Site Selection and Technology Evaluations for Pilot Demonstrations

Arsenic Water Technology Partnership

New Mexico Environmental Health Conference

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Arsenic Water Technology Partnership

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**
  - **Reduce energy consumption**
  - **Minimize costs- capital, operating, maintenance**
  - **Minimize residual quantities & disposal costs**

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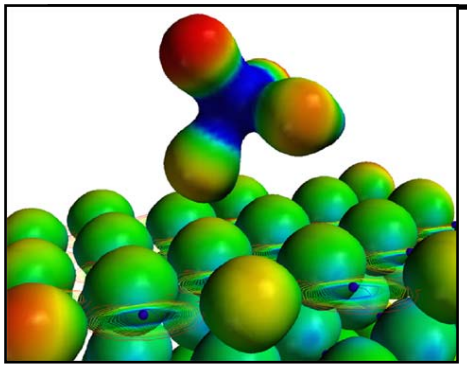
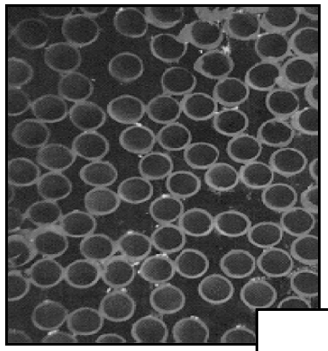
Why Sandia?

Advances in water treatment technology will have significant impact on safety, security, and sustainability



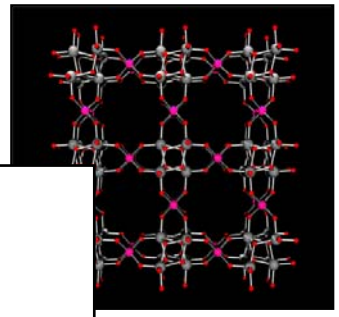
Design of arsenic-specific chemical filter materials

Safety:
Cost-effective contaminant removal technologies

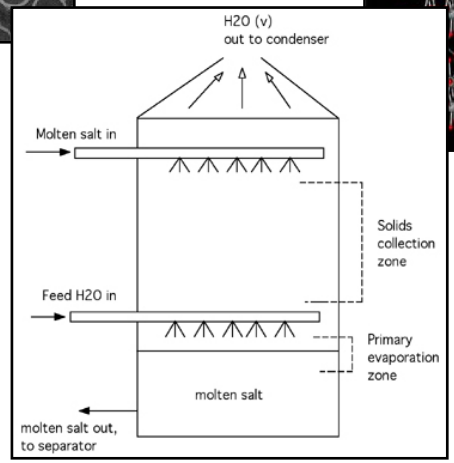


Pervaporation

Sustainability:
Next-generation desalination technologies



In situ crystallization



Direct contact distillation

Integrated chem/bio treatment technologies

Security:
Future treatment strategies for reducing vulnerability of water infrastructure

