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Summary of Resources Available to Small Water Systems for Meeting the 10 ppb Arsenic Drinking Water Limit

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ABSTRACT

With the lowering of the EPA maximum contaminant level of arsenic from 50 parts per billion (ppb) to 10 ppb, many public water systems in the country and in New Mexico in particular, are faced with making decisions about how to bring their system into compliance. This document provides detail on the options available to the water systems and the steps they need to take to achieve compliance with this regulation. Additionally, this document provides extensive resources and reference information for additional outreach support, financing options, vendors for treatment systems, and media pilot project results.

ACKNOWLEDGMENTS

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.

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ABBREVIATIONS

AA	Activated Alumina
ACEC NM	American Consulting Engineering Council of New Mexico
ANSI	American National Standards Institute
ARCE	Cost Estimating Tool Cost Estimating Tool for Arsenic Removal by Small Drinking Water Facilities
As	Arsenic
AwwaRF	American Water Works Association Research Foundation
CoAsT	Comprehensive Arsenic Tool
DFA	Department of Finance and Administration
DOE	Department of Energy
DS	Desert Sands pilot
EBCV	Empty Bed Contact Volume
EFC	New Mexico Tech Environmental Finance Center
EPA	Environmental Protection Agency
GFH	Granular Ferric Hydroxide
IX	Ion Exchange
LGD	Local Government Division, NM Department of Finance & Administration
MCL	Maximum Contaminant Level
MDWCA	Mutual Domestic Water Consumers Association
MGD	Million Gallons per Day
NM	New Mexico
NMED	New Mexico Environment Department
NSF	National Science Foundation
NMRWA	New Mexico Rural Water Association
O&M	Operation and Maintenance
PE	Professional Engineer
PER	Preliminary Engineering Report
POE	Point of Entry
POU	Point of Use
ppb	parts per billion (µg/L)
ppm	parts per million (mg/L)
RCAC	Rural Community Assistance Corporation
RFP	Request for Proposals
RO	Reverse Osmosis
RR	Rio Rancho pilot
SNL	Sandia National Laboratories
SS	Socorro Site pilot
TCLP	Toxicity Characteristic Leaching Procedure
UNM	University of New Mexico
WERC	A Consortium for Environmental Education and Technology Development
WET	Waste Extraction Test

I. INTRODUCTION

In January of 2006, EPA lowered the maximum contaminant level (MCL) of arsenic from 50 parts per billion (ppb) to 10 ppb. Because of this reduction, many water systems in New Mexico faced a decision regarding how to reduce the arsenic level in their drinking water. To assist these systems, there are a wide range of programs available that include technical assistance, funding, and research. The technical assistance efforts include the Rural Arsenic Outreach Program, funded by the Department of Energy (DOE), which includes Sandia National Laboratory, the Environmental Finance Center at New Mexico Tech, and the University of New Mexico. This program was set up to address the specific needs of smaller communities who will have the greatest difficulties in complying with the standard. Additional technical assistance resources, in addition to the Rural Arsenic Outreach Program, are listed in Table A (page 27). There are a variety of funding sources for arsenic treatment and these are discussed in greater detail in Table E (page 35). Research is being conducted by EPA, Sandia National labs and others to develop more effective solutions and to test existing technologies under New Mexico-specific conditions.

The Rural Arsenic Outreach Program began its activities in the summer of 2005. The program was designed to assist communities in the initial stages of determining their potential needs for arsenic compliance and providing analytical services to help in defining the extent of the problem and possible solutions. The program was designed to last approximately a year to a year and a half, and the program is expected to be completed in the winter of 2007. This document was developed to assist systems in continuing to address their needs past the end of the program. The objective of this document is to provide a printed summary of resources that target the particular needs of the smallest water systems impacted by the new arsenic regulations (generally less than 500 connections). This document emphasizes treatment systems and technologies that are currently commercially available and could be purchased (or designed for) immediately. The document is also based on the existing knowledge of arsenic treatment technologies.

Some of the information resources presented in this document are web sites, so internet access will be necessary to take advantage of all of the resources. Internet services can be obtained at most public libraries if the reader does not have internet access at the water system or their home.

It is not possible to state with certainty how many water systems in New Mexico are potentially impacted by the arsenic standard. This determination can not be made until after the New Mexico Environment Department (NMED) completes its compliance testing in 2006 and 2007. However, it is estimated that the number is approximately 90 systems. Of this number, approximately half of the systems have arsenic in the range of 10 to 15 ppb. Figure 1 shows a graph of affected population and arsenic levels.

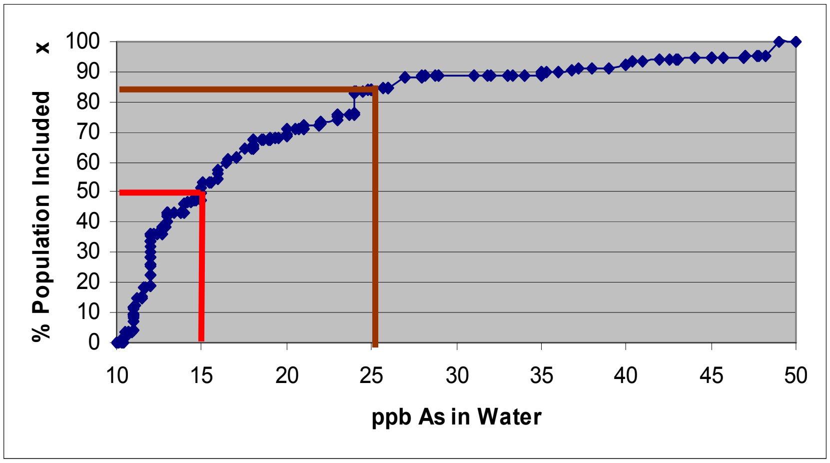

Fig. 1: Arsenic Level and Affected Population

Figure 1 shows that slightly less than half the affected population has arsenic levels between 10 and 15 ppb (thick red lines), while almost 85% of the affected population has arsenic levels between 10 and 25 ppb (thin brown lines). (Compiled from data supplied by the NMED.)

In general, communities faced with complying with the new Arsenic standard have three major categories of options to consider: non-treatment options, collaborating with a neighboring system, and treating the raw water to remove arsenic. Each of these categories has several options available to systems which are presented in Table 1. It should be noted that the options presented for treatment of arsenic are not the only methods available. However, after extensive testing, research, and consideration of options, the general consensus is that the 5 treatment options presented are the most applicable options for small communities faced with arsenic removal. If the reader is interested in the other treatment options available, there are several sources of information. One is EPA's document titled, "Technologies, and Costs for Removal of Arsenic in Drinking Water," from December 2000. Another source of information is the EPA website http://www.arsenictradeshow.org/ that includes detailed (though occasionally dated) discussions of various aspects of this topic.

Table 1 includes information regarding the various options for communities in addressing the arsenic issue and considerations related to each option.

Table 1. Community options for addressing arsenic compliance.

Category	Specific Options	Description	Considerations
Non Treatment Options	Blending Source Water	A low arsenic (As) well is blended with a higher As well	• Requires a low level As well • Blending must occur prior to any customer receiving water • Will not work if the high Arsenic well is above 20 ppb (generally should be less than 15 ppb • May require extensive piping or water storage modifications
	New Source	Either a new well with As less than 10 ppb must be found or a surface water source must be obtained	• May be difficult to find a well with low As • May be limited to no surface water sources • Purchase, transfer, or modifications may be required to existing water rights permit • Surface water sources will require additional treatment
	Abandon High Arsenic Source	Well with high As is shut down and only low As well(s) are used	• Requires existing well with low As • Well(s) with low As must be capable of meeting all community needs
Collaborating With A Neighboring System	Physically interconnect with a new system to purchase water for full supply or blending purposes	Additional water supply is obtained from a neighboring system to meet all the needs of the system or to blend with the system's water supply to meet standard. Management of the two systems remains separate.	• Must be a system nearby with water below the arsenic standard • System must have adequate water supplies and rights to serve the existing customers • If blending, system supplying water must have water with very low As levels and the water being blended with should not have As levels over about 15 ppb
	Physically interconnect with system and dissolve the current system's management	Another water system supplies all the needs of the community and takes over the water system operation and delivery system	• Must be a water system nearby with water below the arsenic standard • System must be willing to take over the operations and management of the system with high arsenic • System must have sufficient water supply and rights to meet the needs of the high arsenic system

Table 1. Community options for addressing arsenic compliance.

Category	Specific Options	Description	Considerations
Treatment Options	Reverse Osmosis (RO)	Removes dissolved contaminants by using high pressure to force water through a membrane	• High energy usage; therefore, high costs • Rejects from about 10 to 40% of the feed water, creating a lot of waste • Can be used to remove multiple contaminants if the system needs to treat for more than just arsenic • Pretreatment may be required prior to RO
	Ion Exchange (IX)	Feed water is passed through a solid resin in which ions from the resin are exchanged with arsenic ions in the water	• Other constituents in the water, particularly sulfate, interfere with the removal of arsenic (NM groundwaters often contain high concentrations of sulfates) • Suspended solids must be removed prior to IX • Regeneration of IX resins creates chemical handling and liquid waste disposal issues • Frequent regeneration may be necessary
	Adsorption	Feed water is passed through sorption media (most commonly iron-based) and the arsenic sorbs (or sticks) to the media	• Process may require pH adjustment (process does not work or work well at pHs above 8) • Pre-oxidation of arsenic through chlorination may be required • Other constituents in the water may compete with arsenic for sorption sites, reducing effectiveness of arsenic removal • Process relatively simple to operate • Media replacement can be expensive and may be frequent in certain conditions
	Coagulation/ Filtration	Iron is added to the feed water and mixed to create an iron/arsenic floc that can be filtered out of the water. The filters are then backwashed to remove the solids and the solids are dewatered and disposed of	• Process requires chemical addition, solids handling and disposal • Process less susceptible to interfering or competing constituents in the water • May require substantial operation and maintenance, at least initially, until system is adjusted properly • Requires a relatively large enclosed area for all equipment
	Point of Use/Point of Entry (POU/POE)	Can be either RO, IX, or adsorption type system. Treatment is NOT at the source. Small treatment systems are located throughout the distribution system at sources of drinking water or at the entry to a house or building	• Based on NMED guidelines, can only be used with very small systems (generally less than 100 connections) • All users must agree to POU/POE • POU/POE device operation and maintenance is the responsibility of the water system and must have a failure indicator • May be a good option for non-community systems with few connections

A water system should thoroughly consider all of the possibilities for compliance before deciding how to proceed. There are several questions a community should consider in determining what option(s) they wish to consider:

1. Will the chosen option continuously and reliably meet the new standard of 10 ppb?
2. Are there options that are not feasible for my community (e.g., if there is no water source with arsenic less than 10 ppb, the options of blending or drilling a new well are not feasible.)
3. Which options remain after removing those that are infeasible?
4. How much will these options cost the community to purchase?
5. How much is the initial installation cost?
6. How much will these options cost in annual operation and maintenance?
7. How complicated are the various options in terms of operation and maintenance?
8. Will any of the options require a higher level of operator certification?
9. What is the energy requirement of the various options?

Choosing the correct option requires a community to think about the long-term operation and maintenance considerations as well as all of the larger ramifications of the various options to ensure that the best decision is made for the community. Additional information regarding alternatives analysis/evaluation is presented in the next section.

