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

ORBIT SYSTEMS, INC. – ROSHARON TOWNSHIP
PWS ID# 0200036, CCN# 11982

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 Rosharon Township PWS, located in Brazoria County. Samples for arsenic were below the previous MCL for arsenic of 50 micrograms per liter (μg/L), which was the MCL for arsenic at the time of sample collection; however; the arsenic concentrations were above the 10 μg/L MCL for arsenic effective beginning January 23, 2006 (USEPA 2005a; TCEQ 2004a). Therefore, it was likely that the Rosharon Township PWS would face potential compliance issues under the new standard.

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

Table ES.1
Rosharon PWS
Basic System Information

Population served	255
Connections	85
Average daily flow rate	0.022 million gallons per day (mgd)
Peak demand flow rate	61.1 gallons per minute (gpm)
Typical arsenic range	9.2 – 14.8 μg/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:

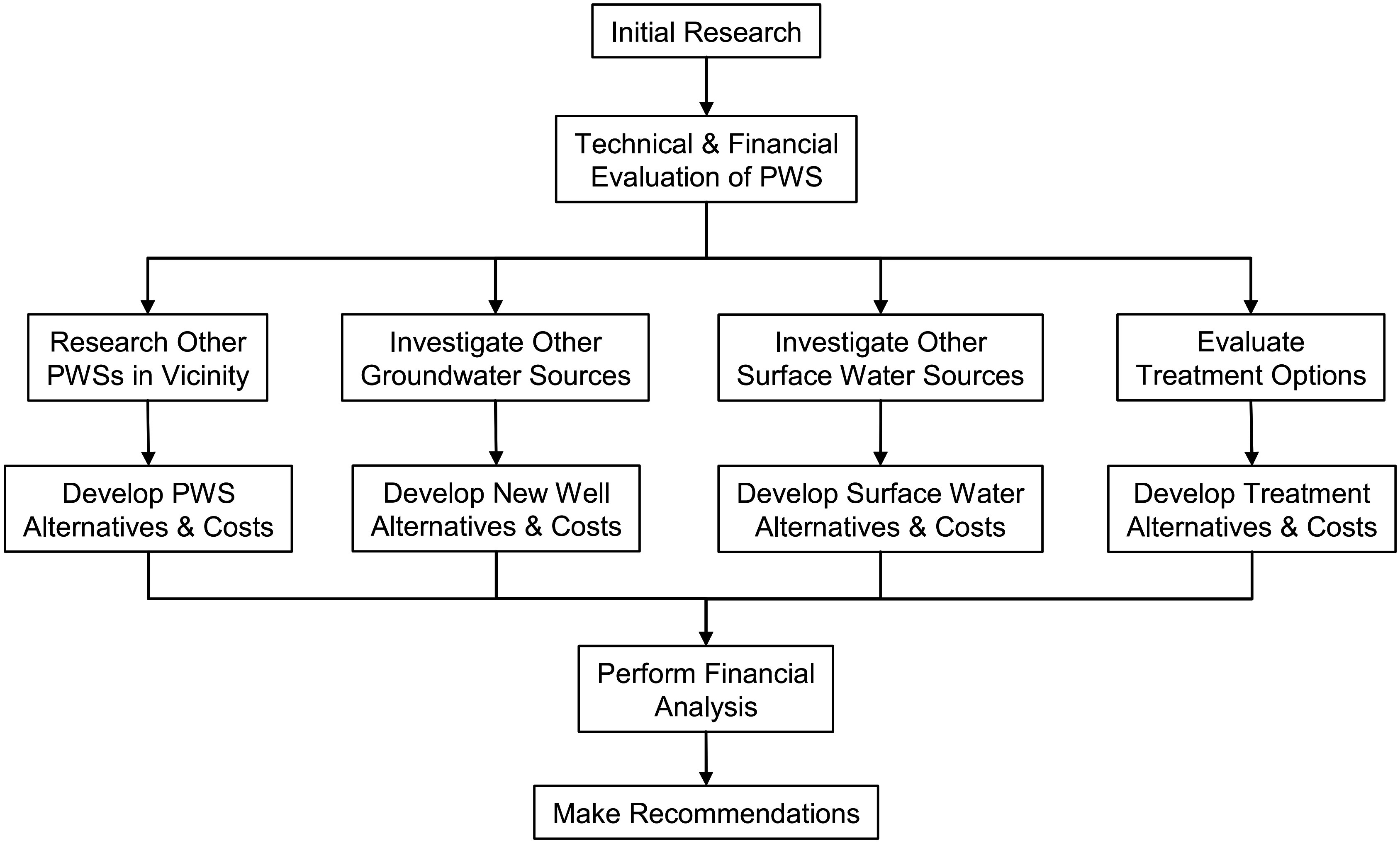
1. Gather data from the TCEQ and Texas Water Development Board databases, from TCEQ files, and from information maintained by the PWS;
2. Conduct financial, managerial, and technical (FMT) evaluations of the PWS;
3. Perform a geologic and hydrogeologic assessment of the study area;
4. Develop treatment 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 Rosharon Township PWS obtains groundwater from the Chicot subunit of the Gulf Coast aquifer. Arsenic is commonly found in area wells at concentrations greater than the MCL. Volcanic ash incorporated into the aquifer material may be the source of arsenic. Arsenic concentrations can vary significantly over relatively short distances; as a

Figure ES-1
Summary of Project Methods



result, there could be good quality groundwater nearby. However, the variability of arsenic concentrations makes it difficult to determine where wells can be located to produce acceptable water. Additionally, systems with more than one well should characterize the water quality of each well. If one of the wells is found to produce compliant water, as much production as possible should be shifted to that well as a method of achieving compliance. It may also be possible to do down-hole testing on non-compliant wells to determine the source of the contaminants. If the contaminants derive primarily from a single part of the formation, that part could be excluded by modifying the existing well, or avoided altogether by completing a new well.

