DRAFT FEASIBILITY REPORT
FEASIBILITY ANALYSIS OF WATER SUPPLY
FOR SMALL PUBLIC WATER SYSTEMS

SHERWOOD ESTATES MANUFACTURED TOWNHOME COMMUNITY
PWS ID# 1650022

Prepared for:

THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Prepared by:

THE UNIVERSITY OF TEXAS BUREAU OF ECONOMIC GEOLOGY

AND

PARSONS

Preparation of this report was financed by the Texas Commission on Environmental Quality through the Drinking Water State Revolving Fund Small Systems Assistance Program

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EXECUTIVE SUMMARY

INTRODUCTION

The University of Texas Bureau of Economic Geology (BEG) and its subcontractor, Parsons Infrastructure and Technology Group Inc. (Parsons), have been contracted by the Texas Commission on Environmental Quality (TCEQ) to assist with identifying and analyzing compliance alternatives for use by Public Water Systems (PWS) to meet and maintain Texas drinking water standards.

The overall goal of this study was to promote compliance with Texas drinking water standards using sound engineering and financial methods and data for PWSs that had recently recorded sample results exceeding maximum contaminant levels (MCL). The primary objectives of this study were to provide feasibility studies for PWSs and the TCEQ Water Supply Division that evaluate water supply compliance options, and to suggest a list of compliance alternatives that may be further investigated by the subject PWS for future implementation.

This feasibility report provides an evaluation of water supply alternatives for the Sherwood Estates Manufactured Townhome Community Water System, which provides water to a manufactured townhome community located southeast of Midland, Texas (hereinafter referred to as the Sherwood Estates PWS). The Sherwood Estates PWS recorded an arsenic concentration of 14 micrograms per liter (µg/L). While this result was below the arsenic MCL of 50 µg/L in effect at that time, the value was above the 10 µg/L MCL for arsenic that went into effect on January 23, 2006 (USEPA 2005a; TCEQ 2004a). Therefore, it is likely that Sherwood Estates PWS would face compliance issues under the new standard. Additionally, water from the Sherwood Estates PWS is very near to the nitrate MCL of 10 mg/L as nitrogen.

Basic system information for the Sherwood Estates PWS is shown in Table ES.1.

Table ES.1
Sherwood Estates
Basic System Information

Population served	65
Connections	25
Average daily flow rate	0.005 million gallons per day (mgd)
Peak demand flow rate	14 gallons per minute
Water system peak capacity	0.2 mgd
Average total arsenic	0.0142 mg/L
Average nitrate	9.36 mg/L

STUDY METHODS

The methods used for this study were based on a pilot study performed in 2004 and 2005 by TCEQ, BEG, and Parsons. Methods for identifying and analyzing compliance options were developed in the pilot study (a decision tree approach).

The process for developing the feasibility study used the following general steps:

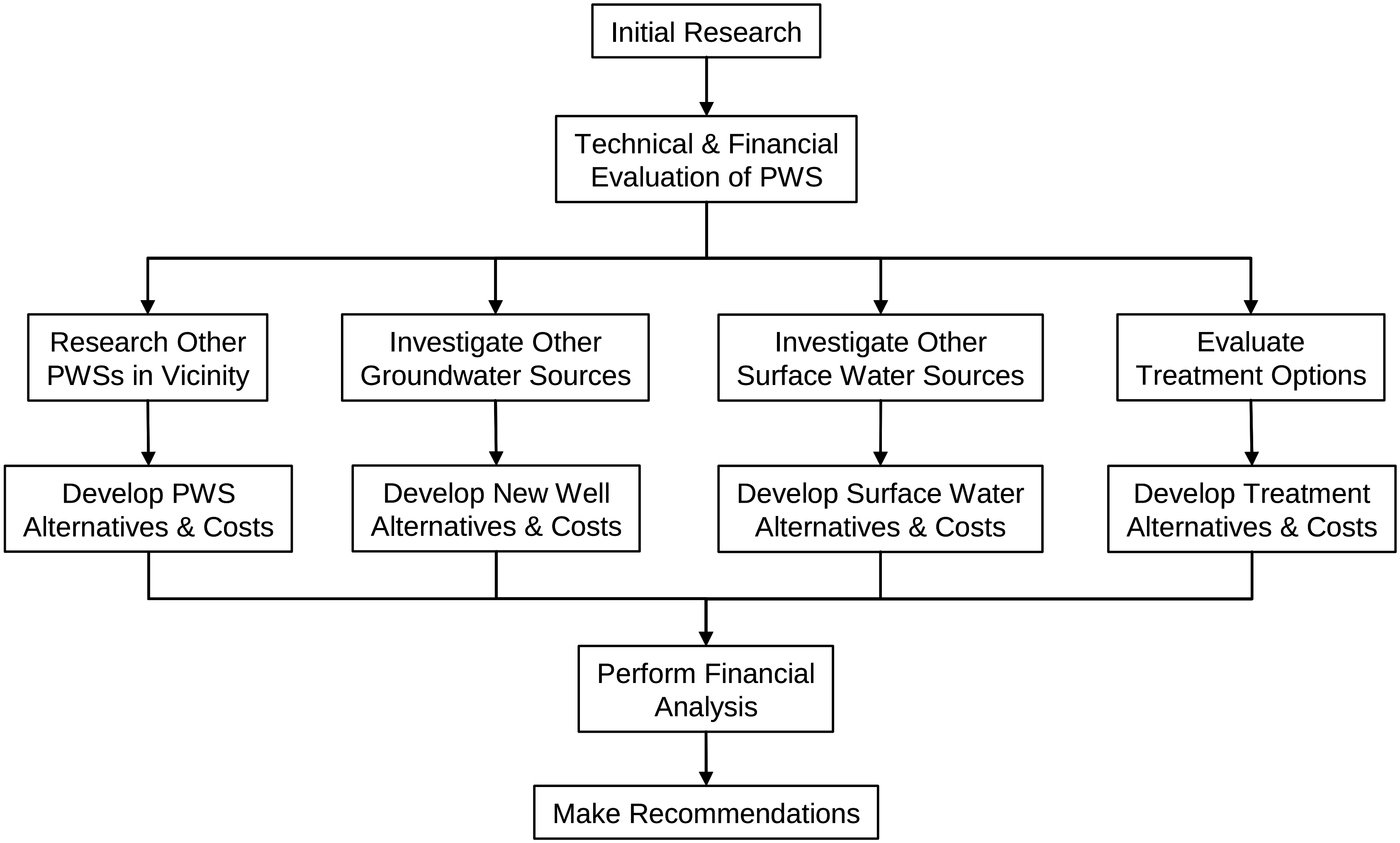
- Gather data from the TCEQ and Texas Water Development Board databases, from TCEQ files, and from information maintained by the PWS;
- Conduct financial, managerial, and technical (FMT) evaluations of the PWS;
- Perform a geologic and hydrogeologic assessment of the study area;
- Develop treatment and non-treatment compliance alternatives which, in general, consist of the following possible options:
- Connecting to neighboring PWSs via new pipeline or by pumping water from a newly installed well or an available surface water supply within the jurisdiction of the neighboring PWS;
- Installing new wells within the vicinity of the PWS into other aquifers with confirmed water quality standards meeting the MCLs;
- Installing a new intake system within the vicinity of the PWS to obtain water from a surface water supply with confirmed water quality standards meeting the MCLs;
- Treating the existing non-compliant water supply by various methods depending on the type of contaminant; and
- Delivering potable water by way of a bottled water program or a treated water dispenser as an interim measure only.
- Assess each potential alternative with respect to economic and non-economic criteria;
- Prepare a feasibility report and present the results to the PWS.

This basic approach is summarized in Figure ES-1.

HYDROGEOLOGICAL ANALYSIS

The Sherwood Estates PWS obtains groundwater from the Ogallala Aquifer. Arsenic and nitrate are commonly found in area Ogallala wells at concentrations greater than the respective MCLs. The arsenic may be naturally occurring, but the nitrate may be the result of agricultural or other human activity. The concentrations of the contaminants can vary based on location, so it may be possible to construct a new well at another location that would produce compliant water.

Figure ES-1
Summary of Project Methods



However, the variability of concentrations makes it difficult to determine where wells can be located to produce acceptable water, and a review of existing nearby wells did not identify existing compliant wells. It may also be possible to install a deeper well into the Edwards Trinity aquifer, but more investigation is required to determine the water quality in the Edwards Trinity aquifer at the site. Since Sherwood Estates has more than one well, the water from each well should be characterized. If one of the wells is found to produce compliant water, as much production as possible should be shifted to that well as a method of achieving compliance. It may also be possible to do down-hole testing on non-compliant wells to determine the source of the contaminants. If the contaminants derive primarily from a single part of the formation, that part could be excluded by modifying the existing wells, or avoided altogether by completing a new well.

COMPLIANCE ALTERNATIVES

Sherwood Estates is one of three small mobile home parks owned and operated by Westgate Village Manufactured Town Home Communities. Overall, the system has an inadequate FMT level due mainly to deficiencies with financial capability; however, the system does have many positive aspects, including a knowledgeable and dedicated staff, very good communication with customers, and a cross-connection control program. Areas of concern for the system included inadequate financial accounting for the water system, inability to meet operating expenses, lack of a reserve account, and lack of long-term planning.

There are several PWSs within 10 miles of Sherwood Estates. Few of these nearby systems also have good water quality. In general, feasibility alternatives were developed based on obtaining water from the nearest PWSs with good quality water, either by directly purchasing water or by expanding the existing well field. One alternative also explores construction of a deeper on-site well into the Edwards Trinity aquifer. There is a minimum of surface water available in the area, and obtaining a new surface water source is considered through the alternatives where treated surface water is obtained through the Cities of Midland, Stanton, and Odessa, which obtain raw surface water from the Colorado River Municipal Water District.

A number of centralized treatment alternatives for arsenic removal have been developed and were considered for this report, including reverse osmosis, electrodialysis reversal, iron-based adsorption, and coagulation/filtration. Point-of-use (POU) and point-of-entry treatment alternatives were also considered. Temporary solutions such as providing bottled water or providing a centralized dispenser for treated or trucked-in water, were also considered as alternatives.

If compliant groundwater can be found, developing a new well on-site or near the Sherwood Estates PWS is likely to be one of the best solutions. Having a new well near the Sherwood Estates PWS is likely to be one of the lower cost alternatives since the PWS already possesses the technical and managerial expertise needed to implement this option. The cost of new well alternatives quickly increases with pipeline length, making proximity of the alternate source a key concern. A new compliant well or obtaining water from a neighboring compliant PWS has the advantage of providing compliant water to all taps in the system.

Central treatment can be cost-competitive with the alternative of new nearby wells, but would require significant institutional changes to manage and operate. Like obtaining an alternate compliant water source, central treatment would provide compliant water to all water taps.

POU treatment can be cost competitive, but does not supply compliant water to all taps. Additionally, significant efforts would be required for maintenance and monitoring POU treatment units.

Providing compliant water through a central dispenser is significantly less expensive than providing bottled water to 100 percent of the population, but a significant effort is required for clients to fill their containers at the central dispenser.

FINANCIAL ANALYSIS

Financial analysis of the Sherwood Estates PWS indicated that current water rates are under funding operations, and that a rate increase of approximately 10 percent would be necessary to meet operating expenses. This increase would raise the average annual water bill from $180 to $200. The current average water bill represents approximately 0.5 percent of the median household income (MHI), and would also represent approximately 0.5 percent of the MHI with the increase. Table ES.2 provides a summary of the financial impact of implementing selected compliance alternatives, including the rate increase necessary to meet current operating expenses. The alternatives were selected to highlight results for the best alternatives from each different type or category.

Some of the compliance alternatives offer potential for shared or regional solutions. A group of PWSs could work together to implement alternatives for developing a new groundwater source or expanding an existing source, obtaining compliant water from a large regional provider, or for central treatment. Sharing the cost for implementation of these alternatives could reduce the cost on a per user basis. Additionally, merging PWSs or management of several PWSs by a single entity offers the potential for reduction in administrative costs.

Table ES.2
Selected Financial Analysis Results

Alternative	Funding Option	Average Annual Water Bill	Percent of MHI
Current	NA	$180	0.5
To meet current expenses	NA	$200	0.5
New well at Sherwood Estates	100% Grant	$200	0.5
	Loan/Bond	$200	0.5
Purchase water from Midland	100% Grant	$417	1.1
	Loan/Bond	$2,794	7.6
Central treatment - adsorption	100% Grant	$2,386	6.5
	Loan/Bond	$3,489	9.5
Point-of-use	100% Grant	$883	2.4
	Loan/Bond	$937	2.6

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ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
µg/L	microgram per liter
AFY	acre-feet per year
APU	arsenic package unit
BEG	Bureau of Economic Geology
CCN	Certificate of Convenience and Necessity
CFR	Code of Federal Regulations
CO	correspondence
CR	county road
CRMWD	Colorado River Municipal Water District
EDR	Electrodialysis reversal
ENR	Engineering News Record
FM	farm-to-market
FMT	financial, managerial, and technical
GAM	groundwater availability model
gpm	gallons per minute
SE	Sherwood Estates
IH	Interstate Highway
IX	ion exchange
kWH	kiloWatt hours
m	meter
MCL	maximum contaminant level
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
MHI	median household income
MOR	monthly operating report
NF	nanofiltration
NLCD	National Land Cover Dataset
NMEFC	New Mexico Environmental Financial Center
NURE	National Uranium Resource Evaluation
O&M	operation and maintenance
Parsons	Parsons Infrastructure and Technology Group Inc.
pCi/L	picoCuries per liter
POE	point-of-entry
POU	point-of-use

ppb	parts per billion
psi	pounds per square inch
PSOC	potential sources of contamination
PWS	public water system
RO	reverse osmosis
RR	ranch road
SDWA	Safe Drinking Water Act
SH	state highway
SSCT	small system compliance technology
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TSS	total suspended solids
TTHM	total trihalomethanes
TWDB	Texas Water Development Board
USEPA	United States Environmental Protection Agency
WAM	water availability model

SECTION 1
INTRODUCTION

The University of Texas Bureau of Economic Geology (BEG) and its subcontractor, Parsons Infrastructure and Technology Group Inc. (Parsons), were contracted by the Texas Commission on Environmental Quality (TCEQ) to assist with identifying and analyzing compliance alternatives for use by Public Water Systems (PWSs) to meet and maintain Texas drinking water standards.

The overall goal of this project is to promote compliance using sound engineering and financial methods and data for PWSs that have recently had sample results that exceed maximum contaminant levels (MCL). The primary objectives of this project are to provide feasibility studies for PWSs and the TCEQ Water Supply Division that evaluate water supply compliance options, and to suggest a list of compliance alternatives that may be further investigated by the subject PWS with regard to future implementation. The feasibility studies identify a range of potential compliance alternatives, and present basic data that can be used for evaluating feasibility. The compliance alternatives addressed include a description of what would be required for implementation, conceptual cost estimates for implementation, and non-cost factors that could be used to differentiate between alternatives. The cost estimates are intended for comparing compliance alternatives, and to give a preliminary indication of potential impacts on water rates resulting from implementation.

It is anticipated the PWS will review the compliance alternatives in this report to determine if there are promising alternatives, and then select the most attractive alternative(s) for more detailed evaluation and possible subsequent implementation. This report contains a decision tree approach that guided the efforts for this project, and also contains steps to guide a PWS through the subsequent evaluation, selection, and implementation of a compliance alternative.

This feasibility report provides an evaluation of water supply compliance options for the Sherwood Estates Manufactured Townhome Community Water System, PWS ID# 1650022, located in Midland County (hereinafter referred to as the Sherwood Estates PWS). Recent sample results from the water system at Sherwood Estates exceeded the MCL for arsenic of 10 micrograms per liter (µg/L) that went into effect January 23, 2006 (USEPA 2005; TCEQ 2004).

The location of the Sherwood Estates PWS is shown on Figure 1.1. Various water supply and planning jurisdictions are shown on Figure 1.2. These water supply and planning jurisdictions are used to evaluate alternate water supplies that may be available in the area.

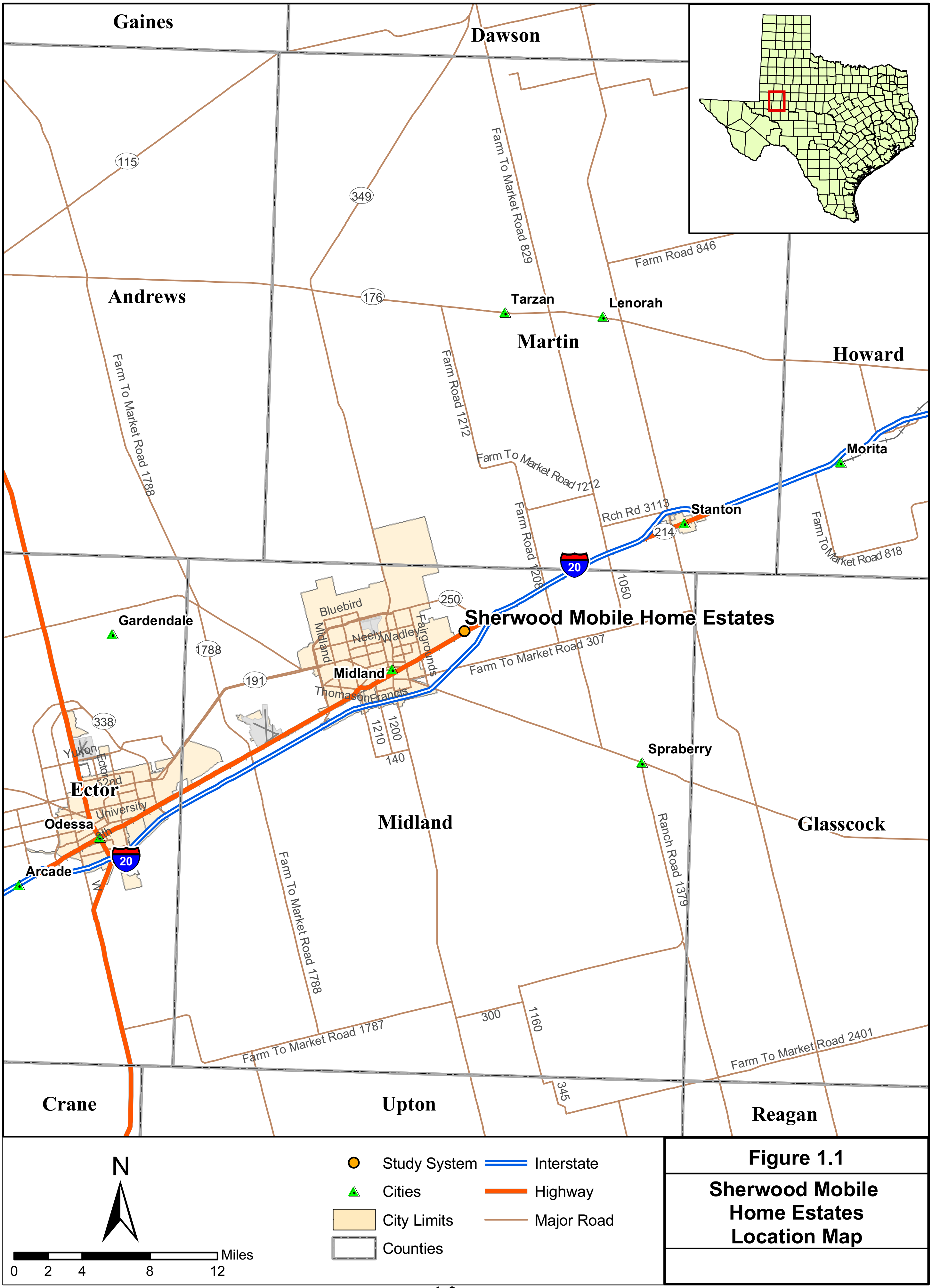

Figure 1.1

Sherwood Mobile Home Estates Location Map

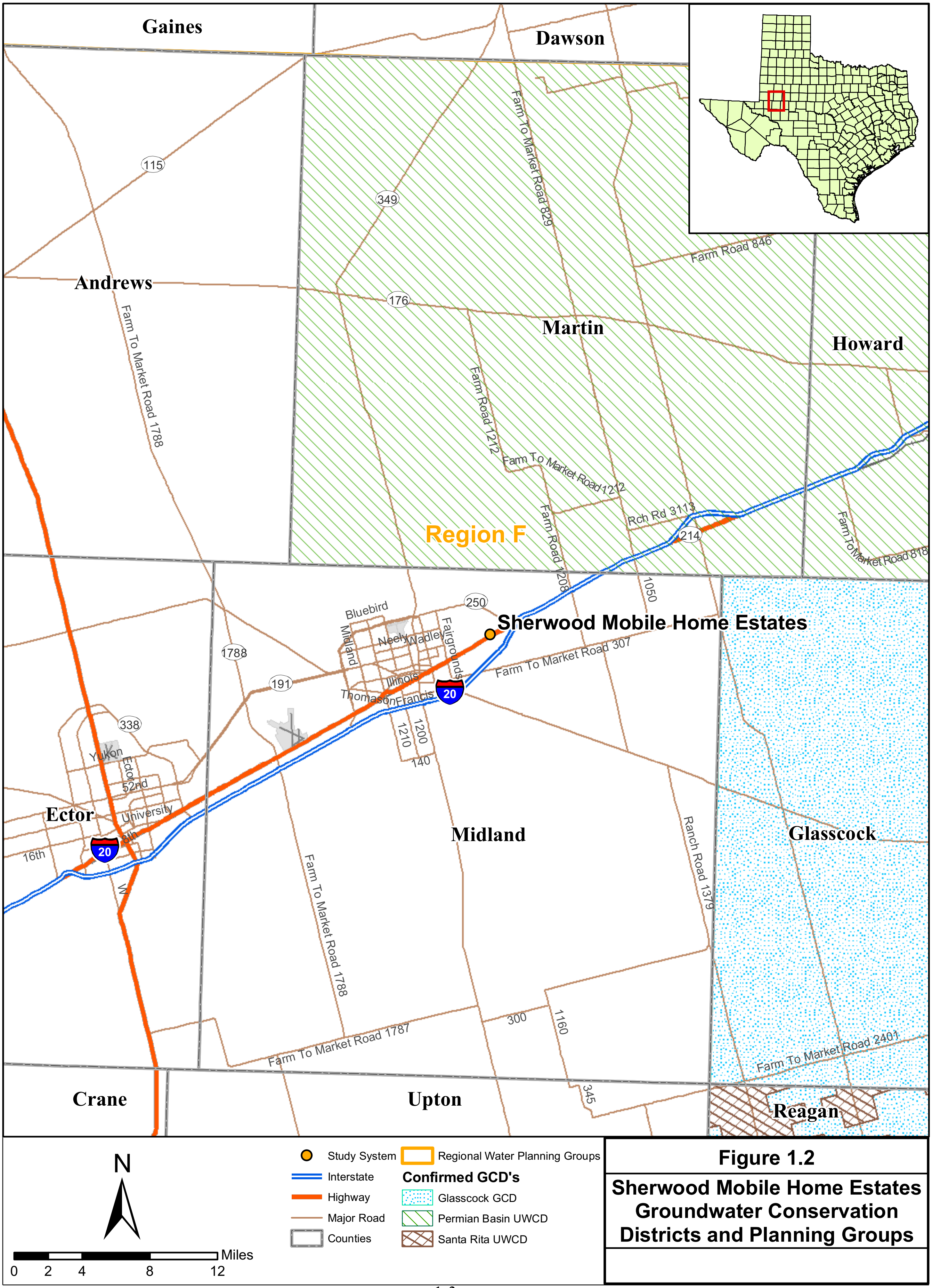

Figure 1.2
Sherwood Mobile Home Estates Groundwater Conservation Districts and Planning Groups

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1.1 PUBLIC HEALTH AND COMPLIANCE WITH MCLS

The goal of this project is to promote compliance for PWSs that supply drinking water containing contaminants that exceed regulatory MCLs. This project only addresses those contaminants and does not address any other violations that may exist for a PWS. As mentioned above, Sherwood Estates PWS had recent sample results that exceeded the MCL for arsenic. Health concerns related to drinking water above MCL for this chemical are briefly described below.

In general, contaminant(s) in drinking water above the MCL(s) can have both short-term (acute) and long-term or lifetime (chronic) effects. Potential health effects from long-term ingestion of water with levels of arsenic above the MCL (0.01 mg/L) include non-cancerous effects, such as cardiovascular, pulmonary, immunological, neurological and endocrine effects, and cancerous effects, including skin, bladder, lung, kidney, nasal passage, liver, and prostate cancer (USEPA 2005c).

1.2 METHOD

The method for this project follows that of the pilot study performed in 2004 and 2005 by TCEQ, BEG, and Parsons. The pilot study evaluated water supply alternatives for PWSs that supply drinking water with nitrate concentrations above U.S. Environmental Protection Agency (USEPA) and Texas drinking water standards. Three PWSs were evaluated in the pilot study to develop the method (*i.e.*, decision tree approach) for analyzing options for provision of compliant drinking water. This project is performed using the decision tree approach developed in the pilot study.

Other tasks of the feasibility study are as follows:

- Identifying available data sources;
- Gathering and compiling data;
- Conducting FMT evaluations of the selected PWSs;
- Performing a geologic and hydrogeologic assessment of the area;
- Developing treatment and non-treatment compliance alternatives;
- Assessing potential alternatives with respect to economic and non-economic criteria;
- Preparing a feasibility report; and
- Suggesting refinements to the approach for future studies.

The remainder of Section 1 of this report addresses the regulatory background, and provides a summary of arsenic abatement options. Section 2 describes the method used to develop and assess compliance alternatives. The groundwater sources of arsenic are addressed in Section 3. Findings for the Sherwood Estates PWS, along with development and evaluation of compliance alternatives, can be found in Section 4. Section 5 references the sources used in this report.

1.3 REGULATORY PERSPECTIVE

The Utilities & Districts and Public Drinking Water Sections of the TCEQ Water Supply Division are responsible for implementing requirements of the Federal Safe Drinking Water Act (SDWA), including oversight of PWSs and water utilities. These responsibilities include:

- Monitoring public drinking water quality;
- Processing enforcement referrals for MCL violators;
- Tracking and analyzing compliance options for MCL violators;
- Providing FMT assessment and assistance to PWSs;
- Participating in the Drinking Water State Revolving Fund program to assist PWSs in achieving regulatory compliance; and
- Setting rates for privately owned water utilities.

This project was conducted to assist in achieving these responsibilities.

1.4 ABATEMENT OPTIONS

When a PWS exceeds a regulatory MCL, the PWS must take action to correct the violation. The MCL exceedances at the Sherwood Estates PWS involve arsenic. The following subsections explore alternatives considered as potential options for obtain/providing compliant drinking water.

1.4.1 Existing Public Water Supply Systems

A common approach to achieving compliance is for the PWS to make arrangements with a neighboring PWS for water supply. For this arrangement to work, the PWS from which water is being purchased (supplier PWS) must have water in sufficient quantity and quality, the political will must exist, and it must be economically feasible.

1.4.1.1 Quantity

For purposes of this report, quantity refers to water volume, flowrate, and pressure. Before approaching a potential supplier PWS, the non-compliant PWS should determine its water demand on the basis of average day and maximum day. Peak instantaneous demands can be met through proper sizing of storage facilities. Further, the potential for obtaining the appropriate quantity of water to blend to achieve compliance should be considered. The concept of blending involves combining water with low levels of contaminants with non-compliant water in sufficient quantity so the resulting blended water is compliant. The exact blend ratio would depend on the quality of the water a potential supplier PWS can provide, and would likely vary over time. If high quality water is purchased, produced or otherwise obtained, blending can reduce the amount of high quality water required. Implementation of blending will require a control system to ensure the blended water is compliant.

If the supplier PWS does not have sufficient quantity, the non-compliant community could pay for the facilities necessary to increase the quantity to the extent necessary to supply the needs of the non-compliant PWS. Potential improvements might include, but are not limited to:

- Additional wells;
- Developing a new surface water supply;
- Additional or larger-diameter piping;
- Increasing water treatment plant capacity;
- Additional storage tank volume;
- Reduction of system losses;
- Higher-pressure pumps; or
- Upsized, or additional, disinfection equipment.

In addition to the necessary improvements, a transmission pipeline would need to be constructed to tie the two PWSs together. The pipeline must tie-in at a point in the supplier PWS where all the upstream pipes and appurtenances are of sufficient capacity to handle the new demand. In the non-compliant PWS, the pipeline must tie in at a point where no down stream bottlenecks are present. If blending is the selected method of operation, the tie-in point must be at the proper point of the existing non-compliant PWS to ensure that all water in the system is blended to achieve regulatory compliance.

1.4.1.2 Quality

If a potential supplier PWS obtains its water from the same aquifer (or same portion of the aquifer) as the non-compliant PWS, the quality of water may not be significantly better. However, water quality can vary significantly due to well location, even within the same aquifer. If localized areas with good water quality cannot be identified, the non-compliant PWS would need to find a potential supplier PWS that obtains its water from a different aquifer or from a surface water source. Additionally, a potential supplier PWS may treat non-compliant raw water to an acceptable level.

Surface water sources may offer a potential higher-quality source. Since there are significant treatment requirements, utilization of surface water for drinking water is typically most feasible for larger local or regional authorities or other entities that may provide water to several PWSs. Where PWSs that obtain surface water are neighbors, the non-compliant PWS may need to deal with those systems as well as with the water authorities that supply the surface water.

1.4.2 Potential for New Groundwater Sources

1.4.2.1 Existing Non-Public Supply Wells

Often there are wells not associated with PWSs located in the vicinity of the non-compliant PWS. The current use of these wells may be for irrigation, industrial purposes, domestic supply, stock watering, and other purposes. The process for investigating existing wells is as follows:

- Use existing data sources (see below) to identify wells in the areas that have satisfactory quality. For the Sherwood Estates PWS, the following standards could be used in a rough screening to identify compliant groundwater in surrounding systems:
  - Arsenic concentrations less than 0.008 mg/L (below the MCL of 0.01 mg/L);
- Review the recorded well information to eliminate those wells that appear to be unsuitable for the application. Often, the "Remarks" column in the Texas Water Development Board (TWDB) hard-copy database provides helpful information. Wells eliminated from consideration generally include domestic and stock wells, dug wells, test holes, observation wells, seeps and springs, destroyed wells, wells used by other communities, etc.
- Identify wells of sufficient size that have been used for industrial or irrigation purposes. Often the TWDB database will include well yields, which may indicate the likelihood that a particular well is a satisfactory source.

At this point in the process, the local groundwater control district (if one exists) should be contacted to obtain information about pumping restrictions. Also, preliminary cost estimates should be made to establish the feasibility of pursuing further well development options.

If particular wells appear to be acceptable, the owner(s) should be contacted to ascertain their willingness to work with the PWS. Once the owner agrees to participate in the program, questions should be asked about the wells. Many owners have more than one well, and would probably be the best source of information regarding the latest test dates, who tested the water, flowrates, and other well characteristics.

After collecting as much information as possible from cooperative owners, the PWS would then narrow the selection of wells and sample and analyze them for quality. Wells with good quality would then be potential candidates for test pumping. In some cases, a particular well may need to be refurbished before test pumping. Information obtained from test pumping would then be used in combination with information about the general characteristics of the aquifer to determine whether a well at this location would be suitable as a supply source.

It is recommended that new wells be installed instead of using existing wells to ensure that well characteristics are known and the well meets construction standards.

Permit(s) would then be obtained from the groundwater control district or other regulatory authority, and an agreement with the owner (purchase or lease, access easements, *etc*.) would then be negotiated.

1.4.2.2 Develop New Wells

If no existing wells are available for development, the PWS or group of PWSs has an option of developing new wells. Records of existing wells, along with other hydrogeologic information and modern geophysical techniques, should be used to identify potential locations for new wells. In some areas, the TWDB's Groundwater Availability Model (GAM) may be applied to indicate potential sources. Once a general area has been identified, land owners and regulatory agencies should be contacted to determine an exact location for a new well or well field. Pump tests and water quality tests would be required to determine if a new well will produce an adequate quantity of good quality water. Permits from the local groundwater control district or other regulatory authority could also be required for a new well.

1.4.3 Potential for Surface Water Sources

Water rights law dominates the acquisition of water from surface water sources. For a PWS, 100 percent availability of water is required, except where a back-up source is available. For PWSs with an existing water source, although it may be non-compliant because of elevated concentrations of one or more parameters, water rights may not need to be 100 percent available.

1.4.3.1 Existing Surface Water Sources

"Existing surface water sources" refers to municipal water authorities and cities that obtain water from surface water sources. The process of obtaining water from such a source is generally less time consuming and less costly than the process of developing a new source; therefore, it should be a primary course of investigation. An existing source would be limited by its water rights, the safe yield of a reservoir or river, or by its water treatment or water conveyance capability. The source must be able to meet the current demand and honor contracts with communities it currently supplies. In many cases, the contract amounts reflect projected future water demand based on population or industrial growth.

A non-compliant PWS would look for a source with sufficient spare capacity. Where no such capacity exists, the non-compliant PWS could offer to fund the improvements necessary to obtain the capacity. This approach would work only where the safe yield could be increased (perhaps by enlarging a reservoir) or where treatment capacity could be increased. In some instances water rights, where they are available, could possibly be purchased.

In addition to securing the water supply from an existing source, the non-compliant PWS would need to arrange for transmission of the water to the PWS. In some cases, that could require negotiations with, contracts with, and payments to an intermediate PWS (an intermediate PWS is one where the infrastructure is used to transmit water from a "supplier" PWS to a "supplied" PWS, but does not provide any additional treatment to the supplied water). The non-compliant PWS could be faced with having to fund improvements to the intermediate PWS in addition to constructing its own necessary transmission facilities.

1.4.3.2 New Surface Water Sources

Communication with the TCEQ and relevant planning groups from the beginning is essential in the process of obtaining a new surface water source. Preliminary assessment of the potential for acquiring new rights may be based on surface water availability maps located on the TWDB website. Where water rights appear to be available, the following activities need to occur:

- Discussions with TCEQ to indicate the likelihood of obtaining those rights. The TCEQ may use the Water Availability Model (WAM) to assist in the determination.
- Discussions with land owners to indicate potential treatment plant locations.
- Coordination with U.S. Army Corps of Engineers and local river authorities.
- Preliminary engineering design to determine the feasibility, costs, and environmental issues of a new treatment plant.

Should these discussions indicate that a new surface water source is the best option, the community would proceed with more intensive planning (initially obtaining funding), permitting, land acquisition, and detailed designs.

1.4.4 Identification of Treatment Technologies

Various treatment technologies were also investigated as compliance alternatives for treatment of arsenic to regulatory levels (*i.e.*, MCL). According to a recent USEPA report for small water systems with <10,000 customers (EPA/600/R-05/001) a number of drinking water treatment technologies are available to reduce arsenic concentrations in source water to below the new MCL of 10 μg/L, including:

- Ion exchange (IX);
- Reverse osmosis (RO);
- Electrodialysis reversal (EDR);
- Adsorption; and
- Coagulation/filtration.

