ARSENIC IN THE GROUNDWATERS OF NEW MEXICO: CHALLENGES AND POTENTIAL SOLUTIONS

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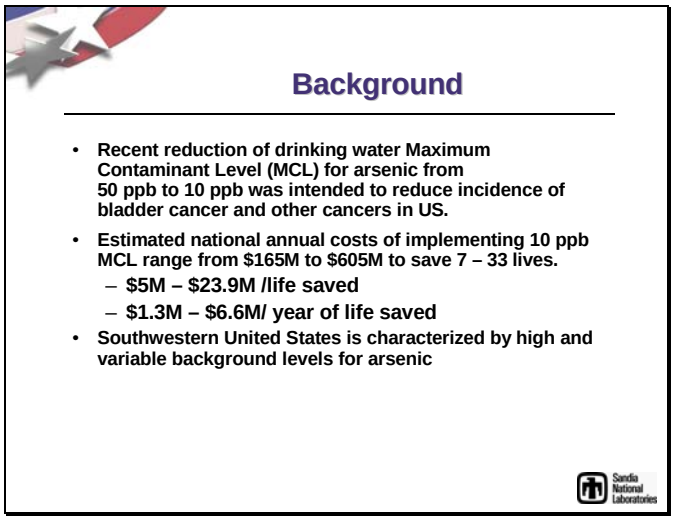
ABSTRACT

On October 31, 2001, the US Environmental Protection Agency (USEPA) finalized a proposed arsenic standard for drinking water that lowered the maximum concentration level (MCL) from 50 parts per billion (ppb) to 10 ppb. The new standard was set to prevent approximately 28 deaths per year from lung cancer and bladder cancer. The risks from arsenic exposure in drinking water and the costs of compliance with the new MCL have particular relevance for areas of New Mexico that are characterized by high and variable background levels for arsenic. Naturally occurring arsenic is associated with aquifers that contain rocks from volcanic sources. It is strongly enriched in silicic volcanics, derived volcanoclastic sediments, hydrothermal systems, and rocks affected by potassium metasomatism, a low-temperature alteration process common in closed hydrographic basins in arid climates.

Some fear that under the new Standard, the costs of water treatment in small communities will be prohibitive and lead to increased reliance on private unregulated water sources. However, adoption of more efficient and safer water treatment approaches, potentially available within 3-5 years, could reduce these costs. The US DOE is funding a multi-year program to develop and verify cost effective methods to remove arsenic from drinking water sources. The Arsenic Water Technology Partnership is a collaborative effort involving the American Water Works Association Research Foundation (AwwaRF), Sandia National Laboratories (SNL), and WERC (Consortium for Environmental Education and Technology Development). The program will accelerate the transition of treatment technologies from bench-scale to field-scale demonstrations.

Sandia National Laboratories will carry out pilot scale tests in which three or four innovative technologies will be compared in side-by-side tests. The test configurations will include demonstrations in existing pump houses, portable skid-mounted units and mobile treatment trailers. Technologies will be chosen to provide a broad cross-section of treatment processes including coagulation/filtration, membranes, and continuous flow (ion exchange, metal oxyhydroxides sorbents). The program will enable water utilities, particularly those serving small, rural communities and Indian tribes, to implement the most cost-effective solutions to their arsenic treatment needs. Pilot communities will be chosen based on a number of criteria including water chemistry criteria (concentrations of competing anions, solids content, redox), choice of distributed vs. point-of-use systems, access and permitting scenarios, local assistance, and socioeconomic factors.



The new drinking water standard for arsenic may be the most costly regulation ever passed.

There is considerable controversy over the health benefit that will result from the standard.

The economic impact on the Southwest will be considerable.