COMPLIANCE ALTERNATIVES

The Rosharon Township PWS is managed by Orbit Systems, an investor-owned utility that manages 33 water systems in the region. Overall, the system had an adequate level of FMT capacity. The system had some areas that needed improvement to be able to address future compliance issues; however, the system does have many positive aspects, including staff longevity, good communication, in-house expertise, effective planning for system growth, the regional nature of the Orbit organization, and maintenance and use of up-to-date system maps. Areas of concern for the system included lack of regular training, lack of ventilation, alarms, and breathing apparatus for chlorine buildings, lack of budgeting for individual systems, lack of capital improvement planning, lack of emergency planning, and lack of independently audited financial reports.

There are several PWSs within 15 miles of Rosharon Township. Many of these nearby systems also have problems with arsenic, but there are several with good quality water. In general, feasibility alternatives were developed based on obtaining water from the nearest PWSs, either by directly purchasing water, or by expanding the existing well field. There is a minimum of surface water available in the area, and obtaining a new surface water source is considered through an alternative where treated surface water is obtained from the Brazosport Water Authority (BWA). In addition to the BWA, the City of Alvin is a potential large regional water supplier, and there are plans for the Gulf Coast Water Authority to build a surface water treatment plant in Fort Bend County that could potentially supply water to Rosharon Township.

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

Developing a new well close to Rosharon Township is likely to be the best solution if compliant groundwater can be found. Having a new well close to Rosharon 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 Rosharon Township PWS indicated that current water rates are under funding operations, and a rate increase of approximately 71.4 percent would be necessary to meet operating expenses. This increase would raise the average annual water bill from $252 to $432. The current average water bill represents approximately 0.5 percent of the median household income (MHI), and would represent approximately 0.9 percent of the MHI with the increase. Table ES.2 provides a summary of the financial impact of implementing selected compliance alternatives, including the rate increase necessary to meet current operating expenses. The alternatives were selected to highlight results for the best alternatives from each different type or category.

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

Table ES.2
Selected Financial Analysis Results

Alternative	Funding Option	Average Annual Water Bill	Percent of MHI
Current	NA	$252	0.5
To meet current expenses	NA	$432	0.9
Nearby well within approximately 1 mile	100% Grant	$865689	1.9
	Loan/Bond	$1,243	2.7
Central treatment	100% Grant	$1,699	3.8
	Loan/Bond	$2,191	4.9
Point-of-use	100% Grant	$1,653	3.7
	Loan/Bond	$1,726	3.9
Public dispenser	100% Grant	$1,018	2.2
	Loan/Bond	$1,033	2.3

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ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
BAT	Best available technology
BEG	Bureau of Economic Geology
BWA	Brazosport Water Authority
CA	Chemical analysis
CCN	Certificate of Convenience and Necessity
CFR	Code of Federal Regulations
CO	Correspondence
ETJ	Extra Territorial Jurisdiction
FMT	Financial, managerial, and technical
ft/mi	Foot per mile
HGCSD	Harris-Galveston Coastal Subsidence District
GAM	Groundwater Availability Model
gpm	Gallons per minute
gpm/ft^2	Gallons per minute per square foot
IX	Ion exchange
MCL	Maximum contaminant level
µg/L	Microgram per liter
mg/L	Milligram per liter
MGD	Million gallons per day
MHI	Median household income
MOR	Monthly operating report
MUD	Municipal utility district
NMEFC	New Mexico Environmental Finance Center
NURE	Natural Uranium Resource Evaluation
O&M	Operation and Maintenance
Parsons	Parsons Infrastructure & Technology, Inc.
POE	Point-of-entry
POU	Point-of-use
PSOC	Potential Sources of Contamination
PVC	Polyvinyl chloride
PWS	Public water system
RO	Reverse osmosis
SCBA	Self Contained Breathing Apparatus
SSCT	Small System Compliance Technology
TCEQ	Texas Commission on Environmental Quality
TDCJ	Texas Department of Criminal Justice
TDS	Total dissolved solids

TSS	Total suspended solids
TWDB	Texas Water Development Board
USEPA	U.S. Environmental Protection Agency
WAM	Water Availability Model
WC&ID	Water Control and Improvement District
WSC	Water Supply Corporation
WTP	Water Treatment Plant

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

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 Rosharon Township Water System, PWS ID# 0200036, Certificate of Convenience and Necessity (CCN) # 11982, located in Brazoria County. The Rosharon Township Water System has recorded arsenic concentrations of 10.5 micrograms per liter (µg/L) in 1998, 9.9 µg/L in 2001, 9.2 µg/L in 2003, and 14.8 µg/L in 2005, which are below the arsenic MCL of 50 µg/L in effect when these samples were collected. Although not currently a violation of the state (30 TAC Chapter 290) and federal (40 Code of Federal Regulations [CFR] Part 141) regulations, one of these measured values is above the arsenic MCL of 10 µg/L that goes into effect January 23, 2006 (USEPA 2005a; TCEQ 2004a). The location of the Rosharon Township Water System, also referred to as the "study area" in this report, is shown on Figure 1.1.

1.1 PUBLIC HEALTH AND COMPLIANCE WITH MCLS

The goal of this project is to promote compliance by PWSs that supply drinking water exceeding regulatory MCL. This project only addresses those contaminants and does not address any other violations that may exist for a PWS. As mentioned above, the Rosharon Township PWS has past sample results that exceed the MCL for arsenic that goes into effect January 23, 2006.

