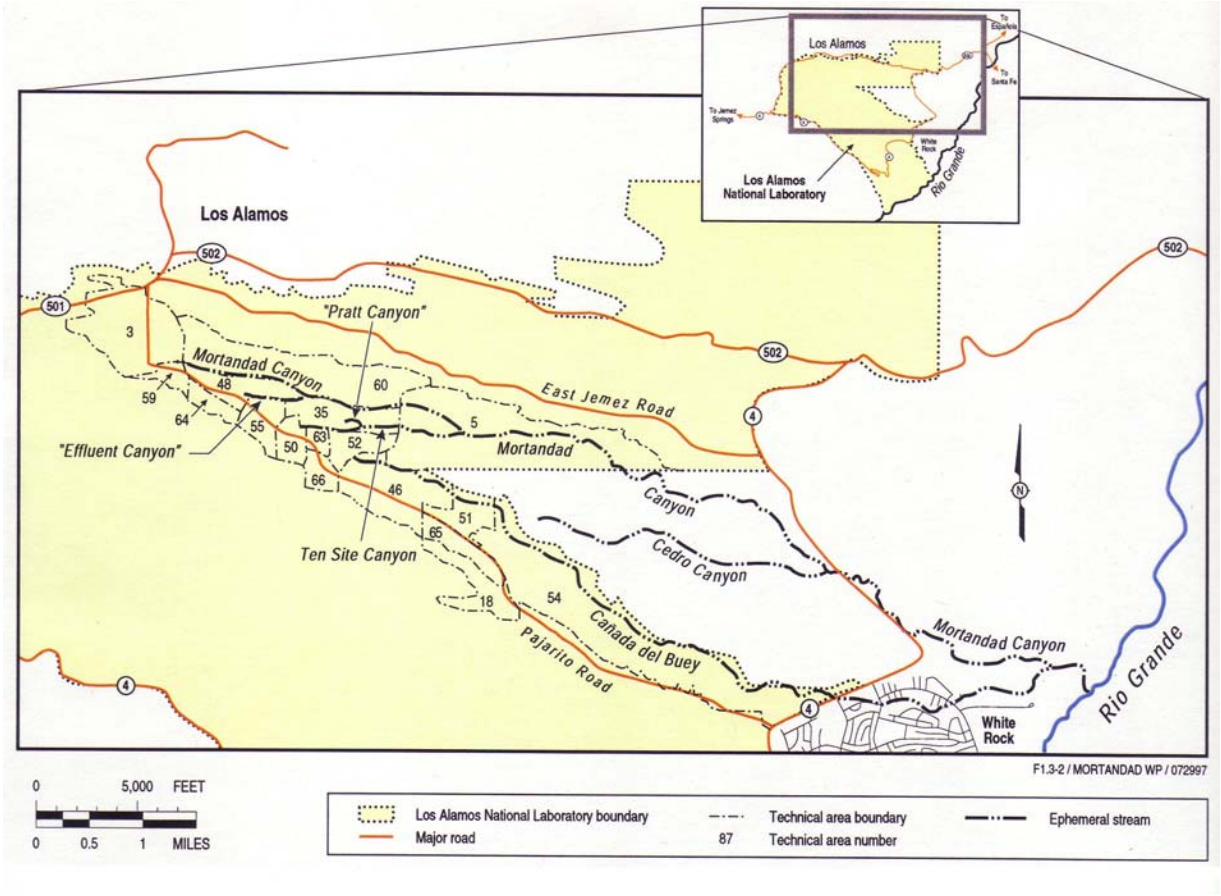
Patrick Longmire

Tammy P. Taylor

Goal for PRB

Plan, design, and install a multi-layered permeable reactive barrier system (multi-barrier) in Mortandad Canyon to demonstrate *in-situ* treatment of contaminant suite (Sr, Pu, Am, nitrate and perchlorate).

First system to treat groundwater at LANL.



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Project Drivers and Benefits

Driver: Radionuclides, including ^{90}Sr, $^{238,239,240}Pu$, and ^{241}Am, are present in alluvial groundwater within Mortandad Canyon. Nitrate and perchlorate also occur in alluvial groundwater and perchlorate is of potential risk. Alluvial groundwater in Mortandad Canyon provides recharge to perched intermediate-depth groundwater and to the regional aquifer.

Benefits

- Demonstrate multi-layered (cell) barrier technology for contaminant suite.
- Demonstrate passive treatment of radionuclides, nitrate, and perchlorate in alluvial groundwater.
- Source control - mitigate possible vulnerabilities from contaminants moving through the shallow subsurface.