Point of use (rather than centralized) treatment technologies

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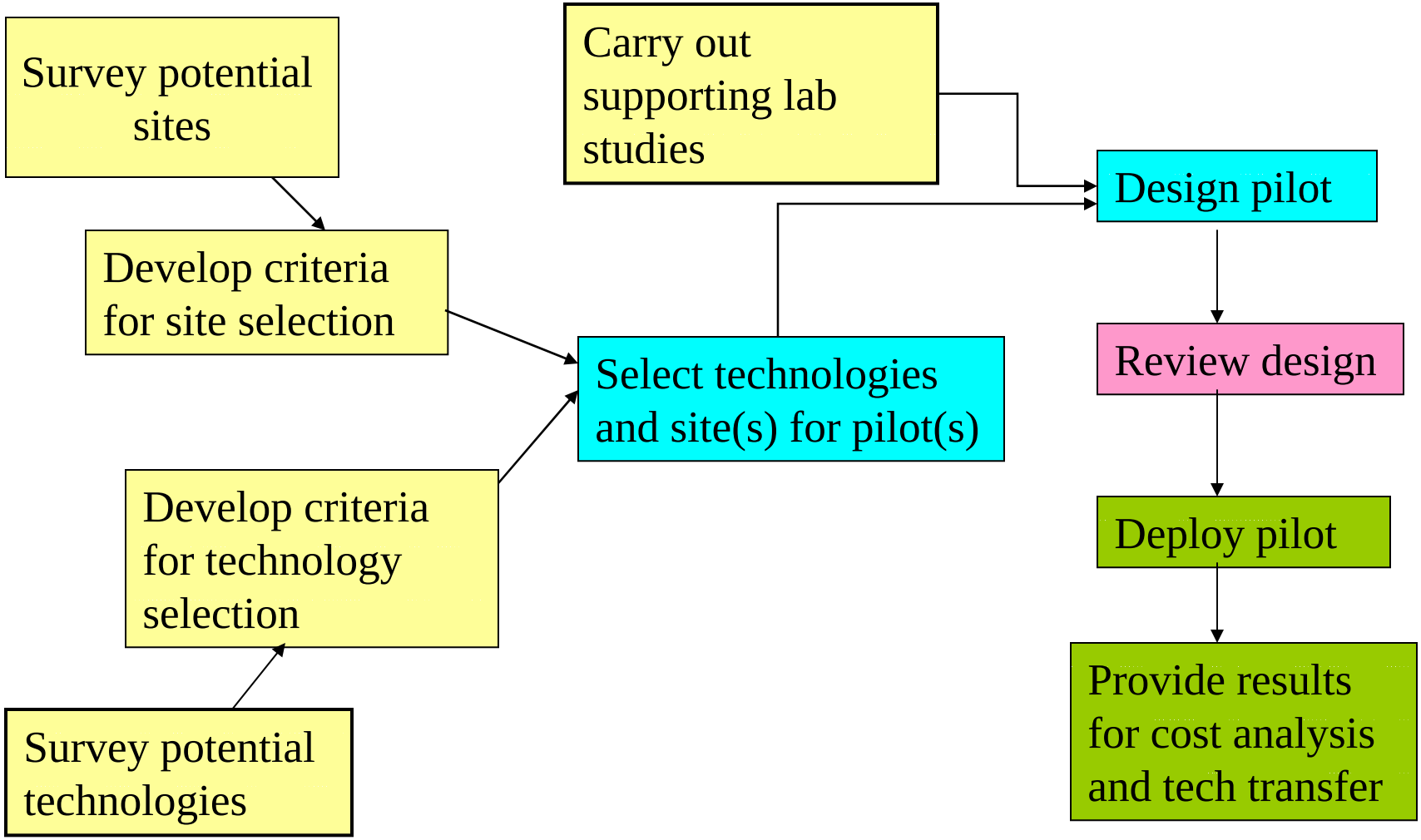
Activities in the Pilot Test Program



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Initial Activities (FY2003 – 2004)

- State-of- the- art Workshop (August 2003)
- Sponsored activities at New Mexico Environ. Health Conference (October 2003)
  - Theme session to introduce program
  - Vendors Forum to evaluate commercial technologies
  - Website: http://www.sandia.gov/water/arsenic.htm
- Initial contact of sites in NM, CO, AZ, FL, NH, OK
  - Contacts through NM Rural Water Assoc., USGS, State agencies
  - AwwaRF projects that identified sites with exposed populations
- Initial technology deployment at Kirtland AFB

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Current Activities (FY2004 – 2005)

- **Sponsor activities at 9th New Mexico Environmental Health Conference (Oct. 19- 20)**
  - **Theme session with invited experts**
  - **2nd Vendors Forum to evaluate commercial technologies**
  - **All 90 systems in New Mexico were invited by NMED.**
- **Start pilot test deployment at Jemez Pueblo, Socorro, and sites in Midwest**
- **Develop plans for pilots in sites in New England, Arizona and additional sites in New Mexico**
- **Identify sites with USEPA, NMED, NNEPA, IHS, NAUM, NM Rural Water Assoc., USGS, State agencies (ITRC), Industry**