According to the U.S. Environmental Protection Agency (USEPA), potential health effects from long-term ingestion of water with levels of arsenic above the future MCL of 10 µg/L include non-cancerous effects, such as cardiovascular, pulmonary, immunological, neurological and endocrine effects, and cancerous effects, including skin, bladder, lung, kidney, nasal passage, liver and prostrate cancer (USEPA 2005b).

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.

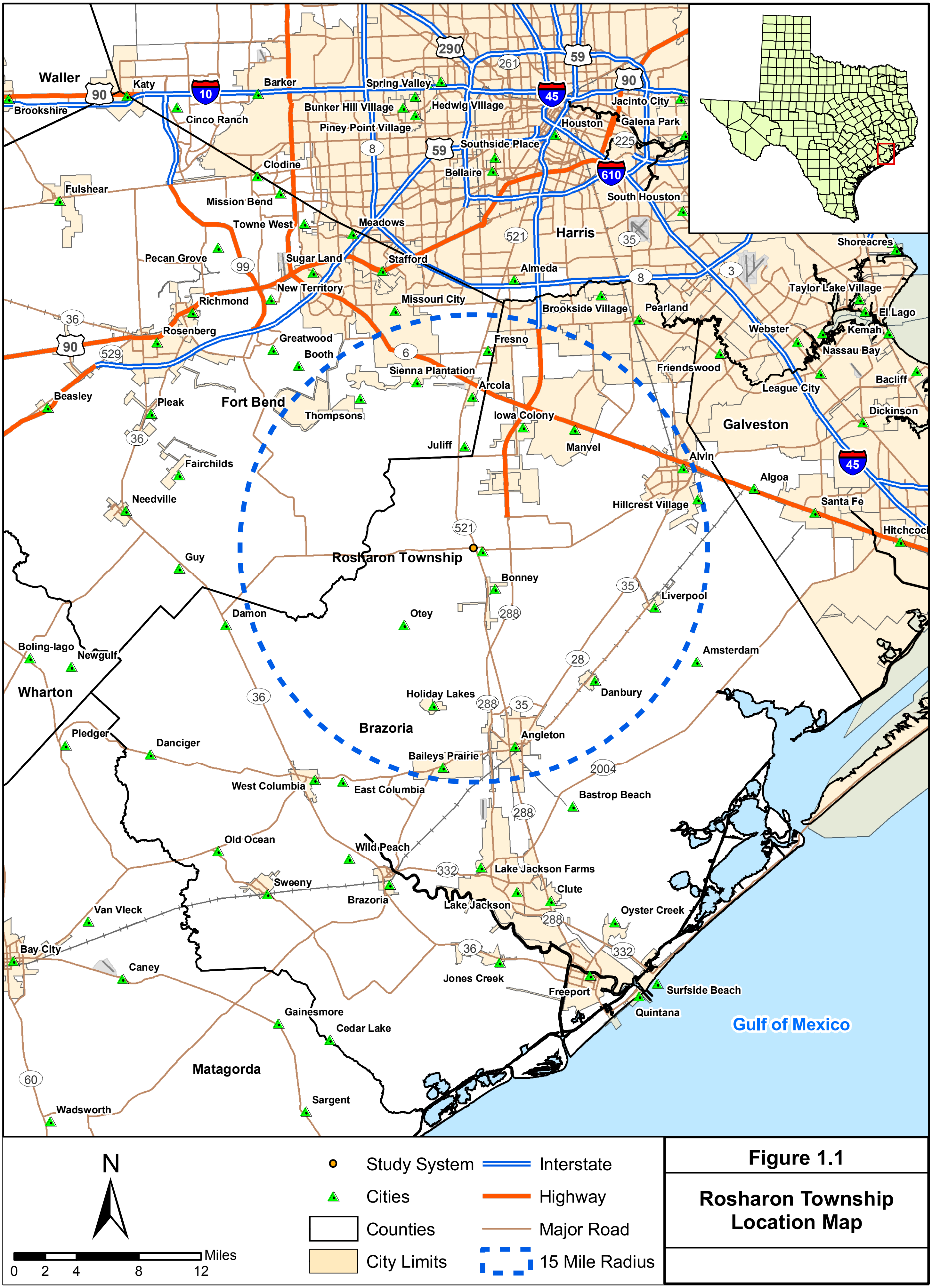

Figure 1.1

Rosharon Township Location Map

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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 compliance alternatives. Section 2 describes the methodology used to develop and assess compliance alternatives. The groundwater sources of arsenic are addressed in Section 3. Findings for the Rosharon Township water system, along with compliance alternatives development and evaluation, can be found in Section 4, and Section 5 references the sources used in this report.

1.3 REGULATORY PERSPECTIVE

The Utilities & Districts and Public Drinking Water Sections of the TCEQ Water Supply Division are responsible for implementing the federal Safe Drinking Water Act 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 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

Past analytical results for arsenic in drinking water suggests the PWS may be in violation of the state and federal regulations following compliance monitoring January 23, 2006. A PWS must take action to correct any non-compliance when it no longer meets the regulatory MCL. 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 supply water. 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, flow rate, 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 usage. Peak instantaneous demands can be met through proper sizing of storage facilities. Furthermore, 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 would need to find a potential supplier PWS that obtains its water from a different aquifer or from a surface water source. Additionally, a potential supplier PWS may treat non-compliant raw water to an acceptable level.

Surface water sources may offer a potential higher-quality source. Facilities for the treatment of surface water may be unreasonably expensive for smaller PWSs. Connecting to large neighboring PWSs or regional authorities, such as the Brazosport Water Authority (BWA), for treated surface water may be more cost effective.