1.4.5 Treatment Technologies Description

Many of the most effective arsenic removal processes available are iron-based treatment technologies such as chemical coagulation/filtration with iron salts, and adsorptive media with iron-based products. These processes are particularly effective at removing arsenic from aqueous systems because iron surfaces have a strong affinity for adsorbing arsenic. Other arsenic removal processes such as activated alumina and enhanced lime softening are more applicable to larger water systems because of their operational complexity and cost. A description and discussion of arsenic removal technologies applicable to smaller systems follow.

1.4.5.1 Ion Exchange

<u>Process</u> – In solution, salts separate into positively charged cations and negatively charged anions. Ion exchange is a reversible chemical process in which ions from an insoluble, permanent, solid resin bed are exchanged for ions in water. The process relies on the fact that certain ions are preferentially adsorbed on the ion exchange resin. Operation begins with a fully charged cation or anion bed, having enough positively or negatively charged ions to carry out the cation or anion exchange. Usually a polymeric resin bed is composed of millions of spherical beads about the size of medium sand grains. As water passes the resin bed, the charged ions are released into the water, being substituted or replaced with the contaminants in the water (ion exchange). When the resin becomes exhausted of positively or negatively charged ions, the bed must be regenerated by passing a strong, sodium chloride solution over the resin bed, displacing the contaminant ions with sodium ions for cation exchange and chloride ion for anion exchange. Many different types of resins can be used to reduce dissolved contaminant concentrations. The IX treatment train for groundwater typically includes cation or anion resin beds with a regeneration system, chlorine disinfection, and clear well storage. Treatment trains for surface water may also include raw water pumps, debris screens, and filters for pre-treatment. Additional treatment or management of the concentrate and the removed solids will be necessary prior to disposal. For arsenic removal, an anion exchange resin in the chloride form is used to remove arsenate [As(V)]. Because arsenite [As(III)] occurs in water below pH 9 with no ionic charge, As(III) is not consistently removed by the anionic exchange process.

<u>Pretreatment</u> – Pretreatment guidelines are available on accepted limits for pH, organics, turbidity, and other raw water characteristics. Pretreatment may be required to reduce excessive amounts of total suspended solids (TSS), iron, and manganese, which could plug the resin bed, and typically includes media or carbon filtration. In addition, chlorination or oxidation may be required to convert As(III) to As(V) for effective removal.

<u>Maintenance</u> – The IX resin requires regular on-site regeneration, the frequency of which depends on raw water characteristics, the contaminant concentration, and the size and number of IX vessels. Many systems have undersized the IX vessels only to realize higher than necessary operating costs. Preparation of the sodium chloride solution is required. If used, filter replacement and backwashing will be required.

<u>Waste Disposal</u> – Approval from local authorities is usually required for disposal of concentrate from the regeneration cycle (highly concentrated salt solution); occasional solid wastes (in the form of broken resin beads) which are backwashed during regeneration; and if used, spent filters and backwash wastewater.

Advantages (IX)

- Well established process for arsenic removal.

- Fully automated and highly reliable process.
- Suitable for small and large installations.

Disadvantages (IX)

- Requires salt storage; regular regeneration.
- Concentrate disposal.
- Resins are sensitive to the presence of competing ions such as sulfate.

In considering application of IX for inorganics removal, it is important to understand what the effect of competing ions will be, and to what extent the brine can be recycled. Similar to activated alumina, IX exhibits a selectivity sequence, which refers to an order in which ions are preferred. Sulfate competes with both nitrate and arsenic, but more aggressive with arsenic in anion exchange. Source waters with TDS levels above 500 mg/L or 120 mg/L sulfate are not amenable to IX treatment for arsenic removal. Spent regenerant is produced during IX bed regeneration, and this spent regenerant may have high concentrations of sorbed contaminants which can be expensive to treat and/or dispose. Research has been conducted to minimize this effect; recent research on arsenic removal shows that the brine can be reduced as many as 25 times.

1.4.5.2 Reverse Osmosis

Process – RO is a pressure-driven membrane separation process capable of removing dissolved solutes from water by means of particle size and electrical charge. The raw water is typically called feed; the product water is called permeate, and the concentrated reject is called concentrate. Common RO membrane materials include asymmetric cellulose acetate and polyamide thin film composite. Common RO membrane configurations include spiral wound hollow fine fiber, but most of RO systems to date are of the spiral wound type. A typical RO installation includes a high pressure feed pump with chemical feed; parallel first and second stage membrane elements in pressure vessels; and valves and piping for feed, permeate, and concentrate streams. Factors influencing membrane selection are cost, recovery, rejection, raw water characteristics, and pretreatment. Factors influencing performance are raw water characteristics, pressure, temperature, and regular monitoring and maintenance. RO is capable of achieving over 97 percent removal of As(V) and 92 percent removal of As(III). The treatment process is relatively insensitive to pH. Water recovery is typically 60-80 percent, depending on the raw water characteristics. The concentrate volume for disposal can be significant.

Pretreatment – RO requires careful review of raw water characteristics and pretreatment needs to prevent membranes from fouling, scaling or other membrane degradation. Removal or sequestering of suspended and colloidal solids is necessary to prevent fouling, and removal of sparingly soluble constituents such as calcium, magnesium, silica, sulfate, barium, etc. may be required to prevent scaling. Pretreatment can include media filters, ion exchange softening, acid and antiscalant feed, activated carbon of bisulfite feed to dechlorinate, and cartridge filters to remove any remaining suspended solids to protect membranes from upsets.

Maintenance – Monitoring rejection percentage is required to ensure contaminant removal below MCL. Regular monitoring of membrane performance is necessary to determine fouling, scaling, or other membrane degradation. Acidic or caustic solutions are regularly flushed through the system at high volume/low pressure with a cleaning agent to remove foulants and scalants. Frequency of membrane replacement is dependent on raw water characteristics, pretreatment, and maintenance.

Waste Disposal – Pretreatment waste streams, concentrate flows, spent filters, and membrane elements all require approved disposal methods.

Advantages (RO)

- Can remove both As(III) and As(V) effectively; and
- Can remove other undesirable dissolved constituents and excessive TDS, if required.

Disadvantages (RO)

- Relatively expensive to install and operate.
- Need sophisticated monitoring systems.
- Need to handle multiple chemicals.
- Waste of water because of the significant concentrate flows
- High silica concentration limits water recovery rate
- Concentrate disposal required.

RO is an expensive alternative to remove arsenic and is usually not economically competitive with other processes unless nitrate and/or TDS removal is also required. The biggest drawback for using RO to remove arsenic is the waste of water through concentrate disposal, which is also difficult or expensive because of the volume involved.

1.4.5.3 Electrodialysis Reversal

Process. EDR is an electrochemical process in which ions migrate through ion-selective semi-permeable membranes as a result of their attraction to two electrically charged electrodes. A typical EDR system includes a membrane stack with a number of cell pairs, each consisting of a cation transfer membrane, a demineralized flow spacer, an anion transfer membrane, and a concentrate flow spacer. Electrode compartments are at opposite ends of the stack. The influent feed water (chemically treated to prevent precipitation) and the concentrated reject flow in parallel across the membranes and through the demineralized and concentrate flow spaces, respectively. The electrodes are continually flushed to reduce fouling or scaling. Careful consideration of flush feed water is required. Typically, the membranes are cation or anion exchange resins cast in sheet form; the spacers are high density polyethylene; and the electrodes are inert metal. EDR stacks are tank-contained and often staged. Membrane selection is based on review of raw water characteristics. A single-stage EDR system usually removes 40-50 percent of arsenic and TDS. Additional stages are required to achieve higher removal efficiency if necessary. EDR uses the technique of regularly reversing the polarity of the electrodes, thereby freeing accumulated ions on the membrane surface. This process requires additional plumbing and electrical controls, but it increases membrane life, may require less added chemicals, and eases cleaning. The conventional EDR treatment train typically includes EDR membranes, chlorine disinfection, and clearwell storage. Treatment of surface water may also require pretreatment steps such as raw water pumps, debris screens, rapid mix with addition of a coagulant, slow mix flocculator, sedimentation basin or clarifier, and gravity filters. Microfiltration (MF) could be used in placement of flocculation, sedimentation and filtration. Additional treatment or management of the concentrate and the removed solids would be necessary prior to disposal.

Pretreatment. There are pretreatment requirements for pH, organics, turbidity, and other raw water characteristics. EDR typically requires chemical feed to prevent scaling, acid addition for pH adjustment, and a cartridge filter for prefiltration.

Maintenance. EDR membranes are durable, can tolerate a pH range from 1 to 10, and temperatures to 115 degrees Fahrenheit (ºF) for cleaning. They can be removed from the unit and scrubbed. Solids can be washed off by turning the power off and letting water circulate through the stack. Electrode washes flush out byproducts of electrode reaction. The byproducts are hydrogen, formed in the cathode space, and oxygen and chlorine gas, formed in the anode space. If the chlorine is not removed, toxic chlorine gas may form. Depending on raw water characteristics, the membranes would require regular maintenance or replacement. EDR requires reversing the polarity. Flushing at high volume/low pressure continuously is required to clean electrodes. If used, pretreatment filter replacement and backwashing would be required. The EDR stack must be disassembled, mechanically cleaned, and reassembled at regular intervals.

Waste Disposal. Highly concentrated reject flows, electrode cleaning flows, and spent membranes require approved disposal methods. Pretreatment processes and spent materials also require approved disposal methods.

Advantages (EDR)

- EDR can operate with minimal fouling or scaling or chemical addition.
- Low pressure requirements; typically quieter than RO.
- Long membrane life expectancy; EDR extends membrane life and reduces maintenance.
- More flexible than RO in tailoring treated water quality requirements.

Disadvantages (EDR)

- Not suitable for high levels of iron, manganese, and hydrogen sulfide.
- High energy usage at higher TDS water.

EDR can be quite expensive to run because of the energy it uses. However, because it is generally automated and allows for small systems. It can be used to simultaneously reduce arsenic and TDS.

1.4.5.4 Adsorption

Process – The adsorptive media process is a fixed-bed process by which ions in solution, such as arsenic, are removed by available adsorptive sites on an adsorptive media. When the available adsorptive sites are filled, spent media may be regenerated or simply thrown away and replaced with new media. Granular activated alumina (AA) was the first adsorptive media successfully applied for the removal of arsenic from water supplies. More recently, other adsorptive media (mostly iron-based) have been developed and marketed for arsenic removal. Recent USEPA studies demonstrated that iron-based adsorption media typically have higher arsenic removal capacities compared to alumina-based media. In the USEPA-sponsored Round 1 full-scale demonstration of arsenic removal technologies for small water systems program, the selected arsenic treatment technologies included nine adsorptive media systems, one IX system, one coagulation/filtration system, and one process modification.

The selected adsorptive media systems used four different adsorptive media, including three iron-based media (*e.g.*, ADI's G2, Severn Trent and AdEdge's E33, and U.S. Filter's GFH), and one iron-modified AA media (*e.g.*, Kinetico's AAFS50, a product of Alcan). The G2 media is a dry powder of diatomaceous earth impregnated with a coating of ferric hydroxide, developed by ADI specifically for arsenic adsorption. ADI markets G2 for both As(V) and As(III) removal, but it preferentially removes As(V). G2 media adsorbs arsenic most effectively at pH values within the 5.5 to 7.5 range, and less effectively at a higher pH value.

The Bayoxide® E33 media was developed by Bayer AG for removal of arsenic from drinking water supplies. It is a dry granular iron oxide media designed to remove dissolved arsenic via adsorption onto its ferric oxide surface. Severn Trent markets the media in the U.S. for As(III) and As(V) removal as Sorb-33, and offers several arsenic package units (APU) with flowrates ranging from 150 to 300 gpm. Another company, AdEdge, provides similar systems using the same media (marketed as AD-33) with flowrates ranging from 5 to 150 gpm. 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 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).

GFH is a moist granular ferric hydroxide media produced by GEH Wasserchemie GmbH of Germany and marketed by U.S. Filter under an exclusive marketing agreement. GFH is capable of adsorbing both As(V) and As(III). GFH media adsorb arsenic with a pH range of 5.5 to 9.0, but less effectively at the upper end of this range. Competing ions such as silica and phosphate in source water can adsorb onto GFH media, thus reducing the arsenic removal capacity of the media.

The AAFS50 is a dry granular media of 83 percent alumina and a proprietary iron-based additive to enhance the arsenic adsorption performance. Standard 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 to achieve optimum arsenic removal. The AAFS50 product is modified with an iron-based additive to improve its performance and increase the pH range within which it can achieve effective removal. Optimum arsenic removal efficiency is achieved with a pH of the feed water less than 7.7. Competing ions such as fluoride, sulfate, silica, and phosphate can adsorb onto AAFS50 media, and potentially reduce its arsenic removal capacity. The adsorption capacity of AAFS50 can be impacted by both high levels of silica (>40 mg/L) and phosphate (>1 mg/L). The vendor recommended that the system be operated in a series configuration to minimize the chance for arsenic breakthrough to impact drinking water quality.

All iron-based or iron-modified adsorptive media are of the throwaway type after exhaustion. The operations of these adsorption systems are quite similar and simple. Some of the technologies such as the E33 and GFH media have been operated successfully on large scale plants in Europe for several years.

Pretreatment – The adsorptive media are primarily used to remove dissolved arsenic and not for suspended solids removal. Pretreatment to remove TSS may be required if raw water turbidity is >0.3 NTU. However, most well waters are low in turbidity and hence, pre-filtration is usually not required. Pre-chlorination may be required to oxidize As(III) to As(V) if the proportion of As(III) is high. No pH adjustment is required unless pH is relatively high.

Maintenance – Maintenance for the adsorption media system is minimal if no pretreatment is required. Backwash is required infrequently (monthly) and replacement and disposal of the exhausted media occur between 1 to 3 years, depending on average water consumption, the concentrations of arsenic and competing ions in the raw water, and the media bed volume.

Waste Disposal – If no pretreatment is required there is minimal waste disposal involved with the adsorptive media system. Disposal of backwash wastewater is required especially during startup. Regular backwash is infrequent, and disposal of the exhausted media occurs once every 1 to 3 years, depending on operating conditions. The exhausted media are usually considered non-hazardous waste.

Advantages (Adsorption)

- Some adsorbents can remove both As(III) and As(V); and
- Very simple to operate.

Disadvantages (Adsorption)

- Relatively new technology; and
- Need replacement of adsorption media when exhausted.

The adsorption media process is the most simple and requires minimal operator attention compared to other arsenic removal processes. The process is most applicable to small wellhead systems with low or moderate arsenic concentrations with no treatment process in place (*e.g.*, iron and manganese removal; if treatment facilities for iron and/or manganese removal are already in place, incorporating ferric chloride coagulation in the existing system would be a more cost-effective alternative for arsenic removal). The choice of media will depend on raw water characteristics, life cycle cost, and experience of the vendor. Many of the adsorption media are at the field-trial stage, but others are already being used in full-scale applications throughout Europe and the U.S. Pilot testing may or may not be necessary prior to implementation depending on the experience of the vendor with similar water characteristics.

1.4.5.5 Coagulation/Filtration and Iron Removal Technologies

Process – Iron removal processes can be used to removal arsenic from drinking water supplies. Iron removal processes involve oxidation of soluble iron and As(III), adsorption and/or co-precipitation of As(V) onto iron hydroxides, and filtration. The filtration can be accomplished with granular media filter or microfilter. When iron in the raw water is inadequate to accomplish arsenic removal an iron salt such as ferric chloride is added to the water to form ferric hydroxide. The iron removal process is commonly called coagulation/filtration because iron in the form of ferric chloride is a common coagulant. The actual capacity to remove arsenic during iron removal depends on a number of factors, including the amount of arsenic present, arsenic speciation, pH, amount and form of iron present, and existence of competing ions, such as phosphate, silicate, and natural organic matter. The filters used in groundwater treatment are usually pressure filters feeding directly by the well pumps. The filter media can be regular dual media filters or proprietary media such as the engineered ceramic filtration media, Macrolite®, developed by Kinetico. Macrolite® is a low-density, spherical media designed to allow for filtration rates up to 10 gpm/ft^2, which is a higher loading rate than commonly used for conventional filtration media.

Pretreatment – Pre-chlorination to oxidize As(III) to As(V) is usually required for most groundwater sources. The adjustment of pH is required only for relatively high pH value. Coagulation with the feed of ferric chloride is required for this process. Sometimes a 5-minute contact tank is required ahead the filters if the pH is high.

Maintenance – Maintenance is mainly to handle ferric chloride chemical and feed system, and for regular backwash of the filters. No filter replacement is required for this process.

Waste Disposal – The waste from the coagulation/filtration process is mainly the iron hydroxide sludge with adsorbed arsenic in the backwash water. The backwash water can be discharged to a public sewer if it is available. If a sewer is not available, the backwash water can be discharged to a storage and settling tank from where the supernatant is recycled in a controlled rate to the front of the treatment system and the settled sludge can be disposed of periodically to a landfill. The iron hydroxide sludge is usually not classified as hazardous waste.

Advantages (Coagulation/Filtration)

- Very established technology for arsenic removal; and
- Most economical process for arsenic removal.

Disadvantages (Coagulation/Filtration)

- Need to handle chemical;
- Need to dispose of regular backwash wastewater; and
- Need to dispose of sludge.

The coagulation/filtration process is usually the most economical arsenic removal alternative, especially if a public sewer is available for accepting the discharge of the backwash water. However, because of the regular filter backwash requirements, more operation and maintenance attention is required from the utilities. Because of potential interference by competing ions bench-scale or pilot scaling testing may be required to ensure that the arsenic MCL can be met with this process alternative.

1.4.6 Point-of-Entry and Point-of-Use Treatment Systems

Point-of-entry (POE) and POU treatment systems can be used to provide compliant drinking water. For arsenic removal, these systems typically use small RO treatment units installed “under the sink” in the case of POU, and where water enters a residence or building in the case of POE. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive. POE and POU treatment units would be purchased and owned by the PWS. These solutions are decentralized in nature, and require utility personnel to enter into houses or at least onto private property for installation, maintenance, and testing. Due to the small number of treatment units that would be employed which would be primarily out of the control of the PWS, it is very difficult to ensure 100 percent compliance. Prior to selection of a POE or POU program for implementation, consultation with TCEQ would be required to address measurement and determination of the level of compliance.

The SDWA [§1412(b)(4)(E)(ii)] regulates the design, management, and operation of POU and POE treatment units used to achieve compliance with an MCL. These restrictions include:

- POU and POE treatment units must be owned, controlled, and maintained by the water system, although the utility may hire a contractor to ensure proper operation and maintenance (O&M) and compliance with MCLs. The water system must retain unit ownership and oversight of unit installation, maintenance and sampling; the utility is ultimately the responsible party for regulatory compliance. The water system staff need not perform all installation, maintenance, or management functions, as these tasks may be contracted to a third party, but the final responsibility for quality and quantity of the water supplied to the community resides with the water system, and the utility must monitor all contractors closely.

Responsibility for the O&M of POU or POE devices installed for SDWA compliance may not be delegated to homeowners.

- POU and POE units must have mechanical warning systems to automatically notify customers of operational problems. Each POU or POE treatment device must be equipped with a warning device (*e.g.*, alarm, light) that will alert users when their unit is no longer adequately treating their water. As an alternative, units may be equipped with an automatic shut-off mechanism to meet this requirement.
- If the American National Standards Institute has issued product standards for a specific type of POU or POE treatment unit, only those units that have been independently certified according to those standards may be used as part of a compliance strategy.

With regard to using POE and POU devices for SDWA compliance, the following observations were made (Raucher, *et al.* 2004):

- If POU devices are used as an SDWA compliance strategy, certain consumer behavioral changes will be necessary (e.g., encouraging people to drink water only from certain treated taps) to ensure comprehensive consumer health protection.
- Although not explicitly prohibited in SDWA, USEPA indicates that POU treatment devices should not be used to treat for radon or for most volatile organic contaminants to achieve compliance, because POU devices do not provide 100 percent protection against inhalation or contact exposure to those contaminants at untreated taps (*e.g.*, shower heads).
- Liability – PWSs considering unconventional treatment options (POU, POE, or bottled water) must address liability issues. These could be meeting the drinking water standards, property entry and ensuing liabilities, and damage arising from improper installation or improper function of the POU and POE devices.

1.4.7 Water Delivery or Central Drinking Water Dispensers

Current USEPA regulations (40 Code of Federal Regulations [CFR] 141.101) prohibit the use of bottled water to achieve compliance with an MCL, except on a temporary basis. State regulations do not directly address the use of bottled water. Use of bottled water at a non-compliant PWS would be on a temporary basis. Every 3 years, the PWSs that employ interim measures are required to present the TCEQ with estimates of costs for piping compliant water to their systems. As long as the projected costs remain prohibitively high, the bottled water interim measure is extended. Until USEPA amends the noted regulation, the TCEQ is unable to accept water delivery or central drinking water dispensers as compliance solutions.

Central provision of compliant drinking water would consist of having one or more dispensers of compliant water where customers could come to fill containers with drinking water. The centralized water source could be from small to medium-sized treatment units or could be compliant water delivered to the central point by truck.

Water delivery is an interim measure for providing compliant water. As an interim measure for a small impacted population, providing delivered drinking water may be cost effective. If the susceptible population is large, the cost of water delivery would increase significantly.

Water delivery programs require consumer participation to a varying degree. Ideally, consumers would have to do no more than they currently do for a piped-water delivery system. Least desirable are those systems that require maximum effort on the part of the customer (*e.g.*, customer has to travel to get the water, transport the water, and physically handle the bottles). Such a system may appear to be lowest cost to the utility; however, should a consumer experience ill effects from contaminated water and take legal action, the ultimate cost could increase significantly.

The ideal system would:

- Completely identify the susceptible population. If bottled water is only provided to customers who are part of the susceptible population, the utility should have an active means of identifying the susceptible population. Problems with illiteracy, language fluency, fear of legal authority, desire for privacy, and apathy may be reasons that some members of the susceptible population do not become known to the utility, and do not take part in the water delivery program.
- Maintain customer privacy by eliminating the need for utility personnel to enter the home.
- Have buffer capacity (*e.g.,* two bottles in service, so when one is empty, the other is being used over a time period sufficient to allow the utility to change out the empty bottle).
- Provide for regularly scheduled delivery so the customer would not have to notify the utility when the supply is low.
- Use utility personnel and equipment to handle water containers, without requiring customers to lift or handle bottles with water in them.
- Be sanitary (*e.g.,* where an outside connection is made, contaminants from the environment must be eliminated).
- Be vandal-resistant.
- Avoid heating the water due to exterior temperatures and solar radiation.
- Avoid freezing the water.

SECTION 2
EVALUATION METHODS

2.1 DECISION TREE

The decision tree is a flow chart for conducting feasibility studies for a non-compliant PWS. The decision tree is shown in Figures 2.1 through 2.4. The tree guides the user through a series of phases in the design process. Figure 2.1 shows Tree 1, which outlines the process for defining the existing system parameters, followed by optimizing the existing treatment system operation. If optimizing the existing system does not correct the deficiency, the tree leads to six alternative preliminary branches for investigation. The groundwater branch leads through investigating existing wells to developing a new well field. The treatment alternatives address centralized and on-site treatment. The objective of this phase is to develop conceptual designs and cost estimates for the six types of alternatives. The work done for this report follows through Tree 1 and Tree 2, as well as a preliminary pass through Tree 4.

Tree 3, which begins at the conclusion of the work for this report, starts with a comparison of the conceptual designs, selecting the two or three alternatives that appear to be most promising, and eliminating those alternatives which are obviously infeasible. It is envisaged that a process similar to this would be used by the study PWS to refine the list of viable alternatives. The selected alternatives are then subjected to intensive investigation, and highlighted by an investigation into the socio-political aspects of implementation. Designs are further refined and compared, resulting in selection of a preferred alternative. The steps for assessing the financial and economic aspects of the alternatives (one of the steps in Tree 3) are given in Tree 4 in Figure 2.4.

2.2 DATA SOURCES AND DATA COLLECTION

2.2.1 Data Search

2.2.1.1 Water Supply Systems

The TCEQ maintains a set of files on public water systems, utilities, and districts at its headquarters in Austin, Texas. The files are organized under two identifiers: a PWS identification number and a Certificate of Convenience and Necessity (CCN) number. The PWS identification number is used to retrieve four types of files:

- CO – Correspondence,
- CA – Chemical analysis,
- MOR – Monthly operating reports (quality/quantity), and
- FMT – Financial, managerial and technical issues.

Figure 2.1
TREE 1 – EXISTING FACILITY ANALYSIS

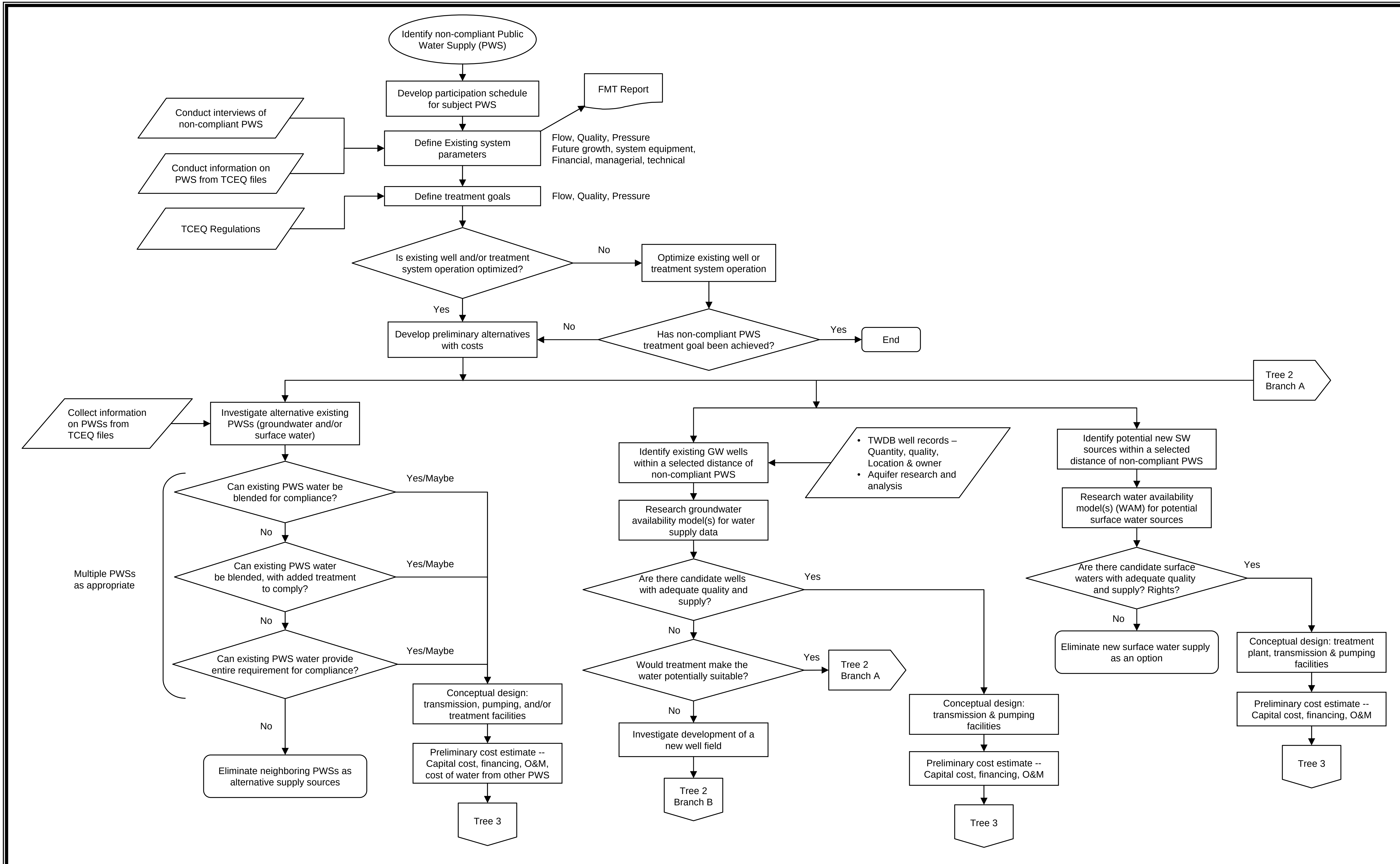


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATIVES

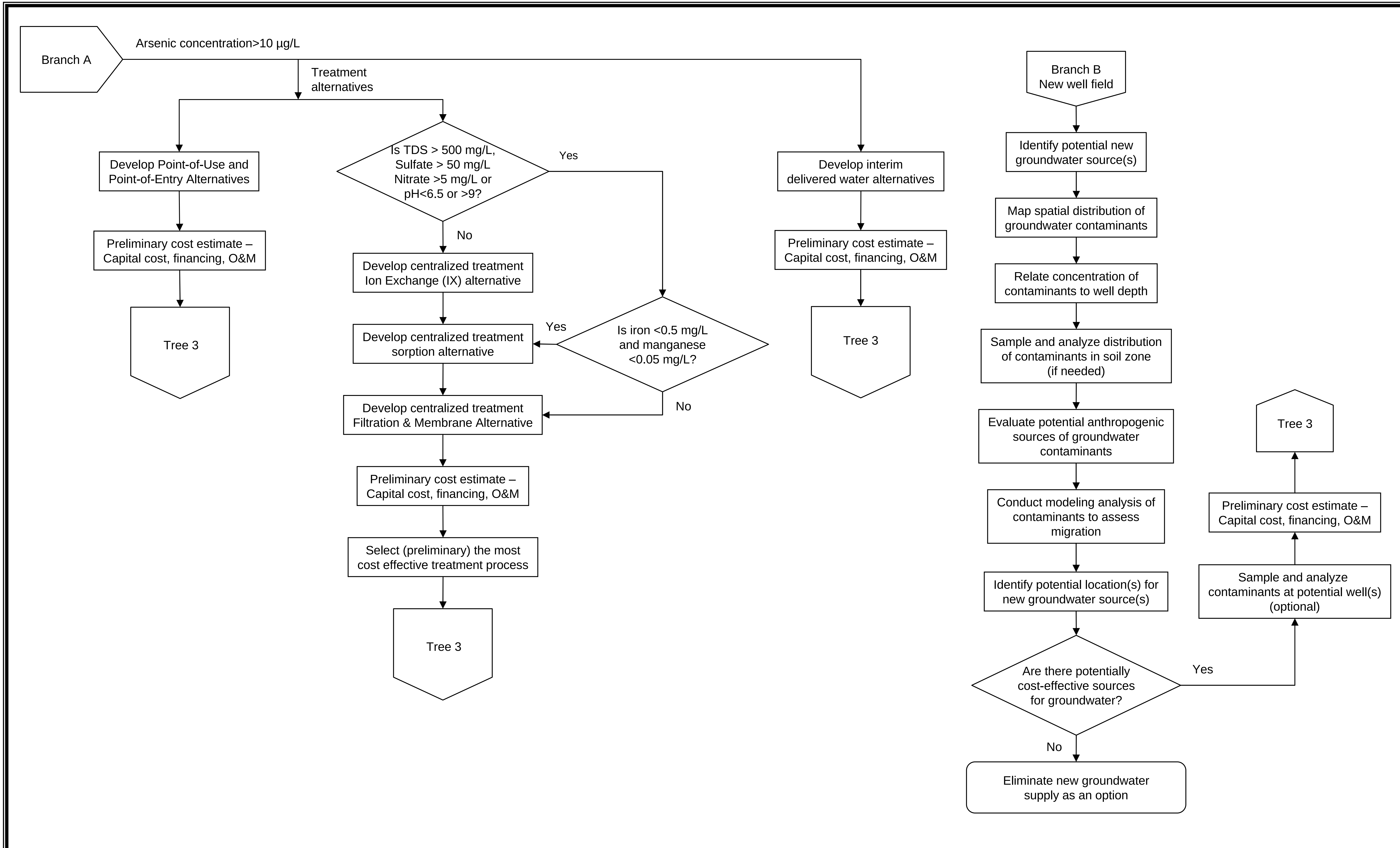


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS

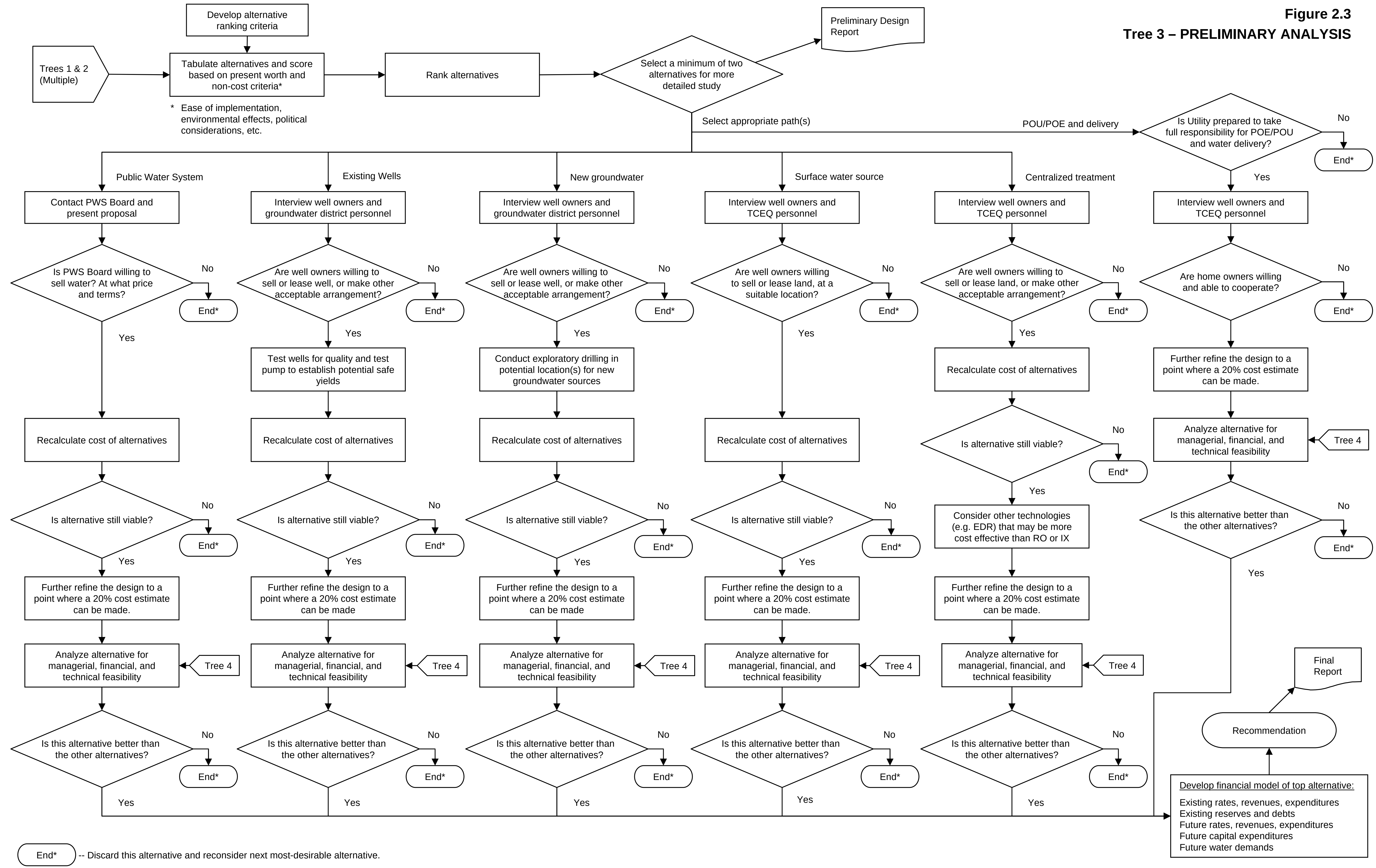
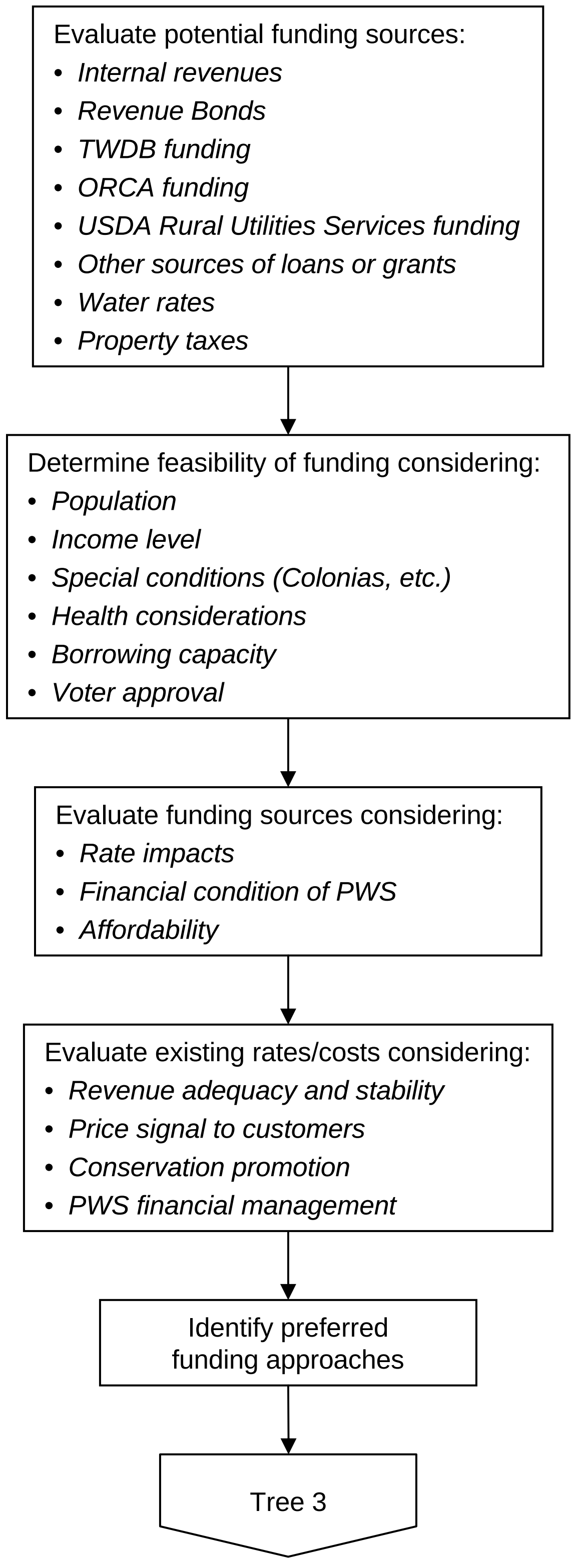


Figure 2.4
TREE 4 – FINANCIAL



The CCN files generally contain a copy of the system's Certificate of Convenience and Necessity, along with maps and other technical data.

