Pilot Testing of Technologies to Treat Multiple Contaminants in Drinking Water at the Pinehill School on the Ramah Navajo Reservation

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New Mexico Environmental Health Conference
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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Background

- **Recent reduction of drinking water Maximum Concentration Level (MCL) for arsenic from 50 ppb to 10 ppb (January 2006) was intended to reduce incidence of bladder cancer and other cancers in US.**
- **Southwestern United States is characterized by high and variable background levels for arsenic.**
- **New Arsenic MCL is controversial due to high costs and uncertain health benefits.**
  - **Estimated national annual costs of implementing 10 ppb MCL range from $165M to $605M to save 7 – 33 lives**
  - **About 1 life/500,000 exposed persons per year**

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Background (II)

Uranium and its radioactive daughters (radium and radon) are also high and variable in New Mexico drinking water

- **Treatment costs to comply with standards for As, Ra and U will be high for small communities.**
- **Systems that can remove several contaminants (e.g. arsenic and radium) can increase public health benefit of program.**

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Arsenic Water Technology Partnership

- **Congressional Appropriation - $13M for FY03-FY06**
- **DOE- funded peer-reviewed, cost-shared research program to develop and demonstrate innovative technologies for removal and disposal of arsenic from drinking water.**
- **Partners**
  - **Bench-Scale Studies (AwwaRF)**
  - **Demonstration Studies (Sandia)**
  - **Economic Analysis/Outreach (WERC)**
- **Focus on small systems**
  - **40% of resources directed to rural and Native American utility needs**
  - **Minimize costs - capital, operating, maintenance**
  - **Minimize residual quantities & disposal costs**

Which advances in treatment technology can significantly reduce costs?

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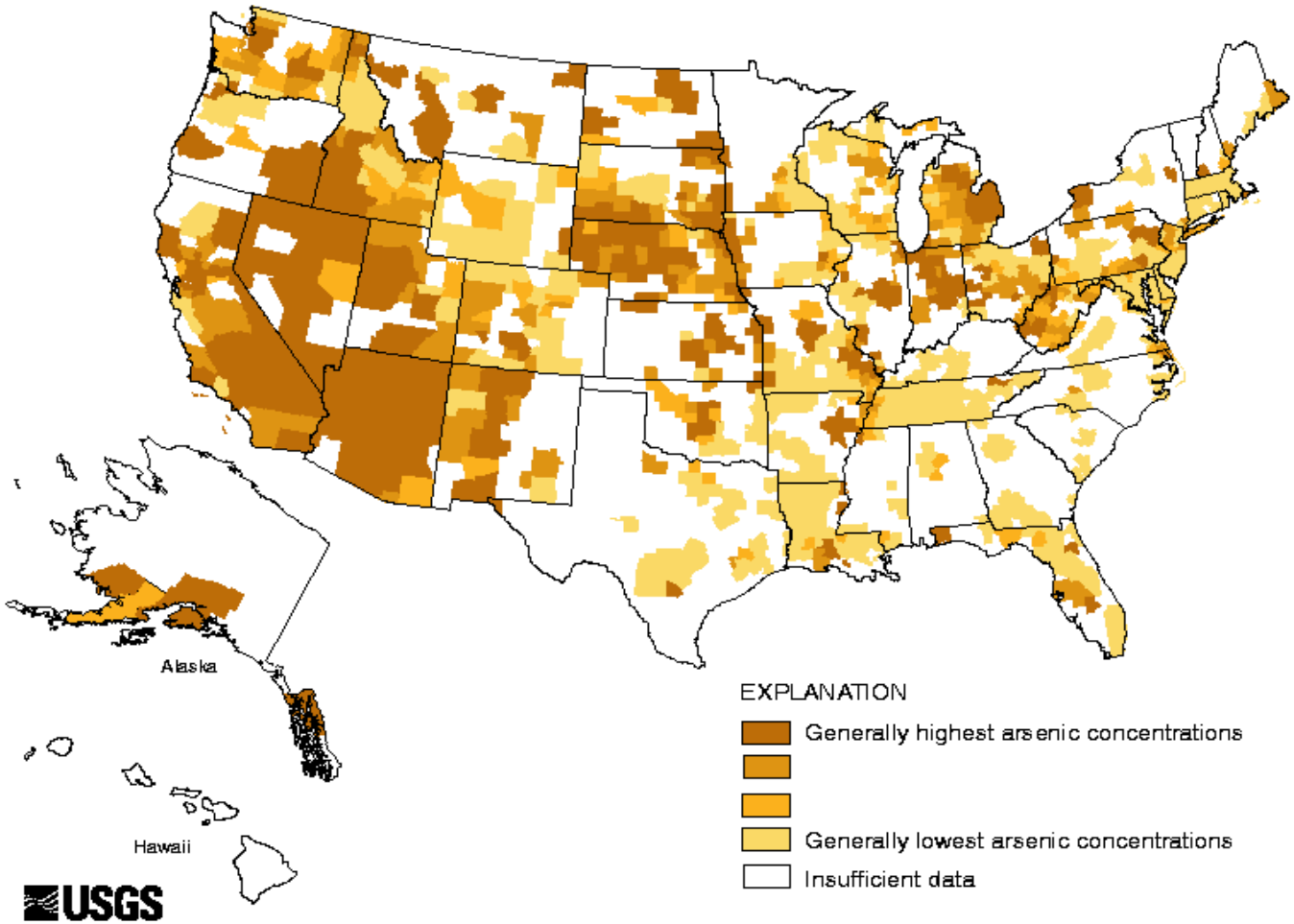
Arsenic Occurrence in the US



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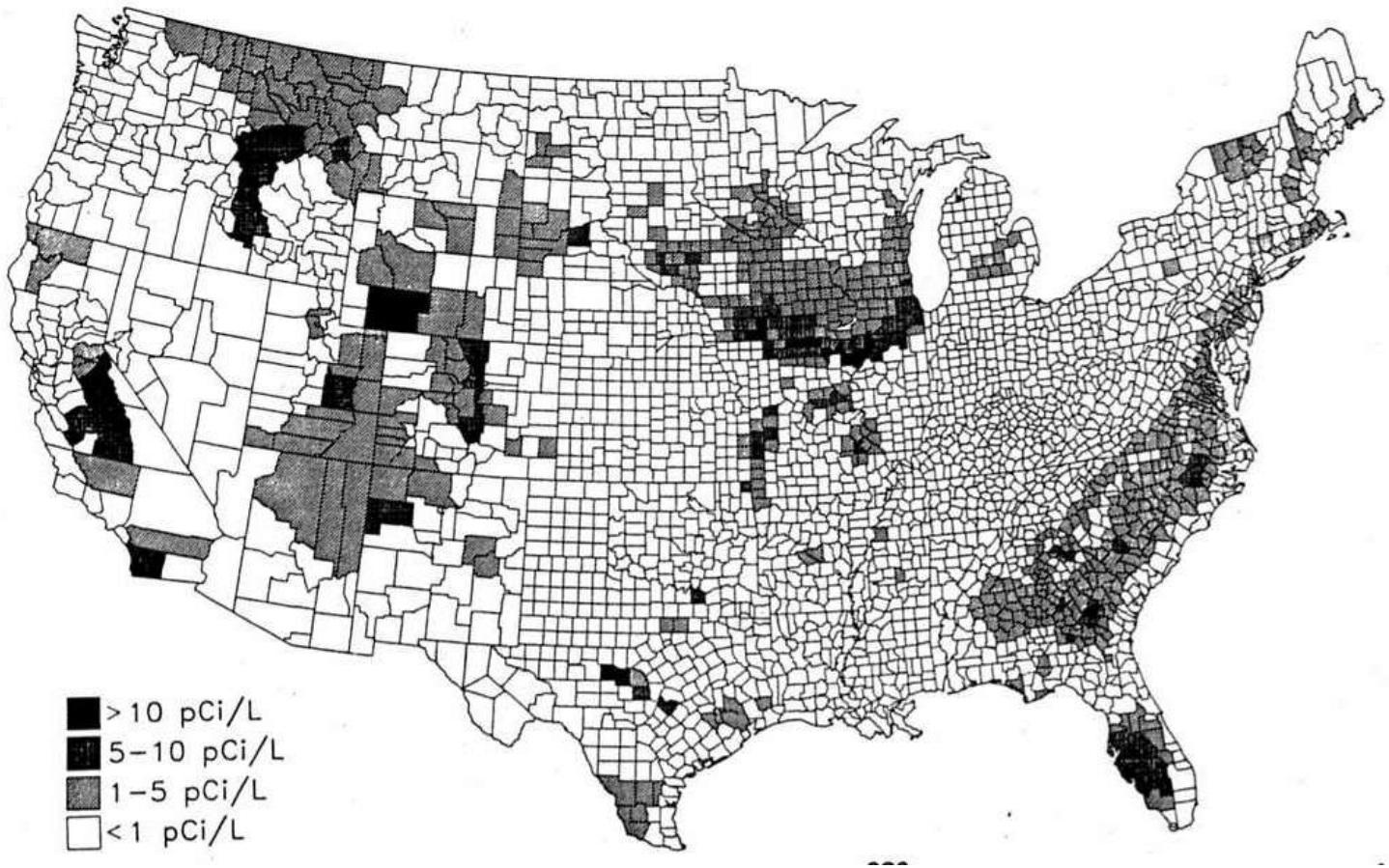
Ra-226 Occurrence in the US