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 non-compliant PWS. The current use of these wells may be for irrigation, industrial supply, domestic supply, stock watering, and other purposes. The process for investigating existing wells is as follows:

- Use existing data sources to identify wells in the areas that have satisfactory quality. For Brazoria County, the following standards could be used in a rough screening to identify compliant groundwater:
    - Arsenic concentrations less than 8 µg/L (below the MCL of 10 µg/L); and
    - Total dissolved solids (TDS) concentrations less than 1,000 milligram per liter (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 that have been used for industrial or irrigation purposes. Often the TWDB database includes 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. Owners are probably the best source of information regarding the latest test dates, who tested the water, flow rates, and other well characteristics.
- After collecting as much information as possible from cooperative owners, the PWS would then narrow down the selection of wells and sample and analyze the selected wells 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

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 water rights could possibly be purchased if they are available.

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, contracts, 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 water rights may be based on surface water availability maps located on the TWDB website. Where water rights appear to be available, the following activities need to occur:

- Discussions with TCEQ to indicate the likelihood of obtaining those rights. The TCEQ may use the Water Availability Model (WAM) to assist in the determination.
- Discussions with land owners to indicate potential treatment plant locations.
- Coordination with U.S. Army Corps of Engineers and local river authorities.

- Preliminary engineering design to determine the feasibility, costs, and environmental issues of a new intake, treatment plant, and conveyance system.

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

1.4.4 Identification of Treatment Technologies

Various treatment technologies were also investigated as compliance alternatives for treatment of arsenic to the regulatory MCL. Numerous options have been identified by the USEPA as best available technologies (BAT) for the non-compliant constituents. Identification and descriptions of the various BATs are provided in the following sections.

1.4.4.1 Treatment Technologies for Arsenic

In January 2001, the USEPA published a final rule in the Federal Register that established an MCL for arsenic of 10 µg/L (USEPA 2001). The regulation applies to all community water systems and non-transient, non-community water systems, regardless of size.

The new arsenic MCL of 10 µg/L becomes effective on January 23, 2006, at which time the running average annual arsenic level must be at or below 10 µg/L at each entry point to the distribution system, although point-of-use (POU) treatment can be instituted in place of centralized treatment. All groundwater systems must complete initial monitoring or have a State-approved waiver by December 31, 2007.

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

- Ion Exchange (IX);
- Reverse Osmosis (RO);
- Adsorption; and
- Coagulation/Filtration with Iron Removal.

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

- IX;
- RO (centralized and POU);
- Activated Alumina (AA) Adsorption; and
- Coagulation/Filtration, Enhanced Coagulation/Filtration, and Coagulation-Assisted Microfiltration.

1.4.5 Description of Treatment Technologies

According to a recent USEPA report for small water systems with less than 10,000 customers (EPA/600/R-05/001) a number of drinking water treatment technologies are available to reduce arsenic concentrations in source water to below the new MCL of 10 µg/L, including IX, membrane processes such as RO, adsorption, and coagulation/filtration-related processes. Many of the most effective arsenic removal processes available are iron-based treatment technologies such as chemical coagulation/filtration with iron salts, and adsorptive media with iron-based products. These processes are particularly effective at removing arsenic from aqueous systems because iron surfaces have a strong affinity for adsorbing arsenic. Other arsenic removal processes such as AA and enhanced lime softening are more applicable to larger water systems because of their operational complexity and cost. A description and discussion of arsenic removal technologies applicable to smaller systems follows.

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

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

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 wastes (in the form of broken resin beads) which are backwashed during regeneration; and if used, spent filters and backwash wastewater.

Advantages (IX)

- Well established process for arsenic removal.
- Fully automated and highly reliable process.
- Suitable for small and large installations.

Disadvantages (IX)

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

In considering the application of IX for removal of inorganics, 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. Sulfate competes with both nitrate and arsenic, but more aggressive with arsenic in anion exchange. Source waters with TDS levels above 500 mg/L or sulfate above 50 mg/L are not amenable to IX treatment for arsenic removal. Spent regenerant is produced during IX bed regeneration, and it may have high concentrations of the sorbed contaminants which would be expensive to treat and/or dispose because of hazardous waste regulations. Research has been conducted to minimize this effect. Recent research on arsenic removal shows that the brine can be reused as many as 25 times.

1.4.5.2 Reverse Osmosis

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

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

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

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

Advantages (RO)

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

Disadvantages (RO)

- Relatively expensive to install and operate.
- Need sophisticated monitoring systems.
- Need to handle multiple chemicals.
- Waste of water because of the significant concentrate flows.
- Concentrated disposal.

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

1.4.5.3 Adsorption

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

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

The Bayoxide® E33 media was developed by Bayer AG for the removal of arsenic from drinking water supplies. It is a dry granular iron oxide media designed to remove dissolved arsenic via adsorption onto its ferric oxide surface. Severn Trent markets the media in the U.S. for As(III) and As(V) removal as Sorb-33, and offers several arsenic package units with flow rates ranging from 150 to 300 gallons per minute (gpm). Another company, AdEdge, provides similar systems using the same media (marketed as AD-33) with flow rates ranging from 5 to 150 gpm. E33 adsorbs arsenic and other ions, such as antimony, cadmium, chromate, lead, molybdenum, selenium, and vanadium. The adsorption is effective at pH values ranging between 6.0 and 9.0. At greater than 8.0 to 8.5, pH adjustment is recommended to maintain its adsorption capacity. Two competing ions that can reduce the adsorption capacity are silica (at levels greater than 40 mg/L) and phosphate (at levels greater than 1 mg/L).

