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

HUBER GARDEN ESTATES
PWS ID# 0680163

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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AUGUST 2005

EXECUTIVE SUMMARY

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 conduct a study to assist with identifying and analyzing alternatives for use by Public Water Systems (PWS) to meet and maintain Texas drinking water standards.

The overall goal of this project was to promote compliance 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 project 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 Huber Garden Estates PWS, a mobile home community located in Ector County. Recent sample results from the Huber Garden Estates PWS have exceeded the MCL for arsenic of 10 micrograms per liter (µg/L) that will go into effect on January 23, 2006 (USEPA 2005a; TCEQ 2004a). Recent sample results also exceeded the MCL for nitrate of 10 milligrams per liter (mg/L) and the MCL for total dissolved solids (TDS) of 1,000 mg/L (USEPA 2005a; TCEQ 2004a).

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

Table ES.1
Huber Garden Estates PWS
Basic System Information

Population served	75
Connections	25
Average daily flow rate	0.0075 million gallons per day (mgd)
Peak demand flow rate	20.8 gallons per minute
Water system peak capacity	0.12 mgd
Typical nitrate range	8 to 11 mg/L
Typical arsenic range	0.005 to 0.01 mg/L
Typical TDS range	1,150 to 1,180 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:

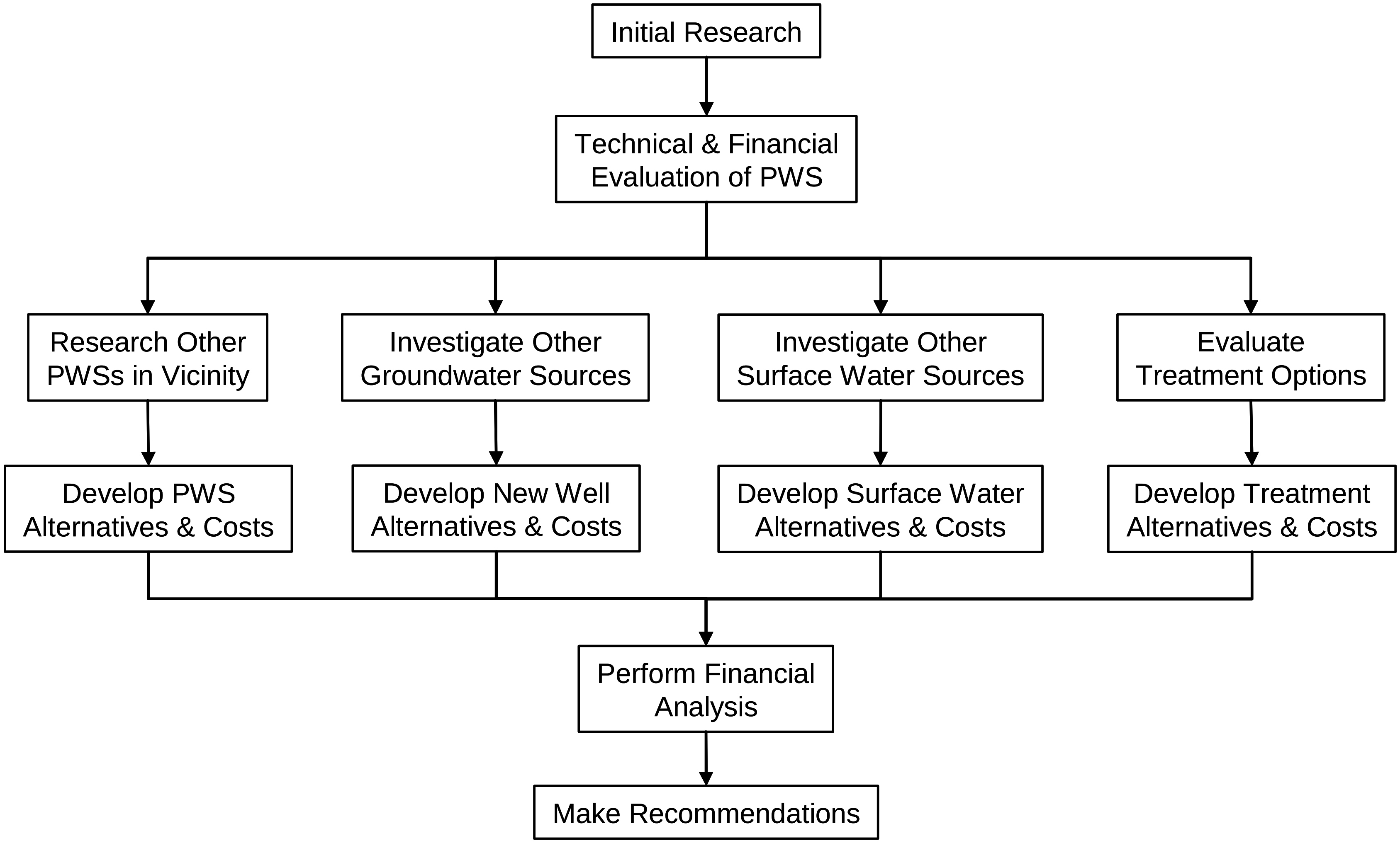
1. Gather data from the TCEQ and Texas Water Development Board databases, from TCEQ files, and from information maintained by the PWS;
2. Conduct financial, managerial, and technical (FMT) evaluations of the PWS;
3. Perform a geologic and hydrogeologic assessment of the study area;
4. Develop treatment and non-treatment compliance alternatives which, in general, consist of the following possible options:
   a. 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;
   b. Installing new wells within the vicinity of the PWS into other aquifers with confirmed water quality standards meeting the MCLs;
   c. 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;
   d. Treating the existing non-compliant water supply by various methods depending on the type of contaminant; and
   e. Delivering potable water by way of a bottled water program or a treated water dispenser as an interim measure only.
5. Assess each of the potential alternatives with respect to economic and non-economic criteria; and
6. Prepare a feasibility report and present the results to the PWS.

This basic approach is summarized in Figure ES-1.

HYDROGEOLOGICAL ANALYSIS

The Huber Garden Estates PWS obtains groundwater from two wells completed in the Antler Sand aquifer. Nitrate and arsenic are commonly found in area wells at concentrations greater than the MCL. The arsenic may be naturally occurring, but the nitrate may be the result of agricultural or other human activity. Nitrate and arsenic concentrations can vary significantly over relatively short distances; as a result, there could be good quality groundwater nearby. However, the variability of nitrate and arsenic concentrations makes it difficult to determine where wells can be located to produce acceptable water. Additionally, systems with more than one well should characterize the

Figure ES-1
Summary of Project Methods



water quality of each well. 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 well, or avoided altogether by completing a new well.

COMPLIANCE ALTERNATIVES

There are several PWSs within 30 miles of Huber Garden Estates. Many of these nearby systems also have problems with nitrates and arsenic, but there are several with good quality water. In general, feasibility alternatives were developed based on obtaining water from the nearest PWSs, either by directly purchasing water, or by expanding the existing well field. There is a minimum of surface water available in the area, and obtaining a new surface water source is considered through an alternative where treated surface water is obtained from the City of Odessa.

A number of centralized treatment alternatives for nitrate and arsenic removal have been developed and were considered for this report, for example, reverse osmosis and electrodialysis treatments. Point-of-use (POU) and point-of-entry (POE) 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.

Developing a new well close to Huber Garden Estates is likely to be the best solution if compliant groundwater can be found. Having a new well close to Huber Garden Estates 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 of the 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 Huber Garden Estates PWS indicated that current water rates are underfunding operations. Based on estimates provided by the system operator, the current average annual water use by Huber Garden Estates residential customers is estimated to be $180, or 0.6 percent of 2000 median household income (MHI) for Texas, which is $39,927. Because of the lack of financial data exclusively for the water system, it is difficult to determine exact cash flow needs. 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	0.6
To meet current expenses	NA	$156	0.4
Nearby well within approximately 1 mile	100% Grant	$190	0.5
	Loan/Bond	$1,381	3.5
Central treatment	100% Grant	$4,823	12.1
	Loan/Bond	$7,976	20.0
Point-of-use	100% Grant	$1,357	3.4
	Loan/Bond	$1,445	3.64
Public dispenser	100% Grant	$1,434	3.6
	Loan/Bond	$1,496	3.7

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ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
AA	Activated Alumina
BAT	Best available technology
BEG	Bureau of Economic Geology
CA	Cellulose acetate
CA	Chemical analysis
CAFO	Concentrated animal feeding operation
CCN	Certificate of Convenience and Necessity
CO	Correspondence
CRMWD	Colorado River Municipal Water District
DWSRF	Drinking Water State Revolving Fund
EDR	Electrodialysis reversal
FMT	Financial, managerial, and technical
GAM	Groundwater Availability Model
gpy	Gallons per year
gpm	Gallons per minute
HBR	Heterotrophic biological reduction
ISD	Independent School District
IX	Ion exchange
m^3/day	Cubic meters per day
MBfR	Membrane biofilm reactor
MCL	Maximum contaminant level
MF	Microfiltration
µg	Microgram
mg/L	Milligram per liter
mgd	Million gallons per day
MHI	Median household income
MIWA	Municipal and Industrial Water Authority
MOR	Monthly operating report
NF	Nanofiltration
NLDC	National land cover dataset
NMEFC	New Mexico Environmental Financial Center
O&M	Operation and Maintenance
POE	Point-of-entry
POU	Point-of-use
psi	Pounds per square inch
PVC	Polyvinyl chloride

PWS	Public water system
RO	Reverse osmosis
RRA	Red River Authority
SDWA	Safe Drinking Water Act
SSCT	Small System Compliance Technology
TCEQ	Texas Commission on Environmental Quality
TDS	Total dissolved solids
TFC	Thin film composite
TSS	Total suspended solids
TWDB	Texas Water Development Board
USEPA	U.S. Environmental Protection Agency
WAM	Water Availability Model
WCID	Water Control and Improvement District
WSC	Water Supply Corporation

SECTION 1
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 (PWSs) to meet and maintain Texas drinking water standards. A total of 15 PWSs were evaluated in this project and each is addressed in a separate report. The 15 systems evaluated for this project are listed below:

Public Water System	Texas County
Huber Garden Estates	Ector
Devilla Mobile Home Park	Ector
City of Danbury	Brazoria
Rosharon Road Estates Subdivision	Brazoria
Mark V Estates	Brazoria
Rosharon Township	Brazoria
Sandy Meadows Estates Subdivision	Brazoria
Grasslands	Brazoria
City of Eden	Concho
City of Mason	Mason
Falling Water	Kerr
Greenwood Independent School District (ISD)	Midland
Country Village Mobile Home Estates	Midland
South Midland County Water Systems	Midland
Warren Road Subdivision Water Supply	Midland

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 that 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 study, 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 Huber Garden Estates water system, PWS ID# 0680163, located in Ector County. The Huber Garden Estates system provides drinking water to the Huber Garden Estates mobile home park. Recent sample results from the Huber Garden Estates PWS have exceeded the MCL for arsenic of 10 micrograms per liter (µg/L) that will go into effect January 23, 2006 (USEPA 2005a; TCEQ 2004a); however, the average of the recent two samples was less than 10 µg/L. Recent sample results also exceeded the MCL for nitrate of 10 milligrams per liter (mg/L) and the MCL for total dissolved solids (TDS) of 1,000 mg/L (USEPA 2005a; TCEQ 2004a). The location of the Huber Garden Estates water system, also referred to as the "study area" in this report, 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 in the evaluation of alternate water supplies that may be available in the area.

1.1 PUBLIC HEALTH AND COMPLIANCE WITH MCLS

The goal of this project is to promote compliance for PWSs that supply drinking water exceeding regulatory MCLs. This project only addresses these contaminants and does not address any other violations that may exist for a PWS. As mentioned above, Huber Garden Estates water system has had recent sample results that exceed the MCL for nitrate and arsenic. The health concerns related to drinking water above MCLs for these two chemicals 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. Short-term effects of nitrate in drinking water above the MCL have caused serious illness and sometimes death. Drinking water health publications conclude that the most susceptible population to adverse nitrate health effects includes infants less than 6 months of age; women who are pregnant or nursing; and individuals with enzyme deficiencies or a lack of free hydrochloric acid in the stomach. The serious illness in infants is due to the conversion of nitrate to nitrite by the body, which can interfere with the oxygen-carrying capacity of the child's blood. Symptoms include shortness of breath and blue-baby syndrome. Lifetime exposure to nitrates at levels above the MCL has the potential to cause the following effects: diuresis, increased starchy deposits, and hemorrhaging of the spleen (USEPA 2005a; 2005b).

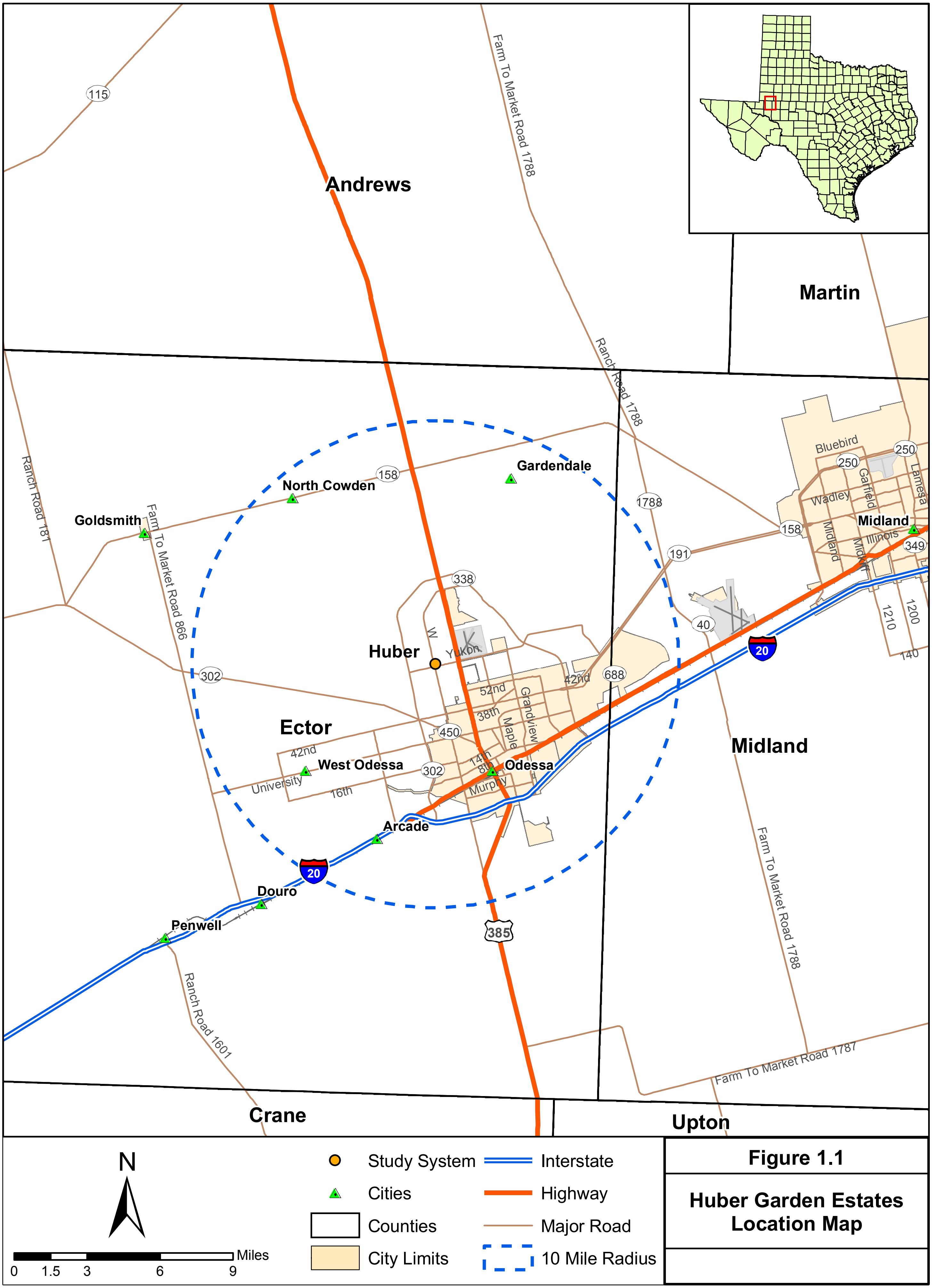

Figure 1.1

Huber Garden Estates Location Map

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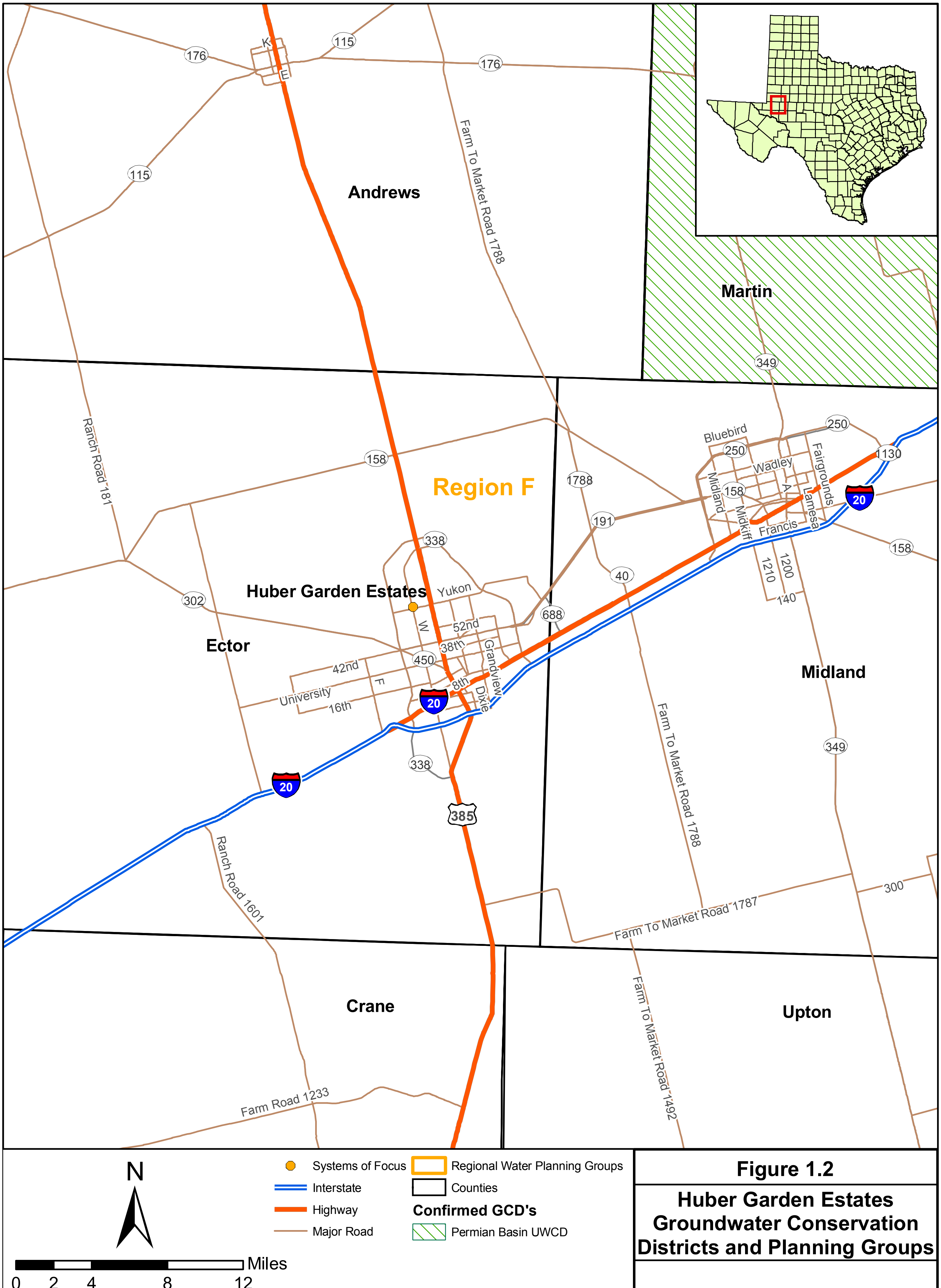

Figure 1.2

Huber Garden Estates Groundwater Conservation Districts and Planning Groups

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According to the USEPA, potential health effects from long-term ingestion of water with levels of arsenic above the MCL (10 µg/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 METHODOLOGY

The methodology 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 USEPA and Texas drinking water standards. Three PWSs were evaluated in the pilot study to develop the methodology (*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 financial, managerial, and technical (FMT) evaluations of the selected PWSs;
- Performing a geologic and hydrogeologic assessment of the study 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 nitrate and arsenic abatement options. Section 2 describes the methodology used to develop and assess compliance alternatives. The groundwater sources of nitrate and arsenic are addressed in Section 3. Findings for the Huber Garden Estates water system, along with compliance alternatives development and evaluation, can be found in Section 4.

1.3 REGULATORY PERSPECTIVE

The Utilities & Districts and Public Drinking Water Sections of the TCEQ Water Supply Division are responsible for implementing the federal Safe Drinking Water Act (SDWA) requirements that include 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 (DWSRF) program to assist PWSs in achieving regulatory compliance; and
- Setting of 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 Huber Garden Estates PWS include: nitrates, and possibly arsenic. The following subsections explore alternatives considered as potential options for obtaining/providing compliant drinking water.

1.4.1 Existing Public Water Supply Systems

A common approach to achieve 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 that 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-complaint 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 the 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 will 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 that are 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. The following standards could be used in a rough screening for compliant groundwater:

- Nitrate (measured as nitrogen) concentrations less than 8 mg/L (below the MCL of 10 mg/L);
- Arsenic concentrations less than 0.008 mg/L (below the MCL of 0.01 mg/L);
- Total dissolved solids (TDS) concentrations less than 1,000 mg/L; and
- Sulfate concentrations less than 300 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 that are of sufficient size and have been used for industrial or irrigation purposes. Often the TWDB database will include well yields, which may indicate the likelihood of a particular well being 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 the willingness to work with the PWS. Once the owner agrees to participate with 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 down the selection and sample selected wells and analyze 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 the 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" of water 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 will 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, where they are available, water rights could possibly be purchased.