[1] Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the US Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Outline

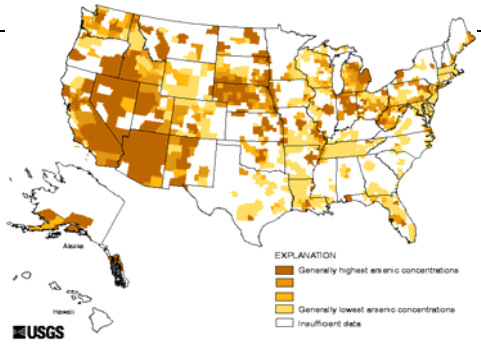
1. Geochemistry and occurrence of arsenic
2. Impact of arsenic MCL in New Mexico
3. Arsenic Treatment Technology Pilot Demonstration Program
4. Examples of sites considered for initial Pilot Tests
5. Evaluation of treatment technologies

Geochemistry of Arsenic

- Sources of arsenic to drinking water
  - leaching of metasomatized and hydrothermally enriched rocks
  - desorption from Fe-oxyhydroxides and secondary minerals
  - sulfide ores (local sources)
- Controls on arsenic concentrations
  - redox controls As(III)/As(V)
  - pH controls sorption - decreases above 8
  - predominantly bound to sediments in surface waters

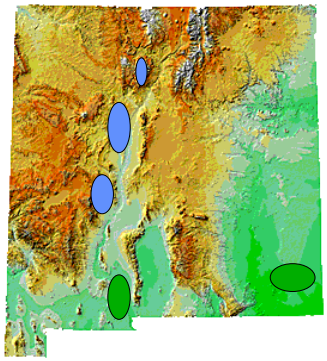
The occurrence of arsenic in drinking water is related both to the source of arsenic and transport in groundwater and surface waters.

As Occurrence in the US



The US Geological Survey has compiled data on arsenic concentrations in tens of thousand of wells across the country. The map summarizes average arsenic concentrations at the county level in the U.S.

High Arsenic in New Mexico's Waters



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

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In New Mexico, high levels of arsenic in groundwater occur along the Rio Grande Rift valley. The listed communities have arsenic concentrations greater than 10 ppb in community water supplies.

Arsenic in New Mexico

- **Local geothermal sources**
  - Leaching of hydrothermally or metasomatically altered rocks
  - Jemez Mtns, Ladron Mtn
    - groundwater range near Socorro: 2- 40 ppb
- **Middle Rio Grande Basin (MRGB)**
  - Range = <1 to>600 ppb, median = 5.3 ppb.
  - higher in NW and central basin due to recharge and desorption (10 - 23 ppb).
  - As concentration increases with depth in many parts of basin

- Source: Bexfield, L., (2001) *Occurrence and sources of arsenic in ground water of the Middle Rio Grande Basin, New Mexico,* MS thesis, New Mexico Tech

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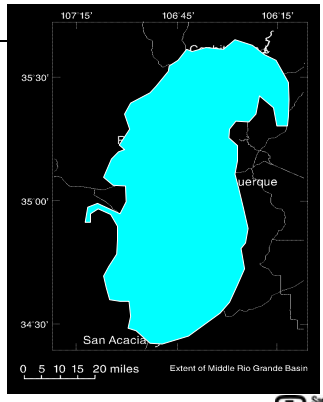
High arsenic concentrations are associated with volcanic, hydrothermal and metasomatic activity in the Jemez and Ladron Mountains. In the Middle Rio Grande Basin, the pattern of arsenic concentration is complex and depends on proximity to the source of arsenic, sorption of arsenic onto iron oxyhydroxides, desorption due to changes in water chemistry, dilution by recharge and mixing with other groundwaters.

Arsenic in the Middle Rio Grand Basin

- Entire population of over 700,000 currently relies on ground water for drinking-water supply
- Almost half of City of Albuquerque drinking-water supply wells would not meet the new standard of 10 ppb.
- Costs for Albuquerque alone to meet the new standard are estimated >150 million dollars



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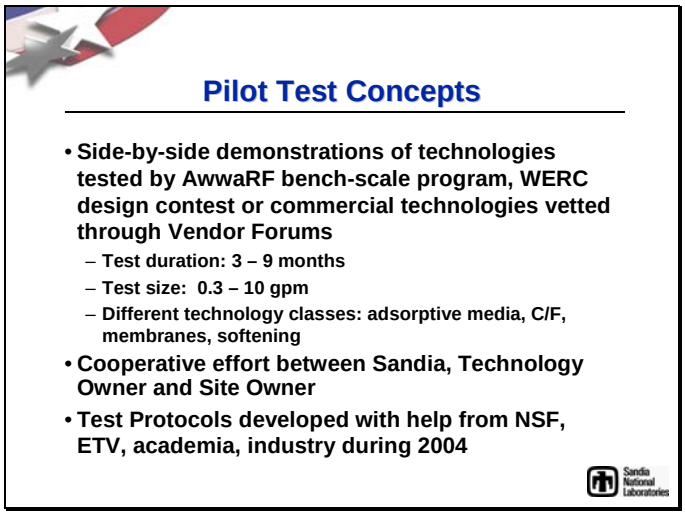
The new arsenic MCL will cause significant increases in water costs for communities in New Mexico. Some communities that have limited treatment capability and expertise will be required to install complex treatment systems for the first time. A recent study at UNM estimated the capital and operating costs for the entire state as well as the monthly increase in water cost per household.