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

The AAFS50 is a dry granular media of 83 percent alumina and a proprietary iron-based additive to enhance the arsenic adsorption performance. Standard AA was the first adsorptive media successfully applied for the removal of arsenic from water supplies. However, it often requires pH adjustment to 5.5 in order to achieve optimum arsenic removal. The AAFS50 product is modified with an iron-based additive to improve its performance and to increase the pH range within which it can achieve effective removal. Optimum arsenic removal efficiency is achieved with a pH of the feed water less than 7.7. Competing ions such as fluoride, sulfate, silica, and phosphate can adsorb onto AAFS50 media, and potentially can reduce its arsenic removal capacity. The adsorption capacity of AAFS50 can be impacted by both high levels of silica (>40 mg/L) and phosphate (>1 mg/L). The vendor recommended that the system be operated in a series configuration to minimize the chance for arsenic breakthrough to impact drinking water quality.

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

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

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

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

Advantages

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

Disadvantages

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

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

1.4.5.4 Coagulation/Filtration and Iron Removal Technologies

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

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

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

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

Advantages

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

Disadvantages

- Need to handle chemical.
- Need to dispose of regular backwash wastewater.
- Sludge disposal.

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

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

Point-of-entry (POE) and POU treatment systems can be used to provide compliant drinking water. For arsenic removal, these systems typically use small RO treatment units that are installed "under the sink" in the case of point-of-use, and where water enters a house or building in the case of point-of-entry. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive. Point-of-entry and point-of-use treatment units would be purchased and owned by the PWS. These solutions are decentralized in nature, and require utility personnel entry 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 point-of-entry or point-of-use program for implementation, consultation with TCEQ will be required to address measurement and determination of 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, relevant to arsenic are:

- 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 O&M and MCL compliance. 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 the 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 operation and maintenance 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 (ANSI) has issued product standards for a specific type of POU or POE treatment unit, only those units that have been independently certified according to these standards may be used as part of a compliance strategy.

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

- If POU devices are used as an SDWA compliance strategy, certain consumer behavioral changes would 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 (VOC) to achieve compliance, because POU devices do not provide 100% 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 found in 40 CFR Section 141.101 prohibit the use of bottled water to achieve compliance with an MCL, except on a temporary basis. State regulations do not directly address the use of bottled water. Use of bottled water at a non-compliant PWS would be on a temporary basis. Every 3 years, the PWSs that employ interim measures are required to present the TCEQ with estimates of costs for piping compliant water to their systems. As long as the projected costs remain prohibitively high, the bottled water interim measure is extended. Until USEPA amends the noted regulation, the TCEQ is unable to accept water delivery or central drinking water dispensers as compliance solutions.

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

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

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

The ideal system would:

