

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

**DEVILLA MOBILE HOME PARK WATER SYSTEM
PWS ID# 0680069**

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 Devilla Mobile Home PWS located in Ector County. Recent sample results from the Devilla Mobile Home Park PWS have 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 Devilla Mobile Home PWS is shown in Table ES.1.

Table ES.1
Devilla Mobile Home PWS
Basic System Information

Population served	56
Connections	23
Average daily flow rate	0.0056 million gallons per day (mgd)
Peak demand flow rate	11.8 gallons per minute
Water system peak capacity	0.15 mgd
Typical nitrate range	10 to 11 mg/L
Typical TDS range	1,200 to 1,500 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.

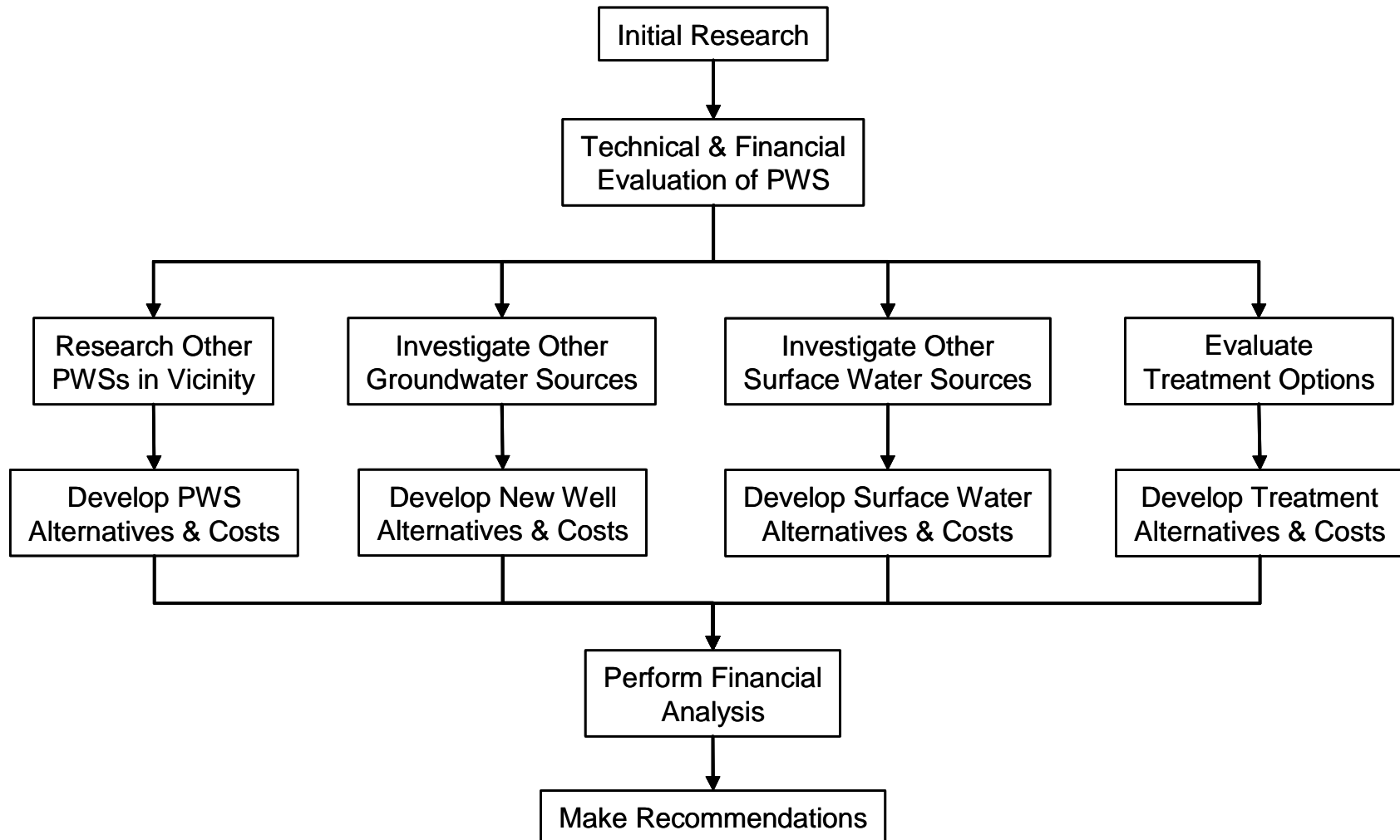
This basic approach is summarized in Figure ES-1.

HYDROGEOLOGICAL ANALYSIS

The Devilla Mobile Home PWS obtains groundwater from four wells completed in the Antler Sand aquifer. Nitrate and TDS are commonly found in area wells at concentrations greater than the MCLs. Conversion of rangeland to agriculture can result in nitrification of soil organic matter. Nitrate and TDS concentrations can vary significantly over relatively short distances; as a result, there could be good quality groundwater nearby. However, the variability of nitrate and TDS 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 water quality of

1
2

Figure ES-1
Summary of Project Methods



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

The Devilla Mobile Home Park PWS is owned and operated by one person and is maintained by contractors working for the owner. There are several PWSs within 20 miles of Devilla Mobile Home Park. Many of these nearby systems also have water quality issues, 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 removal have been developed and were considered for this report, for example, reverse osmosis and electrodialysis reversal 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 Devilla is likely to be the best solution if compliant groundwater can be found. Having a new well close to Devilla 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 Devilla Mobile Home PWS indicated that current water rates are estimated to be \$180 or 0.6 percent of the 2000 median household income (MHI) for Texas, which is \$39,927. Because there are no financial data exclusively for the water system, it is not possible 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	\$180	0.5
	Loan/Bond	\$849	2.1
Central treatment	100% Grant	\$4,785	12.0
	Loan/Bond	\$7,992	20.0
Point-of-use	100% Grant	\$1,260	3.2
	Loan/Bond	\$1,340	3.4
Public dispenser	100% Grant	\$1,429	3.6
	Loan/Bond	\$1,491	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
MBfR	Hollow-fiber membrane biofilm reactor
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
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
Devilla Mobile Home Park	Ector
Huber Garden Estates	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 Devilla Mobile Home Park water system, PWS ID# 0680069, located in Ector County. Recent sample results from the Devilla Mobile Home Park water system have exceeded the MCL for nitrate of 10 milligrams per liter (mg/L) (USEPA 2005a; TCEQ 2004a). Recent sample results from the PWS have also exceeded the drinking water standard for TDS of 1,000 milligrams per liter (mg/L) (USEPA 2005a; TCEQ 2004a). The location of the Devilla Mobile Home Park 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, Devilla Mobile Home Park water system has had recent sample results that exceed the MCL for nitrate. The health concerns related to drinking water above the MCL for nitrate 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).

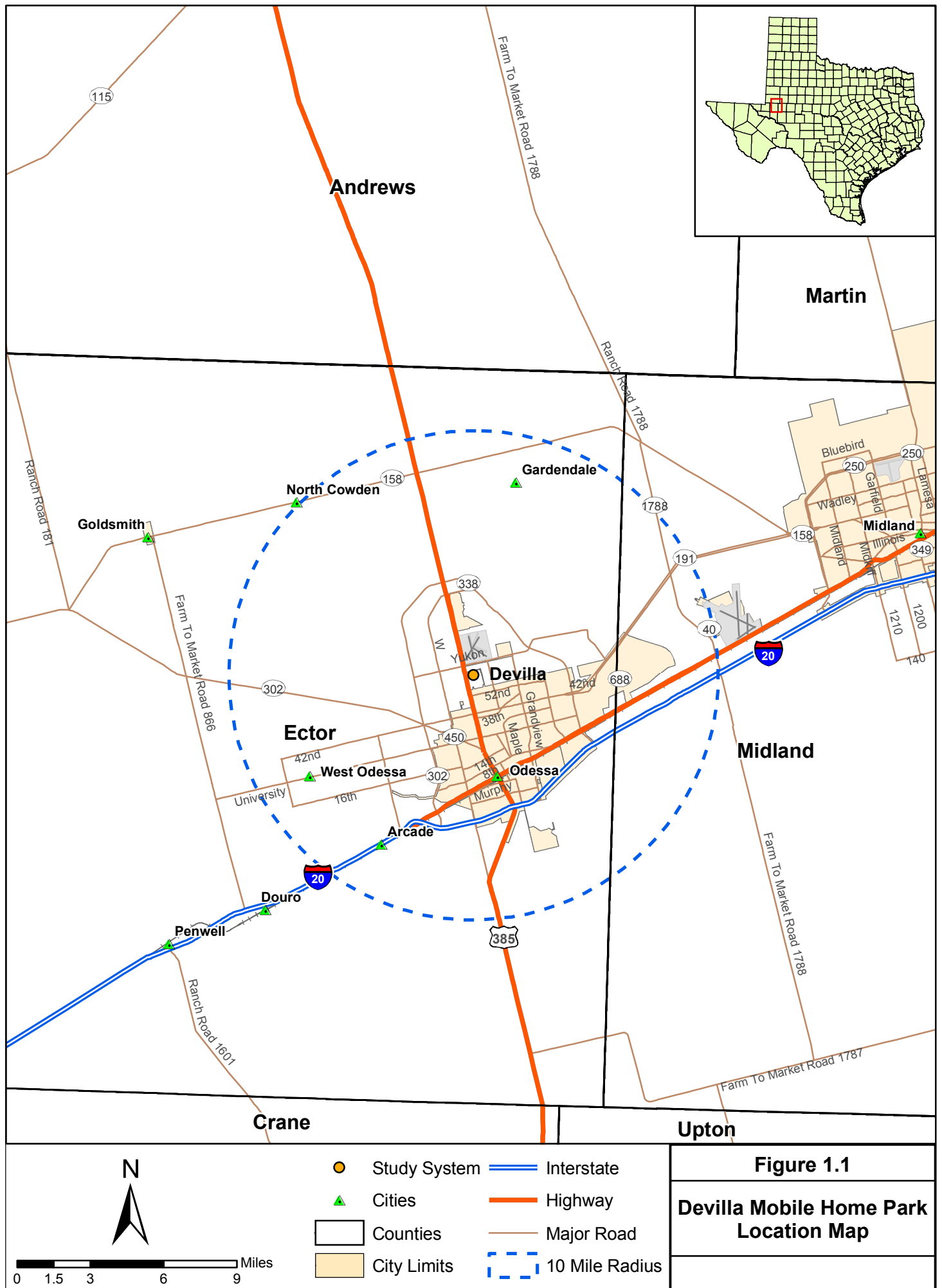


Figure 1.1
Devilla Mobile Home Park
Location Map

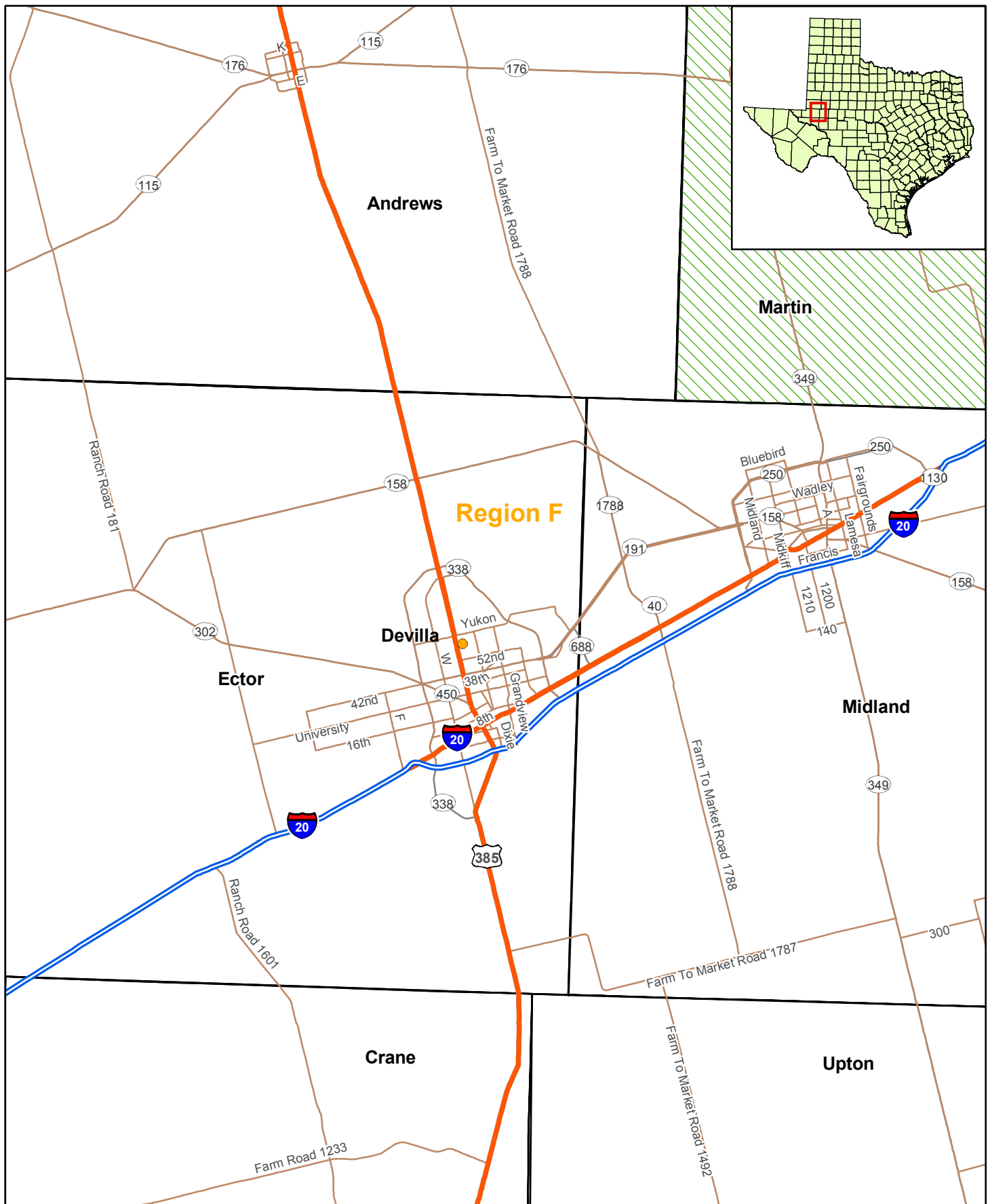


Figure 1.2

**Devilla
Groundwater Conservation
Districts and Planning Groups**

0 2 4 8 12 Miles

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 abatement options. Section 2 describes the methodology used to develop and assess compliance alternatives. The groundwater sources of nitrate are addressed in Section 3. Findings for the Devilla Mobile Home Park 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 Devilla Mobile Home Park PWS involve nitrate. 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 in the area:
 - 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);
- 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 for Nitrates

Various treatment technologies were also investigated as compliance alternatives for treatment of nitrate to its regulatory level (*i.e.*, MCL). 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 paragraphs. 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).

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).

1.4.5 Treatment Technologies Description

Reverse osmosis, IX, and EDR are identified by USEPA as BATs for removal of nitrates. RO and IX are also viable options for point-of-entry (POE) and point-of-use (POU) systems. A description of these technologies and three additional technologies for the removal of nitrate follows.

1.4.5.1 Reverse Osmosis

Process. 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 while NF has a lower nitrate 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.

Pre-treatment. 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 removal, a strong base anion exchange resin in the chloride form can remove 99 percent of the nitrate. Sulfate is a strong competing anion for nitrate adsorption by IX. Regeneration is accomplished with sodium chloride.

Pre-treatment. 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 removal.

Maintenance. 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.

Waste Disposal. 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 nitrate 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.

1.4.5.3 Electrodialysis Reversal

Process. EDR is an electrochemical process in which ions migrate through ion-selective semi-permeable membranes as a result of their attraction to two electrically charged electrodes. A typical EDR system includes a membrane stack with a number of cell pairs, each consisting of a cation transfer membrane, a demineralized flow spacer, an anion transfer membrane, and a concentrate flow spacer. Electrode compartments are at opposite ends of the stack. The influent feed water (chemically treated to prevent precipitation) and the concentrated reject flow in parallel across the membranes and through the demineralized and concentrate flow 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 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 (°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 and TDS.

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 remains 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.

1.4.5.5 Heterotrophic Biological Reduction

Heterotrophic biological reduction (HBR) is the conversion of nitrogen-containing compounds in water, such as nitrate, nitrite, and ammonia, to one or more of the gaseous compounds: nitrogen, nitric oxide, or nitrous oxide. Heterotrophic facultative microorganisms perform this biochemical conversion using an energy source (typically some form of organic carbon) under anoxic conditions to reduce the nitrogen atom from

any of its oxidized states to its reduced states, especially to its most stable form in nature, nitrogen gas.

Since nitrate contamination of groundwater became an increasing concern, several biological denitrification processes were evaluated in the 1990s for commercialization. The BioDen™ process was commercialized when it was first used on a small well system in Coyle, Oklahoma, in December 1998 with a capacity of 150 cubic meters per day (m³/day). The process operated for 2 years before another groundwater well was completed and the system was shut down. Nitrate removals were reported to be between 50 and 90 percent.

Process/control improvements consistently produced 65 percent removals in subsequent pilot and demonstration tests where influent concentrations were on the order of 15 to 20 mg/L. The carbon/nitrogen ratio is the key control parameter. Activation of the microorganisms requires 4 to 6 weeks to reach design capacity. Typically, only a portion of the total water supply is treated. The treated water is then blended with untreated water to achieve the desired concentration.

The biological denitrification process should be located inside a building for freeze protection, but otherwise no temperature control is required. Detention time for water in the reactors is approximately 30 to 60 minutes. Backflushing of the reactor is required periodically, and can be automated or performed manually. Backflushed wastewater can simply be discharged to sanitary sewers. No chemicals are required for the biological denitrification process other than the nutrients, which are primarily a carbon source (food-grade acetic acid works best) and phosphate. The Coyle, Oklahoma, plant used acetic acid as its carbon source.

Filtration of the biomass produced has been the major problem with the process. Slow sand filtration was used in the Coyle facility, which also provided some biodegradation of the biomass. For small systems, slow sand filtration may be adequate, but not for large, high flow systems. During pilot and demonstration tests in New York State, bag and cartridge filters, and ceramic and membrane MF were tested. Bag and cartridge filtration was not successful, whereas MF was. The only drawbacks to membrane MF are periodic backflushing and chemical cleaning, as required by all other membrane processes.

Similar processes are common in wastewater treatment plants where both the microorganisms and the carbon source are already present in the wastewater. By contrast, biological denitrification processes have not been widely used in drinking water treatment because neither the microorganisms nor the carbon source are present in the raw water, and because the process has not been widely accepted for commercial implementation given the perception that cultivating bacteria in water is not an acceptable drinking water treatment technology. Due to the lack of commercial applications for this technology, it is not considered further in this report.

1.4.5.6 Hollow-Fiber Membrane Biofilm Reactor

Hollow-fiber membrane biofilm reactor (MBfR) is a relatively new technology, still in the developmental phase. Unlike RO, IX, EDR, and HBR, MBfR reduces nitrate, perchlorate, and other contaminants without creating waste streams or leaving donor residuals that require special handling. In commercial applications, MBfR is expected to cost substantially less than all these processes.