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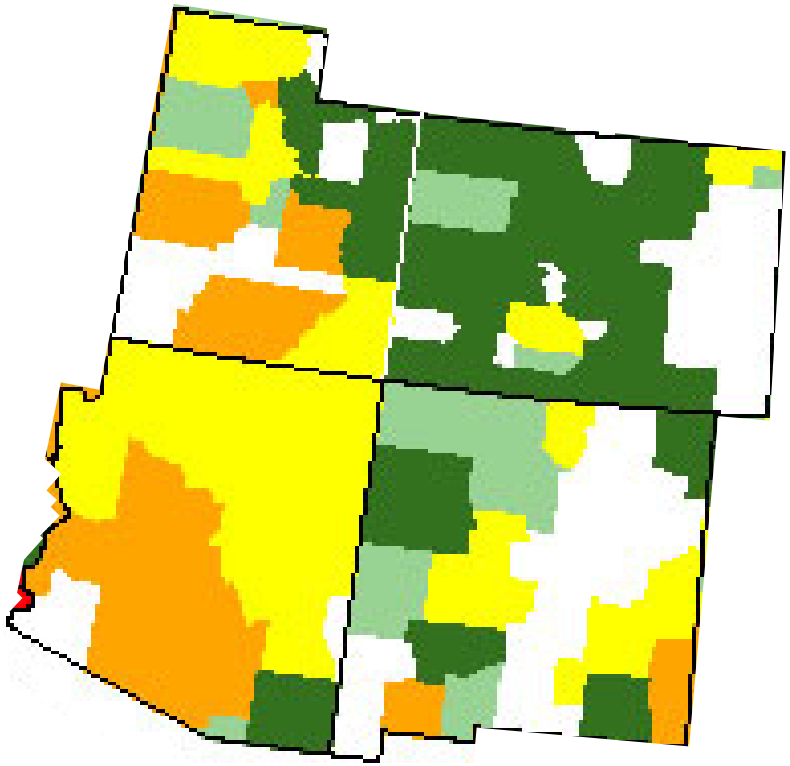
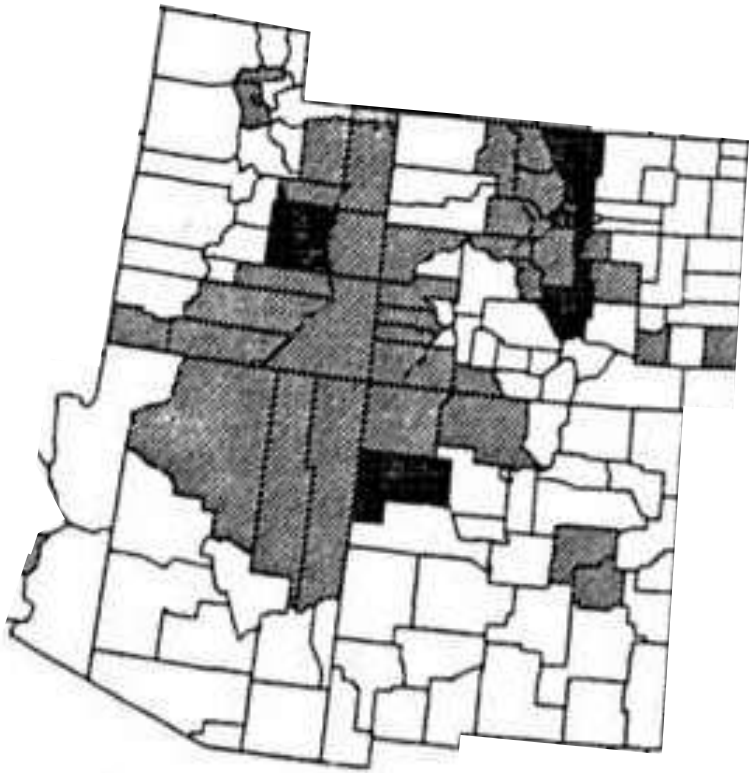
Arsenic and radium in the Southwest





25% As

- 10 μg/L
- 5 μg/L
- 3 μg/L
- 1 μg/L

Ave. Ra

- >5 pCi/L
- 1-5 pCi/L
- <1 pCi/L

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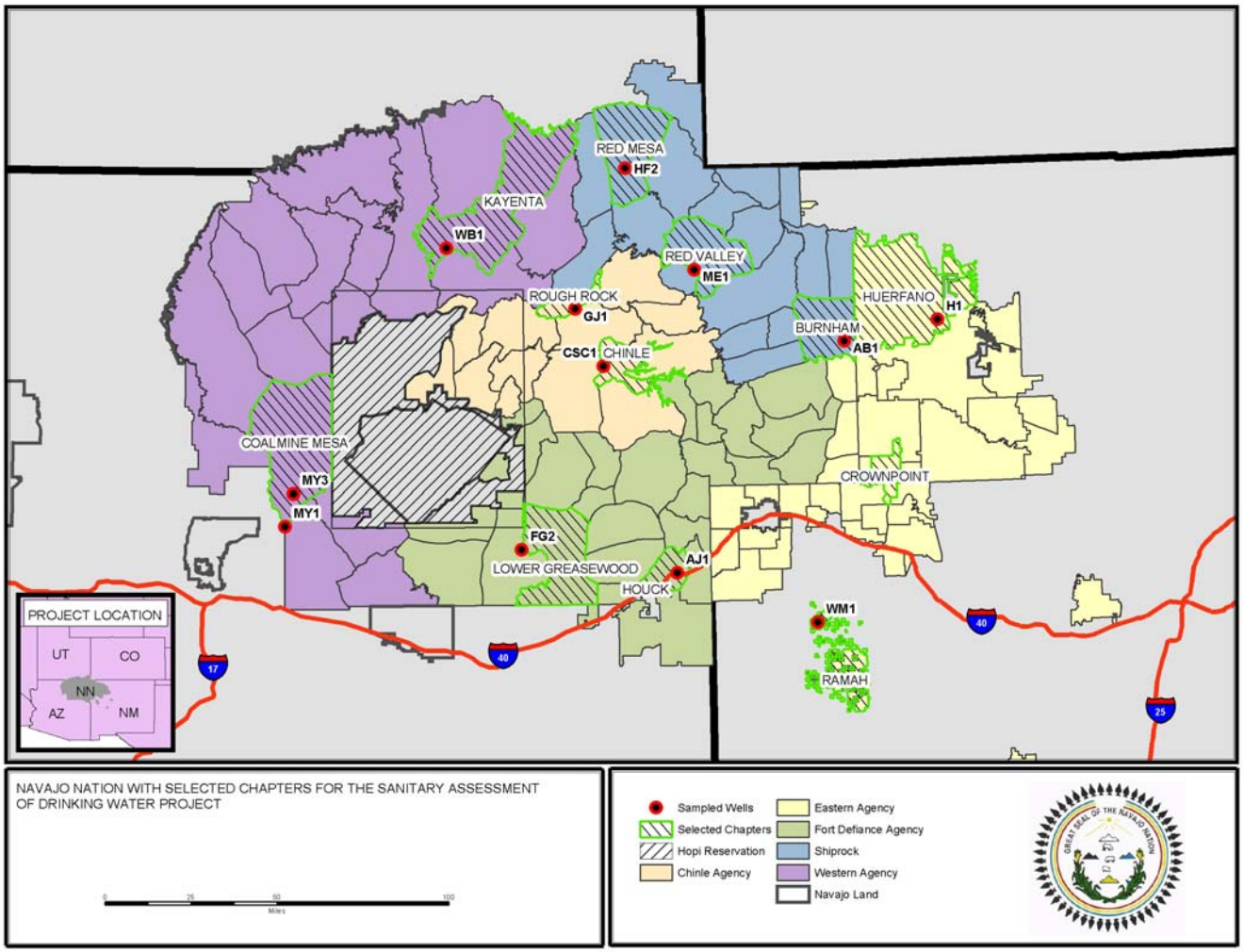
Collaboration with Navajo Nation EPA



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Arsenic Occurrence in Drinking Water Sources on the Navajo Nation

- **Public Water Systems Supervision Program under Navajo Nation EPA regulates approx. 200 public water systems (PWSs)**
- **Water sources of 26 PWSs (13%) exceed Arsenic MCL of 10 ppb; 15 are Community Water Systems (CWSs) and 11 are Non-Transient Non-Community Water Systems (NTNCWSs)**
- **Over 30% of Navajo residents are not connected to PWSs. Most of them haul water from unregulated water sources which contain contaminants such as arsenic, uranium, coliform and pesticides**