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

SECTION 2
EVALUATION METHODOLOGY

2.1 DECISION TREE

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

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

2.2 DATA SOURCES AND DATA COLLECTION

2.2.1 Data Search

2.2.1.1 Water Supply Systems

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

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

Figure 2.1

TREE 1 – EXISTING FACILITY ANALYSIS

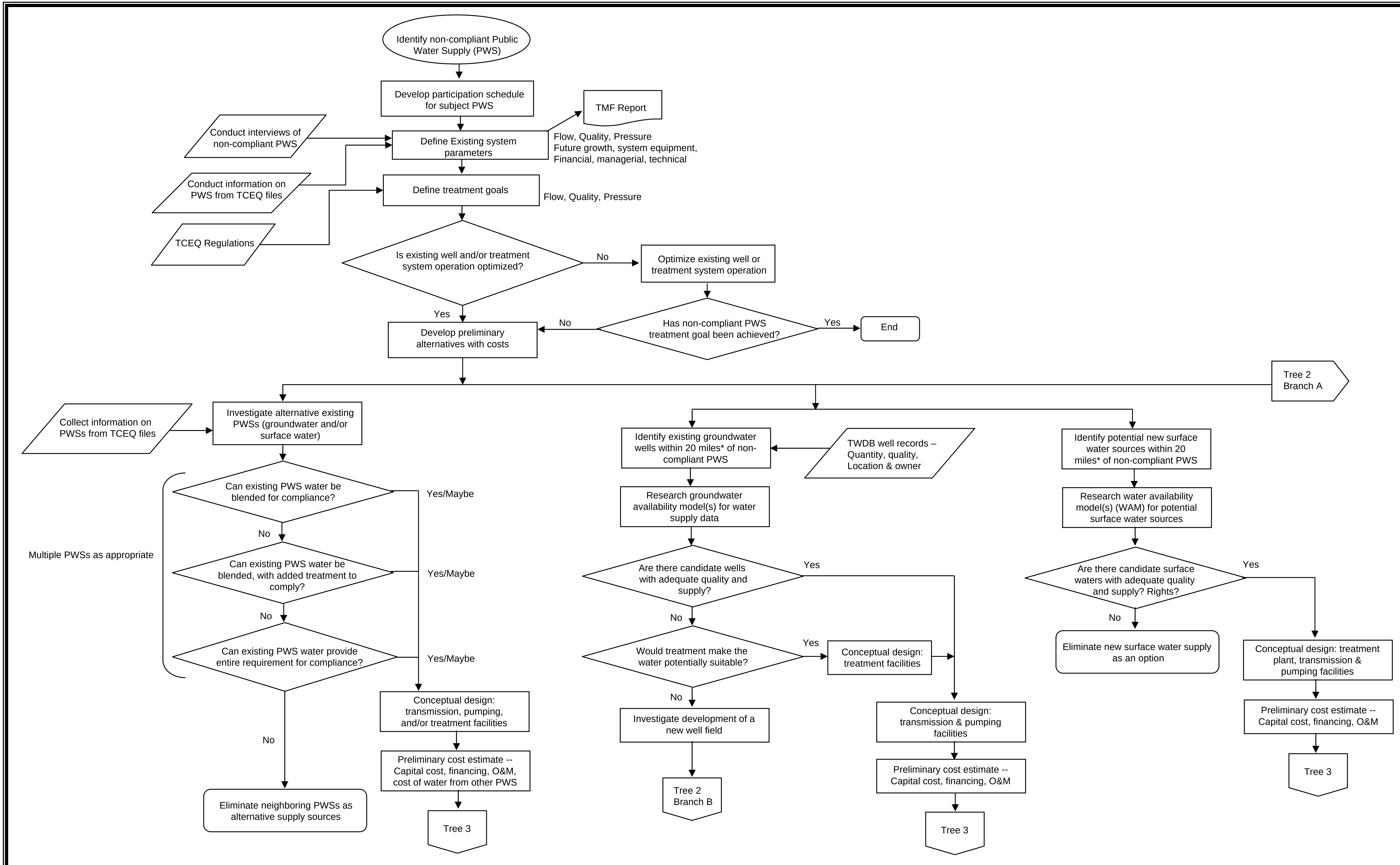
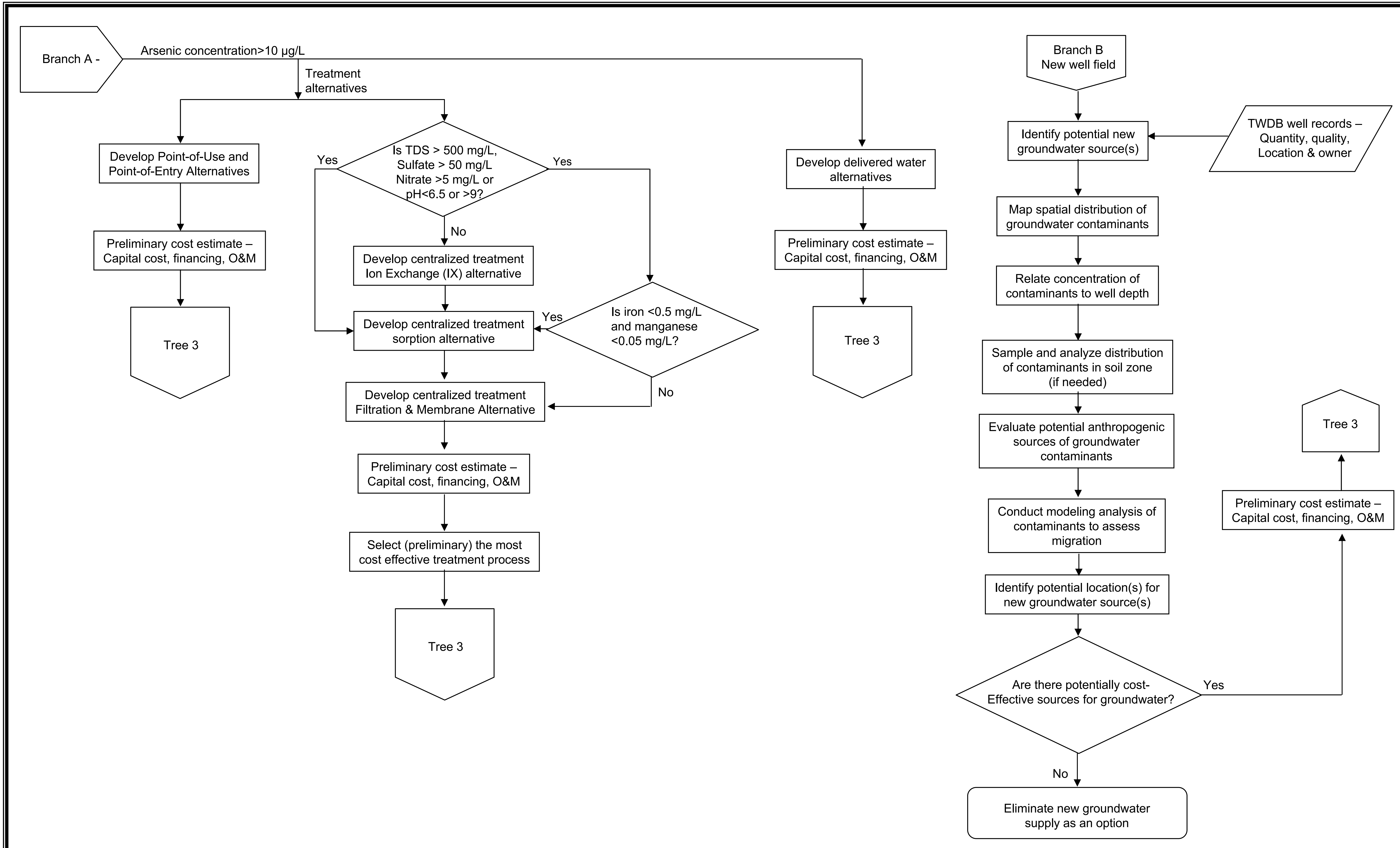