The MBfR contains hollow-fiber membranes that are potted at both ends of the cylindrical module. Hydrogen gas is fed into the bore of the hollow fiber; the raw water is on the outside of the hollow fiber. The hydrogen passively diffuses through the membranes to serve as an electron donor for the biofilm that grows on the outside of the hollow fibers. The hydrogen does not bubble into the water, but is used by the microorganisms in the biofilm. Hydrogen is an ideal electron donor in that it is nontoxic, inexpensive, and sparsely soluble in water.

The biofilm on the outside of the hollow fiber develops from the indigenous bacteria present in the groundwater, and is not artificially inoculated or amended. The microorganisms in the biofilm that reduce nitrate contaminants using hydrogen gas (H_2) as their electron donor ($H_2 = 2H^+ + 2e^-$) perform the following:



Initial use and development of MBfR was conducted at Northwestern University under the direction of Bruce Rittman beginning in 2000. During the two initial steady-state denitrification studies, the influent nitrate concentrations were 10 and 12.5 mg nitrate per liter. With a liquid retention time of 40 minutes, the desired partial removals of nitrate between 76 percent and 92 percent were achieved with effluent hydrogen concentrations as low as 9 $\mu g/L$. In February 2004, additional laboratory experiments with other groundwater demonstrated MBfR's ability to reduce nitrate from 19 mg/L to below the detection limit of 0.2 mg/L within the first 24 hours. Additional development work is on-going, and it is anticipated that additional work will confirm that the MBfR process will provide drinking water denitrification at costs 25 to 50 percent below those of IX or HBR, and 50 to 75 percent less than those of RO processes.

Owing to the lack of commercial application for this technology, it will be eliminated from further consideration. However, further development may make the technology viable in the future.

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 removal, these systems typically use small RO treatment units installed "under the sink" in the case of POU, and where water enters a residence or building in the case of POE. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive. POE

and POU treatment units would be purchased and owned by the PWS. These solutions are decentralized in nature, and require utility personnel to enter into houses or at least onto private property for installation, maintenance, and testing. Due to the 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

- 1 members of the susceptible population do not become known to the utility,
2 and do not take part in the water delivery program.
- 3 • Maintain customer privacy by eliminating the need for utility personnel to
4 enter the home.
 - 5 • Have buffer capacity (*e.g.*, two bottles in service, so that when one is
6 empty, the other is being used over a time period sufficient to allow the
7 utility to change out the empty bottle).
 - 8 • Provide for regularly scheduled delivery so that the customer would not
9 have to notify the utility when the supply is low.
 - 10 • Use utility personnel and equipment to handle water containers, without
11 requiring customers to lift or handle bottles with water in them.
 - 12 • Be sanitary (*e.g.*, where an outside connection is made, contaminants from
13 the environment must be eliminated).
 - 14 • Be vandal-resistant.
 - 15 • Avoid heating the water due to exterior temperatures and solar radiation.
 - 16 • 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.

Figure 2.1
TREE 1 – EXISTING FACILITY ANALYSIS

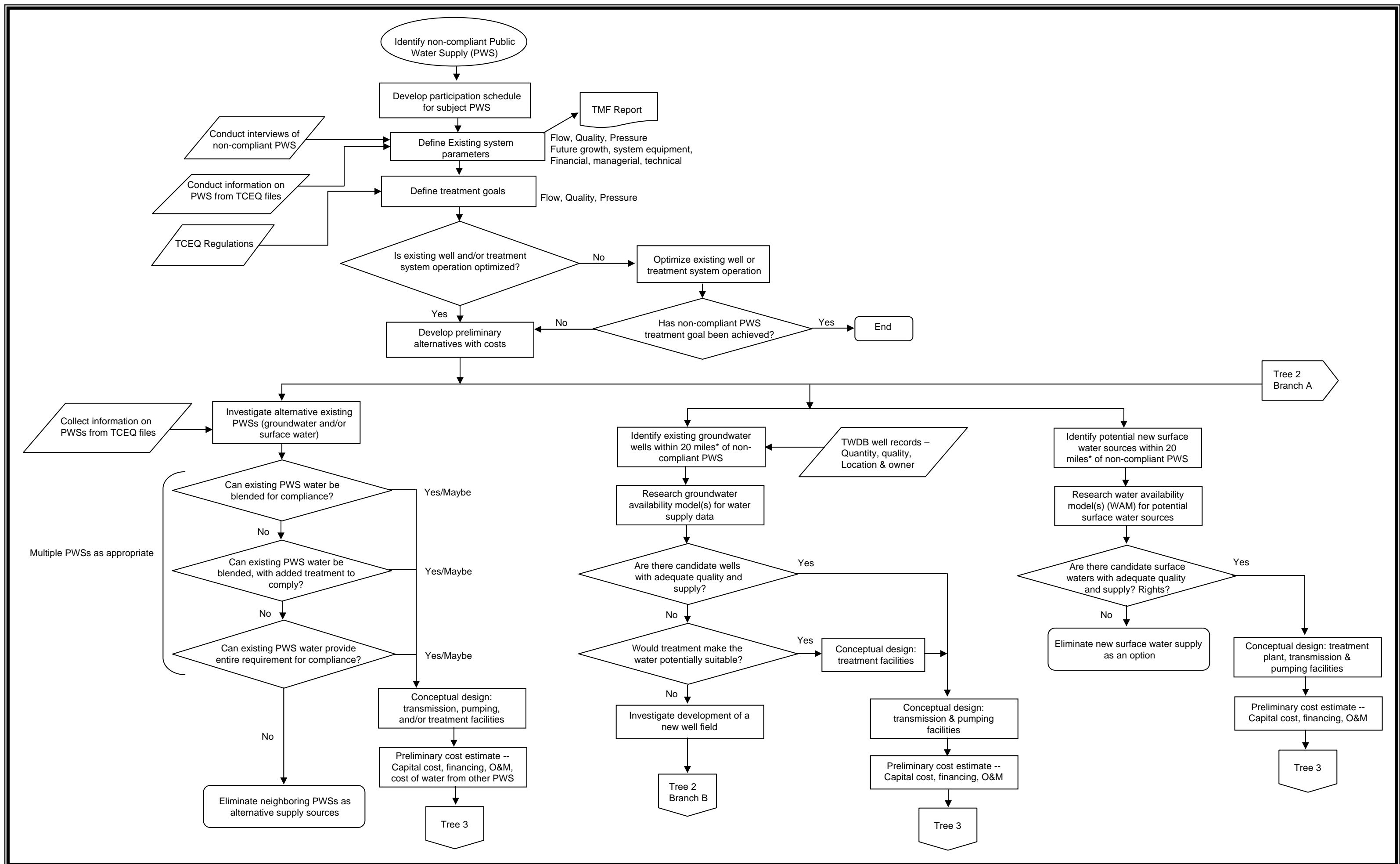


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATIVES

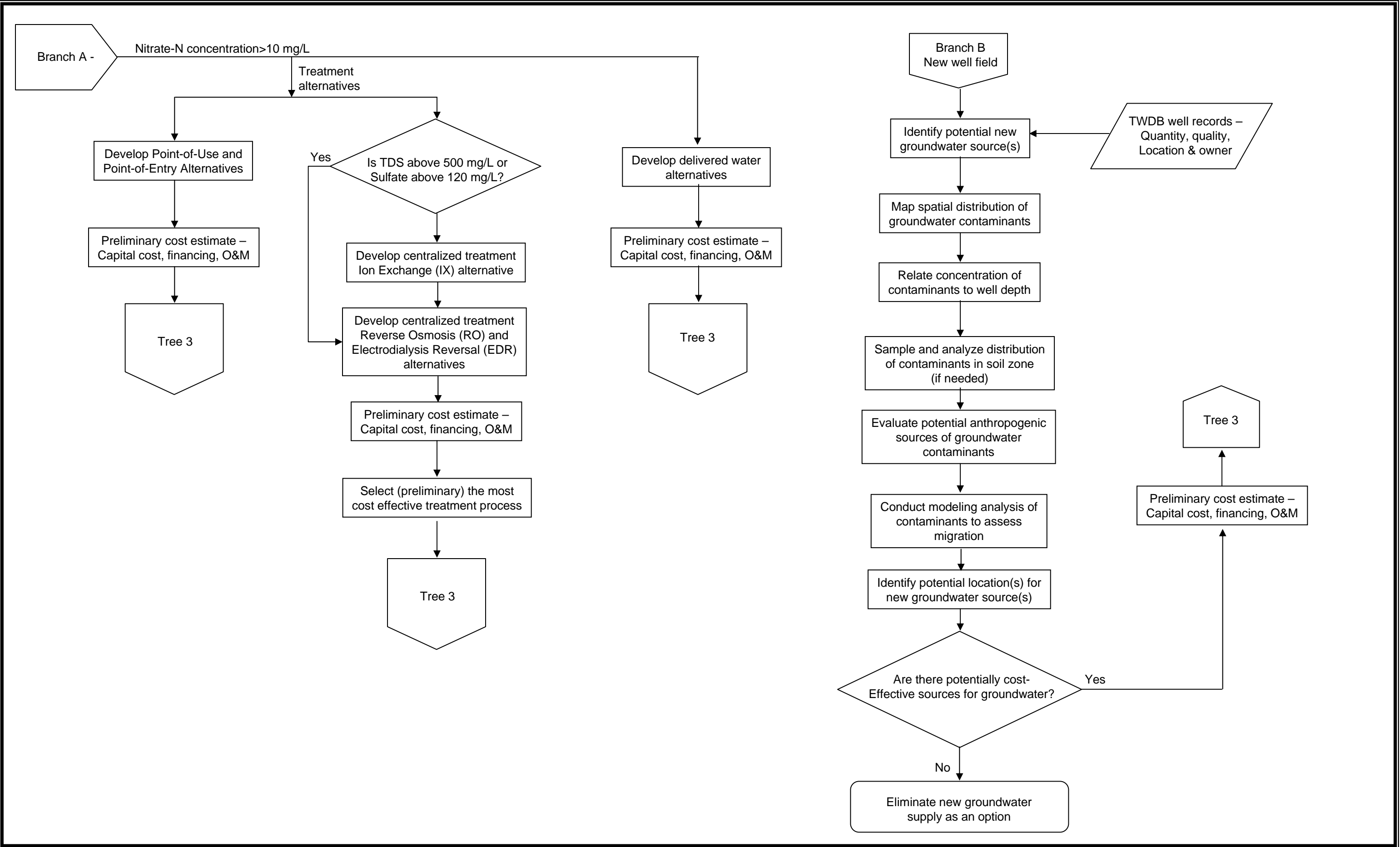


Figure 2.3

Tree 3 – PRELIMINARY ANALYSIS

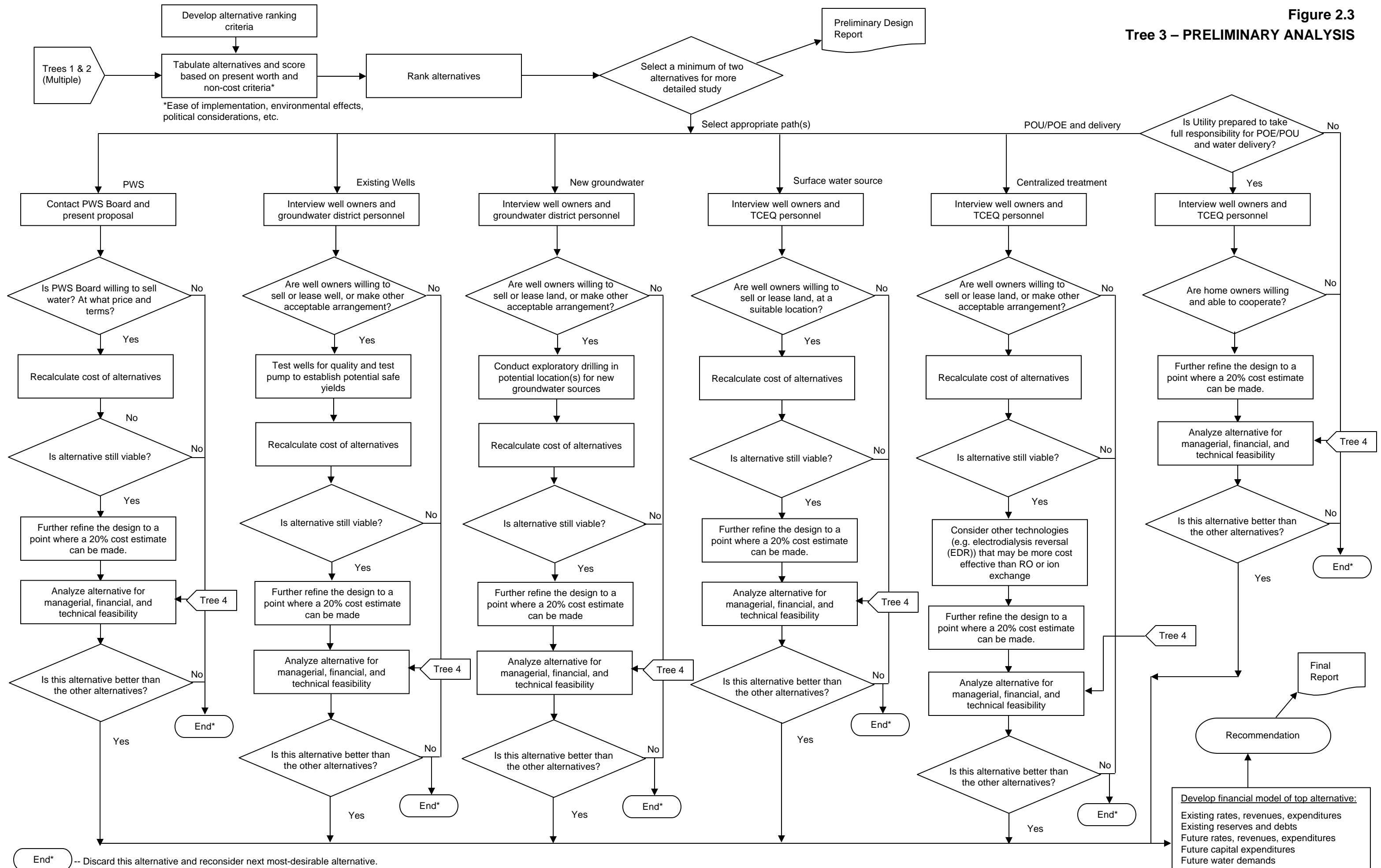
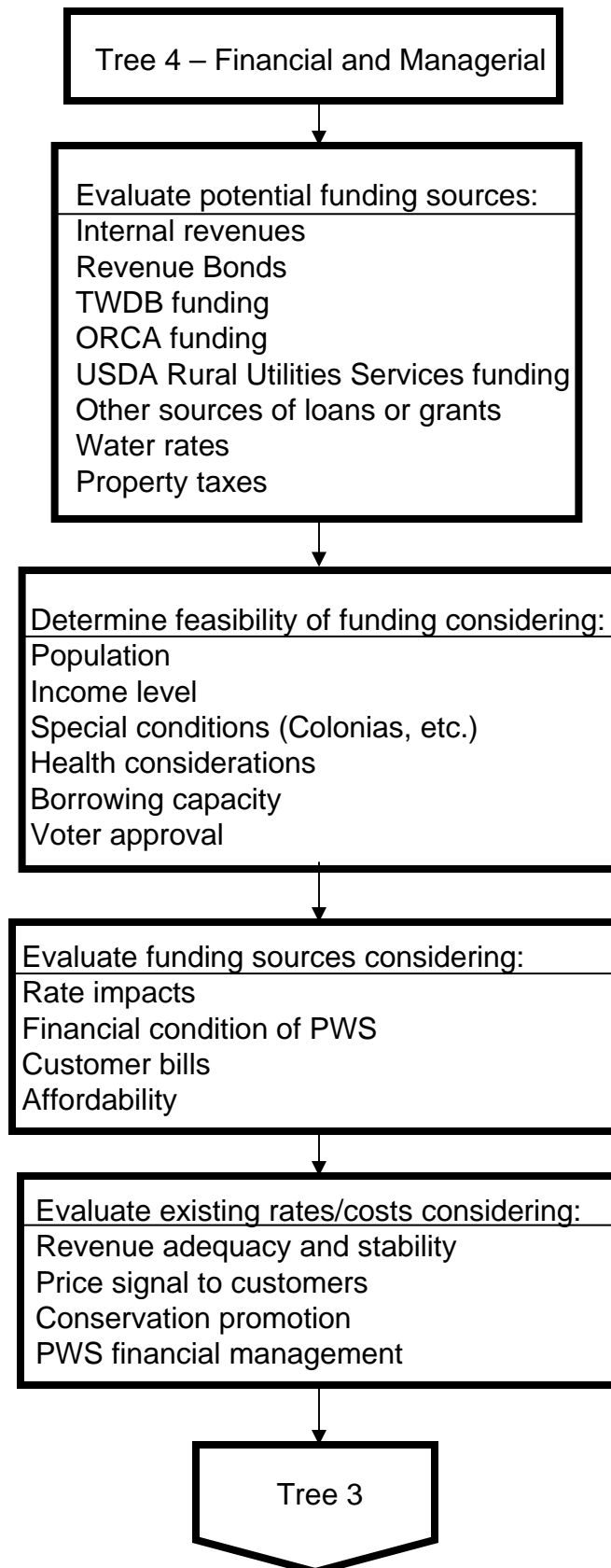


Figure 2.4
TREE 4 – FINANCIAL AND MANAGERIAL



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

2.2.1.5 Water Availability Model

The WAM is a computer-based simulation predicting the amount of water that would be in a river or stream under a specified set of conditions. WAMs are used to determine whether water would be available for a newly requested water right or amendment. If

water is available, these models estimate how often the applicant could count on water under various conditions (e.g., whether water would be available only 1 month out of the year, half the year, or all year, and whether that water would be available in a repeat of the drought of record).