These files were reviewed for the PWS and surrounding systems.

The following websites were consulted to identify the water supply systems in the area:

- Texas Commission on Environmental Quality www3.tnrcc.state.tx.us/iwud/pws/index.cfm?. Under "Advanced Search," type in the name(s) of the County(ies) in the area to get a listing of the public water supply systems.
- USEPA Safe Drinking Water Information System www.epa.gov/safewater/data/getdata.html

Groundwater Control Districts were identified on the TWDB web site, which has a series of maps covering various groundwater and surface water subjects. One of those maps shows groundwater control districts in the State of Texas.

2.2.1.2 Existing Wells

The TWDB maintains a groundwater database available at www.twdb.state.tx.us that has two tables with helpful information. The "Well Data Table" provides a physical description of the well, owner, location in terms of latitude and longitude, current use, and for some wells, items such as flowrate, and nature of the surrounding formation. The "Water Quality Table" provides information on the aquifer and the various chemical concentrations in the water.

2.2.1.3 Surface Water Sources

Regional planning documents were consulted for lists of surface water sources.

2.2.1.4 Groundwater Availability Model

GAMs, developed by the TWDB, are planning tools and should be consulted as part of a search for new or supplementary water sources. The GAM for the Ogallala and Edwards-Trinity Plateau aquifers was investigated as a potential tool for identifying available and suitable groundwater resources.

2.2.1.5 Water Availability Model

The WAM is a computer-based simulation predicting the amount of water that would be in a river or stream under a specified set of conditions. WAMs are used to determine whether water would be available for a newly requested water right or amendment. If water is available, these models estimate how often the applicant could count on water under various conditions (*e.g.*, whether water would be available only 1 month out of the year, half the year, or all year, and whether that water would be available in a repeat of the drought of record).

WAMs provide information that assist TCEQ staff in determining whether to recommend the granting or denial of an application.

2.2.1.6 Financial Data

Financial data were collected through a site visit. Data sought included:

- Annual Budget
- Audited Financial Statements
    - Balance Sheet
    - Income and Expense Statement
    - Cash Flow Statement
    - Debt Schedule
- Water Rate Structure
- Water Use Data
    - Production
    - Billing
    - Customer Counts

2.2.1.7 Demographic Data

Basic demographic data were collected from the 2000 U.S. Census to establish incomes and eligibility for potential low cost funding for capital improvements. Median household income (MHI) and number of families below poverty level were the primary data points of significance. If available, MHI for the customers of the PWS should be used. In addition, unemployment data were collected from current U.S. Bureau of Labor Statistics. These data were collected for the following levels: national, state, and county.

2.2.2 PWS Interviews

2.2.2.1 PWS Capacity Assessment Process

A capacity assessment is the industry standard term for an evaluation of a water system's FMT capacity to effectively deliver safe drinking water to its customers now and in the future at a reasonable cost, and to achieve, maintain, and plan for compliance with applicable regulations. The assessment process involves interviews with staff and management who have a responsibility in the O&M of the system.

FMT capacity are individual yet highly interrelated components of a system's capacity. A system cannot sustain capacity without maintaining adequate capability in all three components.

Financial capacity is a water system's ability to acquire and manage sufficient financial resources to allow the system to achieve and maintain compliance with SDWA regulations. Financial capacity refers to the financial resources of the water system, including but not limited to revenue sufficiency, credit worthiness, and fiscal controls.

Managerial capacity is the ability of a water system to conduct its affairs so that the system is able to achieve and maintain compliance with SDWA requirements. Managerial capacity refers to the management structure of the water system, including but not limited to ownership accountability, staffing and organization, and effective relationships to customers and regulatory agencies.

Technical capacity is the physical and operational ability of a water system to achieve and maintain compliance with the SDWA regulations. It refers to the physical infrastructure of the water system, including the adequacy of the source water, treatment, storage and distribution infrastructure. It also refers to the ability of system personnel to effectively operate and maintain the system and to otherwise implement essential technical knowledge.

Many aspects of water system operations involve more than one component of capacity. Infrastructure replacement or improvement, for example, requires financial resources, management planning and oversight, and technical knowledge. A deficiency in any one area could disrupt the entire effort. A system that is able to meet both its immediate and long-term challenges demonstrates that it has sufficient FMT capacity.

Assessment of the FMT capacity of the PWS was based on an approach developed by the New Mexico Environmental Finance Center (NMEFC), which is consistent with TCEQ FMT assessment process. This method was developed from work the NMEFC did while assisting USEPA Region 6 in developing and piloting groundwater comprehensive performance evaluations. The NMEFC developed a standard list of questions that could be asked of water system personnel. The list was then tailored slightly to have two sets of questions – one for managerial and financial personnel, and one for operations personnel (the questions are included in Appendix A). Each person with a role in the FMT capacity of the system was asked the applicable standard set of questions individually. The interviewees were not given the questions in advance and were not told the answers others provided. Also, most of the questions are open ended type questions so they were not asked in a fashion to indicate what would be the "right" or "wrong" answer. The interviews lasted between 45 to 75 minutes depending on the individual's role in the system and the length of the individual's answers.

In addition to the interview process, visual observations of the physical components of the system were made. A technical information form was created to capture this information. This form is also contained in Appendix A. This information was considered supplemental to the interviews because it served as a check on information provided in the interviews. For example, if an interviewee stated he or she had an excellent preventative maintenance schedule and the visit to the facility indicated a significant amount of deterioration (more than would be expected for the age of the facility) then the preventative maintenance program could be further investigated or the assessor could decide that the preventative maintenance program was inadequate.

Following interviews and observations of the facility, answers that all personnel provided were compared and contrasted to provide a clearer picture of the true operations at the water system. The intent was to go beyond simply asking the question, “Do you have a budget?” to actually finding out if the budget was developed and being used appropriately. For example, if a water system manager was asked the question, “Do you have a budget?” he or she may say, “yes” and the capacity assessor would be left with the impression that the system is doing well in this area. However, if several different people are asked about the budget in more detail, the assessor may find that although a budget is present, operations personnel do not have input into the budget, the budget is not used by the financial personnel, the budget is not updated regularly, or the budget is not used in setting or evaluating rates. With this approach, the inadequacy of the budget would be discovered and the capacity deficiency in this area would be noted.

Following the comparison of answers, the next step was to determine which items noted as a potential deficiency truly had a negative effect on the system’s operations. If a system had what appeared to be a deficiency, but this deficiency was not creating a problem in terms of the operations or management of the system, it was not considered critical and may not have needed to be addressed as a high priority. As an example, the assessment may have revealed an insufficient number of staff members to operate the facility. However, it may also have been revealed that the system was able to work around that problem by receiving assistance from a neighboring system, so no severe problems resulted from the number of staff members. Although staffing may not be ideal, the system does not need to focus on this particular issue. The system needs to focus on items that are truly affecting operations. As an example of this type of deficiency, a system may lack a reserve account which can then lead the system to delay much-needed maintenance or repair on its storage tank. In this case, the system needs to address the reserve account issue so that proper maintenance can be completed.

The intent was to develop a list of capacity deficiencies with the greatest impact on the system’s overall capacity. Those were the most critical items to address through follow-up technical assistance or by the system itself.

2.2.2.2 Interview Process

PWS personnel were interviewed by the project team, and each was interviewed separately. Interview forms were completed during each interview.

2.3 ALTERNATIVE DEVELOPMENT AND ANALYSIS

The initial objective for developing alternatives to address compliance issues was to identify a comprehensive range of possible options that can be evaluated to determine which are the most promising for implementation. Once the possible alternatives are identified, they must be defined in sufficient detail so a conceptual cost estimate (capital and O&M costs) can be developed. These conceptual cost estimates are used to compare the affordability of compliance alternatives, and to give a preliminary indication of rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation. The basis for the unit costs used for the compliance alternative cost estimates is summarized in Appendix B. Other non-economic factors for the alternatives, such as reliability and ease of implementation, are also addressed.

2.3.1 Existing PWS

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 25 miles from the non-compliant PWSs were not considered because the length of the pipeline required would make the alternative cost prohibitive. The quality of water provided was also investigated. For neighboring PWSs with compliant water, options for water purchase and/or expansion of existing well fields were considered. The neighboring PWSs with non-compliant water were considered as possible partners in sharing the cost for obtaining compliant water either through treatment or developing an alternate source.

The neighboring PWSs were investigated to get an idea of the water sources in use and the quantity of water that might be available for sale. They were contacted to identify key locations in their systems where a connection might be made to obtain water, and to explore on a preliminary basis their willingness to partner or sell water. Then, the major system components that would be required to provide compliant water were identified. The major system components included treatment units, wells, storage tanks, pump stations, and pipelines.

Once the major components were identified, a preliminary design was developed to identify sizing requirements and routings. A capital cost estimate was then developed based on the preliminary design of the required system components. An annual O&M cost was also estimated to reflect the change in O&M expenditures that would be needed if the alternative was implemented.

Non-economic factors were also identified. Ease of implementation was considered, as well as the reliability for providing adequate quantities of compliant water. Additional factors were whether implementation of an alternative would require significant increase in the management or technical capability of the PWS, and whether the alternative had the potential for regionalization.

2.3.2 New Groundwater Source

It was not possible in the scope of this study to determine conclusively whether new wells could be installed to provide compliant drinking water. In order to evaluate potential new groundwater source alternatives, three test cases were developed based on distance from the PWS intake point. The test cases were based on distances of 10 miles, 5 miles, and 1 mile. It was assumed that a pipeline would be required for all three test cases, and a storage tank and pump station would be required for the 10-mile and 5-mile alternatives. It was also assumed that new wells would be installed, and that their depths would be similar to the depths of the existing wells, or other existing drinking water wells in the area.

A preliminary design was developed to identify sizing requirements for the required system components. A capital cost estimate was then developed based on the preliminary design of the required system components. An annual O&M cost was also estimated to reflect the change (*i.e.*, from current expenditures) in O&M expenditures that would be needed if the alternative was implemented.

Non-economic factors were also identified. Ease of implementation was considered, as well as the reliability for providing adequate quantities of compliant water. Additional factors were whether implementation of an alternative would require significant increase in the management or technical capability of the PWS, and whether the alternative had the potential for regionalization.

2.3.3 New Surface Water Source

New surface water sources were investigated. Availability of adequate quality water was investigated for the main rivers in the area, as well as the major reservoirs. TCEQ WAMs were inspected, and the WAM was run, where appropriate.

2.3.4 Treatment

Treatment technologies considered potentially applicable to arsenic removal are IX, RO, EDR, adsorption, and coagulation/filtration. However, because of the high TDS in the well water (>1,800 mg/L), IX is not economically feasible. RO and EDR can also reduce TDS higher than the state secondary MCL of 1,000 mg/L. Adsorption and coagulation/filtration processes remove arsenic only without significantly affecting TDS. RO treatment is considered for central treatment alternatives, as well as POU and POE alternatives. EDR, adsorption, and coagulation/filtration are considered for central treatment alternatives only. Both RO and EDR treatments produce a liquid waste: a reject stream from RO treatment and a concentrate stream from EDR treatment. As a result, the treated volume of water is less than the volume of raw water that enters the treatment system. The amount of raw water used increases to produce the same amount of treated water if RO or EDR treatment is implemented. Partial treatment and blending treated and untreated water to meet the arsenic MCL would reduce the amount of raw water used. Adsorption and coagulation filtration treatments produce periodic backwash wastewater for disposal. The treatment units were sized based on flow rates, and capital and annual O&M cost estimates were made based on the size of the treatment equipment required. Neighboring non-compliant PWSs were identified to look for opportunities where the costs and benefits of central treatment could be shared between systems.

Non-economic factors were also identified. Ease of implementation was considered, as well as the reliability for providing adequate quantities of compliant water. Additional factors were whether implementation of an alternative would require significant increases in the management or technical capability of the PWS, and whether the alternative had the potential for regionalization.

2.4 COST OF SERVICE AND FUNDING ANALYSIS

The primary purpose of the cost of service and funding analysis is to determine the financial impact of implementing compliance alternatives, primarily by examining the required rate increases, and also the fraction of household income that water bills represent. The current financial situation is also reviewed to determine what rate increases are necessary for the PWS to achieve or maintain financial viability.

2.4.1 Financial Feasibility

A key financial metric is the comparison of average annual household water bill for a PWS customer to the MHI for the area. MHI data from the 2000 Census are used, at the most detailed level available for the community. Typically, county level data are used for small rural water utilities due to small population sizes. Annual water bills are determined for existing, base conditions, including consideration of additional rate increases needed under current conditions. Annual water bills are also calculated after adding incremental capital and operating costs for each of the alternatives to determine feasibility under several potential funding sources.

Additionally, the use of standard ratios provides insight into the financial condition of any business. Three ratios are particularly significant for water utilities:

- Current Ratio = current assets divided by current liabilities provides insight into the ability to meet short-term payments. For a healthy utility, the value should be greater than 1.0.
- Debt to Net Worth Ratio = total debt divided by net worth shows to what degree assets of the company have been funded through borrowing. A lower ratio indicates a healthier condition.
- Operating Ratio = total operating revenues divided by total operating expenses show the degree to which revenues cover ongoing expenses. The value is greater than 1.0 if the utility is covering its expenses.

2.4.2 Median Household Income

The 2000 U.S. Census is used as the basis for MHI. In addition to consideration of affordability, the annual MHI may also be an important factor for sources of funds for capital programs needed to resolve water quality issues. Many grant and loan programs are available to lower income rural areas, based on comparisons of local income to statewide incomes. In the 2000 Census, MHI for the State of Texas was $39,927, compared to the U.S. level of $41,994. For service areas with a sparse population base, county data may be the most reliable, and for many rural areas corresponds to census tract data. The census broke down MHIs geographically by block group and ZIP code. The MHIs can vary significantly for the same location, depending on the geographic subdivision chosen. The MHI for each PWS was estimated by selecting the most appropriate value based on block group or ZIP code based on results of the site interview and a comparison with the surrounding area.

2.4.3 Annual Average Water Bill

The annual average household water bill was calculated for existing conditions and for future conditions incorporating the alternative solutions. Average residential consumption is estimated and applied to the existing rate structure to estimate the annual water bill. The estimates are generated from a long-term financial planning model that details annual revenue, expenditure, and cash reserve requirements over a 30-year period.

2.4.4 Financial Plan Development

The financial planning model uses available data to establish base conditions under which the system operates. The model includes, as available:

- Accounts and consumption data
- Water tariff structure
- Beginning available cash balance
- Sources of receipts:
  - Customer billings
  - Membership fees
  - Capital Funding receipts from:
    - Grants
    - Proceeds from borrowing.
- Operating expenditures:
  - Water purchases
  - Utilities
  - Administrative costs
  - Salaries.
- Capital expenditures;
- Debt service:
  - Existing principal and interest payments
  - Future principal and interest necessary to fund viable operations.
- Net cash flow
- Restricted or desired cash balances:
  - Working capital reserve (based on 1-4 months of operating expenses)
  - Replacement reserves to provide funding for planned and unplanned repairs and replacements

From the model, changes in water rates are determined for existing conditions and for implementing the compliance alternatives.

2.4.5 Financial Plan Results

Results from the financial planning model are summarized in two areas: percentage of household income and total water rate increase necessary to implement the alternatives and maintain financial viability.

2.4.5.1 Funding Options

Results are summarized in a table that shows the following according to alternative and funding source:

- Percentage of the annual MHI that the average annual residential water bill represents.
- The first year in which a water rate increase would be required.
- The total increase in water rates required, compared to current rates.

Water rates resulting from the incremental capital costs of the alternative solutions are examined under a number of funding options. The first alternative examined is always funding from existing reserves plus future rate increases. Several funding options were analyzed to frame a range of possible outcomes.

- Grant funds for 100 percent of required capital. In this case, the PWS is only responsible for the associated O&M costs.
- Grant funds for 75 percent of required capital, with the balance treated as if revenue bond funded.
- Grant funds for 50 percent of required capital, with the balance treated as if revenue bond funded.
- State revolving fund loan at the most favorable available rates and terms applicable to the communities.
- If local MHI is greater than 75 percent of state MHI, standard terms, currently at 3.8 percent interest for non-rated entities. Additionally:
    - If local MHI = 70-75 percent of state MHI, 1 percent interest rate on loan.
    - If local MHI = 60-70 percent of state MHI, 0 percent interest rate on loan.
    - If local MHI = 50-60 percent of state MHI, 0 percent interest and 15 percent forgiveness of principal.
    - If local MHI less than 50 percent of state MHI, 0 percent interest and 35 percent forgiveness of principal.
- Terms of revenue bonds assumed to be 25-year term at 6.0 percent interest rate.

2.4.5.2 General Assumptions Embodied in Financial Plan Results

The basis used to project future financial performance for the financial plan model includes:

- No account growth (either positive or negative).
- No change in estimate of uncollectible revenues over time.
- Average consumption per account unchanged over time.
- No change in unaccounted for water as percentage of total (more efficient water use would lower total water requirements and costs).
- No inflation included in the analyses (although the model has provisions to add escalation of O&M costs, doing so would mix water rate impacts from inflation with the impacts from the alternatives being examined).
- Minimum working capital fund established for each district, based on specified months of O&M expenditures.
- O&M for alternatives begins 1 year after capital implementation.
- Balance of capital expenditures not funded from primary grant program is funded through debt (bond equivalent).
- Cash balance drives rate increases, unless provision chosen to override where current net cash flow is positive.

2.4.5.3 Interpretation of Financial Plan Results

Results from the financial plan model for each alternative are presented in Table 4.4 in Section 4 of this report. The model used six funding alternatives: paying cash up front (all revenue); 100 percent grant; 75 percent grant; 50 percent grant, State Revolving Fund (SRF); and obtaining a Loan/Bond. Table 4.4 shows the projected average annual water bill, the maximum percent of household income, and the percentage rate increase over current rates.

2.4.5.4 Potential Funding Sources

A number of potential funding sources exist for rural utilities. Both state and federal agencies offer grant and loan programs to assist rural communities in meeting their infrastructure needs.

Within Texas, the following state agencies offer financial assistance if needed:

- TWDB;
- Office of Rural Community Affairs; and
- Texas Department of Health (Texas Small Towns Environment Program).

Small rural communities can also get assistance from the federal government. The primary agencies providing aid are:

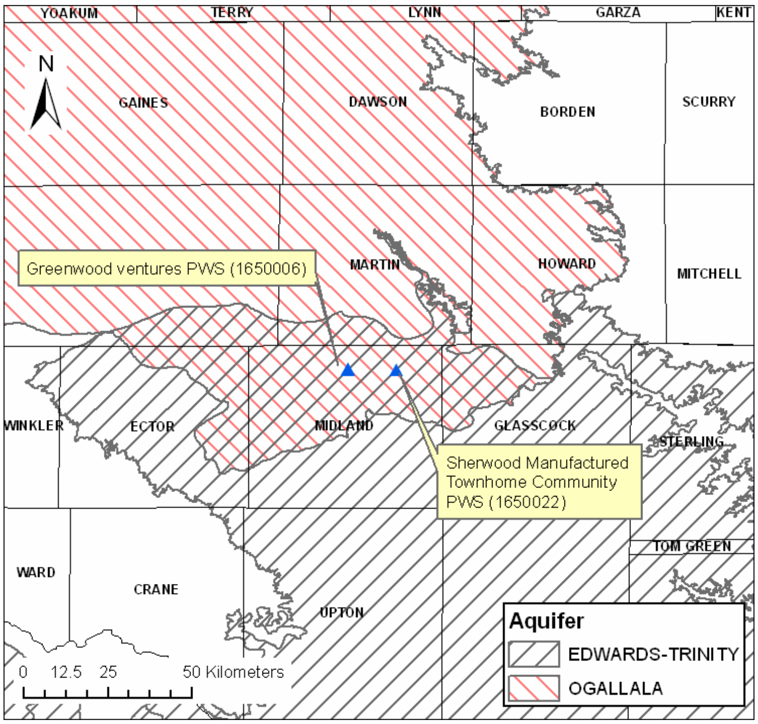
- United States Department of Agriculture, Rural Utilities Service; and
- United States Housing and Urban Development.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 REGIONAL HYDROGEOLOGY

The major aquifers in the vicinity of the evaluated public water systems are the Ogallala aquifer and the Edwards Trinity (Plateau) aquifer (Figure 3.1).

Figure 3.1 Public Water Systems and Major Aquifers in the Study Area



The Ogallala formation consists of sandstone and conglomerates of late Tertiary (Miocene-Pliocene) age (Nativ 1988). The sediments consist of basal coarse fluvial clastics deposited in paleovalleys in a mid-Tertiary erosional surface with upper eolian sands also present in intervening upland areas (Gustavson and Holliday 1985). The Ogallala formation is approximately 30 meters (m) thick in the south (Ector-Midland Counties). The top of the Ogallala formation is marked by a resistant calcite layer termed the “caprock” caliche.

The Ogallala formation is underlain by lower Cretaceous (Comanchean) strata in the southern High Plains. The top of the Cretaceous sediments is marked by an erosional surface that represents the end of the Laramide orogeny. Nonuniform erosion resulted in topographic relief on the Cretaceous beneath the Ogallala formation. (“paleovalleys”). The Cretaceous sediments were deposited in a subsiding shelf environment and consist of (1) the Trinity Group (basal sandy, permeable Antlers formation); (2) Fredericksburg Group (limy to shaley formations including the Walnut, Comanche Peak, and Edwards formations, as well as the Kiamichi formation); and (3) the Washita Group (low-permeability, shaley sediments of Duck

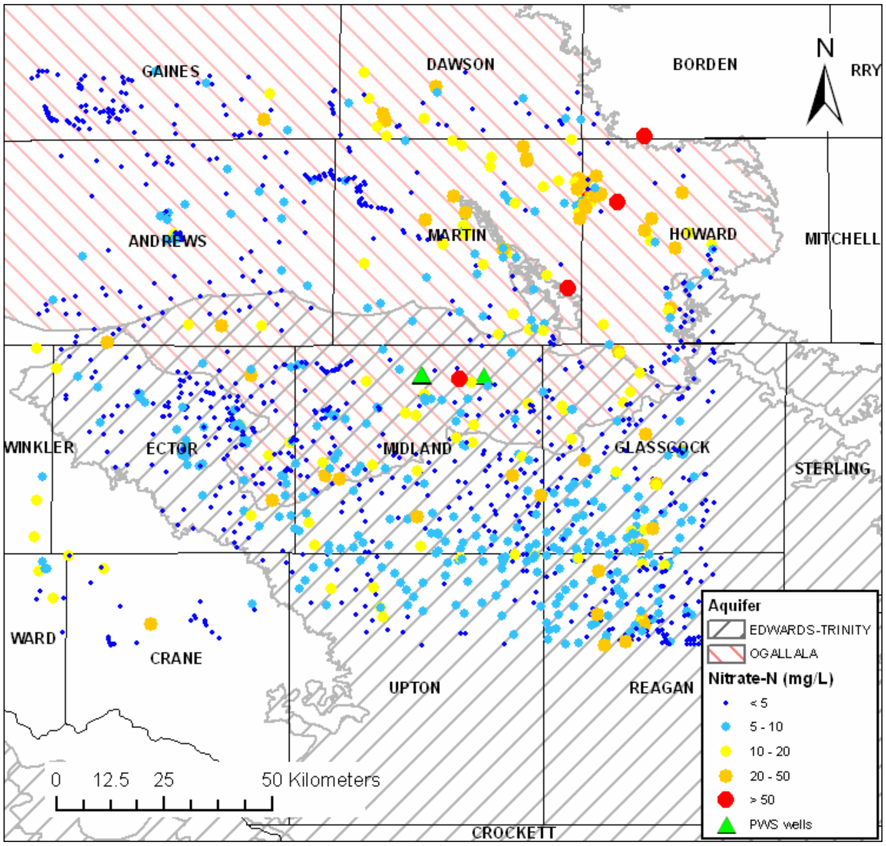
Creek formation) (Nativ 1988). The sequence results in two main aquifer units: the Antlers Sandstone (also termed the Trinity or Paluxy Sandstone, approximately 15 m thick in the overlap area with the Ogallala aquifer) and the Edwards Limestone (approximately 30 m thick). The Antlers Sandstone consists of basal gravels overlain by fluvial-deltaic sands deposited on a pre-Cretaceous unconformity developed on Paleozoic and earlier Mesozoic rocks. The basal gravels are thicker in paleovalleys. The carbonate-dominated with interbedded sandstone formations of the Fredericksburg Group of Lower Cretaceous age were exposed and karstified during Cretaceous times (Mace, *et al*. 2004). The terminology can be complicated at times; for example, the Edwards Limestone transitions laterally in name to the Fort Terrett formation (base) and Fort Lancaster formation in some places and Segovia formation in other places. The term Edwards Trinity (High Plains) aquifer is generally used to describe these water-bearing Mesozoic units subcropping in the High Plains and disconnected from the main Edwards Trinity (Plateau) aquifer that covers most of southwest Texas from west of San Antonio to Reeves County (Ashworth and Hopkins 1995). The term High Plains aquifer denotes the combination of the generally hydrologically connected Ogallala aquifer and the Edwards Trinity (High Plains) aquifer.

The Edwards Trinity (Plateau) aquifer underlies the extreme southern outcrops of the Ogallala formation in Andrews, Martin, Ector, Midland, and Glasscock Counties and crops out south of this region. This section of the Edwards Trinity Aquifer is in continuity with the main outcropping areas of the Edwards Trinity (Plateau) aquifer, and is generally attached to it despite being overlain by Ogallala deposits (*e.g.*, Mace, *et al*. 2004). However, in some areas only the Cretaceous unit is saturated, and the Ogallala sediments are in the unsaturated zone. The Edwards Trinity (Plateau) aquifer is recognized as a major aquifer in the state (Ashworth and Hopkins 1995). This aquifer consists predominantly of the Trinity Group and includes the Antlers Sandstone in Ector and Midland Counties, which is overlain by the Washita and Fredericksburg Divisions in Glasscock County (Barker and Ardis 1996). Water quality is generally good (Anaya and Jones 2004).

3.2 GENERAL TRENDS IN NITRATE CONCENTRATIONS

The geochemistry of nitrate is described in Appendix E. Regional nitrate trends in the area of the assessed public water supplies were examined to assess spatial trends, as well as correlations with other water quality parameters. Nitrate-N concentrations are spatially variable in the study region (Figure 3.2).

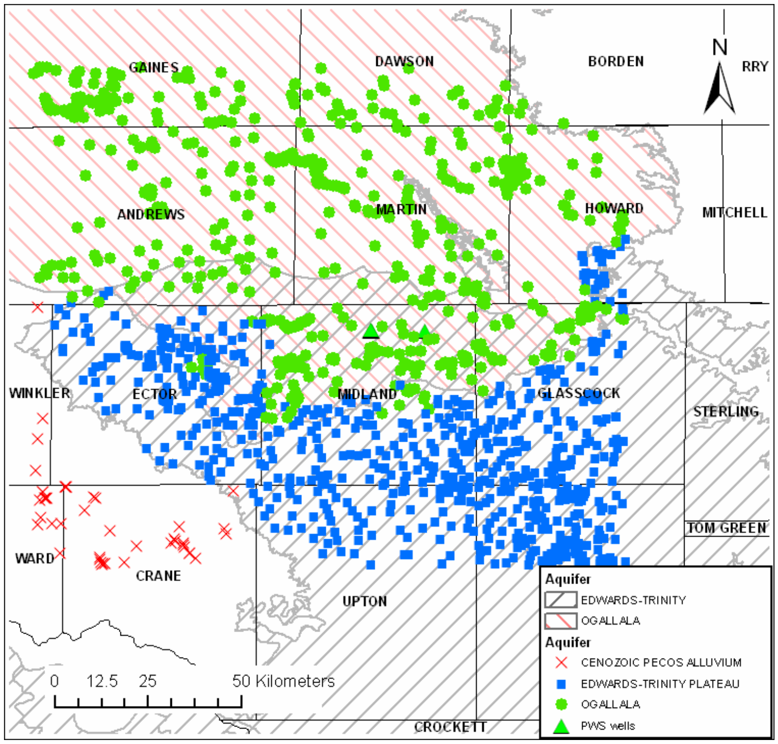
Figure 3.2 Most Recent Detectable Nitrate-N Concentrations in Groundwater



Data from the TWDB database, analyses from 1937 through 2004.

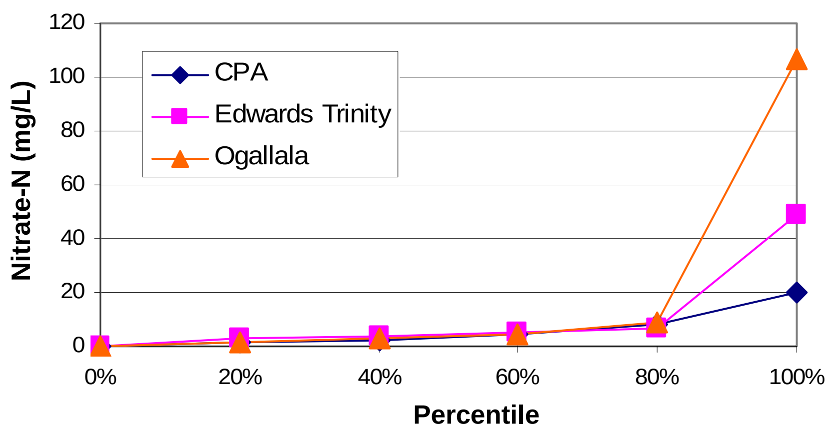
A total of 1,401 measurements were extracted from the TWDB database. In all analyses in this study, the most recent sample was used for each well (if more than one sample exists for the most recent date, the average for that date was calculated). Samples were limited to an area delimited by the following coordinates: bottom left corner -102.84E, 31.46N and upper right corner -101.41E, 32.66N. Coordinates are in decimal degrees and the datum is North American Datum 1983 (NAD 1983). Wells in the study area are designated in three major aquifers, the Ogallala, Edwards Trinity (Plateau), and Cenozoic Pecos Alluvium aquifers (Figure 3.3).

Figure 3.3 Wells with Nitrate Samples Categorized by Aquifer



From the 1,401 wells, 774 are in the Edwards Trinity (Plateau) aquifer, 584 in the Ogallala aquifer, and 43 in the Cenozoic Pecos Alluvium aquifer. The distribution of nitrate-N concentrations within the three aquifers is similar (Figure 3.4). The similarity in nitrate-N levels among the aquifers suggests that the source of nitrate is not a particular geologic unit but may be anthropogenic.