In an effort to reduce the economic impact of the new arsenic MCL, Congress appropriated $7M in FY03 – FY04 to develop and demonstrate more cost-effective methods to reduce arsenic from drinking water. The DOE-funded program will be a partnership between the Awwa Research Foundation, Sandia National Laboratories, and WERC and will use the specialized talents of each organization in achieving the Partnership's objectives.



The objective of the Sandia Arsenic Water Treatment Program (SAWTP) is the field demonstration testing of innovative technologies that have the potential to substantially reduce the costs associated with arsenic removal from drinking water. The scope for this work includes:

1) identification of sites for pilot demonstrations,
2) identification of candidate technologies through Vendor Forums, proof-of-principle laboratory studies including a bench-scale research program managed by the American Water Works Association Research Foundation (AwwaRF) or the WERC design contest, and
3) pilot-scale studies involving side-by-side tests of innovative technologies.

Pilot Test Configurations

- Pump house
- Skid Mount or container
- Mobile unit

The pilot test configuration will depend on the specific conditions at the site such as access, power availability, waste disposal options and existence of permanent structures to house the test.

Initial Activities (FY2003 – 2004)

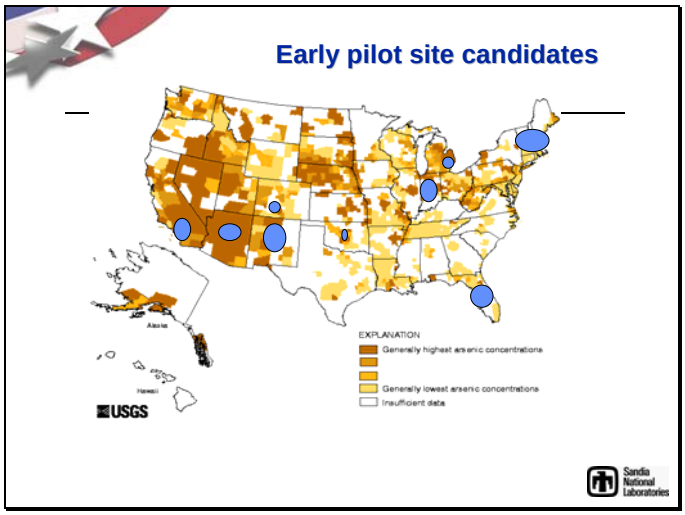
- State-of- the- art Workshop (August 2003)
- Sponsored activities at New Mexico Environ. Health Conference (October 2003)
  - Theme session to introduce program
  - Vendors Forum to evaluate commercial technologies
  - Website: http://www.sandia.gov/water/arsenic.htm
- Evaluate sites in NM, CO, AZ,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

A number of activities were carried out before funding was received from DOE using internal Sandia program development funds and AwwaRF funds.

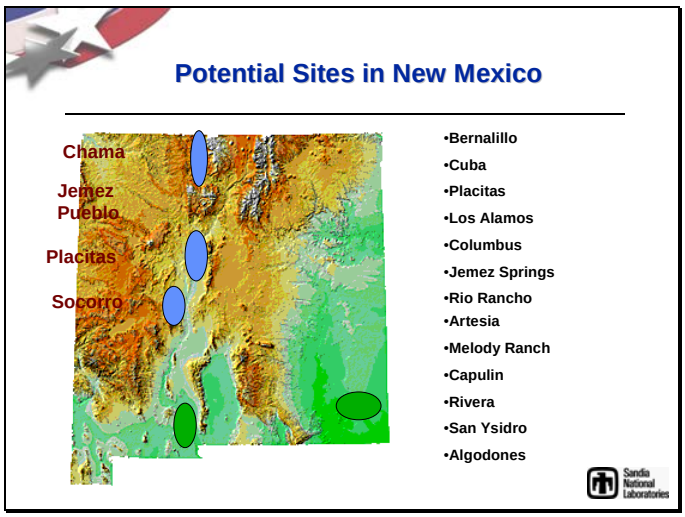
Criteria for Site Selection

- 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
- Good 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