II. STEPS TO COMPLIANCE

In New Mexico (excluding tribal water systems), drinking water systems are regulated by the New Mexico Environment Department under authority granted by the EPA. There are three possible paths towards working with the New Mexico Environment Department (NMED) to achieve compliance. The first possibility is for a system to choose to work proactively on a solution (either non-treatment, collaboration with another system, or treatment of the source water.) The second path is for the system to apply for and receive an arsenic exemption from NMED that provides for additional time to achieve compliance with the standard. This option does not eliminate the need for an arsenic solution, it merely provides for additional time to achieve the intended actions. All exemptions must be received and approved by NMED prior to the time when NMED collects the required arsenic compliance samples (anticipated around late fall/early winter of 2007). The third path is for the system to enter into a compliance agreement with NMED after compliance sampling is completed and a violation notice received. This approach will require the system to work with NMED to establish a schedule and a plan of action for meeting compliance.

No matter which of these paths a system takes, there are many steps in the process from first identifying the arsenic problem through selection of an option, to design, funding, and construction of required capital improvements. The steps in the process are outlined in Figure 2. Additional information regarding general project planning can be found in the document "An Introductory Guide to Developing Water and Wastewater Projects in Small Communities" that can be obtained from the following website: http://www.rcac.org/pubs/Misc/usfsmanual.pdf.

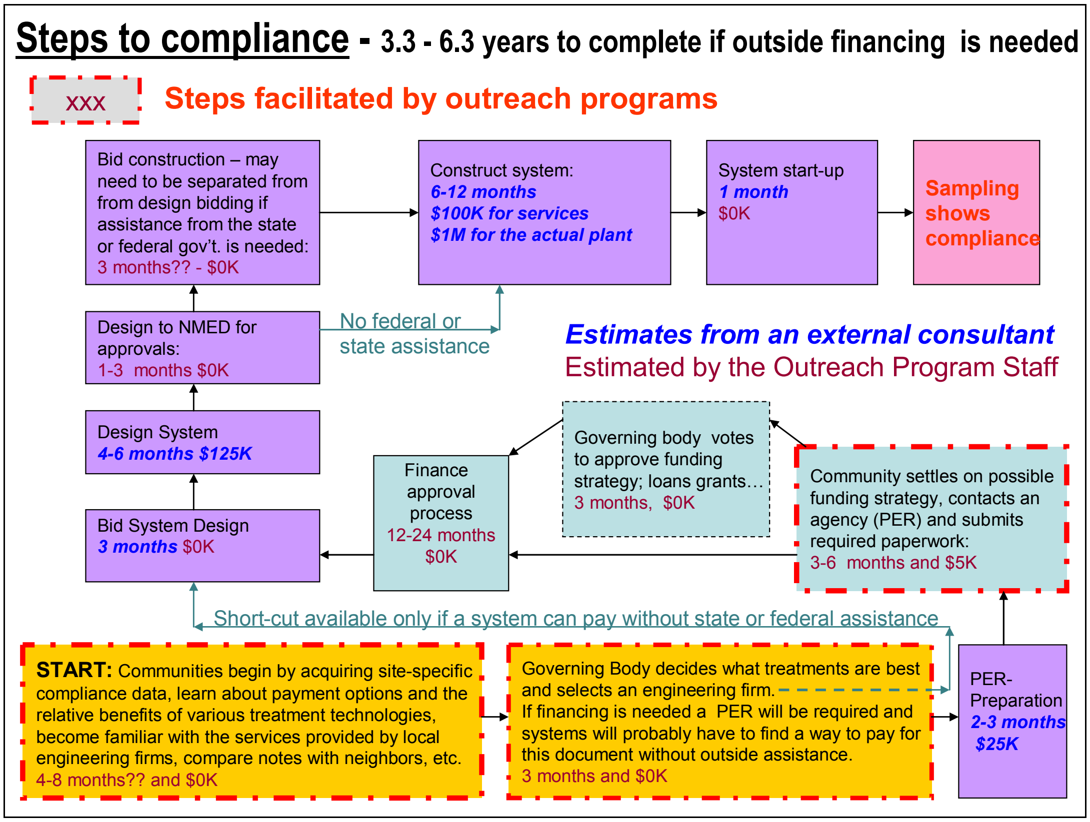

Fig.2: Generalized Flow Diagram for the Steps Required for Compliance with the EPA Arsenic Rule

Figure 2 shows a diagram of the steps in the process for NM communities to achieve compliance with the 10 ppb As MCL. Costs assume a community of (very) roughly 1500 people and would be slightly less for the smaller systems that are the focus of this document. However, allotted times to complete the various tasks would probably be similar.

Once a system determines that it needs to take action to eliminate an arsenic compliance issue, one of the first steps in the process is generally to develop a Preliminary Engineering Report (PER). The PER is a preliminary design (not a blue print detailed enough for construction purposes) that describes the technical needs that the water system must satisfy to comply with the drinking water regulations.

It is critically important that the PER explore all categories of options available to the system. The PER should examine all of the categories of options, including: non-treatment options, potential for collaboration with a neighboring system(s), and treatment options. The PER should very carefully consider all of the issues associated with each of these options including the feasibility of each and the potential capital cost (the cost to purchase and build the system) and operation and maintenance costs (the costs to operate the system once it is built.) A PER must be prepared by a licensed engineer and will typically identify: (1) options examined, (2) a specific treatment technology to be used, (3) the general configuration of the new water system, including location of new treatment facilities, new wells, planning for better pumping facilities and design of hydraulic systems (pipes, pumps, valves & controls) needed to connect the wells, treatment facility, and distribution system and (4) estimated costs of the new system. The person(s) completing the PER should thoroughly discuss all options considered with the water system owners, managers, operators, and customers to determine the best option. An engineering firm will have to be engaged in the completion of the PER to obtain the necessary expertise to complete the plan and to meet the requirements of the state. *By law, the NMED must pre-approve any significant change made to a public water system so this step is not optional*. Once the PER is submitted and approved, the water utility is ready to proceed with finding financing for the project and then actually procuring the facility.

It is very important for the water system personnel to select a well-qualified engineer to complete the PER. In this case, select an engineering firm who is familiar with NMED and EPA regulations, a firm who is qualified to design water systems, and a firm who has experience with arsenic treatment. In selecting an engineer, the system will need to prepare a Request for Proposals (RFP) that specifically states that the system is looking for assistance in preparing an PER. Assistance in the preparation of the RFP may be obtained from the American Consulting Engineers Council of New Mexico or from one of the assistance providers included in Table A (page 27).

In addition, some funding agencies may be able to provide assistance with this process of developing an RFP and preparing a PER. The Guidebook of Infrastructure Financing, which is available from NMED's Construction Programs Bureau at the following website: http://www.nmenv.state.nm.us/cpb/cpbtop.html#GUIDEBOOK contains very useful information regarding PERs and resources to assist in the completion of one. A PER is commonly used to assist the system in obtaining funding for a project. The PER will provide a cost estimate that helps the system know how much money is needed.

Once the PER is completed, there will be an additional step of selecting an engineer for the detailed design of the required project. The detailed design phase will only include the selected alternative from the PER. The detailed design will include a set of plans and specifications that will describe, in detail, all of the needed materials, supplies, and equipment for completion of the project and a estimate of construction costs. The detailed design will be used to construct the project.

For either the PER or the detailed design phase of work, an engineer will need to be selected to complete the work, as described above. Because the expenditure on water treatment may be extremely large, it is extremely important to do a good job in selecting the engineer who will do the work. It is important to make sure the engineer is well-qualified and will be able to complete the work in the time frame required. As stated above, the first step is the Request for Proposals that will clearly state what services the system is seeking. Once the proposals, in response to the RFP, are received by the water system, the next step is to rank the proposals and determine which ones are the best. Once the list of the best engineers has been chosen, it is a good idea to set up face to face interviews with the engineers prior to making a final selection. General questions that might be asked during the interview process are given in Appendix A and at: http://www.arsenictradeshow.org/Prepare.aspx (note particularly the option toward the bottom of the page titled, "Questions for Selecting an Engineering Firm.") In addition, some general information regarding selecting engineers is provided below

- Obtain a summary of the technical qualifications of the firm's design engineers - what degrees (B.S. or M.S), what college or university they attended, whether they are licensed to practice in New Mexico and if so for how many years. A water system should identify an engineer with a degree from an accredited program, at least 10 years of experience in New Mexico or the southwest and a registered Professional Engineer (P.E.).

- What is the engineer's area of specialization? Preference would normally be given to an environmental engineer in contrast to a general civil engineer.

- For work on a water treatment system the water system should determine if the engineer has ever designed a water treatment system before. Most communities use wells as their source of supply, so New Mexico has few water treatment plants, or engineers who have designed them. Next determine their experience with arsenic. Have they ever designed an arsenic treatment plant before?

- Ask what experience the engineer has had working with the NMED Drinking Water Bureau. Also, what experience have they had assisting utilities in obtaining financing or identifying financing alternatives for their projects?

- Finally, obtain the names of at least 3 references of utility managers for water systems they have worked for, *and then call them*. You might also call the NMED Drinking Water Bureau and ask if they have had experience working with the engineer. This is VERY important because this is the organization who must approve your treatment plant. It is important to be sure that they recognize the competence of the engineer who will do the design work for the utility.

The main thing you want to know is that the firm and its engineers are experienced and competent so you will need to get as much information from them, from their references, or any other reputable source to confirm their qualifications and experience.

The problem may not be what questions to ask, but rather, interpreting the answers. Sandia's outreach program will be available to help with such problems through early 2007, after which no further funding is anticipated. However, several New Mexico organizations have long-term charters to provide outreach services, though in most cases dealing with arsenic-related matters is only a small part of their overall business. These organizations are listed below with more detail found in Table A (page 27).

- WERC: A Consortium for Environmental Education and Technology Development
- New Mexico Rural Water Association (NMRWA)
- Rural Community Assistance Corporation (RCAC)

- New Mexico Tech Environmental Finance Center (EFC)
- Arsenic Water Technology Partnership
- New Mexico Environment Department (NMED)
- American Consulting Engineering Council of New Mexico (ACEC NM)

Table B (page 29) contains a list of engineering firms that have interacted with the NMED in the past (or at least these are some firms which are familiar with the NMED processes for upgrading water systems). Several caveats are noteworthy: (1) no government–sponsored agency can endorse any particular business *and the fact that a firm's name appears in Table B here* *__does not constitute__* *such an endorsement*; (2) such lists become dated from the minute they are compiled so referring to the yellow pages ("engineers, civil & consulting"), or contacting media vendors directly (particularly relative to installing off-the-shelf "turn-key" systems) may identify other workable options; and (3) the fact that firms have interacted with the NMED on water projects generally does not mean they have experience in installing arsenic treatment systems. In fact, outside of the EPA pilot projects, few full-scale As-recovery systems have actually been installed in New Mexico, though some of the larger firms may have experience in other states. None the less, the list is supplied to provide affected water systems with a place to start when considering the purchase of engineering services.

III. TREATMENT TECHNOLOGIES FOR SMALL WATER SYSTEMS

As stated in previous sections, communities should investigate all options available to them for compliance with the arsenic standard. In some cases, these may be non-treatment options, such as blending or new sources. These non-treatment options would involve standard engineering and construction practices, so no further discussion is warranted for these options. This section focuses on those communities that will be required to treat the source water to remove arsenic.

For small rural New Mexico water utilities, it is likely that the most applicable treatment technologies will be those based on sorption by metal oxides. The most common sorption materials are based on iron oxide (or hydroxide) – which is similar to rust. Many vendors sell proprietary forms of this material for treating arsenic-contaminated waters. Alumina, zirconia and titanium dioxide are also able to accomplish this removal and there are commercial vendors for these options, though they are less numerous than the iron based media vendors. The process is very simple. Two examples of arsenic adsorption flow diagrams are presented in Figure 3 and a photo of a small unit is presented in Figure 4.