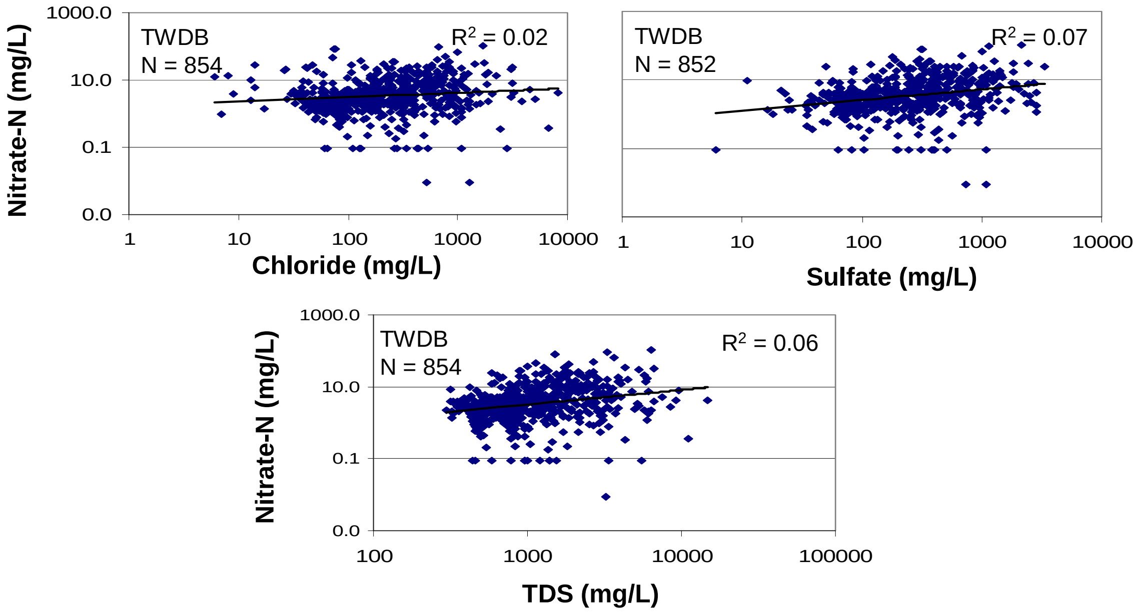
Figure 3.4 Distribution of Nitrate-N Concentrations in the Cenozoic Pecos Alluvium, Edwards Trinity (Plateau), and Ogallala aquifers



Nitrate-N is not strongly related to general water quality parameters (sulfate, chloride, and total dissolved solids) in the Ogallala aquifer (Figure 3.5). Similar results were found for the

Edwards-Trinity (Plateau) aquifer ($r^2 < 0.1$), further suggesting that nitrate-N sources are probably not geologic.

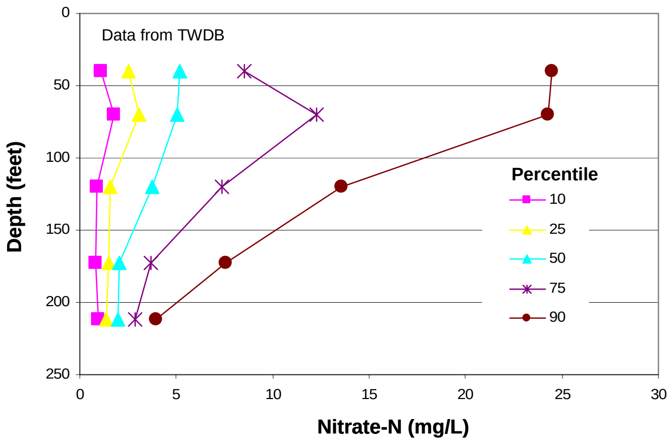
Figure 3.5 Correlation of Nitrate-N with Chloride, Sulfate, and TDS in the Ogallala Aquifer



Data are from the TWDB groundwater database. N represents the number of wells in the analysis. The most recent measurement is shown for each well (when there is more than one sample for the most recent date, the average was calculated; only seven wells had more than one sample for the most recent date).

Nitrate-N concentrations were compared with well depth to assess stratification in nitrate concentrations in the Ogallala aquifer (Figure 3.6) and Edwards Trinity (Plateau) aquifer (Figure 3.7).

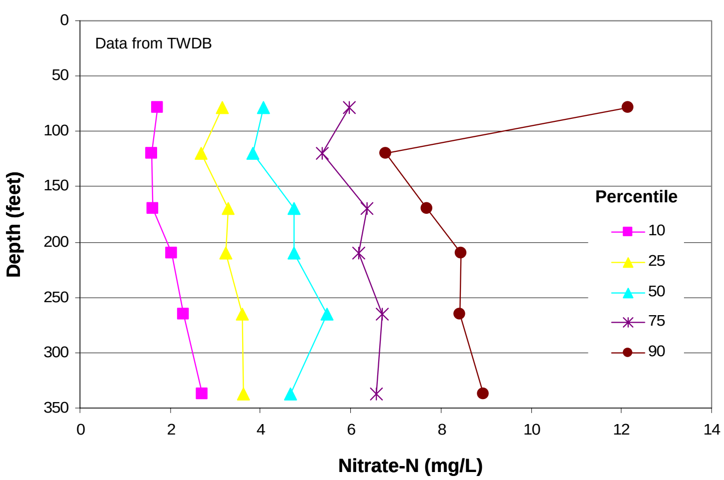
Figure 3.6 Relationship Between Nitrate-N concentrations and Well Depth in the Ogallala Aquifer



Depth interval (feet)	Min. depth (feet)	Max. depth (feet)	Median depth (feet)	No. of wells
< 50	20	49	40	31
50-100	50	99	70	150
100-150	100	148	120	158
150-200	150	197	173	126
> 200	200	306	212	49

Data are from the TWDB groundwater database. Wells were divided into depth bins, and for each bin the nitrate-N concentration is shown with respect to the median depth. The table on the right summarizes depth values for each bin and gives the number of wells in the analysis for that depth range. The analysis shows that within the Ogallala aquifer highest nitrate-N concentrations are found in shallower wells (depth <100 feet), and nitrate-N concentrations generally decrease with depth, particularly the 75th and 90th percentile values. A similar analysis is shown for the Edwards Trinity (Plateau) aquifer in Figure 3.7.

Figure 3.7. Relationship between Nitrate-N Concentrations and Well Depth in the Edwards Trinity (Plateau) Aquifer



Depth range (feet)	Min. depth (feet)	Max. depth (feet)	Median depth (feet)	No. of wells
< 100	37	99	79	77
100-150	100	149	120	170
150-200	150	197	170	143
200-250	200	248	211	106
250-300	250	297	265	72
> 300	300	495	337	116

The analysis shows that within the Edwards Trinity (Plateau) aquifer, nitrate-N concentrations generally show no systematic variation with depth. In general, concentrations remain constant with depth, although some relationship is seen within the 90th percentile, where the shallowest wells (<100 feet) have higher concentrations.

Nitrate-N concentrations were compared with land use from the National Land Cover Dataset (NLCD) (NLCD 1992). Land-use datasets are categorized into three groups (rangeland, cultivated, and urban) and compared with nitrate-N concentrations within the study area. High concentrations of nitrate-N are generally found in cultivated areas (Figure 3.8). Nitrate-N concentrations in groundwater were compared with land use within a 1-km radius of well locations (Figure 3.9).

Figure 3.8 Spatial Relationship Between Land Cover (NLCD) and Nitrate-N Concentrations

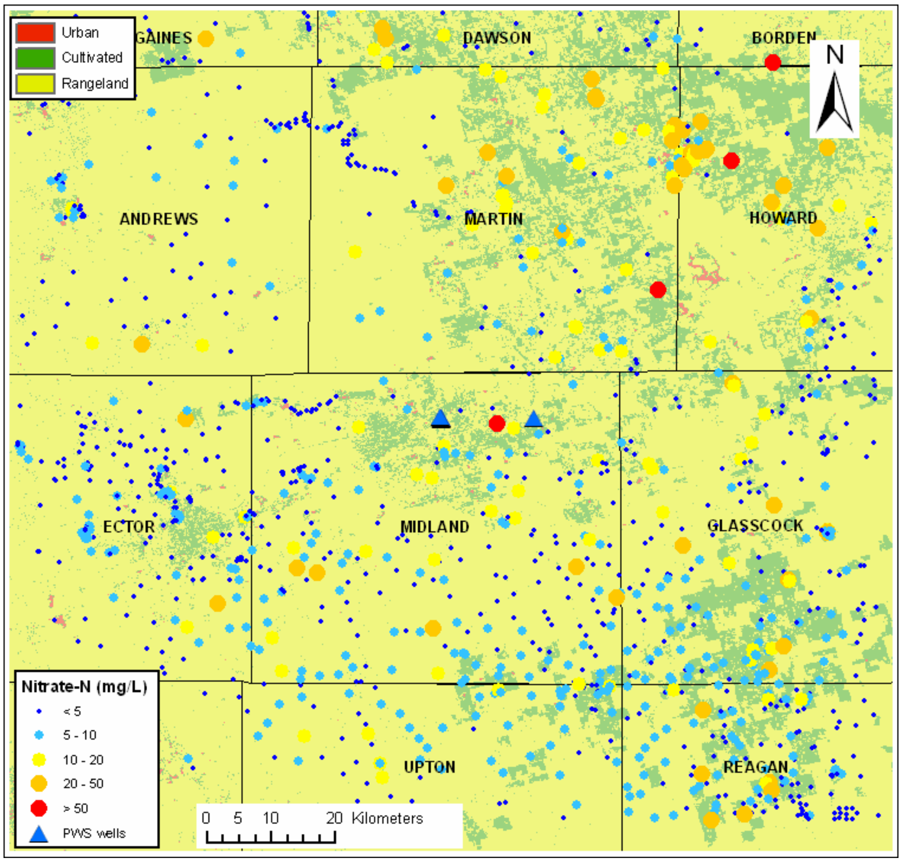
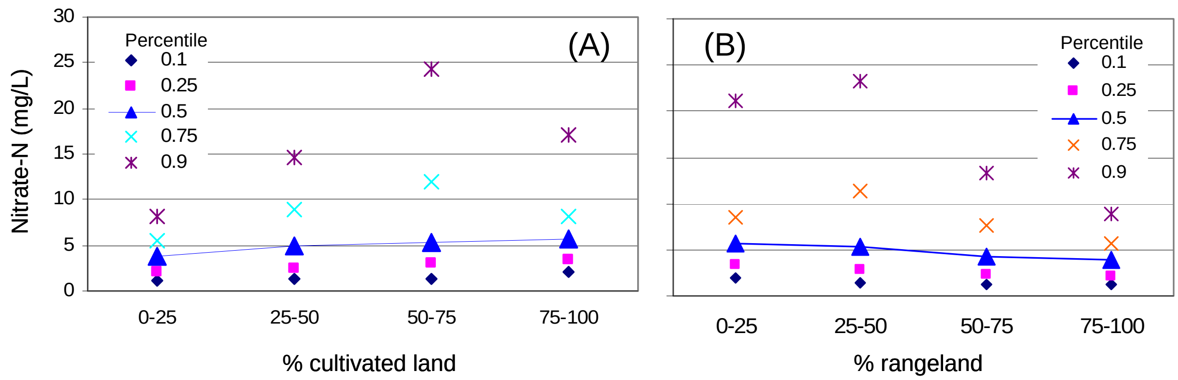


Figure 3.9 Correlation Between Nitrate-N Concentrations and Percentage of (A) Cultivated Land, and (B) Rangeland Within a 1-km Buffer of Wells

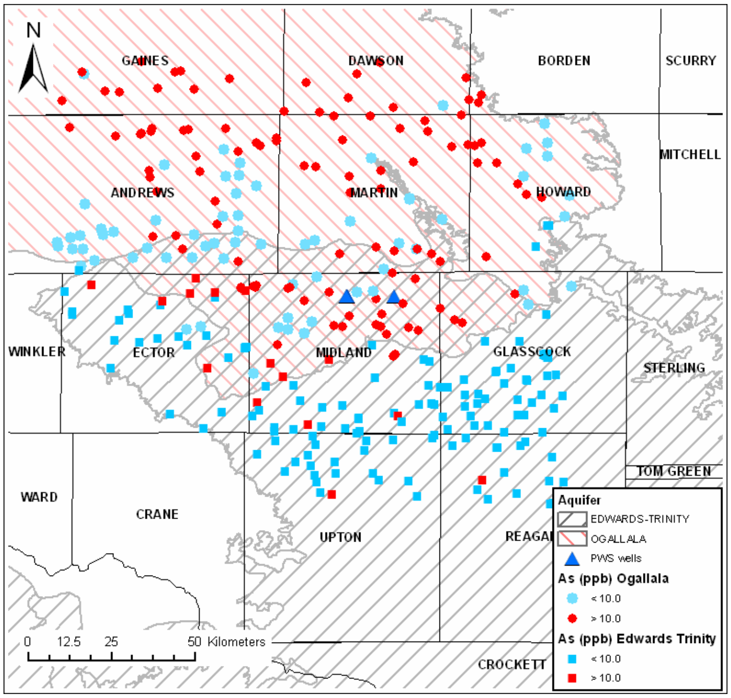


Land use was obtained from the NLCD and was categorized into the following land-use types: rangeland (NLCD codes 51, 71, 41, 42, and 43), cultivated (NLCD codes 81, 82, 83, and 61), and urban (NLCD codes 21, 22, 23, and 85). The complementary analysis accounts for more than 90 percent of the land use in over 95 percent of the wells. Nitrate-N concentrations are from the TWDB database. Nitrate-N concentrations generally increase with percentage of cultivated land (Figure 3.9A) and decrease with percentage of rangeland (Figure 3.9b). The two plots are generally complementary, showing an increase in nitrate-N concentrations with cultivation and a decrease with higher percentage of rangeland. The greatest increases in nitrate-N concentrations with cultivation occur in the upper 75th and 90th percentiles. Population means of the land-use groups (percentage bins) are statistically different ($P < 1E-9$, ANOVA single factor test) for both land-use categories.

3.3 GENERAL TRENDS IN ARSENIC CONCENTRATIONS

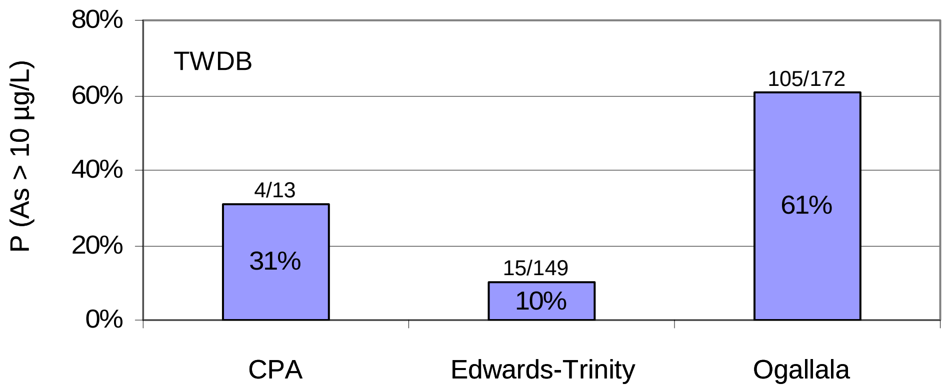
The geochemistry of arsenic is described in Appendix F. Arsenic trends in the vicinity of the analyzed public water supplies were examined to assess spatial trends, as well as correlations with other water quality parameters. Arsenic samples were obtained from the TWDB database and from a subset of the National Geochemical Database, also known as the NURE (National Uranium Resource Evaluation) database. The spatial distribution of arsenic concentrations correlates with the distribution of geologic formations (Figure 3.10). High arsenic concentrations (> 10 parts per billion [ppb]) also correlate with geologic formations (Figure 3.11).

Figure 3.10 Spatial Distribution of Arsenic Concentrations in the Edwards Trinity (Plateau) and Ogallala Aquifers



Data from the TWDB database.

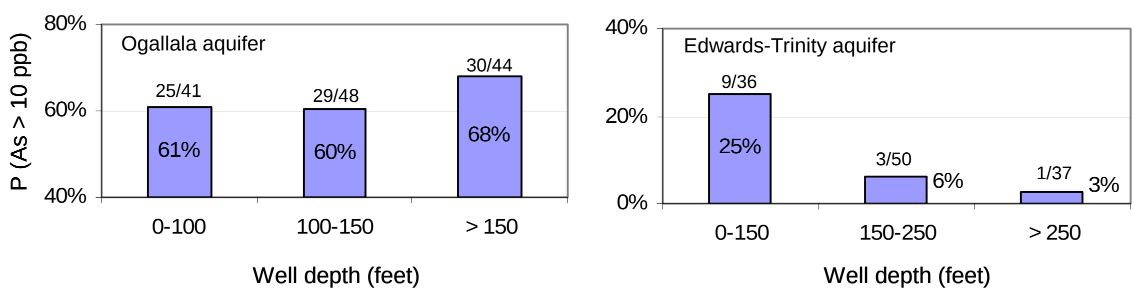
Figure 3.11 Probabilities of Arsenic Concentrations Exceeding the 10 ppb MCL for Aquifers in the Study Area



Data in Figures 3.10 and 3.11 are from the TWDB database. The Ogallala aquifer shows the highest percentage of wells with arsenic concentrations >10 ppb (Figure 3.11). Within the Ogallala aquifer, 61 percent of the wells had arsenic concentrations >10 ppb, in comparison with the Cenozoic Pecos Alluvium (31%) and Edwards Trinity (Plateau) (10%) aquifers. A closer review of the spatial distribution of wells in the Edwards Trinity (Plateau) with high arsenic concentrations reveals that almost all wells with high arsenic concentrations are within the area overlapping the Ogallala aquifer (only seven wells with high arsenic concentrations are outside the area overlapping the aquifer, and three of those seven are within 5 km of the aquifer boundary). It is possible that these wells are screened within the Ogallala aquifer or screened across the Edwards Trinity (Plateau) and Ogallala aquifers together. This assumption cannot be verified because only one well of the seven had a secondary aquifer (Dockum) designation in the TWDB database.

To assess relationships between elevated arsenic concentrations and specific stratigraphic units, arsenic concentrations were compared with well depth for the Ogallala and Edwards Trinity (Plateau) aquifers separately (Figure 3.12). Within the Ogallala aquifer, arsenic concentrations are not strongly correlated with well depth. However, within the Edwards Trinity (Plateau) aquifer, shallower wells (<150 feet) have higher probabilities of arsenic concentrations exceeding 10 ppb. The shallower wells are closer to the Ogallala formation (which overlies the Edwards Trinity Plateau), and these wells may be screened within the Ogallala formation or across both the Edwards Trinity (Plateau) and Ogallala formations. This restriction of high arsenic levels to shallow wells in the Edwards Trinity (Plateau) aquifer suggests that the source of contamination for wells within the Edwards Trinity (Plateau) aquifer is actually from the overlying Ogallala formation.

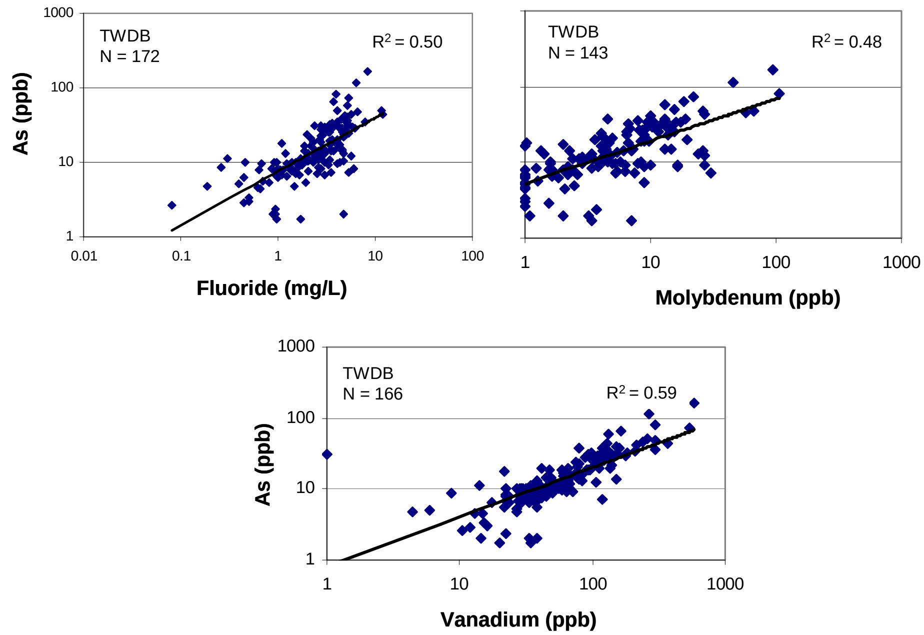
Figure 3.12 Relationship Between Arsenic Concentrations and Well Depth



Data shown in Figure 3.12 are from the TWDB database. Numbers above each column represent the number of arsenic samples that are >10 ppb and the total number of analyses in the bin. For example, 25/41 represents 24 samples >10 ppb out of 41 analyses at a well depth between 0 and 100 feet.

Relationships between arsenic and pH, sulfate, fluoride, chloride, TDS, vanadium, and molybdenum were evaluated using data from the TWDB database. Data from the NURE database were used to evaluate the relationship between arsenic and dissolved oxygen. Strong correlations were found between arsenic and fluoride (R^2 = 0.50), vanadium (R^2 = 0.59), and molybdenum (R^2 = 0.48) within the Ogallala aquifer (Figure 3.13). Arsenic and vanadium were also correlated within the Edwards Trinity (Plateau), but other parameters were not highly correlated with arsenic within the Edwards Trinity (Plateau) aquifer.

Figure 3.13 Relationship between Arsenic and Fluoride, Molybdenum, and Vanadium within the Ogallala Aquifer



Data shown in Figure 3.13 are from the TWDB database. The most recent arsenic sample in each well was used in the analysis. Fluoride, molybdenum, and vanadium concentrations are from the same date as that of the most recent arsenic sample. A total of nine arsenic measurements within the database are below detection limit of 10 ppb, and two samples are below detection limit of 2 ppb. These samples are plotted as equal to the detection limits (10 and 2, respectively). Vanadium samples have a detection limit of 1 ppb and are plotted as equal to the detection limit. Molybdenum concentrations in the TWDB database have detection limits of 50, 20, 4, 2, and 1 ppb. Values below detection limits of 50 and 20 ppb were excluded from the analysis, and the remaining were plotted as equal to detection limits.

Within the NURE database only 25 wells were sampled in the study area. Dissolved oxygen in the 25 samples ranged from 6.7 to 14.3 mg/L. There is no aquifer designation in the NURE database, but 21 of the 25 wells are within the Ogallala aquifer boundary and the other four are proximal to it (<15 km). Well depths for these wells range from 6 to 70 feet, also suggesting they are in the shallow Ogallala aquifer.

Generally high correlations between arsenic and fluoride, molybdenum, and vanadium (Figure 3.13) and dissolved oxygen concentrations from the NURE database suggest natural sources of elevated arsenic within the Ogallala aquifer. Within the Edwards Trinity (Plateau) aquifer, correlations are not as strong, and it is more likely that the source of arsenic is from the Ogallala aquifer overlying the Edwards Trinity (Plateau) aquifer.

3.4 DETAILED ASSESSMENT

The Sherwood Estates PWS has four wells: G1650022A, G1650022B, G1650022C, and G1650022D. Well depths range from 90 to 110 feet and are designated to be within the Ogallala aquifer (121OGLL). All wells are related to one entry point in the water supply system, making it difficult to trace contaminants back to a specific well. Table 3.1 summarizes arsenic concentrations measured at the Sherwood Estates PWS.

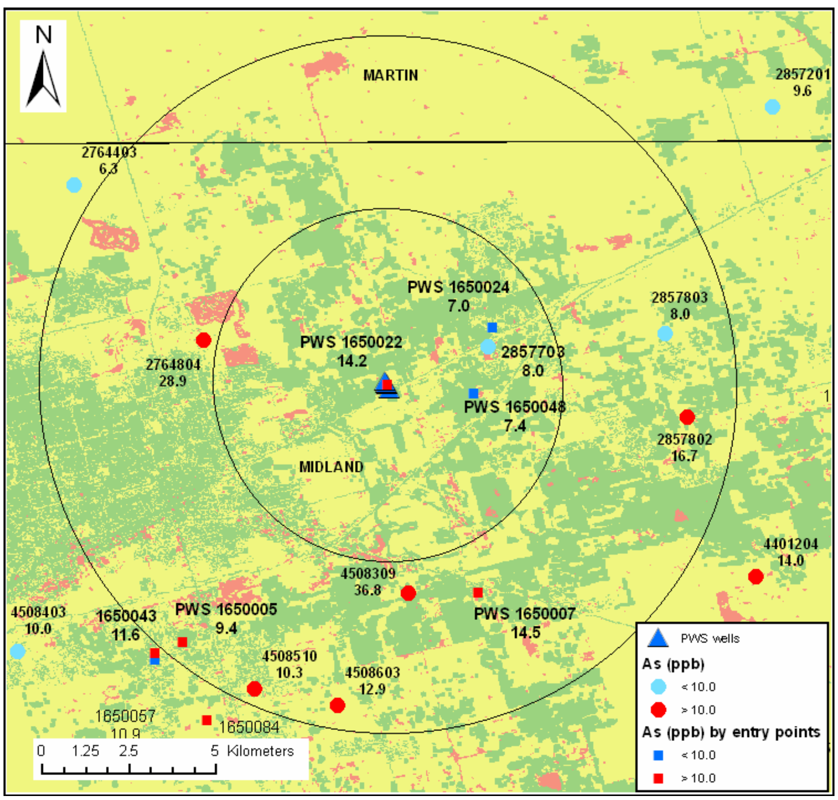
Table 3.1 Arsenic Concentrations in the Sherwood PWS

Date	As (ppb)	Source
6/30/1999	14.2	TCEQ

Data from the TCEQ database.

There is only one arsenic sample from the TCEQ database in 1999, and it exceeds the arsenic MCL (10 ppb). The spatial distribution of arsenic concentrations within 5- and 10-km buffers of the PWS wells is shown in Figure 3.14.

Figure 3.14 Arsenic Concentrations in 5- and 10-km Buffers of the Sherwood Estates PWS Wells



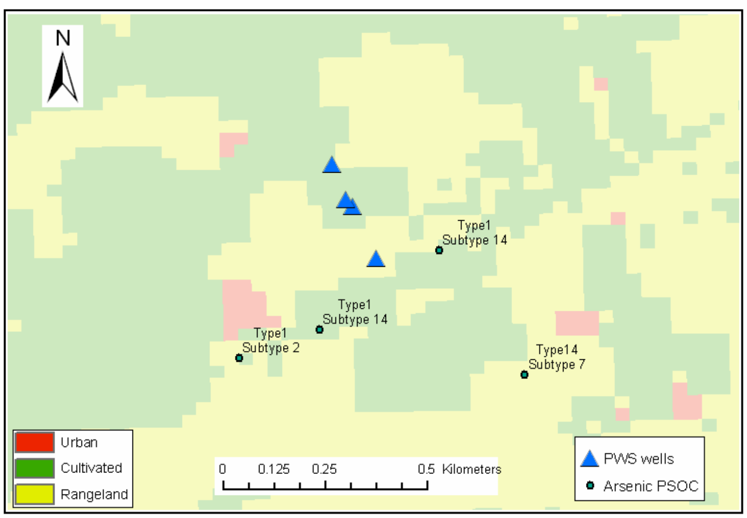
Data from the TWDB and TCEQ databases. Wells are symbolized by the PWS ID (TCEQ database) or well identifier (TWDB database)

Data are from the TCEQ and TWDB databases. The most recent arsenic concentration is shown for each well. Two types of samples were included in the analysis from the TCEQ database: the most recent sample taken at an entry point (shown as squares on the map), and from the TWDB database, samples from single wells (shown as circles in the map). Within the 5-km buffer there are a number of wells to the east of the Sherwood Estates PWS wells that show arsenic concentrations <10 ppb (at about 2-3 km). The nearest well is well 2857703 which is 70 feet deep within the Ogallala aquifer. There are also two public water supplies with arsenic concentrations below 10 ppb. PWS 1650024 (Pecan Grove Mobile Home Park) and PWS 1650048 (Greenwood Terrace Mobile Home Subdivision). The wells of these water supplies are at depth of 97-120 feet and are within the Ogallala. A number of wells in the Pecan Grove PWS have completion information, and these show openings at depths of 30-100 feet.

3.4.1 Potential Point Sources of Contamination

Potential Sources of Contamination (PSOC) are identified as part of TCEQ's Source Water Assessment Program. Within the vicinity of the Sherwood Estates PWS a number of potential sources are identified (Figure 3.15): two pesticide/fertilizer sale or application sites (type 1 subtype 14), one auto repair/sales/salvage/towing site (type 1 subtype 2), and one municipal solid waste site (type 14 subtype 7). These are potential sources of contamination and further investigation is required to establish any connection between the PSOC sites and groundwater arsenic concentrations.

Figure 3.15 Arsenic Potential Sources of Contamination (PSOC) in the vicinity of the Sherwood Estates PWS wells

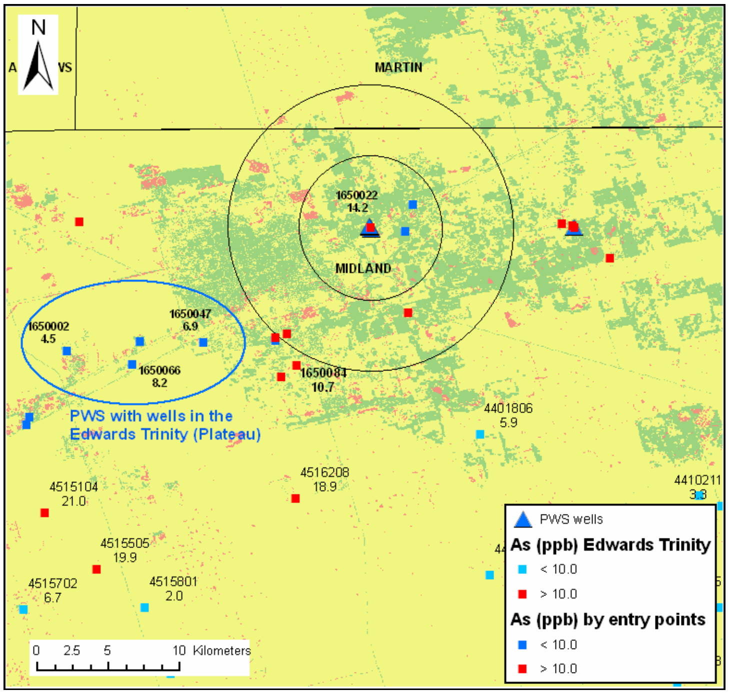


3.4.2 Summary of Alternative Groundwater Sources for the Sherwood Estates PWS

There is an area east of the Sherwood Estates PWS wells with arsenic concentrations <10 ppb (Figure 3.14). These wells are within the Ogallala at depths between 75-120 feet, similar to the Sherwood Estates wells which are 90-110 feet deep. Additional wells east of the existing PWS wells can be used as an alternative source to dilute or replace groundwater from existing wells.

Another option is to extend the existing wells into the Edwards Trinity (Plateau) aquifer. In general, wells in the Edwards Trinity (Plateau) aquifer have lower arsenic concentrations, although the level of arsenic concentrations in this particular area cannot be determined due to lack of information. No wells in the Edwards Trinity (Plateau) exist within the 10-km buffer of the Sherwood Estates PWS wells, but at a further distance 12-20 km to the southwest there are a number of PWS wells (PWS 1650047, 1650066, and 1650002) within the Edwards Trinity (Plateau) aquifer with low arsenic concentrations (Figure 3.16). Depths of these wells are between 110-140 feet. Only two wells of PWS 1650002 have construction information and they show openings at depths of 90-130 feet. The nearest TWDB well (with arsenic samples) in the Edwards Trinity (Plateau) aquifer is well 4401806, which is located about 16 km south of the Sherwood Estates wells and has a depth of 80 feet. PWS 1650084 (located about 11 km southwest of the PWS) has wells within the Edwards Trinity (Plateau), with depths of 120 feet. This PWS has arsenic concentrations >10 ppb. Given the lack of local information in the vicinity of the PWS wells, this option requires further investigation.

Figure 3.16 Arsenic Concentrations in the Edwards Trinity (Plateau) Aquifer in the Vicinity of the Sherwood Estates PWS



Data from the TWDB and TCEQ databases. Wells are symbolized by the PWS ID (TCEQ database) or the well identifier (TWDB database).

SECTION 4
ANALYSIS OF THE SHERWOOD ESTATES PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1. Existing System

Location of the Sherwood Estates (SE) Manufactured Townhome Community is shown in Figure 4.1. The manufactured townhome community has two active wells approximately 110 feet deep, each of which produces 280 gallons per minute (gpm). The system also has two inactive wells. The wells feed into a 20,000-gallon storage tank. Pumps draw from the storage tanks and discharge to two pressure tanks with a total capacity of 1,500 gallons. The water is chlorinated before the pressure tanks, and the distribution system is fed from the pressure tanks.

The treatment employed for disinfection is not appropriate or effective for removal of arsenic, so optimization is not expected to be effective in increasing removal of this contaminant. There is, however, a potential opportunity for system optimization to reduce arsenic concentration. The system has more than one well, and since arsenic concentrations can vary significantly between wells, arsenic concentrations should be determined for each well. If one of the wells happens to produce water with acceptable arsenic levels, as much production as possible should be shifted to that well. It may also be possible to identify arsenic-producing strata through comparison of well logs or through sampling of water produced by various strata intercepted by the well screen.

Basic system information is as follows:

- Population served: 65
- Connections: 25
- Average daily flow: 0.005 mgd
- Total production capacity: 0.403 mgd

Basic system raw water quality data is as follows:

- Typical arsenic value: 0.0142 mg/L
- Typical nitrate value: 9.36 mg/L
- Typical total dissolved solids value: 1,837 mg/L
- Typical pH value: 7.3
- Typical calcium value: 293 mg/L
- Typical magnesium value: 89 mg/L
- Typical sodium range: 228 to 236 mg/L
- Typical chloride value: 690 mg/L

- Typical bicarbonate (HCO3) value: 204 mg/L
- Typical fluoride value: 1.1 mg/L
- Typical iron value: 0.021 mg/L
- Typical conductivity value: 4,082 µS/cm

As can be seen above, the nitrate concentration in the Sherwood Estates PWS water is very near to the nitrate MCL of 10 mg/L as nitrate. This may be a consideration in selection of advantageous central treatment alternatives, making technologies that effectively remove nitrate as well as arsenic more attractive.