Approach

- FY00
  - Treatability studies
  - Site selection
- FY01
  - Site Characterization w/ field study
  - Conceptual design, cost and schedule estimate
- FY02
  - Funding Issues
  - Final design
- FY03
  - Install multi-barrier
  - Evaluate performance (current)

Chemistry

Geology, Aqueous Chemistry, & Hydrology

Engineering

Project Management

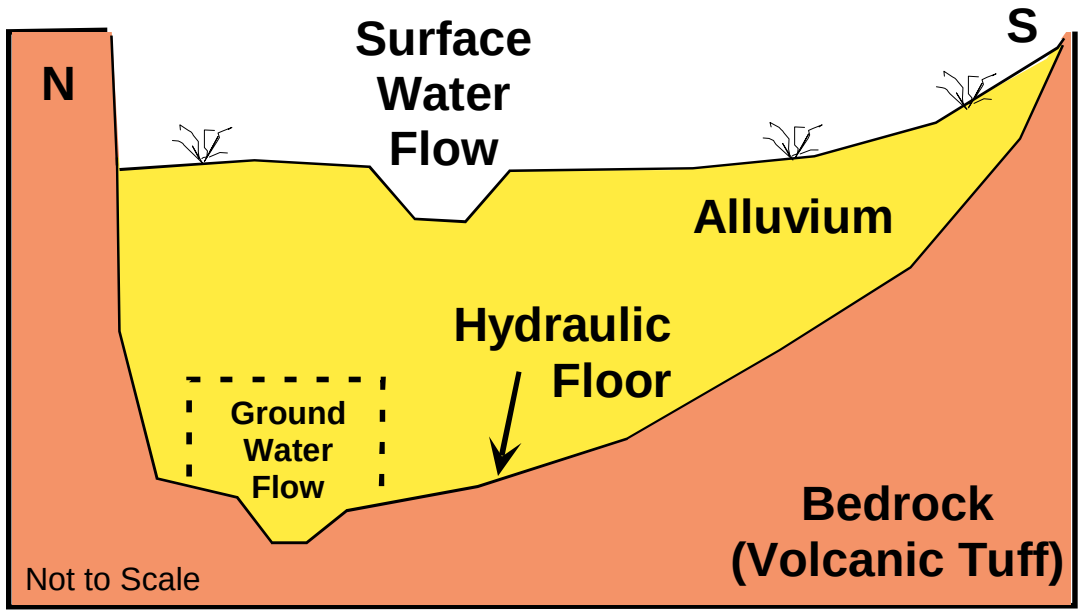
Engineering

Aqueous Chemistry

Site Selection and Characterization

CHEMISTRY

Site Characteristics and Design Parameters