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATAIVES



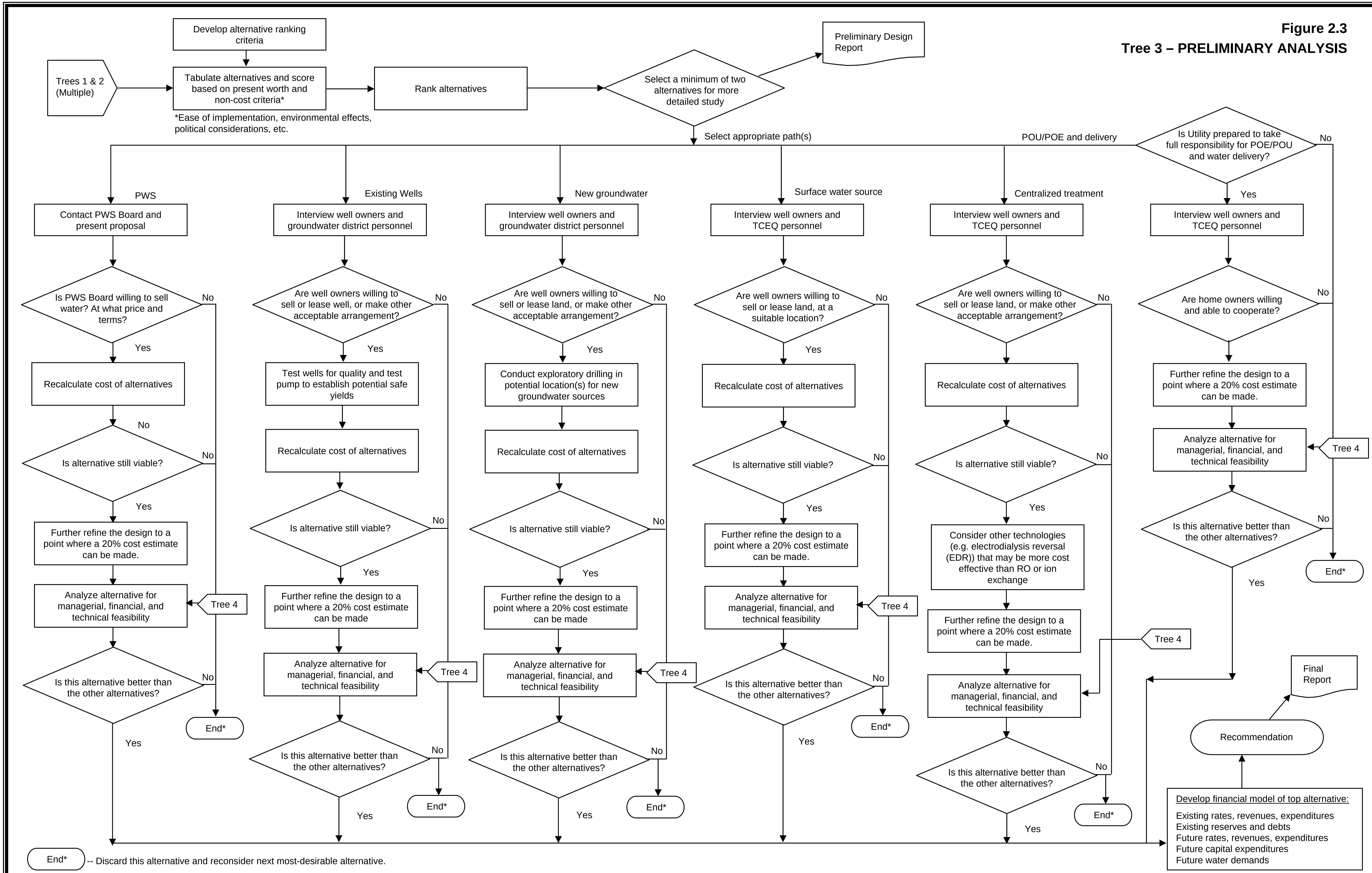
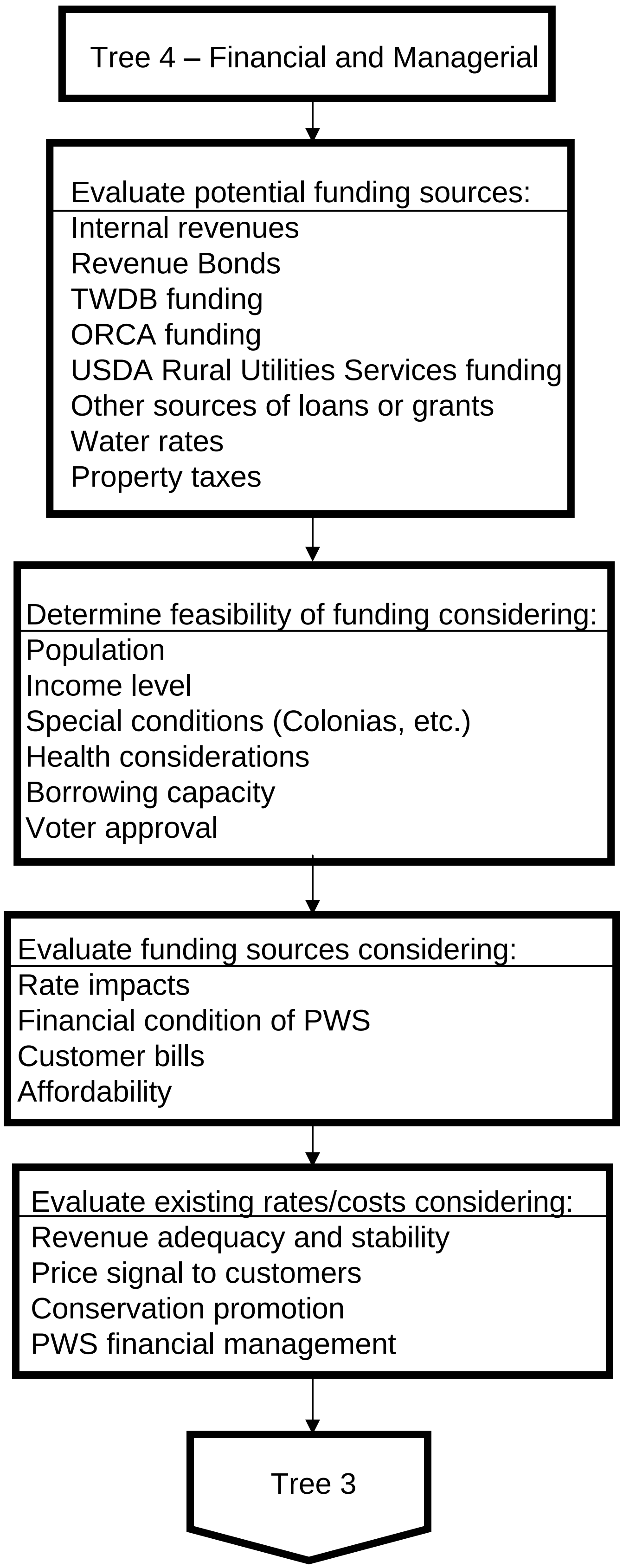