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Criteria for Site Selection

- As concentration >10 ppb
- Example of class of ground water composition
  - pH, TDS, foulants such as Fe, Mn, silica, and organics
  - As(III)/As(V)
  - Competing ions (V, SO_4, etc.)
  - Other metals and radionuclides of concern/benefit
- Sufficient water quality data to assess variability
- Size of system to be treated (< 10,000 users)
- Community support facilitates rapid deployment
  - Water utility
  - Municipal government
- Ability to deal with residuals/treated effluent
- Socioeconomic/Cultural factors

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Current Site Selection Process

- **Phase 1 - FY04 funding**
  - **AwwaRF study/EPA data base and "expert opinion" (NSF, NCS, CH2MHill)**
  - **Local pilot (KAFB) + 2 NM + 1 remote sites**
- **Phase 2 - FY03 funding**
  - **NMED list, Vendors Forum and ITRC**
- **Phase 3 - FY05 – 06 funding**
  - **Website posted by WERC with online application**

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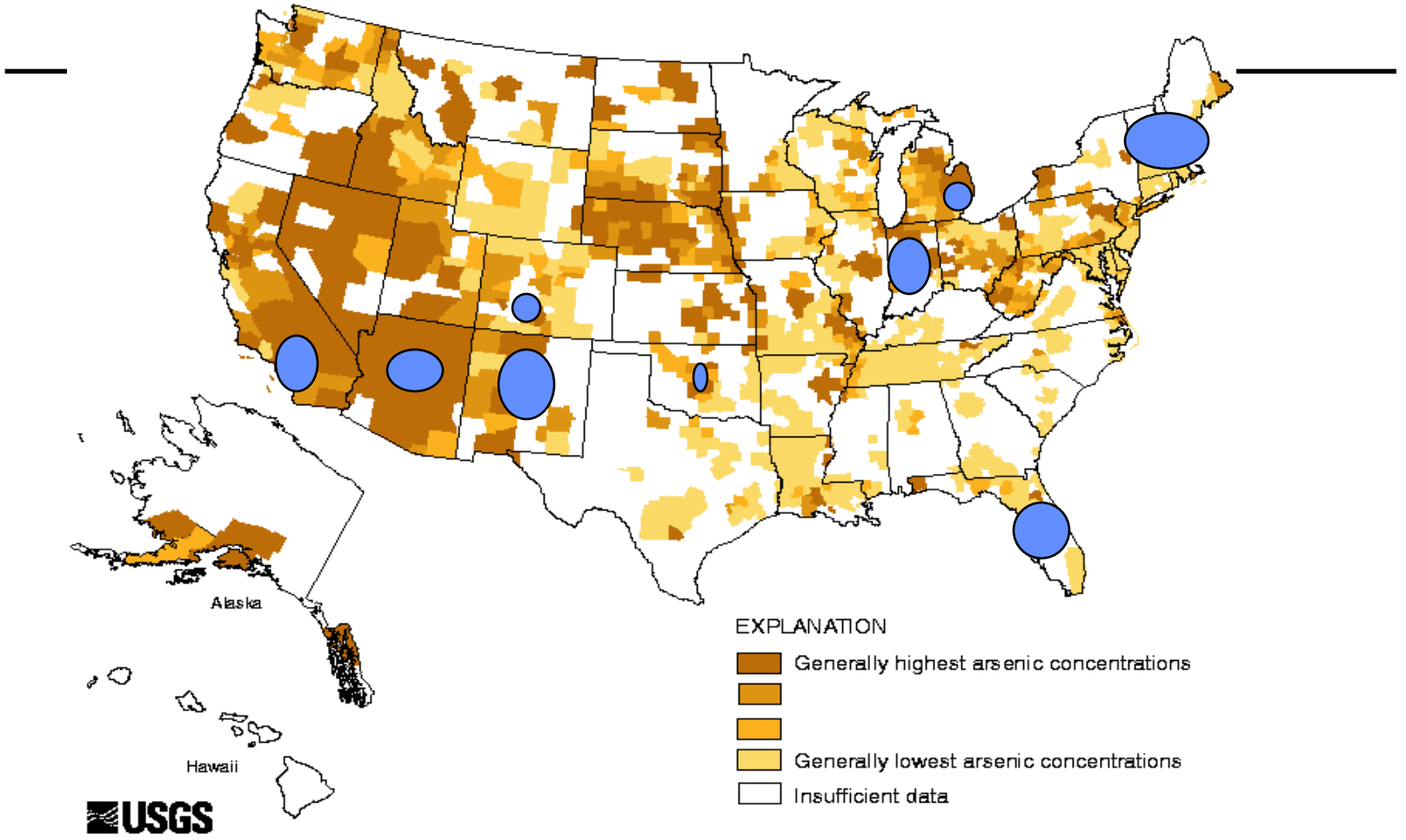
Early Pilot Site Candidates