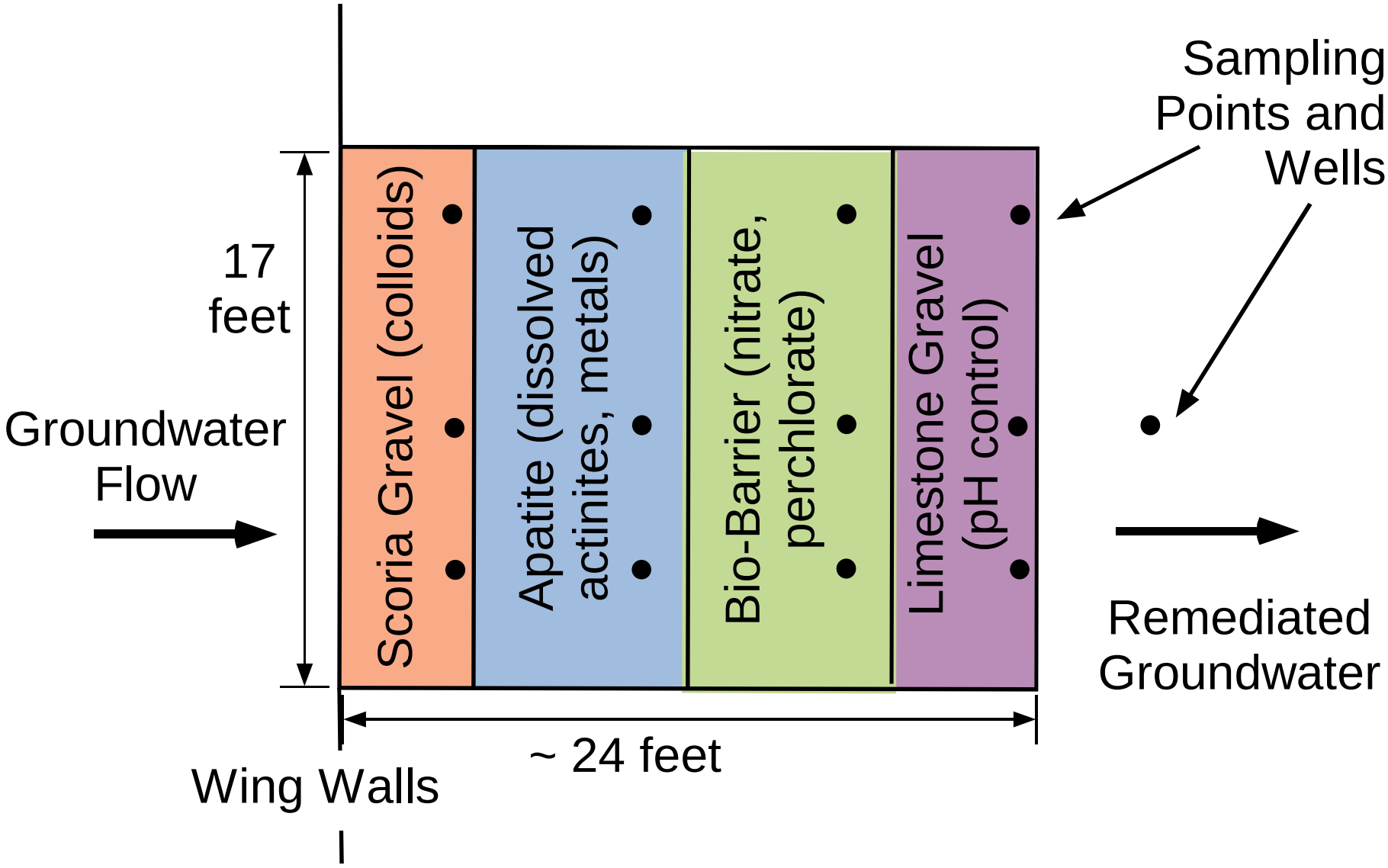
Mortandad Canyon Alluvium

- Hydrologic funnel
- Perching layer
- Groundwater flow ≠ surface water flow
- Low-level rad in soil
- Geotechnically feasible

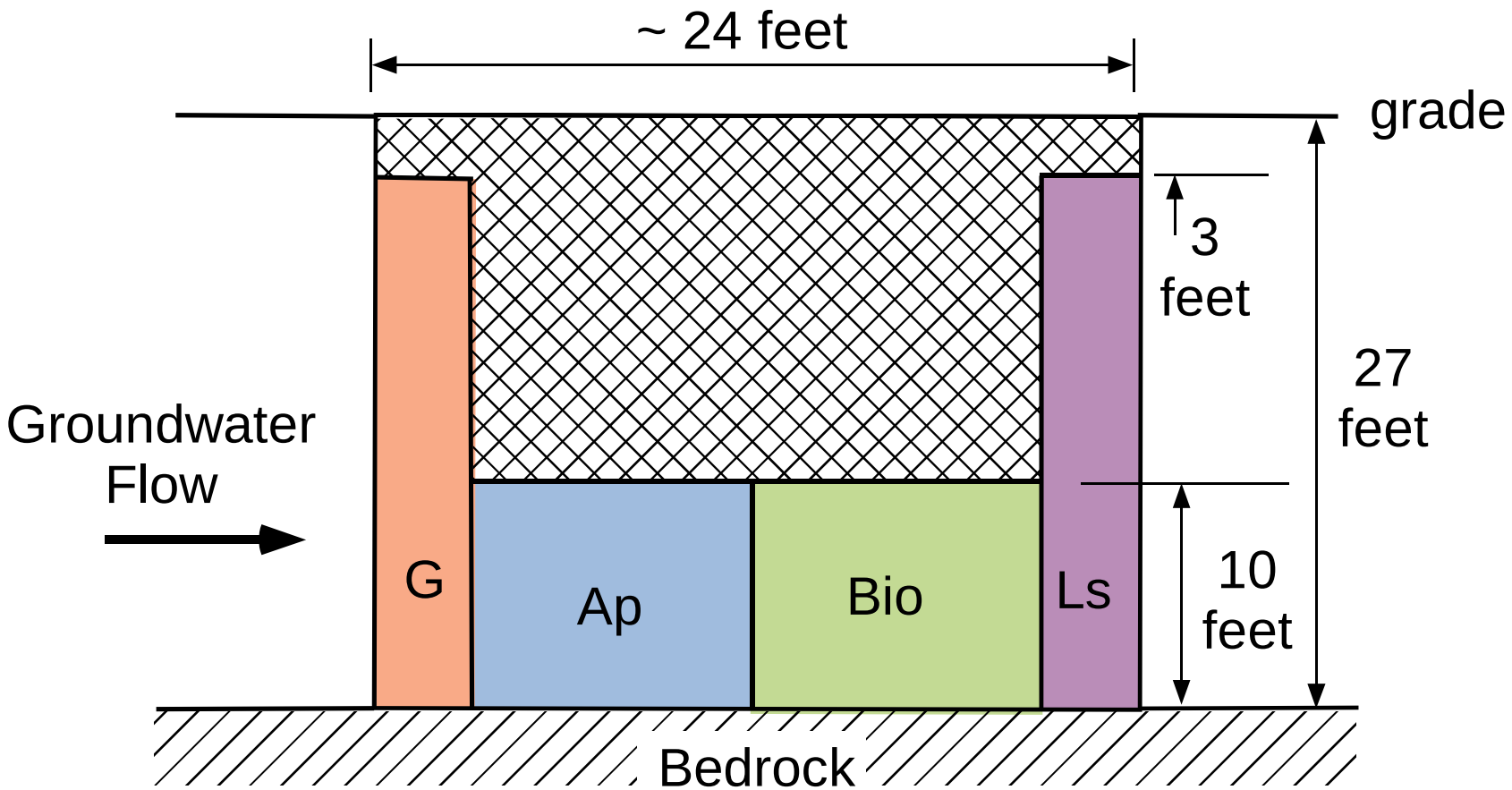
Design Parameters

- Target alluvial groundwater, minimize surface erosion/infiltration
- Optimize hydraulic capture, minimize reactive volume
- Minimize excavated soil requiring waste disposal
- Residence time in the bio-barrier, 1 day minimum
- Lifetime = 10 years
- Install ports for access to solids and aqueous solutions