In addition to securing the water supply from an existing source, the non-compliant PWS would have to arrange for the transmission of the water to the PWS. In some cases, this may 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 US Army Corps of Engineers and local river authorities.
- Preliminary engineering design to determine the feasibility, costs, and environmental issues of a new intake, treatment plant, and conveyance system.

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 nitrate and arsenic to regulatory levels (*i.e.*, MCLs). Numerous options have been identified by the USEPA as best available technologies (BAT) for non-compliant constituents. Identification and descriptions of the various BATs are provided in the following sections. Several other treatment options are also described but were not further considered in the feasibility study (*e.g.*, because of lack of commercial applications or other limitations).

1.4.4.1 Treatment Technologies for Nitrates

The MCL for nitrate (as nitrogen) was set at 10 mg/L by the USEPA on January 30, 1992, as part of the Phase II Rules, and became effective on July 30, 1992 (USEPA 1992). This MCL applies to all community water systems, regardless of size.

BATs identified by USEPA for removal of nitrates include:

- Reverse Osmosis (RO);
- Ion Exchange (IX); and

- Electrodialysis Reversal (EDR).

1.4.4.2 Treatment Technologies for Arsenic

In January 2001, the USEPA published a final rule in the Federal Register that established an MCL for arsenic of 0.01 mg/L (USEPA 2001). The regulation applies to all community water systems and non-transient, non-community water systems, regardless of size.

The new arsenic MCL of 0.01 mg/L becomes effective on January 23, 2006, at which time the running average annual arsenic level must be at or below 0.01 mg/L at each entry point to the distribution system, although point-of-use (POU) treatment can be instituted in place of centralized treatment. All surface water systems must complete initial monitoring for the new arsenic MCL or have a state-approved waiver by December 31, 2006. All groundwater systems must complete initial monitoring or have a state-approved waiver by December 31, 2007.

The following BATs were identified in the final rule for achieving compliance with the arsenic MCL:

- RO;
- IX;
- EDR;
- Activated Alumina (AA);
- Oxidation/Filtration;
- Enhanced Coagulation/Filtration; and
- Enhanced Lime Softening.

In addition, the following technologies are listed in the final rule as Small System Compliance Technologies:

- RO (centralized and POU);
- IX;
- EDR;
- AA (centralized and POU);
- Oxidation/Filtration;
- Coagulation/Filtration, Enhanced Coagulation/Filtration, and Coagulation-Assisted Microfiltration; and
- Lime Softening and Enhanced Lime Softening.

1.4.5 Treatment Technologies Description

Reverse osmosis, IX, and EDR are identified by USEPA as BATs for removal of nitrates. These three treatment technologies are also applicable to arsenic, and are the only three technologies common to both nitrate and arsenic treatment. RO and IX are also viable options for point-of-entry (POE) and POU systems. A description of these technologies follows.

1.4.5.1 Reverse Osmosis

<u>Process</u>**.** RO is a physical process in which contaminants are removed by applying pressure on the feed water to force it through a semi-permeable membrane. RO membranes reject ions based on 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 (CA) or polyamide thin film composite (TFC). The TFC membrane operates at much lower pressure and can achieve higher salt rejection than the CA membranes but is less chlorine resistant. Common membrane construction includes spiral wound or hollow fine fiber. Each material and construction method has specific benefits and limitations depending on the raw water characteristics and pre-treatment. Spiral wound has been the dominant configuration in common RO systems. A newer, lower pressure type membrane which is similar in operation to RO, is nanofiltration (NF) which has higher rejection for divalent ions than mono-valent ions. NF is sometimes used instead of RO for treating water with high hardness and sulfate concentrations. A typical RO installation includes a high pressure feed pump; 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 pre-treatment. Factors influencing performance are raw water characteristics, pressure, temperature, and regular monitoring and maintenance. Depending on the membrane type and operating pressure, RO is capable of removing 95 percent of nitrate and arsenic while NF has a lower nitrate and arsenic rejection efficiency. The treatment process is relatively insensitive to pH. Water recovery is 60-80 percent, depending on raw water characteristics. The concentrate volume for disposal can be significant. The conventional RO treatment train for well water uses anti-scalant addition, cartridge filtration, RO membranes, chlorine disinfection, and clearwell storage.

<u>Pre-treatment</u>. RO requires careful review of raw water characteristics, and pre-treatment needs to prevent membranes from fouling, scaling, or other membrane degradation. Removal or sequestering of suspended solids is necessary to prevent colloidal and bio-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 to remove suspended particles; IX softening to remove hardness; antiscalant feed; temperature and pH adjustment to maintain efficiency; acid to prevent scaling and membrane damage; activated carbon or bisulfite to remove chlorine

(post-disinfection may be required); and cartridge filters to remove any remaining suspended particles to protect membranes from upsets.

Maintenance. Rejection percentages must be monitored to ensure contaminant removal below MCLs. Regular monitoring of membrane performance is necessary to determine fouling, scaling, or other membrane degradation. Use of monitoring equipment to track membrane performance is recommended. Acidic or caustic solutions are regularly flushed through the system at high volume/low pressure with a cleaning agent to remove fouling and scaling. The system is flushed and returned to service. RO stages are cleaned sequentially. Frequency of membrane replacement is dependent on raw water characteristics, pre-treatment, and maintenance.

Waste Disposal. Pre-treatment waste streams, concentrate flows, and spent filters and membrane elements all require approved disposal methods. Disposal of the significant volume of the concentrate stream is a problem for many utilities.

Advantages (RO)

- Produces the highest water quality.
- Can effectively treat a wide range of dissolved salts and minerals, turbidity, health and aesthetic contaminants, and certain organics. Some highly-maintained units are capable of treating biological contaminants.
- Low pressure - less than 100 pounds per square inch (psi), compact, self-contained, single membrane units are available for small installations.

Disadvantages (RO)

- Relatively expensive to install and operate.
- Frequent membrane monitoring and maintenance; pressure, temperature, and pH requirements to meet membrane tolerances. Membranes can be chemically sensitive.
- Additional water usage depending on rejection rate.
- Concentrated disposal.

A concern with RO for treatment of inorganics is that if the full stream is treated, then most of the alkalinity and hardness would also be removed. In that event, post-treatment may be necessary to avoid corrosion problems. If feasible, a way to avoid this issue is to treat a slip stream of raw water and blend the slip stream back with the raw water rather than treat the full stream. The amount of water rejected is also an issue with RO. Discharge concentrate can be between 10 and 50 percent of the influent flow.

1.4.5.2 Ion Exchange

Process**.** 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 IX resin. Operation begins with a fully recharged cation or anion resin bed, having enough positively or negatively charged ions to carry out the cation or anion exchange. Usually a polymer resin bed is composed of millions of spherical beads about the size of medium sand grains. As water passes through the resin bed, the positively or negatively charged ions are released into the water, being substituted or replaced with the contaminant ions 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, usually sodium chloride, solution over the resin bed, displacing the contaminant ions with sodium ions for cation exchange and chloride ions 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, chlorine disinfection, and clearwell storage. Treatment trains for surface water may also include raw water pumps, debris screens, and gravity filters for pre-treatment. Additional treatment or management of the concentrate and the removed solids will be necessary prior to disposal. For nitrate and arsenic removal, a strong base anion exchange resin in the chloride form can remove 99 percent of the nitrate and arsenic. Sulfate is a strong competing anion for nitrate and arsenic adsorption by IX. Regeneration is accomplished with sodium chloride.

<u>Pre-treatment</u>. There are pretreatment requirements pH, organics, turbidity, and other raw water characteristics. Pre-treatment 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. Pre-treatment may also be required to remove sulfate that can interfere with nitrate and arsenic 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 would 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 waste (in the form of broken resin beads) which is backwashed during regeneration; and if used, spent filters and backwash wastewater.

Advantages (IX)

- Acid addition, degasification, and repressurization are not required.
- Ease of operation; highly reliable.
- Lower initial cost; resins will not wear out with regular regeneration.
- Effective; widely used.
- Suitable for small and large installations.

- A variety of specific resins are available for removing specific contaminants.

Disadvantages (IX)

- Requires salt storage; regular regeneration.
- Concentrate disposal.
- Usually not feasible with high levels of TDS.
- Resins are sensitive to the presence of competing ions.

In considering application of IX for inorganics removal, it is important to understand what the effect of competing ions would be, and to what extent the brine can be recycled. Similar to AA, IX exhibits a selectivity sequence, which refers to an order in which ions are preferred. Barium, lead, and copper are highly preferred cations. Sulfate competes with both nitrate and arsenic, but more aggressively with arsenic in anion exchange. Source waters with TDS levels above 500 mg/L and sulfate levels above 120 mg/L are not amenable to IX treatment. 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 reused as many as 25 times.

1.4.5.3 Electrodialysis Reversal

<u>Process</u>. 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 spacers, 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 nitrate, 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 pre-treatment steps such as raw water pumps, debris screens, rapid mix with addition of an anti-scalant, slow mix flocculator, sedimentation basin or clarifier, and gravity filters. Microfiltration (MF) could be used in

place of flocculation, sedimentation, and filtration. Additional treatment or management of the concentrate and the removed solids would be necessary prior to disposal.

Pre-treatment**.** 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 (^{o}F) 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, pre-treatment 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. Pre-treatment 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 part-time operation, it may be an appropriate technology for small systems. It can be used to simultaneously reduce nitrate, TDS, and arsenic.

1.4.5.4 Distillation

Distillation heats water until it turns to steam. The steam travels through a condenser coil where it is cooled and returned to liquid. The nitrate and arsenic remain in the boiler section. Distillation is energy-intensive in relation to the other processes, and not well suited for production of drinking water for the centralized-treatment, POU or POE applications.

Owing to the lack of commercial applications for this technology, it will be eliminated from further consideration.

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

Point-of-entry and POU treatment systems can be used to provide compliant drinking water. For nitrate and 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. Point-of-entry 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 large number of treatment units that would be employed and would be largely 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 ultimately is the responsible party when it comes to 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 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 that is 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, the consumer would have to do no more than he/she currently does 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 that 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 that 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 METHODOLOGY

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 the 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.

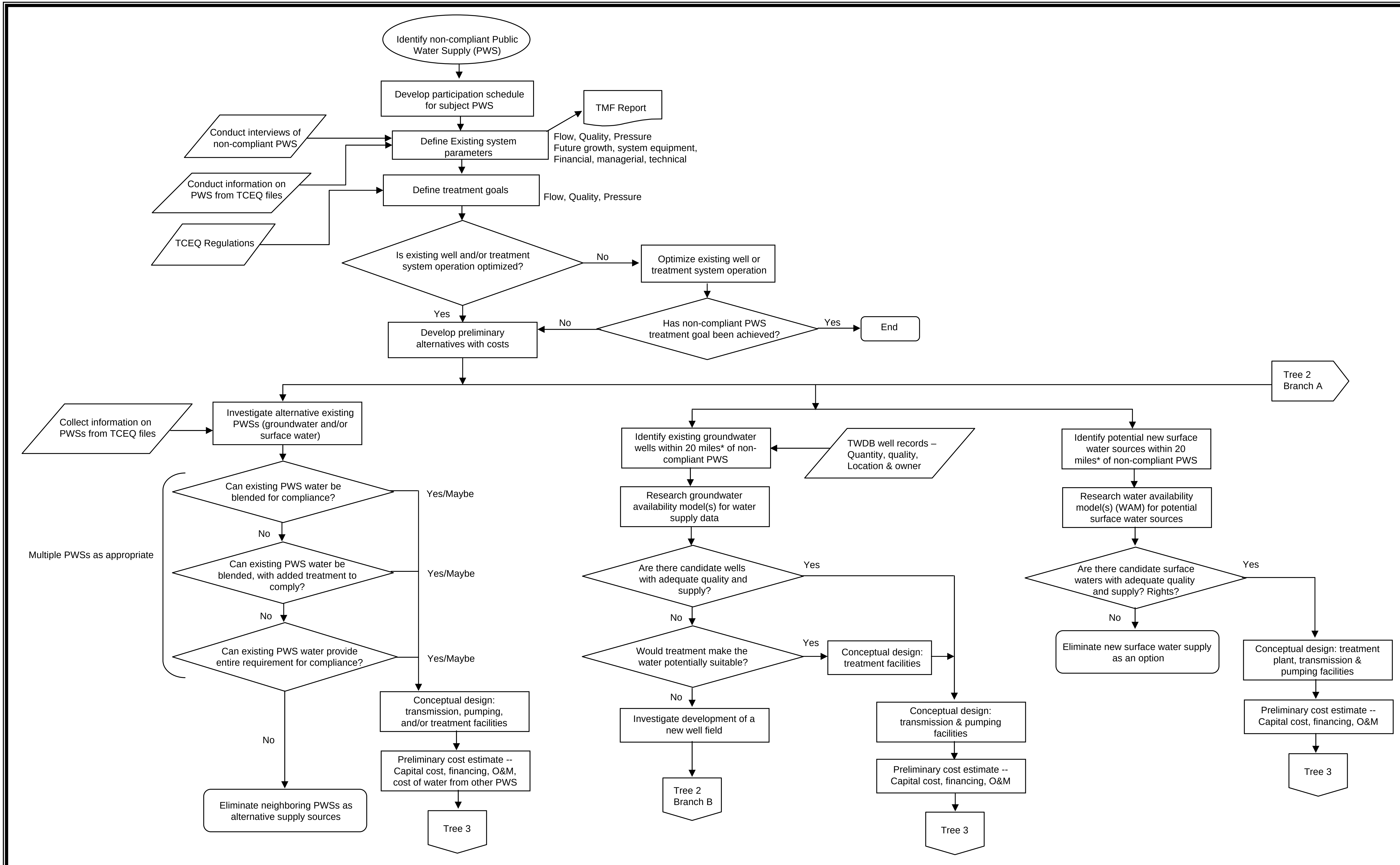
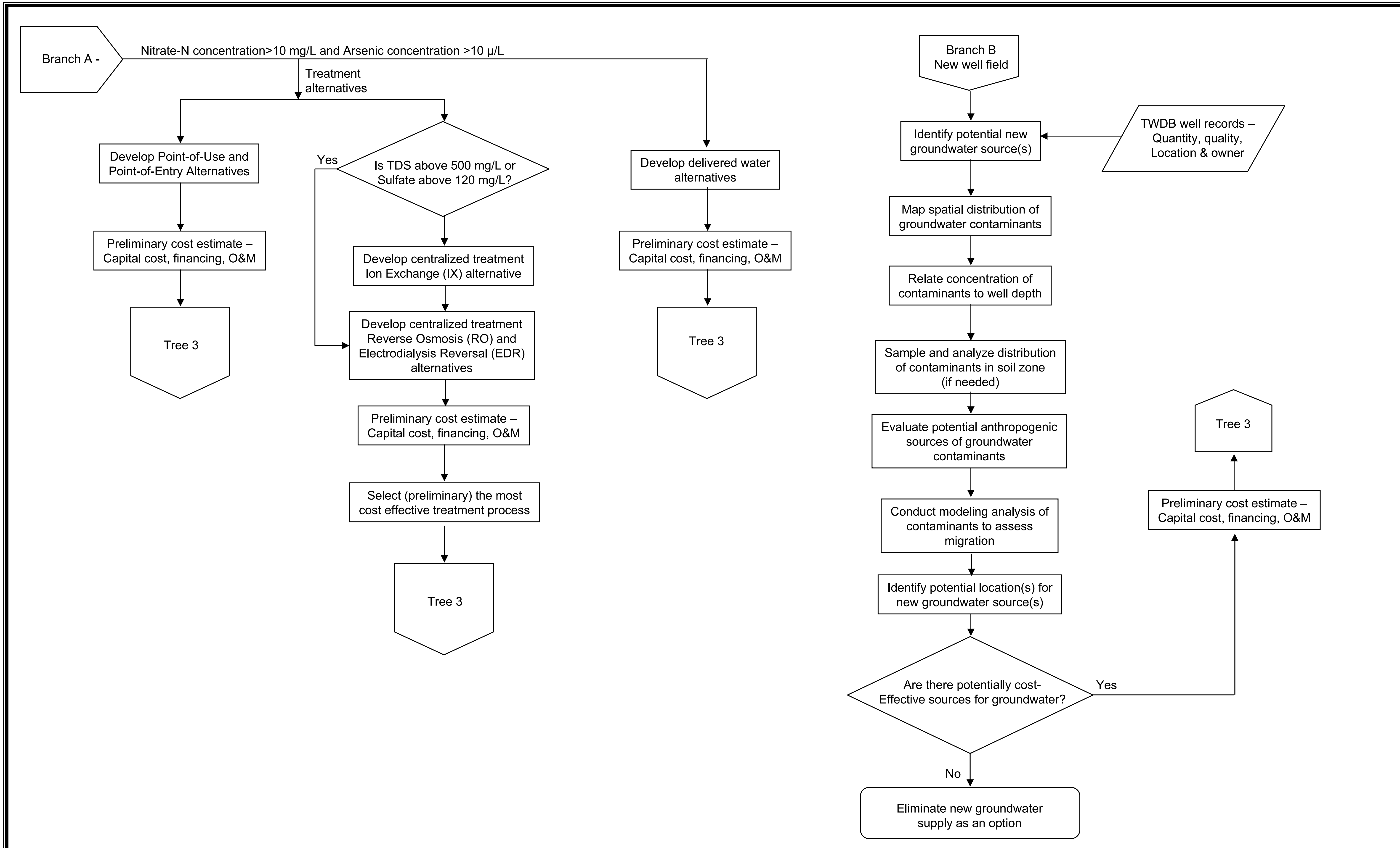

Identify non-compliant Public Water Supply (PWS)
Develop participation schedule for subject PWS
TMF Report
Conduct interviews of non-compliant PWS
Define Existing system parameters
Flow, Quality, Pressure
Future growth, system equipment,
Financial, managerial, technical
Conduct information on PWS from TCEQ files
Define treatment goals
Flow, Quality, Pressure
TCEQ Regulations
Is existing well and/or treatment system operation optimized?
No
Optimize existing well or treatment system operation
Yes
Develop preliminary alternatives with costs
No
Has non-compliant PWS treatment goal been achieved?
Yes
End
Tree 2 Branch A
Collect information on PWSs from TCEQ files
Investigate alternative existing PWSs (groundwater and/or surface water)
Multiple PWSs as appropriate
Can existing PWS water be blended for compliance?
Yes/Maybe
No
Can existing PWS water be blended, with added treatment to comply?
Yes/Maybe
No
Can existing PWS water provide entire requirement for compliance?
Yes/Maybe
No
Eliminate neighboring PWSs as alternative supply sources
Conceptual design: transmission, pumping, and/or treatment facilities
Preliminary cost estimate -- Capital cost, financing, O&M, cost of water from other PWS
Tree 3
Identify existing groundwater wells within 20 miles* of non-compliant PWS
TWDB well records – Quantity, quality, Location & owner
Research groundwater availability model(s) for water supply data
Are there candidate wells with adequate quality and supply?
Yes
No
Would treatment make the water potentially suitable?
Yes
Conceptual design: treatment facilities
No
Investigate development of a new well field
Tree 2 Branch B
Conceptual design: transmission & pumping facilities
Preliminary cost estimate -- Capital cost, financing, O&M
Tree 3
Identify potential new surface water sources within 20 miles* of non-compliant PWS
Research water availability model(s) (WAM) for potential surface water sources
Are there candidate surface waters with adequate quality and supply? Rights?
Yes
No
Eliminate new surface water supply as an option
Conceptual design: treatment plant, transmission & pumping facilities
Preliminary cost estimate -- Capital cost, financing, O&M
Tree 3

Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATAIVES



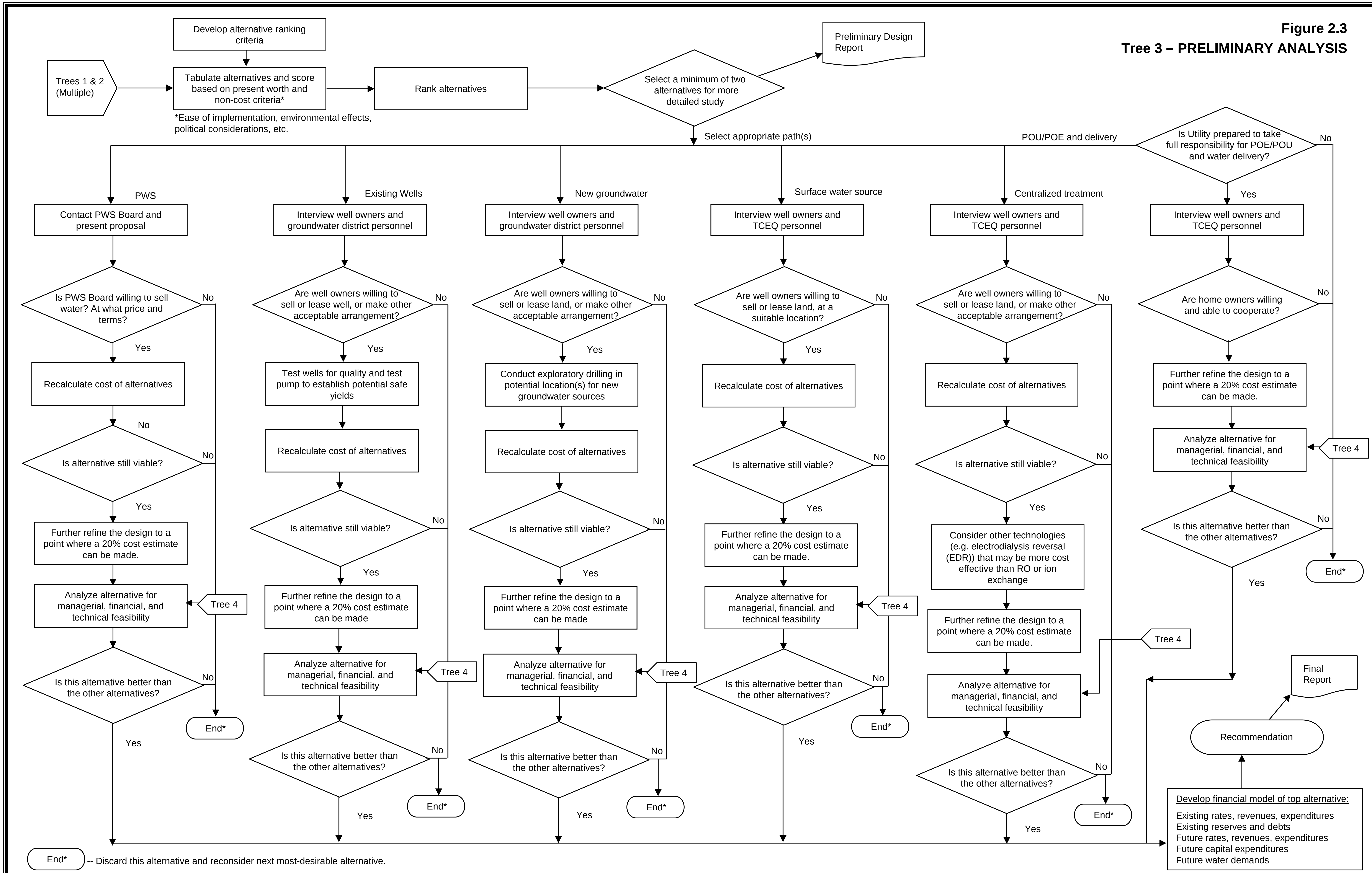
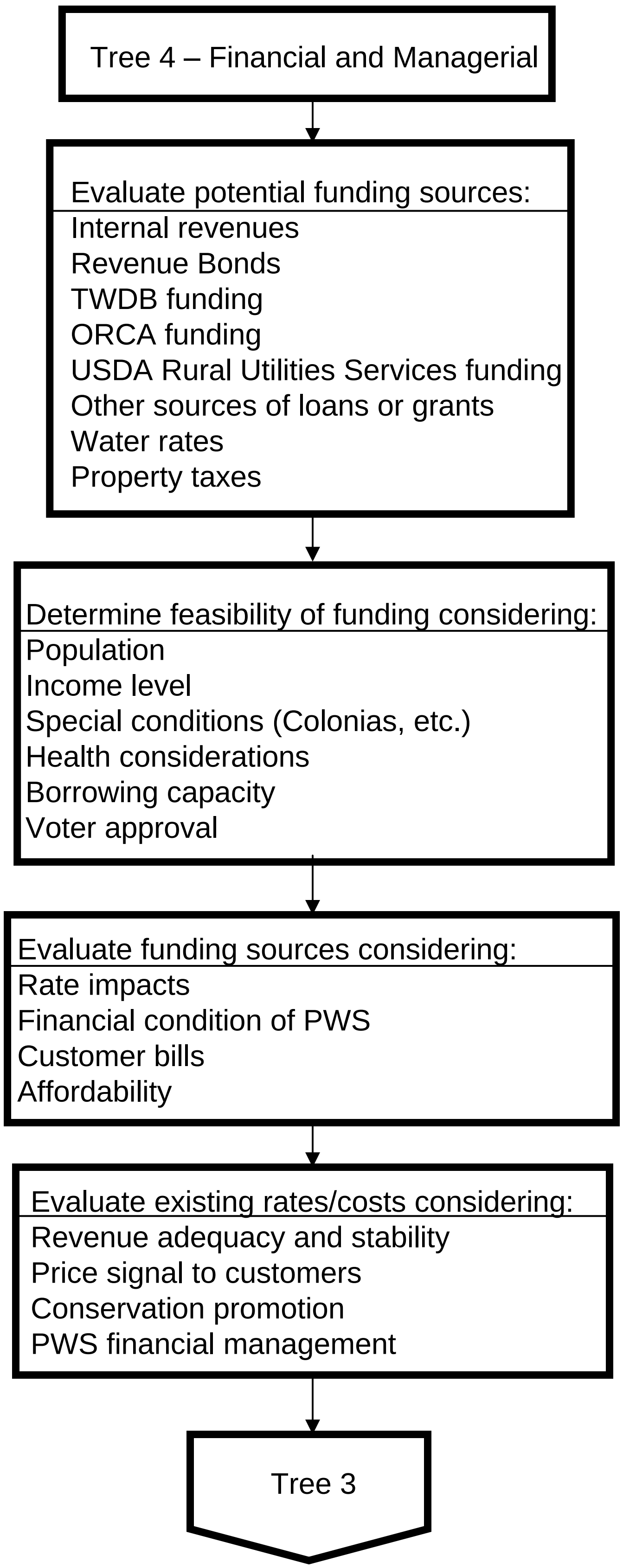


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS
Trees 1 & 2 (Multiple)
Develop alternative ranking criteria
Tabulate alternatives and score based on present worth and non-cost criteria*
*Ease of implementation, environmental effects, political considerations, etc.
Rank alternatives
Select a minimum of two alternatives for more detailed study
Preliminary Design Report
Select appropriate path(s)
POU/POE and delivery
Is Utility prepared to take full responsibility for POE/POU and water delivery?
PWS
Existing Wells
New groundwater
Surface water source
Centralized treatment
Contact PWS Board and present proposal
Interview well owners and groundwater district personnel
Interview well owners and TCEQ personnel
Is PWS Board willing to sell water? At what price and terms?
Are well owners willing to sell or lease well, or make other acceptable arrangement?
Are well owners willing to sell or lease land, or make other acceptable arrangement?
Are well owners willing to sell or lease land, at a suitable location?
Are home owners willing and able to cooperate?
Recalculate cost of alternatives
Test wells for quality and test pump to establish potential safe yields
Conduct exploratory drilling in potential location(s) for new groundwater sources
Is alternative still viable?
Further refine the design to a point where a 20% cost estimate can be made.
Consider other technologies (e.g. electrodialysis reversal (EDR)) that may be more cost effective than RO or ion exchange
Analyze alternative for managerial, financial, and technical feasibility
Tree 4
Is this alternative better than the other alternatives?
Yes
No
End*
Final Report
Recommendation
Develop financial model of top alternative:
Existing rates, revenues, expenditures
Existing reserves and debts
Future rates, revenues, expenditures
Future capital expenditures
Future water demands
End* -- Discard this alternative and reconsider next most-desirable alternative.

Figure 2.4
TREE 4 – FINANCIAL AND MANAGERIAL



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 study area:

- Texas Commission on Environmental Quality www.tnrcc.state.tx.us/iwud/pws/index.cfm. Under "Advanced Search", type in the name(s) of the County(ies) in the study 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. For this study, it was assumed that the nitrate concentration given in this database was the concentration of nitrate, with a molecular weight of 62. To convert to the same basis used for the MCL (Nitrate-N), the value given in the TWDB database was divided by 4.5.

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 Edwards-Trinity Plateau and Ogallala aquifers were investigated as a potential tool for identifying available and suitable groundwater resources.

Regional groundwater withdrawal in the Huber Garden area is extensive and is likely to remain near current levels over the next decades. In eastern Ector County, where the Huber Garden system is located, the primary groundwater source for public supplies is the Edwards-Trinity Plateau aquifer. The aquifer's outcrop transitions into the southern edge of another major aquifer, the Ogallala, in the north and east sections of the county.

Supply wells for the Huber Garden system and its vicinity withdraw groundwater primarily from the Antlers Sand formation of the Edwards-Trinity Plateau aquifer. In September 2004 the TWDB published results of the GAM for the Edwards-Trinity Plateau aquifer (Anaya and Jones, 2004). GAM data indicated that, under drought-of-record conditions, significant water declines would occur in the Trinity unit of the Edwards-Trinity Plateau throughout sections of Ector, Midland, and Uptown counties (Anaya and Jones, 2004). The withdrawal rate from the aquifer declined steadily in Ector County from a peak annual use of 5,593 acre-feet in 1996 to 3,891 acre-feet in 2000. This trend, however, is reversing, with withdrawals in Ector County expected to reach 5,607 acre-feet per year by 2010, and remain near those levels through the year 2050. The anticipated water level drawdown over the 50-year simulation period for north and central Ector County falls between the 50 and 100 feet range (Anaya and Jones, 2004).

The Southern Ogallala aquifer extends over most of the Texas panhandle and into eastern New Mexico, reaching sections of north and east Ector County. The Texas Water Development Board's 2002 Texas Water Plan anticipates a 24 percent drop in the Ogallala supply over the next decades, from 5,000,097 acre-feet per year estimated in 2000 to 3,785,409 acre-feet per year in 2050. A GAM for the Ogallala aquifer was recently developed by the TWDB (Blandford *et al*., 2003). Predictive simulations indicated that, if estimated future withdrawals are realized, aquifer water levels could decline in excess of 100 feet, to a point at which significant regions currently practicing irrigated agriculture could be essentially dewatered by 2050 (Blandford *et al*., 2003). For central Ector County, the simulated drawdown by the year 2050 would be more moderate, within the 0 to 25 feet range (Blandford *et al*., 2003).

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

Huber Garden is located in the upper reach of the Colorado River 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 an 11 percent reduction in surface water availability in the Colorado River Basin over the next 50 years, from 879,400 AFY in 2002 to 783,641 AFY in 2050.

In the site vicinity, and over the entire Ector County, unappropriated flows of the Colorado River Basin for new uses are available at most 50 percent of the time. This supply is inadequate as the TCEQ requires a 100 percent supply availability for a municipal water supply.

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 & 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 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 financial, managerial, and technical 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 operations and the management of the system.

Financial, managerial, and technical 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 the Safe Drinking Water Act (SDWA) requirements. 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 regulations. 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 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 financial, managerial, and technical 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 the TCEQ FMT assessment process. This methodology 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 who has a role in the FMT capacity of the system is asked the applicable standard set of questions individually. The interviewees are not given the questions in advance and are not told the answers others have provided. Also, most of the questions are open ended type questions so they are not asked in a fashion to indicate what would be the "right" or "wrong" answer. The interviews last between 45 minutes 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 are made. A technical information form was created to capture this information. This form is contained in Appendix A. This information was considered supplemental to the interviews because it could serve 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 the 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 is asked the question, "Do you have a budget?" he or she may say, "yes" and the capacity assessor is 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 is to develop a list of capacity deficiencies with the greatest impact on the system's overall capacity. These are 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 compliance alternative development is 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 have been identified, they must be defined in sufficient detail so that 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 Public Water Services

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 30 miles from the non-compliant PWS were not considered because the length of pipelines 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 they use and the quantity of water they might have 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 of the 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 study 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 both nitrate and arsenic removal are RO, IX, and EDR since they are proven technologies with numerous successful installations. However, all systems with elevated nitrate and arsenic also have TDS levels higher than 1,000 mg/L and thus, IX is not economically feasible. RO treatment is considered for central treatment alternatives, as well as POU and POE alternatives. EDR treatment is considered for central treatment alternatives only. Both RO and EDR treatment 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. 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 increase 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 was to determine the financial impact of implementing compliance alternatives, primarily by examining the required rate increases, and analyzing the fraction of household income that water bills consume. The current financial situation was also reviewed to determine what rate increases were necessary for the PWS to achieve or maintain financial viability.

2.4.1 Financial Feasibility

A key financial metric is the comparison of the average annual household water bill for a PWS customer to the MHI for the area. MHI data from the 2000 Census were 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 were determined for existing base conditions and included consideration of additional rate increases needed under current conditions. Annual water bills were 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 provided 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 the 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 shows 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 Census was used as the basis for MHI. In addition to consideration of affordability, 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.

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 was estimated and applied to the existing rate structure to estimate the annual water bill. The estimates were generated from a long-term financial planning model that detailed annual revenue, expenditure, and cash reserve requirements over a 30-year period.

2.4.4 Financial Plan Development

The financial planning model used available data to establish base conditions under which the system operates. The model included, 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 reserve to provide funding for planned and unplanned repairs and replacements.

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

2.4.5 Financial Plan Results

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

2.4.5.1 Funding Options

Results, summarized in Table 4.4, show the following according to alternative and funding source:

- Percentage that the average annual residential water bill represents of median annual household income,
- The first year in which a water rate increase will be required, and
- The total increase in water rates required, compared to current rates

Water rates resulting from the incremental capital costs of the alternative solutions were examined under a number of funding options. The first alternative examined was always funded 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 was 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 > 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 included:

- 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 had 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

The results from the financial plan model, as presented in Table 4.4, show the percentage of MHI that is represented by the annual water bill that resulted from any rate increases necessary to maintain financial viability over time. In some cases, this may require rate increases even without implementing a compliance alternative (the no action alternative). The table shows any increases such as these separately. The results table shows the total increase in rates necessary, including both the no-action alternative increase and any increase required for the alternative. For example, if the no action alternative required a 10 percent increase in rates and the results table shows a rate increase of 25 percent, then the impact from the alternative was an increase in water rates of 15 percent. Likewise, the percentage of household income in the table reflects the total impact from all rate increases.

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:

- Texas Water Development Board,
- 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:

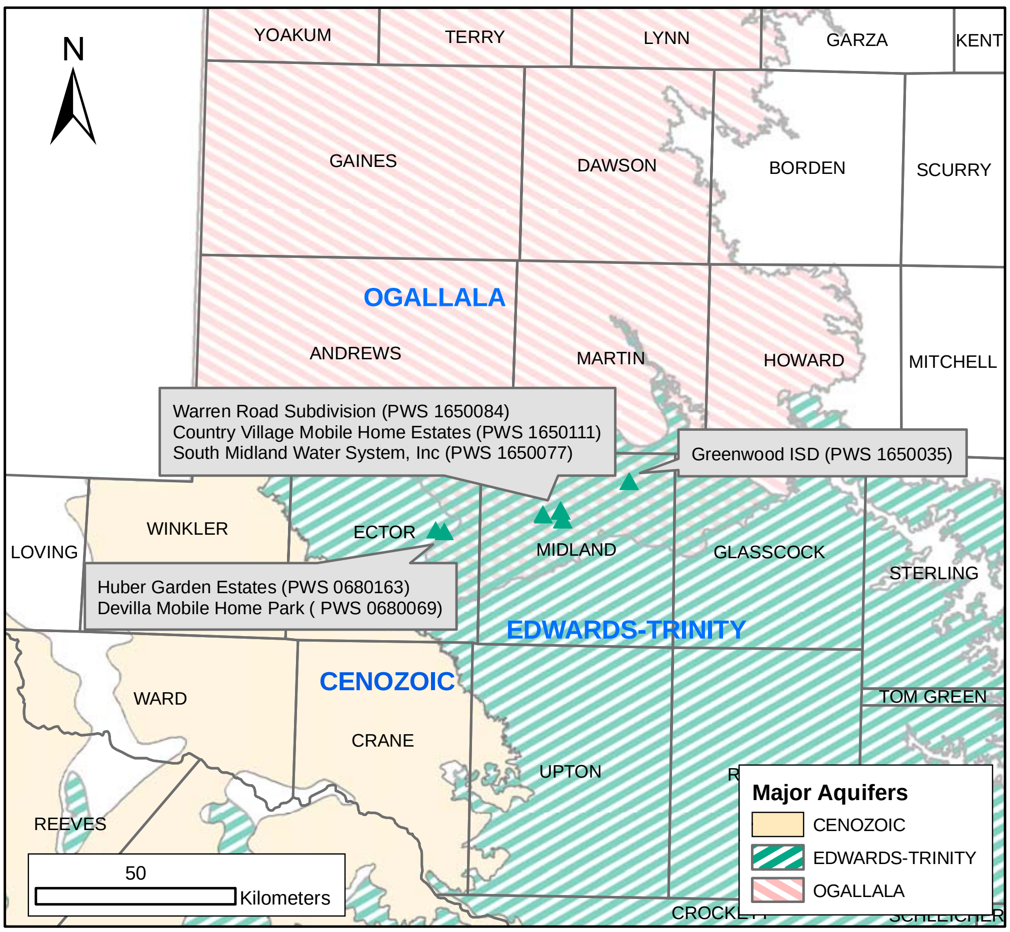
- United States Department of Agriculture, Rural Utilities Service, and
- United States Housing and Urban Development.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 NITRATE AND ARSENIC IN THE SOUTHERN HIGH PLAINS AND EDWARDS TRINITY (PLATEAU) AQUIFERS

The major aquifers in the vicinity of the evaluated public water systems include the Ogallala aquifer (Miocene–Pliocene age), the Edwards Trinity (Plateau) aquifer (Cretaceous age), and the Cenozoic Pecos Alluvium (CPA) aquifer (Tertiary and Quaternary age) (Ashworth and Hopkins 1995). Figure 3.1 shows assessed public water supplies and major aquifers in the study area.

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



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

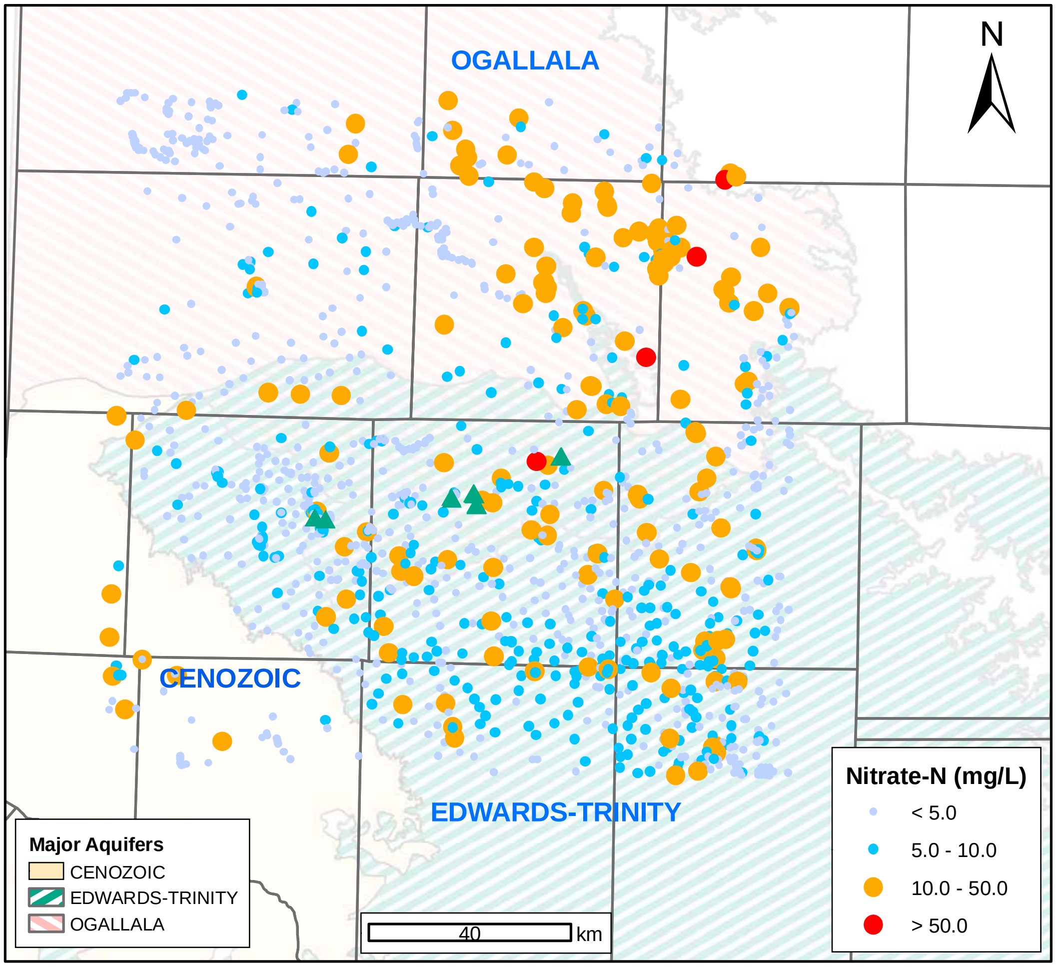
The Edwards Trinity (Plateau) aquifer underlies the Ogallala aquifer in Andrews, Martin, Ector, Midland, and Glasscock Counties and crops out south of this region. This aquifer consists predominantly of the Trinity Group (Early Cretaceous age) and includes the Antlers Sandstone in Ector and Midland Counties, which is overlain by the Washita and Fredericksburg Divisions in Glasscock County (Barker and Ardis 1996). 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 overlying Washita and Fredericksburg Divisions are carbonate dominated with interbedded sandstones. The Lower Cretaceous formations were karstified before deposition of the Upper Cretaceous formations. These units are divided into several formations with complicated terminology: Walnut Formation, Comanche Peak Limestone, and Edwards Limestone transitioning laterally in name to Fort Terrett Formation (base) and Fort Lancaster Formation in some places, and Segovia Formation in other places. The most prolific producing unit is the Fort Terrett Formation. When overlain by the Ogallala Formation, both formations are hydrologically connected and form the High Plains aquifer. However, in some areas only the Cretaceous unit is saturated, and the Ogallala sediments are in the unsaturated zone.

The CPA aquifer consists of up to 1,500 feet of alluvial fill and occupies two separate basins: the Pecos Trough to the west, and the Monument Draw Trough in the east (E. Ector, Winkler, Ward, Crane, and Pecos Counties). These troughs formed as a result of dissolution of underlying evaporites (rock salt, anhydrite, gypsum) in the Permian units. Groundwater occurs under unconfined (water table) or semiconfined conditions. The alluvium consists of unconsolidated or poorly cemented clay, sand, gravel, and caliche (White 1971). North of the Pecos River the alluvium is overlain by windblown sand deposited in dunes. The sand dunes are up to 250 feet thick.