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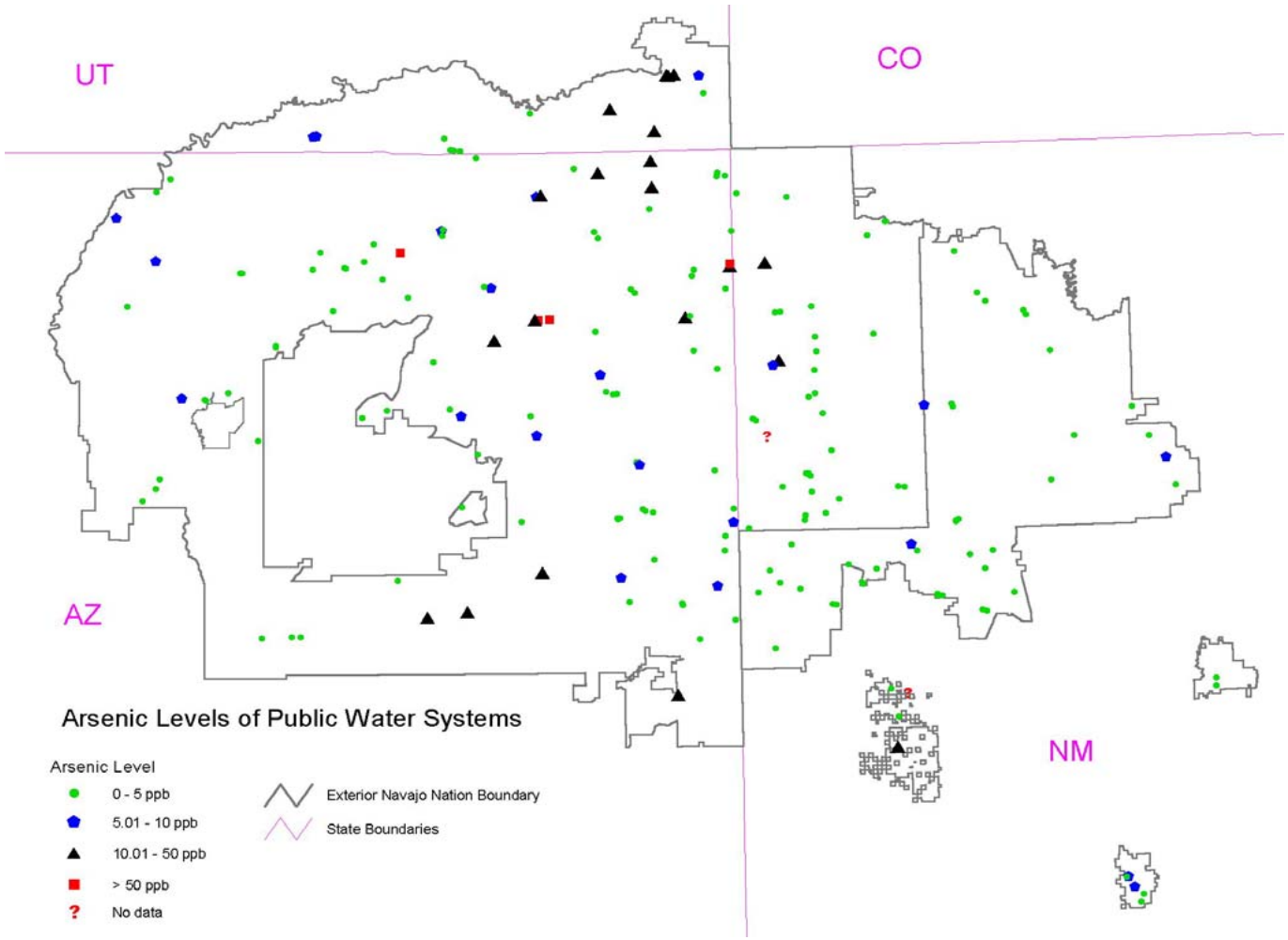
Arsenic Levels in Navajo Nation PWS Wells



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Pinehill School, Ramah Navajo Reservation

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MAPQUEST
602
53
Ramah
Pescado
Cibola
McKinley
Sawyer
Diener
Copperton
Aragon
Sand Corner
Tinaja
El Morro
Pine Hill
Paxton Springs
San Rafael
40
0
5mi
5km
El Malpais National Monument
117
Grassie Place
Hogg Place
Tingle
Fence Lake
Julian Place
© 2006 MapQuest, Inc.; © 2006 Tele Atlas

Pinehill Water Quality

Red values exceed standards

	Well #2	Standard
As (ppb)	30	10
pH	7.8	NA
Gross alpha (^{230}Th pCi/L)	44.2	15
Gross beta (^{90}Sr pCi/L)	23.5	4 rem
Ra-226 (pCi/L)	12.0	Total = 5
Ra-228 (pCi/L)	2.3	
U (ppb)	2.9	30
SO_4^{2-}	302	250
Hardness as $CaCO_3$ ppm	146	NA

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Pinehill Water Treatment Plant

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disinfection/fluoridation

softening

iron removal

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Proposal to Ramah Navajo School Board

- Naturally-occurring arsenic and radium in Pinehill water supply are above regulatory standards causing shut down of Well#2.
- Community wanted second well for future growth and backup.
- Sandia National Labs (SNL) proposed to test innovative treatment technologies to augment the current system at Pinehill.
- No treated water to be returned to the drinking water system during the pilot test.
- Results of test will help community choose new treatment system.

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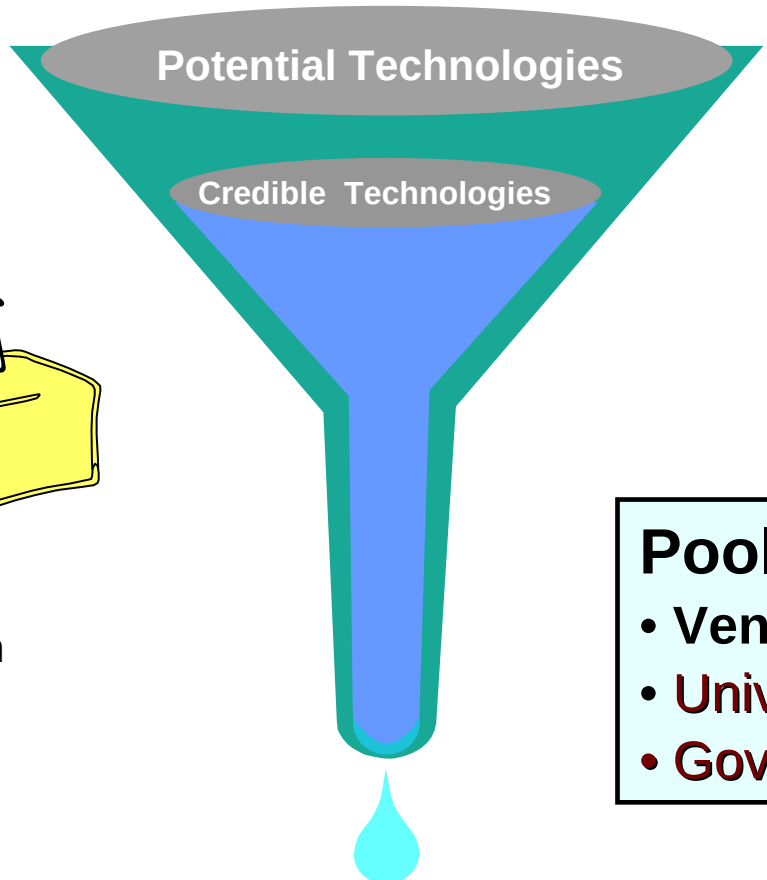
Pilot Technology Selection Process

Technical Evaluation Teams



- Performance
- Cost
- Complexity
- Maturity

Pool of technologies
- Vendors
- Universities
- Government labs

Suggested Pilot Technologies

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General Treatment Innovations

- **Sorption treatment processes**
  - Regenerable, higher capacity and selectivity
  - More stable residuals
  - 'Tougher' sorbents
  - Coatings on inexpensive materials (industrial waste, natural materials)
- **Precipitation/filtration processes**
  - Enhanced coagulation with Fe compounds or polyelectrolytes
  - Improved filtration with nanocomposite materials
  - Recycle systems to minimize chemical addition

2003, 2004, 2005 Vendor Forums led to recommendation of innovative technologies for initial pilots and others for additional bench-scale studies

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Proposed Technologies

- **McPhee/Purolite**
  - **Mixture of ion exchange resins for separate removal of arsenic and radium**
  - **Regeneration brines to sewer**
- **Calgon Carbon**
  - **CalMedia ™ GSR Plus synthetic granular manganese dioxide coated filter media**
    - **Addition of iron and manganese to assist in removal**
    - **Filter removes Fe, Mn, As, Ra and U**
    - **Backwash to sewer**
- **None of the treated water will be returned to the distribution system from the pilot**

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Material Used in Proposed Tests

Calgon CalMedia GSR Plus

ArsenX^{np}

Both materials are NSF/ANSI 61 certified safe for drinking water systems.