4.1.2 Capacity Assessment for Sherwood Estates Manufactured Townhome Community

The project team conducted a capacity assessment of the Sherwood Estates PWS. The results of this evaluation are separated into four categories: general assessment of capacity; positive aspects of capacity; capacity deficiencies; and, capacity concerns. The general assessment of capacity describes the overall FMT capability of the water system. The positive aspects of capacity describe those factors that the system is doing well. These factors should provide opportunities for the system to build upon to improve capacity deficiencies. The capacity deficiencies noted are those aspects that are creating a particular problem for the system related to long-term sustainability. Primarily, these problems are related to the system's ability to meet current or future compliance, ensure proper revenue to pay the expenses of running the system, and to ensure proper operation of the system. The last category, capacity concerns, includes items not currently associated with a significant problem for the system. However, the system should consider addressing those items so that they do not have the opportunity to cause problems in the future.

The following individuals were interviewed:

- Michael Deutsch - Manager
- Richard Morales – Certified Water Operator
- Frank O'Neil - Assistant Water Operator

4.1.2.1 General Structure of the Water System

Sherwood Estates is one of three small mobile home parks owned and operated by Westgate/Village Manufactured Town Home Communities (hereafter referred to as "Westgate"). The business owner's son is the manager and provides managerial and financial oversight of the system. The primary operator maintains the system on a daily basis, and is a certified operator. He has one assistant who is not certified, but has worked at the water system for several years, and has extensive knowledge of the water system. The primary operator reports directly to the manager.

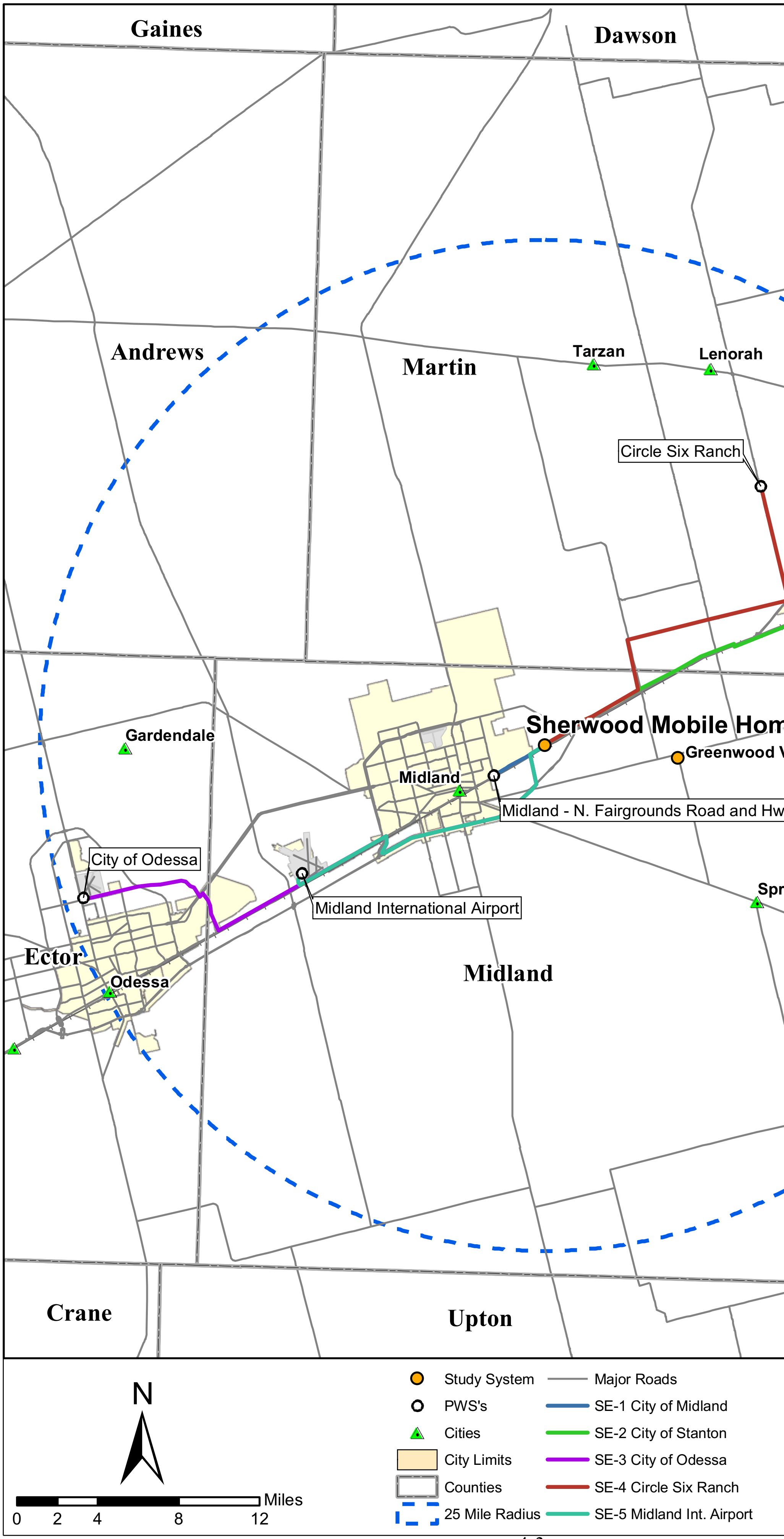


Figure 4.1

Sherwood Mobile Home Estates Pipeline Alternatives

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The mobile home park provides low-income housing to residents in an industrial area near Midland, Texas. The water system has 22 connections, and serves a population of about 110 people. Although the system is metered, the meters are not read. The water service fee is included in the monthly lot rent.

4.1.2.2 General Assessment of Capacity

Based on the team's assessment, the Sherwood Estates PWS has an inadequate level of capacity due mainly to deficiencies with financial capabilities. There are several positive managerial and technical aspects of the PWS, but there are also a number of deficiencies, that prevent the PWS from being able to comply with the arsenic standard. The deficiencies may also impact the PWS's long-term sustainability.

4.1.2.3 Positive Aspects of Capacity

In assessing a PWS's overall capacity, it is important to look at all aspects – positive and negative. It is important for owners of these PWSs to understand those characteristics that are working well, so that those activities can be continued or strengthened. In addition, these positive aspects can assist owners in addressing the capacity deficiencies or concerns. The factors that were particularly important for the Sherwood Estates PWS are listed below.

- **Knowledgeable and Dedicated Staff –** The manager has worked for the Sherwood Estates PWS for about 10 years and is currently working on becoming certified. The primary operator has been working at Sherwood Estates PWS for 2.5 years, and his assistant has been working there for 5 years. All positions have written job descriptions. They are familiar with the challenges of providing safe water and are working hard to address problems. The operators are responsible for setting their own schedule, and receive their daily tasks through a work order book and phone calls. They are available 24 hours a day and alternate being on-call. The mobile home park residents have been given the operator's phone numbers and can call them directly, if needed. The manager and both operators live in the park, so they can respond to customer requests in a timely manner.

- **Communication with Customers –** The Sherwood Estates PWS issues a Public Notice regarding the arsenic violation every 3 months, as required. The notices are **hand delivered to every customer. They distribute a water conservation notice and a** Consumer Confidence Report annually. In addition, they notify customers prior to shutting down the system for scheduled repairs.

- **Cross-Connection Control Program –** The Sherwood Estates PWS has an active program for preventing cross connections in the distribution system. This program includes installation of backflow devices at all new service connections and providing educational materials to all residents. This program provides an increased level of public health protection.

4.1.2.4 Capacity Deficiencies

The following capacity deficiencies, which seriously impact the ability of the water system to comply with current and future regulations and to ensure long-term sustainability, were discovered while conducting the assessment:

- **Inadequate Financial Accounting for the Water System –** The Sherwood Estates PWS charges the residents of the mobile home park a flat fee for lot rental, including garbage and septic. This rental fee has remained unchanged over the past several years and the owner has been reluctant to increase it because most of the residents are low-income families. There are no other fees assessed for utility services such as hook-up or disconnection fees. Westgate is aware that the lot rental fee of $140 per month does not cover all of the expenses associated with the mobile home park.

  The revenue for all of Westgate's mobile home parks is combined into one account. The water system expenses are tracked separately from other expenses incurred by Westgate. However, this includes expenses related to all three water systems of the mobile home parks, and electricity has been excluded. Therefore, it is not an accurate reflection of the cost of providing water services, and it is impossible to determine if any of the water systems are self-sustaining. The manager indicated that the owner uses his own money to cover the shortfalls incurred by all three water systems. Furthermore, Westgate is not soliciting new customers for Sherwood Estates, and has no plans to increase the fees to cover the shortfalls.

  Without tracking revenue and expenses specifically for each water system, it is not possible to determine the income needed to cover the cost of current operation, repair and replacement, compliance with the arsenic standard and provide a reserve fund. The lack of availability of financial records made it impossible to determine whether the system is self-sufficient.

- **Inability to Meet Operating Expenses -** It appears the PWS is only able to meet O&M expenses because they are subsidized by the owner. If these funds were no longer available, the water system would not be able to cover these expenses, which increases the risk to public health. This is not a sustainable method of operating a water system.

- **No Reserve Account –** The lack of a reserve account for anticipated expenses, emergencies, and future capital expenditures is a problem. For most items, the owner covers these expenses with his own funds as the need occurs. However, it doesn't appear that funds have been set-aside specifically to address the current arsenic compliance issue.

- **Lack of Long-Term Planning for Compliance and Sustainability –** The lack of planning negatively impacts the system's ability to develop a budget and associated rate structure that will provide for the system's long term needs. Needs are assessed on a day-to day basis. Although Westgate has been aware of the arsenic compliance problem for the past several years, but have not developed a plan for returning to compliance. In addition, they have not provided the residents alternative water sources.

- The manager indicated the PWS was considering POU RO devices for each resident, and are waiting for TCEQ to approve the technology. However, they have not allocated funds to purchase or install this type of treatment.

4.1.2.5 Potential Capacity Concerns

The following items were concerns regarding capacity but no specific FMT problems can be attributed to these items at this time. The system should focus on addressing the deficiencies noted above in the capacity deficiency section, but should address the items listed below to further improve technical, managerial, and financial capabilities and to improve the system's long-term sustainability.

- **Preventative Maintenance Program –** According to the operators, the preventative maintenance program is limited to the disinfection system, and in general they make repairs on a reactive basis instead of a proactive one. However, they do maintain a small inventory of spare parts, including pipe fittings and some chlorine pump fittings. These supplies are accessible in their main office and in vehicles. There is no scheduled maintenance for line flushing or valve exercising. Routine flushing would clear sediment in the lines, and routine valve exercising would identify valves that need replacement and ensure proper operation during the next line repair.

- **Operating Records –** It was indicated that the master water meter was only read about once a month, and that the water usage was not recorded. If maintained, flow meters provide an accurate account of water being pumped, and can help the operator detect changes in the system in order to take corrective action before a serious problem develops.

- **Written Operational Procedures –** According to the manager, there are only a few written operations procedures available to the operators. For the most part, the operators operate the system without written instructions. However, if the staff leaves or if additional staff is hired, the lack of written operating procedures may cause problems.

- **Emergency Plan -** The system does not have a written emergency plan, nor does it have emergency equipment such as generators. The system should have an emergency or contingency plan that outlines what actions will be taken and by whom. The emergency plan should meet the needs of the facility, the geographical area, and the nature of the likely emergencies. Conditions such as storms, floods, major line breaks, electrical failure, drought, system contamination, or equipment failure should be considered. The emergency plan should be updated annually, and larger facilities should practice implementation of the plan annually.

4.2 ALTERNATIVE WATER SOURCE DEVELOPMENT

4.2.1 Identification of Alternative Existing Public Water Supply Sources

Using data drawn from the TCEQ drinking water and TWDB groundwater well databases, PWSs surrounding the Sherwood Estates PWS were reviewed with regard to their reported drinking water quality and production capacity. PWSs that appeared to have water supplies with water quality issues were ruled out from consideration as alternative sources, while those without identified water quality issues were investigated further. If it was determined that these PWSs had excess supply capacity and might be willing to sell the excess, or might be a suitable location for a new groundwater well, the system was taken forward for further consideration.

Table 4.1 is a list of the existing PWSs within approximately 25 miles of the Sherwood Estates PWS. Twenty five miles was selected as the radius for the evaluation owing to the small number of PWSs with compliant water in proximity to the Sherwood Estates PWS.

Based on the initial screening summarized in Table 4.1, five alternatives were selected for further evaluation. These alternatives were selected based on factors such as water quality, distance from the Sherwood Estates PWS, sufficient total production capacity for selling or sharing water, and willingness of the system to sell or share water or drill a new well. These are summarized in Table 4.2.

4.2.1.1 Colorado River Municipal Water District

The Colorado River Municipal Water District (CRMWD) supplies water to both the Cities of Midland and Odessa and, while it would not supply water directly to the Sherwood Estates PWS, a brief description is included here because of its role in supplying water to these two cities. The CRMWD was authorized in 1949 by the 51st Legislature of the State of Texas for the purpose of providing water to the District's Member cities of Odessa, Big Spring, and Snyder. The CRMWD also has contracts to provide specified quantities of water to the cities of Midland, San Angelo, Stanton, Robert Lee, Grandfalls, Pyote, and Abilene (through the West Central Texas Municipal Water District).

The CRMWD owns and operates three major surface water supplies on the Colorado River in west Texas. These are Lake J. B. Thomas, the E. V. Spence Reservoir, and the O. H. Ivie Reservoir. Together, the full combined capacity of these reservoirs is 1.272 million acre-feet. Additionally, CRMWD operates five well fields for water supply. Three of those fields were developed by the Member Cities prior to 1949. The fourth field, located in Martin County, began delivering water in 1952. The fifth field, located in Ward County southwest of Monahans, can supply up to 28 mllion gallons per day (mgd). CRMWD primarily uses these well fields to supplement surface water deliveries during the summer months.

Table 4.1 Existing Public Water Systems within 25 miles of the Sherwood Estates PWS

System Name	Dist. From SE WS (Miles)	Comments/ Other Issues
Pecan Grove Mobile Home Park	0.8	Small system with WQ issues: TDS; marginal exceedances: NO3
City of Midland	1.5	Large system (>60 mgd) that uses both surface water and groundwater. No current violations. **Evaluate Further.**
Water Runners Inc.	2.7	Small system; current use requires extensive treatment to address WQ issues.
Valley View Mobile Home Park	4.3	Small system with WQ issues: As, TDS, NO3, gross alpha; marginal exceedances: Se
Greenwood ISD	6.5	Small system with WQ issues: arsenic, TDS, nitrate, total hardness
South Midland Co. Water Systems	6.6	Small system with WQ issues: As, TDS, NO3
Johns Mobile Home Park	7.0	Small system with WQ issues: As, TDS, NO3
Warren Roads	7.5	Small system with WQ issues: As, TDS, NO3
Greenwood Water System	8.0	Small system with WQ issues: As, fluoride; marginal exceedances: TDS
Twin Oaks Mobile Home Park	8.3	Small system with WQ issues: As, TDS, NO3; marginal exceedances: Se
Country Village Mobile Home Estates	8.9	Small system with WQ issues: As, TDS, NO3
Westgate Mobile Home Park	9.1	Small system with marginal As, TDS exceedances
Airline Mobile Home Park LTD	11.1	Small system with WQ issues: TDS, gross alpha; marginal exceedances: As
Spring Meadow Mobile Home Park	11.8	Small system with WQ issues: As, TDS; marginal exceedances: NO3
Pecan Acres Homeowners Association	11.9	Small system with WQ issues: As, TDS; marginal exceedances: gross alpha
City of Stanton	13.5	Large System (>1 mgd) with WQ issues: As, Fe, TDS, NO3; marginal exceedances: Se. Uses compliant surface water. **Evaluate Further.**
City of Odessa	13.5	Large system (>80 mgd) that uses both surface water and groundwater. No current violations. **Evaluate Further.**
Texas Water Station	13.8	Small system; current use requires extensive treatment to address WQ issues.
Circle Six Ranch Baptist Camp Inc	17.0	Small system with marginal As WQ issues. **Evaluate Further.**
Martin County Freshwater District	19.5	Small system with WQ issues: NO3; marginal exceedances: As, TDS
Grady ISD	19.7	Small system with WQ issues: As, TDS, NO3
Midland International Airport	24.0	Large system (>1 mgd) with no known WQ issues. **Evaluate Further.**

Table 4.2 Public Water Systems within 25 miles of Sherwood Estates PWS Selected for Further Evaluation

System Name	Pop	Conn	Total Production (mgd)	Ave Daily Usage (mgd)	Approx. Dist. from SE Water System	Comments/ Other Issues
Sherwood Estates Manufactured Townhome Community Water System	**65**	**25**	**0.403**	**0.005**	**n/a**	**n/a**
City of Midland	98,045	35,494	64.644	23.040	1.5 miles	Large system (>60 mgd) that uses both surface water and groundwater. No current violations.
City of Stanton	2,556	998	1.678	0.379	13.5 miles	Large System (>1 mgd) with WQ issues: As, Fe, TDS, NO3; marginal exceedances: Se. Uses compliant surface water.
City of Odessa	101,719	41,588	80.2	19.583	13.5 miles	Large system (>80 mgd) that uses both surface water and groundwater. No current violations.
Circle Six Ranch Baptist Camp Inc	350	40	0.180	–	17.0 miles	Small system with marginal As WQ issues
Midland International Airport	1,000	56	1.880	0.327	24.0 miles	Large system (>1 mgd) with no known WQ issues

4.2.1.2 City of Midland

The City of Midland is located approximately 1.5 miles northwest of Sherwood Estates PWS. The City of Midland purchases approximately 75 to 80 percent of its water from the CRMWD through a 1966 contract. This purchased water comprises mainly untreated surface water from several reservoirs, including Lake J.B. Thomas, Lake E.V. Spence, and Lake O.H. Ivie, though the CRMWD may also supplement the supply with groundwater during the high demand summer months. The City of Midland gets the other 20 to 25 percent of its water from various City-owned well fields, which provide lower quality water. Midland is classified as a member city of CRMWD and is allowed to use alternate water supplies, unlike Odessa whose water can only be provided by CRMWD.

As part of Midland's primary water sources, raw water from CRMWD is delivered to one of three reservoirs. Two of the three reservoirs are owned by CRMWD and include a 15 MG reservoir located at the water purification plant and the 100 MG Terminal Reservoir located on FM 1788, approximately 2 miles south of Highway 191. The Terminal Reservoir is shared by both Midland and Odessa. The third reservoir, Lake Peggy Sue, is owned by Midland and is located approximately 2 miles west of the City's water treatment plant. In addition to the surface water provided by CRMWD, under a 1995 agreement, Midland owns 16.54 percent of Lake Ivie, located approximately 170 miles southwest of Midland. Each day, 15 MGs from Lake Ivie and 16 MGs from CRMWD reservoirs are delivered via pipeline from Ballinger to San Angelo, and then to one of the three reservoirs around Midland.

In addition to CRMWD surface water, the City owns or leases water rights in three well fields. The McMillen well field was in operation from the early 1950s until it was depleted in the mid 1960s. It was used as a reserve water supply but is no longer used following detection of perchlorate in water samples from the well field. The Paul Davis well field, located 30 miles north of Midland, was developed in the late 1950s and is used during peak periods to offset the demand exceeding the 31 mgd provided by the surface water from CRMWD reservoirs. The well field can sustain a pumping rate of 18 to 19 mgd, but normally averages 10 mgd annually. The well field currently consists of two 2.5-MG tanks that receive groundwater from 29 wells. These wells are installed between 150 and 200 feet deep in the Ogallala aquifer (Code 121OGLL). Since arsenic, fluoride, perchlorate, and radionuclides were reported, both in samples from individual wells and in batch samples from the well field, the City of Midland carefully monitors the blending of surface water from CRMWD and the groundwater from the Paul Davis Well Field to maintain a potable water supply that does not exceed the MCLs for these four constituents. The third well field is the T-Bar Ranch, located in western Winkler County approximately 70 miles west of Midland. This well field is still being developed and will be brought online as the Paul Davis well field is depleted.

The City of Midland operates two treatment plants to treat surface water supplied by CRMWD and provides water to a service population of approximately 100,000. The City has a total of approximately 35,000 connections, about 32,000 of which are metered. The major users of water in Midland include college, parks, and schools which use the water for irrigation. The current monthly rates per connection are a $12 base charge for the first 2,000 gallons and $2.75 for each additional 1,000 gallons.

In Fall 2003, the Midland City Council decided that water can only be provided to areas annexed by the City of Midland. Consequently, while the City of Midland does have sufficient excess drinking water capacity, any location to receive water from the City would have to agree to be annexed. To be annexed, a commission representing the community to be annexed must submit a petition signed by at least 50 percent of the community residents wanting to be annexed. This commission would then appoint a Public Improvement District to build a water line from a Midland supply line to the community. In the past, Midland has financed the Public Improvement District through the sale of bonds. The community would be subject to the same rates as the other residences in Midland.

4.2.1.3 City of Stanton

The City of Stanton is located approximately 9.5 miles northwest of the Sherwood Estates PWS. Stanton is under contract with the CRMWD to receive up to 90 million gallons (MG) of raw water per year via pipeline to Stanton's water treatment facility. Over the past few years, the water source has been either Lake Ivie or Lake Thomas, both located southeast of Stanton. In 2004, Stanton received a total of 113 MG of water or 0.31 mgd from CRMWD. In addition to receiving surface water from CRMWD, Stanton also has an emergency source consisting of a six-well ground water collection system. When water is needed, it is pumped to a central storage area consisting of two 150,000-gallon storage tanks. Each well is completed to approximately 180 feet in the Ogallala aquifer, and each well is capable of producing an average sustained rate of 65 gpm. The wells were tested individually, and sample results indicate elevated levels of nitrate above the MCL and also arsenic just below the current MCL. In 2004, no water was pumped from the six-well system.

The utility department in Stanton is currently providing water to several rural communities beyond city limits and is willing to provide water to other communities. However, the current water treatment plant serving Stanton was built in 1965 and needs to be replaced or upgraded prior to allocating any excess water supplies to additional users. Trucking of treated water to a nearby community can be approved by the Stanton utility manager. If a community requests treated water be piped to its area, then the plan must be approved by the five-member city council.

Current rates for city residential areas are as follows:

- Raw water – Minimum use of 3,000 gallons/month for a cost of $4.55 and $1.50/every 1,000 gallons over the initial 3,000 gallons.
- Treated water – Minimum use of 3,000 gallons/month for a cost of $21.00 and $3.50/every 1,000 gallons over 3,000 gallons.

The current rate for outlying communities using City of Stanton water is:

- Treated water - $42.00 for the first 3,000 gallons and then $7.00 for every 1,000 gallons over 3,000 gallons.

The population of Stanton is around 2,700 with approximately 1,000 connections. There is no anticipated growth for Stanton, but that may change if gambling casinos are approved in Texas. Stanton is currently identified as a candidate site for a casino.

4.2.1.4 City of Odessa

The intake point for the City of Odessa is located approximately 13.5 miles west of the Sherwood Estates PWS. The City of Odessa is one of three original members of CRMWD and, by contract, may only obtain its water supply through them. The water supplied to the City of Odessa originates in a network of three reservoirs (Lake Ivie, Lake Spence, and Lake Thomas), but this water may be supplemented with groundwater during the high-demand summer months. The untreated water from the reservoirs is pumped from Ballinger, Texas to San Angelo, Texas via a 60-inch pipeline and then through a 53-inch pipeline from San Angelo northwest to Odessa, which is 1,400 feet higher in elevation than San Angelo. Ground water is pumped from a well field in Ward County.

The raw water is delivered to a treatment facility, where it is filtered and chlorinated, and then stored in a 4.3 MG concrete storage tank prior to distribution to the City of Odessa. In addition to the water delivered via CRMWD pipeline, a relatively small amount of water (less than 10%) is also delivered by a second pipeline from the Ward County well field located approximately 60 miles west of Odessa. This water is pH-adjusted and chlorinated prior to being pumped to the 4.3 MG storage tank.

In 2004, approximately 6.7 billion gallons of water were delivered to Odessa via the CRMWD pipeline, and 4.5 percent or 0.31 billion gallons, originated from the Ward County well field. Average usage by the City of Odessa ranges from 12 to 15 mgd in the winter to 35 to 36 mgd in the summer. The City of Odessa provides water to a population of approximately 108,000 and has a total of approximately 42,000 connections. The current customer rate per connection for potable water is $2.50 per 1,000 gallons.

The City of Odessa has an excess capacity of treated water and may be willing to sell water to other PWSs. A community wanting to purchase treated water from the City of Odessa must submit a formal request to the City for review by the five-member city council. The community does not have to be annexed in order to receive treated water via pipeline, but it would have to fund the cost of the connecting pipeline.

4.2.1.5 Circle Six Ranch Baptist Camp Inc

The Circle Six Ranch Baptist Camp Inc is located adjacent to Highway 137 north of the City of Stanton. The camp, which is approximately 17 miles from the Sherwood Estates PWS, contains bunkhouses, a motel, and conference centers. It is operated by the Circle Six Ranch Baptist Camp Inc, and serves a population of 350 with 40 connections. The PWS is supplied by five local groundwater wells (G1590003 A, B, C, D, and E), all of which were drilled to a depth of 110 feet with a rated flow rate of 20 to 30 gpm. The total system production is 0.180 mgd, the average daily consumption is unknown, the total storage is 0.085 MG, the booster pump capacity is 0.864 mgd, and the pressure tank capacity is 0.003 MG. The water is used primarily for summer camp purposes. The water is hypo-chlorinated for disinfection before distribution.

The wells do not have enough capacity to meet the peak demand flow rate of the Sherwood Estates PWS. However, based on the Circle Six Ranch Baptist Camp water quality data and its proximity to the Sherwood Estates PWS, Circle Six Ranch Baptist Camp may provide a suitable location for a new well.

4.2.1.6 Midland International Airport

Midland International Airport is located approximately 24 miles west of Sherwood Estates PWS. The Midland International Airport is supplied by 10 groundwater wells which are completed in the Antler Sands aquifer (Code 218ALRS), range in depth from 85 to 130 feet, and are rated from 61 to 203 gpm. These wells are maintained and operated by the City of Midland Utility Department. Water from the wells is chlorinated and piped to an elevated 500,000-gallon storage tank before entering the airport's distribution system. The system is capable of producing up to 1.5 mgd, and average daily consumption is approximately 0.5 mgd.

A Midland consulting firm, Arcadis, is currently evaluating the ability for the Midland International Airport well field to continue meeting the demands of the airport. Currently, the operators of the Midland International Airport PWS do not consider there to be sufficient excess capacity to provide water to offsite facilities or areas. However, based on available water quality data, the location may be a suitable point for a new groundwater well.

4.2.2 Potential for New Groundwater Sources

4.2.2.1 Installing New Compliant Wells

Developing new wells or well fields is recommended, provided good quality groundwater available in sufficient quantity can be identified. Since a number of water systems in the area also have problems with arsenic, it should be possible to share in the cost and effort of identifying compliant groundwater and constructing well fields.

Installation of a new well in the vicinity of the system intake point is likely to be an attractive option provided compliant groundwater can be found, since the PWS is already familiar with operation of water wells. As a result, existing nearby wells with good water quality should be investigated. Re-sampling and test pumping would be required to verify and determine the quality and quantity of water at those wells.

The use of existing wells should probably be limited to use as indicators of groundwater quality and availability. If a new groundwater source is to be developed, it is recommended that a new well or wells be installed instead of using existing wells. This will ensure the well characteristics are known and the well construction meets standards for drinking water wells.

Some of the alternatives suggest new wells be drilled in areas where existing wells are compliant. In developing the cost estimates, it is assumed that the aquifer in these areas would produce the required amount of water with only one well. Site investigations and geological research, which are beyond the scope of this study, could indicate whether the aquifer at a particular site and depth would provide the amount of water needed or if more than one well would need to be drilled in separate areas. Two wells are used in cases where the PWS is large enough that two wells are required by TCEQ rules.

4.2.2.2 Results of Groundwater Availability Modeling

Regional groundwater withdrawal in the PWS area is extensive and likely to remain near current levels over the next decades. In northern Midland County, where the PWS is located, two aquifers are potential groundwater sources for public supplies: the Ogallala aquifer, and the downdip of the Edwards Trinity (Plateau) aquifer.

Supply wells for the Sherwood Estates PWS and its vicinity withdraw groundwater primarily from the Southern Ogallala aquifer. The 2002 Texas Water Plan anticipates 24 percent depletion in the Ogallala supply over the next decades, from 5,000,097 acre-feet per year (AFY) estimated in 2000 to 3,785,409 AFY in 2050. Nearly 95 percent of the groundwater pumped is used for irrigated agriculture.

A GAM for the Ogallala aquifer was recently developed by the TWDB (Blandford, *et al.* 2003). Modeling was performed to simulate historical conditions and to develop long-term groundwater projections. Predictive simulations using the GAM model indicated that, if estimated future withdrawals are realized, aquifer water levels could decline to a point at which significant regions currently practicing irrigated agriculture could be essentially dewatered by

2050 (Blandford, *et al.* 2003). The model predicted the most critical conditions for Cochran, Hockley, Lubbock, Yoakum, Terry, and Gaines Counties where the simulated drawdown could exceed 100 feet. For northern Midland County, the simulated drawdown by the year 2050 would be more moderate, within the 0 to 25-foot range (Blandford, *et al*. 2003). The Ogallala aquifer GAM was not run for the Sherwood Estates PWS. Water use by the system would represent a minor addition to regional withdrawal conditions, making potential changes in aquifer levels beyond the spatial resolution of the regional GAM model.

In northern Midland County, the downdip of the Edwards-Trinity Plateau aquifer underlies the Ogallala aquifer. A GAM for the Edwards-Trinity Plateau aquifer was published by the TWDB in September 2004 (Anaya and Jones 2004). GAM data for the aquifer indicate that total withdrawal in Midland County had a steady decline in recent years, from a peak annual use of 21,127 acre-feet in 1995 to 13,484 acre-feet in 2000. This reduced water withdrawal from the Edwards-Trinity Plateau aquifer in Midland County is expected to remain nearly constant over the simulation period ending in the year 2050 (Anaya and Jones 2004).

4.2.3 Potential for New Surface Water Sources

The Sherwood Estates PWS is located in the upper reach of the Colorado Basin where current surface water availability is expected to steadily decrease as a result of the increased water demand. The Texas Water Development Board's 2002 Water Plan anticipates a 11 percent reduction in surface water availability in the Colorado River basin over the next 50 years, from 879,400 AFY in 2000 to 783,641 AFY in 2050.

There is a minimum potential for development of new surface water sources for the Sherwood Estates PWS system as indicated by limited water availability over the entire river basin, and within the site vicinity.

In the site vicinity, and over all of Midland County, unappropriated flows of the Colorado River Basin for new uses are available at most 50 percent of the time. This supply is inadequate because the TCEQ requires 100 percent supply availability for a PWS.

4.2.4 New Water Source Options for Detailed Consideration

The initial review of alternative sources of water results in the following options for more-detailed consideration:

1. City of Midland. Obtain treated CRMWD water through the City of Midland system. A pipeline and pump station would be constructed to transfer the water to the Sherwood Estates PWS storage tank (Alternative SE-1).

2. City of Stanton. Obtain treated CRMWD water through the City of Stanton PWS. A pipeline and pump station would be constructed to transfer the water to the Sherwood Estates PWS storage tank (Alternative SE-2).

3. City of Odessa. Obtain treated CRMWD water through the City of Odessa PWS. A pipeline and pump station would be constructed to transfer the water to the Sherwood Estates PWS storage tank (Alternative SE-3).

4. Circle Six Ranch Baptist Camp Inc. A new well would be installed in the vicinity of the wells at the Circle Six Ranch Baptist Camp. A pipeline and pump station would be constructed to transfer the water to the Sherwood Estates PWS storage tank (Alternative SE-4).

5. Midland International Airport. A new well would be installed in the vicinity of the wells at Midland International Airport. A pipeline and pump station would be constructed to transfer the water to the Sherwood Estates PWS storage tanks (Alternative SE-5).

6. Installing a new deeper well at the Sherwood Estates PWS that would produce compliant water in place of the water produced by the existing active wells (Alternative SE-6).

7. Installing a new well within 10, 5, or 1 mile of the Sherwood Estates PWS that would produce compliant water in place of the water produced by the existing active wells (Alternative SE-7, SE-8, and SE-9).

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of the well field water is identified as a potential alternative for the Sherwood Estates PWS. RO, EDR, iron-Based Adsorption, and Coagulation/Filtration treatments are potential applicable processes. RO, EDR, iron-based adsorption, and Coagulation/Filtration treatments can reduce TDS and arsenic to produce compliant water. The central RO treatment alternative is Alternative SE-10, the central EDR treatment alternative is Alternative SE-11, the central iron-based adsorption treatment is Alternative SE-12, and the central Coagulation/Filtration Treatment is Alternative SE-13.

4.3.2 Point-of-Use Systems

POU treatment using RO technology is valid for arsenic removal. The POU treatment alternative is SE-14.

4.3.3 Point-of-Entry Systems

POE treatment using RO technology is valid for arsenic removal. The POE treatment alternative is SE-15.

4.4 BOTTLED WATER

Providing bottled water is considered an interim measure to be used until a compliance alternative is implemented. Even though the community is small and people know each other, it would be reasonable to require a quarterly communication advising customers of the need to take advantage of a bottled water program. An alternative to providing bottled water is to provide a central, publicly accessible dispenser for treated drinking water. Alternatives addressing bottled water are SE-16, SE-17, and SE-18.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

A number of potential alternatives for compliance with the MCL for arsenic have been identified. Each of the potential alternatives is described in the following subsections. It should be noted that the cost information given is the capital cost and change in O&M costs associated with implementing a particular alternative. Appendix C contains cost estimates for the compliance alternatives. These compliance alternatives represent a range of possibilities, and a number of them are likely not feasible. However, all have been presented to provide a complete picture of the range of alternatives considered. It is anticipated that a PWS will be able to use the information contained herein to select the most attractive alternative(s) for more detailed evaluation and possible subsequent implementation.

4.5.1 Alternative SE-1: Purchase Treated Water from the City of Midland

This alternative involves purchasing treated water from the City of Midland, which will be used to supply the Sherwood Estates PWS. The City of Midland currently has sufficient excess capacity for this alternative to be feasible, although current City policy only allows drinking water to be provided to areas annexed by the City. For purposes of this report, in order to allow direct and straightforward comparison with other alternatives, this alternative assumes that water would be purchased from the City. Also, it is assumed that the Sherwood Estates PWS would obtain all its water from the City of Midland.

This alternative would require constructing a pipeline from a City of Midland water main to the existing storage tank for the Sherwood Estates PWS. It is assumed that a pump station would also be required to overcome pipe friction and elevation differences between Midland and the Sherwood Estates PWS. The required pipeline would be approximately 13.3 miles long and constructed of 4-inch pipe, along State Highway (SH) 80. The required pump horsepower would be 2 hp.