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

2.2.1.6 Financial Data

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

- Annual Budget
- Audited Financial Statements
 - Balance Sheet
 - Income & 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 is to determine which items that were noted as a potential deficiency truly have a negative effect on the system’s operations. If a system has what appears to be a deficiency, but this deficiency is not creating a problem in terms of the operations or management of the system, it is not critical and may not need to be addressed as a high priority. As an example, the assessment may reveal that there appear to be insufficient staff members to operate the facility. However, it may also be revealed that the system is able to work around this problem by receiving assistance from a neighboring system so no severe problems result 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 their 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 Systems

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 20 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 nitrate removal are RO, IX, and EDR since they are proven technologies with numerous successful installations. However, all study systems with elevated nitrate 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, correspond 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 model 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.
- 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:

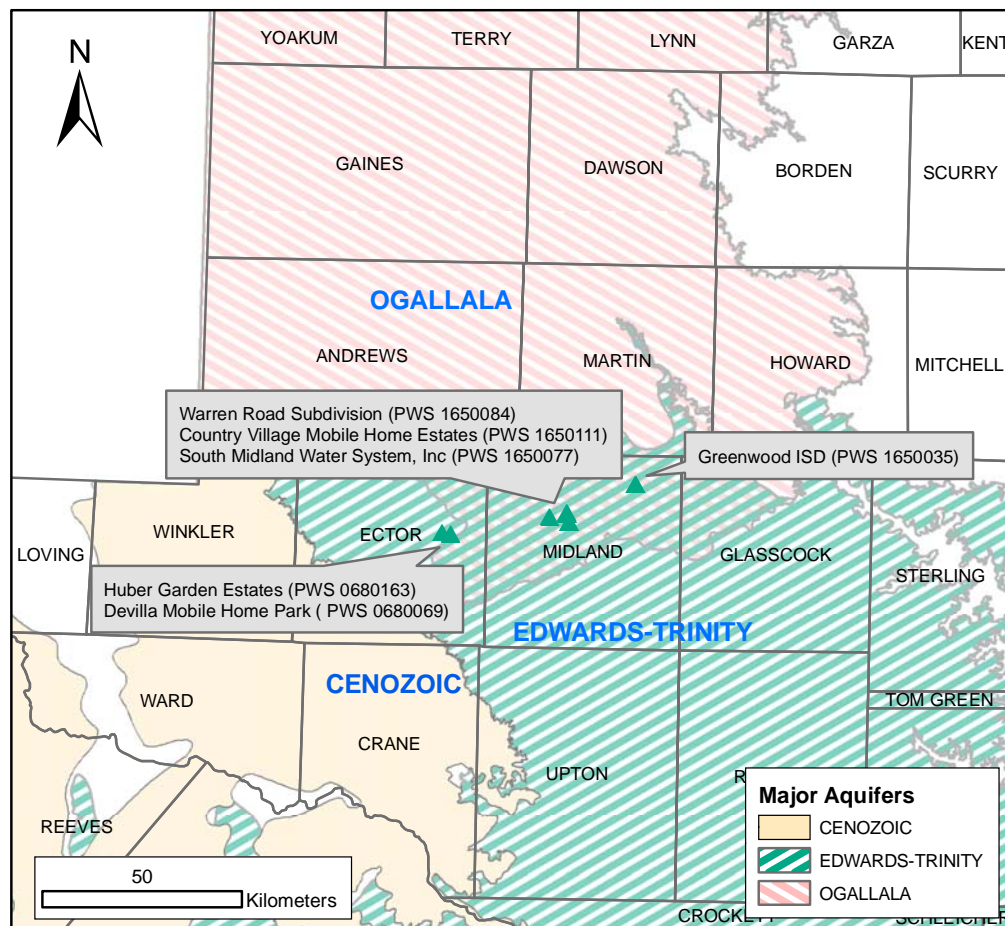
- United States Department of Agriculture, Rural Utilities Service, and
- United States Housing and Urban Development.

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.

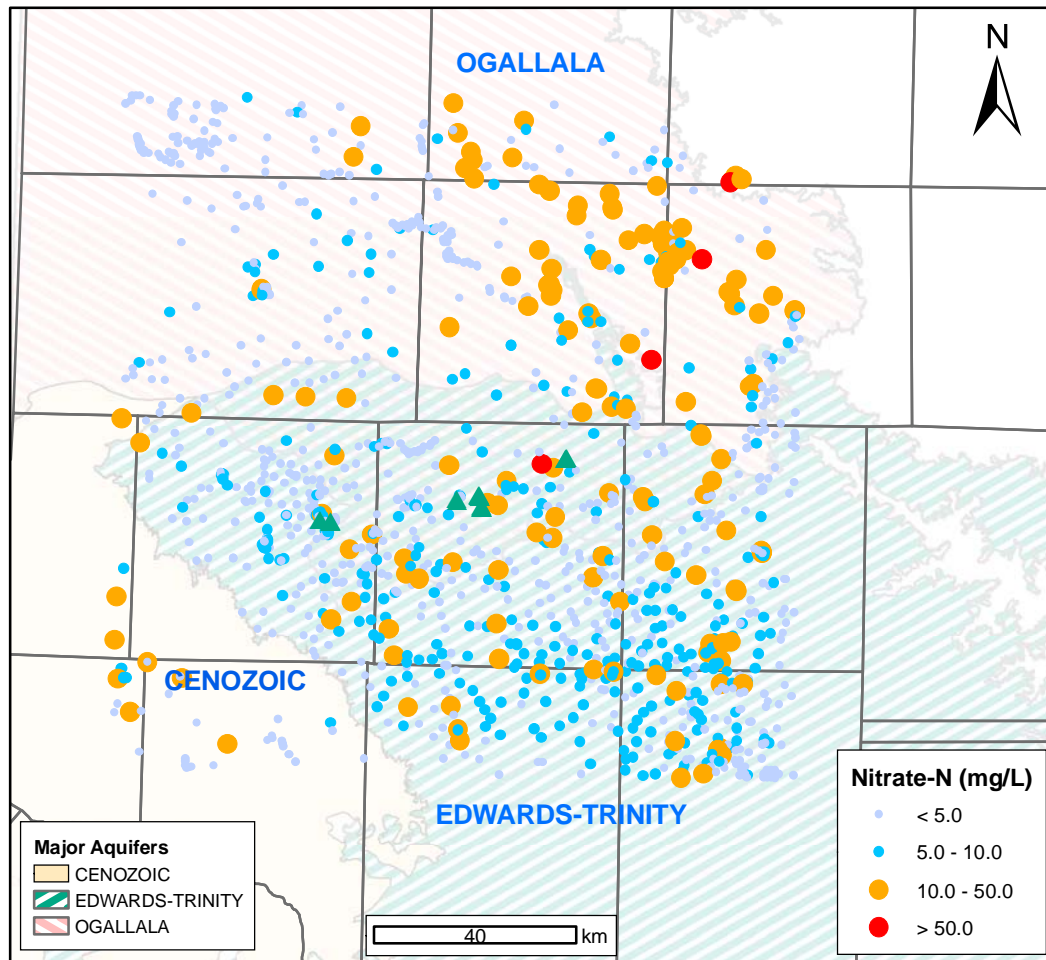
The Edwards Trinity (Plateau) aquifer underlies the Ogallala aquifer in Andrews, Martin, Ector, Midland, and Glasscock Counties and crops out south of this region. This aquifer consists predominantly of the Trinity Group (Early Cretaceous age) and includes the Antlers Sandstone in Ector and Midland Counties, 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

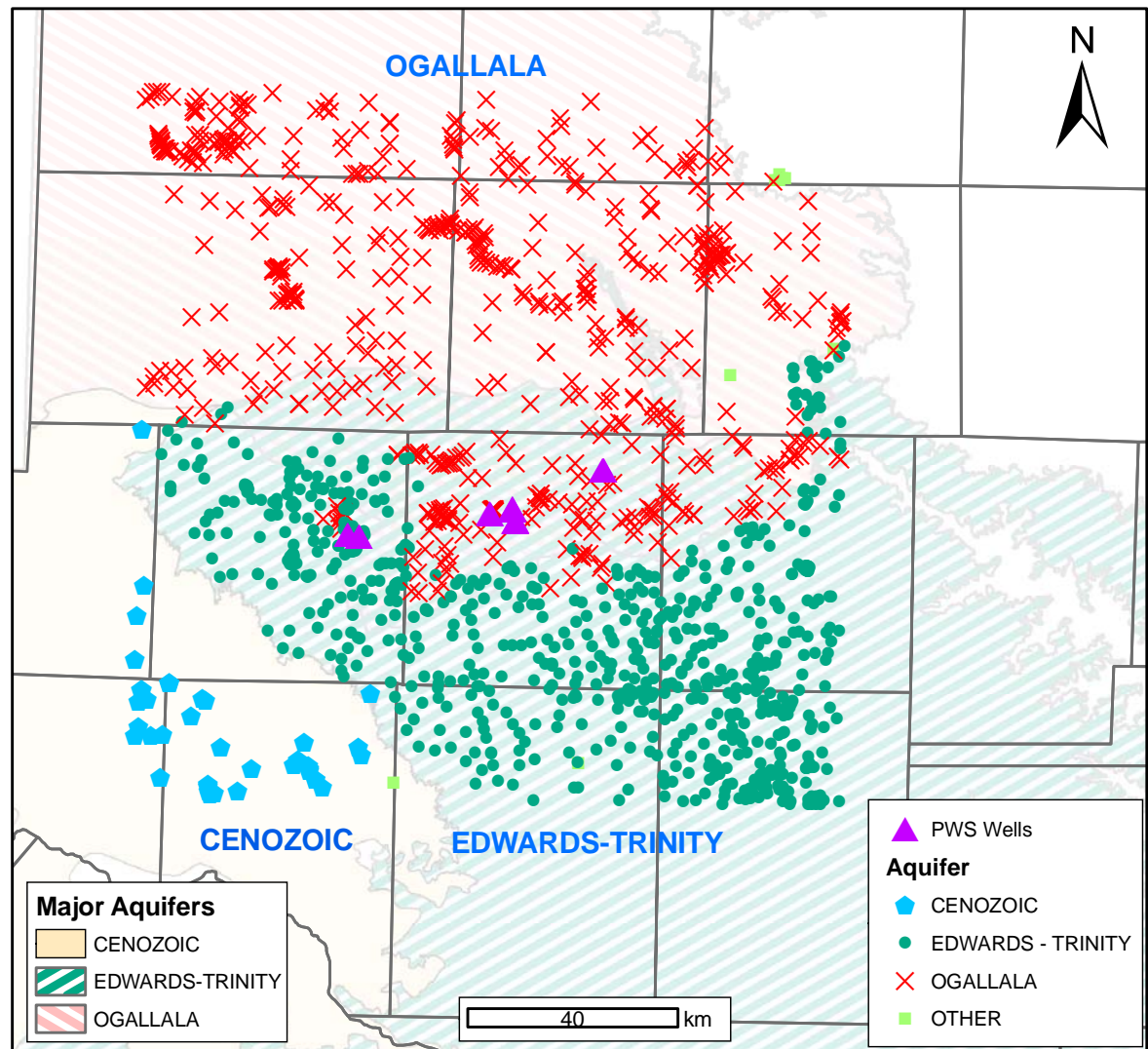
The geochemistry of nitrate is described in Appendix E. Nitrate trends in the vicinity of the assessed PWSs were examined to assess spatial trends, as well as correlations with other water quality parameters. Nitrate measurements are from the TWDB database. Figure 3.2 shows spatial distribution of nitrate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

1 **Figure 3.3 Wells with Nitrate Samples Categorized by Aquifer**



2

3 The above map (Figure 3.3) shows 1,410 wells that have nitrate measurements from

4 the TWDB database: 774 are in the Edwards Trinity (Plateau) aquifer, 584 in the

5 Ogallala aquifer, 43 in the CPA aquifer, and 9 in other aquifers. The distribution of

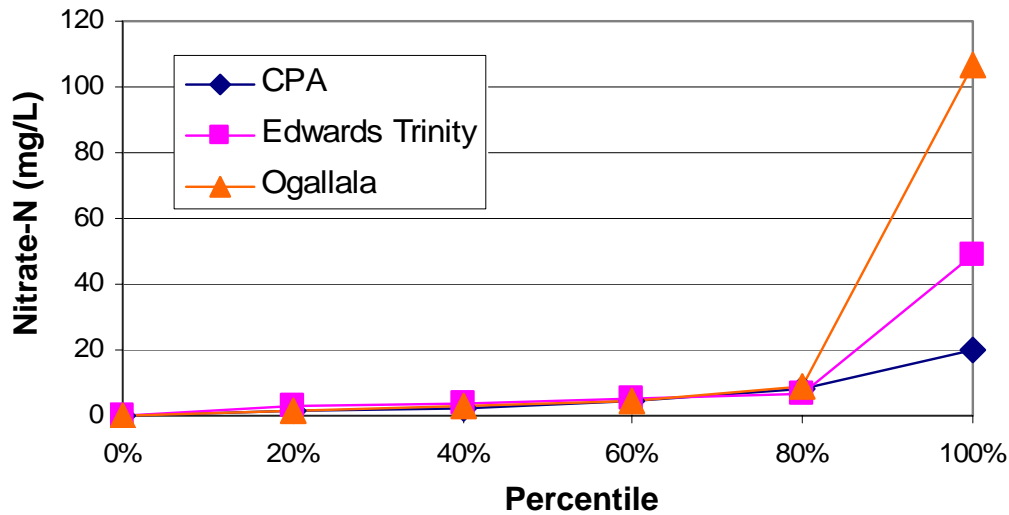
6 nitrate-N concentrations within the three aquifers (CPA, Edwards Trinity (Plateau), and

7 Ogallala) is similar (Figure 3.4). The similarity in nitrate-N levels among the aquifers

8 suggests the source of nitrate is not a particular geologic unit but probably anthropogenic

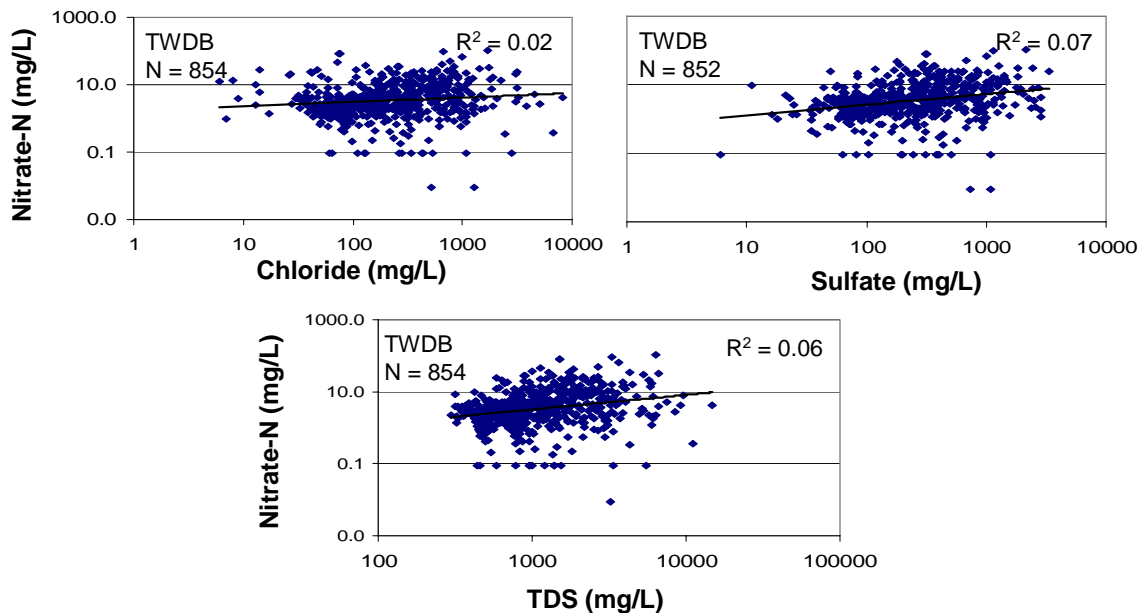
9 in origin.

Figure 3.4 Distribution of Nitrate-N Concentrations



Nitrate-N is not strongly related to general water quality parameters (sulfate, chloride, and total dissolved solids (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.

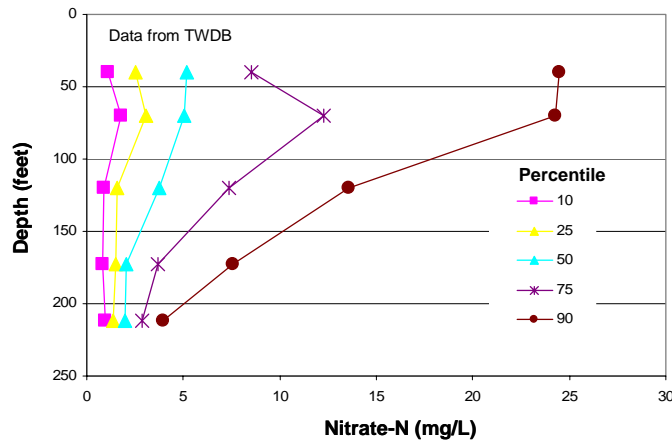
Figure 3.5 Correlation of Nitrate with Chloride, Sulfate, and TDS in the Ogallala Aquifer



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).

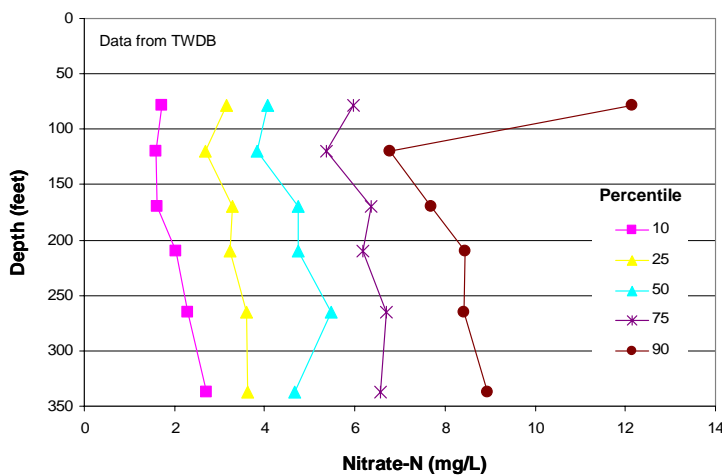
Figure 3.6 Relationship Between Nitrate-N Concentrations and Well Depth in the Ogallala Aquifer



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



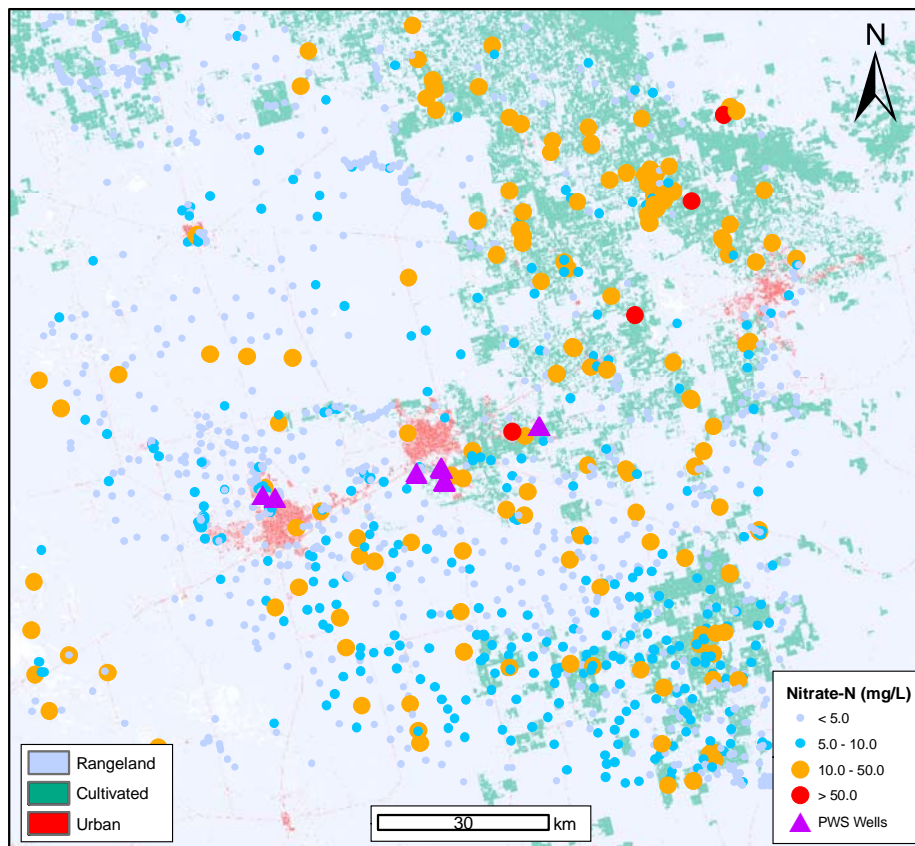
Depth range (feet)	Min. depth (feet)	Max. depth (feet)	Median depth (feet)	Num. of wells
< 100	37	99	79	77
100-150	100	149	120	170
150-200	150	197	170	143
200-250	200	248	211	106
250-300	250	297	265	72
> 300	300	495	337	116