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Pilot Treatment Shed and Storage Tank Supplied by Pinehill Schools Facilities

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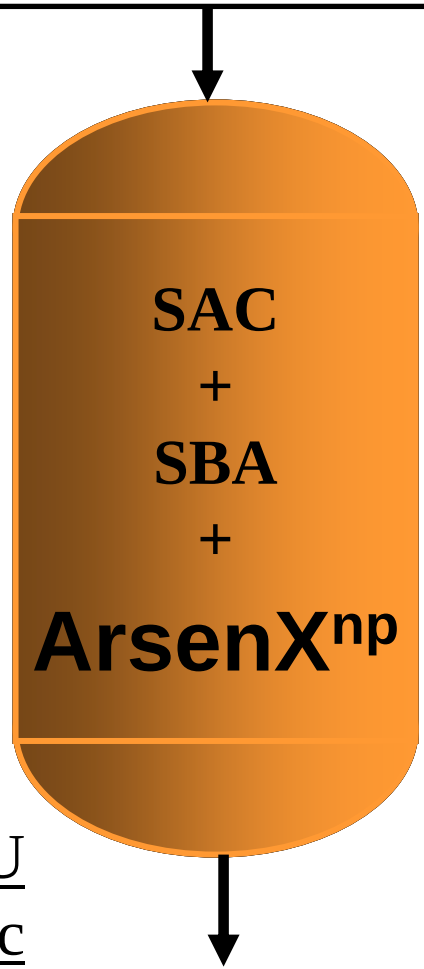
McPhee/Purolite Resins

Combine removal of Cation

& Anion Contaminants:

- **Hardness**
- **Radium**
- **Arsenic**
- **Uranium**



Brine regenerate for radium, U
Alkaline regenerate for arsenic

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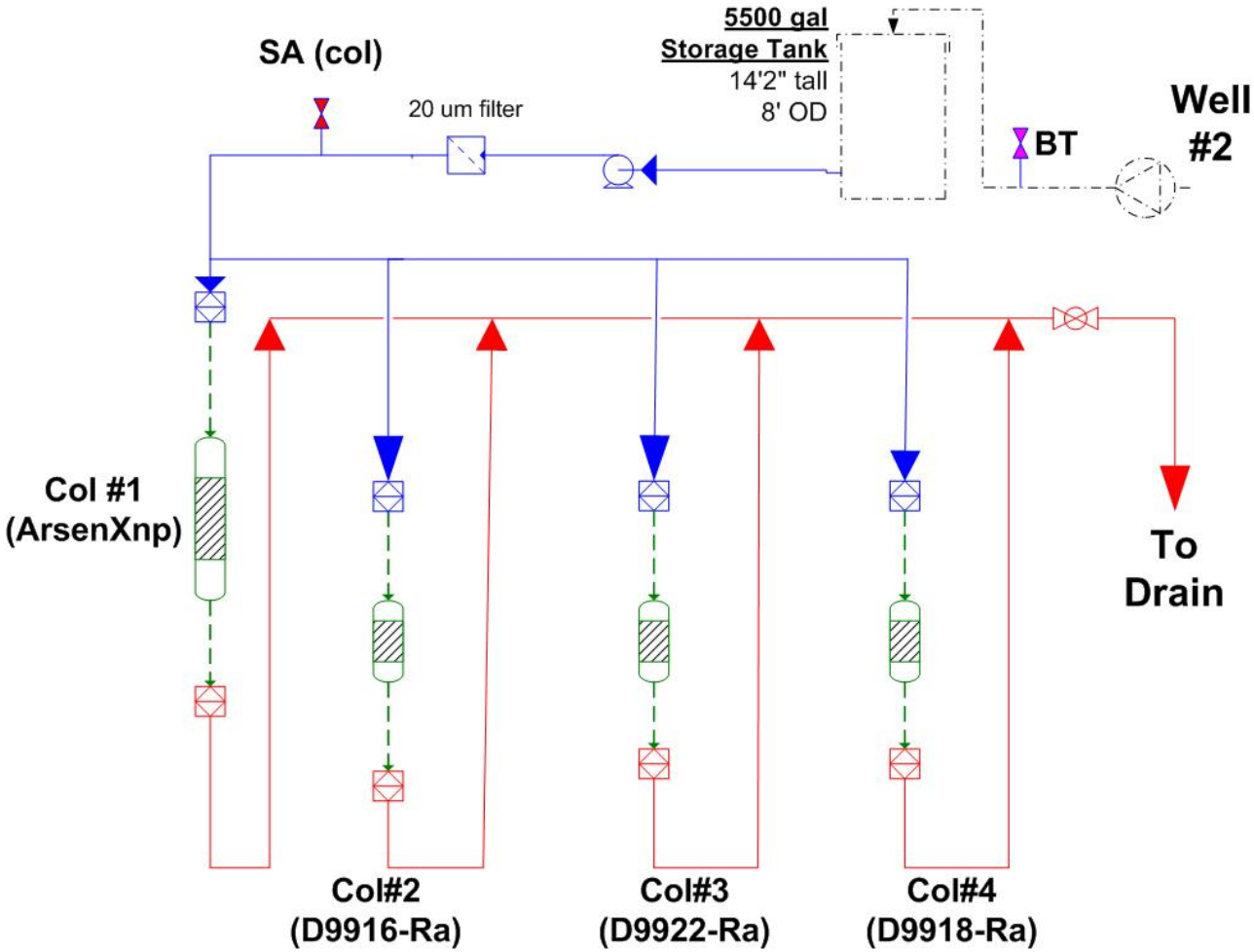
Schematic of Adsorptive Media System



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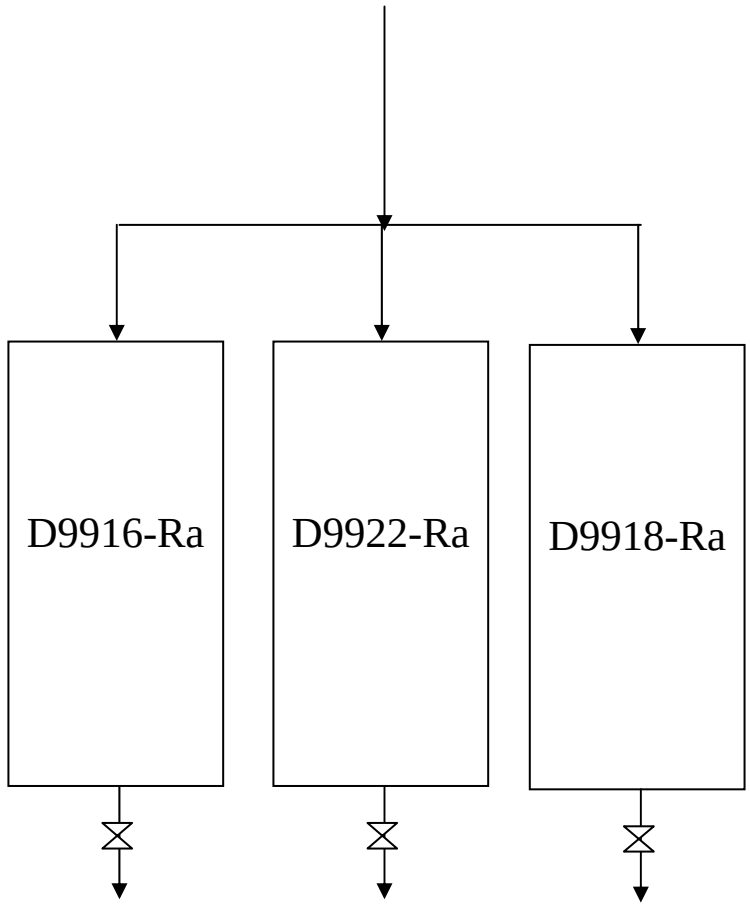
Test of Three Resins for Radium Removal