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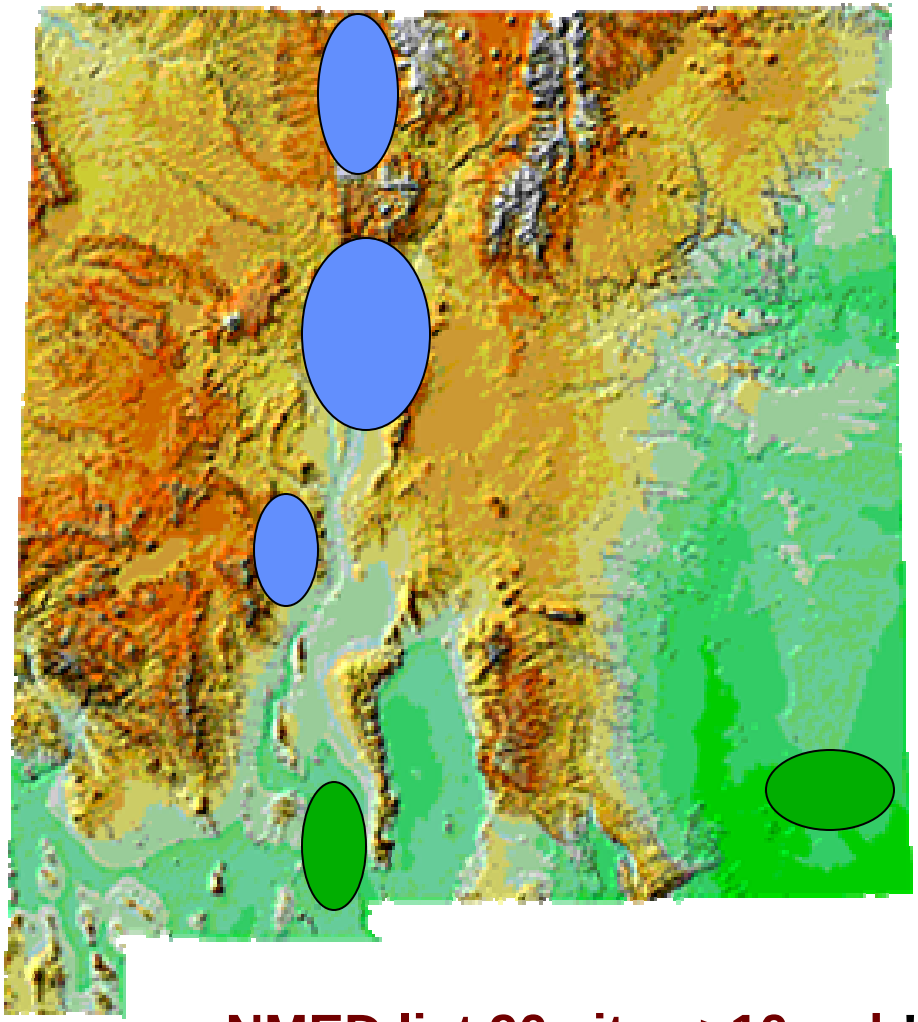
High Arsenic in New Mexico's Waters



NMED list 90 sites >10 ppb!