A typical treatment plant set-up for an adsorption system involves obtaining the oxides (or hydroxides) in a granular form from a vendor and then loading it into columns (e.g. a pipe with filters at either end to prevent the media from being swept away) through which the contaminated groundwater is then pumped. Unless there are mechanical problems with piping or pumps the process operates with little human intervention, though generally the water needs to be pre-oxidized if the arsenic is not already in As(V) form. The sorption media must be replaced when it is exhausted, which incurs a cost for new media and a cost for disposal of the spent media.

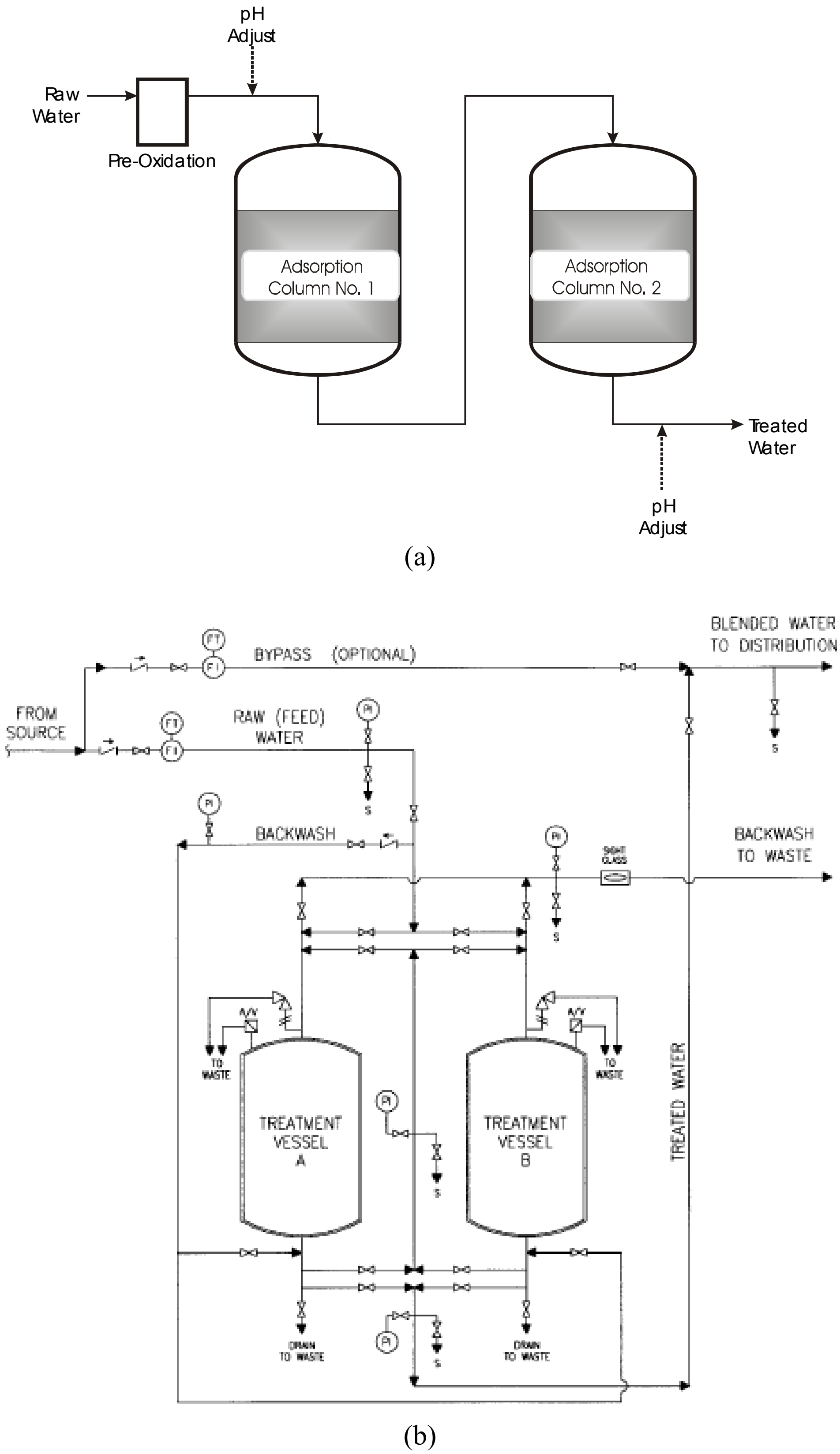

Figure 3 (a,b). Two flow diagrams for an arsenic adsorption process.

Figure 4. Arsenic adsorption treatment plant at Desert Sands, NM.

There are basically two approaches a community can take in procuring a treatment process they can contract for installation of a "turn-key" system which has previously been designed to deliver a particular flow (or range of flows), or they can contract with an engineering firm to specifically design a custom system. The distinction is somewhat artificial, however, as a custom design may, in fact, be nothing more than a grouping together of several turnkey modular units to deliver the desired flow. In either case, the NMED will require plans and specifications to be submitted for any additions or alterations to the water system and this submission will require a professional engineer.

To gain some perspective on what "small" systems actually look like the reader is encouraged to access the design document for the EPA pilot tests and then refer to the photographs in Appendix A: (Wang, et al., EPA/600/R-05/001) available at:

http://www.epa.gov/ORD/NRMRL/pubs/600r05001/600r05001a.htm).

By comparing these pictures with the design flow rates (Table 1-1 of the same document) a utility operator can judge what sort of a physical plant may be needed to satisfy his/her specific needs.

A summary of arsenic treatment system vendors has been provided to assist operators in their research for the right treatment system for their community. The summary can be found in Table C (page 30) and provides the vendor's name and web site and briefly describes the nature of the media being provided and attempts to identify which vendors actually sell complete water treatment systems rather than just the media. Two abbreviations, POE (point of entry) and POU (point of use) appear in Table C (page 30). These terms refer to very small systems that traditionally are directed at servicing a single household or a single water tap, such as a kitchen sink, a water fountain, or a beverage station in a commercial facility. These POU and POE systems are not applicable to larger water systems, but may be applicable to very small systems or to non-community systems that have only a few drinking water stations (water fountains, break rooms, kitchens) in their facilities.

It is important to stress that Table C (page 30) reflects a snapshot in time of available services as of late 2006. The Outreach Program tried to obtain as much information as possible, but because the practice of arsenic treatment on a large scale is relatively new and the market is in flux, some materials/vendors may have been overlooked (please, accept our apologies). In addition, there is no way to predict what new or revised technologies may come on the market in the future. Thus, to obtain additional information beyond what is presented here, the reader is encouraged to go on the internet and search for additional information using search term combinations such as: "Small System Arsenic Treatment Technologies," "Arsenic Removal from Water Systems," "Arsenic Treatment Turnkey", "Arsenic Treatment POE" "Arsenic Treatment point of entry", "Arsenic Treatment POU" "Arsenic Treatment point of use". Updated information may also become available in the EPA and Arsenic Partnership websites referred to above. Finally, it should also be pointed out that if a system is designed for one media, and another is later substituted, that change constitutes a "significant modification" according to the NMED and, hence, would require NMED approval prior to implementing the change.

Information on coagulation-filtration technologies (relatively larger systems) and reverse osmosis systems (very small water needs), plus additional performance and information on sorptive media, can be found at the Arsenic Water Technology Partnership site: http://www.sandia.gov/water/evaluation.htm - note particularly Tables 1-4 and other hot-links at the bottom of the web page.

System operators can directly contact vendors (see Table C on page 30 for example) and request quotes, and are encouraged to do so. However, several web based cost estimation tools (summarized in Table D on page 34) are available at: http://wercstation.nmsu.edu:8080/arsenic/Tabs.dsb (and then click costs tab), and the EPA has a handbook available that can also help small systems estimate costs. Note that construction and energy costs may be several years out of date and that all the cost estimation tools have limitations with regard to how they treat water chemistry and how much of the capital improvement package, debt service, etc. is also actually included. In spite of this, using a few of these tools before contacting an engineering firm will help define what kinds of information a community must assemble to make such interchanges fruitful. For sorption-based treatment technologies it is also generally true that the cost of replacing the media is less than half of the overall operating expense. Consequently, if the idea is to just get a ballpark estimate of the cost, the fact that some aspects of water chemistry are not well represented in a particular model is probably less of a drawback than would seem initially.

As an example, for the E33 media at the Socorro Springs site, the 20-year amortized cost estimates (including building, arsenic removal equipment, and typical Operations & Maintenance (O&M)) ranged from $0.85-$1.32/1000 gallons for a 20-yr period. The annual O&M cost ranged from $0.63-$1.20/1000 gallons. These estimates were performed using the ARCE model with a 0.35 MGD design with 2-5 minute empty bed contact times. This estimate is provided in more detail in the Socorro Summary report (Arsenic Pilot Plant Operation and Results- Socorro Springs, New Mexico-Phase 1, SANDXXXX.doc), which will be posted at http://www.sandia.gov/water/pilot-demos.htm.

IV. MEDIA PERFORMANCE

For most sorption-based treatment systems, the media costs are a significant (though not necessarily dominant) factor in the overall cost. Moreover, not all media will perform the same. Consequently, the following discussion is another "snapshot in time" that summarizes what we currently know about the relative performance of media in New Mexico groundwaters. Unfortunately, no single comprehensive database addresses this question so information had to be assembled for multiple sources, including: (1) the EPA's full scale pilot testing of arsenic treatment facilities across the United States (two in NM); (2) individual vendors demonstrations at a number of localities, and (3) research programs, ranging from experimental laboratory studies to medium-scale pilot demonstrations performed by various other educational and governmental institutions outside of the EPA. In New Mexico, the lead in experimental studies has been taken by the various state universities (notably at UNM in Albuquerque), while a comprehensive DOE-sponsored pilot test approach is being carried out jointly by the Arsenic Water Technology Partnership consisting of Sandia National Laboratories (fielding pilot tests), WERC (cost modeling) and AwwaRF (technology development and laboratory scale testing). The information produced from this partnership is still being gathered and assembled.

The metric used in judging media performance is a variable known as empty bed contact volumes (EBCV), which is simply the number of column volumes which can be treated by a column loaded with a particular media before the water coming out exceeds the EPA drinking water limit. Clearly determining the EBCV has a lot to do with the specifics of how a test is run, as well as the actual feed water used in that particular experiment. Thus, the most meaningful comparisons of relative media performance can be obtained when several tests were run in parallel at the same facility. In contrast, it is very risky, indeed, to compare EBCV values from tests that were run at different times and places, or to use experimental ECBV values to judge actual performance in a full-scale water treatment plant.

Of particular concern in New Mexico is the wide range of potential water chemistries that will have to be treated. In addition to the pH of the water (generally, a lower pH is more desirable), the amounts of dissolved vanadium, phosphorus (likely in shallow wells near agricultural enterprises), and silica can all impact EBCV values. For example if the pH of water is decreased from 8.5 to 7, the media life can be expected to at least double. (As a consequence, for higher pH waters vendors may recommend pH adjustment. This option should receive careful consideration if the vendor or design engineer can make a good case for the economic benefits.) Vanadium, phosphorous, and to a lesser degree silica, all compete with arsenic and can lower the ECBV value of a material.

Some examples of testing to determine EBCV values are presented below. However, the applicability of any of these examples to any particular water system will be based on how similar the tested water chemistry is to the water systems actual water.

Example 1: Bench Scale Laboratory Testing of Media

Method

Test Parameters: These tests employed small several-inch long columns, accelerated flow rates, artificially high initial arsenic concentrations (100 ppb) and three different grain sizes of each media[1].

Test Fluid: Albuquerque tap water spiked to 100 ppb As and 10 mM $NaHCO_3$ buffer.