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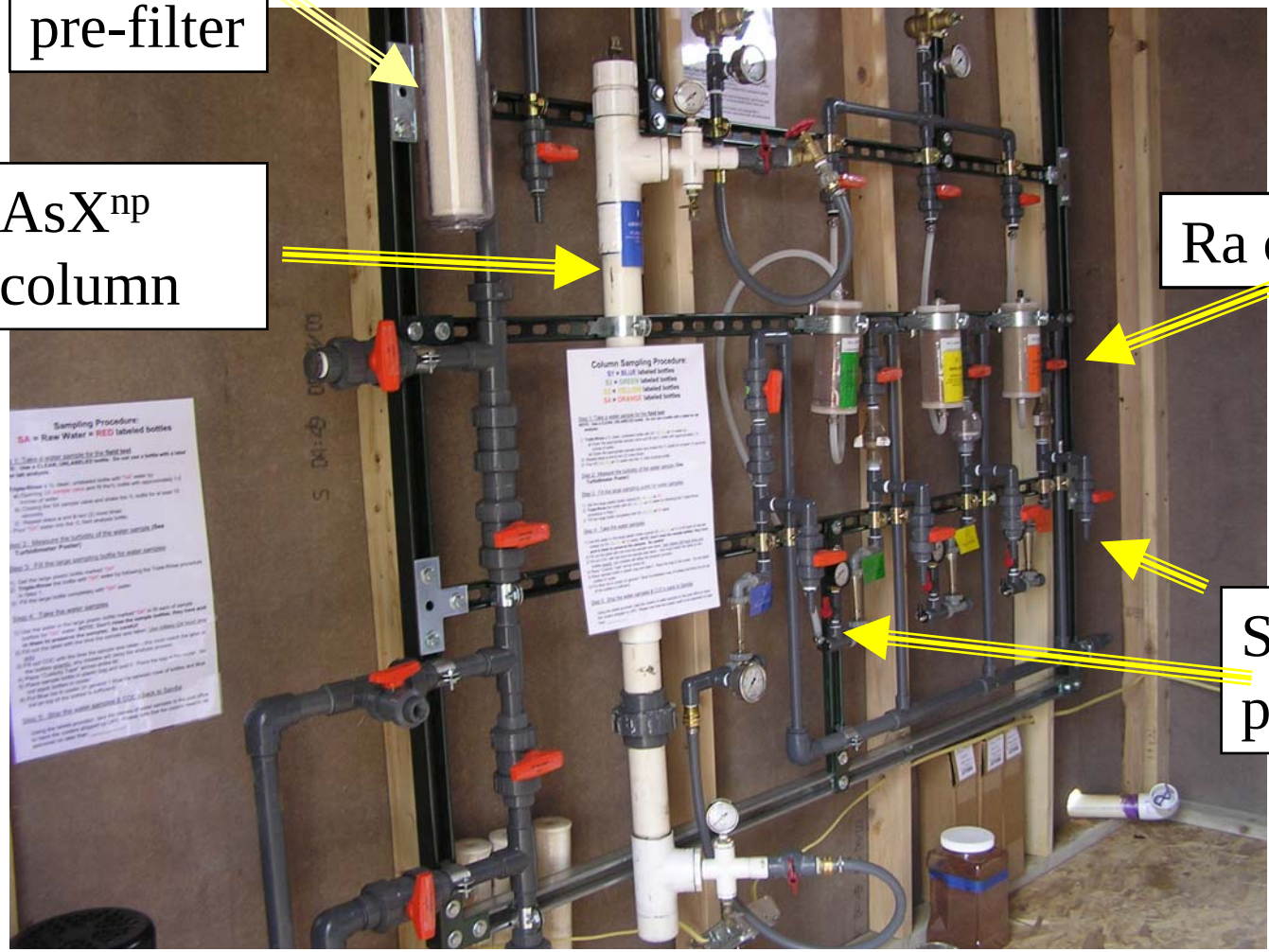
SNL Adsorptive media skid



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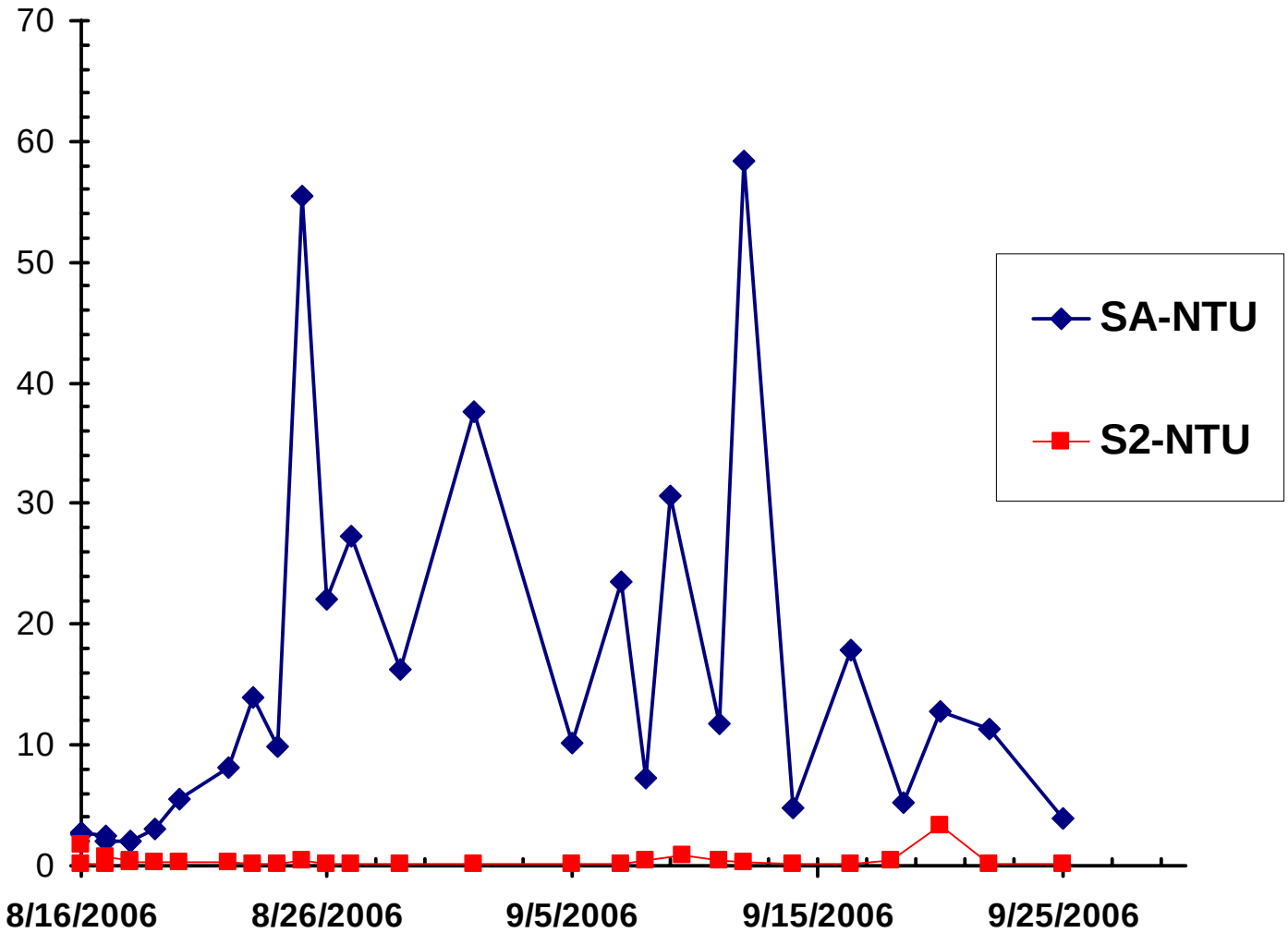
Turbidities of influent and treated waters



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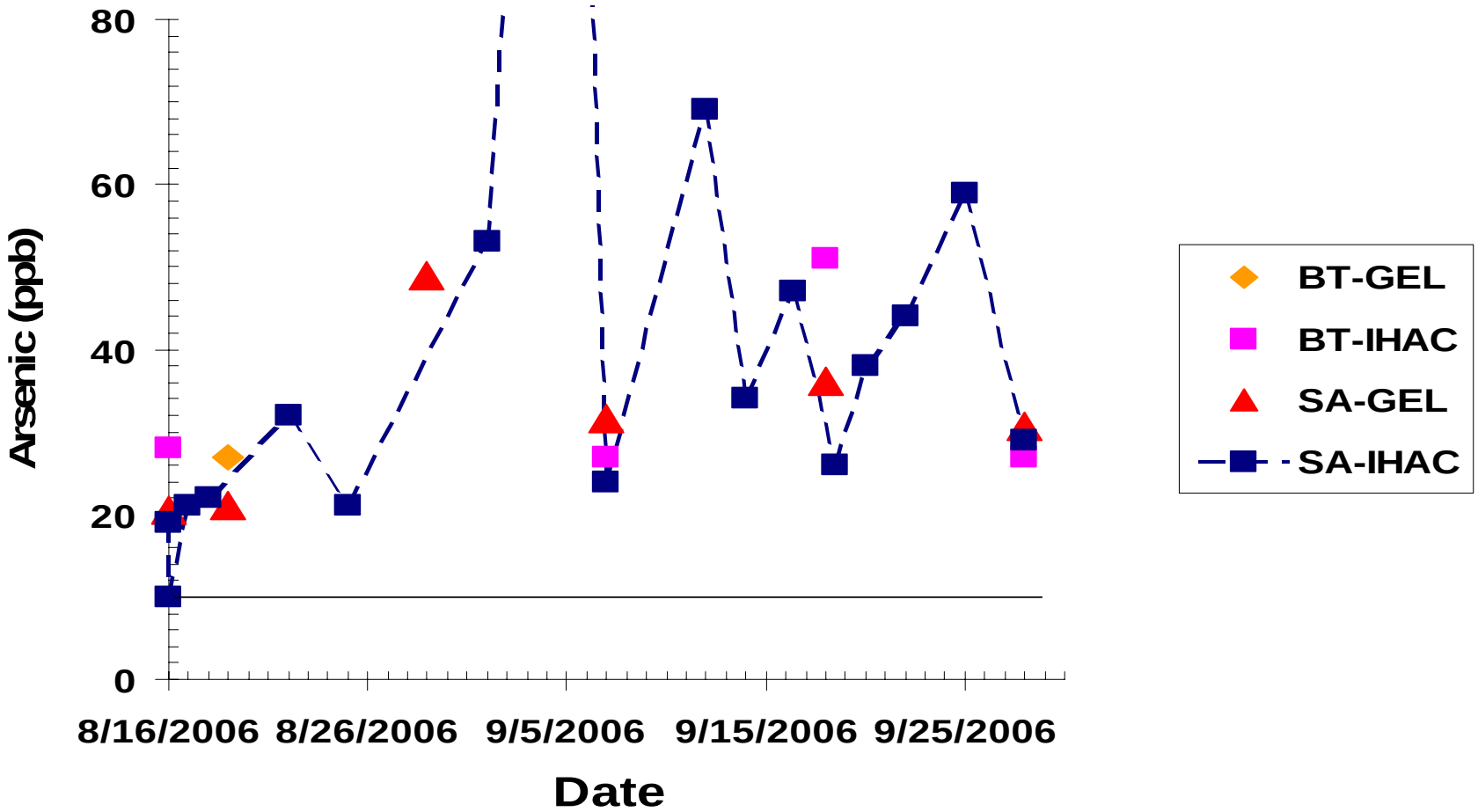
Influent Water Arsenic