3.2 GENERAL TRENDS IN NITRATE CONCENTRATIONS

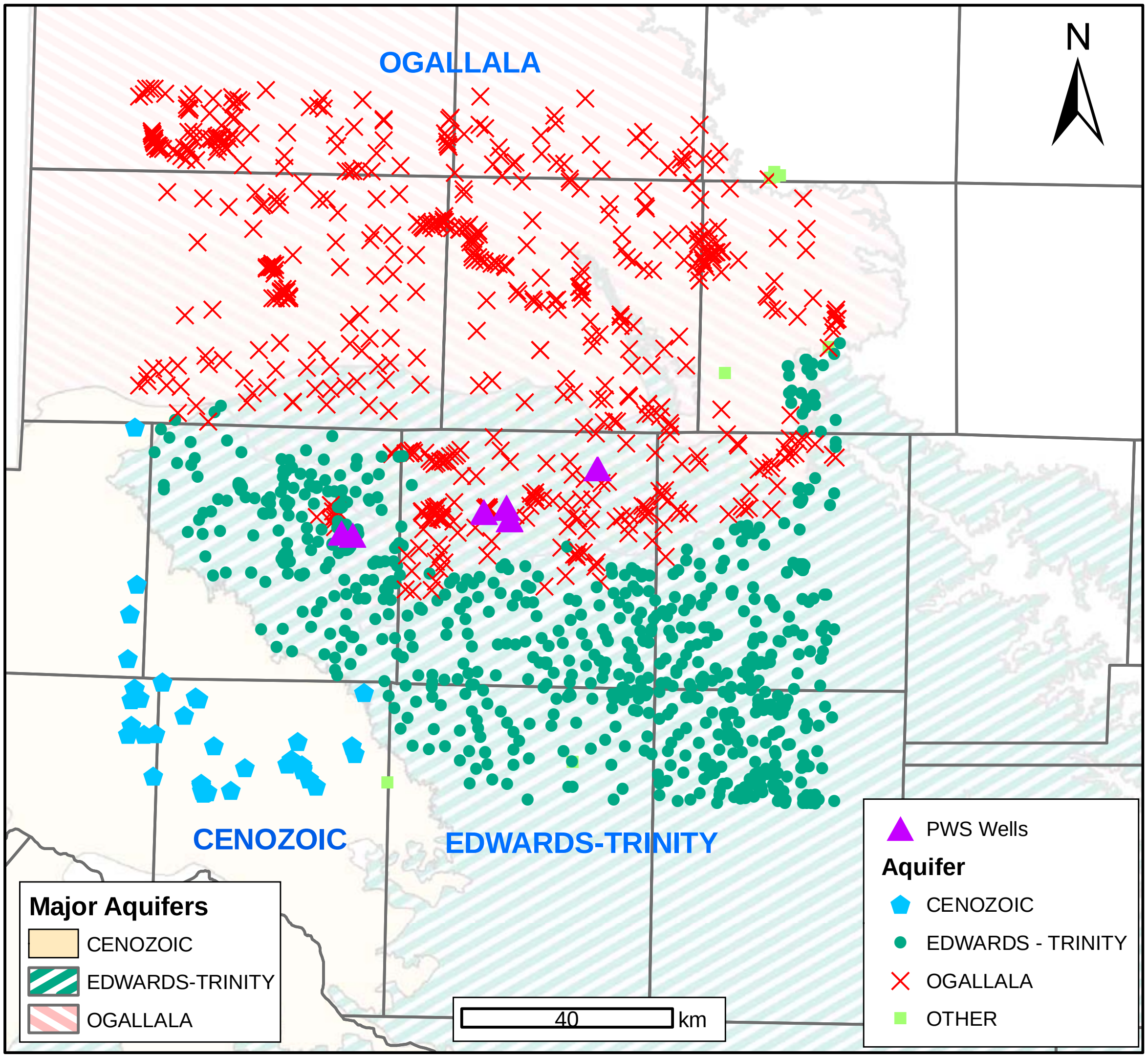
The geochemistry of nitrate is described in Appendix E. Nitrate trends in the vicinity of the assessed PWSs were examined to assess spatial trends, as well as correlations with other water quality parameters. Nitrate measurements are from the TWDB database. Figure 3.2 shows spatial distribution of nitrate concentrations from the TWDB database.

Figure 3.2 Detectable Nitrate-N Concentrations in Groundwater (TWDB Database, Analyses from 1937 through 2004)



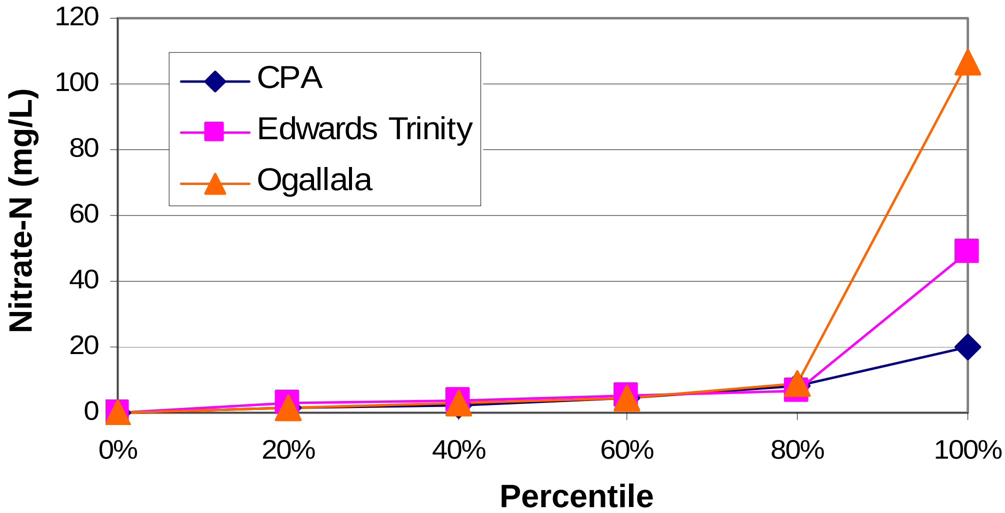
From the TWDB database, 1,410 measurements were extracted, representing the most recent nitrate measurements taken at a specific well (if more than one sample existed for 1 day the average for the day was calculated). Samples were limited to an area delimited by the following coordinates: bottom left 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). Figure 3.3 shows wells with nitrate samples categorized by aquifers.

Figure 3.3 Wells with Nitrate Samples Categorized by Aquifer



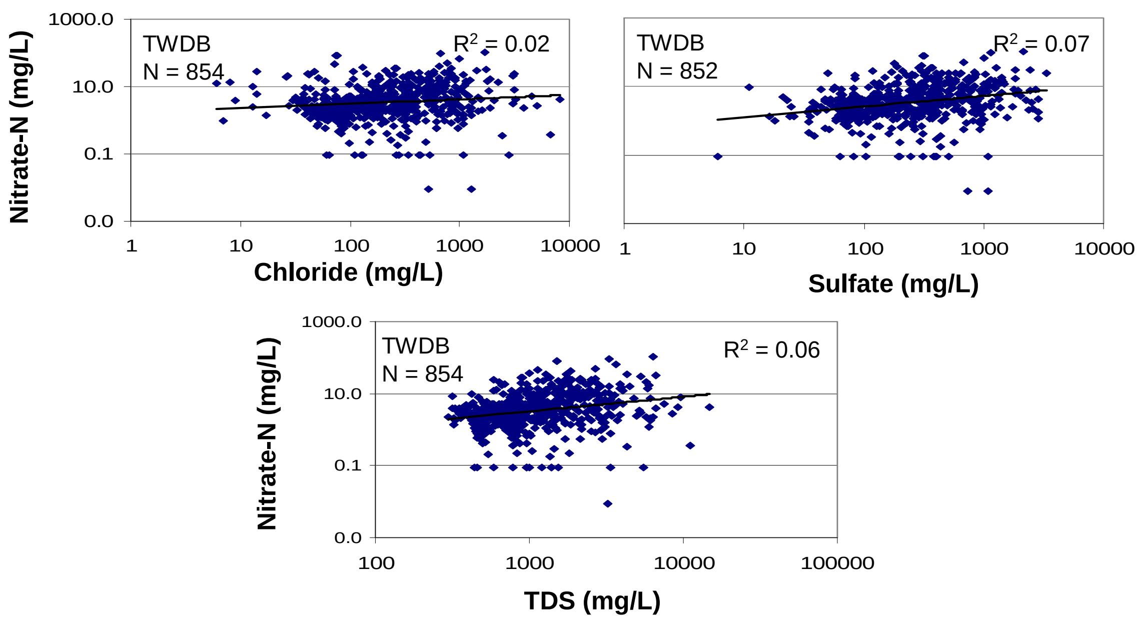
The above map (Figure 3.3) shows 1,410 wells that have nitrate measurements from the TWDB database: 774 are in the Edwards Trinity (Plateau) aquifer, 584 in the Ogallala aquifer, 43 in the CPA aquifer, and 9 in other aquifers. The distribution of nitrate-N concentrations within the three aquifers (CPA, Edwards Trinity (Plateau), and Ogallala) is similar (Figure 3.4). The similarity in nitrate-N levels among the aquifers suggests the source of nitrate is not a particular geologic unit but probably anthropogenic in origin.

Figure 3.4 Distribution of Nitrate-N Concentrations



Nitrate-N is not strongly related to general water quality parameters (sulfate, chloride, and TDS) in the Ogallala aquifer (Figure 3.5). Similar results were found for the Edwards-Trinity (Plateau) aquifer where the coefficient of determination or R-squared (R^2) is less than 0.1 (*i.e.*, little to no correlation), strengthening the conclusion that nitrate-N sources are anthropogenic rather than geologic in origin.

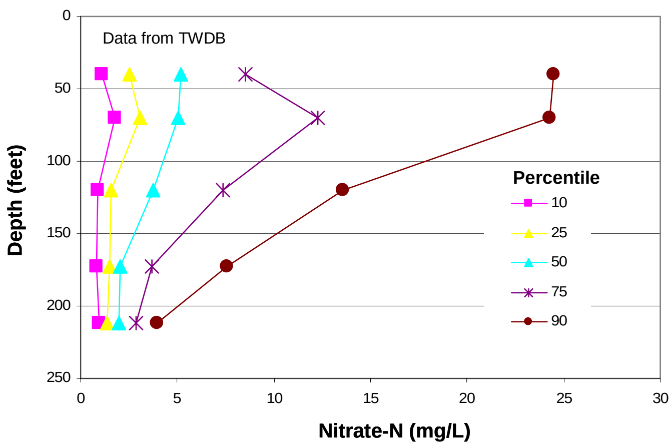
Figure 3.5 Correlation of Nitrate with Chloride, Sulfate, and TDS in the Ogallala Aquifer



Note: 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 in 1 day the average concentration is calculated; only seven wells had more than one sample for the most recent day).

Nitrate-N concentrations are 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).

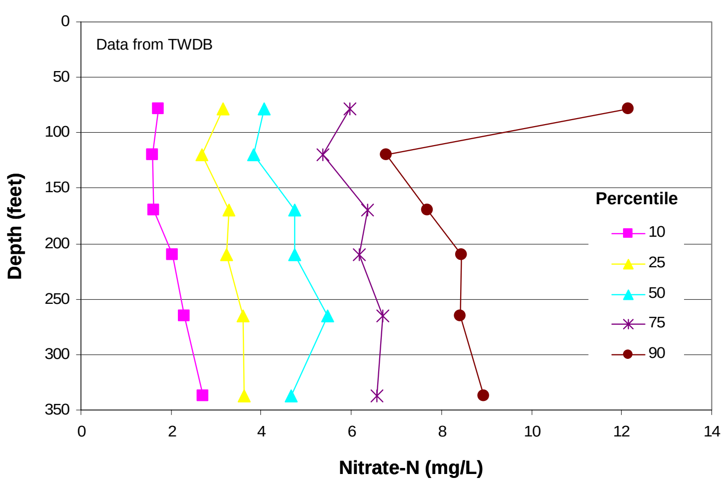
Figure 3.6 Relationship Between Nitrate-N Concentrations and Well Depth in the Ogallala Aquifer



Depth interval (feet)	Min. depth (feet)	Max. depth (feet)	Median depth (feet)	Num. 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

For Figure 3.6, wells are 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.

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



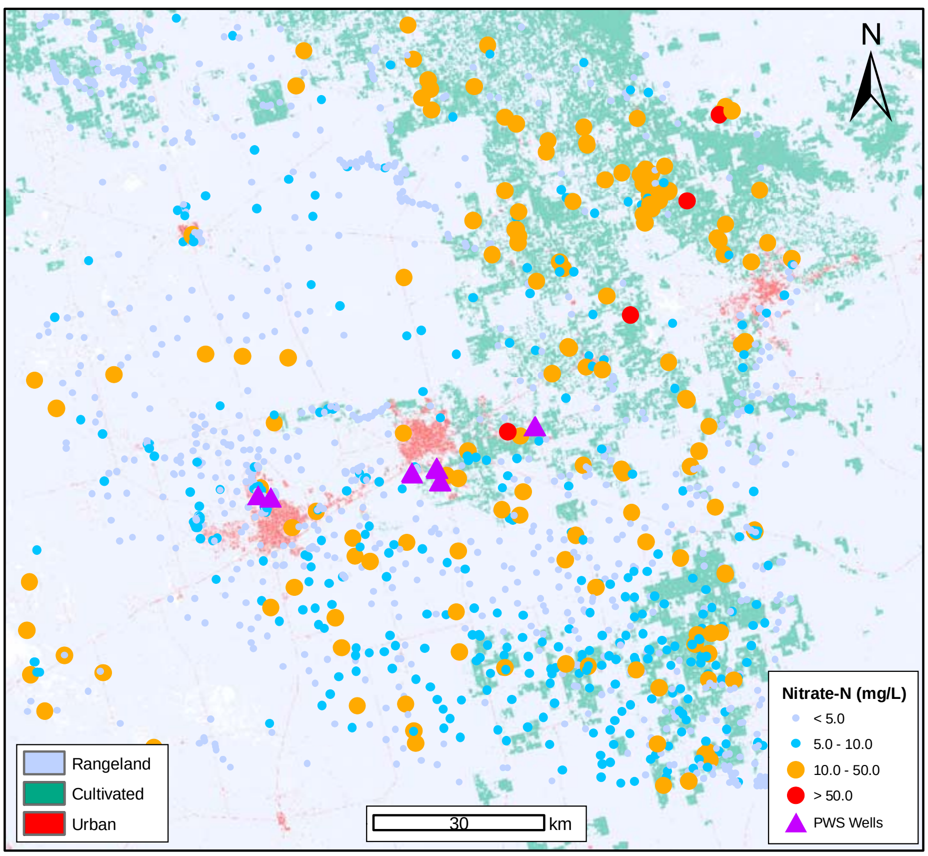
Depth range (feet)	Min. depth (feet)	Max. depth (feet)	Median depth (feet)	Num. of wells
< 100	37	99	79	77
100-150	100	149	120	170
150-200	150	197	170	143
200-250	200	248	211	106
250-300	250	297	265	72
> 300	300	495	337	116

Figure 3.7 shows the relationship between nitrate-N concentrations and depth within the Edwards-Trinity (Plateau) aquifer. Wells are divided into depth bins, and for each bin, nitrate-N concentrations are shown with respect to median depth. The table on the

right summarizes the depth values for each bin and gives the number of wells in the analysis for that depth range. 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 shallower wells (< 100 feet) have higher concentrations.

Nitrate-N concentrations from the TWDB database were compared with land use from the National Land Cover Dataset (NLCD 1992). Land-use datasets are categorized into three groups (rangeland, cultivated, and urban) and compared with nitrate-N concentrations within the study area. Figure 3.8 shows the spatial distribution of nitrate-N and land use; high concentrations of nitrate-N are generally found in cultivated areas. Figure 3.9 shows the correlation between land-use types and nitrate-N concentrations.

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



Note: Nitrate concentrations are from the TWDB database, and the most recent nitrate measurement is shown for each well.

Figure 3.9 Relationship Between Nitrate-N Concentrations and Land Use

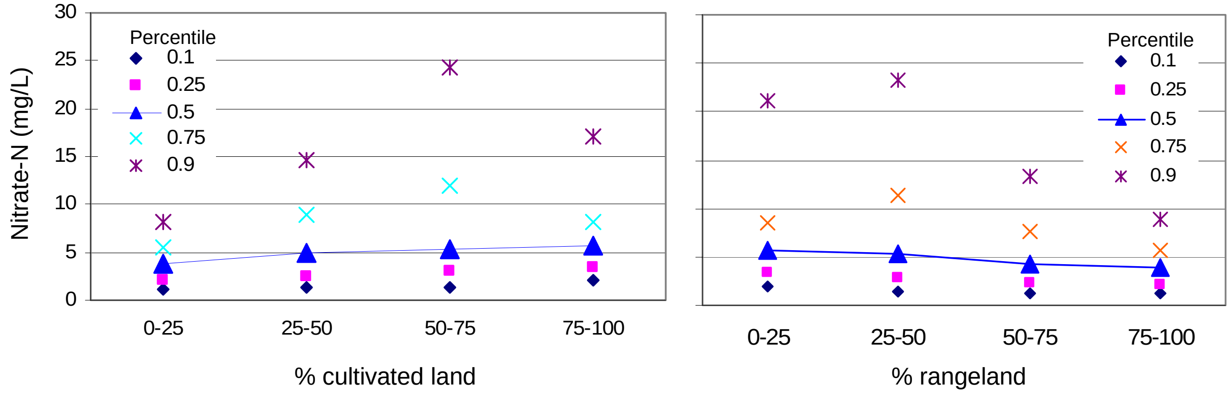


Figure 3.9 shows nitrate-N concentrations in groundwater in relation to land use within a 1-km radius of well locations. Land use was obtained from the NLCD and was categorized into the following land-use types: rangeland (NLCD codes 51, 71, 41, 42, and 43), cultivated (NLCD codes 81, 82, 83, and 61), and urban (NLCD codes 21, 22, 23, and 85). The complementary analysis accounts for more than 90 percent of the land use related to over 95 percent of the wells. Nitrate-N concentrations are from the TWDB database, and the most recent measurement is used for each well. Nitrate-N concentrations generally increase with percentage of cultivated land (left plot) and decrease with percentage of rangeland (right plot). The two plots are generally complementary with increases in nitrate-N with cultivation and decreases in nitrate-N with rangeland. The greatest increases in nitrate-N with cultivation occur in the upper 75th and 90th percentiles. Population means of the land-use groups (percentage bins) are statistically different ($P < 1e^{-9}$) for both land-use categories.

3.3 GENERAL TRENDS IN ARSENIC CONCENTRATIONS

The geochemistry of arsenic is described in Appendix E. Arsenic trends in the vicinity of the analyzed PWSs were examined to assess spatial trends, as well as correlations with other water quality parameters. Arsenic measurements 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. Figure 3.10 shows spatial distribution of arsenic concentrations from the TWDB database, and Figure 3.11 shows percentages of wells in each aquifer that exceed the MCL of arsenic of 10 µg/L.