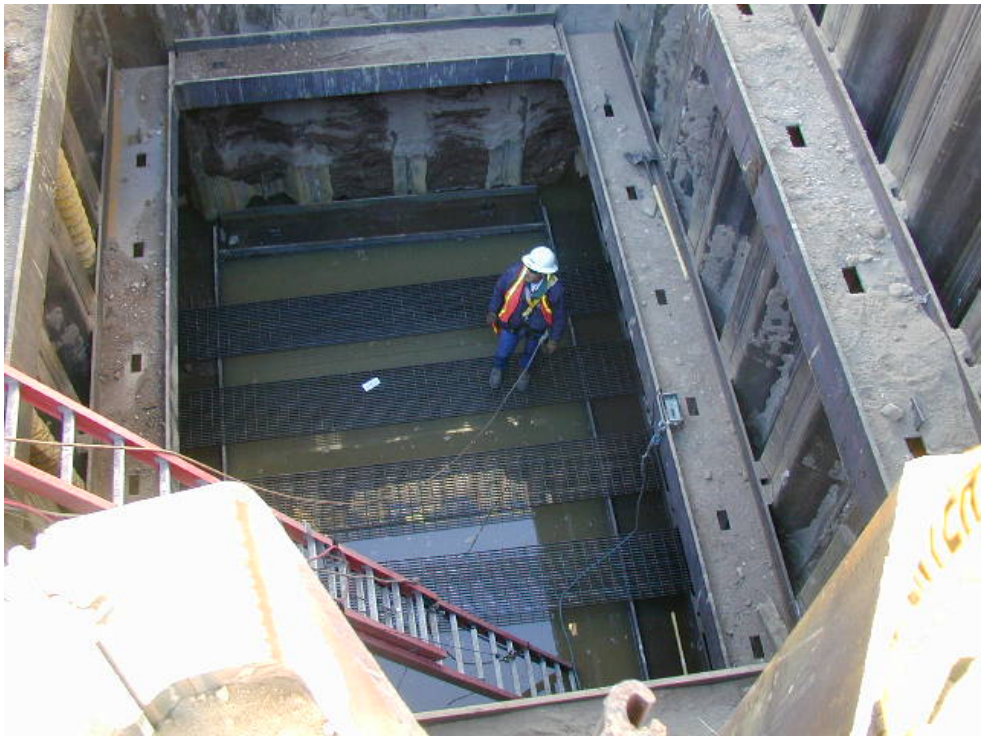
Schematic Plan View



Schematic Cross Section



Installation



Installation

Installation

What Next? Performance Assessment and Science

Performance Assessment - How well does the PRB work? Collect groundwater samples and analyze them for contaminants (nitrate, perchlorate, ^{90}Sr), major ions, trace metals, and microbial populations.

Science

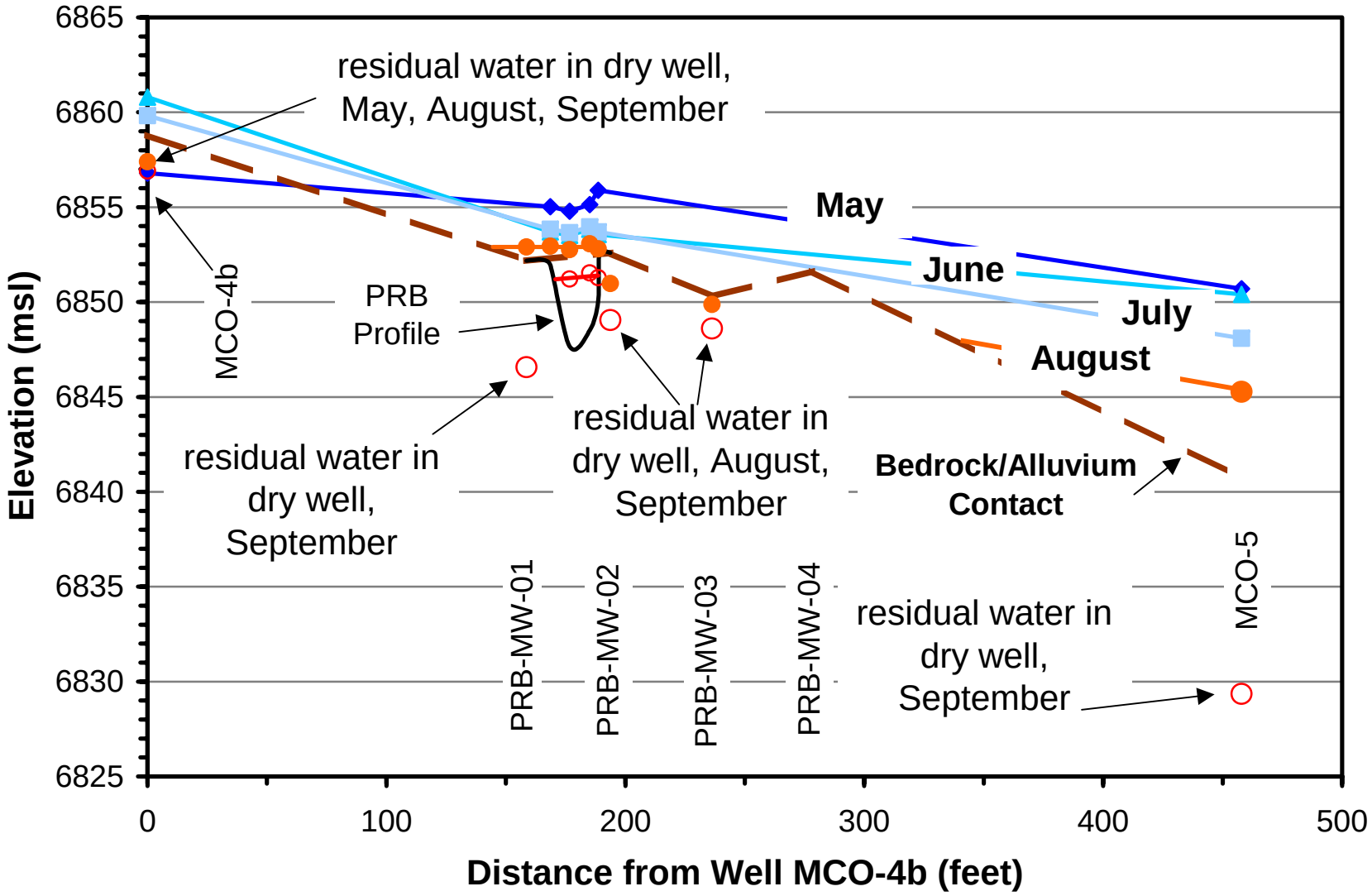
Identify geochemical/biogeochemical reactions/processes critical to PRB success and failure.