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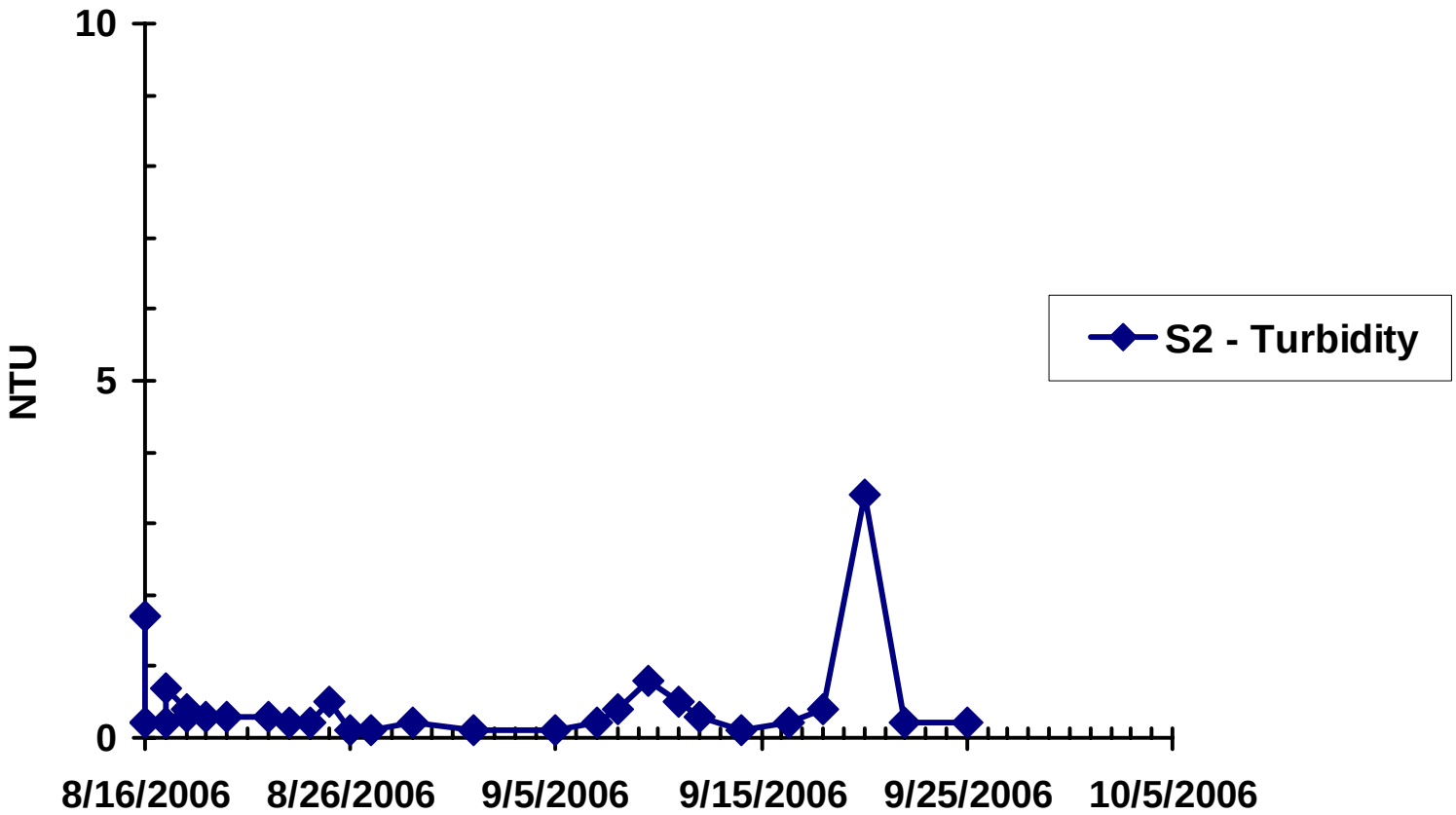
Turbidity of Treated Water at S2



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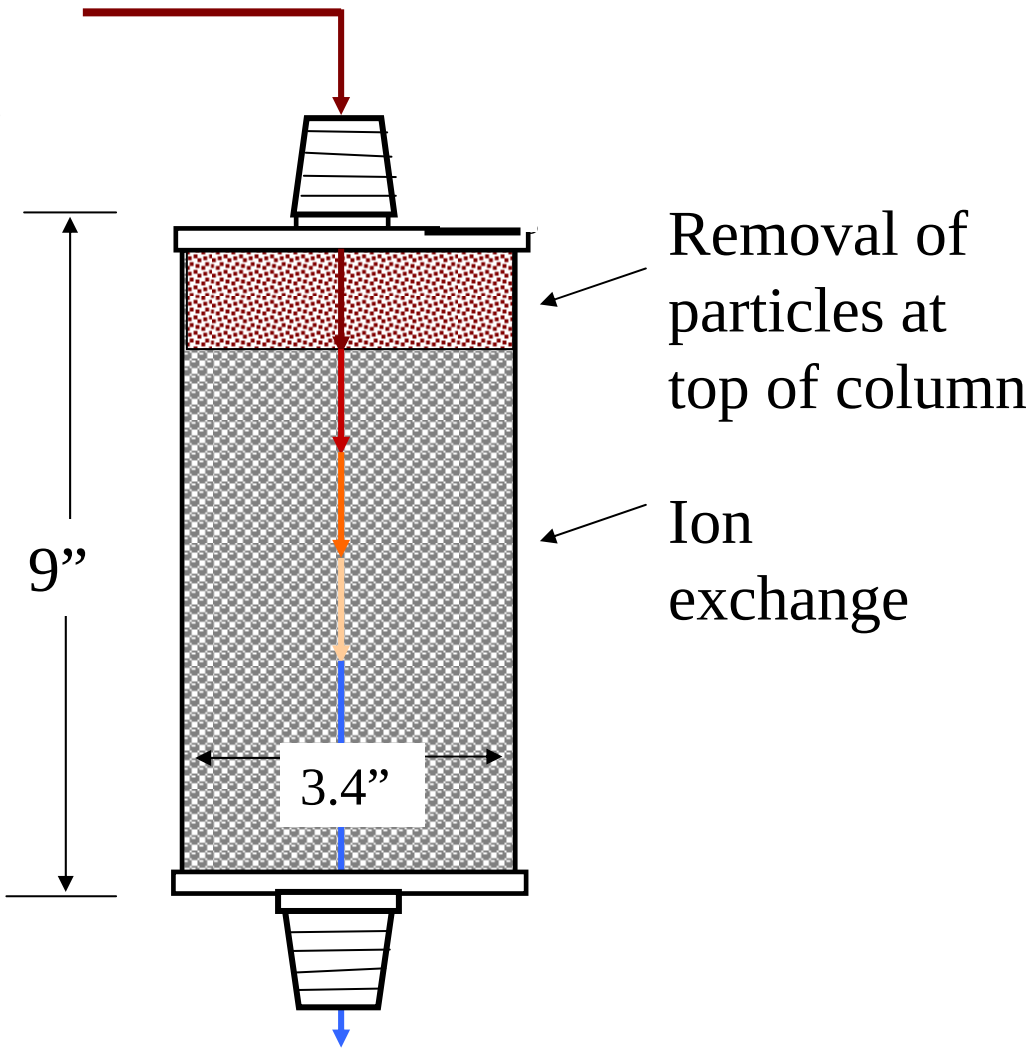
Removal of Contaminants by Filtration and Sorption