The pump station would include two pumps, including one standby, and would be housed in a building. A storage tank would also be constructed for the pumps to draw from. The pumps and piping would be installed with capacity to meet all water demand for the Sherwood Estates PWS.

This alternative involves regionalization by definition, since the Sherwood Estates PWS would be obtaining drinking water from an existing larger supplier. Also, other PWSs near the

Sherwood Estates PWS are in need of compliant drinking water and could share in implementation of this alternative.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the Sherwood Estates PWS wells, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $721,530, and the alternative's estimated annual O&M cost is $5,157.

The reliability of adequate amounts of compliant water under this alternative should be good. City of Midland provides treated surface water on a large scale, facilitating adequate O&M resources. From the perspective of the Sherwood Estates PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood. If the decision is made to perform blending, then the operational complexity would increase.

The feasibility of this alternative is dependent on an agreement being reached with the City of Midland to purchase treated drinking water.

4.5.2 Alternative SE-2: Purchase Treated Water from the City of Stanton

This alternative involves purchasing treated surface water from the City of Stanton, which would be used to supply the Sherwood Estates PWS. The City of Stanton currently has sufficient excess capacity for this alternative to be feasible and has indicated it would be amenable to negotiating an agreement to supply water to PWSs in the area. Records as late as 2004 indicate that the City of Stanton treated potable water has excessive concentrations of total trihalomethanes (TTHM). TTHMs are a disinfection by-product that can be reduced with operational and chemical use changes. The City of Stanford has also been cited for not reporting MCL exceedances to the public. These two issues would need to be resolved before this alternative is viable.

This alternative would require constructing a pipeline from a City of Stanton water main to the existing storage tank for the Sherwood Estates PWS. A pump station would also be required to overcome pipe friction and the elevation differences between Stanton and Sherwood Estates. The 4-inch pipeline would primarily follow SH 80 and Interstate Highway (IH) 20. The pipeline would be approximately 13.9 miles long. The required pump horsepower would be 3 hp.

The pump station would include two pumps, including one standby, and would be housed in a building. A tank would also be constructed for the pumps to draw from. The pumps and piping would be installed with capacity to meet all water demand for the Sherwood Estates PWS.

This alternative involves regionalization by definition, since the Sherwood Estates PWS would be obtaining drinking water from an existing larger supplier. It is possible the Sherwood

Estates PWS could turn over provision of drinking water to the City of Stanton instead of purchasing water. Also, other PWSs near the Sherwood Estates PWS are in need of compliant drinking water and could share in implementation of this alternative.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the Sherwood Estates PWS wells, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $3.0 million, and the alternative's estimated annual O&M cost is $7,420.

The reliability of adequate amounts of compliant water under this alternative is fair based on compliance history for the City of Stanton. From the perspective of the Sherwood Estates PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood. If the decision was made to perform blending then the operational complexity would increase.

The feasibility of this alternative is dependent on an agreement being reached with the City of Stanton to purchase treated drinking water.

4.5.3 Alternative SE-3: Purchase Treated Water from the City of Odessa

This alternative involves purchasing treated surface water from the City of Odessa, which will be used to supply the Sherwood Estates PWS. The City of Odessa currently has sufficient excess capacity for this alternative to be feasible and has indicated it would be amenable to negotiating an agreement to supply water to PWSs in the area. Records indicate the City of Odessa water has low levels arsenic (less than 0.004 mg/L), which is low enough to make blending a realistic consideration. However, for this alternative, it is assumed the Sherwood Estates PWS would obtain all its water from the City of Odessa.

This alternative would require constructing a pipeline from a City of Odessa water main to the existing storage tank for the Sherwood Estates PWS. A pump station would also be required to overcome pipe friction and the elevation differences between Odessa and Sherwood Estates PWS. The 4-inch pipeline would primarily follow Elkins Rd., I-20, HWY 80, Faudree Road, and Yukon Road, and would be approximately 29.9 miles long. The required pump horsepower would be 5 hp.

The pump station would include two pumps, including one standby, and would be housed in a building. A tank would also be constructed for the pumps to draw from. It is assumed the pumps and piping would be installed with capacity to meet all water demand for the Sherwood Estates PWS, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative involves regionalization by definition, since the Sherwood Estates PWS would be obtaining drinking water from an existing larger supplier. It is possible that the Sherwood Estates PWS could turn over provision of drinking water to the City of Odessa instead of purchasing water. Also, other PWSs near the Sherwood Estates PWS are in need of compliant drinking water and could share in implementation of this alternative.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the Sherwood Estates PWS wells, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $6.72 million, and the alternative's estimated annual O&M cost is $10,695.

The reliability of adequate amounts of compliant water under this alternative should be good. City of Odessa provides treated surface water on a large scale, facilitating adequate O&M resources. From the perspective of the Sherwood Estates PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood. If the decision was made to perform blending then the operational complexity would increase.

The feasibility of this alternative is dependent on an agreement being reached with the City of Odessa to purchase treated drinking water.

4.5.4 Alternative SE-4: New Well at Circle Six Ranch Baptist Camp Inc.

This alternative consists of drilling a new well in the Circle Six Ranch Baptist Camp Inc area that would replace the Sherwood Estates PWS wells. It is assumed that Sherwood Estates PWS would obtain all its water from the new well.

This alternative would require drilling a new well and installing a well pump, small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Sherwood Estates PWS. One of the two pumps in the pump station is for backup in case the other pump fails. The 4-inch pipeline would primarily follow IH 20, RR 1208, HWY 1050, RR 3113, and SH 137, would be approximately 21.9 miles long, and would discharge to the existing storage tank in the Sherwood Estates PWS. The required pump horsepower would be 3 hp.

This alternative presents a limited regional solution, since other PWSs in the area also need compliant water. Some regionalization could be accomplished by sharing the cost of drilling the well and possibly constructing the pipeline and pump station with other non-compliant PWSs in the area.

The estimated capital cost for this alternative includes constructing a new well and small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Sherwood Estates PWS. The estimated O&M cost for this alternative includes maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $4.69 million, and the estimated annual O&M cost for this alternative is $13,080.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the Sherwood Estates PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pumps stations is well understood, and the Sherwood Estates PWS currently operates pumps.

The feasibility of this alternative is dependent on finding a suitable well site.

4.5.5 Alternative SE-5: New Well at Midland International Airport

This alternative consists of drilling a new well in the Midland International Airport area that would replace the wells at the Sherwood Estates PWS. It is assumed that the Sherwood Estates Manufactured PWS would obtain all its water from the new well.

This alternative would require drilling a new well and installing a well pump, small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Sherwood Estates PWS. One of the two pumps in the pump station is for backup in the event the other pump fails. The pipeline, approximately 17.5 miles long, would primarily follow Elkins Rd., IH 20, SH 158, and SH 80, and would be a 4-inch line that discharges to the existing storage tank in the Sherwood Estates PWS. The required pump horsepower would be 3 hp.

This alternative presents a limited regional solution, since other PWSs in the area also need compliant water. Some regionalization could be accomplished by sharing the cost of drilling the well and possibly constructing the pipeline and pump station with other non-compliant PWSs in the area.

The estimated capital cost for this alternative includes constructing a new well and small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Sherwood Estates PWS. The estimated O&M cost for this alternative are related to maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is $4.04 million, and the estimated annual O&M cost for this alternative is $12,190.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the Sherwood Estates PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pumps stations is well understood, and Sherwood Estates PWS currently operates pumps.

The feasibility of this alternative is dependent on finding a suitable well site.

4.5.6 Alternative SE-6: New Well at Sherwood Estates

This alternative involves completing a new, deeper well at Sherwood Estates that would be screened in the Edwards Trinity aquifer, and tying it into the existing water system. The new well would be 140 feet deep. There are limited data available regarding water quality in the Edwards Trinity aquifer in this area, so further investigation would be necessary.

The estimated capital cost for this alternative includes completing the new well and constructing the connection piping to the existing treatment system. The estimated O&M cost for this alternative includes O&M costs for the new well (labor, power, and materials) minus O&M cost for operating the existing wells. The estimated capital cost for this alternative is $48,445, and the alternative's estimated annual savings is $7,007. The savings is a result of operating one well instead of two.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the Sherwood Estates PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of the current system is well understood, and the Sherwood Estates PWS currently operates it. If the decision were made to perform blending, then the operational complexity would increase.

Obtaining agreements is not necessary for implementing this option, and should not impact the feasibility of this alternative.

4.5.7 Alternative SE-7: New Well at 10 miles

This alternative consists of installing a new well within 10 miles of the Sherwood Estates PWS that would produce compliant water in place of the water produced by the existing active wells. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed. To address a range of solutions, three different well alternatives are developed, assuming the new well is located within 10 miles, 5 miles, and 1 mile from the existing intake point.

This alternative would require constructing a new 110-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the Sherwood Estates PWS. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 10 miles long, and would be a 4-inch line that discharges to the existing storage tank at the Sherwood Estates PWS. The pump station would include two pumps, including one standby, and would be housed in a building.

Depending on well location and capacity, this alternative could present some options for a more regional solution. It may be possible to share water and costs with one or more nearby systems.

The estimated capital cost for this alternative includes installing the well and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the cost for O&M for the pipeline and pump station. The estimated capital cost for this alternative is $2.3 million, and the estimated annual O&M cost for this alternative is $10,608.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From the perspective of the Sherwood Estates PWS, this alternative would be similar to the existing system in terms of operation. The Sherwood Estates PWS has experience with O&M of wells and pumps.

The feasibility of this alternative is dependent on the ability to find an adequate existing well or success in installing a well that produces an adequate supply of compliant water. It is likely an alternate groundwater source would not be found on land controlled by the Sherwood Estates PWS, so landowner cooperation would be required.

4.5.8 Alternative SE-8: New Well at 5 miles

This alternative consists of installing a new well within 5 miles that would produce compliant water in place of the water produced by the Sherwood Estates PWS wells. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed.

This alternative would require constructing a new 110-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the Sherwood Estates PWS. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 5 miles long, and would be a 4-inch line that discharges to the existing storage tank at Sherwood Estates PWS. The pump station would include two pumps, including one standby, and would be housed in a building.

Depending on well location and capacity, this alternative could present some options for a more regional solution. It may be possible to share water and costs with one or more nearby systems.

The estimated capital cost for this alternative includes installing the well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the cost for O&M for the pipeline and pump station. The estimated capital cost for this alternative is $1.3 million, and the estimated annual O&M cost for this alternative is $9,551.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From the perspective of Sherwood Estates PWS, this alternative would be similar in terms of operation as the existing system. Sherwood Estates PWS has experience with O&M of wells and pumps.

The feasibility of this alternative is dependent on the ability to find an adequate existing well or success in installing a well that produces an adequate supply of compliant water. It is likely an alternate groundwater source would not be found on land controlled by Sherwood Estates PWS, so landowner cooperation would be required.

4.5.9 Alternative SE-9: New Well at 1 mile

This alternative consists of installing a new well within 1 mile that would produce compliant water in place of the water produced by the existing active wells. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed.

This alternative would require constructing a new 110-foot well, and a pipeline from the new well to the existing intake point for the Sherwood Estates PWS. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 4-inch line that discharges to the existing storage tank at Sherwood Estates PWS.

Depending on well location and capacity, this alternative could present some options for a more regional solution. It may be possible to share water and costs with another nearby system.

The estimated capital cost for this alternative includes cost to install the well, and construct the pipeline. The estimated O&M cost for this alternative includes the cost for O&M for the pipeline. The estimated capital cost for this alternative is $259,511, and the alternative's estimated annual savings is $6,821. The savings is a result of operating one well instead of two.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells and pipelines are commonly employed. From the perspective of Sherwood Estates PWS, this alternative would be similar in terms of operation compared to the existing system. The Sherwood Estates PWS has experience with O&M of wells.

The feasibility of this alternative is dependent on the ability to find an adequate existing well or success in installing a well that produces an adequate supply of compliant water. It is possible that an alternate groundwater source would not be found on land controlled by Sherwood Estates PWS, so landowner cooperation may be required.

4.5.10 Alternative SE-10: Central RO Treatment

This system would continue to pump water from the Sherwood Estates PWS wells, and would treat the water through an RO system prior to distribution. For this option, a fraction of the raw water would be treated and the blended with the untreated stream to obtain overall compliant water. The RO process concentrates impurities in the reject stream which would require disposal. It is estimated the RO reject generation would be approximately 10,000 gpd when the system is operated at full flow. It should be noted that RO treatment would be effective for removal of nitrate, and would also reduce TDS.

This alternative consists of constructing the RO treatment plant inside an existing structure that houses the Sherwood Estates PWS service pumps. The plant is composed of a skid with the pre-constructed RO plant; two transfer pumps, a 20,000-gallon tank for storing the treated water, and a 260,000-gallon pond for storing reject water. The treated water would be stored in the existing water tank, and chlorinated prior to being pumped into the existing pressure tanks that feed the distribution system. The capital cost includes purchase of a water truck-trailer to periodically haul reject water for disposal.

The estimated capital cost for this alternative is $484,794, and the estimated annual O&M cost is $52,607.

The reliability of adequate amount of compliant water under this alternative is good, since RO treatment is a common and well-understood treatment technology. However, O&M efforts required for the central RO treatment plant may be significant, and O&M personnel would require training with RO. The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.11 Alternative SE-11: Central EDR Treatment

The system would continue to pump water from the Sherwood Estates PWS wells, and would treat the water through an EDR system prior to distribution. For this option the EDR would treat the full flow without bypass as the EDR operation can be tailored for desired removal efficiency. It is estimated the EDR reject generation would be approximately 10,000 gpd when the system is operated at full flow. It should be noted that RO treatment would be effective for removal of nitrate, and would also reduce TDS.

This alternative consists of constructing the EDR treatment plant inside an existing structure that houses the Sherwood Estates PWS service pumps. The plant is composed of a skid with the pre-constructed EDR system; two transfer pumps; a 20,000-gallon tank for storing the treated water, and a 260,000-gallon pond for storing concentrated water. The treated water would be stored in the existing water tank, and chlorinated prior to being pumped into the existing pressure tanks that feed the distribution system. The capital cost includes purchase of a water truck-trailer to periodically haul reject water for disposal.

The estimated capital cost for this alternative is $644,294 and the estimated annual O&M cost is $50,184.

The reliability of adequate amounts of compliant water under this alternative is good, since EDR treatment is a common and well-understood treatment technology. However, O&M efforts required for the central EDR treatment plant may be significant, and O&M personnel would require training with EDR. The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.12 Alternative SE-12: Central iron-Based Adsorption Treatment

The system would treat groundwater from the existing wells using an iron-based adsorption system prior to distribution. This alternative consists of constructing the adsorption treatment plant inside an existing structure that houses the Sherwood Estates PWS service pumps. The plant comprises the pre-constructed adsorption system on a skid (*e.g.,* one AdEdge APU-100 package units), and a 15,000-gallon backwash wastewater equalization tank. The water would be pre-chlorinated to oxide AS(III) to AS(V) and post chlorinated for disinfection prior to flowing to the distribution system. Backwash would be required monthly with raw well water supplied directly by the well pump. The backwash would be equalized in the 15,000-gallon tank and recycled to the APU-100 system at a very low rate. Accumulated sludge would be trucked off-site periodically for disposal. The adsorption media are expected to last approximately two years before replacement and disposal. This treatment would not remove nitrate or TDS.

The estimated capital cost for this alternative is $334,900, and the estimated annual O&M cost is $51,918, which includes the annual media replacement cost of $27,000. Reliability of supply of adequate amounts of compliant water under this alternative is good as the adsorption technology has been demonstrated effective in full-scale and pilot-scale facilities. The technology is simple and requires minimal O&M effort.

4.5.13 Alternative SE-13: Central Coagulation/Filtration Treatment

The system would treatment groundwater from the wells using a coagulation/filtration system prior to distribution. This alternative consists of constructing the coagulation/filtration plant inside an existing structure that houses the Sherwood Estates PWS service pumps. The plant comprises the pre-constructed coagulation/filtration system on a skid (*e.g.*, two Macrolite filters from Kinetico), a ferric chloride feed and storage system, and a 20,000-gallon backwash wastewater equalization tank. The water would be pre-chlorinated to oxidize As(III) to As(V) and post-chlorinated for disinfection prior to flowing to the distribution system. Ferric chloride solution would be fed to the well water after pre-chlorination and before entering the filters. The filters would be backwashed every 1 to 2 days by well water directly from the well pump. The backwash wastewater would be equalized in the 20,000-gallon tank and recycled to the treatment system at a controlled rate. Accumulated sludge would be trucked off-site for disposal. The Macrolite media do not need replacement. This treatment would not remove nitrate or TDS.

The estimated capital cost for this alternative is $366,075, and the estimated annual O&M cost is $79,580. This alternative requires more O&M labor cost and sludge disposal than the adsorption alternative. Reliability of supply of adequate amounts of compliant water under this alternative is good as the coagulation/filtration process is a well-established technology for arsenic removal. The technology is simple but requires significant effort for chemical handling and backwash monitoring. The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.14 Alternative SE-14: Point-of-Use Treatment

This alternative consists of the continued operation of the existing active Sherwood Estates PWS wells, plus treatment of water to be used for drinking or food preparation at the POU to remove arsenic. The purchase, installation, and maintenance of POU treatment systems to be installed "under the sink" would be necessary for this alternative. Blending is not an option in this case. Reverse osmosis POU treatment units would also be effective for reducing other potential contaminants such as TDS and sulfate.

This alternative would require installing the POU treatment units in dwellings and other buildings that provide drinking or cooking water. The Sherwood Estates PWS would be responsible for purchasing and maintaining the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. In residences, the most convenient point for installing treatment units is typically under the kitchen sink, with a separate tap installed for dispensing treated water. Installation of the treatment units in kitchens would require entry by personnel from the Sherwood Estates PWS or contract personnel into residences of customers. As a result, the cooperation of customers would be important for success in implementing this alternative. The treatment units could be installed so access could be made without entry into the residence, which would complicate the installation and increase costs.

POU RO treatment processes typically produce liquid waste streams that are equal in volume to the treated water and require disposal. These waste streams result in an increased overall volume of water used. POU systems have the advantage that only a minimum volume of water is treated (only that for human consumption). This minimizes the size of the treatment units, the increase in water required, and the waste for disposal. For this alternative, it is assumed that the increase in water consumption is insignificant in terms of supply cost and that the waste stream can be recovered for reuse or discharged to the house sewer or septic system.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the POU treatment systems. The estimated O&M cost for this alternative includes purchasing and replacing filters and membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $16,500, and the estimated annual O&M cost for this alternative is $16,210. For the cost estimate, it is assumed that one POU treatment unit would be required for each of the 25 existing connections to the Sherwood Estates PWS. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive.

The reliability of adequate amounts of compliant water under this alternative is fair, since it relies on the active cooperation of the customers for system installation, use, and maintenance, and only provides compliant water to single tap within a house. Additionally, the O&M efforts required for the POU systems will be significant, and Sherwood Estates PWS personnel are inexperienced in this type of work. From the perspective of Sherwood Estates PWS, this alternative would be characterized as more difficult to operate due to the in-home requirements.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.15 Alternative SE-15: Point-of-Entry Treatment

This alternative consists of the continued operation of the two existing active Sherwood PWS wells, plus treatment of water to remove arsenic as it enters the residence. The purchase, installation, and maintenance of the treatment systems at the POE would be necessary for this alternative. Blending is not an option in this case. Reverse osmosis POE treatment units would also be effective for reducing other potential contaminants such as TDS and sulfate.

This alternative would require installing the POE treatment units at dwellings and other buildings that provide water for drinking or cooking. The Sherwood Estates PWS would be responsible for purchasing and maintaining the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. The plumbing in houses should be investigated to ensure that the aggressive water that would result from RO treatment would not cause damage. It may also be desirable to modify piping so that water for non-consumptive uses could be withdrawn upstream of the treatment unit. The POE treatment units would be installed outside the residence, so entry would not be necessary for O&M. Some cooperation from customers would be necessary for installation and maintenance of the treatment systems.

POE RO treatment processes typically produce liquid waste streams that are equal in volume to the treated water and require disposal. These waste streams result in an increased overall volume of water used. Point-of-entry systems treat a greater volume of water than POU systems. For this alternative, it is assumed that the increase in water consumption is insignificant in terms of supply cost and that the waste stream can be recovered for reuse or discharged to the house sewer or septic system.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the POE treatment systems. The estimated O&M cost for this alternative includes purchasing and replacing filters and membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $288,750, and the estimated annual O&M cost for this alternative is $35,585. For the cost estimate, it is assumed that one POE treatment unit would be required for each of the 25 existing connections to the Sherwood Estates PWS.

The reliability of adequate amounts of compliant water under this alternative are fair, but better than POU systems since it relies less on the active cooperation of customers for system installation, use, and maintenance, and compliant water is supplied to all taps within a residence. Additionally, the O&M efforts required for the POE systems would be significant, and Sherwood Estates PWS personnel are inexperienced in this type of work. From the perspective of the Sherwood Estates PWS, this alternative would be characterized as more difficult to operate due to the on-property requirements.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.16 Alternative SE-16: Public Dispenser for Treated Drinking Water

This alternative consists of the continued operation of the existing active the Sherwood Estates PWS wells, plus dispensing treated water for drinking and cooking at a publicly accessible location. Implementing this alternative would require purchasing and installing a treatment unit where customers would be able to fill their own containers. This alternative also includes notifying customers of the importance of obtaining drinking water from the dispenser. In this way, only a relatively small volume of water requires treatment, but customers would be required to pick up and deliver their own water. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

The Sherwood Estates PWS would be responsible for maintenance of the treatment unit, including membrane and filter replacement, periodic sampling, and necessary repairs. A method for disposal of the reject waste stream produced by the treatment system will have to be found. This alternative relies on a great deal of cooperation and action from the customers to be effective.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes purchasing and replacing filters and membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $11,600, and the estimated annual O&M cost for this alternative is $17,504.

The reliability of adequate amounts of compliant water under this alternative is fair, because of the large amount of effort required from the customers and the associated inconvenience. The Sherwood Estates PWS has not provided this type of service in the past. From the perspective of the Sherwood Estates PWS, this alternative would be characterized as relatively easy to operate, since these types of treatment units are highly automated, and there is only one unit.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.17 Alternative SE-17: 100 Percent Bottled Water Delivery

This alternative consists of the continued operation of the existing active the Sherwood Estates PWS wells, but compliant drinking water will be delivered to customers in containers. This alternative involves setting up and operating a bottled water delivery program to serve all the customers in the system. It is expected that the Sherwood Estates PWS would find it convenient and economical to contract a bottled water service. The bottle delivery program would have to be flexible enough to allow for delivery of smaller containers should customers be incapable of lifting and manipulating 5-gallon bottles. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

This alternative does not involve capital cost for construction, but would require some initial costs for system setup, and then ongoing costs to have the bottled water furnished. It is assumed for this alternative that bottled water is provided to 100 percent of the Sherwood Estates PWS.

This alternative does not present options for a regional solution.

The estimated initial capital cost is for setting up the program. The estimated O&M cost for this alternative includes program administration and purchase of the bottled water. The estimated initial cost for this alternative is $25,807, and the estimated annual O&M cost for this alternative is $63,090. For the cost estimate, it is assumed that each person requires 1 gallon of bottled water per day.

The reliability of adequate amounts of compliant water under this alternative is fair, since it relies on the active cooperation of customers to order and utilize the water. Management and administration of the bottled water delivery program will require attention from Sherwood Estates PWS.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.18 Alternative SE-18: Public Dispenser for Trucked Drinking Water

This alternative consists of continued operation of the existing active Sherwood Estates PWS wells, plus dispensing compliant water for drinking and cooking at a publicly accessible location. The compliant water would be purchased from a nearby system with compliant drinking water, and delivered by truck to a tank at a central location where customers would be able to fill their own containers. This alternative also includes notifying customers of the importance of obtaining drinking water from the dispenser. In this way, only a relatively small volume of compliant water is required, but customers are required to pick up and deliver their own water. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

The Sherwood Estates Manufactured PWS would purchase a truck that would be suitable for hauling potable water, and install a storage tank. It is assumed the storage tank would be filled once a week, and that the chlorine residual would be tested for each truckload. This alternative relies on cooperation and action from the customers for it to be effective.

This alternative presents limited options for a regional solution if two or more systems share the purchase and operation of the water truck.

The estimated capital cost for this alternative includes constructing the storage tank to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes the contract water delivery service, maintenance for the tank, water quality testing, and record keeping. The estimated capital cost for this alternative is $102,986, and the estimated annual O&M cost for this alternative is $16,581.

The reliability of adequate amounts of compliant water under this alternative is fair because of the large amount of effort required from the customers and the associated inconvenience. The Sherwood Estates PWS has not provided this type of service in the past. From the perspective of Sherwood Estates PWS, this alternative would be characterized as relatively easy to operate, but the water hauling and storage would have to be done with care to ensure sanitary conditions.

The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

4.5.19 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for Sherwood Estates PWS.

Table 4.3 Summary of Compliance Alternatives for Sherwood Estates Manufactured Townhome Community Water System

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
SE-1	Purchase treated water from the City of Midland	- Storage Tank - Pump station - 13.3-mile pipeline	$721,530	$5,157	$68,064	Good	N	Agreement must be successfully negotiated with the City of Midland. City currently requires annexation before it will do this. Blending may be possible.
SE-2	Purchase treated water from the City of Stanton	Storage Tank - Pump station - 13.9-mile pipeline	$3,049,072	$7,420	$273,252	Good	N	Agreement must be successfully negotiated with the City of Stanton. Blending may be possible. Costs could be shared with other nearby small systems.
SE-3	Purchase treated water from the City of Odessa	- Storage Tank - Pump station - 29.9-mile pipeline	$6,720,301	$10,695	$596,601	Good	N	Agreement must be successfully negotiated with the City of Midland. Blending may be possible. Costs could be shared with other nearby small systems.
SE-4	New Well at Circle Six Ranch Baptist Camp Inc	- New well - Storage Tank - Pump station - 21.9-mile pipeline	$4,690,547	$13,080	$422,024	Good	N	Agreement must be successfully negotiated with Circle Six Ranch Baptist Camp Inc, or land must be purchased. Blending not possible. Costs could be shared with other nearby small systems.
SE-5	New Well at Midland International Airport	- New well - Storage Tank - Pump station - 17.5-mile pipeline	$4,037,068	$12,190	$364,160	Good	N	Agreement must be successfully negotiated with Midland International Airport, or land must be purchased. Blending not possible. Costs could be shared with other nearby small systems.
SE-6	Install new compliant well at SE	- New well - Storage tank - Pump station	$48,445	($7,007)	($2,784)	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
SE-7	Install new compliant well within 10 miles	- New well - Storage tank - Pump station - 10-mile pipeline	$2,295,662	$10,608	$210,755	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
SE-8	Install new compliant well within 5 miles	- New well - Storage tank - Pump station - 5-mile pipeline	$1,300,795	$9,551	$122,960	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
SE-9	Install new compliant well within 1 mile	- New well - Storage tank - Pump station - 1-mile pipeline	$259,511	($6,821)	$15,804	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
SE-10	Continue operation of Sherwood Estates well field with central RO treatment	- Central RO treatment plant	$484,794	$52,607	$94,874	Good	T	Costs could possibly be shared with nearby small systems.

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
SE-11	Continue operation of Sherwood Estates well field with central EDR treatment	- Central EDR treatment plant	$644,294	$50,184	$106,356	Good	T	Costs could possibly be shared with nearby small systems.
SE-12	Continue operation of Sherwood Estates well field with central IBAT treatment	- Central IBAT treatment plant	$334,900	$51,918	$81,116	Good	T	Costs could possibly be shared with nearby small systems.
SE-13	Continue operation of Sherwood Estates well field with C/F treatment	- Central C/F treatment plant	$366,075	$79,580	$111,496	Good	T	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
SE-14	Continue operation of current well field, with POU treatment	- POU treatment units	$16,500	$16,210	$17,649	Fair	T, M	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
SE-15	Continue operation of current well field, with POE treatment	- POE treatment units	$288,750	$35,585	$60,760	Fair (*better than POU*)	T, M	All home taps compliant and less resident cooperation required.
SE-16	Continue operation of current well field, but furnish public dispenser for treated drinking water	- Water treatment and dispenser unit	$11,600	$17,504	$18,515	Fair/interim measure	T	Does not provide compliant water to all taps, and requires a lot of effort by customers.
SE-17	Continue operation of current well field, but furnish bottled drinking water for all customers	- Set up bottled water system	$25,807	$63,090	$65,340	Fair/interim measure	M	Does not provide compliant water to all taps, and requires customers to order and use. Management of program may be significant.
SE-18	Continue operation of current well field, but furnish public dispenser for trucked drinking water.	- Construct storage tank and dispenser - Purchase potable water truck	$102,986	$16,581	$25,560	Fair/interim measure	M	Does not provide compliant water to all taps, and requires a lot of effort by customers.

Notes: *N – No significant increase required in technical or management capability*
T – Implementation of alternative will require increase in technical capability
M – Implementation of alternative will require increase in management capability
1 – See cost breakdown in Appendix C
2 – 20-year return period and 6 percent interest

4.6 COST OF SERVICE AND FUNDING ANALYSIS

4.6.1 Sherwood Estates PWS Financial Data

No separate financial data are maintained by the system operator for the Sherwood Estates PWS. Financial information on the water system is included in the consolidated financial data for the mobile home park. Water usage does not constitute a separate monthly billing, but is included in the monthly rent for the mobile home pads. The estimated water usage per connection is approximately $15/month, or approximately 10 percent of monthly pad rental. This value was used in the financial model as the basic monthly charge for unlimited water usage with no additional rate structure tiers. Financial data for system expenditures for Sherwood Estates PWS were based on estimates and pro-rating of expenses based on documented expenses of similar systems.

This analysis will need to be performed in a more detailed fashion and applied to alternatives that are deemed attractive and worthy of more detailed evaluation. A more detailed analysis should include additional factors such as:

- Cost escalation,
- Price elasticity effects where increased rates may result in lower water consumption,
- Costs for other system upgrades and rehabilitation needed to maintain compliant operation.

4.6.2 Current Financial Condition

4.6.2.1 Cash Flow Needs

Based on estimates for the system, the current average annual water use by residential customers of Sherwood Estates PWS is estimated to be $180, or less than 1.0 percent of the annual household income of $36,678 for the Census Block Group that includes the Sherwood Estates PWS. Because of the lack of separate financial data exclusively for the water system, it is difficult to determine exact cash flow needs. Water usage revenues likely fall short of expenditures with the system being subsidized by other revenues.

4.6.2.2 Ratio Analysis

Current Ratio

The Current Ratio for the Sherwood Estates PWS could not be determined due to lack of necessary financial data to determine this ratio.

Debt to Net Worth Ratio

A Debt-to-Net-Worth Ratio also could not be determined owing to lack of the necessary financial data to determine this ratio.

Operating Ratio = 0.95

Because of the lack of complete separate financial data on expenses specifically related to the Sherwood Estates PWS, the Operating Ratio could not be accurately determined. However, based on expenditure estimates for the system, the system's estimated operating expenditures of approximately $4,750 were greater than the operating revenues, with a resulting operating ratio of 0.95. Thus, since the operating ratio is less than 1.0, revenues most probably do not cover expenses for the system.

4.6.3 Financial Plan Results

Each compliance alternative for the Sherwood Estates PWS was evaluated, with emphasis on the impact on affordability (expressed as a percentage of household income), and the overall increase in water rates necessary to pay for the improvements. Each alternative was examined under the various funding options described in Section 2.4.

For State Revolving Fund (SRF) funding options, customer MHI compared to the state average determines the availability of subsidized loans. Since the MHI for customers of Sherwood Estates PWS was not available, Census Block Group data were used. The Census Block Group for the Sherwood Estates PWS is located had an estimated annual household income of $31,678 according to the 2000 U.S. Census compared to a statewide average of $39,927, or 79 percent of the statewide average. Since the MHI for Census Zipcode Tract is greater than 75 percent of the statewide average, Sherwood Estates PWS may qualify for an interest rate of 3.8 percent. If the actual MHI for Sherwood Estates PWS is below 75 percent of the statewide average, then Sherwood Estates PWS may qualify for an interest rate of 0.0.

Results of the financial impact analysis are provided in Table 4.4 and Figure 4.2. Table 4.4 presents rate impacts assuming that any deficiencies in reserve accounts are funded immediately in the year following the occurrence of the deficiency, which would cause the first few years' water rates to be higher than they would be if the reserve account was built-up over a longer period of time. Figure 4.2 provides a bar chart that in terms of the yearly billing to an average customer (6,083 gallons/month consumption), shows the following:

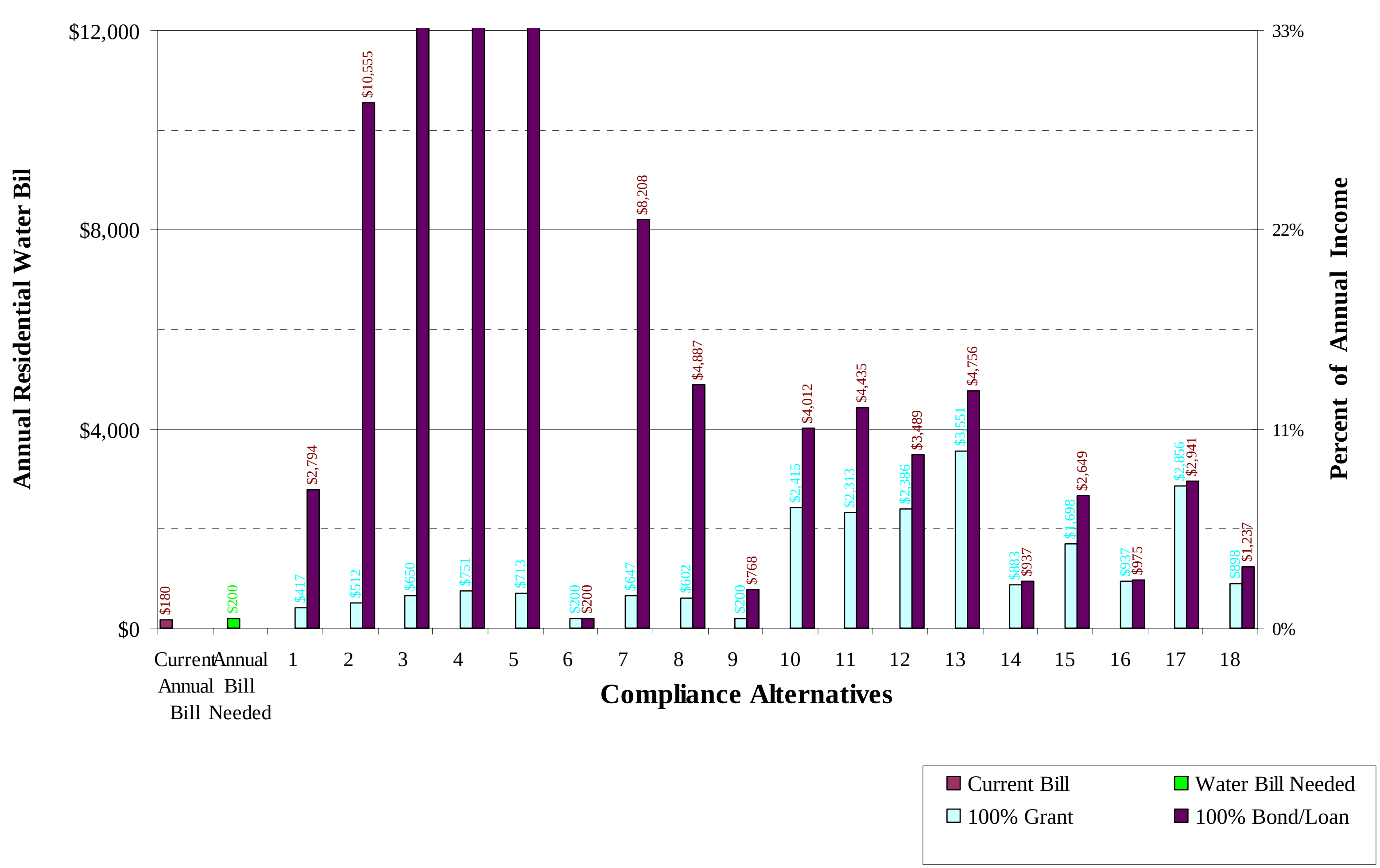
- Current annual average bill,
- Projected annual average bill including rate increase, if needed, to match existing expenditures, and
- Projected annual bill including rate increases needed to fund implementation of a compliance alternative (this does not include funding for reserve accounts).