Figure 3.10 Spatial Distribution of Arsenic Concentrations (TWDB Database)

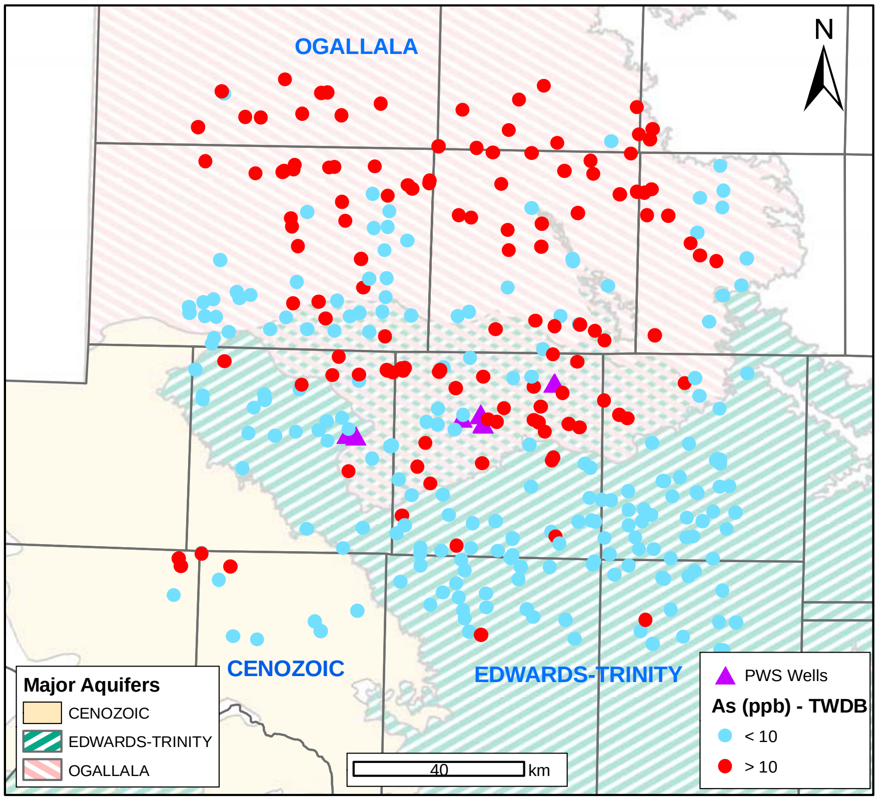
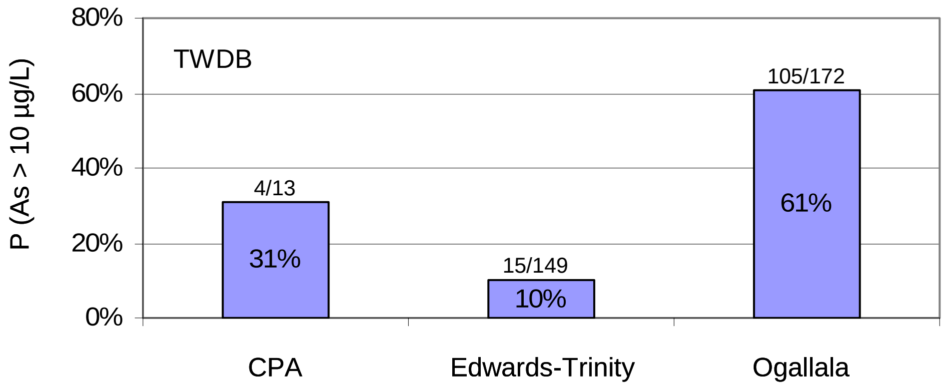


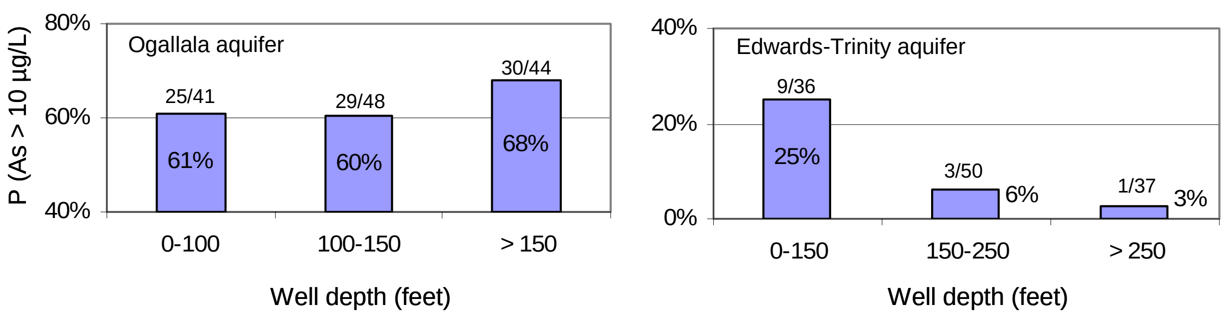
Figure 3.11 Probabilities of Arsenic Concentrations Exceeding 10 µg/L MCL for Aquifers in the Study Area



Data in Figures 3.10 and 3.11 are from the TWDB database. The most recent arsenic measurement was used for each well. The Ogallala aquifer has a percentage of wells with arsenic concentrations >10 µg/L which is higher than the other aquifers (Figure 3.11). Within the Ogallala aquifer, 61 percent of the wells had arsenic concentrations >10 µg/L, in comparison with the CPA (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 boundary of the Ogallala aquifer (only seven wells with high arsenic are outside the aquifer boundary, and three of those seven are within 5 km of the boundary). It is possible 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 has a secondary aquifer (Dockum) designated 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 were not strongly correlated with well depth. Within the Edwards-Trinity (Plateau) aquifers the shallower wells (<150 feet) have higher probabilities of arsenic concentrations exceeding 10 µg/L. 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 strengthens the assumption that the source of contamination for wells within the Edwards-Trinity (Plateau) aquifers is actually from the Ogallala aquifer.

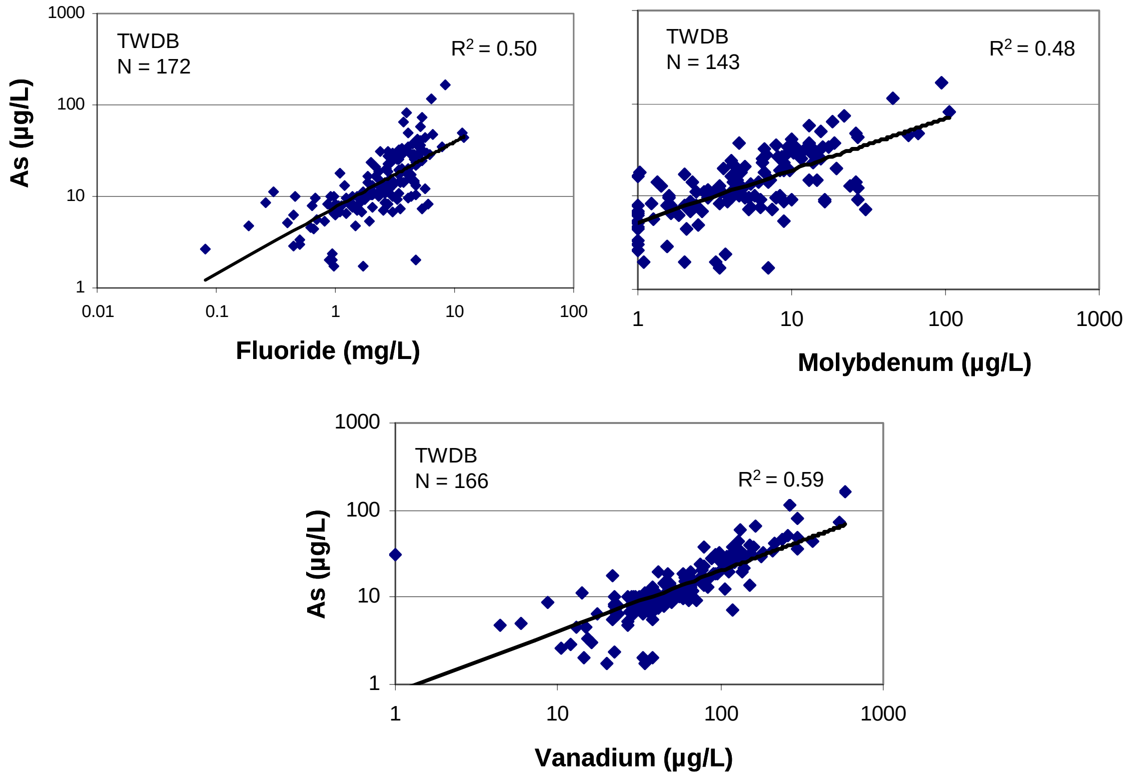
Figure 3.12 Relationship Between Arsenic Concentrations and Well Depth



Data are from the TWDB database, and the most recent arsenic measurement was used for analysis for each well. Numbers above each column represent numbers of arsenic measurements that are >10 µg/L and total number of analyses in the bin. For example, 25/41 represents 24 samples >10 µg/L out of 41 analyses at a well depth between 0 and 100 feet.

Relationships between arsenic and pH, SO_4, 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 concentrations and dissolved oxygen concentrations. Strong coefficients of determination or R-squared values (R^2 >0.48) were found between arsenic and fluoride, arsenic and vanadium, and arsenic and molybdenum 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 are from the TWDB database, and the most recent arsenic sample was used in the analysis for each well. Fluoride, molybdenum, and vanadium concentrations were measured the same day as those of the most recent arsenic measurements. A total of nine arsenic measurements within the database were below the detection limit of 10 µg/L, and two samples are below the detection limit of 2 µg/L. These samples are plotted as equal to detection limits (10 and 2, respectively). Vanadium samples have a detection limit of 1 µg/L 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 µg/L. Values below detection limits of 50 and 20 were excluded from analysis, and remaining values 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 between 6.7 and 14.3 mg/L. No aquifer designation is within 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). Depths for these wells range from 6 to 70 feet, also suggesting they are in the shallow Ogallala aquifer. Dissolved oxygen values show that groundwater is oxidizing and that arsenic should be present as arsenate and may have been mobilized under high pH (see Appendix E).

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 the source of arsenic is from the Ogallala aquifer overlying the Edwards-Trinity (Plateau) aquifer.

3.4 DETAILED ASSESSMENT FOR HUBER GARDEN ESTATES (PWS 0680163)

Two wells are in this water supply system: G0680163A and G0680163B. Both wells have depths of 160 feet, but have no screen information. Both wells are designated within the Twin Mountain/Antlers/Travis Peak aquifers, and both are related to one entry point in the water supply system, making it difficult to trace contaminants to a specific well. Table 3.1 summarizes nitrate-N concentrations measured at the Huber Garden Estates PWS.

Groundwater nitrate and arsenic concentrations can have a high degree of spatial variability. Because of this variability, an investigation of the existing wells should be conducted to determine whether both or only one produces non-compliant water. If one well is found to produce compliant water, as much production as possible should be shifted to the compliant well. Also, if one well is found to produce compliant water, the wells should be compared in terms of depths and well logs to try and identify differences that could be responsible for the elevated concentration of nitrate or arsenic in the other well. Then if blending of water from the existing wells does not produce a sufficient quantity of compliant water, it may be possible to install a new well similar to the existing compliant well that also would provide compliant water.

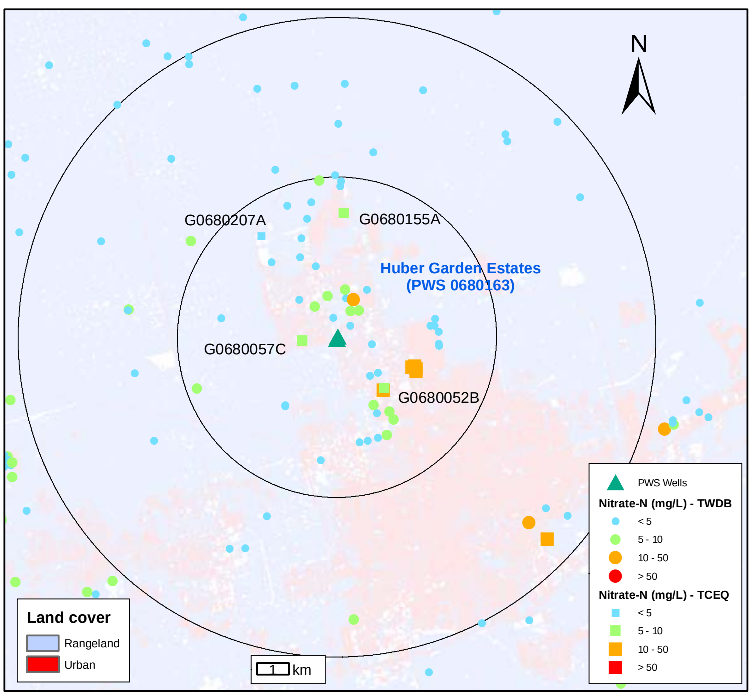
Table 3.1 Nitrate-N Concentrations in the Huber Garden Estates PWS (TCEQ Database)

Date	Nitrate-N (mg/L)	Source
3/5/1997	10.25	TCEQ
6/18/1997	10.58	TCEQ
9/23/1997	10.59	TCEQ
2/17/1998	10.57	TCEQ
2/17/1998	10.81	TCEQ
4/23/1998	10.98	TCEQ
8/12/1998	11.28	TCEQ
11/30/1998	9.58	TCEQ
3/29/1999	10.43	TCEQ
6/7/1999	10.91	TCEQ
8/19/1999	11.71	TCEQ
11/8/1999	12.73	TCEQ
2/14/2000	10.7	TCEQ
6/22/2000	9.68	TCEQ
12/19/2000	9.8	TCEQ
4/16/2001	7.82	TCEQ
9/24/2001	9.37	TCEQ
12/13/2001	9.32	TCEQ

Date	Nitrate-N (mg/L)	Source
2/21/2002	8.79	TCEQ
6/25/2002	10.12	TCEQ
8/28/2002	10.45	TCEQ
10/29/2002	9.1	TCEQ
4/23/2003	10.16	TCEQ
7/30/2003	10.37	TCEQ
11/3/2003	9.73	TCEQ
2/16/2004	10.11	TCEQ
6/1/2004	11.26	TCEQ
8/16/2004	10.16	TCEQ

Twenty eight nitrate-N samples were collected at the PWS between 1997 and 2004. The majority of the samples were above the nitrate-N MCL (10 mg/L), and the rest were just below the MCL (between 9 and 10 mg/L). Figure 3.14 shows the spatial distribution of nitrate-N concentrations within 5- and 10-km buffers of the PWS wells.

Figure 3.14 Nitrate-N Concentrations in 5- and 10-km Buffers of Huber Garden Estates PWS Wells (TWDB and TCEQ Databases)



Data are from the TCEQ and TWDB databases. Maximum nitrate-N concentration is shown for each well. Two types of samples were included in the analysis from the TCEQ database: raw samples that can be related to a single well and entry-point samples taken from a single entry point, which can be related to a single well.

Two wells from the TWDB database, and six wells from the TCEQ database, within buffers of the PWS wells have high (>10 mg/L) nitrate-N concentrations. Four PWS wells within the 5-km buffer, G0680052B, G0680057C, G0681055A, and

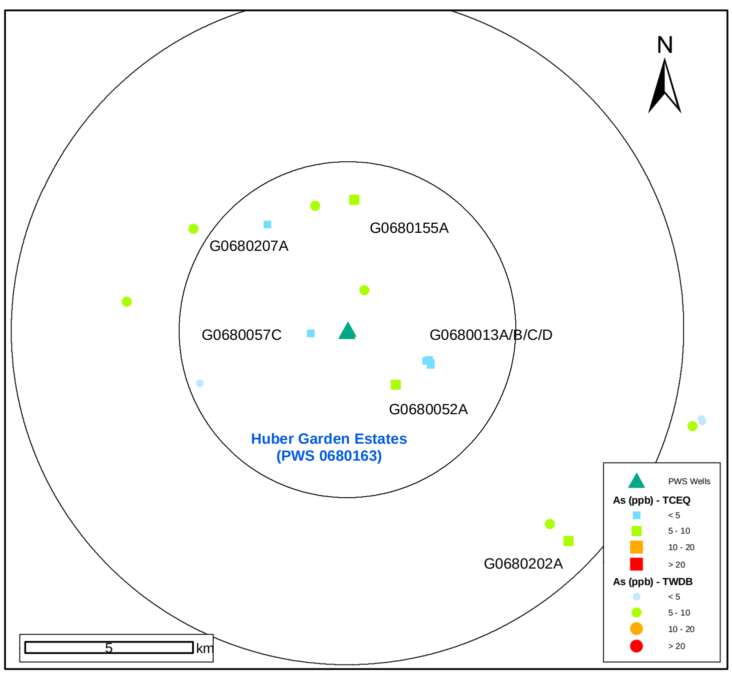
G0680207A, had nitrate-N concentrations <10 mg/L and may be considered alternative water sources. These wells are within the same formation as the PWS wells (Twin Mountain/Antlers/Travis Peak) and have well depths of 160, 150, 200, and 160 feet, respectively. Within the 10-km buffer, there are no PWS wells with nitrate-N concentrations below the MCL. Table 3.2 summarizes arsenic concentrations measured at the Huber Garden Estates PWS.

Table 3.2 Arsenic Concentrations in the Huber Garden Estates PWS (TCEQ Database)

Date	As (µg/L)	Source
2/17/1998	5.0	TCEQ
4/16/2001	10.0	TCEQ
2/16/2004	5.3	TCEQ

Three arsenic measurements are from the TCEQ database, between 1998 and 2004. Two of the three samples are below the arsenic MCL (10 µg/L), and one is equal to the MCL. Figure 3.15 shows spatial distribution of arsenic concentrations within 5- and 10-km buffers of the PWS wells.

Figure 3.15 Arsenic Concentrations in 5- and 10-km Buffers of Huber Garden Estates PWS Wells (TWDB and TCEQ Databases)



Data are from the TCEQ and TWDB databases. The maximum arsenic concentration is shown for each well. Two types of samples were included in the analysis from the TCEQ database: raw samples that can be related to a single well and entry-point samples taken from a single entry point, which can be related to a single well. None of the TWDB or TCEQ samples within the buffers exceeded the arsenic MCL. Within 5- and 10-km buffers, nine PWS wells had arsenic concentrations below the MCL. The closest well, G0680057C (~1 km), is located to the west of the PWS wells. Other PWS wells with low arsenic concentrations are G0680013A/B/C/D, G0680207A, G0680155A, G0680052A, and G0680202A, which all have arsenic concentrations <10 μg/L.

SECTION 4
ANALYSIS OF THE HUBER GARDEN ESTATES PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1. Existing System

The location of the Huber Garden Estates PWS is shown on Figure 4.1. The system provides drinking water to the Huber Garden Estates mobile home park. The system has two wells, which were completed in the Antler Sand Aquifer (Code 218ALRS), approximately 160 feet deep. The wells feed into a 10,000-gallon storage tank. The 10,000-gallon storage tank feeds a booster pump that pumps into two 1,000-gallon hydropneumatic tanks, which in turn feed the distribution system. The water is chlorinated before flowing into the hydropneumatic tanks. A flow meter measures the volume of water fed to the distribution system. Nitrate concentration of the combined flow from the two wells averages approximately 10 mg/L, and arsenic concentrations have ranged from 0.005 to 0.01 mg/L, with TDS concentrations in the 1,150 to 1,180 mg/L range.

The treatment employed is not appropriate or effective for removal of arsenic or nitrate, so optimization is not expected to be effective in increasing removal of either of these contaminants. 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 or more wells happen 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 within the well screen interval.

Basic system information is as follows:

- Population served: 75
- Connections/residences: 25
- Average daily flow: 0.0075 mgd*
- Maximum daily flow: 0.030 mgd**
- Total production capacity: 0.12 mgd
- Typical nitrate range: 8 to 11 mg/L
- Typical arsenic range: 0.005 to 0.01 mg/L
- Typical TDS range: 1,150 to 1,180 mg/L

** Based on 100 gpcd.*
*** Based on 4 x average daily flow.*

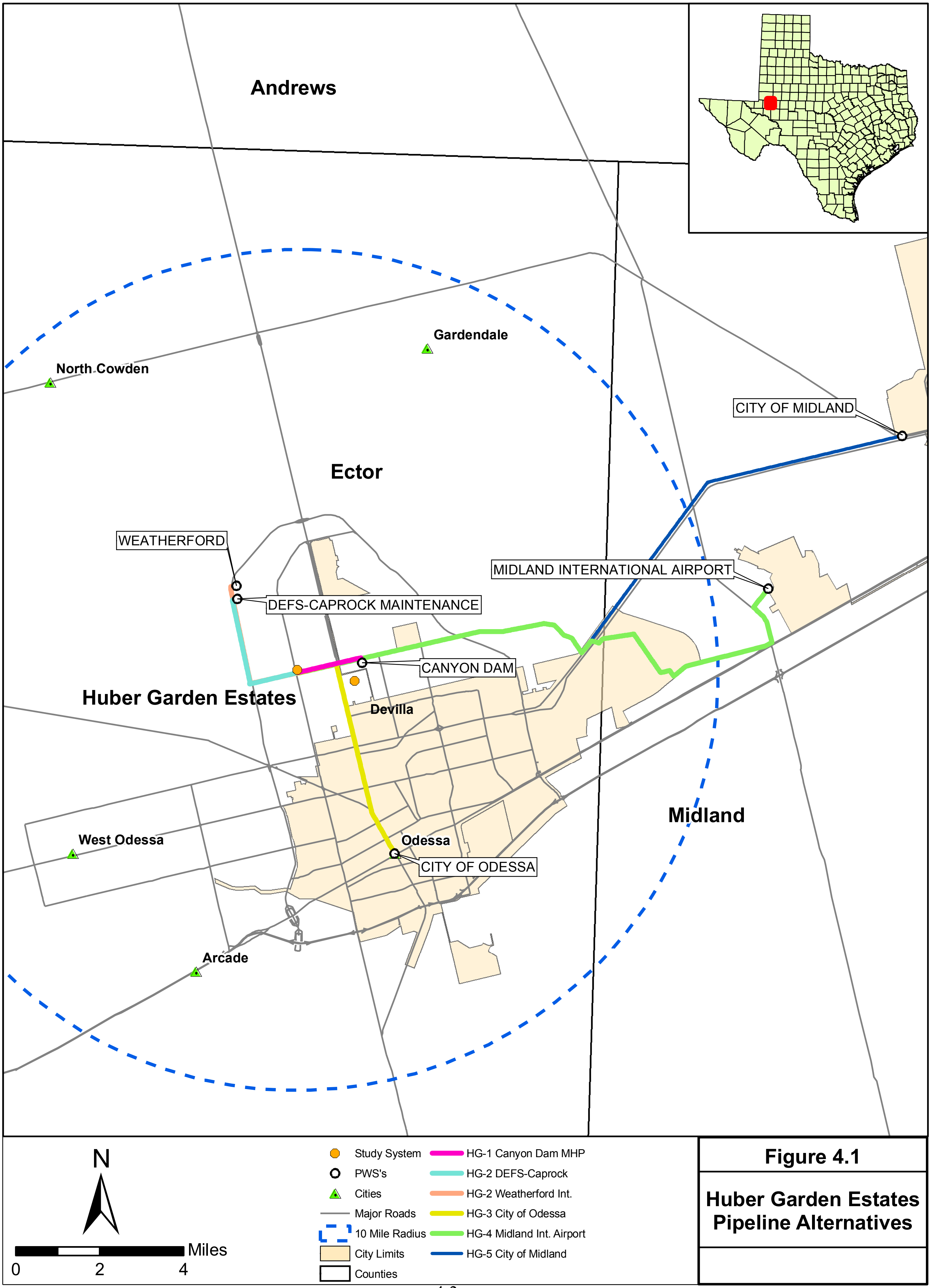


Figure 4.1

Huber Garden Estates Pipeline Alternatives

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4.1.2 Capacity Assessment for Huber Garden Estates

This section is currently incomplete because owners/operators have been unavailable for interviews. This section will be completed once the interview has been conducted.

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, the PWSs surrounding the Huber Garden Estates 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 public water supply systems within approximately 30 miles of Huber Garden Estates. Thirty miles was selected as the radius for the evaluation owing to the large number of PWSs in the proximity of the Huber Garden Estates.

Based upon the initial screening summarized in Table 4.1 above, six alternatives were selected for further evaluation. These are summarized in Table 4.2.