Media Evaluated:
- Kinetico Alcan® FS-50 iron-coated activated alumina (AA)
- US Filter® Granular Ferric Hydroxide (GFH)
- Severn Trent® BayOxide iron-based media (SORB E-33)
- Developmental iron-based media from Sandia National Labs (SANS)

Results

Results for the bench scale testing can be found in Table 2 below. The results for activated alumina were not included in this table due to poor performance. This result is typical for most NM groundwaters because the pH is generally too high for the activated alumina to work effectively without having some provision for pH adjustment. SANS presented the best data set, but is not currently commercially available and therefore, is not currently available for a water system trying to meet the current EPA time lines. The performance of SORB-E33 is only marginally better than that for GFH so the less expensive media would be preferred presuming that the cost of obtaining and operating the treatment plant was similar in both cases.

Table 2: EBCV to breakthrough for three media tested in bench scale laboratory experiments. (AA performance was so poor that comprehensive testing was not completed)

Grain size - mesh	Empty Bed Contact Volume (EBCV) GFH	SORB E-33	SANS
28x48	15,000	22,000	25,000
48x100	25,000	18,000	29,000
100x200	20,000	27,000	46,000

[1] Aragon, A.R. (2004) Development of a Rapid Small-Scale Column Testing Procedure for the Evaluation of Arsenic Adsorption Media, Ph.D Engineering Thesis, University of New Mexico, 144 pages.

Example 2: Arsenic Partnership Pilot Demonstration Project Results

Method

Test Parameters: These tests involve multiple media types in columns 3-inches in diameter and 20-50 inches in length. The Socorro site represents normal water chemistry (Appendix B) so these results probably give a general idea of relative media performance in many New Mexico groundwaters.

Test Fluid: Socorro site water, arsenic concentration = 42 ppb

Media Evaluated:
- Engelhard ARM-200 iron-based media
- Hydroglobe Metsorb titania-based media (TiO_2)
- Purolite ArsenX iron-loaded resin
- MEI Isolux zirconia-based media (ZrO_2)
- AdEdge AD-33 iron-based media

Results

Only Phase 1 results for the Socorro site are presently available and can be found below in Table 3. For a comparative look at the Pilot Demonstration Results, you can find a table comparing Socorro, Rio Rancho and Desert Sands media performance in Appendix B. To stay apprised of the most current research results access: http://www.sandia.gov/water/arsenic.htm and then select "Pilot Demonstrations."

Of the materials tested it appears that the ARM-200 and Metsorb products performed poorly, while the others were close enough that other factors (capital and miscellaneous operating costs) would be of significance in choosing between media. It is noteworthy that these results are just the first product of a much larger testing program (see Appendix B for planned and in progress testing).

Table 3: Relative performance of media in Socorro groundwater (from Aragon, M., et al., 2006: http://www.sandia.gov/water/docs/SAND2006-0372C.pdf)

Manufacturer	Media	Composition	EBCV- Socorro water
Engelhard	*ARM-200*	FeOOH-based	9,000
Hydroglobe	*Metsorb*	TiO2-based	13,000
Purolite	*ArsenX*	Fe-loaded resin	27,000
MEI	*Isolux*	ZrO_2-based	32,000
AdEdge	*AD-33*	FeOOH-based	26,000 – 2 minutes bed contact time 43,000 – 4 minutes bed contact time 42,000 – 5 minutes bed contact time

Example 3: Results of EPA Pilot Studies

Method

A third source of performance data can be found from the results of the EPA pilot tests (the general EPA arsenic site is: http://www.arsenictradeshow.org/). Data from the EPA program only evaluates a single material at a particular site.

Test Parameters: Test parameters including water quality and media properties are summarized in Appendix C.

Test Fluid: Ground water from the six pilot test sites. Water composition varies.

Media Evaluation:
- ADI Media G2®
- Kinetico Alcan® FS-50 iron-coated activated alumina (AA)
- US Filter® Granular Ferric Hydroxide (GFH)
- Severn Trent® BayOxide iron-based media (SORB E-33)

Results

Six of the Round 1 EPA pilots have made six-month performance reports available at http://www.epa.gov/ORD/NRMRL/arsenic/research.htm#round1. No Round 2 performance reports have been issued but test details are available at: http://www.epa.gov/ORD/NRMRL/arsenic/demo2/index.html . For updated information one may wish to e-mail the technical contact at: sorg.tom@epa.gov. Table 4 summarizes the currently available information regarding performance of various media in the EPA pilot studies.

Table 4: Six-month EPA Pilot Program Test Results (on line access at: http://clu-in.org/contaminantfocus/default.focus/sec/arsenic/cat/Treatment_Technologies/)

Site	Media /Technology Tested	As ppb	Estimated EBCV to breakthrough	Reference	Cost / 1000 gallons (includes capital, equipment, O&M)
Rimrock, AZ	E-33 / AdEdge	50-64	Greater than 25,000	http://www.epa.gov/ORD/NRMRL/pubs/600r05159/600r05159.htm	$0.13, $0.09, $1.27
Queen Anne's County Stevensville, MD	E-33 / Severn Trent	17-19	7,400 (AsIII, before Cl_2 was added)	http://www.epa.gov/ORD/NRMRL/pubs/600r06007/600r06007.htm	$0.09, $0.06, $0.40
Brown City Brown City, MI	E-33 / Severn Trent	14	20,000	http://www.epa.gov/ORD/NRMRL/pubs/600r06004/600r06004.htm	$0.06, $0.04, $0.40
Town of Climax Climax, MN	Kinetico Oxidation / Co-Precipitation / Filtration		N/A – not a column-type system	http://www.epa.gov/ORD/NRMRL/pubs/600r06006/600r06006.htm	Not yet available
White Rock Water Co. Bow, NH	G2 / ADI	49	7800	http://www.epa.gov/ORD/NRMRL/pubs/600r06031/600r06031.htm	Not yet available
Rollinsford, NH	E-33 / AdEdge	34-60	15,000	http://www.epa.gov/ORD/NRMRL/pubs/600r05116/600r05116.htm	$0.14, $0.10, $3.25
Desert Sands in Anthony, NM	E-33 / Severn Trent	17-23	Greater than 12,500	http://www.epa.gov/ORD/NRMRL/pubs/600r05079/600r05079.htm	$0.06, $0.04, $0.22

V. OPTIONS FOR PROJECT FINANCING

There are a number of funding sources for financing projects for community drinking water systems in New Mexico. A summary of these sources with contact information is presented in Table E (page 35). This table also gives some information about the eligibility requirements, amount of funding available, and application cycles. However, eligibility, deadlines, and other characteristics of a funding program can change over time, so a community is encouraged to contact the funding agency directly for information about specific programs. For large complex capital projects, a community may need to secure funding from several sources.

In an effort to reduce the time spent and expense that communities incur when applying to multiple agencies for financing, the New Mexico Environment Department/Construction Programs Bureau, the New Mexico Finance Authority, the Department of Finance and Administration/Local Government Division, and USDA Rural Development agreed to use the Uniform Funding Application. The application can be accessed through the Local Government Division/Capital Outlay Unit web site: http://www.state.nm.us/capitalprojects/. The applicant must log on as a user. If the community is a new user, they must first register online by inputting a user name and password. Once the application is completed, saved and submitted to DFA/LGD, it is also submitted to the other funding agencies. Each agency reviews the application and makes recommendations for funding, based on financial eligibility and debt capacity. For more information on the Uniform Funding Application, a community can contact Joy Ansley, Project Manager, DFA/LGD, at (505) 827-4797 or joy.ansley@state.nm.us. Expected turn around times may range from one month to several months.

Each of the funding agencies may have additional application requirements, but they all perform some type of financial analysis to ensure that the applicant has sufficient revenue to repay any loan amount. This financial analysis usually involves reviewing user charge rates and other sources of revenue.

When developing a project, a community should think about the impact the project will have on operations and maintenance. For example, some of the treatment technologies for arsenic removal will require a higher level of certified water operator which will impact funds available for salaries and benefits. Installation of new treatment could also impact the cost of electrical utilities, cost of chemicals, spare parts, and other maintenance activities. There may also be a cost associated with disposal of spent media.

It is important to note that there is no funding available for the cost of operating and maintaining a project. That cost is the responsibility of the community and should be supported from user fees and other system revenues. A community may need to revise their user rate schedule to increase revenues in order to have enough money available for long-term operations as well as loan repayments. There are several sources of technical assistance in conducting a rate analysis. The New Mexico Tech Environmental Finance Center uses a computer program developed by the State of Missouri Natural Resources Department. That program as well as technical assistance is available from the NM EFC.

TABLES

Table A. List of Organizations with Outreach & Support Services Available to Communities

Organization	Outreach Service	Contact Information
WERC: A Consortium for Environmental Education and Technology Development	Cost models, regional workshops, outreach through 2007	Abbas Ghassemi, Executive Director New Mexico State University PO Box 30001, MSC WERC Las Cruces, NM 88003-8001 (505) 646-2357 (505) 646-4149 fax aghassem@nmsu.edu http://engr.nmsu.edu/research_funded_arsenic.htm
New Mexico Rural Water Association (NMRWA)	Circuit riders for small water systems	Matthew Holmes, Executive Director 3413 Carlisle Boulevard NE Albuquerque, NM 87110 (505) 884-1031 www.nmrwa.org
Rural Community Assistance Corporation (RCAC)	Identify potential funding sources	Main Office: 811 St. Michael's Drive, Suite 202 Santa Fe, NM 87505 Phone: 505/983 5074 Fax: 505/983 2338 http://www.rcac.org/ Additional Contacts: Cynthia Griswold Rex 3150 Carlisle Blvd. NE, Suite 208 Albuquerque, NM 87110 (505) 298-4511 crex@rcac.org Olga Morales-Sanchez PO Box 1223 Dona Ana, NM 88032 (505) 382-6992 olgams@rcac.org

Organization	Outreach Service	Contact Information
New Mexico Tech Environmental Finance Center (EFC)	Identify funding options, submitting applications, practical experience in financial and engineering aspects of the problem, experience on Native American lands	Heather G. Himmelberger, P.E., Director 901 University Blvd SE Albuquerque, NM, 87106-4339 (505) 272-7357 Email at: heatherh@efc.nmt.edu http://efc.nmt.edu
Arsenic Water Technology Partnership	Help communities find low-cost arsenic removal solutions	AwwaRF/Sandia National Labs/WERC Abbas Ghassemi, Executive Director New Mexico State University PO Box 30001, MSC WERC Las Cruces, NM 88003-8001 (505) 646-2357 (505) 646-4149 fax aghassem@nmsu.edu https://www.arsenicpartners.org
New Mexico Environment Department	Compliance issues, general regulatory and sampling information	Chuck Thomas, Interim Bureau Chief Drinking Water Bureau 5500 San Antonio Dr, NE Albuquerque, NM 87109 (505) 222-9500 http://www.nmenv.state.nm.us/dwb/dwbtop.html Richard Rose, Bureau Chief Construction Programs Bureau New Mexico Environment Department Harold Runnels Building 1190 St. Francis Drive PO Box 26110 Santa Fe, NM 87502 (505) 827-2806
American Council of Engineering Companies of New Mexico (ACEC NM)	Assist with RFP's	PO Box 3773 Albuquerque, NM 87190-3773 Phone (505) 888- 6161 FAX (505) 830-1670 http://kumo.swcp.com/acecnm/

Table B. Engineering firms with a history of working with NMED.