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

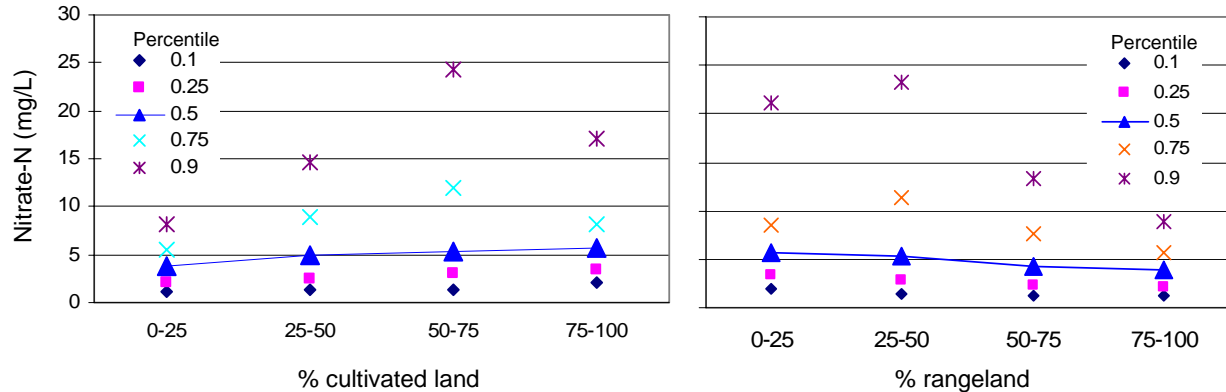
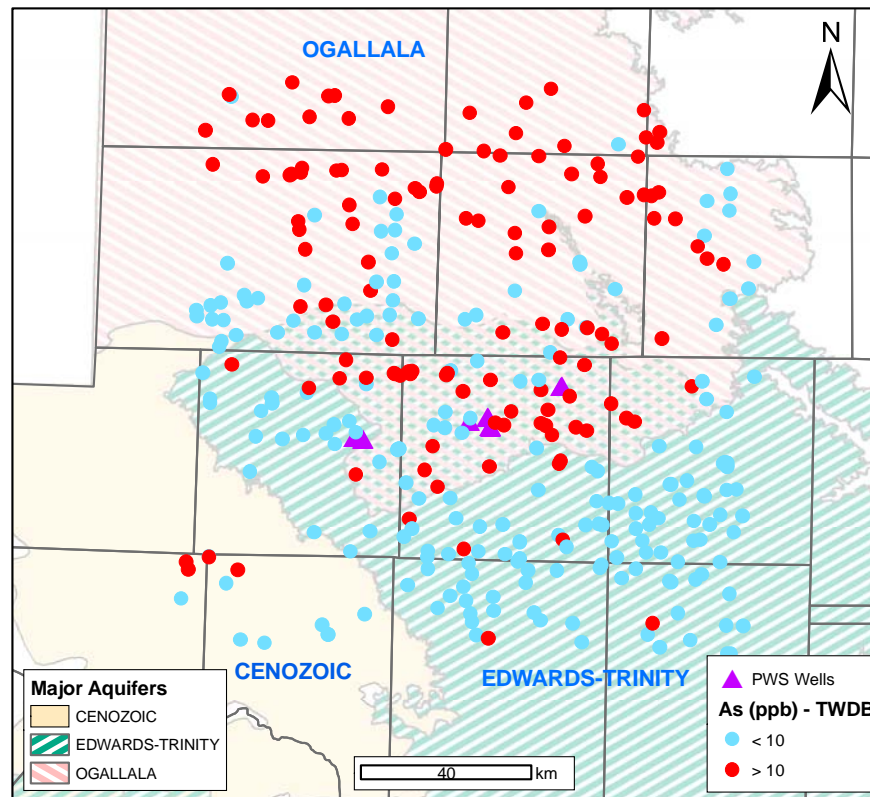


Figure 3.9 shows nitrate-N concentrations in groundwater in relation to land use within a 1-km radius of well locations. Land use was obtained from the NLCD and was categorized into the following land-use types: rangeland (NLCD codes 51, 71, 41, 42, and 43), cultivated (NLCD codes 81, 82, 83, and 61), 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.

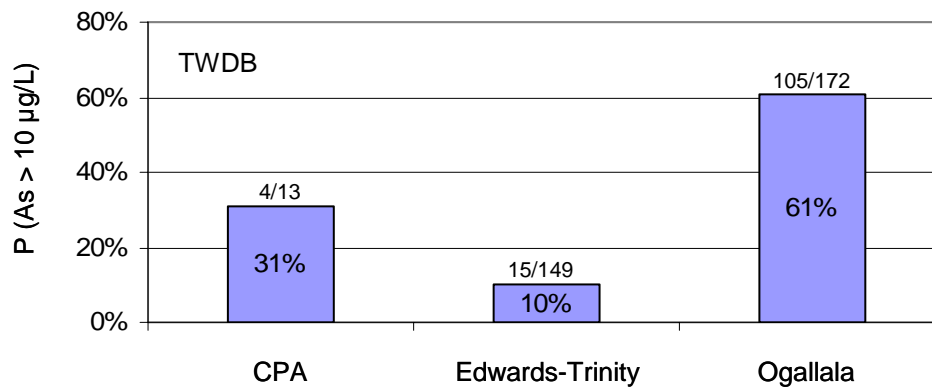
3.3 GENERAL TRENDS IN ARSENIC CONCENTRATIONS

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.

1 **Figure 3.10 Spatial Distribution of Arsenic Concentrations (TWDB Database)**



2
3 **Figure 3.11 Probabilities of Arsenic Concentrations Exceeding 10 µg/L MCL**
4 **for Aquifers in the Study Area**

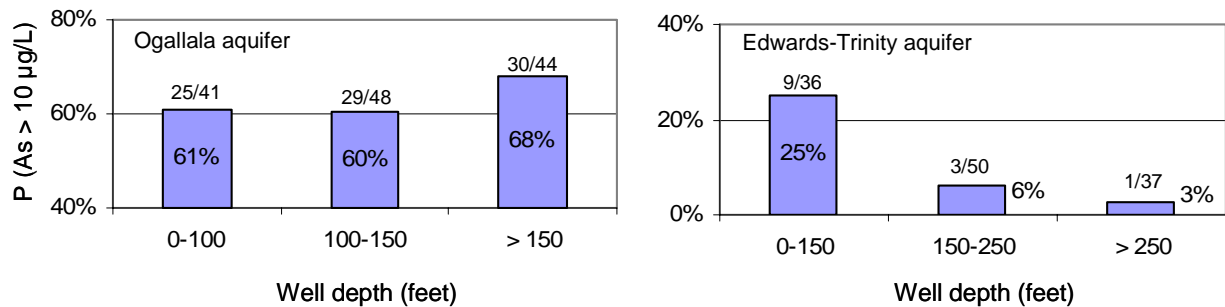


5
6 Data in Figures 3.10 and 3.11 are from the TWDB database. The most recent arsenic
7 measurement was used for each well. The Ogallala aquifer has a percentage of wells
8 with arsenic concentrations >10 µg/L which is higher than the other aquifers
9 (Figure 3.11). Within the Ogallala aquifer, 61 percent of the wells had arsenic
10 concentrations >10 µg/L, in comparison with the CPA (31%) and Edwards-Trinity
11 (Plateau) (10%) aquifers. A closer review of the spatial distribution of wells in the
12 Edwards-Trinity (Plateau) with high arsenic concentrations reveals that almost all wells
13 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.

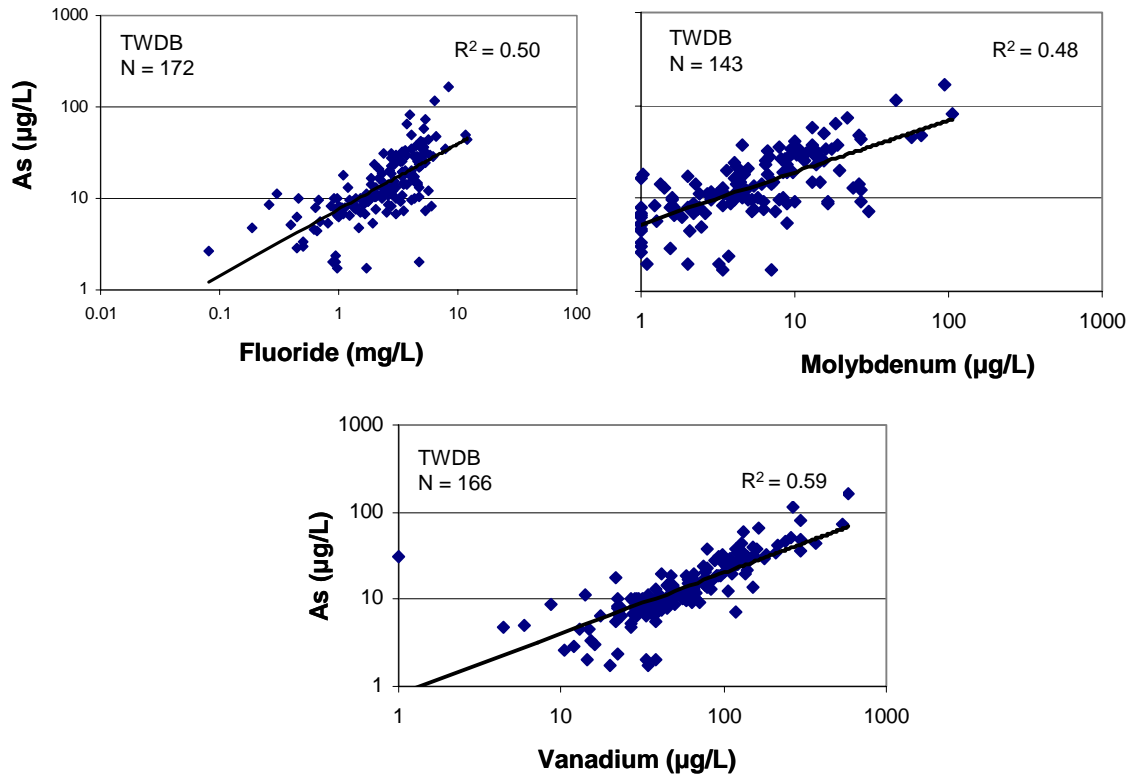
Figure 3.12 Relationship Between Arsenic Concentrations and Well Depth



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, SO₄, 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

1 suggest natural sources of elevated arsenic within the Ogallala aquifer. Within the
2 Edwards-Trinity (Plateau) aquifer, correlations are not as strong, and it is more likely the
3 source of arsenic is from the Ogallala aquifer overlying the Edwards-Trinity (Plateau)
4 aquifer.

5 **3.4 DETAILED ASSESSMENT FOR DEVILLA MOBILE HOME PARK** 6 **(PWS 0680069)**

7 Four wells are in this water supply system: G0680069A, G0680069B, G0680069C,
8 and G0680069D. Wells A, B and C have a depth of 152 feet and are screened between
9 130 and 150 feet. These three wells are designated as being within the Twin
10 Mountain/Antlers/Travis Peak Formations. Well D has a depth of 148 feet and does not
11 have aquifer information in the TCEQ PWS database. All wells are related to one entry
12 point in the water supply system, making it difficult to trace contaminants to a specific
13 well. Table 3.1 summarizes nitrate-N concentrations measured at the Devilla Mobile
14 Home Park PWS.

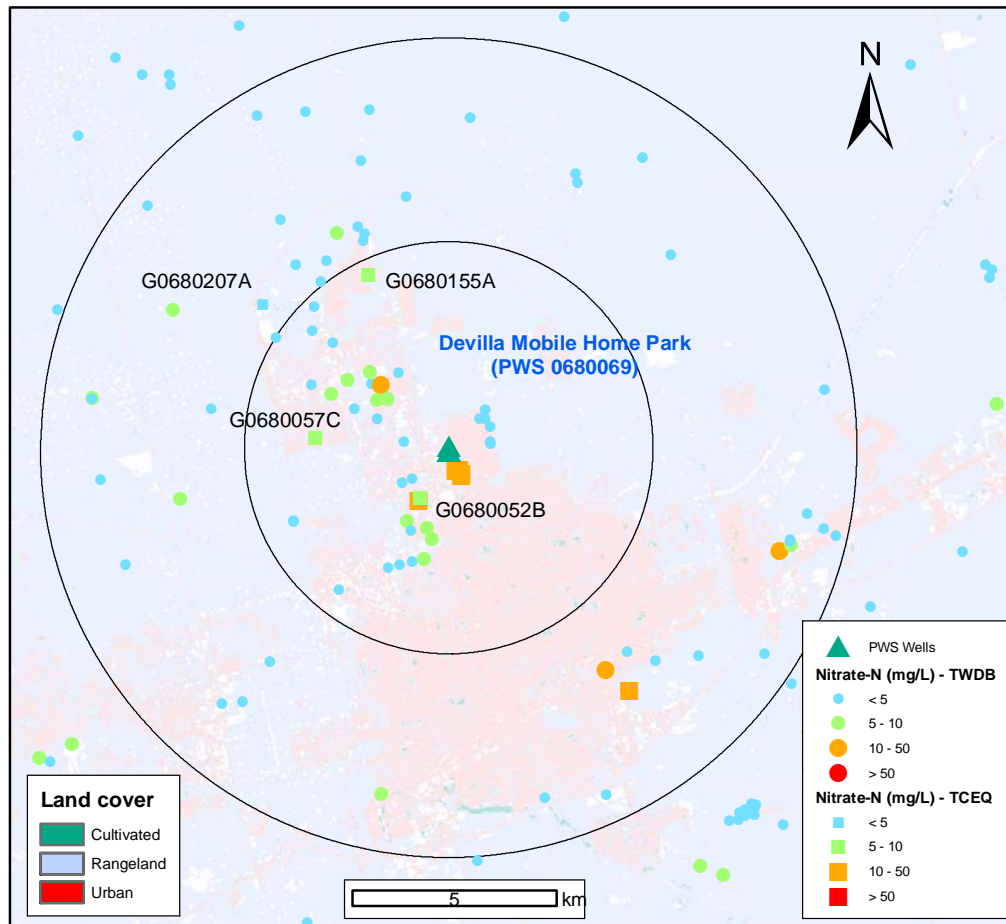
15 Regionally, nitrate and arsenic concentrations can have a high degree of spatial
16 variability in the groundwater. Because of this variability, an investigation of the
17 existing wells should be conducted to determine whether all four wells or only one
18 produces the water with elevated concentrations of nitrate. If one well is found to
19 produce compliant water, as much production as possible should be shifted to the
20 compliant well. Also, if one well is found to produce compliant water, the wells should
21 be compared in terms of depths and well logs to try and identify differences that could be
22 responsible for the elevated concentration of nitrate in the other well. Then if blending of
23 water from the existing wells does not produce a sufficient quantity of compliant water, it
24 may be possible to install a new well similar to the existing compliant well that also
25 would provide compliant water.

**Table 3.1 Nitrate-N Concentrations in the Devilla Mobile Home Park PWS
(TCEQ Database)**

Date	Nitrate-N (mg/L)	Source
3/19/1997	13	TCEQ
7/8/1997	12.99	TCEQ
9/24/1997	15.01	TCEQ
12/10/1997	14.54	TCEQ
2/3/1998	13.91	TCEQ
4/15/1998	13.66	TCEQ
8/4/1998	12.23	TCEQ
8/4/1998	12.23	TCEQ
6/30/1999	14.41	TCEQ
8/17/1999	13.29	TCEQ
11/1/1999	13.42	TCEQ
2/8/2000	13.3	TCEQ
6/22/2000	13.48	TCEQ
7/26/2000	13.81	TCEQ
11/16/2000	14.62	TCEQ
2/26/2001	13.74	TCEQ
6/25/2001	14.19	TCEQ
9/25/2001	15.33	TCEQ
12/4/2001	14.29	TCEQ
2/20/2002	13.24	TCEQ
6/24/2002	14.69	TCEQ
8/29/2002	14.76	TCEQ
11/6/2002	14.08	TCEQ
4/24/2003	16.12	TCEQ
4/24/2003	15.89	TCEQ
7/24/2003	15.24	TCEQ
2/10/2004	16.17	TCEQ
5/5/2004	0.75	TCEQ
11/29/2004	15.9	TCEQ
2/28/2005	16.9	TCEQ

Thirty nitrate-N samples were collected at the PWS between 1997 and 2005. All samples but one were above the nitrate-N MCL (10 mg/L). Figure 3.14 shows the spatial distribution of nitrate-N concentrations within the 5- and 10-km buffers of the PWS wells.

Figure 3.14 Nitrate-N Concentrations in 5- and 10-km buffers of Devilla Mobile Home Park PWS Wells (TWDB and TCEQ Databases)



Data are from TCEQ and TWDB databases, and the 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.

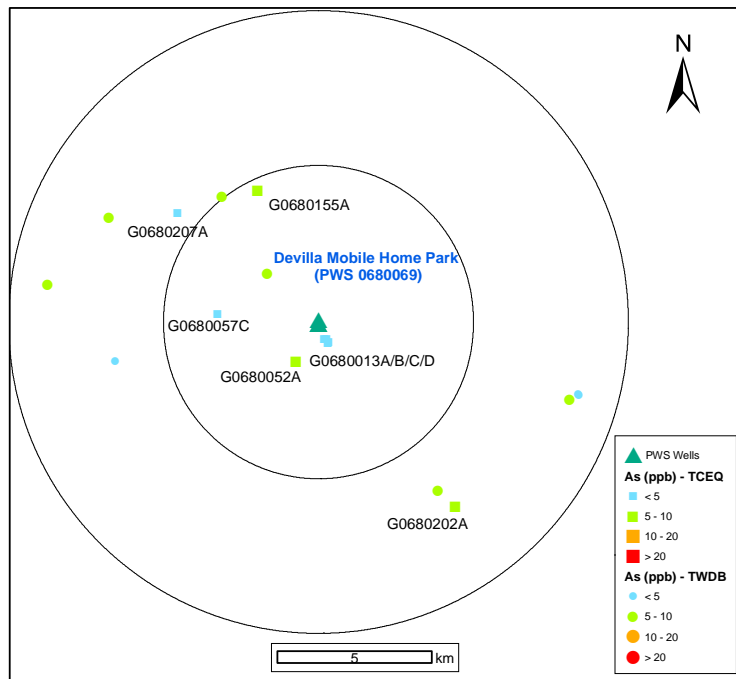
Only three wells from the TWDB database within buffers of the PWS wells had high (>10 mg/L) nitrate-N concentrations, and six wells from the TCEQ PWS database had high nitrate-N concentrations. Within the 5-km buffer, three PWS wells had nitrate-N concentrations below the MCL, wells G0680057C, G0680052B, and G0680155A. These wells are within the same formation as the PWS wells (Twin Mountain/Antlers/Travis Peak) and have well depths of 150, 160 and 200 feet, respectively. Within the 10-km buffer, one PWS well (G0680207A) had nitrate-N concentrations below the MCL. Table 3.2 summarizes arsenic concentrations measured at the Devilla Mobile Home Park PWS.