Table 4.1 Existing Public Water Systems within 30 miles of Huber Garden Estates

System Name	Distance from Huber Garden	Comments/Other Issues
Richeys Mobile Home Park	0.7	Small system with WQ issues: TDS, NO3, SO4; marginal exceedances: gross alpha
Devilla Mobile Home Park	1.4	Small system with WQ issues: TDS, NO3, SO4, gross alpha; marginal exceedances: combined uranium
Canyon Dam Mobile Home Park	1.5	Small system without identified WQ issues. **Evaluate further**.
Northgate Mobile Home Park 1	1.6	Small system with WQ issues: TDS, NO3, gross alpha; marginal exceedances: SO4, combined uranium
Duke Energy Field Services - Caprock Maintenance Facility	2.2	Small system without identified WQ issues. **Evaluate further**.
Williams Trailer Court	2.2	Small system with WQ issues: Fe, TDS, SO4, hardness, combined uranium, gross alpha; marginal exceedances: As, NO3
Orchard Water Supply	2.3	Small system with WQ issues: As; marginal exceedances: TDS, fluoride, gross alpha
Weatherford International Inc.	2.5	Small system without identified WQ issues. **Evaluate further**.
Occidental Permian Ltd. S. Cowden	4.2	Small system without identified WQ issues
City of Odessa	5.0	Large system (>1 mgd) with WQ issues: TDS, SO4. **Evaluate further**.
Double H Mobile Home Park	7.7	Small system with marginal As exceedances
Gardendale County Water Inc.	8.9	Small system with marginal NO3, TDS exceedances
Depot Water Store	8.9	Small system with WQ issues: TDS, SO4
Occidental Permian Ltd. N. Cowden	10.3	Small system with WQ issues: As, Fe
Midland International Airport	11.6	Large system (>1 mgd) with marginal As exceedances. **Evaluate further**.
Colorado River MWD - Ector County Well	12.6	Large system (>1 mgd) with marginal TDS exceedances. **Evaluate further**.
Spring Meadow Mobile Home Park	13.9	Small system with WQ issues: As, SO4, TDS; marginal exceedances: combined uranium, NO3
Airline Mobile Home Park LTD	14.4	Small system with WQ issues: TDS, SO4, gross alpha; marginal exceedances: As
Pecan Acres Homeowners Association	14.4	Small system with WQ issues: As, TDS, SO4, gross alpha; marginal exceedances: hardness
Southdown Inc.	14.7	Small system with WQ issues: SO4; marginal exceedances: TDS
Westgate Mobile Home Park	16.7	Small system with WQ issues: trichloroethylene (TCE) and methyl t-butyl ether (MTBE) have been detected
Country Village Mobile Home Estates	17.1	Small system with WQ issues: As, TDS, NO3, SO4, hardness
Twin Oaks Mobile Home Park	19.4	Small system with WQ issues: As, TDS, NO3, SO4, gross alpha; marginal exceedances: combined uranium, selenium, hardness
Johns Mobile Home Park	19.4	Small system with WQ issues: As, TDS, NO3, SO4, hardness
South Midland County Water Systems	19.8	Small system with WQ issues: As, TDS, NO3, SO4; marginal exceedances: hardness
Warren Road Subdivision	20.0	Small system with WQ issues: As, TDS, NO3, SO4
Valley View Mobile Home Park	24.5	Small system with WQ issues: As, TDS, NO3, SO4, uranium, gross alpha; marginal exceedances: selenium, hardness
Water Runners Inc.	25.0	Small system without identified WQ issues
Pecan Groove Mobile Home Park	25.9	Small system with WQ issues: TDS; marginal exceedances: As, NO3, SO4, hardness
City of Midland	28.1	Large system (>1 mgd) with WQ issues: As, TDS, SO4, fluoride. **Evaluate further**.

Table 4.2 Public Water Systems within 30 miles of Huber Garden Estates Selected for further Evaluation

Canyon Dam Mobile Home Park
Duke Energy Field Services – Caprock Maintenance Facility
Weatherford International
City of Odessa
Midland International Airport
City of Midland

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 Huber Garden Estates, 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 these 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 mgd. CRMWD primarily uses these well fields to supplement surface water deliveries during the summer months.

4.2.1.2 Canyon Dam Mobile Home Park

Canyon Dam Mobile Home Park is located approximately 2 miles to the east of Huber Garden Estates. Canyon Dam Mobile Home Park has a population of 50 and is served by 19 connections. It has two wells, both rated 40 gpm (0.058 mgd), both of which are about 150 feet deep. The owners are currently making plans to install a third well. The water system has a maximum rated capacity of 0.144 mgd. The water is disinfected using hypochlorite prior to distribution. The estimated average and maximum daily demand is 0.007 mgd and 0.026 mgd, respectively.

This system does not currently have sufficient capacity to supply water to another system; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.3 Duke Energy Field Services – Caprock Maintenance Facility

Duke Energy Field Services – Caprock Maintenance Facility is located approximately 2 miles northwest of Huber Garden Estates, and is a privately-owned industrial facility that provides oilfield support services. The facility has two wells that draw water from the Antler Sands aquifer (Code 218ALRS). The wells are approximately 160 feet deep, and are rated at 35 and 45 gpm. There are 96 employees at the location and the on-site water is disinfected using RO.

According to the personnel that manage the PWS, the Duke Energy Field Services – Caprock Maintenance Facility has insufficient capacity to be able to supply water to another system. However, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.4 Weatherford International

The Weatherford International, Inc. facility is located approximately 2 miles northwest of Huber Garden Estates, and is a privately-owned industrial facility that provides oilfield support services. The facility has one well that draws water from the Antler Sands Aquifer (Code 218ALRS), is approximately 160 feet deep, and is rated at 18 gpm. The water is pumped to a 100-gallon storage tank and disinfected using chlorination before use in the office building. No contaminants have been reported above the standards during prior sampling events.

According to the personnel managing the PWS, the Weatherford International, Inc. facility currently has insufficient capacity to supply water to another system. However, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.5 City of Odessa

The intake point for the City of Odessa is located within 5 miles southeast of Huber Garden Estates. 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. Groundwater 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 is then stored in a 4.3 million gallon concrete storage tank prior to distribution to the

City of Odessa. In addition to the water delivered via the CRMWD pipeline, a relatively small amount of water (less than 10 percent) is also delivered by a second pipeline from the Ward County Well Field, which is located approximately 60 miles west of Odessa. This water is pH-adjusted and chlorinated prior to being pumped to the 4.3 million gallon storage tank.

In 2004, approximately 6.7 billion gallons of water was delivered to Odessa from San Angelo via the CRMWD pipeline, and 4.5 percent or 0.31 billion gallons originated from the Ward County Well Field. The 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 does have an excess capacity of treated water and may be willing to sell water to other PWSs. A community that wishes 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 they would have to fund cost of the connecting pipeline.

4.2.1.6 Midland International Airport

Midland International Airport is located approximately 12 miles east of Huber Garden Estates. 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. Data for this report was collected during the summer of 2005, and the evaluation report will be completed in the fall of 2005.

Currently the operators of the PWS do not consider that there is sufficient excess capacity to provide water to offsite facilities or areas. However, based on the available water quality data, the location may be a suitable point for a new groundwater.

4.2.1.7 City of Midland

The City of Midland is located approximately 28 miles east of Huber Garden Estates. The City of Midland purchases approximately 75 to 80 percent of its water from the CRWMD through a 1966 contract agreement. 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 CRWMD 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 first 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 million gallon reservoir located at the water purification plant and the 100 million gallon 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 CRWMD, under a 1995 agreement, Midland owns 16.54 percent of Lake Ivie, which is located approximately 170 miles southwest of Midland. Each day, 15 million gallons from Lake Ivie and 16 million gallons from CRWMD reservoirs are delivered via pipeline from Ballinger to San Angelo, and then to one of the three reservoirs around Midland.

In addition to the 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 a 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 million gallon 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 have been 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 CRWMD and the groundwater from the Paul Davis Well Field to maintain a potable water supply that does not exceed the MCLs for these constituents. The third well field is the T-Bar Ranch, which is 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 the surface water supplied by CRWMD and provides water to a service population of approximately 100,000. The City has a total of approximately 35,500 connections, about 32,000 of which are metered. The major users of water in Midland include the college, parks and schools which use the water for irrigation. The current monthly rates per connection are $12 base charge for the first 2,000 gallons and $2.75 for each additional 1,000 gallons.

In the fall of 2003, the Midland City Council decided that water can only be provided to areas that are 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. In order to be annexed, a commission representing the town to be annexed must submit a petition signed by at least 50 percent of the community residents wanting to be annexed. The commission representing the community then appoints 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.

4.2.2 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 nitrate and 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 well. As a result, existing wells identified 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.

4.2.2.2 Results of Groundwater Availability Modeling

Regional groundwater withdrawal in the vicinity of Huber Garden Estates is extensive and is likely to remain near current levels over the next decades. In central Ector County, where the Huber Garden Estates system is located, the primary groundwater source for public supplies is the Edwards-Trinity Plateau aquifer. The aquifer’s outcrop transitions into the southern edge of another major aquifer, the Ogallala, in the north and east sections of the county.

Supply wells for the Huber Garden Estates system and its vicinity withdraw groundwater primarily from the Antlers Sand formation of the Edwards-Trinity Plateau aquifer. In September 2004, the TWDB published results of the GAM for the Edwards-Trinity Plateau aquifer (Anaya and Jones, 2004). GAM data indicated that, under drought-of-record conditions, significant water declines would occur in the Trinity unit of the Edwards-Trinity Plateau throughout sections of Ector, Midland, and Uptown counties (Anaya and Jones, 2004). The withdrawal rate from the aquifer declined steadily in Ector

County from a peak annual use of 5,593 acre-feet in 1996 to 3,891 acre-feet in 2000. This trend, however, is reversing, with withdrawals in Ector County expected to reach 5,607 acre-feet per year by 2010, and remain near those levels through the year 2050. The anticipated water level drawdown over the 50-year simulation period for north and central Ector County falls between the 50 and 100 feet range (Anaya and Jones, 2004).

The Southern Ogallala aquifer extends over most of the Texas panhandle and into eastern New Mexico, reaching sections of north and east Ector County. The 2002 Texas Water Plan anticipates a 24 percent drop in the Ogallala supply over the next decades, from 5,000,097 acre-feet per year estimated in 2000 to 3,785,409 acre-feet per year in 2050. A GAM for the Ogallala aquifer was recently developed by the TWDB (Blandford *et al*., 2003). Predictive simulations indicated that, if estimated future withdrawals are realized, aquifer water levels could decline in excess of 100 feet, to a point at which significant regions currently practicing irrigated agriculture could be essentially dewatered by 2050 (Blandford *et al*., 2003). For central Ector County, the simulated drawdown by the year 2050 would be more moderate, within the 0 to 25 feet range (Blandford *et al*., 2003).

4.2.3 Potential for New Surface Water Sources

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

Huber Garden Estates is located in the upper reach of the Colorado River 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 an 11 percent reduction in surface water availability in the Colorado River Basin over the next 50 years, from 879,400 acre-feet per year in 2002 to 783,641 acre-feet per year in 2050.

In the site vicinity, and over the entire Ector County, unappropriated flows of the Colorado River Basin for new uses are available at most 50 percent of the time. This supply is inadequate as the TCEQ requires 100 percent supply availability for a municipal water supply.

4.2.4 Options for Detailed Consideration

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

1. Canyon Dam Mobile Home Park. A new well would be installed in the vicinity of the wells at the Canyon Dam Mobile Home Park. A pipeline and pump station would be constructed to transfer the water to the Huber Garden Estates storage tank (Alternative HG-1).

2. Duke Energy Field Services/Weatherford International. A new well would be installed in the vicinity of either the Duke Energy facility or the Weatherford International facility wells. A pipeline and pump station would be constructed to transfer the water to the Huber Garden Estates storage tank (Alternative HG-2).

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

4. 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 Huber Garden Estates storage tanks (Alternative HG-4).

5. 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 Huber Garden Estates storage tank (Alternative HG-5).

In addition to the location-specific alternatives above, three hypothetical alternatives are considered in which new wells would be installed 10-, 5-, and 1-miles from the Huber Garden Estates PWS. Under each of these alternatives, it is assumed that a source of compliant water can be located and then a new well would be completed and a pipeline would be constructed to transfer the compliant water to Huber Garden Estates. These alternatives are HG-10, HG-11, and HG-12.

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of the well field water is identified as a potential option. Both RO and EDR could be potentially applicable. The central RO treatment alternative is Alternative HG-6, and the central EDR treatment alternative is Alternative HG-7.

4.3.2 Point-of-Use Systems

Point-of-use treatment using RO technology is valid for nitrate and arsenic removal. The point-of-use RO treatment alternative is HG-8.

4.3.3 Point-of-Entry Systems

Point-of-entry treatment using RO technology is valid for nitrate and arsenic removal. The point-of-entry RO treatment alternative is HG-9.

4.4 BOTTLED WATER

Provision of 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 the bottled water program. An alternative to providing delivered bottled water is to provide a central, publicly accessible dispenser for treated drinking water. Alternatives addressing bottled water are HG-13, HG-14, and HG-15.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

A number of potential alternatives for compliance with the MCLs for nitrate and 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 the 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 HG-1: New Well at Canyon Dam Mobile Home Park

This alternative consists of drilling a new well in the Canyon Dam Mobile Home Park area that would replace Huber Garden Estates' wells. Records indicate nitrate levels around 5 mg/L in the Canyon Dam Mobile Home Park wells, which is not low enough to provide a high confidence level that blending will be possible. As a result, for this alternative, it is assumed that Huber Garden Estates would obtain all of its water from the new well.

This alternative would require the drilling of a new well and installation of a well pump, small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Huber Garden Estates system. One of the two pumps in the pump station is for backup in case the other pump fails. The 4-inch polyvinyl chloride (PVC) pipeline would be installed adjacent to West and East Yukon Road for approximately 1.7 miles and discharge to the existing storage tank in Huber Garden Estates.

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 the cost to construct a new well and small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Huber Garden Estates system. The estimated O&M cost for this alternative includes additional costs related to taking the existing well field out of service, 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 $548,200, and the estimated annual O&M cost for this alternative is $9,900.

Reliability of supply of adequate amounts of compliant water under this alternative should be good. Huber Garden Estates has a well field with adequate capacity. From Huber Garden Estates' perspective, 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 Huber Garden Estates currently operates pumps.

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

4.5.2 Alternative HG-2: New Well at either Duke Energy Field Services Facility or Weatherford International Facility

This alternative consists of drilling a new well in the area of the Duke Energy Field Services Caprock Maintenance Facility or the Weatherford International facility that would replace Huber Garden Estates' wells. Records indicate, with relatively few analyses, nitrate levels around 5 mg/L in the Duke Energy Field Services and the Weatherford International wells, which is not low enough to provide a high confidence level that blending will be possible. As a result, for this alternative, it is assumed that Huber Garden Estates would obtain all of its water from the new well.

This alternative would require the drilling of a new well and installation of a well pump, small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Huber Garden Estates system. One of the two pumps in the pump station is for backup in case the other pump fails. The 4-inch PVC pipeline would be installed adjacent to West Yukon Road then north along Loop 338 for approximately 3.4 miles and discharge to the existing storage tank in Huber Garden Estates.

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 the cost to construct a new well and small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Huber Garden Estates system. The estimated O&M cost for this alternative includes additional costs related to taking the existing well field out of service, 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 $0.90 million, and the estimated annual O&M cost for this alternative is $11,600.

Reliability of supply of adequate amounts of compliant water under this alternative should be good. Huber Garden Estates has a well field with adequate capacity. From Huber Garden Estates' perspective, 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 Huber Garden Estates currently operates pumps.

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

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

This alternative involves the purchase of treated surface water from the City of Odessa, which will be used to supply the Huber Garden Estates PWS. The City of Odessa currently has sufficient excess capacity for this alternative to be feasible and they have indicated that they 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 of nitrate (less than 1 mg/L), which is low enough to make blending a realistic consideration. However, for this alternative, it is assumed that Huber Garden Estates would obtain all of its water from the City of Odessa.

This alternative would require the construction of a pipeline along Highway 385 in the City of Odessa and then west on West Yukon Road to the existing storage tank for the Huber Garden Estates system. A pump station would also be required to overcome pipe friction and the elevation differences between Odessa and Huber Garden Estates. The required pipeline would be approximately 5.8 miles long, and be constructed of 4-inch PVC pipe.

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 Huber Garden Estates, since the incremental cost would be relatively small, and it would provide operational flexibility.

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

The estimated capital cost for this alternative includes the cost to construct 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 Huber Garden Estates 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 $1.45 million, and the alternatives’ estimated annual O&M cost is $10,200.

Reliability of supply 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 Huber Garden Estates’ perspective, 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 dependant on an agreement being reached with the City of Odessa to purchase treated drinking water.

4.5.4 Alternative HG-4: Purchase Groundwater from Midland International Airport

This alternative consists of drilling a new well in the Midland International Airport area that would replace Huber Garden Estates' wells. Records indicate nitrate levels have been in a range of 4 to 6 mg/L in the Midland International Airport wells, which is not low enough to provide a high confidence level that blending will be possible. As a result, for this alternative, it is assumed that Huber Garden Estates would obtain all of its water from the new well.

This alternative would require the drilling of a new well and installation of a well pump, small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Huber Garden Estates system. One of the two pumps in the pump station is for backup in case the other pump fails. The pipeline, approximately 14.2 miles long, would primarily follow West then East Yukon Road, then Loop 588 to Copper Street, then north on County Road 1788 to the airport. The pipeline would be a 4-inch PVC line that discharges to the existing storage tank in Huber Garden Estates.

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 the cost to construct a new well and small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Huber Garden Estates system. The estimated O&M cost for this alternative includes additional costs related to taking the existing well field out of service, 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 $3.30 million, and the estimated annual O&M cost for this alternative is $18,500.

Reliability of supply of adequate amounts of compliant water under this alternative should be good. Huber Garden Estates has a well field with adequate capacity. From Huber Garden Estates' perspective, 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 Huber Garden Estates currently operates pumps.

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

4.5.5 Alternative HG-5: Purchase Treated Water from the City of Midland

This alternative involves the purchase of treated water from the City of Midland, which will be used to supply the Huber Garden 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 through annexation. 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 Huber Garden Estates would obtain all of its water from the City of Midland.

This alternative would require the construction of a pipeline from the City of Midland along State Highway 191 to Loop 588 then East and West Yukon Road to the existing storage tank for the Huber Garden Estates system. A pump station would also be required to overcome pipe friction and the elevation differences between Midland and Huber Garden Estates. The required pipeline would be approximately 17 miles long, and be constructed of 4-inch PVC pipe.

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 Huber Garden Estates, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative involves by definition regionalization, since Huber Garden Estates would be obtaining drinking water from an existing larger supplier. Also, other PWSs near Huber Garden Estates are in need of compliant drinking water and could share in implementation of this alternative.

The estimated capital cost for this alternative includes the cost to construct 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 Huber Garden Estates 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 $3.75 million, and the alternatives' estimated annual O&M cost is $33,100.

Reliability of supply 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 Huber Garden Estates' perspective, 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 dependant on an agreement being reached with the City of Midland to purchase treated drinking water.

4.5.6 Alternative HG-6: Central RO Treatment

This system would continue to pump water from the Huber Garden Estates well field, 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 then 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 836 gpd when the system is operated at full flow.

This alternative consists of constructing the RO treatment plant near the existing Huber Garden Estates service pumps. The plant is composed of a 500 square foot building with a paved driveway; 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 chlorinated and stored in the new treated water tank prior to being pumped into the distribution system. The existing above-grade storage tank would continue to be used to accumulate feed water from the well field. The entire facility is fenced. 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 $592,100, and the estimated annual O&M cost is $62,000.

The reliability of adequate amounts 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.

4.5.7 Alternative HG-7: Central EDR Treatment

The system would continue to pump water from the Huber Garden Estates well field, and would treat the water through an EDR system prior to distribution. For this option, a fraction of the raw water would be treated by the EDR and then blended with the untreated stream to obtain compliant water and minimize the volume of the reject for disposal. It is estimated the EDR reject generation would be 360 gpd when the system is operated at full flow.

This alternative consists of constructing the EDR treatment plant near the existing Huber Garden Estates service pumps. The plant is composed of a 500 square foot building with a paved driveway; 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 reject water. The treated water would be chlorinated and stored in the new treated water tank prior to being pumped into the distribution system. The existing above-grade storage tank would continue to be used to accumulate feed water from the well field. The entire facility is fenced. 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 $805,200, and the estimated annual O&M cost is $59,100.

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.

4.5.8 Alternative HG-8: Point-of-Use Treatment

This alternative consists of the continued operation of the two existing Huber Garden Estates wells, plus treatment of water to be used for drinking or food preparation at the point of use to remove nitrate and 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 the installation of the POU treatment units in houses and other buildings that provide drinking or cooking water. Huber Garden Estates would be responsible for purchase and maintenance of the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. In houses, the most convenient point for installation of the treatment units is typically under the kitchen sink, with a separate tap installed for dispensing treated water. Installation of the treatment units in kitchens will require the entry of Huber Garden Estates or contract personnel into the houses of customers. As a result, the cooperation of customers will be important for success in implementation of this alternative. The treatment units could be installed so that they could be accessed without house entry, which would complicate the installation and increase costs.

POU reverse osmosis 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 a minimum volume of water (only that for human consumption) is treated. 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 the cost to purchase and install the POU treatment systems. The estimated O&M cost for this alternative includes the purchase and replacement of 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 $15,600. For the cost estimate, it is assumed that one POU treatment unit will be required for each of the 25 existing connections to the Huber Garden Estates system. 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.

Reliability of supply 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 Huber Garden Estates personnel are inexperienced in this type of work. From the perspective of Huber Garden Estates, this alternative would be characterized as more difficult to operate due to the in-home requirements.