> 20 ppb levels

- **Bernalillo**
- **Cuba**
- **Rio Rancho**
- **Columbus**
- **Jemez Springs**
- **Artesia**
- **Melody Ranch**
- **Capulin**
- **Rivera**
- **San Ysidro**
- **Algodones**

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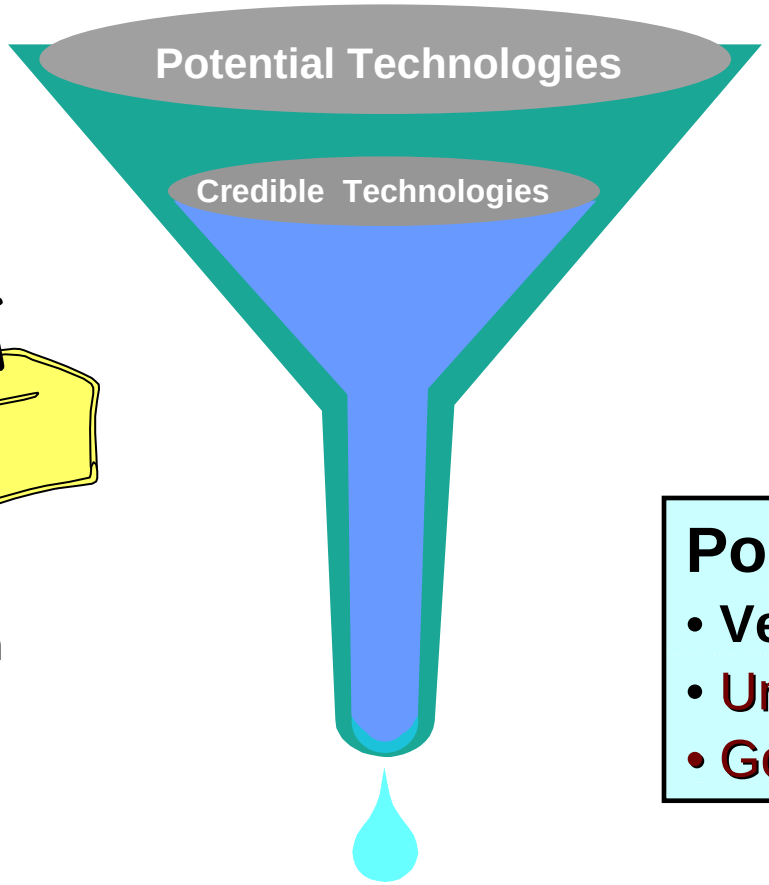
Pilot Technology Selection Process

Technical Evaluation Teams



- Performance
- Cost
- Complexity
- Maturity

Pool of technologies
- Vendors ☆
- Universities
- Government labs

Suggested Pilot Technologies

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Current Treatment Alternatives

- Sorption treatment processes
  - Ion exchange
  - Activated alumina
  - Iron-based sorbents
- Membrane treatment processes
  - Reverse-osmosis
  - Precipitation/filtration processes
    - Conventional gravity coagulation/filtration
    - Coagulation-assisted microfiltration
    - Enhanced lime softening
    - Oxidation/filtration

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Proposed Treatment Innovations

- **Sorption treatment processes**
  - **Regenerable, higher capacity and selectivity**
    - **Modified Fe-based sorbents**
    - **Ti, Zr-based sorbents**
    - **Resin-metal oxide hybrids**
  - **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**

Performance Criteria

- Site-specific As adsorptive capacity and selectivity
- Robustness of performance with respect to possible changes in water quality
  - pH, TDS, foulants such as Fe, Mn, silica, and organics
  - competing ions
- Potential to remove other metals and radionuclides
- Potentially deleterious effects on water system
  - Corrosion from low pH, fluoride removal, increased disinfection by-products
- Insights into full-scale costs
  - Likely M&O issues

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Cost Criteria

- **Design/engineering costs**
- **Initial Capital Costs**
- **Construction/installation**
- **Operation & Maintenance**
  - **Energy requirements and chemical(s) usage**
  - **Predicted waste generation**
  - **Pre/post-treatment requirements**

Costs will be compared to “baseline” technology.
(currently being used or considered by community)

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Complexity and Maturity

- Operation & maintenance requirements
- Training level required by O & M personnel
- ES&H concerns: materials, other hazards
- Package system vs. new construction vs. add-on technology
- How many plants have been installed
- Equipment mass-produced or custom-designed
- Operational and performance record at different sites