Engineering Firm	Address	City	State	Zip
ACG Engineering	220 Copper Ave., NW, Suite 650	Albuquerque	NM	87102
ACG Engineering	P.O. Box 93906	Albuquerque	NM	87199-3906
ASCG, Inc.	6501 Americas Parkway, NE, Ste 600	Albuquerque	NM	87110-5372
B & L Enterprises	8 Ridge Road	Placitas	NM	87043
Bohannan Huston	425 S. Telshor Blvd., Suite C-103	Las Cruces	NM	88011-8237
Bohannan Huston Inc.	7500 Jefferson St., NE, Courtyard 1	Albuquerque	NM	87109
Burton Engineers Inc	2900 Vista Grande Dr NW	Albuquerque	NM	87120
Camp Dresser & McKee, Inc.	6000 Uptown Blvd N E	Albuquerque	NM	87110-4162
CDS, Inc	343 Pinon Creek Trail S.E.	Albuquerque	NM	87123
CH2M-Hill	6001 Indian School Rd NE	Albuquerque	NM	87110-4182
C.H. Guernsey & Co.	2501 San Pedro Dr NE	Albuquerque	NM	87110-4131
Cheney-Walters-Echols, Inc.	909 West Apache	Farmington	NM	87401
City of Alamogordo	1376 East Ninth Street	Alamogordo	NM	88310-5938
Consulting Engineers	PO Box 2025	Taos	NM	87571
Cromwell Architects & Engineers	101 S. Spring Street	Little Rock	AR	72201
Dennis Engineering Company	P.O. Box 909 (38 Cactus Road)	Edgewood	NM	87105
Depauli Engineering & Surveying	102 W. Hill Ave	Gallup	NM	87301
Engineers Inc.	1601 S. Camino Del Coronado, Box 826	Tucumcari	NM	88401
Engineers Inc.	202 S. Guadalupe St.	Carlsbad	NM	88220
Engineers Inc.	301 W. College Ave., Suite 1	Silver City	NM	88061
Florentino Engineering	#26 Sunset Blvd.	Edgewood	NM	87015
Ganett Fleming West, Inc.	460 St. Michaels Dr., Suite 460	Santa Fe	NM	87505
Gannett Fleming West, Inc.	2155 Louisiana Blvd., NE, Ste 9000	Albuquerque	NM	87110
Greeley and Hanson, LLC	426 North 44th Street, Suite 400	Phoenix	AZ	85008
Isaacson & Arfman, P.A.	128 Monroe St., NE	Albuquerque	NM	87108
Larkin Group NM, Inc.	8500 Menaul Blvd. NE Ste A-440	Albuquerque	NM	87112
Larry Read & Associates, Inc.	4800 Juan Tabo Blvd NE, Suite C	Albuquerque	NM	87111
Lawrence A. Ortega & Associates	P.O. Box 2025	Taos	NM	87571
Livingston Associates, P.C.	500 10th St., Ste. 300	Alamogordo	NM	88310
Molzen-Corbin & Associates	1155 Commerce Drive, Suite F	Las Cruces	NM	88011
Molzen-Corbin & Associates	2701 Miles Rd. SE	Albuquerque	NM	87111
NM State Parks	1220 S. St. Francis Dr.	Santa Fe	NM	87504
Oden & Associates Inc	PO Box 1976	Moriarty	NM	87035
Parsons	8000 Centre Park Dr., Suite 200	Austin	TX	78754
Parsons Brinckerhoff Quade & Douglas	5801 Osuna Rd., NE Ste 201	Albuquerque	NM	87109
Planning and Development	201 North Nevada Suite B	Roswell	NM	88201
POWER Engineers, Inc.	1295 S. Eagle Flight Way	Boise	ID	83709
Private Consultant	2090 Thomas Drive	Las Cruces	NM	88001
Resource Technology, Inc.	5501 Jefferson NE	Albuquerque	NM	87109
Shaw Engineering	717 White Mt. Drive	Ruidoso	NM	88341
Smith Engineering	6400 Uptown Blvd., NE Suite 500E	Albuquerque	NM	87110
Smith Engineering Company	2201 San Pedro NE, 4 Suite 200	Albuquerque	NM	87110
Smith Engineering Company	P.O. Box 2565	Roswell	NM	88202-2565
Souder Miller & Associates	1201 Parkway Drive	Santa Fe	NM	87507-7258
Souder Miller & Associates	2101 San Juan Blvd.	Farmington	NM	87401-2247
Souder Miller and Associates	11930 Menaul Boulevard NE Suite 105	Albuquerque	NM	87112-2461
Souder Miller and Associates	2101 San Juan Blvd	Farmington	NM	87401
Souder Miller and Associates	401 North Seventeenth Street Suite 4	Las Cruces	NM	88005-8131
Sullivan Design Group, Inc.	227 East Palace Ave., P.O. Box 283	Santa Fe	NM	87504-0283
SV Enterprises	P.O. Box 223	Organ	NM	88052
SW Designs	12 Feather Catcher Road	Santa Fe	NM	87501
Terracon	1630 Hickory Loop, Suite H	Las Cruces	NM	88005
Tetra Tech EM, Inc.	6121 Indian School Rd. NE, Suite 205	Albuquerque	NM	87110
Wilson & Company	4775 Indian School Rd., NE	Albuquerque	NM	87110

Table C: List of arsenic adsorption media and vendors

Media	Company	Web Site or Reference	Small System Available?	Media Composition
Media G2®	ADI Group	http://www.adi.ca/water/arsenic.html	No, 100 gpm + systems	FeOOH bonded to a granular calcined diatomite.
Aqua-Bind™	Apyron Technologies, Inc. (Cascadian)	http://www.apyron.com/	Y, POE POU	Activated Alumina (Metal oxide composite, oxidizer)
KDF® Drinking Water Filters	KDF Fluid Treatment, Inc .	http://www.software-exchange.com/what_s_kdf.html	POU only	Granulated activated carbon plus a pre-filter of FeOOH
AAFS50	Alcan Actiguard AAFS50 = media Kinetico = systems			Activated alumina
ATS adsorption media ARM-200 as ATS A/I	Aquatic Treatment Systems, Inc. Probably with Engelhard	http://www.aquatictreatment.com/	POU, POE to 1000 gpm	Fe-based, ARM-200 is Hematite (ARM-100 is activated alumina)
Adedge AD33 is the System; E33 is the Media ↓	Adedge Technologies For small systems >>>>>>>>>>>>>>>	http://www.adedgetechnologies.com/ http://www.adedgetechnologies.com/products/sws.htm	Yes	FeOOH-based
Bayoxide® SORB E33	Severn Trent	http://www.severntrentservices.com/	Yes	
ZS500As	GSA Resources Inc	http://www.gsaresources.com/arsenic.htm	M only	Fe-loaded Chabazite (Zeolite)
FS-50 (also AA400-G)	Alcan (MAGC in Asia) City of Albuquerque	http://www.chemicals.alcan.com/ and http://www.apsu-bd.org/draft_projects%20and_organsiations/ab-technologies/drannexb1.pdf http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=JOEEDU00012900006000561000001&idtype=cvips&gifs=yes	Yes at least in Asia!	Fe-doped activated alumina (just activated alumina)
Z33™	Water Remediation Technology, LLC	http://www.wrtnet.com/ (home page) http://www.wrtnet.com/other_contaminants.htm	Yes, probably	Zeolite-based - probably Fe doped

Media	Company	Web Site or Reference	Small System Available?	Media Composition
	Rio Rancho Pilot Study Bernalillo Pilot Study	http://www.wrnet.com/pdf/RioRancho.pdf http://www.wrnet.com/pdf/BernalilloNM.pdf		
WHOLLY Water® Systems: no media given	Life Streams International Mfg. Co.	http://www.wholly-water.com/	Yes	Just sells systems, no media specified
Granular Ferric Hydroxide	Reade Advanced Materials	http://www.reade.com/home_index.html	Media Only	Fe(OH)3
Iron oxide coated sand		Benjamin et al., 1996		
Granular Ferric Hydroxide	US Filter	http://www.usfilter.com/en/Product+Lines/General_Filter_Products/General_Filter_Products/general_filter_gfh.htm http://www.usfilter.com/NR/rdonlyres/1EFD9755-F000-4DC1-AE83-4B1779806EC4/0/gfh_brochure.pdf Driehaus et al., 1998	Mostly Larger Systems	FeOOH-based (GFH)
ArsenX	SolmeteX/Purolite/Mcphee now with: MPT-Mobil Processing Technology Rio Rancho Test	http://www.solmetex.com/apparsenic.html http://www.mobileprocess.com/SERVICES_arsenic.html and http://www.wateronline.com/ecommcenters/mobileprocesstechnology.html http://solmetex.com/pdfs.RioRanchodata.pdf	Yes	Fe-loaded cation exchange resin
Metsorb	GroverTech (HydroGlobe)	http://www.hydroglobe.com/	M only	TiO_2-based
Isolux	MEI (Magnesium Elektron Inc. – Isolux Technologies) For somewhat larger than POE systems	http://www.zrpure.com/ and http://www.zrpure.com/products_point_of_use.html http://www.zrpure.com/images/pdf/ISOLUX_Cntrl_Trtmnt.pdf	Y, POE, POU and Municipal	ZrO_2 (probably Zr-hydroxide)

Media	Company	Web Site or Reference	Small System Available?	Media Composition
CFH 12, 24	Kemiron	http://www.kemiron.com	M only	FeOOH-based
Adsorbsia-G10	Dow Dist. By Aquacell >>>>>>>>>>>>>	http://www.dow.com/liquidseps/prod/pt_as.htm http://www.dow.com/PublishedLiterature/dh_04e1/09002f13804e10f4.pdf?filepath=liquidseps/pdfs/noreg/177-02053.pdf&fromPage=GetDoc http://www.dow.com/PublishedLiterature/dh_058d/09002f138058d2a8.pdf?filepath=liquidseps/pdfs/noreg/016-00180.pdf&fromPage=GetDoc http://news.dow.com/dow_news/prodbus/2006/20060524b.htm http://www.aquacellwater.com/	Yes	TiO_2 granular
ASM-10HP	Resin Tech	http://www.resintech.com/index.cfm?Point=About	M only	Fe-coated resin
NXT-2	Eagle-Pitcher Aquatic Treatment Systems (ATS), Inc.	http://www.eaglepicher.com/EaglePicherInternet/ and search on "arsenic"; or go to http://www.aquatictreatment.com/ and then http://www.aquatictreatment.com/small-community-arsenic-removal.htm	M (E-P); Community Systems (ATS)	Fe-Mg coated La_2O_3
Amended Silicate	ADA, partnered with CH2M Hill to form a joint-venture "Amended Silicates, LLC" to market systems that may distribute with Kinetico.	http://www.adatech.com/default.asp and search "arsenic" for information on media – no systems yet though an EPA releases indicates they have been developed ↓…. http://es.epa.gov/ncer/sbir/success/pdf/arsenic.pdf	M only now - POE/POU soon?	Fe-amended silicate
BRIMAC 216	Brimac Carbon distributed by: Tate & Lyle Process Technology or Brimac Carbon Services Carbon Resources, LLC in USA	http://www.brimacservices.com/potable_water.htm http://www.brimacservices.com/potable_faq.htm http://www.carbonresources.com/index.htm	M, cartridges might also be Available	Bone char (not GAC) http://www.sandia.gov/water/2005vendors/BrimacCarbonServices.pdf

Media	Company	Web Site or Reference	Small System Available?	Media Composition
CPN-AA	Alcoa	http://www.alcoa.com/global/en/about_alcoa/overview.asp search arsenic; http://www.alcoa.com/global/en/search/search.asp?sTopNav=true&WebTrends=global%7Cen&QueryText=arsenic	M only	Activated Alumina

"M only" indicates that the company apparently just sells the media and not systems to use it in. In this case a separate engineering firm would be needed to design the system.