Enable rational selection of measurement and performance elements that monitor these processes.

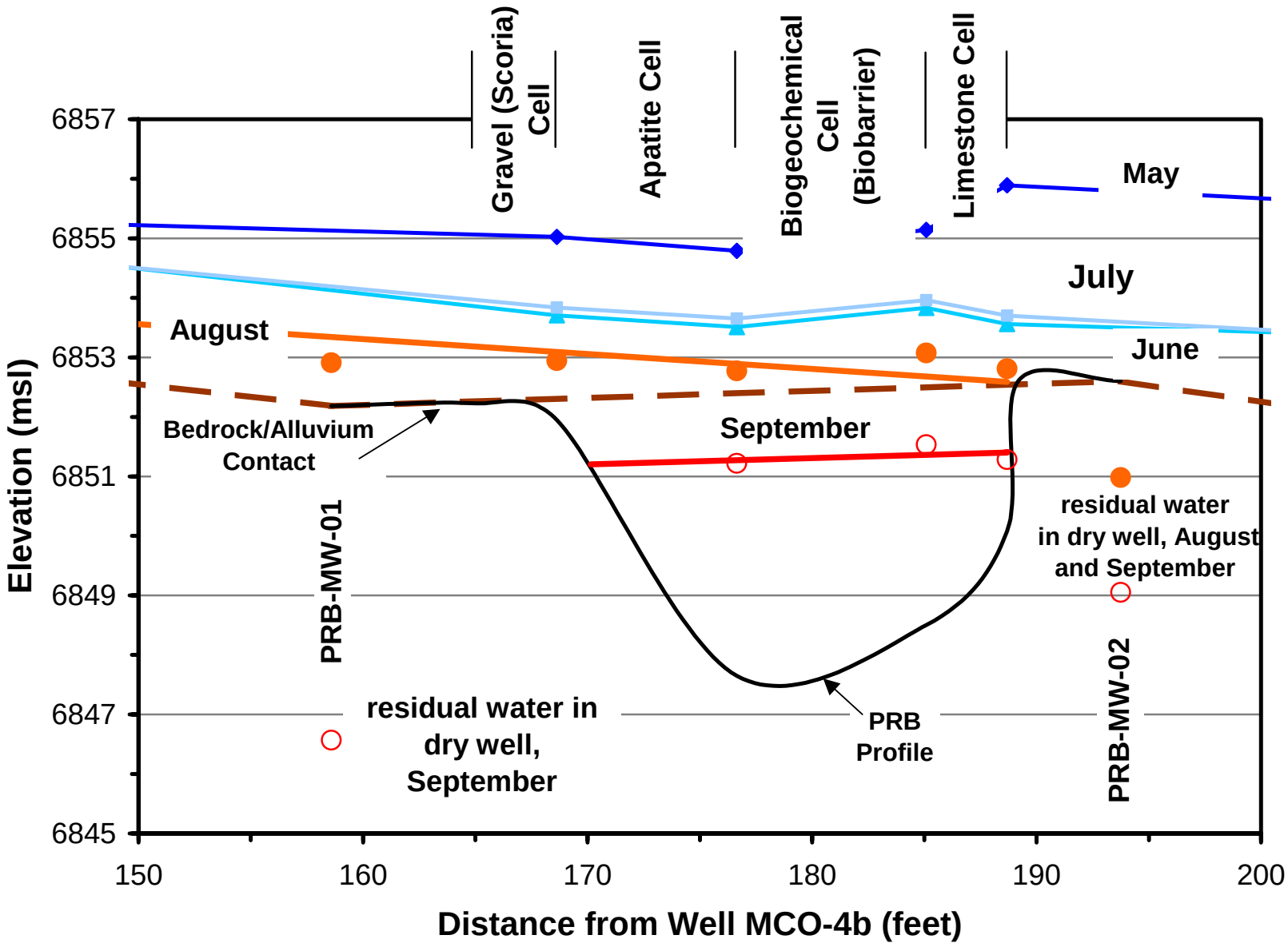
Facilitate barrier design and installation at other LANL/DOE sites.