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Laboratory Studies

- **Characterization of adsorptive media**
  - **Raw media – is it tough?**
  - **Spent media – is it stable in landfill?**
- **Batch sorption studies - predict capacity in different waters**
- **Batch kinetic studies – required residence time in columns**
- **Preliminary column studies**
  - **Relate EBCT (residence time) to capacity**
- **RSSCTs**
  - **Small-scale columns to speed up evaluation process**
  - **Role of surface vs. pore diffusion for As in metal oxides**
  - **Proportional vs constant diffusivity models for scaling relationship**

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Pilot Test Concepts

- **Side-by-side demonstrations of technologies tested by AwwaRF bench-scale program, WERC design contest or commercial technologies vetted through Vendor Forums**
  - **Test duration: 3 – 9 months**
  - **Test size: 0.3 – 10 gpm**
  - **Different technology classes: adsorptive media, C/F, membranes, softening**
- **Cooperative effort between Sandia, Technology Owner and Site Owner**
- **Test Protocols developed with help from NSF, ETV, academia, industry during 2004**

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Roles and Responsibilities

- **Technology Owner**
  - **Provides material or technology**
- **Sandia National Laboratories**
  - **Funds and oversees test**
- **Site Owner**
  - **Assists with test**
- **WERC**
  - **Economic analysis and tech transfer**

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Pilot Test Configurations

- **Pump house**
- **Skid Mount or container**
- **Mobile unit**

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Kirtland AFB 'Local' Pilot

- **Phase I Design**
  - 5L columns: AAFS50 and GFH
  - 5 min EBCT; 4" diam x 20'' bed height
  - Pre-chlorination
  - Ave [As] = 13 μg/L or 17 μg/L
  - pH = 7.2 – 8.1; SiO_2 = 26-33 mg/L
- **Phase I Results**
  - Media As capacity to 5 μg/L BT
    - AAFS50 – 29.9 μg/g @ pH 8.1
    - GFH – 286 μg/g @ pH 7.2
  - Both media passed TCLP
  - Differences in selectivity for F

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First Community Pilot: Socorro, NM

- 100% groundwater source for drinking water
- Warm springs (90°F) provide 500 gpm, 20 – 40 ppb As by gravity flow.
- Formerly site of tap for bottled water company

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Objectives of Socorro Springs Pilot

- Compare As capacities of 4 adsorptive media
  - AD33 (a.k.a. SORB-33, Bayoxide, E33, GFO) - AdEdge
  - MetSorb (TiO_2) – Hydroglobe Inc.
  - Isolux 302M (ZrO_2) – M.E.I. Inc.
  - Media selected at 2004 NMEHC
- Determine effect of pH adjustment on adsorptive capacities: significant increase?
  - Lower pH from 7.7 to 6.8 via CO_2 injection
- Determine effect of EBCT on adsorptive capacities: linear?
  - 3 EBCTs bracket optimum vendor EBCT
- Evaluate potential corrosivity of treated water
- Evaluate coagulation/filtration alternatives

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Potential Community Pilot #2: Jemez Pueblo, NM

- Single well serves 550 water connections (3000 people)
- As levels : 20-30 ppb ; optimal F level
- Existing treatment: only chlorination
- Future treatment in new treatment plant
  - As removal
  - High organics content
  - Fe and Mn, hardness
- Treatment plant under construction (Nov. 2004)
- Opportunities for training and outreach will be important aspects of pilot test program