* Media Supplier = "M", Supplies treatment plants for little systems = "S"
# Synonymous with "Bayoxide", "E-33", AdEdge is the small system arm for Savern-Trent.
@ SolmeteX actually developed the ArsenX media, Purolite is the main manufacturer of the media, McPhee is our local distributor of the media, and systems that employ this media. Actually sold by Mobile Process Technology
Ω Kinetico is a large company with multiple products. When they develop sorption systems they will probably employ Dow or Engelhard media

Table D: Summary of CoAsT Estimation Software (Compiled April, 2006)

Model	What it Does	Technologies Evaluated	Chemical Inputs*
Decision tree for selecting technology - no cost data here	Selects technologies based on community characteristics	• Blending – new sources, • Enhanced coagulation plus filtration • Enhanced lime softening • Iron and Mn filtering • Ion Exchange processes • Sorption processes • Filtration and membrane processes	Chemistry inputs as appropriate for sorption and ion-exchange: • Cl^- (0-250 ppm) • F^- (0-2 ppm) • Silica (0-30 ppm) • SO_4^{-2} (0-360) • TDS (O-1000) • TOC (O-4 ppm) • PO_4^{-3} (0-1 ppm) • pH • Fe (0-15 ppm) • Mn (0-15 ppm) • H_2S (0-5 ppm) • Fe:As ratio Note: Model does not have an input for alkalinity.
Costing by AwwaRF Developed by CU and Malcolm Pirnie	Costs per 1000 gal For sorption media: • FS-50 • GFH • Bayoxide E33 • MetSorb G • Z33 – rev. B • SMI-III • AA-G400 User Defined Wastes Produced Other operating details/costs	Sorption and anion exchange	Inputs are: • Raw Water As (0-100 ppb) • Treated As (2-10 ppb) • Raw water pH (6-10) • pH adjustment (Y/N) • Alkalinity (0-100 ppm as $CaCO_3$) • PO_4^{-3} (0-250 ppb) • Silica (0-22 ppm as SiO_2) • V (0-4 ppb as V) • F^- (0-10 ppm) Freundlich / Langmuir isotherms
Costing by ARCE	• Costs per 1000 gal • Wastes Produced • Other operating details/costs	• Ion exchange • Adsorption + regeneration • Adsorption + throw away	Inputs are: • Alkalinity (as $CaCO_3$) • Raw water pH • Sulfate (ppm) • Arsenic (ppb) • Treated Water pH
Costing-Multiple Technologies Costing from USEPA Small System Handbook originally	• Costs for My Water System • Capital costs as a function of peak flow • O&M as a function of average flow (including waste disposal)	• AA (pH 7-8) • AA (pH adj to 6 with H_2SO_4) • Coagulation microfiltration • Green sand filtration • Ion exchange (< 20 mg/l sulfate) • Ion exchange (20-50 mg/l sulfate) • Enhanced coagulation-filtration • Enhanced lime softening	Just sulfate, model is focused on the construction and M&O costs without doing much with the water chemistry.
Costing - POU	Costs per person and per community	Reverse Osmosis	*No chemistry*

* These limitations reflect the status of the CoAsT tool in April 2006. This program is being continuously updated.

Table E: Funding Sources for NM Drinking Water Infrastructure Projects

Funding Entity	Program	Eligibility	Funding Potential	Application Process
New Mexico Finance Authority (NMFA) 207 Shelby St. Santa Fe, NM 87501	Drinking Water Revolving Loan Fund (DWRLF)	Community water systems, either privately or publicly owned; must be ranked on NMED Comprehensive Priority List & evaluated through NMED Capacity Assessment Program	Approximately $8 million per year Entities can qualify for lower interest rate (0% to 3%) based on Median Household Income (MHI)	Contact for assistance. John Brooks, Financial Advisor Phone: (505) 984-1454 Toll free: 1-877-ASK-NMFA or 1-877-275-6632 E-mail: frontdesk@nmfa.net Website: www.nmfa.net
New Mexico Finance Authority (NMFA) 207 Shelby St. Santa Fe, NM 87501	Public Project Revolving Loan Fund (PPRLF)	Municipalities, special districts, community water associations, Tribes and Pueblos	Funds for capital equipment and infrastructure projects	Contact for assistance. Phone: (505) 984-1454 Toll free: 1-877-ASK-NMFA or 1-877-275-6632 E-mail: frontdesk@nmfa.net Website: www.nmfa.net
New Mexico Finance Authority (NMFA) 207 Shelby St. Santa Fe, NM 87501	Water/Wastewater Grant Fund Program	Municipalities, special districts, community water associations, Tribes and Pueblos	Maximum grant is $400,000 per project Projects are approved by Legislature	Contact for assistance. Phone (505) 984-1454 Toll free: 1-877-ASK-NMFA E-mail: frontdesk@nmfa.net Website: www.nmfa.net
New Mexico Finance Authority (NMFA) 207 Shelby St. Santa Fe, NM 87501	Water Trust Board Program	Loans and grants to qualified entities for water infrastructure and other types of water projects; emphasis on regional cooperation and cost sharing	Solicitation for Letters of Interest to begin application process; selected entities invited to submit complete application	Contact for assistance. Water Trust Board Program Phone: (505) 984-1454 Toll free: 1-877-ASK-NMFA or 1-877-275-6632 E-mail: frontdesk@nmfa.net Website: www.nmfa.net
NM Environment Department Construction Programs Bureau Harold Runnels Building 1190 St. Francis Dr. PO Box 26110 Santa Fe, NM 87502	Rural Infrastructure Program (RIP)	Any incorporated municipality, county, MDWCA, public water cooperative assoc., or Water & Sanitation District serving less than 10,000 people; Entities that serve a population less than 3,000 are eligible for 0% interest loans	Total available funds vary with legislative appropriations Standard interest rate is 3% or below Maximum loan amount is $500,000; up to 100% of project can be financed	See Website or contact: Richard Rose, NMED/Construction Programs Bureau (505) 827-9691 Email: Richard_Rose@nmenv.state.nm.us Website: www.nmenv.state.nm.us/cpb/cpbtop.html

Funding Entity	Program	Eligibility	Funding Potential	Application Process
NM Environment Department Construction Programs Bureau Harold Runnels Building 1190 St. Francis Dr. PO Box 26110 Santa Fe, NM 87502	Special Appropriations Program	Any public entity or Tribe	Varies with state funds; use uniform funding application	Legislative appropriations Contact: Joy Ansley, Uniform Application Coordinator (505) 827-4797 E-mail: Joy.Ansley@state.nm.us Website: http://www.state.nm.us/capitalprojects/
NM Department of Finance & Administration, Local Government Division Bataan Memorial Bldg. Santa Fe, NM 87503	Community Development Block Grants (CDBG)	Municipalities & Counties; special districts and non-profits must apply through municipality or county: Indian tribes apply directly to HUD	Between $9 – 16 million available from HUD; grant limit is $500,000; planning grant limit is $50,000	Contact Dolores Gonzales, Bureau Chief (505) 827-4950 Website: http://www.cdbg.nmdfa.state.nm.state Applications due in January of each year
United States Department of Agriculture (USDA) - Rural Development 6200 Jefferson NE Albuquerque, NM 87109	Water and Waste Disposal Loan and Grant Program	Public entities such as municipalities, counties, Indian tribes, non-profits, under 10,000 population	Grants may be made up to 75% of project	Contact USDA – Rural Development (505) 761-4951
Border Environment Cooperation Commission (BECC) PO Box 221648 El Paso, TX 79913	EPA Border Infrastructure Program supports the Project Development Assistance Program (PDAP), administered by BECC.	Communities 62 miles on US side of international border and 186 miles on the Mexico side	Provides technical assistance; certifies all projects to be funded by NADBank	For application see website: www.cocef.org
North American Development Bank 203 South St. Mary's Suite 300 San Antonio, TX 78205 (210) 231-8000	EPA Border Infrastructure Program supports the Border Environment Infrastructure Fund (BEIF), administered by NADB	Communities 62 miles on US side of international border and 186 miles on the Mexico side	Projects are selected for BEIF/PDAP funding through a prioritization process Capitalized by US and Mexico	Contact BECC to initiate certification process or see website: www.nadb.org

Funding Entity	Program	Eligibility	Funding Potential	Application Process
US Environmental Protection Agency (EPA) Region 6 1445 Ross Ave. Dallas, TX	Tribal Set Aside Infrastructure Grants	Federally recognized Indian Tribes	Projects are prioritized; Funds administered by Indian Health Service; amount is approximately $1 - $1.5 million per year	Contact: Arnold Bierschenk (214) 665-7435 E-mail: Bierschenk.Arnold@epamail.epa.gov
Indian Health Service Albuquerque Area Office 5300 Homestead Rd. NE Albuquerque, NM 87110	Funding through SDS Program	Federally recognized Indian Tribes	$2.4 million/year; design, construction or both	Contact Mitch Constant, Director Sanitation Facilities Construction, (505) 248-4595 E-mail: mconstant@abq.ihs.gov
US Bureau of Reclamation Area Office 555 Broadway NE, Suite 100 Albuquerque, NM 87102	Challenge Grant Program	Western US; Priority given to projects that can be completed within 24 months of award and will decrease likelihood of conflict over water	$1.3 million for FY2006 Requires matching contribution	Contact local office at (505) 462-3542 For application see website: www.doi.gov/water2025/grant
US Army Corps of Engineers Albuquerque District 4101 Jefferson Plaza NE Albuquerque, NM 87109	Section 595 Environmental Infrastructure and Resource Protection	Public entities	Funds for design or construction or both; 75% grant and 25% match	Contact Pete Doles, Albuquerque District (505) 342-3201301 E-mail: peter.k.doles@spa02.usace.army.mil

Prepared by the New Mexico Environmental Finance Center at New Mexico Tech

Source: Catalog of Local Assistance Programs, 2005, NM Department of Finance and Administration, Local Government Division

APPENDICES

APPENDIX A.
QUESTIONS FOR ENGINEERS & VENDORS

Questions for Engineers

Engineer Selection

1. How much experience do you have designing treatment facilities for small public water systems? Do you have a list of references?

2. How much experience do you have in designing arsenic removal technologies for public water systems? Do you have a list of references?

3. How much experience have you had getting water treatment facilities approved in our state? References.

4. What kinds of water treatment facilities have you designed? References.

5. Who in your firm is best qualified in the area of arsenic removal technologies.

6. To what extent will your most qualified engineer(s) be involved in the project?

7. Do you have a full understanding of all the complex, interrelated, and continuously increasing drinking water regulations?

8. Are you aware of upcoming regulations and able to provide some level of planning for them while addressing our arsenic problem?

Arsenic Technology Design

1. How do you deal with the many vendors who provide proprietary arsenic removal technologies?

2. Do have you worked with specific vendors in the past? Are there any vendors you favor?

3. When dealing with a proprietary technology, how can you be sure of success?

4. When using a proprietary adsorptive media can you be sure that other types of media can be used in the same vessels?

5. What are the alternatives to meet the arsenic requirements?

6. Assuming we have water quality problems in addition to arsenic, will your proposed treatment also address those problems (e.g., iron, tastes, etc.)?

7. Will the proposed treatment process aggravate any other water quality problems (e.g., cause turbidity, staining, etc.)?

Relevant Data

1. Are my water's arsenic levels elevated throughout the year?
2. Will I have to provide treatment to all my sources?
3. Will I have to provide treatment on a continuous basis?
4. What are my neighboring utilities doing to meet the new arsenic standard?
5. Are there regionalization/consolidation options that I can/should consider?

Technology Design

1. What flow rate do we have to design for, and why?
2. Will other utilities be needed at our treatment site (e.g., improved power, standby power, sewer, gas, telephone, and radio communications)?
3. What will be the requirements for the building (i.e., height, width, length, heating, ventilation, etc.)?
4. What permits will be required (NPDES, building, electrical, plumbing, construction, operating)?
5. Will we have the ability to add additional capacity or treatment processes at the new facility at a later date?
6. Will we have pressure and capacity losses through the new facility that will have to be compensated for with pump change-out?
7. Will we have water losses through the new facility that will have to be compensated for by additional wells?
8. Will there be increased process monitoring sampling requirements for the treatment process?