Radium columns

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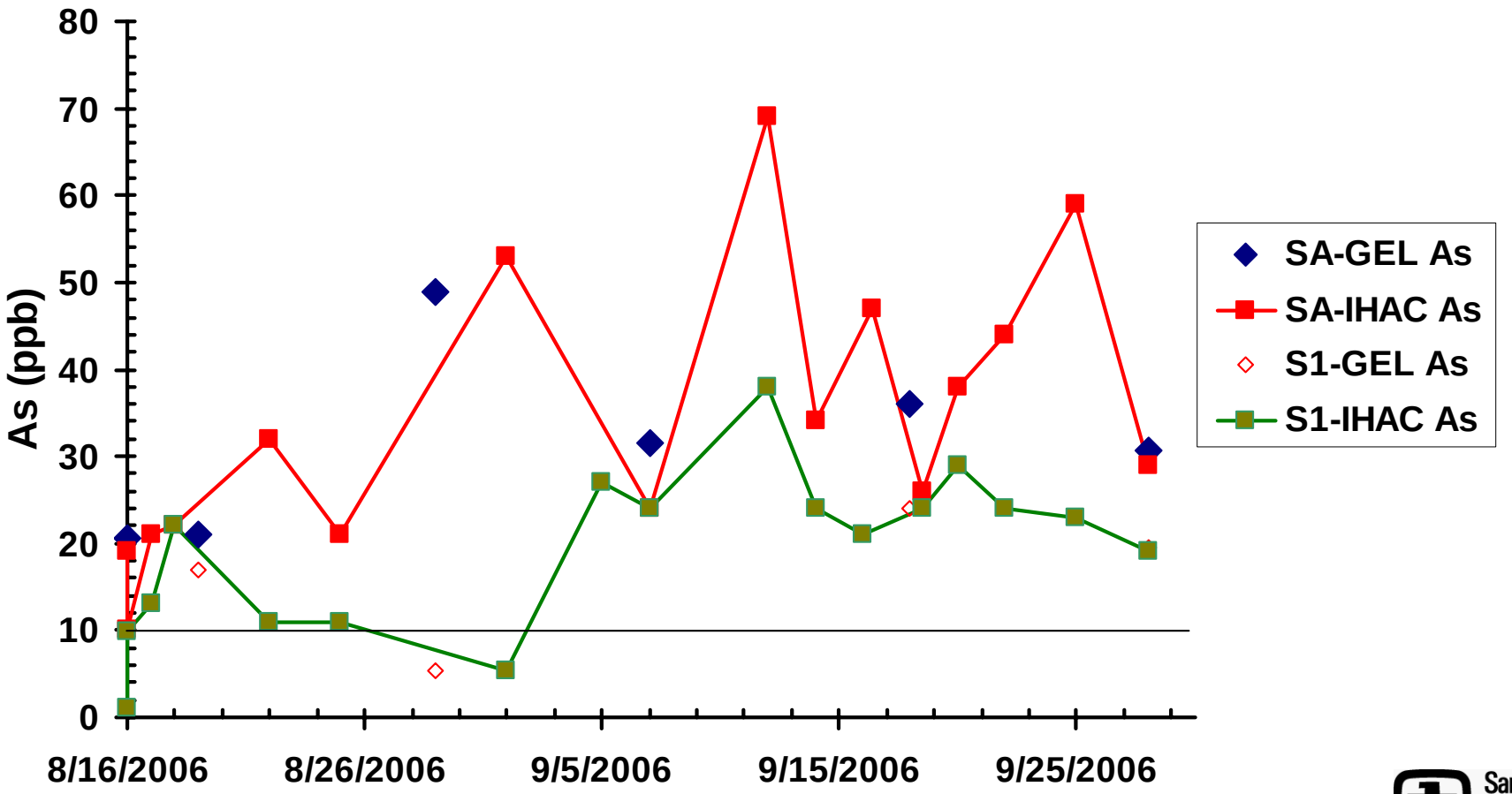
Arsenic removal by ArsenX^{np}



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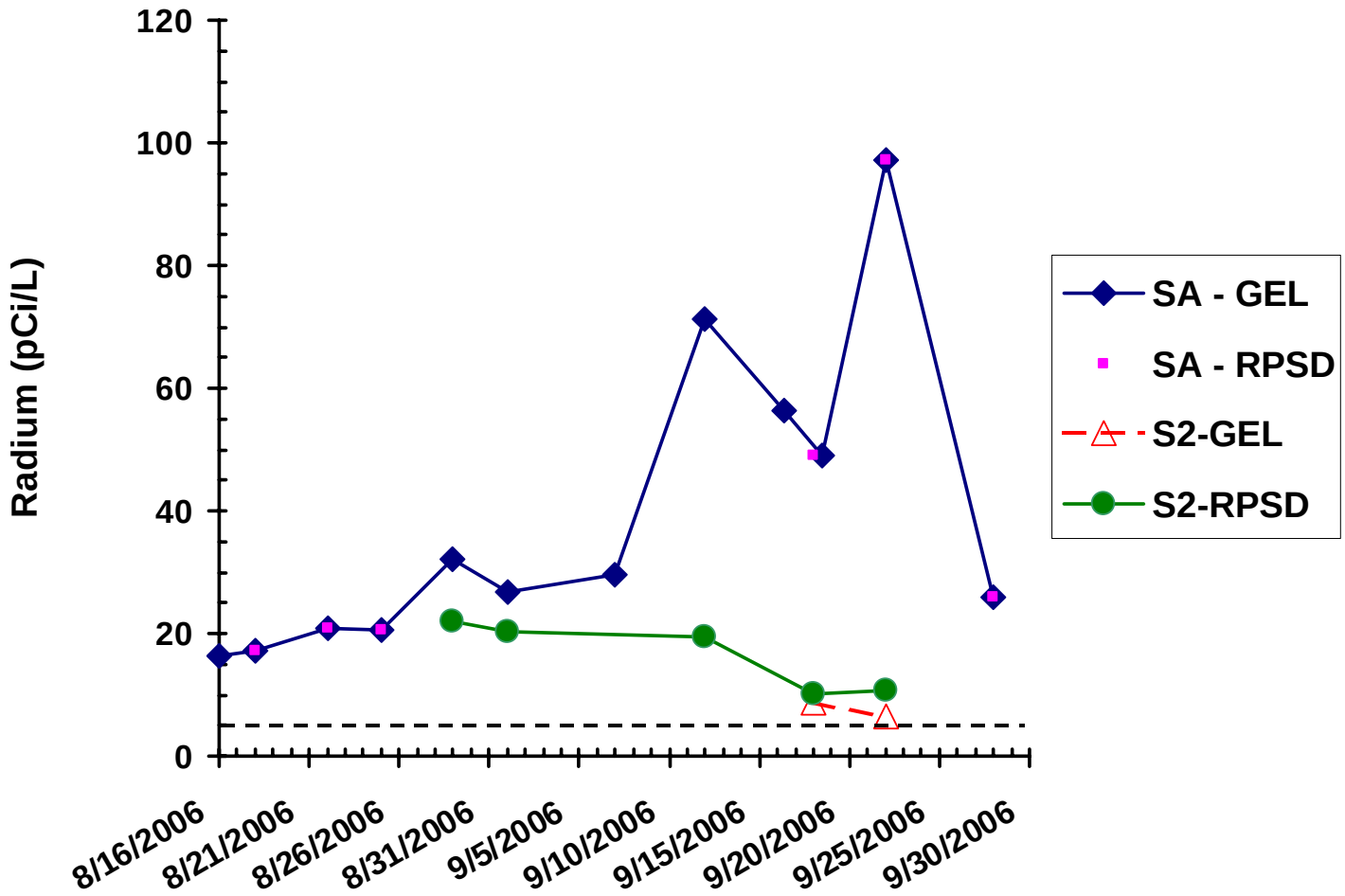
Radium removal by S2 Column