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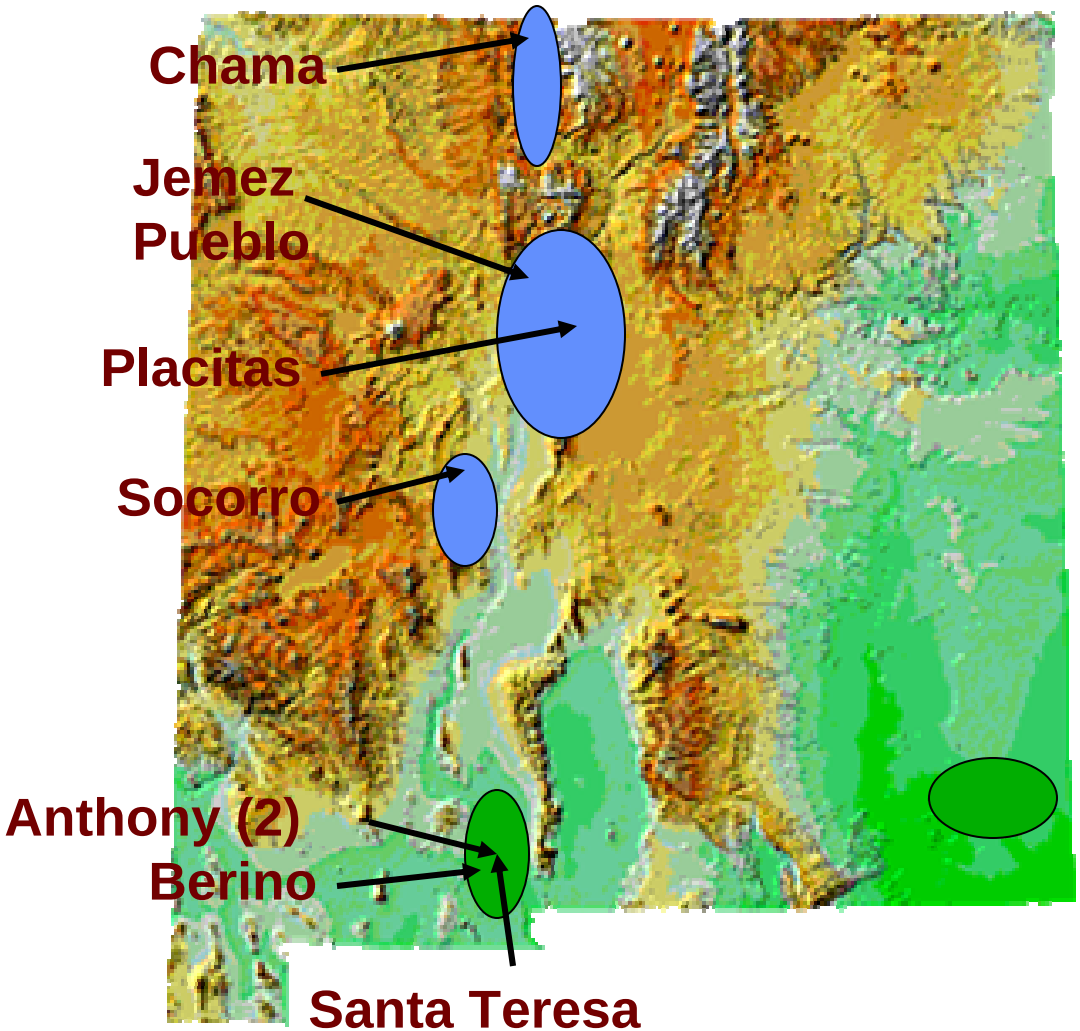
Possible New Pilots in New Mexico



Test objectives

- Compare > 4 Fe-based media at full-scale plant
- Mobile treatment lab with rapid tests in SW New Mexico
- Compare throw-way vs. regenerable media
- Compare coagulation approaches in hi Fe-Mn waters
- Test in very small communities
- Tests on Navajo lands

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Summary I

- **Pilot Test Demonstration Objectives**
  - **Generate cost/performance data for innovative technologies selected through Vendor Forum, WERC contest or AwwaRF bench scale research program**
  - **Provide methods to reduce Arsenic for selected community**
  - **Look for ways to improve other aspects of water quality where possible**

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Summary II

- **Site Selection**
  - **Initial sites in New Mexico (expediency)**
  - **Subsequent sites chosen through State and Tribal contacts and Web site applications**
- **Technology Selection**
  - **Initial technologies chosen from participants in Vendors Forum**
  - **Should later stages include university and government labs?**
- **Pilot and lab studies**
  - **How to design most efficient testing programs that will benefit target communities?**

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Acknowledgements

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