Scaling issues (chemical potential, time)

Hydrogeology of Mortandad Canyon



Hydrogeology of Mortandad Canyon



pH and Dissolved Oxygen

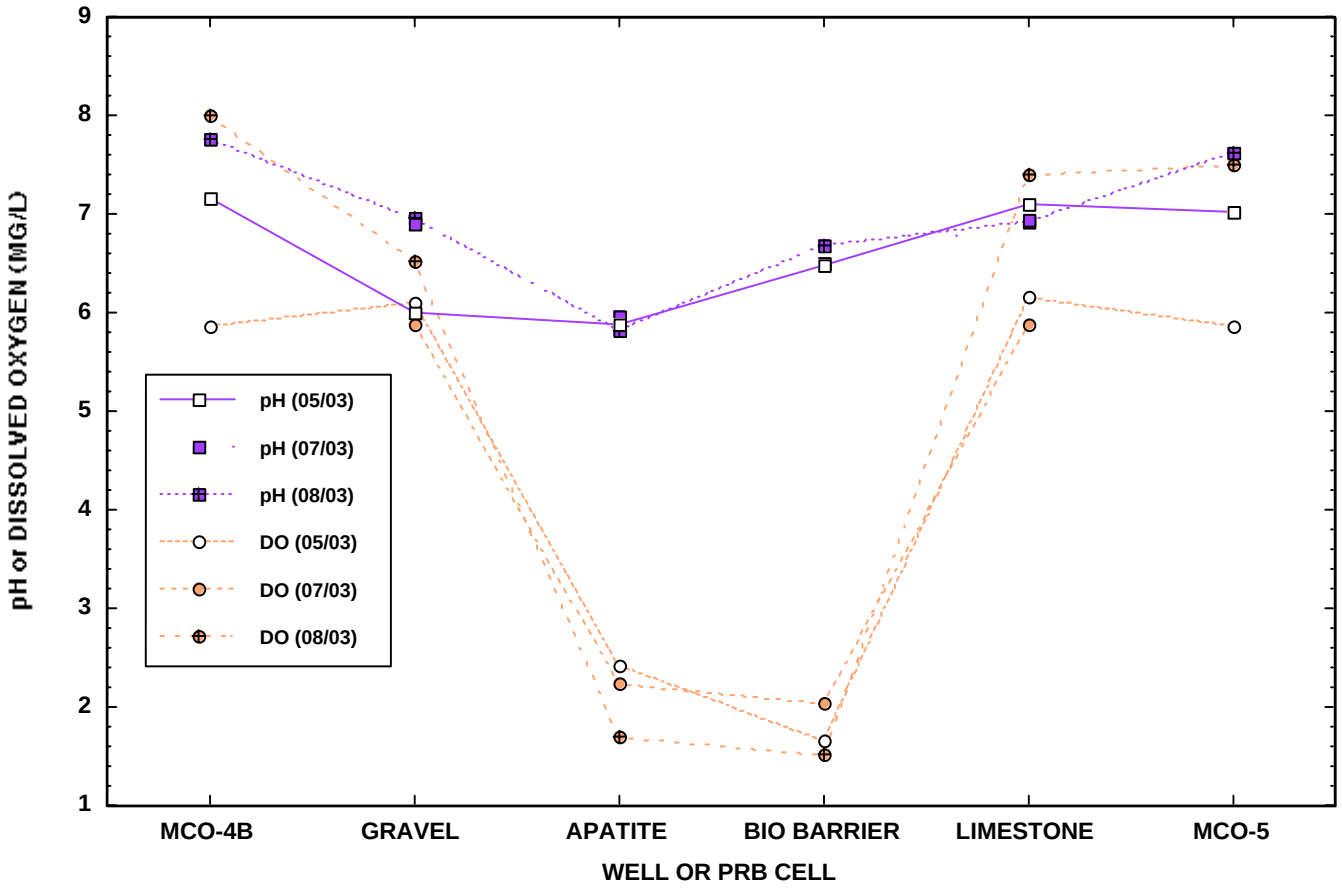


Figure C-1. Distributions of pH and dissolved oxygen (mg/L) in wells MCO-4B and MCO-5 and in the multiple permeable reactive barrier (PRB) installed in Mortandad Canyon.