Technology Operation and Monitoring

1. What preliminary water quality monitoring will I have to complete and how much will this cost?
2. What level of operator expertise is necessary?

Funding

1. Are there sources of funding available for the capital improvements to meet the new standard?
2. Do you have experience helping systems obtain funding?

Questions for Vendors

General Information on Technology

1. Do you have installations in place for arsenic removal?
   a. How long have they been in place?
   b. Can I get contact names and numbers for those systems?

2. Are all coatings and contact surfaces NSF certified?

3. Adsorptive media:
   a. Is the medium NSF certified?
   b. What are the typical design criteria for your technology:
      i. EBCT.
      ii. Surface loading rate.

4. What chemical additions will I have to make? What is the cost and availability of the chemicals? Do they require special handling? Are they all NSF certified?

5. What waste streams are produced by your technology?

6. Do all waste streams pass the TCLP (or WET in CA)?
   a. Please identify and characterize in terms of quantity and quality, each waste stream.

7. What is the typical range of water loss using your technology?
   a. Please identify each point in the process where water loss occurs, show the range (in percent of total raw water flow) of loss, and indicate what operating conditions increase water losses.

8. What is the system footprint? What is the required building height and square footage?

9. Do I have to provide pretreatment and if so what? Can the pretreatment cause any water quality or operational problems?

10. Does the technology remove arsenic III and arsenic V? Can it remove both with equal efficiency?

11. If the system is purchased as a custom unit, i.e. the media is bought from one supplier and the equipment from another, who do you see as the responsible party to make the system work?

12. Do you have a local representative for assistance on a timely basis?

Costs and Financing

1. If adsorbents are used, what is cost of the media in dollars/ft3?

2. What types of guarantees (e.g., performance bonding) do you provide for your treatment equipment?
    a. Life of capital components?
    b. Life and capacity of media?
    c. Finished water quality?

3. Do you offer a leasing option or lease/purchase option?

Start-Up

1. What conditioning of the new treatment plant or media will be needed (e.g., chemical conditioning media)?

2. How is the equipment delivered? Who is responsible for the equipment on-site until it s installed?

3. Do you provide ON-SITE technical assistance and troubleshooting during the installation, startup, and for a period of time afterwards?

Operations

1. What is the ease of operation? What level of operator expertise is necessary?

2. Can the treatment facility be automated? If so, do I have to provide special monitoring and communication equipment? Can you estimate the number of person-hours/week that would be required to operate and maintain the plant?

3. Will there be headlosses through the system that are likely to require a change-out or modification of the well's pump?

4. How flexible is the technology? Can it be easily updated with greater capacity? Can other media be used? Can it be modified to handle other contaminants?

5. Will you pilot your technology at my site? At what cost to me?

POE and POU

1. Are the units NSF/ANSI certified?

2. Based on my water quality, what will be the necessary frequency of service (media, carbon, and/or membrane change out, regeneration, etc.)?

3. Have you used your technology for applications similar to mine? Will you provide phone numbers for contacts?

4. Will you be willing to pilot your units on a limited number of homes at our system? At what cost?

5. Is it necessary to add an oxidant to the source water to convert arsenic III to arsenic V?
6. Is any other pre-treatment necessary?
7. What are some of the water quality limitations of this technology?
8. Is chromatographic peaking a potential risk with this unit?

APPENDIX B. ARSENIC PARTNERSHIP PILOT TEST PROGRAM DETAILS

Table B-1. Water Characteristics & Media Selection for Various Pilot Study Sites

	Socorro	**Desert Sands**	**Rio Rancho**	**Pine Hill**	**Jemez Pueblo**
Water Characteristics					
Conductivity (µS)	356-360	1380	605-620	484	770, 884
Temp. (^{o}C)	30.1-30.5	30.2	23	21	18.7
pH	8.0-8.1	7.7	7.7-7.9	7.2-7.6	7.5, 7.4
Iron (ppb)	43	154	<200	0.5-2.5	1,200
Turbidity	0.1	---	---		
Σ As/AsIII (ppb)	42/<2	23.5/19.7	18-20/ ND	21/18-30	20/19, 22
Alkalinity - as ppm $CaCO_3$	123	177	160	194-123	290, 315
Nitrate (ppm)	0.48	<0.2	2.3	<0.2	<0.2
Calcium (ppm)	17	27	23	127	155, 59
Magnesium (ppm)				13-37	16
Silica (as ppm SiO_2)	25	34	25 to 30	16	50, 57
Vanadium (ppb)	11	4	15	---	<1, <5
Sulfate (ppm)	29	180	100	295	24, 56
Chloride (ppm)	11.5	174	16	5.9	77
Sodium (ppm)	52	247	116	29	67
Fluoride (ppm)	0.5	0.9	0.9	0.4	1.0, 1.3
Pilot Media Selection					
Phase 1	-AdEdge -Engelhard -GraverTech (HydroGlobe) -MEI/Isolux -Purolite	-AdEdge -Dow -Eagle Picher -Engelhard -GraverTech (HydroGlobe) -Kemiron -MEI/Isolux -Purolite -Resin Tech	*Phase 1 and 2* -ADA -AdEdge -Brimac -Carbon -Dow -Kemiron -MEI/Isolux -Purolite -ResinTech -WattsPremier (Phase 1) -SANS	-Calgon Carbon -WRT -McPhee/ Purolite/ SollmeteX	*Coagulation/Filtration Technologies* -Safe Water Technologies -Orca -Hungerford & Terry -Kinetico -Blue Water
Phase 2	-GraverTech (HydroGlobe) -MEI/Isolux -Kemiron -Purolite -SANS	-ADA (retry) -AdEdge -Dow -Eagle Picher (retry, newNXT-2) -Engelhard -GraverTech (HydroGlobe) -Kemiron -MEI/Isolux -Purolite (new ArsenX^{np}) -ResinTech -Virotec (retry,Bauxsol-coated GAC) -SANS			

Table B-2: Details on Pilot Test Media and Suppliers.

Company	Service*	Media	Composition	Small System Contacts
		Sorption Systems		
AdEdge # 5-300 gpm	M, S	AD-33#	FeOOH-based TCLP OK	http://www.adedgetechnologies.com/products/sws.htm
Engelhard Ω	M	ARM-200	FeOOH-based	
GraverTech (HydroGlobe)	M	Metsorb	TiO_2-Based	
MEI POU (5-6 gpm) and up.	M, S	Isolux	ZrO2-Based TCLP OK Calif. OK	http://www.zrpure.com/products_central_treatment.html and then click on "Technical Specifications" "Products" and second level buttons are also helpful
McPhee/Purolite SolmeteX @ 5-60 gpm vessel; Multiples up to 1000 gpm +	M,S	ArsenX	Fe-loaded resin Media-recycle service	http://www.wateronline.com/ecommcenters/mobileprocesstechnology.html: then click on "arsenic removal and regeneration service".
Kemiron	M,?	CFH-12 or 24	FeOOH-based	
Dow Ω Dist. By Aquacell	M,?	Adsorbsia-G10	TiO_2 granular	http://news.dow.com/prodbus/2006/20060406b.htm
Eagle-Pitcher	M,?	NXT-2	Fe-Mg coated La_2O_3	
Resin Tech	M, ?	ASM-10HP	Fe-coated resin	
ADA	M,?	MMSI	Fe(?)-amended silicate	
Brimac Carbon	M		Bone Char	
Virotec	M	Bauxsol	Fe-Al oxide on a substrate of granulated activated carbon	
		RO Systems		
Watts-Premier##	S			
		Coagulation –Filtration Systems		
Orca 10 to 800 gpm	S	Fully Automated System		http://www.orcawatertech.com/Kemloop.php :then click on system size, 10-35 gpm for example.
Hungerford & Terry	?			
Blue H2O	?			
Calgon Carbon	?			
WRT	?			
KineticoΩ	?			

* Media Supplier = “M”, Supplies treatment plants for little systems = “S”

Synonymous with “Bayoxide”, “E-33”, AdEdge is the small system arm for Severn-Trent.

@ SolmeteX actually developed the ArsenX media, Purolite is the main manufacturer of the media, McPhee is our local distributor of the media, and systems that employ this media. Actually sold by Mobile Process Technology

Ω Kinetico is a large company with multiple products. When they develop sorption systems they will probably employ Dow or Engelhard media.

An EPA verification report on the Watts Premier M-15,000 RO systems can be found at (last entry): http://www.epa.gov/etv/verifications/vcenter2-1.html
AdEdge: http://www.adedgetechnologies.com/products/sws.htm

Note: 5 gpm = 7,500 gpd

Note: Information on the pilot tests can be found at http://www.sandia.gov/water/arsenic.htm and general information on a broad range of different technologies (sorptive media plus others) is available at http://www.sandia.gov/water/evaluation.htm; both sites are presently being updated regularly.

Table B-3: Relative performance of different sorptive materials tested in three pilot programs. Performance results are tabulated as column volumes to "breakthrough" (see above) *in that experimental configuration*. Comparisons down a column provide a measure of relative performance. However, because of differences in water chemistry and experimental set-up comparisons horizontally across rows are not very meaningful. Nor can the breakthrough volumes from these small scale columns be used to reliably estimate performance in actual (full sized) water treatment plants.

Comparison of media performance

Manufacturer	Media	SS Phase 1	SS Phase 2b (pH 6.8/ pH 8)	RR Phase 1	RR Phase 2	DS (Phase 1/2)
MEI	Isolux	34000	90000/34000	>11000	20000	>18000
Sandia	SANS		>53000/31000		>40000	>30000
Kemiron	CFH10		30000 (pH 8)[1]	>22000		
Kemiron	CFH12		>46000/18000		>22000	>32000
AdEdge/STS	E33	25000/43000/42000 (2/4/5 min EBCT)		>25000	>40000	>33000
Engelhard	ARM200	9000 [2]				18000 (Ph1)[2]
Dow	Adsorbsia™ GTO™			>22000	>40000	25000 [3]
Hydroglobe	Metsorb	14000 [3]	40000/21000			28000 [3]
Purolite	ArsenX^{np}	28000	>60000/37000	>35000	36000	>10,000/>24000
Resin Tech	ASM-10HP (1st batch)			18000		8500
Resin Tech	ASM-10HP (2nd batch)				13000	
EP Minerals	NXT-2					2400 [4]

[1]The media installed in Phase 2b was CFH12, a larger diameter particle, which may not have been conducive to the 3" column size & pilot flow rates. The smaller diameter particle was installed for comparison in the ambient stream only.

[2]The media installed in Phase 1 from Engelhard was a pre-production media, as stated by the vendor, Engelhard. Newer media is currently being tested.

[3]These media had clogged and flow was stopped. Both had reached As>10 ppb, but hadn't fully broken through.

[4]This media broke down physically, causing total clogging of the column. The vendor has provided an improved media that is currently being tested.

NOTE: FUTURE PERFORMANCE RESULTS WILL BE TABULATED ON THE SANDIA ARSENIC WEB SITE.

APPENDIX C. EPA PILOT TEST MATERIALS SUMMARY

Titles for 6-month progress reports on EPA pilot tests

(see: http://clu-in.org/contaminantfocus/default.focus/sec/arsenic/cat/Treatment_Technologies/)

Arsenic Removal from Drinking Water by Adsorptive Media: U.S. EPA Demonstration Project at Bow, NH. Six-Month Evaluation Report
J.L. Oxenham, A.S.C. Chen, and L. Wang.
EPA 600-R-06-031, 60 pp, 2006.