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

4.5.9 Alternative HG-9: Point-of-Entry Treatment

This alternative consists of the continued operation of the two existing Huber Garden Estates wells, plus treatment of water as it enters residences to remove nitrate and arsenic. The purchase, installation, and maintenance of the treatment systems at the point of entry to a household would be necessary for this alternative. Blending is not an option in this case. RO POE treatment units would also be effective for reducing other potential contaminants such as TDS and sulfate.

This alternative would require the installation of the POE treatment units at houses and other buildings that provide drinking or cooking water. Huber Garden Estates would be responsible for purchase and maintenance of 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 will result from RO treatment will not cause damage. It may also be desirable to modify piping so that water for non-consumptive uses can be withdrawn upstream of the treatment unit. The POE treatment units will be installed outside of the houses, so that entry will not be necessary for O&M. Some cooperation from customers will 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. POE 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 cost to purchase and install the POE treatment systems. The estimated O&M cost for this alternative includes the purchase and replacement of filters and membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $288,800, and the estimated annual O&M cost for this alternative is $35,000. For the cost estimate, it is assumed that one POE treatment unit will be required for each of the 25 existing connections to the Huber Garden Estates system.

Reliability of supply 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 the customers for system installation, use, and maintenance, and compliant water is supplied to all taps within a house. Additionally, the O&M efforts required for the POE systems will be significant, and Huber Garden Estates personnel are inexperienced in this type of work. From the perspective of Huber Garden Estates, this alternative would be characterized as more difficult to operate due to the on-property requirements.

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

4.5.10 Alternative HG-10: New Well at 10 miles

This alternative consists of the installation of a new well within 10 miles of Huber Garden Estates that would produce compliant water in place of the water produced by the existing two wells. Blending is not considered to be an option since the new well is expected to be installed in the Antler Sands aquifer, which is characterized by relatively high nitrate concentrations, and would not be feasible for blending with the groundwater currently produced. 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. In order 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 the construction of a new 300-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 Huber Garden Estates system. 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 PVC line that discharges to the existing storage tank at Huber Garden Estates. 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 cost to install the well, and construct 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, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing well field. The estimated capital cost for this alternative is $2.34 million, and the estimated annual O&M cost for this alternative is $15,800.

Reliability of supply 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 Huber Garden Estates, this alternative would be similar to the existing system in terms of operation. Huber Garden Estates has experience with O&M of wells and pumps.

The feasibility of this alternative is dependant 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 that the alternate groundwater source will not be found on Huber Garden Estates controlled land, so landowner cooperation will be required.

4.5.11 Alternative HG-11: New Well at 5 miles

This alternative consists of the installation of a new well within 5 miles that would produce compliant water in place of the water produced by the Huber Garden Estates wells. Blending is not considered to be an option since the new well is expected to be installed in the Antler Sands aquifer, which is characterized by relatively high nitrate concentrations, and would not be feasible for blending with the groundwater currently produced. 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 the construction of a new 300-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 Huber Garden Estates system. 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 PVC line that discharges to the existing storage tank at Huber Garden Estates. 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 cost to install the well, and construct 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, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the Gilliland well field. The estimated capital cost for this alternative is $1.31 million, and the estimated annual O&M cost for this alternative is $12,000.

Reliability of supply 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 Huber Garden Estates, this alternative would be similar in terms of operation of the existing system. Huber Garden Estates has experience with O&M of wells and pumps.

The feasibility of this alternative is dependant 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 that the alternate groundwater source will not be found on Huber Garden Estates controlled land, so landowner cooperation will be required.

4.5.12 Alternative HG-12: New Well at 1 mile

This alternative consists of the installation of a new well within 1 mile that would produce compliant water in place of the water produced by the existing two wells. Blending is not considered to be an option since the new well is expected to be installed in the Antler Sands aquifer, which is characterized by relatively high nitrate concentrations, and would not be feasible for blending with the groundwater currently produced. 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 the construction of a new 300-foot well and a pipeline from the new well to the existing intake point for the Huber Garden Estates system. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 4-inch PVC line that discharges to the existing storage tank at Huber Garden Estates.

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, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the Gilliland well field. The estimated capital cost for this alternative is $268,600, and the estimated annual O&M cost for this alternative is $6,400 less than current costs.

Reliability of supply of adequate amounts of compliant water under this alternative should be good, since water wells and pipelines are commonly employed. From the perspective of Huber Garden Estates, this alternative would be similar in term of operation compared to the existing system. Huber Garden Estates has experience with O&M of wells.

The feasibility of this alternative is dependant 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 will not be found on Huber Garden Estates controlled land, so landowner cooperation may be required.

4.5.13 Alternative HG-13: Public Dispenser for Treated Drinking Water

This alternative consists of the continued operation of the existing two Huber Garden Estates wells, plus dispensing treated water for drinking and cooking at a publicly accessible location. Implementing this alternative would require the purchase and installation of a treatment unit where customers would be able to come and fill their own containers. This alternative also includes notifying the 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 are required to pickup 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.

Huber Garden Estates 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 in order to be effective.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes cost to purchase and install the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes the purchase and replacement of 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 $16,700.

Reliability of supply 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. Huber Garden Estates has not provided this type of service in the past. From the perspective of Huber Garden Estates, 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 dependant on the cooperation, willingness, or capability of other water supply entities.

4.5.14 Alternative HG-14: 100 Percent Bottled Water Delivery

This alternative consists of the continued operation of the existing two Huber Garden Estates 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 of the customers in the system. It is expected that Huber Garden Estates will find it most convenient and economical to contract a bottled water service. The bottle delivery program will have to be flexible enough to allow the 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 Huber Garden Estates customers.

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 $23,900, and the estimated annual O&M cost for this alternative is $67,500. For the cost estimate, it is assumed that each person requires 1 gallon of bottled water per day.

Reliability of supply 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 Huber Garden Estates.

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

4.5.15 Alternative HG-15: Public Dispenser for Trucked Drinking Water

This alternative consists of continued operation of the existing two Huber Garden Estates 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.

Huber Garden Estates would contract a trucked drinking water service 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 a great deal of 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 the construction of 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 $103,000, and the estimated annual O&M cost for this alternative is $14,800.

Reliability of supply 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. Huber Garden Estates has not provided this type of service in the past. From the perspective of Huber Garden Estates, 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.

4.5.16 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for Huber Garden Estates.

1 **Table 4.3 Summary of Compliance Alternatives for Huber Garden Estates**

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
HG-1	Canyon Dam MHP	Well, pump station, tank, and 1.7 mile pipeline.	$548,200	$9,900	$57,700	Good	N	Alternative assumes adequate amount of compliant water.
HG-2	DEFS-Caprock	Well, pump station, tank, and 3.4 mile pipeline.	$900,800	$11,600	$90,200	Good	N	Alternative assumes adequate amount of compliant water.
HG-3	City of Odessa	Pump station, tank, and 5.8 mile pipeline.	$1,447,000	$10,200	$136,300	Good	N	Alternative assumes the City of Odessa will provide adequate amount of compliant water.
HG-4	Midland Intern. Airport	Pump station, tank and 14.2 mile pipeline.	$3,300,800	$18,500	$306,300	Good	N	Alternative assumes the Midland Airport will provide adequate amount of compliant water.
HG-5	City of Midland	Pump station, tank and 17.1 mile pipeline.	$3,752,200	$33,100	$360,300	Good	N	Alternative assumes the City of Midland will provide adequate amount of compliant water.
HG-6	Central RO	One central reverse osmosis treatment unit and reject pond.	$592,100	$62,000	$113,600	Good	T, M	Costs could possibly be shared with other nearby small systems.
HG-7	Central EDR	One electrodialysis reversal treatment unit and reject pond.	$805,200	$59,100	$129,300	Good	T, M	Costs could possibly be shared with other nearby small systems.
HG-8	POU-RO	Small reverse osmosis treatment unit for each customer.	$16,500	$15,600	$17,100	Fair	T, M	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
HG-9	POE-RO	Small reverse osmosis treatment unit for each customer.	$288,800	$35,000	$60,200	Fair	T, M	All home taps compliant and less resident cooperation required.
HG-10	New well 10 miles	Well, pump station, tank, and 10 mile pipeline.	$2,341,700	$15,800	$220,000	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
HG-11	New well 5 miles	Well, pump station, tank, and 5 mile pipeline.	$1,307,700	$12,000	$126,000	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
HG-12	New well 1 mile	Well, pump station, tank, and 1 mile pipeline.	$268,600	$(6,400)	$17,000	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
HG-13	Dispenser	- Water treatment and dispenser unit	$11,600	$16,700	$17,700	Fair, interim method	T	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires a lot of effort by customers.

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
HG-14	100% Bottled	- Set up bottled water system	$23,900	$67,500	$69,600	Fair, interim method	M	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires customers to order and use. Management of program may be significant.
HG-15	Central Trucked	- Construct storage tank and dispenser - Purchase potable water truck	$103,000	$14,800	$23,800	Fair, interim method	M	INTERIM SOLUTION: 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 D
2 – 15-year return period and 6 percent interest

4.6 COST OF SERVICE AND FUNDING ANALYSIS

To evaluate the financial impact of implementing the compliance alternatives, a 30-year financial planning model was developed. This model can be found in Appendix D. The financial model is based on estimated cash flows, with and without implementation of the compliance alternatives. Data for such models are derived from established budgets, audited financial reports, published water tariffs, and consumption data.

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.

4.6.1 Financial Plan Development

4.6.1.1 Huber Garden Estates Financial Data

No separate financial data for the Huber Garden Estates water system are maintained by the system operator. Water usage does not constitute a separate monthly billing, but is included in the monthly rent for mobile home pads. Based on financial data and estimates provided by operators of other water systems serving mobile home parks, water usage cost per customer at Huber Garden Estates is estimated at $15/month. 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 on system expenditures for Huber Garden Estates were based on estimates and financial data provided by water system operators of similar mobile home parks.

4.6.1.2 Current Financial Condition

4.6.1.2.1 Cash Flow Needs

Based on estimates provided by the system operator, the current average annual water use by Huber Garden Estates residential customers is estimated to be $180, or less than 1.0 percent of annual household income of $31,152, as given in the 2000 Census. Because of the lack of financial data exclusively for the water system, it is difficult to determine exact cash flow needs. However, it is obvious the water usage revenues fall considerably short of expenditures with the system being subsidized by other revenues.

4.6.1.2.2 Ratio Analysis

Current Ratio

The Current Ratio for the Huber Garden Estates water system 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 due to lack of the necessary financial data to determine this ratio.

Operating Ratio = Negative

Because of the lack of complete separate financial data on expenses specifically related to the Huber Garden Estates water system, the Operating Ratio could not be accurately determined. However, the system's estimated operating revenues of approximately $4,500 are assumed to considerably less than its operating expenses. Thus, there is a negative operating ratio for this water system.

4.6.1.3 Financial Plan Results

Each compliance alternative for Huber Garden Estates 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 funding options, customer MHI compared to the state average determines the availability of subsidized loans. Since the MHI for customers of Huber Garden Estates was not available, county-wide data were used. Ector County, where the Huber Garden Estates water system is located, had an annual household income of $31,152 according to the 2000 U.S. Census compared to a statewide average of $39,927. Consequently, Huber Garden Estates would not qualify for an interest rate of 0 or 1 percent since county incomes are in excess of 70 percent of the state average.

Results of the financial impact analysis are provided in Table 4.4 and Figure 4.2. Figure 4.2 provides a bar chart that in terms of the yearly billing to an average customer (6,000 gallons/month consumption) shows the following:

- Current yearly billing, and
- Projected yearly billing including rate increases to maintain financial viability and also for implementing the various compliance alternatives.

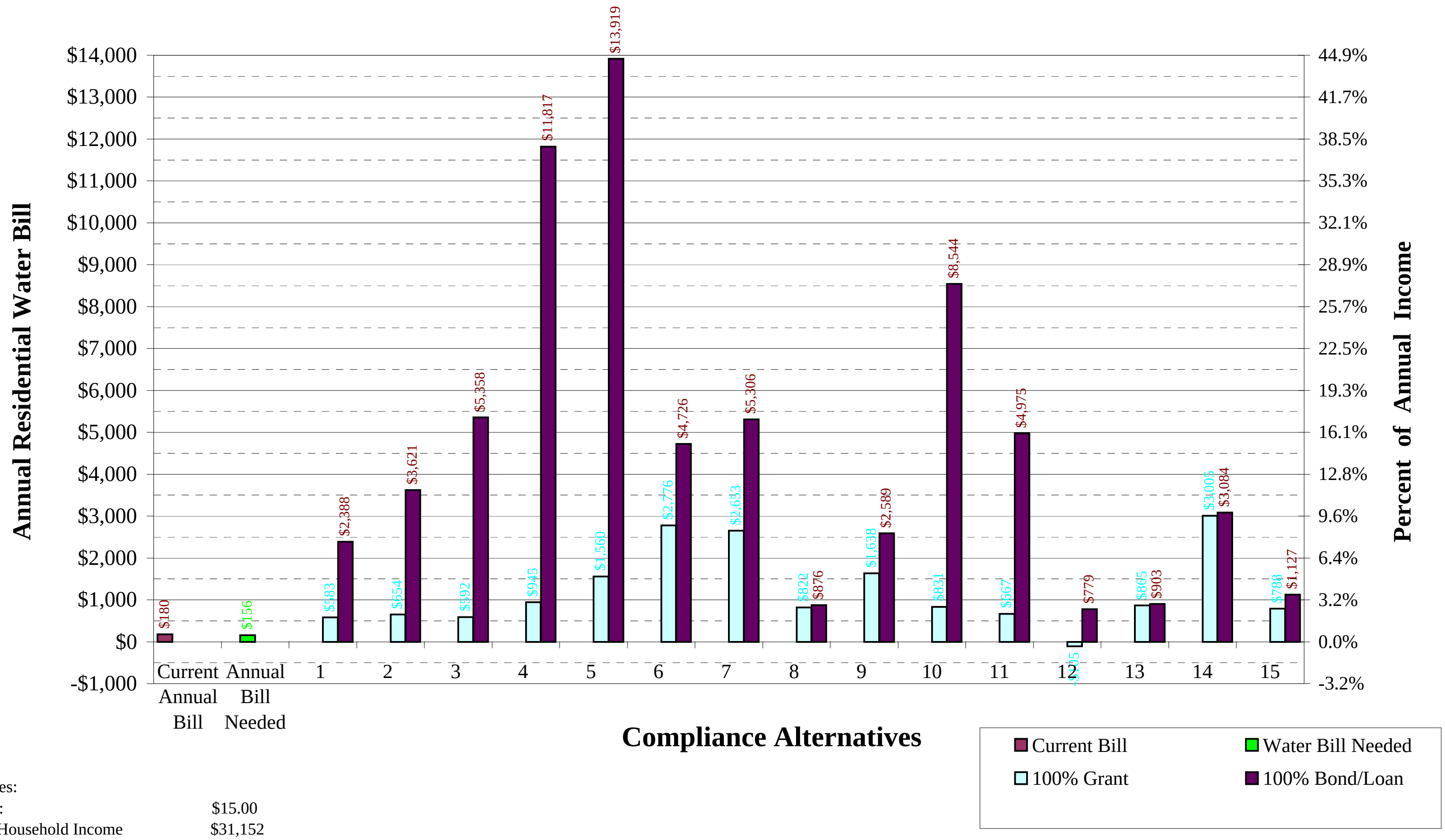
The two bars shown for each compliance alternative represent the maximum rate increases necessary assuming 100 percent grant funding and 100 percent loan/bond funding. Most funding options would fall between 100 percent grant and 100 percent loan/bond funding, with the exception of 100 percent revenue financing. If existing reserves are insufficient to fund a compliance alternative, rates would need to be raised before implementing the compliance alternative. This would allow the 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 Households for Huber Garden Estates

	Funding Source #	0	1	2	3	4	5
		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Loan/Bond
ALTERNATIVES							
HG-1	% of HH Income	76%	3%	6%	9%	13%	15%
	Rate Increase %	13064%	471%	972%	1474%	2235%	2477%
	Year	2005	2005	2005	2005	2005	2005
HG-2	% of HH Income	124%	4%	9%	13%	21%	23%
	Rate Increase %	21353%	550%	1374%	2198%	3449%	3847%
	Year	2005	2005	2005	2005	2005	2005
HG-3	% of HH Income	198%	3%	11%	19%	30%	34%
	Rate Increase %	34094%	481%	1805%	3129%	5137%	5777%
	Year	2005	2005	2005	2005	2005	2005
HG-4	% of HH Income	449%	6%	23%	41%	67%	75%
	Rate Increase %	77654%	873%	3893%	6913%	11494%	12953%
	Year	2005	2005	2005	2005	2005	2005
HG-5	% of HH Income	512%	10%	29%	49%	79%	89%
	Rate Increase %	88556%	1556%	4990%	8423%	13630%	15289%
	Year	2005	2005	2005	2005	2005	2005
HG-6	% of HH Income	89%	17%	21%	24%	28%	30%
	Rate Increase %	15310%	2907%	3449%	3991%	4813%	5074%
	Year	2005	2005	2005	2005	2005	2005
HG-7	% of HH Income	117%	17%	21%	25%	32%	34%
	Rate Increase %	20228%	2772%	3508%	4245%	5363%	5719%
	Year	2005	2005	2005	2005	2005	2005
HG-8	% of HH Income	5%	5%	5%	5%	5%	5%
	Rate Increase %	760%	737%	752%	767%	790%	797%
	Year	2005	2005	2005	2005	2005	2005
HG-9	% of HH Income	44%	10%	12%	13%	15%	16%
	Rate Increase %	7582%	1643%	1907%	2172%	2572%	2700%
	Year	2005	2005	2005	2005	2005	2005

	Funding Source #	0	1	2	3	4	5
		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Loan/Bond
ALTERNATIVES							
HG-10	% of HH Income	319%	5%	17%	30%	48%	54%
	Rate Increase %	55156%	747%	2889%	5032%	8282%	9317%
	Year	2005	2005	2005	2005	2005	2005
HG-11	% of HH Income	179%	4%	11%	18%	28%	31%
	Rate Increase %	30877%	565%	1761%	2958%	4773%	5351%
	Year	2005	2005	2005	2005	2005	2005
HG-12	% of HH Income	37%	1%	1%	3%	5%	5%
	Rate Increase %	6288%	6%	129%	351%	723%	842%
	Year	2005	2005	2005	2005	2005	2005
HG-13	% of HH Income	5%	5%	5%	5%	5%	5%
	Rate Increase %	785%	785%	795%	806%	822%	827%
	Year	2005	2005	2005	2005	2005	2005
HG-14	% of HH Income	19.0%	19.0%	191%	19%	19%	19%
	Rate Increase %	3162%	3162%	3184%	3206%	3240%	3250%
	Year	2005	2005	2005	2005	2005	2005
HG-15	% of HH Income	17%	5%	5%	6%	7%	7%
	Rate Increase %	2764%	699%	793%	887%	1030%	1076%
	Year	2005	2005	2005	2005	2005	2005

Figure 4-2 Alternative Cost Summary



Current Rates:

Monthly:	$15.00
Median Household Income	$31,152
Average Monthly Residential Usage	6,000 gallons

SECTION 5
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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:

B. Managerial Capacity Assessment Questions

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 on 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 PVC 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 include 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.

Electrical power cost is estimated to be $0.128 per kWH. 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 2005 dollars based on the 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 2005 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 2005 dollars based on the ENR construction cost index.

The purchase price for point-of-use (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 point-of-entry (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 a 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 each week, and that chlorine residual would be determined for each truck load.

Table B.1
Summary of General Data
Huber Garden Estates
PWS #0680163
General PWS Information

Service Population	75	**Number of Connections**	25
Total PWS Daily Water Usage	0.0075 (mgd)	**Source**	2005 Report

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	$ 30
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	$ 30
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	$ 40
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**
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
Electrical, RO	JOB	$ 50,000
Electrical, EDR	JOB	$ 50,000
Piping, RO	JOB	$ 20,000
Piping, EDR	JOB	$ 20,000
RO package	UNIT	$ 81,000
EDR package	UNIT	$ 238,000
Transfer pumps (5 hp)	EA	$ 5,000
Permeate Tank	GAL	$ 3.00
Backwash tank	GAL	$ 2.00
Mixer on tank	EA	$ 15,000
Salt feeder	EA	$ 20,000
Tank, 20,000 GAL	GAL	$ 1.00
Tank, 10,000 GAL	GAL	$ 1.50
Excavation	CYD	$ 3.00
Compacted fill	CYD	$ 7.00
Lining	SF	$ 0.50
Vegetation	SY	$ 1.00
Access road	LF	$ 30
Reject water haul truck	EA	$ 100,000
Building Power	kwh/yr	$ 0.128
Equipment power	kwh/yr	$ 0.128
Labor	hr	$ 40
RO Materials	year	$ 3,000
EDR Materials	year	$ 3,000
Chemicals, RO	year	$ 1,500
Chemicals, EDR	year	$ 1,500
Analyses	test	$ 200
Haul reject water	miles	1.0
Truck rental	day	$ 700
Mileage	mile	$ 1.00
Disposal fee	kgal	$ 5.00

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.15. 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.