Perchlorate (ClO_4^-), Chlorate (ClO_3^-), Chlorite (ClO_2^-), and Bromide (Br^-) Concentrations

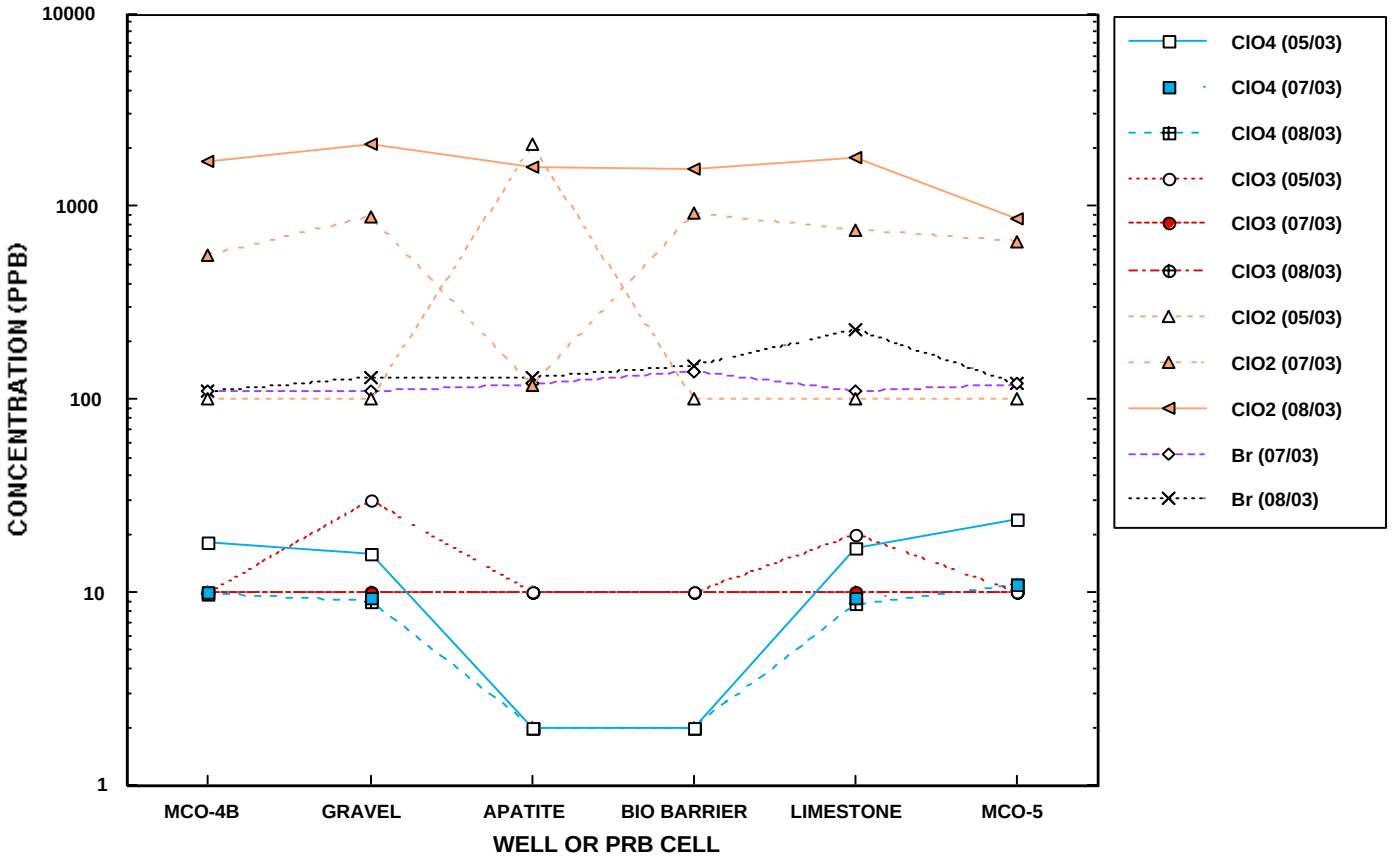


Figure C-2. Distributions of perchlorate (ClO4-1), chlorate (ClO3-1), chlorite (ClO2-1), and bromide (Br) in wells and in the multiple permeable reactive barrier (PRB) installed in Mortandad Canyon. Detection limits (DL) for ClO4-1, ClO3-1, and ClO2-1 are 2, 10, and 100 ppb, respectively, using ion chromatography.

Strontium-90 (pCi/L) and Calcium (ppm)