**Table 3.2 Arsenic Concentrations in the Devilla Mobile Home Park PWS
(TCEQ Database)**

Date	As (µg/L)	Source
2/16/1998	5.7	TCEQ
4/17/2001	6.3	TCEQ
2/16/2004	5.1	TCEQ

Three arsenic measurements are from the TCEQ database, between 1998 and 2004, and all three samples were below the arsenic MCL (10 µg/L). Figure 3.15 shows the 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 Devilla Mobile Home Park PWS Wells (TWDB and TCEQ Databases)



Data are from the TCEQ and TWDB databases, and 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. Within the 5-km buffer, seven PWS wells had arsenic concentrations below the MCL. The closest wells (about 500 m) are G0680013A, G0680013B, G0680013C, and G0680013D, and they all have arsenic concentrations <5 µg/L. Other PWS wells within the 5-km buffer with arsenic concentrations <10 µg/L are G0680155A, G0680052A, and G0680057C. Within the 10-km buffer, two PWS wells had arsenic concentrations <10 µg/L, wells G0680207A and G0680202A.

SECTION 4 ANALYSIS OF THE DEVILLA MOBILE HOME PARK PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1. Existing System

The location of the Devilla Mobile Home Park PWS is shown on Figure 4.1. The system has four active wells that are completed in the Antler Sand aquifer (Code 218ALRS). The wells are approximately 148 to 152 feet deep. The wells feed into a 5,000-gallon storage tank. The 5,000-gallon storage tank feeds a booster pump that pumps into 200-gallon and 1,200-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 wells averages approximately 10.6 mg/L and TDS concentration averages 1,410 mg/L.

The system was not designed to remove nitrates; therefore, system optimization will not result in a reduction in nitrate concentration.

Basic system information is as follows:

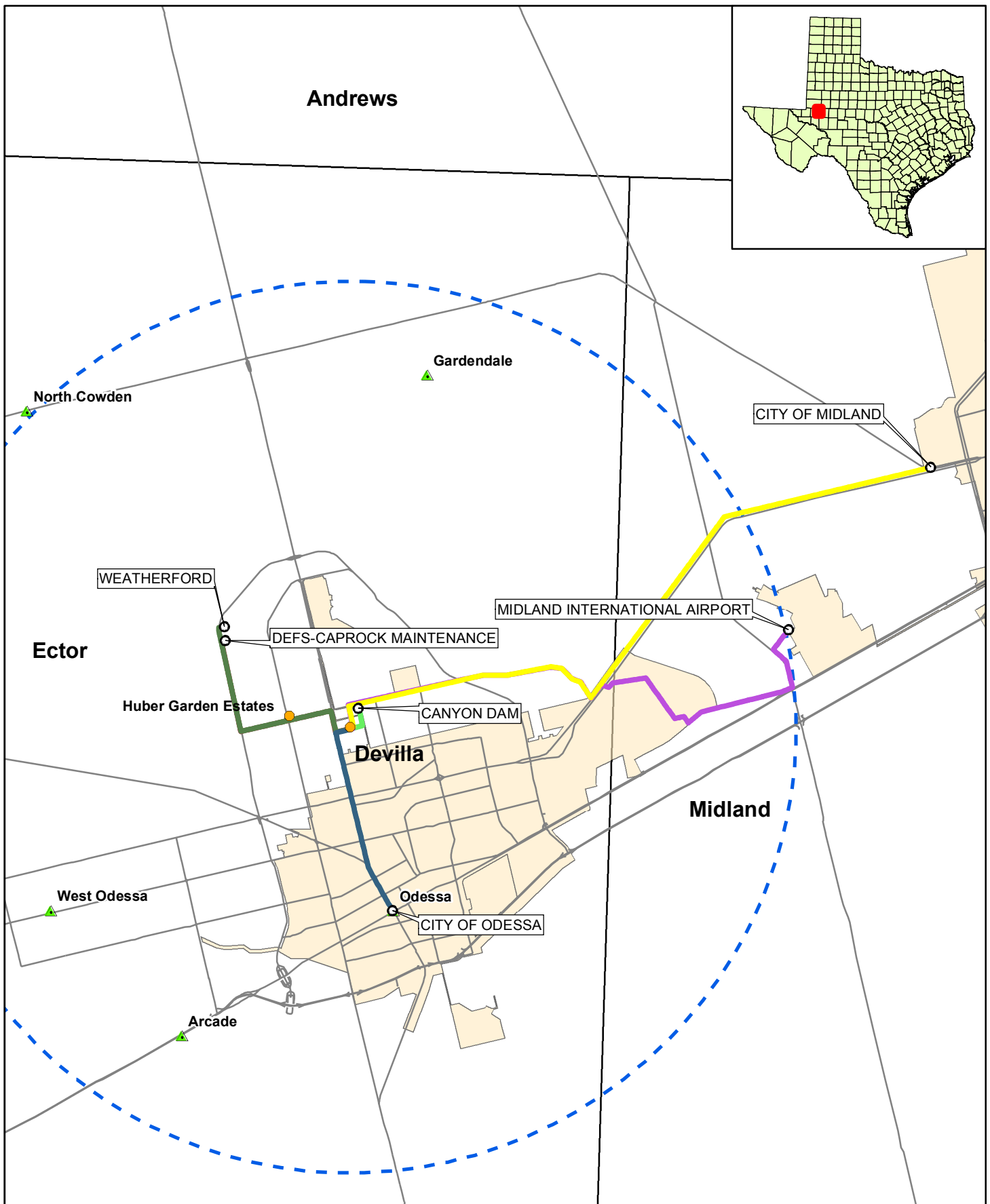
- Population served: 56
- Connections: 23
- Average daily flow: 0.0056 mgd*
- Maximum daily flow: 0.017 mgd**
- Total production capacity: 0.15 mgd
- Typical nitrate range: 10 to 11 mg/L
- Typical TDS range: 1,200 to 1,500 mg/L
- Typical sulfate range: 300 to 500 mg/L



* Based on 100 gpcd.

** Based on 3 times average daily flow.

Additionally, gross alpha radiation results and gross uranium results have been elevated to levels approaching MCLs, but no violations have been recorded.

The treatment employed is not appropriate or effective for removal of nitrate, so optimization is not expected to be effective in increasing removal of this contaminant.



 	<ul style="list-style-type: none"> Study System PWS's Cities Major Roads 10 Mile Radius City Limits Counties 	<ul style="list-style-type: none"> DM-1 Canyon Dam MHP DM-2 Weatherford DM-2 DEFS-Caprock DM-3 City of Odessa DM-4 Midland Int. Airport DM-5 Midland 	<p>Figure 4.1</p> <p>Devilla Pipeline Alternatives</p>
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4.1.2 Capacity Assessment for Devilla Mobile Home Park PWS

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

4.1.2.1 General Structure

The Devilla Mobile Home Park water system is owned and operated by Mr. Rick Montilla of San Diego, California. The owner travels to the system when complaints are made, or once per month to collect rent and refill the chlorinator supply. Maintenance is provided by contractors working for the owner (Montilla, 2005). There are 40 spaces in the Devilla MHP which are not all occupied. Residents are mostly low-income families.

4.2 ALTERNATIVE WATER SOURCE DEVELOPMENT

4.2.1 Identification of Alternative Existing Public Water Supply Sources

Table 4.1 is a list of the existing groundwater-supplied public water supply systems within approximately 20 miles of the Devilla Mobile Home Park. Selected sources are shown on Figure 4.1.

**Table 4.1 Existing Public Water Systems within 30 miles of
Devilla Mobile Home Park**

System Name	Distance from Devilla	Comments/Other Issues
Northgate Mobile Home Park 1	0.4	Small system with WQ issues: NO3, gross alpha, TDS; marginal exceedances: SO4
Canyon Dam Mobile Home Park	0.4	Small system without identified WQ issues
Huber Garden Estates	1.4	Small system with WQ issues: As, NO3, gross alpha, TDS, SO4
Orchard Water Supply	1.7	Small system with WQ issues: As; marginal exceedances: fluoride, TDS
Richeys Mobile Home Park	2.0	Small system with WQ issues: NO3, TDS, SO4; marginal exceedances: gross alpha
Williams Trailer Court	2.6	Small system with WQ issues: Fe, SO43, hardness, gross alpha, TDS; marginal exceedances: : NO3
Duke Energy Field Services - Caprock Maintenance Facility	3.3	Small system without identified WQ issues
Weatherford International Inc.	3.6	Small system without identified WQ issues
City of Odessa	4.2	Large system (>1 mgd) with WQ issues: SO4, TDS
Double H Mobile Home Park	7.6	Small system with marginal As exceedances
Gardendale County Water Inc.	8.9	marginal exceedances: : NO3, TDS
Depot Water Store	8.9	Small system with WQ issues: TDS, SO4
Midland International Airport	10.4	Large system (>1 mgd) with marginal As exceedances
Spring Meadow Mobile Home Park	12.6	Small system with WQ issues: As, TDS, gross alpha, SO4, NO3; marginal exceedances: combined uranium
Airline Mobile Home Park LTD	13.1	Small system with WQ issues: TDS, SO4, gross alpha; marginal As exceedances
Pecan Acres Homeowners Association	13.4	Small system with WQ issues: As, TDS, SO4; marginal exceedances: hardness, gross alpha
Colorado River MWD - Ector County Well	13.7	Large system (>1 mgd) with marginal TDS exceedances
Westgate Mobile Home Park	15.4	Small system with WQ issues: trichloroethylene (TCE) and methyl t-butyl ether (MTBE) have been detected
Country Village Mobile Home Estates	15.8	Small system with WQ issues: NO3, TDS, hardness, SO4, As
Twin Oaks Mobile Home Park	18.0	Small system with WQ issues: As, TDS, NO3, SO4, gross alpha; marginal exceedances: hardness, Se, combined uranium
Johns Mobile Home Park	18.1	Small system with WQ issues: As, TDS, NO3, SO4; marginal exceedances: hardness
South Midland Co. Water Systems	18.5	Small system with WQ issues: As, TDS, NO3, SO4; marginal exceedances: hardness
Warren Road Subdivision	18.7	Small system with WQ issues: As, TDS, NO3, SO4
Valley View Mobile Home Park	23.2	Small system with WQ issues: As, TDS, NO3, SO4, gross alpha, hardness, combined uranium; marginal exceedances: Se
Water Runners Inc.	23.9	Small system without identified WQ issues
Pecan Groove Mobile Home Park	24.7	Small system with WQ issues: TDS; marginal exceedances: hardness, SO4, NO3, As
City of Midland	27.7	Large system (>1 mgd) with WQ issues: As, fluoride, SO3, TDS
Greenwood ISD	30.0	Small system with WQ issues: As, TDS, NO3, SO4, Se, hardness; marginal exceedances: fluoride

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 4.2 Public Water Systems within 20 miles of Devilla Mobile Home Park
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 Devilla Mobile Home Park, 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 0.5 miles to the west of Devilla Mobile Home Park. 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

The Duke Energy Field Services – Caprock Maintenance Facility is located approximately 3 miles northwest of Devilla Mobile Home Park, and is a privately-owned industrial facility that provides oilfield support services. The facility has two wells that were drilled in 1899 and 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 4 miles northwest of Devilla Mobile Home Park, 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 4 miles southeast of Devilla Mobile Home Park. 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

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

6 In 2004, approximately 6.7 billion gallons of water was delivered to Odessa from
7 San Angelo via the CRMWD pipeline, and 4.5 percent or 0.31 billion gallons originated
8 from the Ward County Well Field. The average usage by the City of Odessa ranges from
9 12 to 15 mgd in the winter to 35 to 36 mgd in the summer. The City of Odessa provides
10 water to a population of approximately 108,000 and has a total of approximately 42,000
11 connections. The current customer rate per connection for potable water is \$2.50 per
12 1,000 gallons.

13 The City of Odessa does have an excess capacity of treated water and may be willing
14 to sell water to other PWSs. A community that wishes to purchase treated water from the
15 City of Odessa must submit a formal request to the City for review by the five-member
16 City Council. The community does not have to be annexed in order to receive treated
17 water via pipeline, but they would have to fund the cost of the connecting pipeline.

18 **4.2.1.6 Midland International Airport**

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

27 A Midland consulting firm, Arcadis, is currently evaluating the ability for the
28 Midland International Airport well field to continue meeting the demands of the airport.
29 Data for this report was collected during the summer of 2005, and the evaluation report
30 will be completed in the fall of 2005.

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

34 **4.2.1.7 City of Midland**

35 The City of Midland is located approximately 28 miles east of Devilla Mobile Home
36 Park. The City of Midland purchases approximately 75 to 80 percent of its water from
37 the CRWMD through a 1966 contract agreement. This purchased water comprises
38 mainly untreated surface water from several reservoirs including Lake J.B. Thomas, Lake
39 E.V. Spence, and Lake O.H. Ivie, though the CRWMD may also supplement the supply

1 with groundwater during the high demand summer months. The City of Midland gets the
2 other 20 to 25 percent of its water from various City-owned well fields, which provide
3 lower quality water. Midland is classified as a member city of CRMWD and is allowed
4 to use alternate water supplies, unlike Odessa whose water can only be provided by
5 CRMWD.

6 As part of Midland's first primary water sources, raw water from CRMWD is
7 delivered to one of three reservoirs. Two of the three reservoirs are owned by CRMWD
8 and include a 15 million gallon reservoir located at the water purification plant and the
9 100 million gallon Terminal Reservoir located on FM 1788, approximately 2 miles south
10 of Highway 191. The Terminal Reservoir is shared by both Midland and Odessa. The
11 third reservoir, Lake Peggy Sue, is owned by Midland and is located approximately
12 2 miles west of the City's water treatment plant. In addition to the surface water
13 provided by CRWMD, under a 1995 agreement, Midland owns 16.54 percent of Lake
14 Ivie, which is located approximately 170 miles southwest of Midland. Each day,
15 15 million gallons from Lake Ivie and 16 million gallons from CRWMD reservoirs are
16 delivered via pipeline from Ballinger to San Angelo, and then to one of the three
17 reservoirs around Midland.

18 In addition to the CRMWD surface water, the City owns or leases water rights in
19 three well fields. The McMillen Well Field was in operation from the early 1950s until it
20 was depleted in the mid 1960s. It was used as a reserve water supply but is no longer
21 used following a detection of perchlorate in water samples from the well field. The Paul
22 Davis Well Field, located 30 miles north of Midland, was developed in the late 1950s and
23 is used during peak periods to offset the demand exceeding the 31 mgd provided by the
24 surface water from CRMWD reservoirs. The well field can sustain a pumping rate of
25 18 to 19 mgd, but normally averages 10 mgd annually. The well field currently consists
26 of two 2.5 million gallon tanks that receive groundwater from 29 wells. These wells are
27 installed between 150 and 200 feet deep in the Ogallala Aquifer (Code 121OGLL). Since
28 arsenic, fluoride, perchlorate, and radionuclides have been reported both in samples from
29 individual wells and in batch samples from the well field, the City of Midland carefully
30 monitors the blending of surface water from CRWMD and the groundwater from the Paul
31 Davis Well Field to maintain a potable water supply that does not exceed the MCLs for
32 these constituents. The third well field is the T-Bar Ranch, which is located in western
33 Winkler County approximately 70 miles west of Midland. This well field is still being
34 developed and will be brought online as the Paul Davis well field is depleted.

35 The City of Midland operates two treatment plants to treat the surface water supplied
36 by CRWMD and provides water to a service population of approximately 100,000. The
37 City has a total of approximately 35,500 connections, about 32,000 of which are metered.
38 The major users of water in Midland include the college, parks and schools which use the
39 water for irrigation. The current monthly rates per connection are \$12 base charge for the
40 first 2,000 gallons and \$2.75 for each additional 1,000 gallons.

41 In the fall of 2003, the Midland City Council decided that water can only be
42 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, it should be possible to share in the cost and effort of identifying compliant groundwater and constructing well fields.

Since the PWS is already familiar with well operation, 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. 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 the Devilla Mobile Home Park is extensive and is likely to remain near current levels over the next decades. In central Ector County, where the Devilla Mobile Home Park 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 Devilla Mobile Home Park 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 Devilla Mobile Home Park as indicated by limited water availability over the entire river basin, and within the site vicinity.

Devilla Mobile Home Park 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 Devilla Mobile Home Park storage tank (Alternative DM-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 Devilla Mobile Home Park storage tank (Alternative DM-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 Devilla Mobile Home Park storage tank (Alternative DM-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 Devilla Mobile Home Park storage tanks (Alternative DM-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 Devilla Mobile Home Park storage tank (Alternative DM-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 Devilla Mobile Home Park 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 Devilla Mobile Home Park. These alternatives are DM-10, DM-11, and DM-12.

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of the well field water is identified as a potential alternative for Devilla MHP. RO and EDR are potential applicable processes. RO and EDR can reduce nitrate and TDS to produce compliant water. The central RO treatment alternative is Alternative DM-6, and the central EDR treatment alternative is Alternative DM-7.

4.3.2 Point-of-Entry Systems

Point-of-entry treatment using RO technology is valid for nitrate removal. The point-of-entry RO treatment alternative is DM-8.

4.3.3 Point-of-Use Systems

Point-of-use treatment using RO technology is valid for nitrate removal. The point-of-use RO treatment alternative is DM-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 DM-13, DM-14, DM-15, and DM-16.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

A number of potential alternatives for compliance with the MCL for nitrate 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 DM-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 Devilla Mobile Home Park's 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 Devilla Mobile Home Park 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 Devilla Mobile Home Park system. One of the two pumps in the pump station is for backup in case the other pump fails. The pipeline would be approximately $\frac{3}{4}$ of a mile long, and would be a 4-inch PVC line that discharges to the existing storage tank in Devilla Mobile Home Park.

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 Devilla Mobile Home Park 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 \$288,800, and the estimated annual O&M cost for this alternative is \$3,800 less than current costs.

1 Reliability of supply of adequate amounts of compliant water under this alternative
2 should be good. Devilla Mobile Home Park has a well field with adequate capacity.
3 From Devilla Mobile Home Park's perspective, this alternative would be characterized as
4 easy to operate and repair, since O&M and repair of pipelines and pumps stations is well
5 understood, and Devilla Mobile Home Park currently operates pumps.