Table C.1

PWS Name *Huber Garden Estates*
Alternative Name *New Well at Canyon Dam*
Alternative Number *HG-1*

Distance from PWS to new well location	1.72	miles
Estimated well depth	300	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	7	n/a	n/a	n/a
PVC water line, Class 200, 04"	9,095	LF	$ 26	$ 236,470
Bore and encasement, 10"	600	LF	$ 60	$ 36,000
Open cut and encasement, 10"	350	LF	$ 30	$ 10,500
Gate valve and box, 04"	2	EA	$ 340	$ 618
Air valve	2	EA	$ 1,000	$ 2,000
Flush valve	2	EA	$ 750	$ 1,364
Metal detectable tape	9,095	LF	$ 0.15	$ 1,364
Subtotal				**$ 288,317**
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	300	LF	$ 25	$ 7,500
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				**$ 28,500**
Subtotal of Component Costs				**$ 378,052**
Contingency	20%			$ 75,610
Design & Constr Management	25%			$ 94,513
TOTAL CAPITAL COSTS				**$ 548,175**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	1.7	mile	$ 200	$ 345
Subtotal				**$ 345**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	12,000	kWH	$ 0.128	$ 1,536
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 16,196**
Well O&M				
Pump power	288	kWH	$ 0.128	$ 37
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,637**
O&M Credit for Existing Well Closure				
Pump power	288	kWH	$ 0.128	$ (37)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,237)**
TOTAL ANNUAL O&M COSTS				**$ 9,941**

Table C.2

PWS Name *Huber Garden Estates*
Alternative Name *New Well at DEFS - Caprock & Weatherford*
Alternative Number *HG-2*

Distance from PWS to new well location	3.42	miles
Estimated well depth	300	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	3	n/a	n/a	n/a
PVC water line, Class 200, 04"	18,053	LF	$ 26	$ 469,378
Bore and encasement, 10"	800	LF	$ 60	$ 48,000
Open cut and encasement, 10"	150	LF	$ 30	$ 4,500
Gate valve and box, 04"	4	EA	$ 340	$ 1,228
Air valve	3	EA	$ 1,000	$ 3,000
Flush valve	4	EA	$ 750	$ 2,708
Metal detectable tape	18,053	LF	$ 0.15	$ 2,708
Subtotal				**$ 531,522**
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	300	LF	$ 25	$ 7,500
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				**$ 28,500**
Subtotal of Component Costs				**$ 621,257**
Contingency	20%			$ 124,251
Design & Constr Management	25%			$ 155,314
TOTAL CAPITAL COSTS				**$ 900,822**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	3.4	mile	$ 200	$ 684
Subtotal				**$ 684**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	22,550	kWH	$ 0.128	$ 2,886
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 17,547**
Well O&M				
Pump power	288	kWH	$ 0.128	$ 37
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,637**
O&M Credit for Existing Well Closure				
Pump power	288	kWH	$ 0.128	$ (37)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$(10,800)
Subtotal				**$(13,237)**
TOTAL ANNUAL O&M COSTS				**$ 11,631**

Table C.3

PWS Name *Huber Garden Estates*
Alternative Name *Purchase Water from City of Odessa*
Alternative Number *HG-3*

Distance from Alternative to PWS (along pipe)	5.8	miles
Total PWS annual water usage	2.738	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	6	n/a	n/a	n/a
Number of Crossings, open cut	43	n/a	n/a	n/a
PVC water line, Class 200, 04"	30,404	LF	$ 26.00	$ 790,504
Bore and encasement, 10"	1,200	LF	$ 60.00	$ 72,000
Open cut and encasement, 10"	2,150	LF	$ 30.00	$ 64,500
Gate valve and box, 04"	6	EA	$ 340.00	$ 2,067
Air valve	6	EA	$ 1,000.00	$ 6,000
Flush valve	6	EA	$ 750.00	$ 4,561
Metal detectable tape	30,404	LF	$ 0.15	$ 4,561
Subtotal				**$ 944,193**
Pump Station(s) Installation				
Pump	1	EA	$ 7,500	$ 7,500
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				**$ 53,735**
Subtotal of Component Costs				**$ 997,928**
Contingency	20%			$ 199,586
Design & Constr Management	25%			$ 249,482
TOTAL CAPITAL COSTS				**$ 1,446,995**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	5.8	mile	$ 200	$ 1,152
Subtotal				**$ 1,152**
Water Purchase Cost				
From Source	2,738	1,000 gal	$ 1.60	$ 4,380
Subtotal				**$ 4,380**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	25,050	kWH	$ 0.128	$ 3,206
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 17,867**
O&M Credit for Existing Well Closure				
Pump power	288	kWH	$ 0.128	$ (37)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$(10,800)
Subtotal				**$(13,237)**
TOTAL ANNUAL O&M COSTS				**$ 10,162**

Table C.4

PWS Name — ***Huber Garden Estates***
Alternative Name — ***New Well at Midland International Airport***
Alternative Number — ***HG-4***

Distance from PWS to new well location	14.25	miles
Estimated well depth	300	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	10	n/a	n/a	n/a
Number of Crossings, open cut	46	n/a	n/a	n/a
PVC water line, Class 200, 04"	75,230	LF	$ 26	$ 1,955,980
Bore and encasement, 10"	2,000	LF	$ 60	$ 120,000
Open cut and encasement, 10"	2,300	LF	$ 30	$ 69,000
Gate valve and box, 04"	15	EA	$ 340	$ 5,116
Air valve	14	EA	$ 1,000	$ 14,000
Flush valve	15	EA	$ 750	$ 11,285
Metal detectable tape	75,230	LF	$ 0.15	$ 11,285
Subtotal				**$ 2,186,665**
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	300	LF	$ 25	$ 7,500
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				**$ 28,500**
Subtotal of Component Costs				**$ 2,276,400**
Contingency	20%			$ 455,280
Design & Constr Management	25%			$ 569,100
TOTAL CAPITAL COSTS				**$ 3,300,779**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	14.2	mile	$ 200	$ 2,850
Subtotal				**$ 2,850**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.128	$ 1,510
Pump Power	59,650	kWH	$ 0.128	$ 7,635
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 22,296**
Well O&M				
Pump power	288	kWH	$ 0.128	$ 37
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,637**
O&M Credit for Existing Well Closure				
Pump power	288	kWH	$ 0.128	$ (37)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$(10,800)
Subtotal				**$(13,237)**
TOTAL ANNUAL O&M COSTS				**$ 18,545**

Table C.5

PWS Name *Huber Garden Estates*
Alternative Name *Purchase Water from City of Midland*
Alternative Number *HG-5*

Distance from Alternative to PWS (along pipe)	17.1	miles
Total PWS annual water usage	2.738	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	2	

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	11	n/a	n/a	n/a
PVC water line, Class 200, 04"	90,063	LF	$ 26.00	$ 2,341,638
Bore and encasement, 10"	1,200	LF	$ 60.00	$ 72,000
Open cut and encasement, 10"	550	LF	$ 30.00	$ 16,500
Gate valve and box, 04"	18	EA	$ 340.00	$ 6,124
Air valve	17	EA	$ 1,000.00	$ 17,000
Flush valve	18	EA	$ 750.00	$ 13,509
Metal detectable tape	90,063	LF	$ 0.15	$ 13,509
Subtotal				**$ 2,480,281**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	2	EA	$ 4,000	$ 8,000
Gate valve, 04"	8	EA	$ 370	$ 2,960
Check valve, 04"	4	EA	$ 430	$ 1,720
Electrical/Instrumentation	2	EA	$ 10,000	$ 20,000
Site work	2	EA	$ 2,000	$ 4,000
Building pad	2	EA	$ 4,000	$ 8,000
Pump Building	2	EA	$ 10,000	$ 20,000
Fence	2	EA	$ 5,870	$ 11,740
Tools	2	EA	$ 1,000	$ 2,000
Storage Tank - 5,000 gals	2	EA	$ 7,025	$ 14,050
Subtotal				**$ 107,470**
Subtotal of Component Costs				**$ 2,587,751**
Contingency	20%			$ 517,550
Design & Constr Management	25%			$ 646,938
TOTAL CAPITAL COSTS				**$ 3,752,239**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	17.1	mile	$ 200	$ 3,411
Subtotal				**$ 3,411**
Water Purchase Cost				
From Source	2,738	1,000 g	$ 1.65	$ 4,517
Subtotal				**$ 4,517**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.128	$ 3,021
Pump Power	71,350	kWH	$ 0.128	$ 9,133
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 30	$ 21,900
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 38,454**
O&M Credit for Existing Well Closure				
Pump power	288	kWH	$ 0.128	$ (37)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$(10,800)
Subtotal				**$(13,237)**
TOTAL ANNUAL O&M COSTS				**$ 33,145**

Table C.6

PWS Name *Huber Garden Estates*
Alternative Name *Central Treatment - RO*
Alternative Number *HG-6*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Central-RO				
Site preparation	0.5	acre	$ 4,000	$ 2,000
Slab	15	CY	$ 1,000	$ 15,000
Building	500	SF	$ 60	$ 30,000
Building electrical	500	SF	$ 8.00	$ 4,000
Building plumbing	500	SF	$ 8.00	$ 4,000
Heating and ventilation	500	SF	$ 7.00	$ 3,500
Fence	700	LF	$ 15	$ 10,500
Paving	2,000	SF	$ 2.00	$ 4,000
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
RO package including:				
High Pressure pumps-15 hp				
Cartridge filters & vessels				
RO membranes & vessels				
Control system				
Chemical feed systems				
Freight cost and startup services by vendor	1	UNIT	$ 81,000	$ 81,000
Transfer pumps (5 hp)	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				**$ 339,375**
Contingency	20%			67,875
Design & CM	25%			84,844
Reject water haul truck	1	EA	$ 100,000	$ 100,000
Total				**$ 592,094**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
Building Power	7,500	kwh/yr	$ 0.128	$ 960
Equipment power	3000	kwh/yr	$ 0.128	$ 384
Labor	1,000	hrs/yr	$ 40	$ 40,000
Materials	1	year	$ 3,000	$ 3,000
Chemicals	1	year	$ 1,500	$ 1,500
Analyses	24	test	$ 200	$ 4,800
Subtotal				**$ 50,644**
Backwash Disposal				
Mileage	10,000	miles	$ 1.00	$ 10,000
Disposal fee	275	kgal/yr	$ 5.00	$ 1,375
Subtotal				**$ 11,375**
Total				**$ 62,019**

Table C.7

PWS Name *Huber Garden Estates*
Alternative Name *Central Treatment - EDR*
Alternative Number *HG-7*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Central-EDR				
Site preparation	0.5	acre	$ 4,000	$ 2,000
Slab	15	CY	$ 1,000	$ 15,000
Building	500	SF	$ 60	$ 30,000
Building electrical	500	SF	$ 8.00	$ 4,000
Building plumbing	500	SF	$ 8.00	$ 4,000
Heating and ventilation	500	SF	$ 7.00	$ 3,500
Fence	700	LF	$ 15	$ 10,500
Paving	2,000	SF	$ 2.00	$ 4,000
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 & concentrate pumps; Cartridge filters & vessels; EDR membrane stacks; Electrical module; Chemical feed systems; Freight cost & startup services by vendor	1	UNIT	$ 238,000	$ 238,000
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				**$ 486,375**
Contingency	20%			97,275
Design & CM	25%			121,594
Reject water haul truck	1	EA	$ 100,000	$ 100,000
Total				**$ 805,244**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
Building Power	7,500	kwh/yr	$ 0.128	$ 960
Equipment power	1800	kwh/yr	$ 0.128	$ 230
Labor	1,000	hrs/yr	$ 40	$ 40,000
Materials	1	year	$ 3,000	$ 3,000
Chemicals	1	year	$ 1,500	$ 1,500
Analyses	24	test	$ 200	$ 4,800
Subtotal				**$ 50,490**
Backwash Disposal				
Mileage	8000	miles	$ 1.00	$ 8,000
Disposal fee	126	kgal/yr	$ 5.00	$ 630
Subtotal				**$ 8,630**
Total				**$ 59,120**

Table C.8

PWS Name ***Huber Garden Estates***
Alternative Name ***Point-of-Use Treatment***
Alternative Number ***HG-8***

Number of Connections for POU Unit Installation 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 Costs

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	$ 30	$ 7,500
Subtotal				**$ 15,625**
TOTAL ANNUAL O&M COSTS				**$ 15,625**

Table C.9

PWS Name *Huber Garden Estates*
Alternative Name *Point-of-Entry Treatment*
Alternative Number *HG-9*

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 mater	25	EA	$ 1,000	$ 25,000
Contamina	25	EA	$ 100	$ 2,500
Program la	250	hrs	$ 30	$ 7,500
Subtotal				**$ 35,000**
TOTAL ANNUAL O&M COSTS				**$ 35,000**

Table C.10

PWS Name *Huber Garden Estates*
Alternative Name *New Well at 10 Miles*
Alternative Number *HG-10*

Distance from PWS to new well location	10.0	miles
Estimated well depth	300	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	7	n/a	n/a	n/a
Number of Crossings, open cut	26	n/a	n/a	n/a
PVC water line, Class 200, 04"	52,800	LF	$ 26	$ 1,372,800
Bore and encasement, 10"	1,400	LF	$ 60	$ 84,000
Open cut and encasement, 10"	1,300	LF	$ 30	$ 39,000
Gate valve and box, 04"	11	EA	$ 340	$ 3,590
Air valve	10	EA	$ 1,000	$ 10,000
Flush valve	11	EA	$ 750	$ 7,920
Metal detectable tape	52,800	LF	$ 0.15	$ 7,920
Subtotal				**$ 1,525,230**
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	300	LF	$ 25	$ 7,500
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				**$ 28,500**
Subtotal of Component Costs				**$ 1,614,965**
Contingency	20%			$ 322,993
Design & Constr Management	25%			$ 403,741
TOTAL CAPITAL COSTS				**$ 2,341,700**

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	45,160	kWH	$ 0.128	$ 5,780
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 20,441**
Well O&M				
Pump power	288	kWH	$ 0.128	$ 37
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,637**
O&M Credit for Existing Well Closure				
Pump power	288	kWH	$ 0.128	$ (37)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$(10,800)
Subtotal				**$(13,237)**
TOTAL ANNUAL O&M COSTS				**$ 15,841**

Table C.11

PWS Name *Huber Garden Estates*
Alternative Name *New Well at 5 Miles*
Alternative Number *HG-11*

Distance from PWS to new well location	5.0	miles
Estimated well depth	300	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	13	n/a	n/a	n/a
PVC water line, Class 200, 04"	26,400	LF	$ 26	$ 686,400
Bore and encasement, 10"	1,800	LF	$ 60	$ 108,000
Open cut and encasement, 10"	100	LF	$ 30	$ 3,000
Gate valve and box, 04"	5	EA	$ 340	$ 1,795
Air valve	5	EA	$ 1,000	$ 5,000
Flush valve	5	EA	$ 750	$ 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	300	LF	$ 25	$ 7,500
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				**$ 28,500**
Subtotal of Component Costs				**$ 901,850**
Contingency	20%			$ 180,370
Design & Constr Management	25%			$ 225,463
TOTAL CAPITAL COSTS				**$ 1,307,683**

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	22,580	kWH	$ 0.128	$ 2,890
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 17,551**
Well O&M				
Pump power	288	kWH	$ 0.128	$ 37
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,637**
O&M Credit for Existing Well Closure				
Pump power	288	kWH	$ 0.128	$ (37)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,237)**
TOTAL ANNUAL O&M COSTS				**$ 11,951**

Table C.12

PWS Name	***Huber Garden Estates***
Alternative Name	***New Well at 1 Mile***
Alternative Number	***HG-12***

Distance from PWS to new well location	1.0	miles
Estimated well depth	300	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	3	n/a	n/a	n/a
PVC water line, Class 200, 04"	5,280	LF	$ 26	$ 137,280
Bore and encasement, 10"	200	LF	$ 60	$ 12,000
Open cut and encasement, 10"	150	LF	$ 30	$ 4,500
Gate valve and box, 04"	1	EA	$ 340	$ 359
Air valve	1.00	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 792
Metal detectable tape	5,280	LF	$ 0.15	$ 792
Subtotal				**$ 156,723**
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	300	LF	$ 25	$ 7,500
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				**$ 28,500**
Subtotal of Component Costs				**$ 185,223**
Contingency	20%			$ 37,045
Design & Constr Management	25%			$ 46,306
TOTAL CAPITAL COSTS				**$ 268,573**

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	$ 30	$ -
Tank O&M	-	EA	$ 1,000	$ -
Subtotal				**$ -**
Well O&M				
Pump power	288	kWH	$ 0.128	$ 37
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,637**
O&M Credit for Existing Well Closure				
Pump power	288	kWH	$ 0.128	$ (37)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$(10,800)
Subtotal				**$(13,237)**
TOTAL ANNUAL O&M COSTS				**$ (6,400)**

Table C.13

PWS Name ***Huber Garden Estates***
Alternative Name ***Public Dispenser for Treated Drinking Water***
Alternative Number ***HG-13***

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 Manage	25%			$ 2,000
TOTAL CAPITAL COSTS				**11,600**

Annual Operations and Maintenance Costs

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 unit	52	EA	$ 100	$ 5,200
Sampling/reporting, 1 hr/day	365	HRS	$ 30	$ 10,950
Subtotal				**$ 16,650**
TOTAL ANNUAL O&M COSTS				**$ 16,650**

Table C.14

PWS Name ***Huber Garden Estates***
Alternative Name ***Supply Bottled Water to Population***
Alternative Number ***HG-14***

Service Population	75	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	27,375	gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Implementation				
Initial program set-up	500	hours	$ 40	$ 19,950
Subtotal				**$ 19,950**
Subtotal of Component Costs				**$ 19,950**
Contingency	20%			$ 3,990
TOTAL CAPITAL COSTS				**$ 23,940**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water purchase costs	27,375	gals	$ 1.60	$ 43,800
Program admin, 9 hrs/wk	468	hours	$ 40	$ 18,673
Program materials	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 67,473**
TOTAL ANNUAL O&M COSTS				**$ 67,473**

Table C.15

PWS Name ***Huber Garden Estates***
Alternative Name ***Central Trucked Drinking Water***
Alternative Number ***HG-15***

Service Population	75	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	27,375	gallons
Travel distance to compliant water source (roundtri	4	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 Managemen	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	$ 30	$ 6,240
Truck operation, 1 round trip/wk	208	miles	$ 1.00	$ 208
Water purchase	27	1,000 ga	$ 1.80	$ 49
Water testing, 1 test/wk	52	EA	$ 100	$ 5,200
Sampling/reporting, 2 hrs/wk	104	hrs	$ 30	$ 3,120
Subtotal				**$ 14,817**
TOTAL ANNUAL O&M COSTS				**$ 14,817**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Table D.1 Example Financial Model

Step 1

Water System: **Huber Garden Estates**

Step 2

Click Here to Update Verification and Raw

Water System	Huber Garden Estates
Alternative Description	Point-of-Use Treatment

Sum of Amount		Year	Funding Alternative
		2007	
Group	Type	100% Grant	Bond
Capital Expenditures	Capital Expenditures-Funded from Bonds	$ -	$ 16,500
	Capital Expenditures-Funded from Grants	$ 16,500	$ -
	Capital Expenditures-Funded from Revenue/Reserves	$ -	$ -
	Capital Expenditures-Funded from SRF Loans	$ -	$ -
Capital Expenditures Sum		$ 16,500	$ 16,500
Debt Service	Revenue Bonds	$ -	$ 1,291
	State Revolving Funds	$ -	$ -
Debt Service Sum		$ -	$ 1,291
Operating Expenditures	Chemicals, Treatment	$ 300	$ 300
	Contract Labor	$ 1,200	$ 1,200
	Repairs	$ 900	$ 900
	Supplies	$ 400	$ 400
	Utilities	$ 450	$ 450
	Maintenance	$ 650	$ 650
Operating Expenditures Sum		$ 3,900	$ 3,900
Residential Operating Reven	Residential Base Monthly Rate	$ 4,275	$ 4,275
	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

Location_Name	Huber Garden Estates
Alt_Desc	Point-of-Use Treatment

		Current_Year
Funding_Alt	Data	2007
100% Grant	Sum of Beginning_Cash_Bal	$ (125)
	Sum of Total_Expenditures	$ 20,400
	Sum of Total_Receipts	$ 20,775
	Sum of Net_Cash_Flow	$ 375
	Sum of Ending_Cash_Bal	$ 250
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ 500
	Sum of Total_Reqd_Resv	$ 500
	Sum of Net_Avail_Bal	$ (250)
	Sum of Add_Resv_Needed	$ (250)
	Sum of Rate_Inc_Needed	6%
	Sum of Percent_Rate_Increase	0%
Bond	Sum of Beginning_Cash_Bal	$ (125)
	Sum of Total_Expenditures	$ 21,691
	Sum of Total_Receipts	$ 20,775
	Sum of Net_Cash_Flow	$ (916)
	Sum of Ending_Cash_Bal	$ (1,041)
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ 500
	Sum of Total_Reqd_Resv	$ 500
	Sum of Net_Avail_Bal	$ (1,541)
	Sum of Add_Resv_Needed	$ (1,541)
	Sum of Rate_Inc_Needed	36%
	Sum of Percent_Rate_Increase	0%

APPENDIX E
GENERAL GEOCHEMISTRY FOR ARSENIC AND NITRATE

GENERAL ARSENIC GEOCHEMISTRY

On January 22, 2001 the 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 is 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 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.

GENERAL NITRATE GEOCHEMISTRY

Nitrate contamination occurs when nitrate-N concentrations exceed 10 mg/L nitrate-N (MCL for nitrate-N). Nitrate is negatively charged and behaves conservatively; *i.e.*, it does not sorb onto soil, volatilize, precipitate readily, *etc*. Natural sources of nitrate include fixed nitrogen by shrubs such as mesquite in rangeland settings. Nitrate concentrations in soil profiles in most rangeland settings in the Southern High Plains are generally low (Scanlon, *et al*. 2003; McMahon, *et al*. 2005). Conversion of rangeland to agriculture can result in nitrification of soil organic matter. Anthropogenic sources of nitrate include chemical and organic (manure) fertilizers, nitrogen fixation through growth of leguminous crops, and barnyard and septic tank effluent. Nitrogen isotopes have been used to distinguish these various sources; however, such a study has not been conducted in the Southern High Plains. Nitrogen profiles measured in soil in Dawson County indicated that nitrate concentrations in soil pore water were generally low to moderate (Scanlon, *et al*. 2003). The highest concentrations were found in irrigated areas because irrigation water contains higher nitrate concentrations than rain water and irrigation rates are low enough to result in evapoconcentration of nitrate in the soil.

APPENDIX REFERENCES

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