The two bars shown for each compliance alternative represent the rate changes necessary for revenues to match total expenditures assuming 100 percent grant funding and 100 percent loan/bond funding. Most funding options will fall between 100 percent grant and 100 percent loan/bond funding, with the exception of 100 percent revenue financing. Establishing or increasing reserve accounts would require an increase in rates. If existing reserves are insufficient to fund a compliance alternative, rates would need to be raised before implementing the compliance alternative. This would allow for accumulation of sufficient reserves to avoid larger but temporary rate increases during the years the compliance alternative was being implemented.

Table 4.4 Financial Impact on Household

Alternative	Description		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Bond
1	Purchase Water from City of Midland	Max % of HH Income	85%	2%	6%	9%	14%	15%
		Max % Rate Increase Compared to Current	10246%	178%	575%	971%	1571%	1763%
		Average Water Bill Required by Alternative	$ 29,035	$ 771	$ 1,863	$ 2,956	$ 4,613	$ 5,141
2	Purchase Water from City of Stanton	Max % of HH Income	353%	3%	17%	30%	51%	58%
		Max % Rate Increase Compared to Current	42950%	253%	1926%	3600%	6139%	6948%
		Average Water Bill Required by Alternative	$ 120,815	$ 968	$ 5,585	$ 10,201	$ 17,204	$ 19,434
3	Purchase Water from City of Odessa	Max % of HH Income	776%	4%	34%	64%	110%	125%
		Max % Rate Increase Compared to Current	94530%	360%	4049%	7738%	13334%	15117%
		Average Water Bill Required by Alternative	$ 265,565	$ 1,254	$ 11,429	$ 21,604	$ 37,038	$ 41,954
4	New Well at Circle Six Ranch Baptist Camp Inc	Max % of HH Income	543%	4%	26%	47%	79%	89%
		Max % Rate Increase Compared to Current	66081%	438%	3013%	5588%	9494%	10738%
		Average Water Bill Required by Alternative	$ 185,722	$ 1,462	$ 8,563	$ 15,665	$ 26,438	$ 29,869
5	New Well at Midland International Airport	Max % of HH Income	468%	4%	22%	41%	68%	77%
		Max % Rate Increase Compared to Current	56895%	409%	2625%	4841%	8203%	9274%
		Average Water Bill Required by Alternative	$ 159,942	$ 1,384	$ 7,496	$ 13,609	$ 22,881	$ 25,834
6	New Well at Sherwood Estates	Max % of HH Income	6%	1%	1%	1%	1%	1%
		Max % Rate Increase Compared to Current	690%	10%	23%	36%	56%	63%
		Average Water Bill Required by Alternative	$ 2,227	$ 319	$ 356	$ 394	$ 450	$ 468
7	New Well at 10 Miles	Max % of HH Income	267%	4%	14%	24%	40%	45%
		Max % Rate Increase Compared to Current	32428%	357%	1617%	2877%	4789%	5398%
		Average Water Bill Required by Alternative	$ 91,280	$ 1,246	$ 4,722	$ 8,198	$ 13,470	$ 15,149
8	New Well at 5 Miles	Max % of HH Income	152%	3%	9%	15%	24%	27%
		Max % Rate Increase Compared to Current	18448%	322%	1036%	1751%	2834%	3179%
		Average Water Bill Required by Alternative	$ 52,047	$ 1,154	$ 3,123	$ 5,093	$ 8,080	$ 9,032
9	New Well at 1 Mile	Max % of HH Income	31%	1%	1%	3%	4%	5%
		Max % Rate Increase Compared to Current	3652%	10%	81%	208%	424%	493%
		Average Water Bill Required by Alternative	$ 10,541	$ 319	$ 519	$ 870	$ 1,466	$ 1,655
10	Central Treatment - RO	Max % of HH Income	64%	15%	17%	19%	23%	24%
		Max % Rate Increase Compared to Current	7700%	1732%	1999%	2265%	2668%	2797%
		Average Water Bill Required by Alternative	$ 21,816	$ 4,906	$ 5,640	$ 6,374	$ 7,488	$ 7,842
11	Central Treatment - EDR	Max % of HH Income	82%	14%	17%	20%	25%	26%
		Max % Rate Increase Compared to Current	9899%	1653%	2007%	2360%	2897%	3068%
		Average Water Bill Required by Alternative	$ 27,991	$ 4,695	$ 5,671	$ 6,646	$ 8,126	$ 8,597
12	Central Treatment - Adsorption	Max % of HH Income	47%	15%	16%	18%	20%	21%
		Max % Rate Increase Compared to Current	5585%	1710%	1894%	2078%	2356%	2445%
		Average Water Bill Required by Alternative	$ 15,881	$ 4,846	$ 5,353	$ 5,861	$ 6,630	$ 6,875
13	Central Treatment - Coag-Filt	Max % of HH Income	54%	22%	24%	26%	28%	29%
		Max % Rate Increase Compared to Current	6475%	2616%	2817%	3018%	3322%	3420%
		Average Water Bill Required by Alternative	$ 18,336	$ 7,257	$ 7,811	$ 8,366	$ 9,207	$ 9,474
14	Point-of-Use Treatment	Max % of HH Income	5%	5%	5%	5%	6%	6%
		Max % Rate Increase Compared to Current	540%	540%	550%	559%	572%	577%
		Average Water Bill Required by Alternative	$ 1,779	$ 1,734	$ 1,759	$ 1,784	$ 1,822	$ 1,834
15	Point-of-Entry Treatment	Max % of HH Income	39%	10%	12%	13%	15%	16%
		Max % Rate Increase Compared to Current	4670%	1175%	1333%	1492%	1732%	1809%
		Average Water Bill Required by Alternative	$ 13,339	$ 3,423	$ 3,860	$ 4,297	$ 4,960	$ 5,172
16	Public Dispenser for Treated Drinking Water	Max % of HH Income	6%	6%	6%	6%	6%	6%
		Max % Rate Increase Compared to Current	583%	583%	589%	596%	605%	608%
		Average Water Bill Required by Alternative	$ 1,879	$ 1,847	$ 1,865	$ 1,882	$ 1,909	$ 1,917
17	Supply Bottled Water to 100% of Population	Max % of HH Income	18%	18%	18%	18%	18%	18%
		Max % Rate Increase Compared to Current	2076%	2076%	2090%	2104%	2126%	2132%
		Average Water Bill Required by Alternative	$ 5,890	$ 5,820	$ 5,859	$ 5,898	$ 5,957	$ 5,976
18	Central Trucked Drinking Water	Max % of HH Income	15%	5%	6%	6%	7%	7%
		Max % Rate Increase Compared to Current	1751%	553%	609%	666%	751%	779%
		Average Water Bill Required by Alternative	$ 5,179	$ 1,767	$ 1,923	$ 2,079	$ 2,315	$ 2,390

Figure 4-2 Alternative Cost Summary



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APPENDIX A
PWS INTERVIEW FORM

CAPACITY DEVELOPMENT ASSESSMENT FORM

*Prepared By*___________________________________ *Date*____________________________

Section 1. Public Water System Information

1. PWS ID # [ ] 2. Water System Name [ ]
3. County [ ]

4. Owner [ ] Address [ ]
Tele. [ ] E-mail [ ]
Fax [ ] Message [ ]

5. Admin [ ] Address [ ]
Tele. [ ] E-mail [ ]
Fax [ ] Message [ ]

6. Operator [ ] Address [ ]
Tele. [ ] E-mail [ ]
Fax [ ] Message [ ]

7. Population Served [ ] 8. No. of Service Connections [ ]

9. Ownership Type [ ] 10. Metered (Yes or No) [ ]

11. Source Type [ ]

12. Total PWS Annual Water Used [ ]

13. Number of Water Quality Violations (Prior 36 months)

Total Coliform [ ] Chemical/Radiological [ ]

Monitoring (CCR, Public Notification, etc.) [ ] Treatment Technique, D/DBP [ ]

A. Basic Information

1. Name of Water System:

2. Name of Person Interviewed:

3. Position:

4. Number of years at job:

5. Number of years experience with drinking water systems:

6. Percent of time (day or week) on drinking water system activities, with current position (how much time is dedicated exclusively to the water system, not wastewater, solid waste or other activities):

7. Certified Water Operator (Yes or No):

   If Yes,
   7a. Certification Level (water):

   7b. How long have you been certified?

8. Describe your water system related duties on a typical day.

B. Organization and Structure

1. Describe the organizational structure of the Utility. Please provide an organizational chart. (Looking to find out the governance structure (who reports to whom), whether or not there is a utility board, if the water system answers to public works or city council, etc.)

2. If not already covered in Question 1, to whom do you report?

3. Do all of the positions have a written job description?

    3a. If yes, is it available to employees?

    3b. May we see a copy?

C. Personnel

1. What is the current staffing level (include all personnel who spend more than 10% of their time working on the water system)?

2. Are there any vacant positions? How long have the positions been vacant?

3. In your opinion, is the current staffing level adequate? If not adequate, what are the issues or staffing needs (how many and what positions)?

4. What is the rate of employee turnover for management and operators? What are the major issues involved in the turnover (e.g., operator pay, working conditions, hours)?

5. Is the system staffed 24 hours a day? How is this handled (on-site or on-call)? Is there an alarm system to call an operator if an emergency occurs after hours?

D. Communication

1. Does the utility have a mission statement? If yes, what is it?

2. Does the utility have water quality goals? What are they?

3. How are your work priorities set?

4. How are work tasks delegated to staff?

5. Does the utility have regular staff meetings? How often? Who attends?

6. Are there separate management meetings? If so, describe.

7. Do management personnel ever visit the treatment facility? If yes, how often?

8. Is there effective communication between utility management and state regulators (e.g., NMED)?

9. Describe communication between utility and customers.

E. Planning and Funding

1. Describe the rate structure for the utility.

2. Is there a written rate structure, such as a rate ordinance? May we see it?

   2a. What is the average rate for 6,000 gallons of water?

3. How often are the rates reviewed?

4. What process is used to set or revise the rates?

5. In general, how often are the new rates set?

6. Is there an operating budget for the water utility? Is it separate from other activities, such as wastewater, other utilities, or general city funds?

7. Who develops the budget, how is it developed and how often is a new budget created or the old budget updated?

8. How is the budget approved or adopted?

9. In the last 5 years, how many budget shortfalls have there been (i.e., didn't collect enough money to cover expenses)? What caused the shortfall (e.g., unpaid bills, an emergency repair, weather conditions)?

    9a. How are budget shortfalls handled?

10. In the last 5 years how many years have there been budget surpluses (i.e., collected revenues exceeded expenses?

    10a. How are budget surpluses handled (i.e., what is done with the money)?

11. Does the utility have a line-item in the budget for emergencies or some kind of emergency reserve account?

12. How do you plan and pay for short-term system needs?

13. How do you plan and pay for long- term system needs?

14. How are major water system capital improvements funded? Does the utility have a written capital improvements plan?

15. How is the facility planning for future growth (either new hook-ups or expansion into new areas)?

16. Does the utility have and maintain an annual financial report? Is it presented to policy makers?

17. Has an independent financial audit been conducted of the utility finances? If so, how often? When was the last one?

18. Will the system consider any type of regionalization with any other PWS, such as system interconnection, purchasing water, sharing operator, emergency water connection, sharing bookkeeper/billing or other?

F. Policies, Procedures, and Programs

1. Are there written operational procedures? Do the employees use them?

2. Who in the utility department has spending authorization? What is the process for obtaining needed equipment or supplies, including who approves expenditures?

3. Does the utility have a source water protection program? What are the major components of the program?

4. Are managers and operators familiar with current SDWA regulations?

5. How do the managers and operators hear about new or proposed regulations, such as arsenic, DBP, Groundwater Rule? Are there any new regulations that will be of particular concern to the utility?

6. What are the typical customer complaints that the utility receives?

7. Approximately how many complaints are there per month?

8. How are customer complaints handled? Are they recorded?

9. (If not specifically addressed in Question 7) If the complaint is of a water quality nature, how are these types of complaints handled?

10. Does the utility maintain an updated list of critical customers?

11. Is there a cross-connection control plan for the utility? Is it written? Who enforces the plan's requirements?

12. Does the utility have a written water conservation plan?

13. Has there been a water audit of the system? If yes, what were the results?

14. (If not specifically answered in 11 above) What is the estimated percentage for loss to leakage for the system?

15. Are you, or is the utility itself, a member of any trade organizations, such as AWWA or Rural Water Association? Are you an active member (i.e., attend regular meetings or participate in a leadership role)? Do you find this membership helpful? If yes, in what ways does it help you?

G. Operations and Maintenance

1. How is decision-making authority split between operations and management for the following items:

    a. Process Control

    b. Purchases of supplies or small equipment

    c. Compliance sampling/reporting

    d. Staff scheduling

2. Describe your utility's preventative maintenance program.

3. Do the operators have the ability to make changes or modify the preventative maintenance program?

4. How does management prioritize the repair or replacement of utility assets? Do the operators play a role in this prioritization process?

5. Does the utility keep an inventory of spare parts?

6. Where does staff have to go to buy supplies/minor equipment? How often?

    6a. How do you handle supplies that are critical, but not in close proximity (for example if chlorine is not available in the immediate area or if the components for a critical pump are not in the area)

7. Describe the system's disinfection process. Have you had any problems in the last few years with the disinfection system?

    7a. Who has the ability to adjust the disinfection process?

8. How often is the disinfectant residual checked and where is it checked?

    8a. Is there an official policy on checking residuals or is it up to the operators?

9. Does the utility have an O & M manual? Does the staff use it?

10. Are the operators trained on safety issues? How are they trained and how often?

11. Describe how on-going training is handled for operators and other staff. How do you hear about appropriate trainings? Who suggests the trainings – the managers or the operators? How often do operators, managers, or other staff go to training? Who are the typical trainers used and where are the trainings usually held?

12. In your opinion is the level of your on-going training adequate?

13. In your opinion is the level of on-going training for other staff members, particularly the operators, adequate?

14. Does the facility have mapping of the water utility components? Is it used on any routine basis by the operators or management? If so, how is it used? If not, what is the process used for locating utility components?

15. In the last sanitary survey, were any deficiencies noted? If yes, were they corrected?

16. How often are storage tanks inspected? Who does the inspection?

    16a. Have you experienced any problems with the storage tanks?

H. SDWA Compliance

1. Has the system had any violations (monitoring or MCL) in the past 3 years? If so, describe.

2. How were the violations handled?

3. Does the system properly publish public notifications when notified of a violation?

4. Is the system currently in violation of any SDWA or state regulatory requirements, including failure to pay fees, fines, or other administrative type requirements?

5. Does the utility prepare and distribute a Consumer Confidence Report (CCR)? Is it done every year? What type of response does the utility get to the CCR from customers?

I. Emergency Planning

1. Does the system have a written emergency plan to handle emergencies such as water outages, weather issues, loss of power, loss of major equipment, etc?

2. When was the last time the plan was updated?

3. Do all employees know where the plan is? Do they follow it?

4. Describe the last emergency the facility faced and how it was handled.

Attachment A

A. Technical Capacity Assessment Questions

1. Based on available information of water rights on record and water pumped has the system exceeded its water rights in the past year? YES ☐ NO ☐

   In any of the past 5 years? YES ☐ NO ☐ How many times? _____

2. Does the system have the proper level of certified operator? *(Use questions a – c to answer.)*
   YES ☐ NO ☐

   a. What is the Classification Level of the system by NMED? _____

   b. Does the system have one or more certified operator(s)? [20 NMAC 7.4.20]

   YES ☐ NO ☐

   c. If YES, provide the number of operators at each New Mexico Certification Level. [20 NMAC 7.4.12]

   _____NM Small System _____Class 2

   _____NM Small System Advanced _____Class 3

   _____Class 1 _____Class 4

3. Did the system correct any sanitary deficiency noted on the most recent sanitary survey within 6 months of receiving that information? [20 NMAC 7.20.504]

   YES ☐ NO ☐ No Deficiencies ☐

   What was the type of deficiency? *(Check all that are applicable.)*

   Source ☐ Storage ☐

   Treatment ☐ Distribution ☐

   Other _____

   From the system's perspective, were there any other deficiencies that were not noted on the sanitary survey? Please describe.

4. Will the system's current treatment process meet known future regulations?

   Radionuclides YES ☐ NO ☐ Doesn't Apply ☐

   Arsenic YES ☐ NO ☐ Doesn't Apply ☐

   Stage 1 Disinfectants and Disinfection By-Product (DBP)

   YES ☐ NO ☐ Doesn't Apply ☐

   Surface Water Treatment Rule YES ☐ NO ☐ Doesn't Apply ☐

5. Does the system have a current site plan/map? [20 NMAC 7.10.302 A.1.]

   YES ☐ NO ☐

6. Has the system had a water supply outage in the prior 24 months?

YES ☐ NO ☐

What were the causes of the outage(s)? *(Include number of outages for each cause.)*

Drought _____ Limited Supply _____

System Failure _____ Other _____

7. Has the system ever had a water audit or a leak evaluation?

YES ☐ NO ☐ Don't Know ☐

If YES, please complete the following table.

Type of Investigation	Date Done	Water Loss (%)	What approach or technology was used to complete the investigation?	Was any follow-up done? If so, describe

8. Have all drinking water projects received NMED review and approval? [20 NMAC 7.10.201]

YES ☐ NO ☐

If NO, what types of projects have not received NMED review and approval.

Source ☐ Storage ☐

Treatment ☐ Distribution ☐

Other ☐ _____

9. What are the typical customer complaints that the utility receives?

10. Approximately how many complaints are there per month? _____

11. How are customer complaints handled? Are they recorded?

12. What is the age and composition of the distribution system? ***(Collect this information from the Sanitary Survey)***

Pipe Material	Approximate Age	Percentage of the system	Comments
			Sanitary Survey Distribution System Records Attached

13. Are there any dead end lines in the system?

YES ☐ NO ☐

14. Does the system have a flushing program?

YES ☐ NO ☐

If YES, please describe.

15. Are there any pressure problems within the system?

YES ☐ NO ☐

If YES, please describe.

16. Does the system disinfect the finished water?

YES ☐ NO ☐

If yes, which disinfectant product is used? ______

Interviewer Comments on Technical Capacity:

<u>B. Managerial Capacity Assessment Questions</u>

17. Has the system completed a 5-year Infrastructure Capital Improvement Plan (ICIP) plan?

YES ☐ NO ☐

If YES, has the plan been submitted to Local Government Division?

YES ☐ NO ☐

18. Does the system have written operating procedures?

YES ☐ NO ☐

19. Does the system have written job descriptions for all staff?

YES ☐ NO ☐

20. Does the system have:

A preventative maintenance plan?
YES ☐ NO ☐
A source water protection plan?
YES ☐ NO ☐ N/A ☐
An emergency plan?
YES ☐ NO ☐
A cross-connection control program?
YES ☐ NO ☐
An emergency source?
YES ☐ NO ☐
System security measures?
YES ☐ NO ☐

21. Does the system report and maintain records in accordance with the drinking water regulations concerning:

Water quality violations
YES ☐ NO ☐

Public notification
YES ☐ NO ☐

Sampling exemptions
YES ☐ NO ☐

22. Please describe how the above records are maintained:

23. Describe the management structure for the water system, including board and operations staff. Please include examples of duties, if possible.

24. Please describe type and quantity of training or continuing education for staff identified above.

25. Describe last major project undertaken by the water system, including the following: project in detail, positive aspects, negative aspects, the way in which the project was funded, any necessary rate increases, the public response to the project, whether the project is complete or not, and any other pertinent information.

26. Does the system have any debt? YES ☐ NO ☐

If yes, is the system current with all debt payments?
YES ☐ NO ☐

If no, describe the applicable funding agency and the default.

27. Is the system currently contemplating or actively seeking funding for any project?
YES ☐ NO ☐

If yes, from which agency and how much?

Describe the project?

Is the system receiving assistance from any agency or organization in its efforts?

28. Will the system consider any type of regionalization with other PWS? *(Check YES if the system has already regionalized.)*

YES ☐ NO ☐

If YES, what type of regionalization has been implemented/considered/discussed? *(Check all that apply.)*

- System interconnection ☐
- Sharing operator ☐
- Sharing bookkeeper ☐
- Purchasing water ☐
- Emergency water connection ☐
- Other: _____

29. Does the system have any of the following? *(Check all that apply.)*

- Water Conservation Policy/Ordinance ☐
- Current Drought Plan ☐
- Water Use Restrictions ☐
- Water Supply Emergency Plan ☐

Interviewer Comments on Managerial Capacity:

C. Financial Capacity Assessment

30. Does the system have a budget?

YES ☐ NO ☐

If YES, what type of budget?

Operating Budget ☐

Capital Budget ☐

31. Have the system revenues covered expenses and debt service for the past 5 years?

YES ☐ NO ☐

If NO, how many years has the system had a shortfall? _____

32. Does the system have a written/adopted rate structure?

YES ☐ NO ☐

33. What was the date of the last rate increase? _____

34. Are rates reviewed annually?

YES ☐ NO ☐

IF YES, what was the date of the last review? _____

35. Did the rate review show that the rates covered the following expenses? *(Check all that apply.)*

Operation & Maintenance ☐

Infrastructure Repair & replacement ☐

Staffing ☐

Emergency/Reserve fund ☐

Debt payment ☐

36. Is the rate collection above 90% of the customers?

YES ☐ NO ☐

37. Is there a cut-off policy for customers who are in arrears with their bill or for illegal connections?

YES ☐ NO ☐

If yes, is this policy implemented?

38. What is the residential water rate for 6,000 gallons of usage in one month. _____

39. In the past 12 months, how many customers have had accounts frozen or dropped for non-payment? _____

[Convert to % of active connections

Less than 1% ☐ 1% - 3% ☐ 4% - 5% ☐ 6% - 10% ☐

11% - 20% ☐ 21% - 50% ☐ Greater than 50% ☐]

40. The following questions refer to the process of obtaining needed equipment and supplies.

a. Can the water system operator buy or obtain supplies or equipment when they are needed?

YES ☐ NO ☐

b. Is the process simple or burdensome to the employees?

c. Can supplies or equipment be obtained quickly during an emergency?

YES ☐ NO ☐

d. Has the water system operator ever experienced a situation in which he/she couldn't purchase the needed supplies?

YES ☐ NO ☐

e. Does the system maintain some type of spare parts inventory?

YES ☐ NO ☐

If yes, please describe.

41. Has the system ever had a financial audit?

YES ☐ NO ☐

If YES, what is the date of the most recent audit? ______

42. Has the system ever had its electricity or phone turned off due to non-payment? Please describe.

Interviewer Comments on Financial Assessment:

43. What do you think the system capabilities are now and what are the issues you feel your system will be facing in the future? In addition, are there any specific needs, such as types of training that you would like to see addressed by NMED or its contractors?

APPENDIX B
COST BASIS

This section presents the basis for unit costs used to develop the conceptual cost estimates for the compliance alternatives. Cost estimates are conceptual in nature (+50%/-30%), and are intended to make comparisons between compliance options and to provide a preliminary indication of possible rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation. Capital cost includes an allowance for engineering and construction management. It is assumed that adequate electrical power is available near the site. The cost estimates specifically do not include costs for the following:

- Obtaining land or easements.
- Surveying.
- Mobilization/demobilization for construction.
- Insurance and bonds

In general, unit costs are based on recent construction bids for similar work in the area; when possible, consultations with vendors or other suppliers; published construction and O&M cost data; and USEPA cost guidance. Unit costs used for the cost estimates are summarized in Table B.1.

Unit costs for pipeline components are based on recent bids for Texas Department of Highways projects. The amounts of boring and encasement and open cut and encasement were estimated by counting the road, highway, railroad, stream, and river crossings for a conceptual routing of the pipeline. The number of air release valves is estimated by examining the land surface profile along the conceptual pipeline route. It is assumed gate valves and flush valves would be installed on average every 5,000 feet along the pipeline. Pipeline cost estimates are based on use of C-900 polyvinyl chloride pipe. Other pipe materials could be considered for more detailed development of attractive alternatives.

Pump station unit costs are based on experience with similar installations. The cost estimate for the pump stations includes two pumps, station piping and valves, station electrical and instrumentation, minor site improvement, installation of a concrete pad and building, and tools. Construction cost of a storage tank is based on similar recent installations in the area.

Electrical power cost is estimated to be $0.128 per kiloWatt hours (kWH), as supplied by the City of Midland. The annual cost for power to a pump station is calculated based on the pumping head and volume, and includes 11,800 kWH for pump building heating, cooling, and lighting, as recommended in USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992).

In addition to the cost of electricity, pump stations have other maintenance costs. These costs cover: materials for minor repairs to keep the pumps operating; purchase of a maintenance vehicle, fuel costs, and vehicle maintenance costs; utilities; office supplies, small tools and equipment; and miscellaneous materials such as safety, clothing, chemicals, and paint. The non-power O&M costs are estimated based on the USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992), which provides cost curves for O&M components. Costs from the 1992 report are adjusted to 2006 dollars based on the Engineering News Record (ENR) construction cost index.

Pipeline maintenance costs include routine cleaning and flushing, as well as minor repairs to lines. The unit rate for pipeline maintenance is calculated based on the USEPA technical report, *Innovative and Alternate Technology Assessment Manual MCD 53* (1978). Costs from the 1978 report are adjusted to 2006 dollars based on the ENR construction cost index.

Storage tank maintenance costs include cleaning and renewal of interior lining and exterior coating. Unit costs for storage tank O&M are based on USEPA publication *Standardized Costs for Water Supply Distribution Systems* (1992). Costs from the 1992 report are adjusted to 2006 dollars based on the ENR construction cost index.

The purchase price for POU water treatment units is based on vendor price lists for treatment units, plus installation. O&M costs for POU treatment units are also based on vendor price lists. It is assumed that a yearly water sample would be analyzed for the contaminant of concern.

The purchase price for POE water treatment units is based on vendor price lists for treatment units, plus an allowance for installation, including a concrete pad and shed, piping modifications, and electrical connection. O&M costs for POE treatment units are also based on vendor price lists. It is assumed that a yearly water sample would be analyzed for the contaminant of concern.

Central treatment plant costs, for both adsorption and coagulation/filtration, include pricing for buildings, utilities, and site work. Costs are based on pricing given in the various R.S. Means Construction Cost Data References, as well as prices obtained from similar work on other projects. Pricing for treatment equipment was obtained from vendors.

Well installation costs are based on quotations from drillers for installation of similar depth wells in the area. Well installation costs include drilling, a well pump, electrical and instrumentation installation, well finishing, piping, and water quality testing. O&M costs for water wells include power, materials, and labor. It is assumed that new wells located more than 1 mile from the intake point of an existing system would require at least one storage tank and pump station.

Purchase price for the treatment unit dispenser is based on vendor price lists, plus an allowance for installation at a centralized public location. The O&M costs are also based on vendor price lists. It is assumed that weekly water samples would be analyzed for the contaminant of concern.

Costs for bottled water delivery alternatives are based on consultation with vendors that deliver residential bottled water. The cost estimate includes an initial allowance for set-up of the program, and a yearly allowance for program administration.

The cost estimate for a public dispenser for trucked water includes the purchase price for a water truck and construction of a storage tank. Annual costs include labor for purchasing the water, picking up and delivering the water, truck maintenance, and water sampling and testing. It is assumed the water truck would be required to make one trip per dispenser each week, and that chlorine residual would be determined for each truck load.

References:

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Table B.1
Summary of General Data
Sherwood Estates Manufactured Townhome Community
PWS #1650022
General PWS Information

Service Population	65	**Number of Connections**	25
Total PWS Daily Water Usage	0.005 (mgd)	**Source**	Calculated using assumed 75 gpcd

Unit Cost Data
West Texas

General Items	**Unit**	**Unit Cost**
Treated water purchase cost	*See alternative*	
Water purchase cost (trucked)	$/1,000 gals	$ 1.80
Contingency	20%	n/a
Engineering & Constr. Management	25%	n/a
Procurement/admin (POU/POE)	20%	n/a
Pipeline Unit Costs	**Unit**	**Unit Cost**
PVC water line, Class 200, 04"	LF	$ 26
Bore and encasement, 10"	LF	$ 60
Open cut and encasement, 10"	LF	$ 30
Gate valve and box, 04"	EA	$ 340
Air valve	EA	$ 1,000
Flush valve	EA	$ 750
Metal detectable tape	LF	$ 0.15
Bore and encasement, length	Feet	200
Open cut and encasement, length	Feet	50
Pump Station Unit Costs	**Unit**	**Unit Cost**
Pump	EA	$ 7,500
Pump Station Piping, 04"	EA	$ 4,000
Gate valve, 04"	EA	$ 370
Check valve, 04"	EA	$ 430
Electrical/Instrumentation	EA	$ 10,000
Site work	EA	$ 2,000
Building pad	EA	$ 4,000
Pump Building	EA	$ 10,000
Fence	EA	$ 5,870
Tools	EA	$ 1,000
Well Installation Unit Costs	**Unit**	**Unit Cost**
Well installation	*See alternative*	
Water quality testing	EA	$ 1,500
Well pump	EA	$ 7,500
Well electrical/instrumentation	EA	$ 5,000
Well cover and base	EA	$ 3,000
Piping	EA	$ 2,500
Storage Tank - 5,000 gals	EA	$ 7,025
Electrical Power	$/kWH	$ 0.128
Building Power	kWH	11,800
Labor	$/hr	$ 32
Materials	EA	$ 1,200
Transmission main O&M	$/mile	$ 200
Tank O&M	EA	$ 1,000
POU/POE Unit Costs		
POU treatment unit purchase	EA	$ 250
POU treatment unit installation	EA	$ 150
POE treatment unit purchase	EA	$ 3,000
POE - pad and shed, per unit	EA	$ 2,000
POE - piping connection, per unit	EA	$ 1,000
POE - electrical hook-up, per unit	EA	$ 1,000
POU treatment O&M, per unit	$/year	$ 225
POE treatment O&M, per unit	$/year	$ 1,000
Contaminant analysis	$/year	$ 100
POU/POE labor support	$/hr	$ 32
Dispenser/Bottled Water Unit Costs		
Treatment unit purchase	EA	$ 3,000
Treatment unit installation	EA	$ 5,000
Treatment unit O&M	EA	$ 500
Administrative labor	hr	$ 43
Bottled water cost (inc. delivery)	gallon	$ 1.60
Water use, per capita per day	gpcd	1.0
Bottled water program materials	EA	$ 5,000
Storage Tank - 5,000 gals	EA	$ 7,025
Site improvements	EA	$ 4,000
Potable water truck	EA	$ 60,000
Water analysis, per sample	EA	$ 100
Potable water truck O&M costs	$/mile	$ 1.00

Central Treatment Unit Costs	**Unit**	**Unit Cost**
General		
Site preparation	acre	$ 4,000
Slab	CY	$ 1,000
Building	SF	$ 60
Building electrical	SF	$ 8.00
Building plumbing	SF	$ 8.00
Heating and ventilation	SF	$ 7.00
Fence	LF	$ 15
Paving	SF	$ 2.00
Reject pond, excavation	CYD	$ 3
Reject pond, compacted fill	CYD	$ 7
Reject pond, lining	SF	$ 0.50
Reject pond, vegetation	SY	$ 1
Reject pond, access road	LF	$ 30
Reject water haulage truck	EA	$ 100,000
Chlorination point	EA	$ 2,000
Building power	kwh/yr	$ 0.128
Equipment power	kwh/yr	$ 0.128
Labor, O&M	hr	$ 40
Analyses	test	$ 200
Reverse Osmosis		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
RO package plant	UNIT	$ 80,000
Transfer pumps (5 hp)	EA	$ 5,000
Permeate tank	gal	$ 3
RO materials	year	$ 3,000
RO chemicals	year	$ 1,500
Backwash disposal mileage cost	miles	$ 1.00
Backwash disposal fee	1,000 gal/yr	$ 5.00
EDR		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
Product storage tank	gal	$ 3.00
EDR package plant	UNIT	$ 200,000
EDR materials	year	$ 3,000
EDR chemicals	year	$ 1,500
Backwash disposal mileage cost	miles	$ 1.00
Backwash disposal fee	1,000 gal/yr	$ 5.00
Adsorption		
Electrical	JOB	$ 50,000
Piping	JOB	$ 20,000
Adsorption package plant	UNIT	$ 60,000
Backwash tank	GAL	$ 2.00
Sewer connection fee	EA	$ 15,000
Spent media disposal	CY	$ 20
Adsorption materials	year	$ 27,000
Backwash discharge to sewer	MG/year	$ 5,000
Coagulation/filtration		
Electrical	JOB	$ 45,000
Piping	JOB	$ 15,000
Coagulation package plant	UNIT	$ 80,000
Backwash tank	GAL	$ 2.00
Coagulant tank	GAL	$ 3.00
Sewer connection fee	EA	$ 15,000
Coagulation/Filtration Materials	year	$ 2,000
Chemicals, Coagulation	year	$ 2,000
Backwash discharge to sewer	MG/year	$ 5,000

APPENDIX C
COMPLIANCE ALTERNATIVE CONCEPTUAL COST ESTIMATES

This appendix presents the conceptual cost estimates developed for the compliance alternatives. The conceptual cost estimates are given in Tables C.1 through C.18. The cost estimates are conceptual in nature (+50%/-30%), and are intended for making comparisons between compliance options and to provide a preliminary indication of possible water rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation.