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

7 **4.5.2 Alternative DM-2: New Well at either Duke Energy Field Services** 8 **Facility or Weatherford International Facility**

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

16 This alternative would require the drilling of a new well and installation of a well
17 pump, small ground storage tank, a pump station with two transfer pumps, and a pipeline
18 to the Devilla Mobile Home Park system. One of the two pumps in the pump station is
19 for backup in case the other pump fails. The pipeline would be approximately 5.1 miles
20 long, and would be a 4-inch PVC line that discharges to the existing storage tank in
21 Devilla Mobile Home Park.

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

26 The estimated capital cost for this alternative includes the cost to construct a new
27 well and small ground storage tank, a pump station with two transfer pumps, and a
28 pipeline to the Devilla Mobile Home Park system. The estimated O&M cost for this
29 alternative includes additional costs related to taking the existing well field out of
30 service, plus maintenance cost for the pipeline, and power and O&M labor and materials
31 for the pump station. The estimated capital cost for this alternative is \$1.31 million, and
32 the estimated annual O&M cost for this alternative is the same as what the Devilla PWS
33 currently pays.

34 Reliability of supply of adequate amounts of compliant water under this alternative
35 should be good. Devilla Mobile Home Park has a well field with adequate capacity.
36 From Devilla Mobile Home Park's perspective, this alternative would be characterized as
37 easy to operate and repair, since O&M and repair of pipelines and pumps stations is well
38 understood, and Devilla Mobile Home Park currently operates pumps.

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

4.5.3 Alternative DM-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 Devilla Mobile Home Park 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 Devilla Mobile Home Park would obtain all of its water from the City of Odessa.

This alternative would require the construction of a pipeline from the City of Odessa to the existing storage tank for the Devilla Mobile Home Park system. A pump station would also be required to overcome pipe friction and the elevation differences between Odessa and Devilla Mobile Home Park. The required pipeline would follow State Highway 385, be approximately 4½ 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 Devilla Mobile Home Park, since the incremental cost would be relatively small, and it would provide operational flexibility.

This alternative involves by definition regionalization, since Devilla Mobile Home Park would be obtaining drinking water from an existing larger supplier. It is possible that Devilla Mobile Home Park instead of purchasing water could turn over provision of drinking water to the City of Odessa. Also, other PWSs near Devilla Mobile Home Park 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 Devilla Mobile Home Park 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 \$1.13 million, and the alternatives' estimated annual O&M cost is \$4,800 less than current costs.

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 Devilla Mobile Home Park's 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 DM-4: Drill New Well at Midland International Airport

This alternative consists of drilling a new well in the Midland International Airport area. This new well would replace the Devilla MHP 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 Devilla MHP 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 Devilla MHP system. One of the two pumps in the pump station is for backup in case the other pump fails. The pipeline, approximately 13.5 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 Devilla MHP.

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 Devilla MHP 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 \$3.02 million, and the estimated annual O&M cost for this alternative is \$5,000.

Reliability of supply of adequate amounts of compliant water under this alternative should be good. Devilla MHP has a well field with adequate capacity. From Devilla MHP' 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 Devilla MHP currently operates pumps.

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

4.5.5 Alternative DM-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 Devilla Mobile Home Park 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,

1 it is assumed that the Devilla Mobile Home Park would obtain all of its water from the
2 City of Midland.

3 This alternative would require the construction of a pipeline from the City of
4 Midland to the existing storage tank for the Devilla Mobile Home Park system. A pump
5 station would also be required to overcome pipe friction and the elevation differences
6 between Midland and Devilla Mobile Home Park. The required pipeline would primarily
7 follow Business Route I-20 E and other arterial roads, be approximately 16 miles long,
8 and be constructed of 4-inch PVC pipe.

9 The pump station would include two pumps, including one standby, and would be
10 housed in a building. A tank would also be constructed for the pumps to draw from. It is
11 assumed the pumps and piping would be installed with capacity to meet all water demand
12 for the Devilla Mobile Home Park, since the incremental cost would be relatively small,
13 and it would provide operational flexibility.

14 This alternative involves by definition regionalization, since Devilla Mobile Home
15 Park would be obtaining drinking water from an existing larger supplier. Also, other
16 PWSs near Devilla Mobile Home Park are in need of compliant drinking water and could
17 share in implementation of this alternative.

18 The estimated capital cost for this alternative includes the cost to construct the
19 pipeline and pump station. The estimated O&M cost for this alternative includes the
20 purchase price for the treated water minus the cost related to current operation of the
21 Devilla Mobile Home Park wells, plus maintenance cost for the pipeline, and power and
22 O&M labor and materials for the pump station. The estimated capital cost for this
23 alternative is \$3.60 million, and the alternatives' estimated annual O&M cost is \$18,200.

24 Reliability of supply of adequate amounts of compliant water under this alternative
25 should be good. City of Midland provides treated surface water on a large scale,
26 facilitating adequate O&M resources. From Devilla Mobile Home Park's perspective,
27 this alternative would be characterized as easy to operate and repair, since O&M and
28 repair of pipelines and pump stations is well understood. If the decision was made to
29 perform blending then the operational complexity would increase.

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

32 **4.5.6 Alternative DM-6: Central RO Treatment**

33 This system would continue to pump water from the Devilla MHP well field, and
34 would treat the water through an RO system prior to distribution. For this option, a
35 fraction of the raw water would be treated and then blended with the untreated stream to
36 obtain overall compliant water. The RO process concentrates impurities in the reject
37 stream which would require disposal. It is estimated the RO reject generation would be
38 611 gpd when the system is operated at full flow.

This alternative consists of constructing the RO treatment plant near the existing Devilla MHP 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 \$602,200, and the estimated annual O&M cost is \$61,600.

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 DM-7: Central EDR Treatment

The system would continue to pump water from the Devilla MHP 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 Devilla MHP 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 \$822,600, and the estimated annual O&M cost is \$59,300.

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 DM-8: Point-of-Use Treatment

This alternative consists of the continued operation of the four existing Devilla Mobile Home Park wells, plus treatment of water to be used for drinking or food preparation at the point of use to remove nitrate. 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, arsenic, or sulfate.

This alternative would require the installation of the POU treatment units in houses and other buildings that provide drinking or cooking water. Devilla Mobile Home Park 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 Devilla Mobile Home Park 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.

Point-of-use RO treatment processes typically produce liquid waste streams that are equal in volume to the treated water and require disposal. These waste streams result in an increased overall volume of water used. POU systems have the advantage that 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 \$15,200, and the estimated annual O&M cost for this alternative is \$14,400. For the cost estimate, it is assumed that one POU treatment unit will be required for each of the 23 existing connections to the Devilla Mobile Home Park 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.

1 Additionally, the O&M efforts required for the point-of-use systems will be significant,
2 and Devilla Mobile Home Park personnel are inexperienced in this type of work. From
3 the perspective of Devilla Mobile Home Park, this alternative would be characterized as
4 more difficult to operate due to the in-home requirements.

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

7 **4.5.9 Alternative DM-9: Point-of-Entry Treatment**

8 This alternative consists of the continued operation of the four existing Devilla
9 Mobile Home Park wells, plus treatment of water as it enters residences to remove
10 nitrate. The purchase, installation, and maintenance of the treatment systems at the point
11 of entry to a household would be necessary for this alternative. Blending is not an option
12 in this case. Reverse osmosis POE treatment units would also be effective for reducing
13 other potential contaminants such as TDS, arsenic, or sulfate.

14 This alternative would require the installation of the point-of-entry treatment units at
15 houses and other buildings that provide drinking or cooking water. Devilla Mobile Home
16 Park would be responsible for purchase and maintenance of the treatment units, including
17 membrane and filter replacement, periodic sampling, and necessary repairs. The
18 plumbing in houses should be investigated to ensure that the aggressive water that will
19 result from RO treatment will not cause damage. It may also be desirable to modify
20 piping so that water for non-consumptive uses can be withdrawn upstream of the
21 treatment unit. The POE treatment units will be installed outside of the houses, so that
22 entry will not be necessary for O&M. Some cooperation from customers will be
23 necessary for installation and maintenance of the treatment systems.

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

30 This alternative does not present options for a regional solution.

31 The estimated capital cost for this alternative includes cost to purchase and install the
32 point-of-entry treatment systems. The estimated O&M cost for this alternative includes
33 the purchase and replacement of filters and membranes, as well as periodic sampling and
34 record keeping. The estimated capital cost for this alternative is \$265,700, and the
35 estimated annual O&M cost for this alternative is \$32,200. For the cost estimate, it is
36 assumed that one point-of-entry treatment unit will be required for each of the 23 existing
37 connections to the Devilla Mobile Home Park system.

38 Reliability of supply of adequate amounts of compliant water under this alternative
39 are fair, but better than point-of-use 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 point-of-entry systems will be significant, and Devilla Mobile Home Park personnel are inexperienced in this type of work. From the perspective of Devilla Mobile Home Park, 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 DM-10: New Wells at 10 miles

This alternative consists of the installation of a new well within 10 miles of Devilla MHP that would produce compliant water in place of the water produced by the existing four 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 Devilla MHP 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 Devilla MHP. 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 \$2.31 million, and the estimated annual O&M cost for this alternative is \$2,900.

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 Devilla MHP, this alternative would be similar to the existing system in terms of operation. Devilla MHP 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 Devilla MHP controlled land, so landowner cooperation will be required.

4.5.11 Alternative DM-11: New Wells at 5 miles

This alternative consists of the installation of a new well within 5 miles of Devilla MHP that would produce compliant water in place of the water produced by the existing four 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.

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 Devilla MHP 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 Devilla MHP. 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 \$1.31 million, and the estimated annual O&M cost for this alternative is \$1,100 less than current costs.

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 Devilla MHP, this alternative would be similar to the existing system in terms of operation. Devilla MHP 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 Devilla MHP controlled land, so landowner cooperation will be required.

4.5.12 Alternative DM-12: New Wells at 1 mile

This alternative consists of the installation of a new well within 1 mile of Devilla MHP that would produce compliant water in place of the water produced by the existing four 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.

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 Devilla MHP 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 1 mile long, and would be a 4-inch PVC line that discharges to the existing storage tank at Devilla MHP. 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 \$266,400, and the estimated annual O&M cost for this alternative is \$19,600 less than current costs.

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 Devilla MHP, this alternative would be similar to the existing system in terms of operation. Devilla MHP 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 Devilla MHP controlled land, so landowner cooperation will be required.

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

This alternative consists of the continued operation of the existing four Devilla Mobile Home Park 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

1 of obtaining drinking water from the dispenser. In this way, only a relatively small
2 volume of water requires treatment, but customers are required to pickup and deliver
3 their own water. Blending is not an option in this case. It should be noted that this
4 alternative would be considered an interim measure until a compliance alternative is
5 implemented.

6 Devilla Mobile Home Park would be responsible for maintenance of the treatment
7 unit, including membrane and filter replacement, periodic sampling, and necessary
8 repairs. A method for disposal of the reject waste stream produced by the treatment
9 system will have to be found. This alternative relies on a great deal of cooperation and
10 action from the customers in order to be effective.

11 This alternative does not present options for a regional solution.

12 The estimated capital cost for this alternative includes cost to purchase and install the
13 treatment system to be used for the drinking water dispenser. The estimated O&M cost
14 for this alternative includes the purchase and replacement of filters and membranes, as
15 well as periodic sampling and record keeping. The estimated capital cost for this
16 alternative is \$11,600, and the estimated annual O&M cost for this alternative is \$16,700.

17 Reliability of supply of adequate amounts of compliant water under this alternative is
18 fair, because of the large amount of effort required from the customers and the associated
19 inconvenience. Devilla Mobile Home Park has not provided this type of service in the
20 past. From the perspective of Devilla Mobile Home Park, this alternative would be
21 characterized as relatively easy to operate, since these types of treatment units are highly
22 automated, and there is only one unit.

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

25 **4.5.14 Alternative DM-14: 100 Percent Bottled Water Delivery**

26 This alternative consists of the continued operation of the existing four Devilla
27 Mobile Home Park wells, but compliant drinking water will be delivered to customers in
28 containers. This alternative involves setting up and operating a bottled water delivery
29 program to serve all of the customers in the system. It is expected that Devilla Mobile
30 Home Park will find it most convenient and economical to contract a bottled water
31 service. The bottle delivery program will have to be flexible enough to allow the
32 delivery of smaller containers should customers be incapable of lifting and manipulating
33 5-gallon bottles. Blending is not an option in this case. It should be noted that this
34 alternative would be considered an interim measure until a compliance alternative is
35 implemented.

36 This alternative does not involve capital cost for construction, but would require
37 some initial costs for system setup, and then ongoing costs to have the bottled water
38 furnished. It is assumed for this alternative that bottled water is provided to 100 percent
39 of the Devilla Mobile Home Park customers.

1 This alternative does not present options for a regional solution.

2 The estimated initial capital cost is for setting up the program. The estimated O&M
3 cost for this alternative includes program administration and purchase of the bottled
4 water. The estimated initial cost for this alternative is \$23,900, and the estimated annual
5 O&M cost for this alternative is \$56,400. For the cost estimate, it is assumed that each
6 person requires 1 gallon of bottled water per day.

7 Reliability of supply of adequate amounts of compliant water under this alternative is
8 fair, since it relies on the active cooperation of customers to order and utilize the water.
9 Management and administration of the bottled water delivery program will require
10 attention from Devilla Mobile Home Park.

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

13 **4.5.15 Alternative DM-15: 25 Percent Bottled Water Delivery**

14 This alternative consists of the continued operation of the four existing Devilla
15 Mobile Home Park wells, but compliant drinking water will be delivered to customers in
16 containers. This alternative involves setting up and operating a bottled water delivery
17 program to serve only the susceptible population in the system. For this alternative, it is
18 assumed that serving the susceptible population will result in the provision of bottled
19 drinking water to 25 percent of the served population. It is expected that Devilla Mobile
20 Home Park will find it most convenient and economical to contract a bottled water
21 service. The bottle delivery program will have to be flexible enough to allow the
22 delivery of smaller containers should customers be incapable of lifting and manipulating
23 5-gallon bottles. Blending is not an option in this case. It should be noted that this
24 alternative would be considered an interim measure until a compliance alternative is
25 implemented.

26 This alternative does not involve capital cost for construction, but would require
27 some initial costs for system setup, and then ongoing costs to have the bottled water
28 furnished.

29 This alternative does not present options for a regional solution.

30 The estimated initial cost is for setting up the program. The estimated O&M cost for
31 this alternative includes program administration and purchase of the bottled water. The
32 estimated initial cost for this alternative is \$23,900, and the estimated annual O&M cost
33 for this alternative is \$31,800. For the cost estimate, it is assumed that each person
34 requires 1 gallon of bottled water per day.

35 Reliability of supply of adequate amounts of compliant water under this alternative is
36 fair, since it relies on the active cooperation of customers to order and utilize the water.
37 Management and administration of the bottled water delivery program will require
38 attention from Devilla Mobile Home Park.

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

4.5.16 Alternative DM-16: Public Dispenser for Trucked Drinking Water

This alternative consists of continued operation of the existing four Devilla Mobile Home Park 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.

Devilla Mobile Home Park 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 \$14,700.

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. Devilla Mobile Home Park has not provided this type of service in the past. From the perspective of Devilla Mobile Home Park, 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.

4.5.17 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for Devilla Mobile Home Park.

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Table 4.3 Summary of Compliance Alternatives for Devilla Mobile Home Park

Alt No.	Alternative Description	Major Components	Capital Cost ¹	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
DM-1	Canyon Dam MHP	Well, pump station, tank, and 0.75-mile pipeline.	\$288,800	\$(3,800)	\$21,300	Good	N	Alternative assumes adequate amount of compliant water.
DM-2	DEFS-Caprock	Well, pump station, tank, and 5.1-mile pipeline.	\$1,313,000	---	\$114,500	Good	N	Alternative assumes adequate amount of compliant water.
DM-3	City of Odessa	Pump station, tank, and 4.6-mile pipeline.	\$1,129,300	\$(4,800)	\$93,600	Good	N	Alternative assumes the City of Odessa will provide adequate amount of compliant water.
DM-4	Midland Int'l Airport	Pump station, tank and 13.5-mile pipeline.	\$3,023,100	\$5,000	\$268,500	Good	N	Alternative assumes the Midland Airport will provide adequate amount of compliant water.
DM-5	City of Midland	Pump station, tank and 16.2-mile pipeline.	\$3,603,500	\$18,200	\$332,300	Good	N	Alternative assumes the City of Midland will provide adequate amount of compliant water.
DM-6	Central RO	One central reverse osmosis treatment unit and reject pond.	\$602,200	\$61,600	\$114,100	Good	T, M	Costs could possibly be shared with other nearby small systems.
DM-7	Central EDR	One electrodialysis reversal treatment unit and reject pond.	\$822,600	\$59,300	\$131,100	Good	T, M	Costs could possibly be shared with other nearby small systems.
DM-8	POU-RO	Small reverse osmosis treatment unit for each customer.	\$15,200	\$14,400	\$15,700	Fair	T, M	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
DM-9	POE-RO	Small reverse osmosis treatment unit for each customer.	\$265,700	\$32,200	\$55,400	Fair	T, M	All home taps compliant and less resident cooperation required.
DM-10	New well 10 miles	Well, pump station, tank, and 10 mile pipeline.	\$2,306,900	\$2,900	\$204,000	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
DM-11	New well 5 miles	Well, pump station, tank, and 5 mile pipeline.	\$1,307,700	\$(1,100)	\$112,900	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
DM-12	New well 1 mile	Well, pump station, tank, and 5 mile pipeline.	\$266,400	\$(19,600)	\$3,600	Good	N	May be difficult to find well with good water quality. Costs could be shared with other nearby small systems.
DM-13	Dispenser	Dispenser and truck.	\$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
DM-14	100% Bottled	Bottle water and delivery system.	\$23,900	\$56,400	\$58,500	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.
DM-15	25% Bottled	Bottle water and delivery system.	\$23,900	\$31,800	\$33,900	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.
DM-16	Central trucked	Dispenser and truck.	\$103,000	\$14,700	\$23,700	Fair, interim method	M	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires a lot of effort by customers.

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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 Devilla Mobile Home Park Financial Data

No financial data for the Devilla Mobile Home Park were provided by the system operator. Water usage does not constitute a separate monthly billing, but is included in the monthly rent for the 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 the Devilla Mobile Home Park 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 the Devilla Mobile Home Park 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 residential customers of Devilla Mobile Home Park 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 there are no financial data exclusively for the water system, it is not possible to determine exact cash flow needs.

4.6.1.2.2 Ratio Analysis

Current Ratio

The Current Ratio for the Devilla Mobile Home Park 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

Because of the lack of financial data for expenses related to the Devilla Mobile Home Park water system, the Operating Ratio could not be accurately determined. However, the system's estimated operating revenues of approximately \$4,500 are assumed to be approximately equal to or slightly exceeding its operating expenses.