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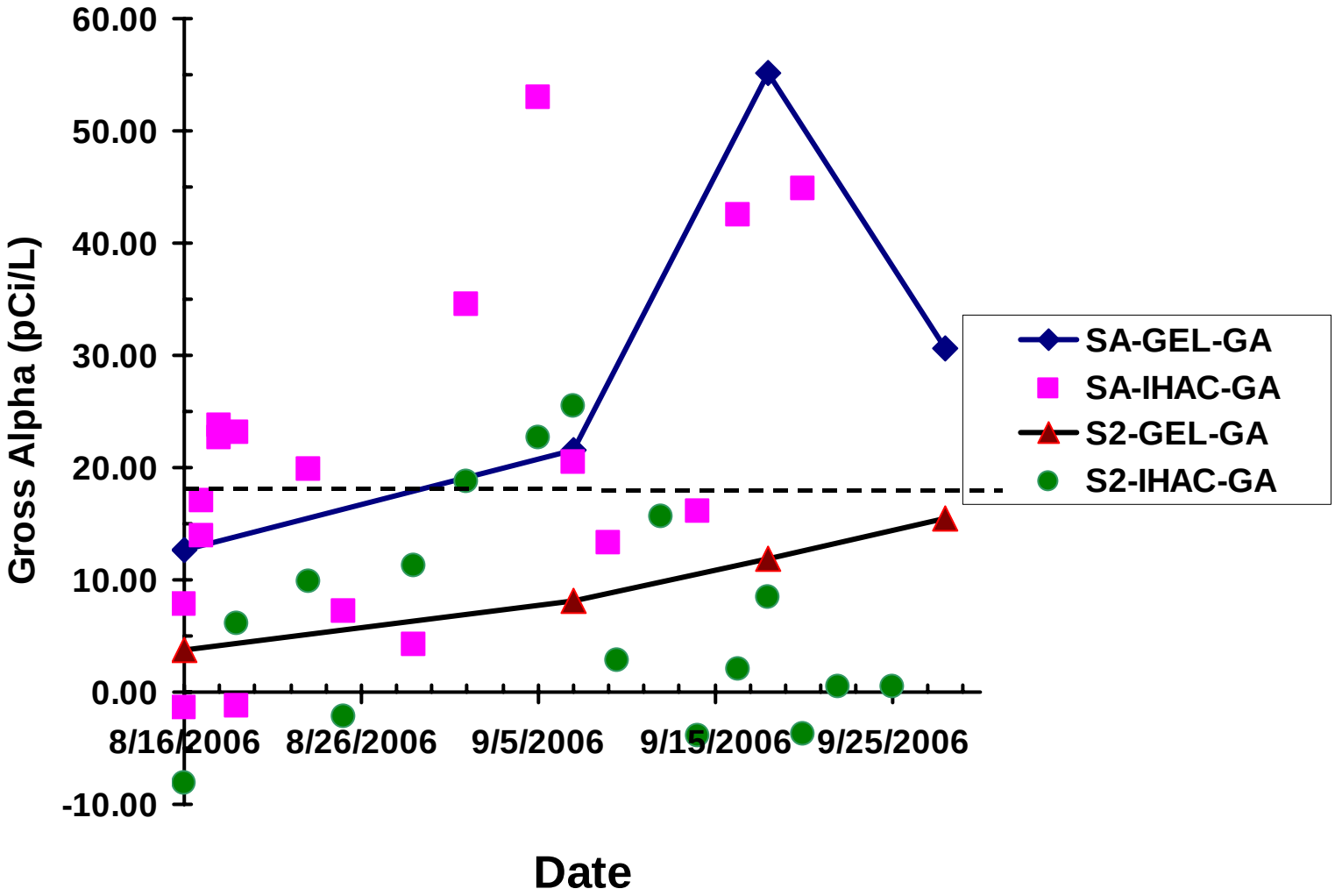
Gross alpha beta removal by S2 column



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Preliminary results: Estimated breakthrough (days)

Treatment Column

COC	MCL	S1	S2	S3	S4
As	10 μg/L	6-10	NA	NA	NA
Ra^{26} + Ra^{228}	5 pCi/L	NA	<13	<30	3-6
Gross alpha	15 pCi/L	NA	>40	>40	10 -13

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Preliminary results: Estimated breakthrough bed (volumes)

Treatment Column

COC	MCL	S1	S2	S3	S4
As	10 μg/L	2600-4600	NA	NA	NA
Ra^{26} + Ra^{228}	5 pCi/L	NA	<9600	<22600	1900-4200
Gross alpha	15 pCi/L	NA	>30000	>40000	7300-9600

Preliminary Observations

- Composition of influent water (SA) variable and dominates column performance
  - May reflect changes in source water during intermittent pumping cycle
  - May reflect changes in storage tank
- Columns not effective for first few days
  - Columns may need breaking in period.
- Low capacity of ArsenX^{np} for As(III)
- Additional verification of activity corrections needed before radium and gross alpha removal can be evaluated.

Calgon Carbon Pilot System

Oxidation/filtration system

Starts Nov 6, 2006.

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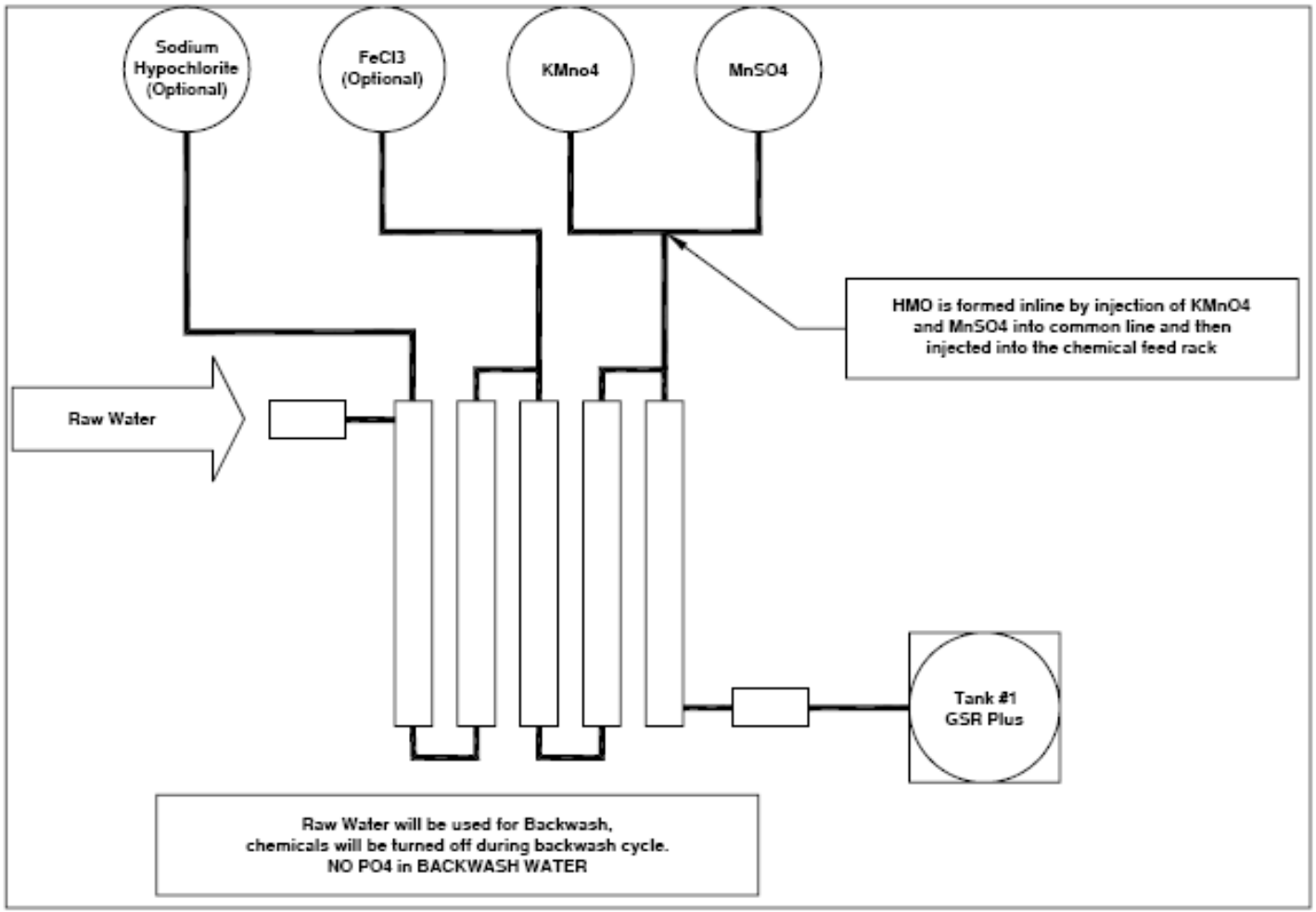
Calgon Carbon System



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Summary

- **Pinehill water presents challenges to conventional treatment technologies:**
  - **Hardness, radioactivity, As(III), hi Fe(II)**
  - **Arsenic, radium and sulfate levels are above regulatory standards.**
- **Collaboration between Sandia National Labs, Pinehill Facilities and NNEPA provides basis for testing innovative treatment technologies to augment the current system.**
  - **Test designed to identify best commercially available technologies.**
- **Results may be applicable to other water systems with multiple contaminants**
  - **Desire to find technologies that can be used in POU applications in non-PWS in Navajo Nation.**

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Team Members

- Randy Everett, William Holub Jr., Carolyn Kirby, Michelle Shedd, Andres Sanchez
- Rose Preston, Joe Zigmond, Jen Ashley, Pam Puissant
- Ron Francis, Dominic Maria, Steve Garcia
- Tom Hinkebein, Pat Brady, Richard Kottenstette
- AwwaRF partners
- WERC partners

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- **Thank you for your interest.**
- **Project website**

http://www.sandia.gov/water/arsenic.htm

- **Questions?**

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