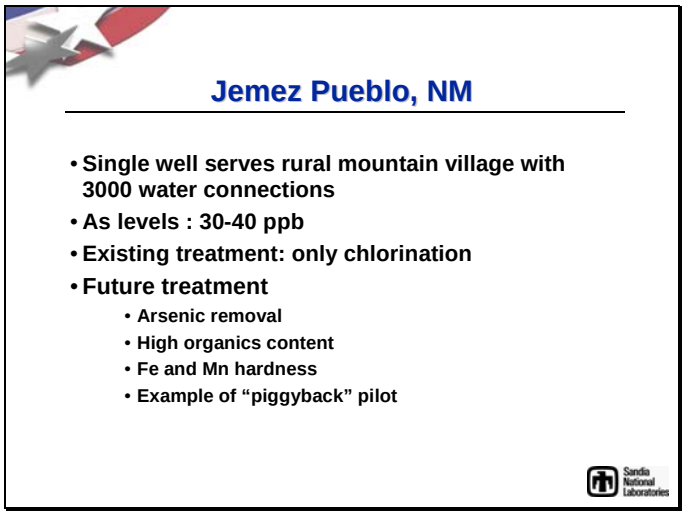
The goal of site selection is identify a suite of sites that exhibit a sufficiently wide range of groundwater chemistries that will allow examination of treatment processes and systems under conditions that are relevant to different geochemical setting throughout the country.



A number of candidate sites have been identified through reviews of groundwater quality data bases, conference proceedings and discussion with state and local officials. These include sites in New Mexico, Arizona, California, Colorado, Oklahoma, Illinois, Michigan, Florida, Massachusetts and New Hampshire.



In New Mexico, discussions have been held with water utility board staff in Chama, Jemez Pueblo, Placitas and Socorro to determine the suitability of those communities for pilot studies. Other communities will be contacted as the program progresses.



Jemez Pueblo provides an opportunity to test technologies that will remove Fe, Mn, As and F.

Soccoro, NM

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

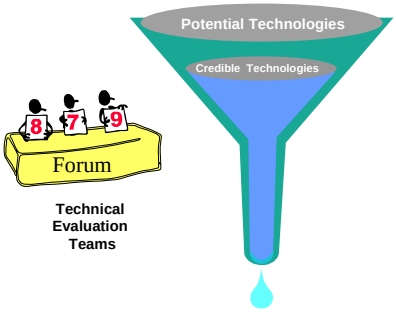
Socorro provides an opportunity to test technologies at higher temperatures.

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

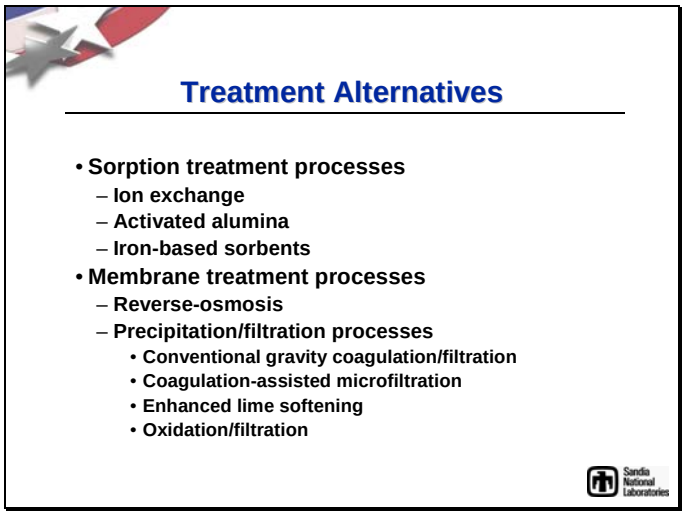
The pilots test will involve cost-sharing including purchases, contracts and in-kind contributions. For example, the vendor may contribute materials and the community water utility (site owner) may take water samples.