4.6.1.3 Financial Plan Results

Each compliance alternative for the Devilla Mobile Home Park 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 the customers of the Devilla Mobile Home Park was not available, county-wide data were used. Ector County, where Devilla Mobile Home Park 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, the Devilla Mobile Home Park 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 rate increases necessary assuming 100 percent grant funding and 100 percent loan/bond funding. Most funding options will fall between 100 percent grant and 100 percent loan/bond funding, with the exception of 100 percent revenue financing. If existing reserves are insufficient to fund a compliance alternative, rates would need to be raised before implementing the compliance alternative. This would allow for accumulation of sufficient reserves to avoid larger but temporary rate increases during the years the compliance alternative was being implemented.

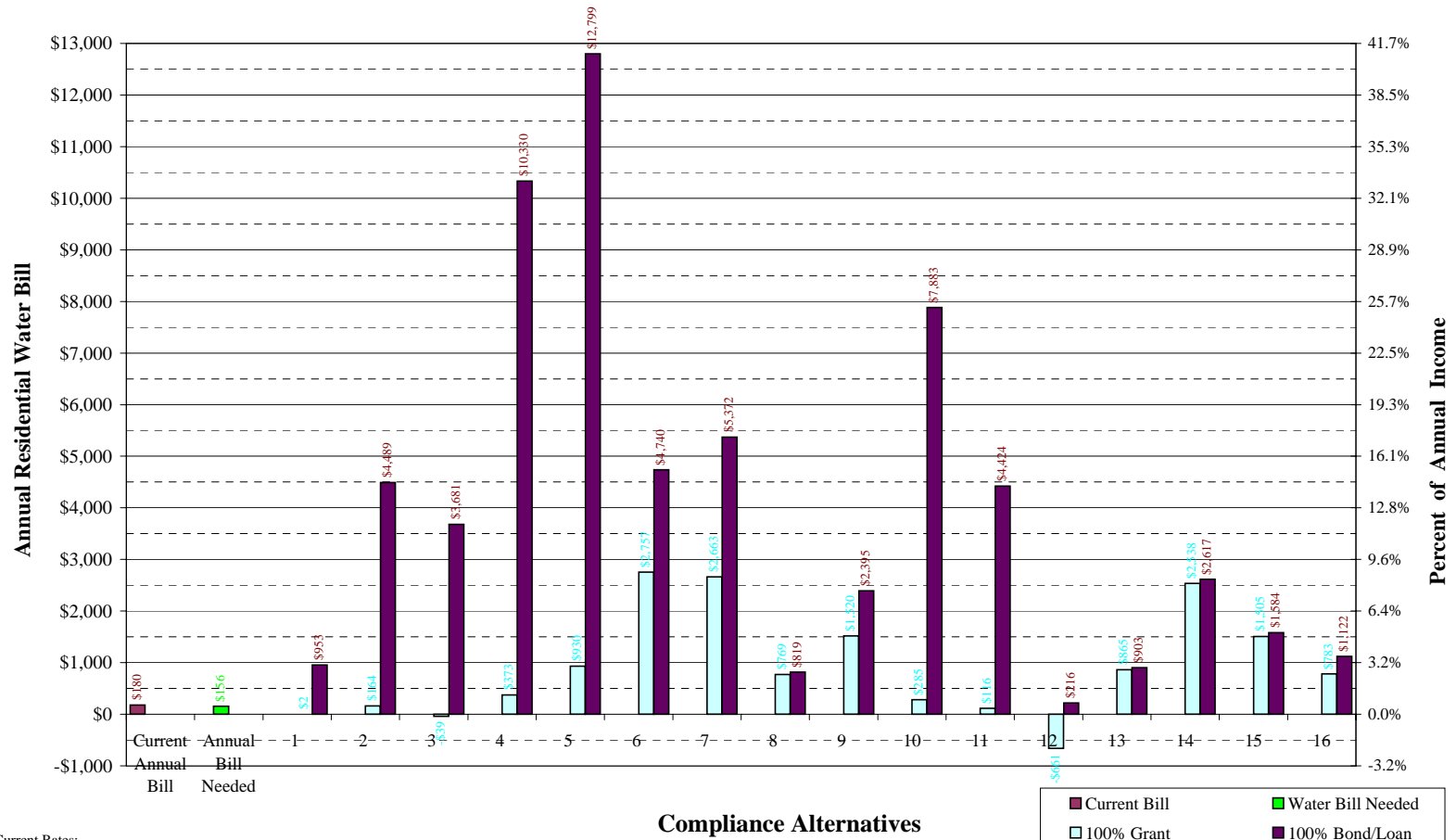
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Table 4.4 Financial Impact on Households for Devilla Mobile Home Park

	Funding Source #	0	1	2	3	4	5
		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Loan/Bond
ALTERNATIVES							
DM-1	% of HH Income	39%	1%	1%	3%	5%	6%
	Rate Increase %	6723%	0%	146%	410%	811%	938%
	Year	2005	2005	2005	2005	2005	2005
DM-2	% of HH Income	178%	1%	8%	14%	25%	28%
	Rate Increase %	30684%	6%	1207%	2408%	4231%	4811%
	Year	2005	2005	2005	2005	2005	2005
DM-3	% of HH Income	153%	1%	6%	12%	21%	24%
	Rate Increase %	26385%	0%	892%	1925%	3492%	3992%
	Year	2005	2005	2005	2005	2005	2005
DM-4	% of HH Income	410%	2%	18%	34%	58%	66%
	Rate Increase %	70804%	237%	3003%	5769%	9965%	11301%
	Year	2005	2005	2005	2005	2005	2005
DM-5	% of HH Income	490%	6%	25%	44%	73%	82%
	Rate Increase %	84689%	856%	4153%	7450%	12451%	14044%
	Year	2005	2005	2005	2005	2005	2005
DM-6	% of HH Income	90%	17%	20%	24%	28%	30%
	Rate Increase %	15499%	2886%	3437%	3988%	4824%	5090%
	Year	2005	2005	2005	2005	2005	2005
DM-7	% of HH Income	120%	17%	21%	25%	32%	34%
	Rate Increase %	20603%	2782%	3534%	4287%	5429%	5792%
	Year	2005	2005	2005	2005	2005	2005
DM-8	% of HH Income	4%	4%	5%	5%	5%	5%
	Rate Increase %	678%	678%	692%	706%	727%	734%
	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							
DM-9	% of HH Income	41%	9%	11%	12%	14%	15%
	Rate Increase %	6939%	1512%	1755%	1998%	2367%	2484%
	Year	2005	2005	2005	2005	2005	2005
DM-10	% of HH Income	313%	1%	14%	26%	44%	50%
	Rate Increase %	54001%	140%	2251%	4361%	7563%	8583%
	Year	2005	2005	2005	2005	2005	2005
DM-11	% of HH Income	177%	1%	7%	14%	25%	28%
	Rate Increase %	30558%	0%	1149%	2346%	4160%	4738%
	Year	2005	2005	2005	2005	2005	2005
DM-12	% of HH Income	36%	1%	1%	2%	3%	3%
	Rate Increase %	6200%	0%	90%	212%	397%	488%
	Year	2005	2005	2005	2005	2005	2005
DM-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
DM-14	% of HH Income	16%	16%	16%	16%	16%	16%
	Rate Increase %	2643%	2643%	2665%	2687%	2720%	2731%
	Year	2005	2005	2005	2005	2005	2005
DM-15	% of HH Income	9%	9%	9%	9%	10%	10%
	Rate Increase %	1496%	1496%	1518%	1540%	1573%	1583%
	Year	2005	2005	2005	2005	2005	2005
DM-16	% of HH Income	16%	5%	5%	6%	7%	7%
	Rate Increase %	2724%	694%	788%	882%	1025%	1071%
	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

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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 | <input type="checkbox"/> | NO | <input type="checkbox"/> |
| A source water protection plan? | | | |
| YES | <input type="checkbox"/> | NO | <input type="checkbox"/> |
| | | N/A | <input type="checkbox"/> |
| An emergency plan? | | | |
| YES | <input type="checkbox"/> | NO | <input type="checkbox"/> |
| A cross-connection control program? | | | |
| YES | <input type="checkbox"/> | NO | <input type="checkbox"/> |
| An emergency source? | | | |
| YES | <input type="checkbox"/> | NO | <input type="checkbox"/> |
| System security measures? | | | |
| YES | <input type="checkbox"/> | NO | <input type="checkbox"/> |
21. Does the system report and maintain records in accordance with the drinking water regulations concerning:
- | | | | |
|--------------------------|--------------------------|----|--------------------------|
| Water quality violations | | | |
| YES | <input type="checkbox"/> | NO | <input type="checkbox"/> |
| Public notification | | | |
| YES | <input type="checkbox"/> | NO | <input type="checkbox"/> |
| Sampling exemptions | | | |
| YES | <input type="checkbox"/> | NO | <input type="checkbox"/> |
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.

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

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

Table B.1
Summary of General Data
Devilla Mobile Home Park
PWS #0680069
General PWS Information

Service Population	56	Number of Connections	23
Total PWS Daily Water Usage	0.006 (mgd)	Source	2005 Report

Unit Cost Data
West Texas

General Items		Unit	Unit Cost	Central Treatment Unit Costs		Unit	Unit Cost
Treated water purchase cost		<i>See alternative</i>		Site preparation		acre	\$ 4,000
Water purchase cost (trucked)		\$/1,000 gals	\$ 1.80	Slab		CY	\$ 1,000
				Building		SF	\$ 60
Contingency		20%	n/a	Building electrical		SF	\$ 8.00
Engineering & Constr. Management		25%	n/a	Building plumbing		SF	\$ 8.00
Procurement/admin (POU/POE)		20%	n/a	Heating and ventilation		SF	\$ 7.00
				Fence		LF	\$ 15
				Paving		SF	\$ 2.00
Pipeline Unit Costs		Unit	Unit Cost	Electrical, RO		JOB	\$ 50,000
PVC water line, Class 200, 04"		LF	\$ 26	Electrical, EDR		JOB	\$ 50,000
Bore and encasement, 10"		LF	\$ 60	Piping, RO		JOB	\$ 20,000
Open cut and encasement, 10"		LF	\$ 30	Piping, EDR		JOB	\$ 20,000
Gate valve and box, 04"		EA	\$ 340	RO package		UNIT	\$ 88,000
Air valve		EA	\$ 1,000	EDR package		UNIT	\$ 250,000
Flush valve		EA	\$ 750	Transfer pumps (5 hp)		EA	\$ 5,000
Metal detectable tape		LF	\$ 0.15	Permeate tank		GAL	\$ 3.00
				Backwash tank		GAL	\$ 2.00
Bore and encasement, length		Feet	200	Mixer on tank		EA	\$ 15,000
Open cut and encasement, length		Feet	50	Salt feeder		EA	\$ 20,000
				Tank, 20,000 GAL		GAL	\$ 1.00
Pump Station Unit Costs		Unit	Unit Cost	Tank, 10,000 GAL		GAL	\$ 1.50
Pump		EA	\$ 7,500	Excavation		CYD	\$ 3.00
Pump Station Piping, 04"		EA	\$ 4,000	Compacted fill		CYD	\$ 7.00
Gate valve, 04"		EA	\$ 370	Lining		SF	\$ 0.50
Check valve, 04"		EA	\$ 430	Vegetation		SY	\$ 1.00
Electrical/instrumentation		EA	\$ 10,000	Access road		LF	\$ 30
Site work		EA	\$ 2,000	Reject water haul truck		EA	\$ 100,000
Building pad		EA	\$ 4,000	Access road		LF	\$ 30
Pump Building		EA	\$ 10,000	Reject water haul truck		EA	\$ 100,000
Fence		EA	\$ 5,870				
Tools		EA	\$ 1,000				
				Building Power		kwh/yr	\$ 0.128
Well Installation Unit Costs		Unit	Unit Cost	Equipment power		kwh/yr	\$ 0.128
Well installation		<i>See alternative</i>		Labor		hr	\$ 40
Water quality testing		EA	\$ 1,500	RO Materials		year	\$ 3,000
Well pump		EA	\$ 7,500	EDR Materials		year	\$ 3,000
Well electrical/instrumentation		EA	\$ 5,000	Chemicals, RO		year	\$ 1,500
Well cover and base		EA	\$ 3,000	Chemicals, EDR		year	\$ 1,500
Piping		EA	\$ 2,500	Analyses		test	\$ 200
Storage Tank - 5,000 gals		EA	\$ 7,025	Haul reject water		miles	1.0
				Truck rental		day	\$ 700
Electrical Power		\$/kWH	\$ 0.128	Mileage		mile	\$ 1.00
Building Power		kWH	11,800	Disposal fee		gal	\$ 5.00
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				

1 **APPENDIX C**
2 **COMPLIANCE ALTERNATIVE CONCEPTUAL COST ESTIMATES**

3 This appendix presents the conceptual cost estimates developed for the compliance
4 alternatives. The conceptual cost estimates are given in Tables C.1 through C.16. The
5 cost estimates are conceptual in nature (+50%/-30%), and are intended for making
6 comparisons between compliance options and to provide a preliminary indication of
7 possible water rate impacts. Consequently, these costs are pre-planning level and should
8 not be viewed as final estimated costs for alternative implementation.

Table C.1

PWS Name *Devilla Mobile Home Park*
Alternative Name *New Well at Canyon Dam*
Alternative Number *DM-1*

Distance from PWS to new well location 0.72 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
<i>Pipeline Construction</i>				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	5	n/a	n/a	n/a
PVC water line, Class 200, 04"	3,827	LF	\$ 26	\$ 99,502
Bore and encasement, 10"	-	LF	\$ 60	\$ -
Open cut and encasement, 10"	250	LF	\$ 30	\$ 7,500
Gate valve and box, 04"	1	EA	\$ 340	\$ 260
Air valve	1	EA	\$ 1,000	\$ 1,000
Flush valve	1	EA	\$ 750	\$ 574
Metal detectable tape	3,827	LF	\$ 0.15	\$ 574
Subtotal				\$ 109,410

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 **\$ 199,145**

Contingency 20% \$ 39,829
 Design & Constr Management 25% \$ 49,786

TOTAL CAPITAL COSTS **\$ 288,761**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Pipeline O&M</i>				
Pipeline O&M	0.7	mile	\$ 200	\$ 145
Subtotal				\$ 145

Pump Station(s) O&M

Building Power	11,800	kWH	\$ 0.128	\$ 1,510
Pump Power	8,950	kWH	\$ 0.128	\$ 1,146
Materials	1	EA	\$ 1,200	\$ 1,200
Labor	365	Hrs	\$ 30	\$ 10,950
Tank O&M	1	EA	\$ 1,000	\$ 1,000
Subtotal				\$ 15,806

Well O&M

Pump power	230	kWH	\$ 0.128	\$ 29
Well O&M matl	1	EA	\$ 1,200	\$ 1,200
Well O&M labor	180	Hrs	\$ 30	\$ 5,400
Subtotal				\$ 6,629

O&M Credit for Existing Well Closure

Pump power	230	kWH	\$ 0.128	\$ (29)
Well O&M matl	4	EA	\$ 1,200	\$ (4,800)
Well O&M labor	720	Hrs	\$ 30	\$ (21,600)
Subtotal				\$ (26,429)

TOTAL ANNUAL O&M COSTS **\$ (3,849)**

Table C.2

PWS Name *Devilla Mobile Home Park*
Alternative Name *New Well at DEFS - Caprock & Weatherford*
Alternative Number *DM-2*

Distance from PWS to new well location 5.10 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
<i>Pipeline Construction</i>				
Number of Crossings, bore	5	n/a	n/a	n/a
Number of Crossings, open cut	27	n/a	n/a	n/a
PVC water line, Class 200, 04"	26,936	LF	\$ 26	\$ 700,336
Bore and encasement, 10"	1,000	LF	\$ 60	\$ 60,000
Open cut and encasement, 10"	1,350	LF	\$ 30	\$ 40,500
Gate valve and box, 04"	5	EA	\$ 340	\$ 1,832
Air valve	5	EA	\$ 1,000	\$ 5,000
Flush valve	5	EA	\$ 750	\$ 4,040
Metal detectable tape	26,936	LF	\$ 0.15	\$ 4,040
Subtotal				\$ 815,748

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 **\$ 905,483**

Contingency 20% \$ 181,097
 Design & Constr Management 25% \$ 226,371

TOTAL CAPITAL COSTS **\$ 1,312,951**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Pipeline O&M</i>				
Pipeline O&M	5.1	mile	\$ 200	\$ 1,020
Subtotal				\$ 1,020

Pump Station(s) O&M

Building Power	11,800	kWH	\$ 0.128	\$ 1,510
Pump Power	32,250	kWH	\$ 0.128	\$ 4,128
Materials	1	EA	\$ 1,200	\$ 1,200
Labor	365	Hrs	\$ 30	\$ 10,950
Tank O&M	1	EA	\$ 1,000	\$ 1,000
Subtotal				\$ 18,788

Well O&M

Pump power	230	kWH	\$ 0.128	\$ 29
Well O&M matl	1	EA	\$ 1,200	\$ 1,200
Well O&M labor	180	Hrs	\$ 30	\$ 5,400
Subtotal				\$ 6,629

O&M Credit for Existing Well Closure

Pump power	230	kWH	\$ 0.128	\$ (29)
Well O&M matl	4	EA	\$ 1,200	\$ (4,800)
Well O&M labor	720	Hrs	\$ 30	\$ (21,600)
Subtotal				\$ (26,429)

TOTAL ANNUAL O&M COSTS **\$ -**

Table C.3

PWS Name *Devilla Mobile Home Park*
Alternative Name *Purchase Water from City of Odessa*
Alternative Number *DM-3*

Distance from Alternative to PWS (along pipe) 4.6 miles
Total PWS annual water usage 2.044 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
<i>Pipeline Construction</i>				
Number of Crossings, bore	6	n/a	n/a	n/a
Number of Crossings, open cut	4	n/a	n/a	n/a
PVC water line, Class 200, 04"	24,351	LF	\$ 26.00	\$ 633,126
Bore and encasement, 10"	1,200	LF	\$ 60.00	\$ 72,000
Open cut and encasement, 10"	200	LF	\$ 30.00	\$ 6,000
Gate valve and box, 04"	5	EA	\$ 340.00	\$ 1,656
Air valve	5	EA	\$ 1,000.00	\$ 5,000
Flush valve	5	EA	\$ 750.00	\$ 3,653
Metal detectable tape	24,351	LF	\$ 0.15	\$ 3,653
Subtotal				\$ 725,087

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 **\$ 778,822**

Contingency 20% \$ 155,764
Design & Constr Management 25% \$ 194,706

TOTAL CAPITAL COSTS **\$ 1,129,292**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Pipeline O&M</i>				
Pipeline O&M	4.6	mile	\$ 200	\$ 922
Subtotal				\$ 922
<i>Water Purchase Cost</i>				
From Source	2,044	1,000 gal	\$ 1.60	\$ 3,270
Subtotal				\$ 3,270

Pump Station(s) O&M

Building Power	11,800	kWH	\$ 0.128	\$ 1,510
Pump Power	21,500	kWH	\$ 0.128	\$ 2,752
Materials	1	EA	\$ 1,200	\$ 1,200
Labor	365	Hrs	\$ 30	\$ 10,950
Tank O&M	1	EA	\$ 1,000	\$ 1,000
Subtotal				\$ 17,412