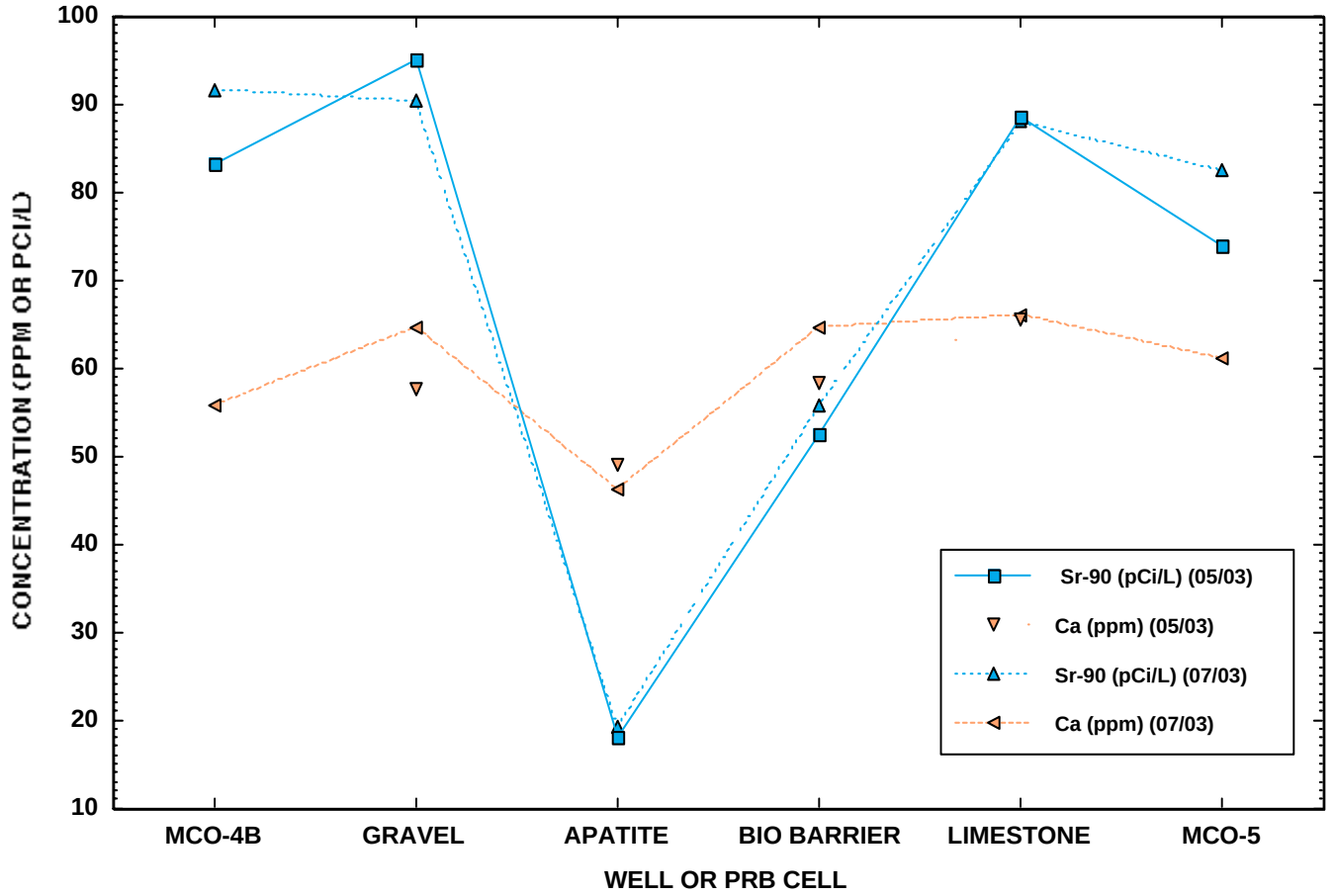


Figure C-4. Distributions of strontium-90 (pCi/L) and calcium (ppm) in wells and in the multiple permeable reactive barrier (PRB) installed in Mortandad Canyon.

Conclusions and Recommendations

The PRB is successfully removing nitrate, perchlorate, and ^{90}Sr from alluvial groundwater.

Groundwater flow in the alluvium has been influenced by the drought and unsaturated and saturated flow conditions occur within the PRB.

Once alluvial groundwater flow returns, additional studies of both the solid materials and the groundwater will be necessary to understand processes occurring in the PRB

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Additional Information

Please leave a business card or send an email (jkaszuba@lanl.gov) if you wish further information

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Betty Strietelmeier, C-INC, MS J514, bastriet@lanl.gov, John P. Kaszuba, C-INC, MS J514, jkaszuba@lanl.gov, Patrick Longmire, EES-6, MS D469, plongmire@lanl.gov, Tammy Taylor, C-SIC, MS J514, taylort@lanl.gov

A multi-layered permeable reactive barrier (PRB) has been installed in Mortandad Canyon, on the Pajarito Plateau in the north-central part of LANL, to demonstrate in-situ treatment of contaminants while mitigating possible vulnerabilities from downstream contaminant movement within alluvial and deeper perched groundwater. Mortandad Canyon was selected as the location for the PRB because the flow of alluvial groundwater is constrained by the geology of the canyon, a large network of monitoring wells already exists along the canyon reach, and the hydrochemistry and contaminant history of the canyon is well-documented. The PRB incorporates a sequence of four reactive media layers to immobilize or destroy a suite of contaminants present in alluvial groundwater, including Sr-90, Pu-238, 239, 240, Am-241, perchlorate, and nitrate. The four sequential media cells consist of gravel-sized scoria, apatite, pecan shells and cottonseed with an admixture of gravel (biobarrier), and limestone.

Design elements of the PRB are based on laboratory-scale treatability studies and on a field investigation of hydrologic, geochemical, and geotechnical parameters. The PRB was designed with the following criteria: 1-day residence time within the biobarrier, 10-year lifetime for the PRB, minimization of surface water infiltration and erosion, optimization of hydraulic capture, and minimization of excavated material requiring disposal. Each layer has been ported to allow sampling of water and reactive media, and monitor wells are located immediately adjacent to the up- and down-gradient edges of the barrier. Preliminary results indicate that both nitrate and perchlorate are being reduced by microbial activity in the biobarrier.

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