Pilot Technology Evaluation Process

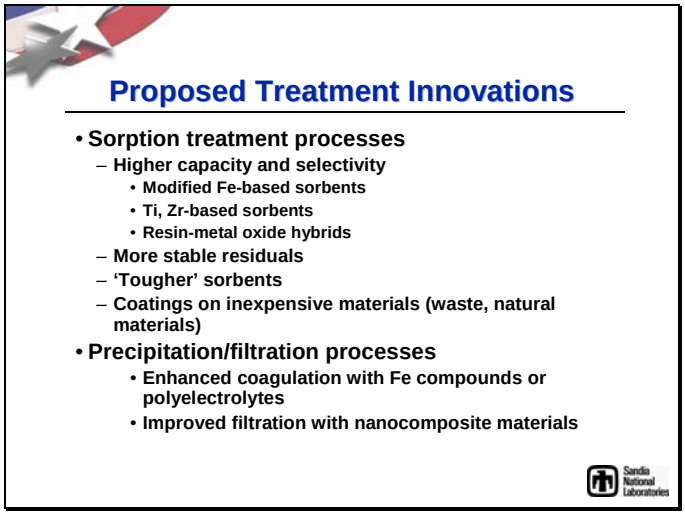


- Performance
- Cost
- Complexity
- Maturity

Candidate technologies for the pilot tests will be reviewed by technical evaluation teams. They will start with as many technologies as possible and then screen out unsuitable ones by considering data from past performance testing, costs, complexity and maturity to obtain a small number of promising technologies for the pilots.

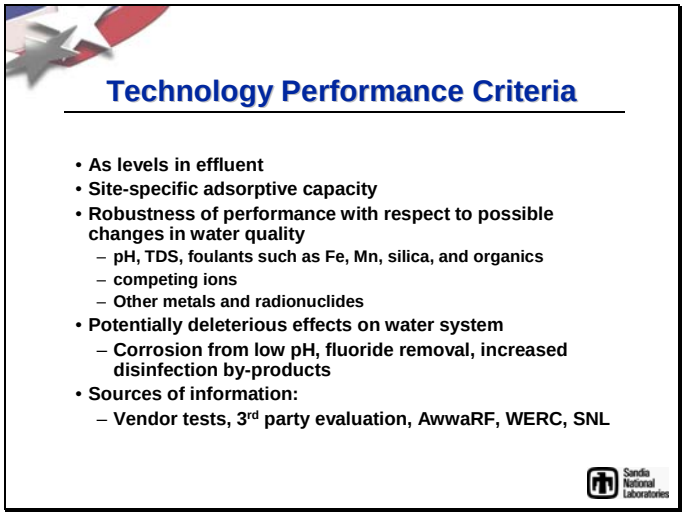


Most of the treatment technologies that will be evaluated can be separated into two broad categories: (1) sorption processes that use fixed bed adsorbents and (2) processes using membranes. The latter include processes that involve formation of a floc or precipitate that contains the arsenic in a reactor followed by separation of the solids from the water by filtration.

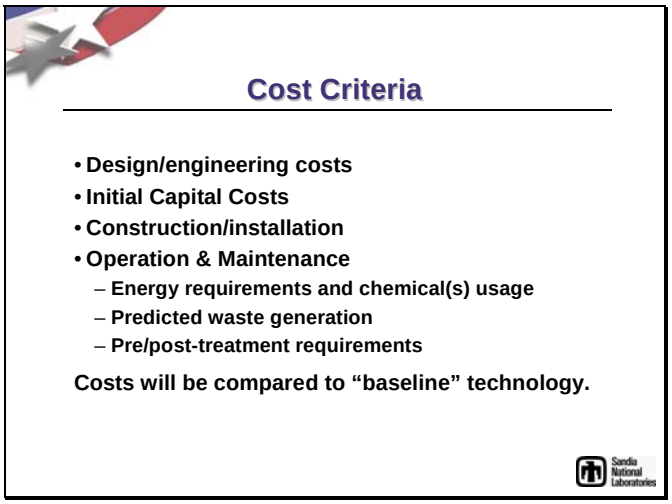


Our review of emerging technologies revealed that proposed innovations include improvements to sorbents or improvements to coagulation/filtration processes. Improvements to sorbents may make them more selective over a wider range of water chemistries, more physically tough to improve hydrologic performance, easier to dispose of when exhausted, and less costly by using cheaper natural materials as a substrate for sorbent coatings.