O&M Credit for Existing Well Closure

Pump power	230	kWH	\$ 0.128	\$ (29)
Well O&M matl	4	EA	\$ 1,200	\$ (4,800)
Well O&M labor	720	Hrs	\$ 30	\$ (21,600)
Subtotal				\$ (26,429)

TOTAL ANNUAL O&M COSTS **\$ (4,824)**

Table C.4

PWS Name *Devilla Mobile Home Park*
Alternative Name *New Well at Midland International Airport*
Alternative Number *DM-4*

Distance from PWS to new well location 13.49 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
<i>Pipeline Construction</i>				
Number of Crossings, bore	5	n/a	n/a	n/a
Number of Crossings, open cut	29	n/a	n/a	n/a
PVC water line, Class 200, 04"	71,249	LF	\$ 26	\$ 1,852,474
Bore and encasement, 10"	1,000	LF	\$ 60	\$ 60,000
Open cut and encasement, 10"	1,450	LF	\$ 30	\$ 43,500
Gate valve and box, 04"	14	EA	\$ 340	\$ 4,845
Air valve	13	EA	\$ 1,000	\$ 13,000
Flush valve	14	EA	\$ 750	\$ 10,687
Metal detectable tape	71,249	LF	\$ 0.15	\$ 10,687
Subtotal				\$ 1,995,194

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 **\$ 2,084,929**

Contingency 20% \$ 416,986
Design & Constr Management 25% \$ 521,232

TOTAL CAPITAL COSTS **\$ 3,023,147**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Pipeline O&M</i>				
Pipeline O&M	13.5	mile	\$ 200	\$ 2,699
Subtotal				\$ 2,699

Pump Station(s) O&M

Building Power	11,800	KWH	\$ 0.128	\$ 1,510
Pump Power	57,750	KWH	\$ 0.128	\$ 7,392
Materials	1	EA	\$ 1,200	\$ 1,200
Labor	365	Hrs	\$ 30	\$ 10,950
Tank O&M	1	EA	\$ 1,000	\$ 1,000
Subtotal				\$ 22,052

Well O&M

Pump power	230	KWH	\$ 0.128	\$ 29
Well O&M matl	1	EA	\$ 1,200	\$ 1,200
Well O&M labor	180	Hrs	\$ 30	\$ 5,400
Subtotal				\$ 6,629

O&M Credit for Existing Well Closure

Pump power	230	KWH	\$ 0.128	\$ (29)
Well O&M matl	4	EA	\$ 1,200	\$ (4,800)
Well O&M labor	720	Hrs	\$ 30	\$ (21,600)
Subtotal				\$ (26,429)

TOTAL ANNUAL O&M COSTS **\$ 4,951**

Table C.5

PWS Name *Devilla Mobile Home Park*
Alternative Name *Purchase Water from City of Midland*
Alternative Number *DM-5*

Distance from Alternative to PWS (along pipe) 16.2 miles
Total PWS annual water usage 2.044 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
<i>Pipeline Construction</i>				
Number of Crossings, bore	8	n/a	n/a	n/a
Number of Crossings, open cut	8	n/a	n/a	n/a
PVC water line, Class 200, 04"	85,471	LF	\$ 26.00	\$ 2,222,246
Bore and encasement, 10"	1,600	LF	\$ 60.00	\$ 96,000
Open cut and encasement, 10"	400	LF	\$ 30.00	\$ 12,000
Gate valve and box, 04"	17	EA	\$ 340.00	\$ 5,812
Air valve	16	EA	\$ 1,000.00	\$ 16,000
Flush valve	17	EA	\$ 750.00	\$ 12,821
Metal detectable tape	85,471	LF	\$ 0.15	\$ 12,821
Subtotal				\$ 2,377,699

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 **\$ 2,485,169**

Contingency 20% \$ 497,034
Design & Constr Management 25% \$ 621,292

TOTAL CAPITAL COSTS **\$ 3,603,496**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Pipeline O&M</i>				
Pipeline O&M	16.2	mile	\$ 200	\$ 3,238
Subtotal				\$ 3,238
<i>Water Purchase Cost</i>				
From Source	2,044	1,000 gal	\$ 1.65	\$ 3,373
Subtotal				\$ 3,373

Pump Station(s) O&M

Building Power	23,600	kWH	\$ 0.128	\$ 3,021
Pump Power	67,800	kWH	\$ 0.128	\$ 8,678
Materials	2	EA	\$ 1,200	\$ 2,400
Labor	730	Hrs	\$ 30	\$ 21,900
Tank O&M	2	EA	\$ 1,000	\$ 2,000
Subtotal				\$ 37,999

O&M Credit for Existing Well Closure

Pump power	230	kWH	\$ 0.128	\$ (29)
Well O&M matl	4	EA	\$ 1,200	\$ (4,800)
Well O&M labor	720	Hrs	\$ 30	\$ (21,600)
Subtotal				\$ (26,429)

TOTAL ANNUAL O&M COSTS **\$ 18,180**

Table C.6

PWS Name *Devilla Mobile Home Park*
Alternative Name *Central Treatment - RO*
Alternative Number *DM-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	\$ 88,000	\$ 88,000
Transfer pumps (5 hp)	2	EA	\$ 5,000	\$ 10,000
Permeate tank	20,000	GAL	\$ 3.00	\$ 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				\$ 346,375
Contingency	20%			69,275
Design & CM	25%			86,594
Reject water haul truck	1	EA	\$ 100,000	\$ 100,000
Total				602,244

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	1500	kwh/yr	\$ 0.128	\$ 192
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				\$ 50,452
Backwash Disposal				
Mileage	10,000	miles	\$ 1.00	\$ 10,000
Disposal fee	223	kgal/yr	\$ 5.00	\$ 1,115
Subtotal				\$ 11,115
Total				\$ 61,567

Table C.7

PWS Name *Devilla Mobile Home Park*
Alternative Name *Central Treatment - EDR*
Alternative Number *DM-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	\$ 250,000	\$ 250,000
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				\$ 498,375
Contingency	20%			99,675
Design & CM	25%			124,594
Reject water haul truck	1	EA	\$ 100,000	\$ 100,000
Total				\$ 822,644

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
Building Power	9,000	kwh/yr	0.128	\$ 1,152
Equipment power	3000	kwh/yr	0.128	\$ 384
Labor	1,000	hrs/yr	40	\$ 40,000
Materials	1	year	3000	\$ 3,000
Chemicals	1	year	1500	\$ 1,500
Analyses	24	test	200	\$ 4,800
Subtotal				\$ 50,836
Backwash Disposal				
Mileage	8000	miles	\$ 1.00	\$ 8,000
Disposal fee	100	kgal/yr	\$ 5.00	\$ 500
Subtotal				\$ 8,500

Total**\$ 59,336**

Table C.8

PWS Name *Devilla Mobile Home Park*
Alternative Name *Point-of-Use Treatment*
Alternative Number *DM-8*

Number of Connections for POU Unit Installation 23

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>POU-Treatment - Purchase/Installation</i>				
POU treatment unit purchase	23	EA	\$ 250	\$ 5,750
POU treatment unit installation	23	EA	\$ 150	\$ 3,450
Subtotal				\$ 9,200
Subtotal of Component Costs				\$ 9,200
Contingency	20%			\$ 1,840
Design & Constr Management	25%			\$ 2,300
Procurement & Administration	20%			\$ 1,840
TOTAL CAPITAL COSTS				\$ 15,180

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>O&M</i>				
POU materials, per unit	23	EA	\$ 225	\$ 5,175
Contaminant analysis, 1/yr per unit	23	EA	\$ 100	\$ 2,300
Program labor, 10 hrs/unit	230	hrs	\$ 30	\$ 6,900
Subtotal				\$ 14,375
TOTAL ANNUAL O&M COSTS				\$ 14,375

Table C.9

PWS Name *Devilla Mobile Home Park*
Alternative Name *Point-of-Entry Treatment*
Alternative Number *DM-9*

Number of Connections for POE Unit Installation 23

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>POE-Treatment - Purchase/Installation</i>				
POE treatment unit purchase	23	EA	\$ 3,000	\$ 69,000
Pad and shed, per unit	23	EA	\$ 2,000	\$ 46,000
Piping connection, per unit	23	EA	\$ 1,000	\$ 23,000
Electrical hook-up, per unit	23	EA	\$ 1,000	\$ 23,000
Subtotal				\$ 161,000

Subtotal of Component Costs **\$ 161,000**

Contingency	20%	\$ 32,200
Design & Constr Management	25%	\$ 40,250
Procurement & Administration	20%	\$ 32,200

TOTAL CAPITAL COSTS **\$ 265,650**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>O&M</i>				
POE materials, per unit	23	EA	\$ 1,000	\$ 23,000
Contaminant analysis, 1/yr per unit	23	EA	\$ 100	\$ 2,300
Program labor, 10 hrs/unit	230	hrs	\$ 30	\$ 6,900
Subtotal				\$ 32,200

TOTAL ANNUAL O&M COSTS **\$ 32,200**

Table C.10

PWS Name *Devilla Mobile Home Park*
Alternative Name *New Well at 10 Miles*
Alternative Number *DM-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
<i>Pipeline Construction</i>				
Number of Crossings, bore	6	n/a	n/a	n/a
Number of Crossings, open cut	18	n/a	n/a	n/a
PVC water line, Class 200, 04"	52,800	LF	\$ 26	\$ 1,372,800
Bore and encasement, 10"	1,200	LF	\$ 60	\$ 72,000
Open cut and encasement, 10"	900	LF	\$ 30	\$ 27,000
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				\$ 1,501,230

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 \$ 1,590,965

Contingency 20% \$ 318,193
 Design & Constr Management 25% \$ 397,741

TOTAL CAPITAL COSTS \$ 2,306,900**Annual Operations and Maintenance Costs**

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Pipeline O&M</i>				
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	46,922	kWH	\$ 0.128	\$ 6,006
Materials	1	EA	\$ 1,200	\$ 1,200
Labor	365	Hrs	\$ 30	\$ 10,950
Tank O&M	1	EA	\$ 1,000	\$ 1,000
Subtotal				\$ 20,666

Well O&M

Pump power	230	kWH	\$ 0.128	\$ 29
Well O&M matl	1	EA	\$ 1,200	\$ 1,200
Well O&M labor	180	Hrs	\$ 30	\$ 5,400
Subtotal				\$ 6,629

O&M Credit for Existing Well Closure

Pump power	230	kWH	\$ 0.128	\$ (29)
Well O&M matl	4	EA	\$ 1,200	\$ (4,800)
Well O&M labor	720	Hrs	\$ 30	\$ (21,600)
Subtotal				\$ (26,429)

TOTAL ANNUAL O&M COSTS \$ 2,866

Table C.11

PWS Name *Devilla Mobile Home Park*
Alternative Name *New Well at 5 Miles*
Alternative Number *DM-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
<i>Pipeline Construction</i>				
Number of Crossings, bore	3	n/a	n/a	n/a
Number of Crossings, open cut	9	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
<i>Pipeline O&M</i>				
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	23,461	kWH	\$ 0.128	\$ 3,003
Materials	1	EA	\$ 1,200	\$ 1,200
Labor	365	Hrs	\$ 30	\$ 10,950
Tank O&M	1	EA	\$ 1,000	\$ 1,000
Subtotal				\$ 17,663

Well O&M

Pump power	230	kWH	\$ 0.128	\$ 29
Well O&M matl	1	EA	\$ 1,200	\$ 1,200
Well O&M labor	180	Hrs	\$ 30	\$ 5,400
Subtotal				\$ 6,629

O&M Credit for Existing Well Closure

Pump power	230	kWH	\$ 0.128	\$ (29)
Well O&M matl	4	EA	\$ 1,200	\$ (4,800)
Well O&M labor	720	Hrs	\$ 30	\$ (21,600)
Subtotal				\$ (26,429)

TOTAL ANNUAL O&M COSTS **\$ (1,137)**

Table C.12

PWS Name *Devilla Mobile Home Park*
Alternative Name *New Well at 1 Mile*
Alternative Number *DM-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
<i>Pipeline Construction</i>				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	2	n/a	n/a	n/a
PVC water line, Class 200, 04"	5,280	LF	\$ 26	\$ 137,280
Bore and encasement, 10"	200	LF	\$ 60	\$ 12,000
Open cut and encasement, 10"	100	LF	\$ 30	\$ 3,000
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				\$ 155,223

Pump Station(s) Installation

Pump	-	EA	\$ 7,500	\$ -
Pump Station Piping, 04"	-	EA	\$ 4,000	\$ -
Gate valve, 04"	-	EA	\$ 370	\$ -
Check valve, 04"	-	EA	\$ 430	\$ -
Electrical/Instrumentation	-	EA	\$ 10,000	\$ -
Site work	-	EA	\$ 2,000	\$ -
Building pad	-	EA	\$ 4,000	\$ -
Pump Building	-	EA	\$ 10,000	\$ -
Fence	-	EA	\$ 5,870	\$ -
Tools	-	EA	\$ 1,000	\$ -
Storage Tank - 5,000 gals	-	EA	\$ 7,025	\$ -
Subtotal				\$ -

Well Installation

Well installation	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 **\$ 183,723**

Contingency 20% \$ 36,745
 Design & Constr Management 25% \$ 45,931

TOTAL CAPITAL COSTS **\$ 266,398**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Pipeline O&M</i>				
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	230	kWH	\$ 0.128	\$ 29
Well O&M matl	1	EA	\$ 1,200	\$ 1,200
Well O&M labor	180	Hrs	\$ 30	\$ 5,400
Subtotal				\$ 6,629

O&M Credit for Existing Well Closure

Pump power	230	kWH	\$ 0.128	\$ (29)
Well O&M matl	4	EA	\$ 1,200	\$ (4,800)
Well O&M labor	720	Hrs	\$ 30	\$ (21,600)
Subtotal				\$ (26,429)

TOTAL ANNUAL O&M COSTS **\$ (19,600)**

Table C.13

PWS Name *Devilla Mobile Home Park*
Alternative Name *Public Dispenser for Treated Drinking Water*
Alternative Number *DM-13*

Number of Treatment Units Recommended 1

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Public Dispenser Unit Installation</i>				
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 Manager 25% \$ 2,000

TOTAL CAPITAL COSTS **11,600**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Program Operation</i>				
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 *Devilla Mobile Home Park*
Alternative Name *Supply Bottled Water to Population*
Alternative Number *DM-14*

Service Population 56
Percentage of population requiring supply 100%
Water consumption per person 1.00 gpcd
Calculated annual potable water needs 20,440 gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Program Implementation</i>				
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
<i>Program Operation</i>				
Water purchase costs	20,440	gals	\$ 1.60	\$ 32,704
Program admin, 9 hrs/wk	468	hours	\$ 40	\$ 18,673
Program materials	1	EA	\$ 5,000	\$ 5,000
Subtotal				\$ 56,377
TOTAL ANNUAL O&M COSTS				\$ 56,377

Table C.15

PWS Name *Devilla Mobile Home Park*
Alternative Name *Supply Bottled Water to Population*
Alternative Number *DM-14*

Service Population 56
Percentage of population requiring supply 25%
Water consumption per person 1.00 gpcd
Calculated annual potable water needs 5,110 gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Program Implementation</i>				
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
<i>Program Operation</i>				
Water purchase costs	5,110	gals	\$ 1.60	\$ 8,176
Program admin, 9 hrs/wk	468	hours	\$ 40	\$ 18,673
Program materials	1	EA	\$ 5,000	\$ 5,000
Subtotal				\$ 31,849
TOTAL ANNUAL O&M COSTS				\$ 31,849

Table C.16

PWS Name *Devilla Mobile Home Park*
Alternative Name *Central Trucked Drinking Water*
Alternative Number *DM-16*

Service Population 56
Percentage of population requiring supply 100%
Water consumption per person 1.00 gpcd
Calculated annual potable water needs 20,440 gallons
Travel distance to compliant water source (roundtrip) 2 miles

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Storage Tank Installation</i>				
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 Manageme	25%	\$ 17,756

TOTAL CAPITAL COSTS **\$ 102,986**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
<i>Program Operation</i>				
Water delivery labor, 4 hrs/wk	208	hrs	\$ 30	\$ 6,240
Truck operation, 1 round trip/wk	104	miles	\$ 1.00	\$ 104
Water purchase	20	1,000 gals	\$ 1.80	\$ 37
Water testing, 1 test/wk	52	EA	\$ 100	\$ 5,200
Sampling/reporting, 2 hrs/wk	104	hrs	\$ 30	\$ 3,120
Subtotal				\$ 14,701

TOTAL ANNUAL O&M COSTS **\$ 14,701**

1
2

APPENDIX D EXAMPLE FINANCIAL MODEL

Table D.1 Example Financial Model

Step 1

Water System: Devilla Mobile Home Park

Step 2

Click Here to Update Verification and Raw

Water System	Devilla Mobile Home Park		
Alternative Description	Central Treatment - RO		
Sum of Amount		Year	Funding Alternative
		2007	
Group	Type	100% Grant	Bond
Capital Expenditures	Capital Expenditures-Funded from Bonds	\$ -	\$ 602,244
	Capital Expenditures-Funded from Grants	\$ 602,244	\$ -
	Capital Expenditures-Funded from Revenue/Reserves	\$ -	\$ -
	Capital Expenditures-Funded from SRF Loans	\$ -	\$ -
Capital Expenditures Sum		\$ 602,244	\$ 602,244
Debt Service	Revenue Bonds	\$ -	\$ 47,112
	State Revolving Funds	\$ -	\$ -
Debt Service Sum		\$ -	\$ 47,112
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	Devilla Mobile Home Park	
Alt_Desc	Central Treatment - RO	
		Current_Year
Funding_Alt	Data	2007
100% Grant	Sum of Beginning_Cash_Bal	\$ 1,468
	Sum of Total_Expenditures	\$ 606,144
	Sum of Total_Receipts	\$ 606,519
	Sum of Net_Cash_Flow	\$ 375
	Sum of Ending_Cash_Bal	\$ 1,843
	Sum of Working_Cap	\$ -
	Sum of Repl_Resv	\$ 500
	Sum of Total_Reqd_Resv	\$ 500
	Sum of Net_Avail_Bal	\$ 1,343
	Sum of Add_Resv_Needed	\$ -
	Sum of Rate_Inc_Needed	0%
Sum of Percent_Rate_Increase	0%	
Bond	Sum of Beginning_Cash_Bal	\$ 1,468
	Sum of Total_Expenditures	\$ 653,256
	Sum of Total_Receipts	\$ 606,519
	Sum of Net_Cash_Flow	\$ (46,737)
	Sum of Ending_Cash_Bal	\$ (45,269)
	Sum of Working_Cap	\$ -
	Sum of Repl_Resv	\$ 500
	Sum of Total_Reqd_Resv	\$ 500
	Sum of Net_Avail_Bal	\$ (45,769)
	Sum of Add_Resv_Needed	\$ (45,769)
	Sum of Rate_Inc_Needed	1071%
	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 Kinniburgh 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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