Insert tables c.1-c.18

Tables C.1 thru C.18 are in J:\744\744655_BEG_2006\Cost Estimates\Midlan Region\Complete\BEG Cost Estimate Worksheet sherwoodDRAFT.xls worksheet "City of Midland" thru worksheet "Trucked".

Table C.1

PWS Name *Sherwood Estates Manufactured Townhome Community*
Alternative Name *Purchase Water from City of Midland*
Alternative Number *SE-1*

Distance from Alternative to PWS (along pipe)	3.0	miles
Total PWS annual water usage	1.825	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	5	n/a	n/a	n/a
PVC water line, Class 200, 04"	15,696	LF	$ 26.00	$ 408,096
Bore and encasement, 10"	200	LF	$ 60.00	$ 12,000
Open cut and encasement, 10"	250	LF	$ 30.00	$ 7,500
Gate valve and box, 04"	3	EA	$ 340.00	$ 1,067
Air valve	3	EA	$ 1,000.00	$ 3,000
Flush valve	3	EA	$ 750.00	$ 2,354
Metal detectable tape	15,696	LF	$ 0.15	$ 2,354
Subtotal				**$ 436,372**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 370	$ 1,480
Check valve, 04"	2	EA	$ 430	$ 860
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,235**
Subtotal of Component Costs				**$ 497,607**
Contingency	20%			$ 99,521
Design & Constr Management	25%			$ 124,402
TOTAL CAPITAL COSTS				**$ 721,530**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	3.0	mile	$ 200	$ 595
Subtotal				**$ 595**
Water Purchase Cost				
City of Midland	1,825	1,000 gal	$ 1.65	$ 3,011
Subtotal				**$ 3,011**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	690	kWH	$ 0.128	$ 88
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 32	$ 11,804
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,603**
O&M Credit for Existing Well Closure				
Pump power	70	kWH	$ 0.128	$ (9)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 32	$ (11,642)
Subtotal				**$ (14,051)**
TOTAL ANNUAL O&M COSTS				**$ 5,157**

Table C.2

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***Purchase Water from City of Stanton***
Alternative Number ***SE-2***

Distance from Alternative to PWS (along pipe)	13.9	miles
Total PWS annual water usage	1.825	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	5	n/a	n/a	n/a
Number of Crossings, open cut	20	n/a	n/a	n/a
PVC water line, Class 200, 04"	73,482	LF	$ 26.00	$ 1,910,532
Bore and encasement, 10"	1,000	LF	$ 60.00	$ 60,000
Open cut and encasement, 10"	1,000	LF	$ 30.00	$ 30,000
Gate valve and box, 04"	15	EA	$ 340.00	$ 4,997
Air valve	14	EA	$ 1,000.00	$ 14,000
Flush valve	15	EA	$ 750.00	$ 11,022
Metal detectable tape	73,482	LF	$ 0.15	$ 11,022
Subtotal				**$ 2,041,573**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 370	$ 1,480
Check valve, 04"	2	EA	$ 430	$ 860
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,235**
Subtotal of Component Costs				**$ 2,102,808**
Contingency	20%			$ 420,562
Design & Constr Management	25%			$ 525,702
TOTAL CAPITAL COSTS				**$ 3,049,072**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	13.9	mile	$ 200	$ 2,783
Subtotal				**$ 2,783**
Water Purchase Cost				
City of Stanton	1,825	1,000 gal	$ 1.65	$ 3,011
Subtotal				**$ 3,011**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	1,264	kWH	$ 0.128	$ 162
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 32	$ 11,804
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,676**
O&M Credit for Existing Well Closure				
Pump power	70	kWH	$ 0.128	$ (9)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 32	$ (11,642)
Subtotal				**$ (14,051)**
TOTAL ANNUAL O&M COSTS				**$ 7,420**

Table C.3

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***Purchase Water from City of Odessa***
Alternative Number ***SE-3***

Distance from Alternative to PWS (along pipe)	29.9	miles
Total PWS annual water usage	1.825	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	25	n/a	n/a	n/a
Number of Crossings, open cut	53	n/a	n/a	n/a
PVC water line, Class 200, 04"	157,917	LF	$ 26.00	$ 4,105,842
Bore and encasement, 10"	5,000	LF	$ 60.00	$ 300,000
Open cut and encasement, 10"	2,650	LF	$ 30.00	$ 79,500
Gate valve and box, 04"	32	EA	$ 340.00	$ 10,738
Air valve	30	EA	$ 1,000.00	$ 30,000
Flush valve	32	EA	$ 750.00	$ 23,688
Metal detectable tape	157,917	LF	$ 0.15	$ 23,688
Subtotal				**$ 4,573,455**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 370	$ 1,480
Check valve, 04"	2	EA	$ 430	$ 860
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,235**

Subtotal of Component Costs		**$ 4,634,690**
Contingency	20%	$ 926,938
Design & Constr Management	25%	$ 1,158,673
TOTAL CAPITAL COSTS		**$ 6,720,301**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	29.9	mile	$ 200	$ 5,982
Subtotal				**$ 5,982**
Water Purchase Cost				
From BWA	1,825	1,000 gal	$ 1.60	$ 2,920
Subtotal				**$ 2,920**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	2,579	kWH	$ 0.128	$ 330
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 32	$ 11,804
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,845**
O&M Credit for Existing Well Closure				
Pump power	70	kWH	$ 0.128	$ (9)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 32	$ (11,642)
Subtotal				**$ (14,051)**

TOTAL ANNUAL O&M COSTS **$ 10,695**

Table C.4

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***New Well at Circle Six Ranch Baptist Camp Inc***
Alternative Number ***SE-4***

Distance from PWS to new well location	21.88	miles
Estimated well depth	110	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	4	n/a	n/a	n/a
Number of Crossings, open cut	22	n/a	n/a	n/a
PVC water line, Class 200, 04"	115,552	LF	$ 26.00	$ 3,004,352
Bore and encasement, 10"	800	LF	$ 60.00	$ 48,000
Open cut and encasement, 10"	1,100	LF	$ 30.00	$ 33,000
Gate valve and box, 04"	23	EA	$ 340.00	$ 7,858
Air valve	22	EA	$ 1,000.00	$ 22,000
Flush valve	23	EA	$ 750.00	$ 17,333
Metal detectable tape	115,552	LF	$ 0.15	$ 17,333
Subtotal				**$ 3,149,875**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 370	$ 1,480
Check valve, 04"	2	EA	$ 430	$ 860
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,235**
Well Installation				
Well installation	110	LF	$ 25	$ 2,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,750**

Subtotal of Component Costs		**$ 3,234,860**
Contingency	20%	$ 646,972
Design & Constr Management	25%	$ 808,715
TOTAL CAPITAL COSTS		**$ 4,690,547**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	21.9	mile	$ 200	$ 4,377
Subtotal				**$ 4,377**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	1,641	kWH	$ 0.128	$ 210
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 32	$ 11,804
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,725**
Well O&M				
Pump power	70	kWH	$ 0.128	$ 9
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,030**
O&M Credit for Existing Well Closure				
Pump power	70	kWH	$ 0.128	$ (9)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 32	$ (11,642)
Subtotal				**$ (14,051)**

TOTAL ANNUAL O&M COSTS **$ 13,080**

Table C.5

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***New Well at Midland International Airport***
Alternative Number ***SE-5***

Distance from PWS to new well location	17.48	miles
Estimated well depth	100	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	16	n/a	n/a	n/a
Number of Crossings, open cut	38	n/a	n/a	n/a
PVC water line, Class 200, 04"	92,288	LF	$ 26.00	$ 2,399,488
Bore and encasement, 10"	3,200	LF	$ 60.00	$ 192,000
Open cut and encasement, 10"	1,900	LF	$ 30.00	$ 57,000
Gate valve and box, 04"	18	EA	$ 340.00	$ 6,276
Air valve	17	EA	$ 1,000.00	$ 17,000
Flush valve	18	EA	$ 750.00	$ 13,843
Metal detectable tape	92,288	LF	$ 0.15	$ 13,843
Subtotal				**$ 2,699,450**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 370	$ 1,480
Check valve, 04"	2	EA	$ 430	$ 860
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,235**
Well Installation				
Well installation	100	LF	$ 25	$ 2,500
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,500**
Subtotal of Component Costs				**$ 2,784,185**
Contingency	20%			$ 556,837
Design & Constr Management	25%			$ 696,046
TOTAL CAPITAL COSTS				**$ 4,037,068**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	17.5	mile	$ 200	$ 3,496
Subtotal				**$ 3,496**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	1,577	kWH	$ 0.128	$ 202
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 32	$ 11,804
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,716**
Well O&M				
Pump power	64	kWH	$ 0.128	$ 8
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,029**
O&M Credit for Existing Well Closure				
Pump power	70	kWH	$ 0.128	$ (9)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 32	$ (11,642)
Subtotal				**$ (14,051)**
TOTAL ANNUAL O&M COSTS				**$ 12,190**

Table C.6

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***New Well at SE***
Alternative Number ***SE-6***

Distance from PWS to new well location	0.1	miles
Estimated well depth	140	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	-	n/a	n/a	n/a
PVC water line, Class 200, 04"	300	LF	$ 26.00	$ 7,800
Bore and encasement, 10"	-	LF	$ 60.00	$ -
Open cut and encasement, 10"	-	LF	$ 30.00	$ -
Gate valve and box, 04"	0	EA	$ 340.00	$ 20
Air valve	1.00	EA	$ 1,000.00	$ 1,000
Flush valve	0	EA	$ 750.00	$ 45
Metal detectable tape	300	LF	$ 0.15	$ 45
Subtotal				**$ 8,910**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 370	$ -
Check valve, 04"	-	EA	$ 430	$ -
Electrical/Instrumentation	-	EA	$ 10,000	$ -
Site work	-	EA	$ 2,000	$ -
Building pad	-	EA	$ 4,000	$ -
Pump Building	-	EA	$ 10,000	$ -
Fence	-	EA	$ 5,870	$ -
Tools	-	EA	$ 1,000	$ -
Storage Tank - 5,000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Well Installation				
Well installation	140	LF	$ 25	$ 3,500
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 24,500**

Subtotal of Component Costs		**$ 33,410**
Contingency	20%	$ 6,682
Design & Constr Management	25%	$ 8,353
TOTAL CAPITAL COSTS		**$ 48,445**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	0.1	mile	$ 200	$ 11
Subtotal				**$ 11**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.128	$ -
Pump Power	-	kWH	$ 0.128	$ -
Materials	-	EA	$ 1,200	$ -
Labor	-	Hrs	$ 32	$ -
Tank O&M	-	EA	$ 1,000	$ -
Subtotal				**$ -**
Well O&M				
Pump power	90	kWH	$ 0.128	$ 12
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,033**
O&M Credit for Existing Well Closure				
Pump power	70	kWH	$ 0.128	$ (9)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 32	$ (11,642)
Subtotal				**$ (14,051)**

TOTAL ANNUAL O&M COSTS **$ (7,007)**

Table C.7

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***New Well at 10 Miles***
Alternative Number ***SE-7***

Distance from PWS to new well location	10.0	miles
Estimated well depth	110	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	6	n/a	n/a	n/a
Number of Crossings, open cut	16	n/a	n/a	n/a
PVC water line, Class 200, 04"	52,800	LF	$ 26.00	$ 1,372,800
Bore and encasement, 10"	1,200	LF	$ 60.00	$ 72,000
Open cut and encasement, 10"	800	LF	$ 30.00	$ 24,000
Gate valve and box, 04"	11	EA	$ 340.00	$ 3,590
Air valve	10	EA	$ 1,000.00	$ 10,000
Flush valve	11	EA	$ 750.00	$ 7,920
Metal detectable tape	52,800	LF	$ 0.15	$ 7,920
Subtotal				**$ 1,498,230**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 370	$ 1,480
Check valve, 04"	2	EA	$ 430	$ 860
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,235**
Well Installation				
Well installation	110	LF	$ 25	$ 2,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,750**

Subtotal of Component Costs		**$ 1,583,215**
Contingency	20%	$ 316,643
Design & Constr Management	25%	$ 395,804
TOTAL CAPITAL COSTS		**$ 2,295,662**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	10.0	mile	$ 200	$ 2,000
Subtotal				**$ 2,000**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	900	kWH	$ 0.128	$ 115
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 32	$ 11,804
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,630**
Well O&M				
Pump power	70	kWH	$ 0.128	$ 9
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,030**
O&M Credit for Existing Well Closure				
Pump power	70	kWH	$ 0.128	$ (9)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 32	$ (11,642)
Subtotal				**$ (14,051)**

TOTAL ANNUAL O&M COSTS **$ 10,608**

Table C.8

PWS Name — ***Sherwood Estates Manufactured Townhome Community***
Alternative Name — ***New Well at 5 Miles***
Alternative Number — ***SE-8***

Distance from PWS to new well location	5.0	miles
Estimated well depth	110	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	3	n/a	n/a	n/a
Number of Crossings, open cut	8	n/a	n/a	n/a
PVC water line, Class 200, 04"	26,400	LF	$ 26.00	$ 686,400
Bore and encasement, 10"	1,800	LF	$ 60.00	$ 108,000
Open cut and encasement, 10"	100	LF	$ 30.00	$ 3,000
Gate valve and box, 04"	5	EA	$ 340.00	$ 1,795
Air valve	5	EA	$ 1,000.00	$ 5,000
Flush valve	5	EA	$ 750.00	$ 3,960
Metal detectable tape	26,400	LF	$ 0.15	$ 3,960
Subtotal				**$ 812,115**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 370	$ 1,480
Check valve, 04"	2	EA	$ 430	$ 860
Electrical/Instrumentation	1	EA	$ 10,000	$ 10,000
Site work	1	EA	$ 2,000	$ 2,000
Building pad	1	EA	$ 4,000	$ 4,000
Pump Building	1	EA	$ 10,000	$ 10,000
Fence	1	EA	$ 5,870	$ 5,870
Tools	1	EA	$ 1,000	$ 1,000
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 61,235**
Well Installation				
Well installation	110	LF	$ 25	$ 2,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,750**

Subtotal of Component Costs		**$ 897,100**
Contingency	20%	$ 179,420
Design & Constr Management	25%	$ 224,275
TOTAL CAPITAL COSTS		**$ 1,300,795**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	5.0	mile	$ 200	$ 1,000
Subtotal				**$ 1,000**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	450	kWH	$ 0.128	$ 58
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 32	$ 11,804
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 15,572**
Well O&M				
Pump power	70	kWH	$ 0.128	$ 9
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,030**
O&M Credit for Existing Well Closure				
Pump power	70	kWH	$ 0.128	$ (9)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 32	$ (11,642)
Subtotal				**$ (14,051)**
TOTAL ANNUAL O&M COSTS				**$ 9,551**

Table C.9

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***New Well at 1 Mile***
Alternative Number ***SE-9***

Distance from PWS to new well location	1.0	miles
Estimated well depth	110	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	2	n/a	n/a	n/a
PVC water line, Class 200, 04"	5,280	LF	$ 26.00	$ 137,280
Bore and encasement, 10"	200	LF	$ 60.00	$ 12,000
Open cut and encasement, 10"	100	LF	$ 30.00	$ 3,000
Gate valve and box, 04"	1	EA	$ 340.00	$ 359
Air valve	1.00	EA	$ 1,000.00	$ 1,000
Flush valve	1	EA	$ 750.00	$ 792
Metal detectable tape	5,280	LF	$ 0.15	$ 792
Subtotal				**$ 155,223**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 370	$ -
Check valve, 04"	-	EA	$ 430	$ -
Electrical/Instrumentation	-	EA	$ 10,000	$ -
Site work	-	EA	$ 2,000	$ -
Building pad	-	EA	$ 4,000	$ -
Pump Building	-	EA	$ 10,000	$ -
Fence	-	EA	$ 5,870	$ -
Tools	-	EA	$ 1,000	$ -
Storage Tank - 5,000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Well Installation				
Well installation	110	LF	$ 25	$ 2,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 23,750**
Subtotal of Component Costs				**$ 178,973**
Contingency	20%			$ 35,795
Design & Constr Management	25%			$ 44,743
TOTAL CAPITAL COSTS				**$ 259,511**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	1.0	mile	$ 200	$ 200
Subtotal				**$ 200**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.128	$ -
Pump Power	-	kWH	$ 0.128	$ -
Materials	-	EA	$ 1,200	$ -
Labor	-	Hrs	$ 32	$ -
Tank O&M	-	EA	$ 1,000	$ -
Subtotal				**$ -**
Well O&M				
Pump power	70	kWH	$ 0.128	$ 9
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 32	$ 5,821
Subtotal				**$ 7,030**
O&M Credit for Existing Well Closure				
Pump power	70	kWH	$ 0.128	$ (9)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 32	$ (11,642)
Subtotal				**$ (14,051)**
TOTAL ANNUAL O&M COSTS				**$ (6,821)**

Table C.10

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***Central Treatment - RO***
Alternative Number ***SE-10***

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Reverse Osmosis Unit Purchase/Installation				
Site preparation	-	acre	$ 4,000	$ -
Slab	-	CY	$ 1,000	$ -
Building	-	SF	$ 60	$ -
Building electrical	-	SF	$ 8	$ -
Building plumbing	-	SF	$ 8	$ -
Heating and ventilation	-	SF	$ 7	$ -
Fence	-	LF	$ 15	$ -
Paving	-	SF	$ 2	$ -
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
Reverse osmosis package including:				
High pressure pumps - 15hp				
Cartridge filters and vessels				
RO membranes and vessels				
Control system				
Chemical feed systems				
Freight cost				
Vendor start-up services	1	UNIT	$ 80,000	$ 80,000
Transfer pumps	2	EA	$ 5,000	$ 10,000
Permeate tank	20,000	gal	$ 3	$ 60,000
Reject pond:				
Excavation	1,500	CYD	$ 3.00	$ 4,500
Compacted fill	1,250	CYD	$ 7.00	$ 8,750
Lining	21,750	SF	$ 0.50	$ 10,875
Vegetation	2,500	SY	$ 1.00	$ 2,500
Access road	625	LF	$ 30.00	$ 18,750
Subtotal of Design/Construction Costs				**$ 265,375**
Contingency	20%			$ 53,075
Design & Constr Management	25%			$ 66,344
Reject water haulage truck	1	EA	$ 100,000	$ 100,000
TOTAL CAPITAL COSTS				**$ 484,794**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Reverse Osmosis Unit O&M				
Building Power	-	kwh/yr	$ 0.128	$ -
Equipment power	1,500	kwh/yr	$ 0.128	$ 192
Labor	1,000	hrs/yr	$ 32	$ 32,000
Materials	1	year	$ 3,000	$ 3,000
Chemicals	1	year	$ 1,500	$ 1,500
Analyses	24	test	$ 200	$ 4,800
Subtotal				**$ 41,492**
Backwash Disposal				
Disposal truck mileage	10,000	miles	$ 1.00	$ 10,000
Backwash disposal fee	223	kgal/yr	$ 5.00	$ 1,115
Subtotal				**$ 11,115**
TOTAL ANNUAL O&M COSTS				**$ 52,607**

Table C.11

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***Central Treatment - EDR***
Alternative Number ***SE-11***

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
EDR Unit Purchase/Installation				
Site preparation	-	acre	$ 4,000	$ -
Slab	-	CY	$ 1,000	$ -
Building	-	SF	$ 60	$ -
Building electrical	-	SF	$ 8	$ -
Building plumbing	-	SF	$ 8	$ -
Heating and ventilation	-	SF	$ 7	$ -
Fence	-	LF	$ 15	$ -
Paving	-	SF	$ 2	$ -
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
Product storage tank	20,000	gal	$ 3.00	$ 60,000
EDR package including:				
Feed and concentrate pumps				
Cartridge filters and vessels				
EDR membrane stacks				
Electrical module				
Chemical feed systems				
Freight cost				
Vendor start-up services	1	UNIT	$ 200,000	$ 200,000
Reject pond:				
Excavation	1,500	CYD	$ 3.00	$ 4,500
Compacted fill	1,250	CYD	$ 7.00	$ 8,750
Lining	21,750	SF	$ 0.50	$ 10,875
Vegetation	2,500	SY	$ 1.00	$ 2,500
Access road	625	LF	$ 30.00	$ 18,750
Subtotal of Design/Construction Costs				**$ 375,375**
Contingency	20%			$ 75,075
Design & Constr Management	25%			$ 93,844
Reject water haulage truck	1	EA	$ 100,000	$ 100,000
TOTAL CAPITAL COSTS				**$ 644,294**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
EDR Unit O&M				
Building Power	-	kwh/yr	$ 0.128	$ -
Equipment power	3,000	kwh/yr	$ 0.128	$ 384
Labor	1,000	hrs/yr	$ 32	$ 32,000
Materials	1	year	$ 3,000	$ 3,000
Chemicals	1	year	$ 1,500	$ 1,500
Analyses	24	test	$ 200	$ 4,800
Subtotal				**$ 41,684**
Backwash Disposal				
Disposal truck mileage	8,000	miles	$ 1.00	$ 8,000
Backwash disposal fee	100	kgal/yr	$ 5.00	$ 500
Subtotal				**$ 8,500**
TOTAL ANNUAL O&M COSTS				**$ 50,184**

Table C.12

PWS Name *Sherwood Estates Manufactured Townhome Community*
Alternative Name *Central Treatment - Adsorption*
Alternative Number *SE-12*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Adsorption Unit Purchase/Installation				
Site preparation	-	acre	$ 4,000	$ -
Slab	-	CY	$ 1,000	$ -
Building	-	SF	$ 60	$ -
Building electrical	-	SF	$ 8	$ -
Building plumbing	-	SF	$ 8	$ -
Heating and ventilation	-	SF	$ 7	$ -
Fence	-	LF	$ 15	$ -
Paving	-	SF	$ 2	$ -
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
Adsorption package including:				
4 Adsorption vessels				
E33 Iron oxide media				
Controls & instruments	1	UNIT	$ 60,000	$ 60,000
Backwash Tank	15,000	GAL	$ 2	$ 30,000
Sewer Connection Fee	-	EA	$ 15,000	$ -
Chlorination Point	1	EA	$ 2,000	$ 2,000
Subtotal of Component Costs				**$ 162,000**
Contingency	20%			$ 32,400
Design & Constr Management	25%			$ 40,500
Reject water haulage truck	1	EA	$ 100,000	$ 100,000
TOTAL CAPITAL COSTS				**$ 334,900**

Annual Operations and Maintenance Cost

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Adsorption Unit O&M				
Building Power	-	kwh/yr	$ 0.128	$ -
Equipment power	1,000	kwh/yr	$ 0.128	$ 128
Labor	500	hrs/yr	$ 32	$ 16,000
Materials	1	year	$ 27,000	$ 27,000
Analyses	24	test	$ 200	$ 4,800
Backwash disposal	0.25	MG/yr	$ 15,000	$ 3,750
Spent Media Disposal	12	CY	$ 20	$ 240
Subtotal				**$ 51,918**
TOTAL ANNUAL O&M COSTS				**$ 51,918**

Table C.13

PWS Name — ***Sherwood Estates Manufactured Townhome Community***
Alternative Name — ***Central Treatment - Coag-Filt***
Alternative Number — ***SE-13***

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Coagulation/Filtration Unit Purchase/Installation				
Site preparation	-	acre	$ 4,000	$ -
Slab	-	CY	$ 1,000	$ -
Building	-	SF	$ 60	$ -
Building electrical	-	SF	$ 8	$ -
Building plumbing	-	SF	$ 8	$ -
Heating and ventilation	-	SF	$ 7	$ -
Fence	-	LF	$ 15	$ -
Paving	-	SF	$ 2	$ -
Electrical	1	JOB	$ 45,000	$ 45,000
Piping	1	JOB	$ 15,000	$ 15,000
Coagulant/filter package including:				
Chemical feed system				
Pressure ceramic filters				
Controls & Instruments	1	UNIT	$ 80,000	$ 80,000
Backwash Tank	20,000	GAL	$ 2	$ 40,000
Coagulant Tank	500	GAL	$ 3	$ 1,500
Sewer Connection Fee	-	EA	$ 15,000	$ -
Chlorination Point	1	EA	$ 2,000	$ 2,000
Subtotal of Component Costs				**$ 183,500**
Contingency	20%			$ 36,700
Design & Constr Management	25%			$ 45,875
Reject water haulage truck	1	EA	$ 100,000	$ 100,000
TOTAL CAPITAL COSTS				**$ 366,075**

Annual Operations and Maintenance Cost

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Coagulation/Filtration Unit O&M				
Building Power	9,000	kwh/yr	$ 0.128	$ 1,152
Equipment power	1,000	kwh/yr	$ 0.128	$ 128
Labor	1,000	hrs/yr	$ 32	$ 32,000
Materials	1	year	$ 2,000	$ 2,000
Chemicals	1	year	$ 2,000	$ 2,000
Analyses	24	test	$ 200	$ 4,800
Backwash disposal	2.5	MG/yr	$ 15,000	$ 37,500
Subtotal				**$ 79,580**
TOTAL ANNUAL O&M COSTS				**$ 79,580**

Table C.14

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***Point-of-Use Treatment***
Alternative Number ***SE-14***

Number of Connections for POU Unit Installatior 25

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POU-Treatment - Purchase/Installation				
POU treatment unit purchase	25	EA	$ 250	$ 6,250
POU treatment unit installation	25	EA	$ 150	$ 3,750
Subtotal				**$ 10,000**
Subtotal of Component Costs				**$ 10,000**
Contingency	20%			$ 2,000
Design & Constr Management	25%			$ 2,500
Procurement & Administration	20%			$ 2,000
TOTAL CAPITAL COSTS				**$ 16,500**

Annual Operations and Maintenance Cost

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POU materials, per unit	25	EA	$ 225	$ 5,625
Contaminant analysis, 1/yr per unit	25	EA	$ 100	$ 2,500
Program labor, 10 hrs/unit	250	hrs	$ 32	$ 8,085
Subtotal				**$ 16,210**
TOTAL ANNUAL O&M COSTS				**$ 16,210**

Table C.15

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***Point-of-Entry Treatment***
Alternative Number ***SE-15***

Number of Connections for POE Unit Installation 25

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POE-Treatment - Purchase/Installation				
POE treatment unit purchase	25	EA	$ 3,000	$ 75,000
Pad and shed, per unit	25	EA	$ 2,000	$ 50,000
Piping connection, per unit	25	EA	$ 1,000	$ 25,000
Electrical hook-up, per unit	25	EA	$ 1,000	$ 25,000
Subtotal				**$ 175,000**
Subtotal of Component Costs				**$ 175,000**
Contingency	20%			$ 35,000
Design & Constr Management	25%			$ 43,750
Procurement & Administration	20%			$ 35,000
TOTAL CAPITAL COSTS				**$ 288,750**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POE materials, per unit	25	EA	$ 1,000	$ 25,000
Contaminant analysis, 1/yr per unit	25	EA	$ 100	$ 2,500
Program labor, 10 hrs/unit	250	hrs	$ 32	$ 8,085
Subtotal				**$ 35,585**
TOTAL ANNUAL O&M COSTS				**$ 35,585**

Table C.16

PWS Name *Sherwood Estates Manufactured Townhome Community*
Alternative Name *Public Dispenser for Treated Drinking Water*
Alternative Number *SE-16*

Number of Treatment Units Recommended 1

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Public Dispenser Unit Installation				
POE-Treatment unit(s)	1	EA	$ 3,000	$ 3,000
Unit installation costs	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 8,000**
Subtotal of Component Costs				**$ 8,000**
Contingency	20%			$ 1,600
Design & Constr Management	25%			$ 2,000
TOTAL CAPITAL COSTS				**11,600**

Annual Operations and Maintenance Cost

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Treatment unit O&M, 1 per unit	1	EA	$ 500	$ 500
Contaminant analysis, 1/wk per ui	52	EA	$ 100	$ 5,200
Sampling/reporting, 1 hr/day	365	HRS	$ 32	$ 11,804
Subtotal				**$ 17,504**
TOTAL ANNUAL O&M COSTS				**$ 17,504**

Table C.17

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***Supply Bottled Water to Population***
Alternative Number ***SE-17***

Service Population	65	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	23,725	gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Implementation				
Initial program set-up	500	hours	$ 43	$ 21,506
Subtotal				**$ 21,506**
Subtotal of Component Costs				**$ 21,506**
Contingency	20%			$ 4,301
TOTAL CAPITAL COSTS				**$ 25,807**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water purchase costs	23,725	gals	$ 1.60	$ 37,960
Program admin, 9 hrs/wk	468	hours	$ 43	$ 20,130
Program materials	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 63,090**
TOTAL ANNUAL O&M COSTS				**$ 63,090**

Table C.18

PWS Name ***Sherwood Estates Manufactured Townhome Community***
Alternative Name ***Central Trucked Drinking Water***
Alternative Number ***SE-18***

Service Population	65	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	23,725	gallons
Travel distance to compliant water source (roundtrip)	24	miles

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Storage Tank Installation				
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Site improvements	1	EA	$ 4,000	$ 4,000
Potable water truck	1	EA	$ 60,000	$ 60,000
Subtotal				**$ 71,025**
Subtotal of Component Costs				**$ 71,025**
Contingency	20%			$ 14,205
Design & Constr Management	25%			$ 17,756
TOTAL CAPITAL COSTS				**$ 102,986**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water delivery labor, 4 hrs/wk	208	hrs	$ 32	$ 6,727
Truck operation, 1 round trip/wk	1248	miles	$ 1.00	$ 1,248
Water purchase	24	1,000 gals	$ 1.80	$ 43
Water testing, 1 test/wk	52	EA	$ 100	$ 5,200
Sampling/reporting, 2 hrs/wk	104	hrs	$ 32	$ 3,363
Subtotal				**$ 16,581**
TOTAL ANNUAL O&M COSTS				**$ 16,581**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Table D.1 Example Financial Model

Water System	Sherwood
Funding Alternative	Bond
Alternative Description	Purchase Water from City of Midland

Sum of Amount		Year																					
Group	Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Capital Expenditures	Capital Expenditures-Funded from Bonds	$ -	$ -	$ -	$721,530	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from Grants	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from Rever	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Capital Expenditures-Funded from SRF L	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Expenditures Sum		$ -	$ -	$ -	$721,530	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service	Revenue Bonds				$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443
	State Revolving Funds				$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt Service Sum					$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443	$ 56,443
Operating Expenditures	Chemicals, Treatment			$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
	Contract Labor			$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500	$ 1,500
	Repairs			$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000
	Supplies			$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
	Utilities			$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
	O&M Associated with Alternative					$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157	$ 5,157
	Maintenance			$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750
Operating Expenditures Sum				$ 4,750	$ 4,750	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907	$ 9,907
Residential Operating Revenues	Residential Base Monthly Rate			$ 4,275	$ 4,275	$ 64,251	$128,477	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$ 132,727	$ 132,727	$ 132,727
	Residential Tier 1 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier2 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier3 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Tier4 Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residential Unmetered Monthly Rate			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Residential Operating Revenues Sum				$ 4,275	$ 4,275	$ 64,251	$128,477	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$ 132,727	$ 132,727	$ 132,727

Location_Name	Sherwood
Alt_Desc	Purchase Water from City of Midland

		Current_Year																					
Funding_Alt	Data	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Bond	Sum of Beginning_Cash_Bal	$ -	$ (1,767)	$(59,976)	$ (64,226)	$ (4,250)	$ 59,976	$124,202	$188,428	$252,655	$316,881	$381,107	$445,333	$509,559	$573,785	$638,011	$702,237	$766,463	$830,689	$894,915	$ 959,142	$1,023,368	$1,087,594
	Sum of Total_Expenditures	$ 4,750	$782,723	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350	$ 66,350
	Sum of Total_Receipts	$ 4,275	$725,805	$ 64,251	$128,477	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$132,727	$ 132,727	$ 132,727	$ 132,727
	Sum of Net_Cash_Flow	$ (475)	$ (56,918)	$ (2,099)	$ 62,127	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377	$ 66,377
	Sum of Ending_Cash_Bal	$ (475)	$ (58,685)	$(62,075)	$ (2,099)	$ 62,127	$126,354	$190,580	$254,806	$319,032	$383,258	$447,484	$511,710	$575,936	$640,162	$704,388	$768,614	$832,840	$897,067	$961,293	$1,025,519	$1,089,745	$1,153,971
	Sum of Working_Cap	$ 792	$ 792	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651	$ 1,651
	Sum of Repl_Resv	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500	$ 500
	Sum of Total_Reqd_Resv	$ 1,292	$ 1,292	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151	$ 2,151
	Sum of Net_Avail_Bal	$ (1,767)	$ (59,976)	$(64,226)	$ (4,250)	$ 59,976	$124,202	$188,428	$252,655	$316,881	$381,107	$445,333	$509,559	$573,785	$638,011	$702,237	$766,463	$830,689	$894,915	$959,142	$1,023,368	$1,087,594	$1,151,820
	Sum of Add_Resv_Needed	$ (1,767)	$ (59,976)	$(64,226)	$ (4,250)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Sum of Rate_Inc_Needed	0%	1403%	100%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0
	Sum of Percent_Rate_Increase	-40%	-40%	802%	1703%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%	1763%

APPENDIX E
GENERAL ARSENIC GEOCHEMISTRY

On January 22, 2001 USEPA adopted a new standard for arsenic in drinking water at 10 ppb, replacing the old standard of 50 ppb. The rule became effective on February 22, 2002. The date by which systems must comply with the new 10 µg/L standard was January 23, 2006. The geochemistry of arsenic is complex because of the possible coexistence of two or even three redox states (-III, III, V) and because of the strong interaction of most arsenic compounds with soil particles, particularly iron oxides. Because groundwater is generally oxidizing in the High Plains, Edwards Trinity (Plateau), and Cenozoic Pecos Alluvium aquifers, it is expected to be in the arsenate form (V). Correlations between arsenic and vanadium and fluoride suggest a geologic rather than an anthropogenic source of arsenic. The large number of potential geologic sources include: volcanic ashes in the Ogallala and underlying units, shales in the Cretaceous, and saline lakes in the Southern High Plains that were evaluated in a separate study and described in Scanlon, *et al.* (2005). Arsenic mobility is generally not controlled by solubility of arsenic-bearing minerals because these minerals are highly soluble. Under oxidizing conditions, arsenic mobility increases with increasing pH (Smedley and Kinniburg 2000). Phosphate can also increase arsenic mobility because phosphate preferentially sorbs onto clays and iron oxides relative to arsenic.

Appendix References

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