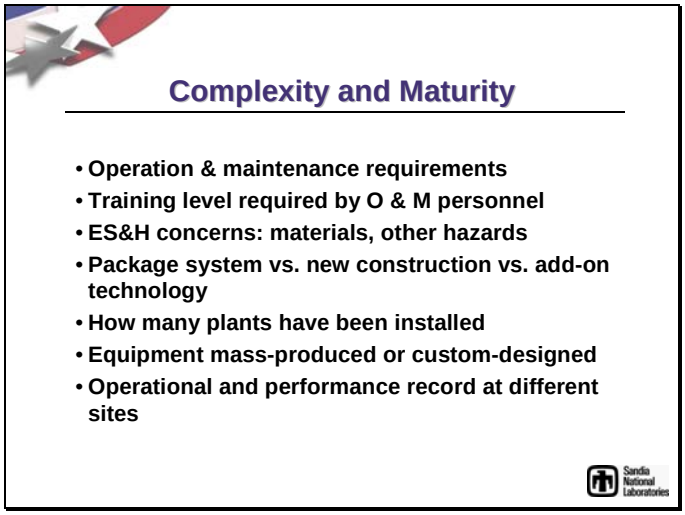
Improved coagulants and filters exhibiting higher surface areas and resistance to fouling can improve processes using membranes.



Candidate technologies for the pilot tests will be screened with respect to expected performance, cost and maturity. Performance is a summary of the technology effectiveness and efficiency as measured in bench scale, pilot, and/or field scale testing by the company or by third party evaluation.

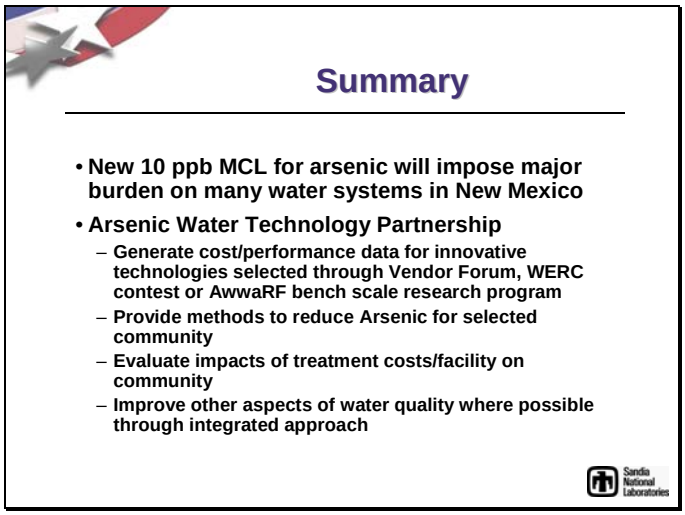


Cost will be measured by comparing a number of cost items to a technology selected as a baseline.



Technologies that are very complex may not be suitable for small rural communities. Technology complexity will determine the operation & maintenance requirements, the level of automation that is possible, and the skill level required by O & M personnel. ES&H concerns include those related to handling of hazardous materials and mechanical safety (such as pressure, electrical, hydraulic, moving parts, etc.) We will also consider if the proposed technology is a packaged system vs. new construction vs. add-on technology to the existing water treatment plant.

Technologies will be chosen for pilot testing only if there is evidence that they are mature enough to be commercialized. The level of maturity of the technology involves consideration of the following: (1) the number and size of the plants that have been installed, (2) the variations in water chemistry that have been successfully treated, (3) whether the equipment is mass-produced or custom designed/fabricated for each installation, (4) the lead-time for treatment system delivery, and (5) ability to scale-up by providing full-scale quantities of material.



The new arsenic MCL will result in modification of many rural water systems that otherwise would not be evaluated. Because of its high profile, the new MCL is spawning a new water treatment industry and infrastructure that has the potential to affect many communities. The Arsenic Water Technology Partnership will complement other programs carried out by the EPA and private industry by evaluating the use of innovative technologies in the removal of arsenic and other improvements to community water systems. Opportunities for improvement of water quality in systems that currently do not comply with other standards would be an added benefit from the new arsenic MCL that has both economic and public health value.