Arsenic Removal from Drinking Water by Adsorptive Media: USEPA Demonstration Project at Brown City, MI. Six-Month Evaluation Report
Wendy E. Condit and Abraham S.C. Chen, Battelle, Columbus, OH.
EPA 600-R-06-004, 66 pp, 2006.

Arsenic Removal from Drinking Water by Iron Removal: USEPA Demonstration Project at Climax, MN. Six-Month Evaluation Report
W.E. Condit and A.S.C. Chen.
EPA 600-R-06-006, 58 pp, 2006.
Contact: Thomas Sorg, sorg.thomas@epa.gov

Arsenic Removal from Drinking Water by Adsorptive Media: EPA Demonstration Project at Queen Anne's County, Maryland. Six-Month Evaluation Report
J.L. Oxenham, A.S.C. Chen, and L. Wang.
EPA 600-R-06-007, 59 pp, 2006.

Arsenic Removal from Drinking Water by Adsorptive Media: EPA Demonstration Project at Rimrock, AZ, Six-Month Evaluation Report
L. Wang, J. Valigore, and A.S.C. Chen.
EPA 600-R-05-159, 55 pp, 2005.

Arsenic Removal from Drinking Water by Adsorptive Media. EPA Demonstration Project at Rollinsford, NH: Six-Month Evaluation Report
J. Oxenham, A.S.C. Chen, and L. Wang, Battelle, Columbus, OH.
EPA 600-R-05-116, 65 pp, 2005.

Arsenic Removal from Drinking Water by Adsorptive Media. USEPA Demonstration Project at Desert Sands MDWCA, NM: Six-Month Evaluation Report
C.T. Coonfare, A.S.C. Chen, L. Wang, and J.M. Valigore, Battelle, Columbus, OH.
EPA 600-R-05-079, 63 pp, 2005.
Contact: Thomas Sorg, sorg.thomas@epa.gov

Table C-1 (EPA Table 2-3)**:** Round 1 Media and Site characteristics: Physical and Chemical Properties and Costs of the Adsorptive Media

Parameter	G2	E33		GFH	AAFS50
Physical and Chemical Properties					
Matrix/Active Ingredient	Diatomaceous earth (Si-based) impregnated with a coating of ferric hydroxide	Iron oxide composite (90.1% FeOOH)		52-57% $Fe(OH)_3$ and β-FeOOH	83% Al_2O_3 + proprietary additive
Physical Form	Dry powder	Dry granular media		Moist granular media	Dry granular media
Color	Dark brown	Amber		Dark brown	Light amber
Bulk Density (g/cm^3)	0.75	0.45		1.22-1.29	0.91
Bulk Density (lb/ft^3)	47	28		76-81	57
BET Area (m^2/g)	27	142		127	220
Particle Size Distribution/ Effective Size (mm)	0.32	10 × 35 mesh		0.32-2	28 × 48 mesh
Zero Point Charge[(a)]	N/A	8.3		7.6	7.3
Operating pH Range	5.5 to 7.5	6.0 to 8.0		5.5 to 9.0	<7.7
EBCT (min)	10	5		5	5
Regenerability	Yes	No		No	No
Media Cost					
Vendor	ADI	Severn Trent	AdEdge	USFilter	Kinetico
Cost ($/ft^3)	35	150	245	238	82
Cost ($/lb)	0.75	5.36	8.75	3.03	1.44

http://www.epa.gov/ORD/NRMRL/pubs/600r05001/600r05001a.htm
(a) Amy et al. (2004).
N/A = not available.
EBCT = empty bed contact time.

Media Capabilities (Also from EPA Round 1 documentation)

EPA sponsored Pilot Test Programs, from:
(http://www.epa.gov/ORD/NRMRL/pubs/600r05001/600r05001a.htm#_Toc84149553)

G2 media adsorbs arsenic most effectively at a pH value within the 5.5 to 7.5 range, and less effectively at a higher pH value. Historic pH measurements indicate that the pH values are in the range of 7.7 to 7.8; therefore, acid addition for lowering the pH is included as part of the treatment system to extend the media life. The presence of other ions in the source water is not expected to impede the arsenic adsorption because of their relatively low concentrations and because arsenic is more preferred than other ions by G2 media.

E33 Media. The Bayoxide® E33 media was developed by Bayer AG for the removal of arsenic from drinking water supplies. It is a granular ferric oxide media designed to remove dissolved arsenic via adsorption onto its ferric oxide surface. Severn Trent markets the media in the United States for As III and As V removal as Sorb-33, and offers several arsenic package units (APUs) with flowrates ranging from 150 to 300 gallons per minute (gpm). Another company, AdEdge, Inc., provides similar systems using the same media (marketed as AD-33) with flowrates ranging from 5 to 150 gpm. The Sorb-33 demonstration sites are located at Desert

Sands Mutual Domestic Water Consumers Association (MDWCA), NM; Brown City, MI; and Queen Anne's County, MD. The AD-33 demonstration sites are located at Nambe Pueblo, NM; Rimrock, AZ; and Rollinsford, NH.

E33 adsorbs arsenic and other ions, such as antimony, cadmium, chromate, lead, molybdenum, selenium, and vanadium. The adsorption is effective at pH values ranging between 6.0 and 9.0. At pH values greater than 8.0 to 8.5, pH adjustment is recommended to maintain its adsorption capacity. Two competing ions that can reduce the adsorption capacity are silica (at levels greater than 40 mg/L) and phosphate (at levels greater than 1 mg/L). In general, water with an iron content of less than 300 µg/L can be treated with E33 media without any pretreatment. Table 2-4 summarizes the impact of water quality at the six E33 sites on the need for pretreatment, including pre-oxidation of As(III) to As(V) and raw water pH adjustment. Pre-chlorination also is used for disinfection with the media having only a slight chlorine demand for only a short period of time, such as one or two weeks.

GFH Media. GFH is a granular ferric hydroxide media produced by GEH Wasserchemie GmbH of Germany and marketed by USFilter under an exclusive marketing agreement. GFH is capable of adsorbing both As(V) and As(III). GFH media adsorbs arsenic within a pH range of 5.5 to 9.0, but less effectively at the upper end of this range. Arsenic in the source water at the STMGID, NV site is predominately As(V). With a moderate pH of 6.9 to 7.9 for the source water, pH adjustment is not recommended. Competing ions such as silica and phosphate in source water can adsorb onto GFH media, thus reducing the arsenic removal capacity of the media. Source water at STMGID, NV contains less than 0.1 mg/L of orthophosphate and 28.0 mg/L of sulfate. Only silica concentrations (68.6 mg/L as SiO_2) appear to be high enough to potentially impact the arsenic adsorption capacity.

AAFS50 Media. The Kinetico arsenic adsorption system at Valley Vista, AZ, uses Alcan's Actiguard AAFS50 media. AAFS50 media is different from conventional AA because it is engineered with a proprietary additive to enhance its arsenic adsorption performance. Standard grade AA was the first adsorptive media successfully applied for the removal of arsenic from water supplies. However, it often requires pH adjustment to 5.5 in order to achieve optimal arsenic removal. The AAFS50 product is modified with an iron-based additive to improve its performance and to increase the pH range within which it can achieve effective removal.

Table C-2 (EPA Table 2-4). Water Quality Impact on Pretreatment Requirements at E33 Demonstration Sites

Site	Pre-Chlorination	pH Adjustment	Water Quality
Severn Trent Systems			
Desert Sands MDWCA, NM	Yes [As(III) = 21.6 µg/L]	No [pH = 7.7]	Sulfate 158 to 190 mg/L
Brown City, MI	No [As(III) = 11.2 µg/L]	No [pH = 7.3]	Iron up to 200 µg/L
Queen Anne's County, MD	No [As(III) = 18.4 µg/L]	No [pH =7.3]	Not Significant
AdEdge Systems			
Nambe Pueblo, NM	No [As(III) = 0.2 µg/L]	Yes [pH =8.5]	Not Significant
Rimrock, AZ	No [As(III) = <0.1 µg/L]	No [pH = 7.1]	Not Significant
Rollinsford, NH	Yes [As(III) = 20.1 µg/L]	Yes [pH = 8.2]	Manganese up to 100 µg/L

Table C-3 (EPA Table 1-2). Groundwater characteristics at various EPA test sites.

State	Facility	Technology	Total As	Soluble As	*Particulate As*	As(III)	As(V)	Total Fe	Soluble Fe	Total Mn	Soluble Mn	Sulfate	Orthophosphate	Silica (as SiO_2)	Alkalinity	Hardness	pH
			µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/[(a)]	mg/[(a)]	–
NH	Bow	AM (G2)	32.0-47.0	44.1	<0.1	0.5	43.6	<25-60	<25	2.1-25.0	1.5	12.0-15.5	<0.10	19.7	54	92.7	7.7
NH	Rollinsford	AM (E33)	33.8-55.9	33.9	2.3	20.1	13.9	46-206	<30	56.7-100	68.6	29.0-40.5	<0.10	13.1-14.3	171	50.9	8.2
MD	Queen Anne's County	AM (E33)	17.0-19.0	18.7	0.1	18.4	0.3	91-300	254	0.4-8.0	1.4	4.2-5.8	<0.10	13.3-14.5	168	102	7.3
MI	Brown City	AM (E33)	14.2-31.0	12.0	2.2	11.2	0.8	127-200	118	13.0-18.7	15.0	74.0-128	<0.10	7.4-8.1	235	83.2	7.3
MN	Climax	C/F	31.0-41.0	34.6	4.2	34.8	<0.1	546-850	540	128-170	130	100-120	<0.10	27.3-29.9	304	228	7.4
ND	Lidgerwood	SM	108-146	126	20.3	121	5.3	1,310-1,620	1,316	544-675	664	344-390	<0.10	27.8-29.4	344	513	7.2
NM	Desert Sands MDWCA	AM (E33)	17.0-22.7	22.3	0.4	21.6	0.7	39-73	<30	8.9-10.0	9.0	158-190	<0.10	34.6-35.1	188	84.0	7.7
NM	Nambe Pueblo	AM (E33)	29.0-33.2	31.4	1.8	0.2	31.2	<30-138	<30	1.3-22.9	1.3	<10-28.2	<0.10	14.1-15.1	168	5.4	8.5
AZ	Rimrock	AM (E33)	50.0-63.6	64.8	<0.1	<0.1	64.8	36-170	<25	<0.4-7.5	8.1	9.5-13.0	<0.10	24.8-27.8	378	335	7.1
AZ	Valley Vista	AM (AAFS50)	39.0-41.0	38.1	2.8	0.3	37.8	<30	<30	<0.1-<50	<0.1	8.4-9.0	<0.10	18.5-21.4	154	172	7.8
ID	Fruitland [(b)]	IX	37.0-44.0	40.1	3.4	0.8	39.3	<30-744	<30	1.6-50.0	0.5	57.3-64.0	<0.10	54.3-57.8	381	233	7.4
NV	STMGID[(c)]	AM (GFH)	45.0-87.9	89.4	<0.1	0.3	89.1	<30	<30	0.1-3.0	<0.1	8.0-28.0	<0.10	52.5-68.6	100	17.1	7.4

(a) As $CaCO_3$.
(b) Nitrate was detected at 13.9 mg/L in Fruitland, ID.
(c) Antimony was detected at 15.8 µg/L in STMGID, NV.
Data range reported for total As, total Fe, total Mn, SO_4, and SiO_2 only.

ADDITIONAL RESOURCES

For general compliance information:
http://www.epa.gov/safewater/arsenic/pdfs/quicksheet_arseinc_2006.pdf
http://www.epa.gov/safewater/arsenic/pdfs/ars_final_app_f.pdf.

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