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS
Develop alternative ranking criteria
Trees 1 & 2 (Multiple)
Tabulate alternatives and score based on present worth and non-cost criteria*
*Ease of implementation, environmental effects, political considerations, etc.
Rank alternatives
Select a minimum of two alternatives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

Figure 2.4
TREE 4 – FINANCIAL AND MANAGERIAL



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

These files were reviewed for the PWS and surrounding systems.

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

- Texas Commission on Environmental Quality www3.tceq.state.tx.us/iwud/pws/index.cfm. Under "Advanced Search", type in the name(s) of the Counties in the study area to get a listing of the public water supply systems.
- USEPA Safe Drinking Water Information System (SDWIS) 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 flow rate, and nature of the surrounding formation. The "Water Quality Table" provides information on the aquifer and the various chemical concentrations in the water. The database contained both total and dissolved arsenic. Water samples analyzed for dissolved arsenic are filtered to remove suspended solids. Since the suspended solids in drinking water are near zero, the values reported for total and dissolved arsenic were considered equivalent.

2.2.1.3 Surface Water Sources

The 2002 Texas Water Plan published by the TWDB divides the state into regional planning areas. Brazoria County falls within Region H. The Region H Water Management Plan planning documents were consulted for lists of surface water sources. Rosharon Township falls within the San Jacinto-Brazos Coastal Basin. Almost all surface water available in Brazoria County comes from the Brazos River.

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 applicable GAM (Gulf Coast aquifer) was investigated as a potential tool for identifying available and suitable groundwater resources.

2.2.1.5 Water Availability Model

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

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

2.2.1.6 Financial Data

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

- Annual Budget
- Audited Financial Statements
  - Balance Sheet
  - Income & 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 Financial 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 SDWA regulations. Financial capacity refers to the financial resources of the water system, including but not limited to revenue sufficiency, credit worthiness, and fiscal controls.

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

Technical capacity is the physical and operational ability of a water system to achieve and maintain compliance with 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 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. The compliance alternative conceptual cost estimates are provided in Appendix C. Cost analyses for shared solutions with other PWSs in the area are provided in Appendix G.

2.3.1 Existing PWS

Neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 15 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.

Neighboring PWSs were investigated to get an idea of the water sources in use and the quantity of water it 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. 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. The Gulf Coast Water Authority plans to build a regional water treatment plant (WTP) in the future to treat Brazos River water. The BWA currently treats Brazos River water in a WTP with excess capacity.

2.3.4 Treatment

Treatment technologies considered potentially applicable are adsorption and coagulation/filtration for arsenic removal since they are proven technologies with numerous successful installations that can be implemented with relatively low cost.

Reverse osmosis and IX were not deemed applicable in this study, since they are typically more expensive and more difficult to operate.

Adsorption treatment is considered for central treatment alternatives, as well as POU and POE alternatives. Coagulation/filtration treatment is considered for central treatment alternatives only. Adsorption treatment produces a spent media solid waste stream, and both adsorption and coagulation/filtration treatments produce a liquid backwash stream. The backwash volume from adsorption is much less than from filtration/coagulation. As a result, the treated volume of water is less than the volume of raw water that enters the treatment system. 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 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 assets of the company have been funded through borrowing. A lower ratio indicates a healthier condition.
- Operating Ratio = total operating revenues divided by total operating expenses show the degree to which revenues cover ongoing expenses. The value is greater than 1.0 if the utility is covering its expenses.

2.4.2 Median Household Income

The 2000 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 reserves 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 4.8, show the following according to alternative and funding source:

- Percentage of median annual household income that the average annual residential water bill represents.
- 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 is more than 75 percent of state MHI, standard terms, currently at 3.8 percent interest for non-rated entities. Additionally:
    - If local MHI = 70-75 percent of state MHI, 1 percent interest rate on loan.
    - If local MHI = 60-70 percent of state MHI, 0 percent interest rate on loan.
    - If local MHI = 50-60 percent of state MHI, 0 percent interest and 15 percent forgiveness of principal.
    - If local MHI less than 50 percent of state MHI, 0 percent interest and 35 percent forgiveness of principal.
- Terms of revenue bonds assumed to be 25-year term at 6.0 percent interest rate.

2.4.5.2 General Assumptions Embodied in Financial Plan Results

The basis used to project future financial performance for the financial plan model 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 water supply based on specified months of O&M expenditures.
- O&M for alternatives begins 1 year after capital implementation.
- Balance of capital expenditures not funded from primary grant program is funded through debt (bond equivalent).
- Cash balance drives rate increases, unless provision chosen to override where current net cash flow is positive.

2.4.5.3 Interpretation of Financial Plan Results

Results from the financial plan model, as presented in Section 4, Table 4.8, show the percentage of MHI 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:

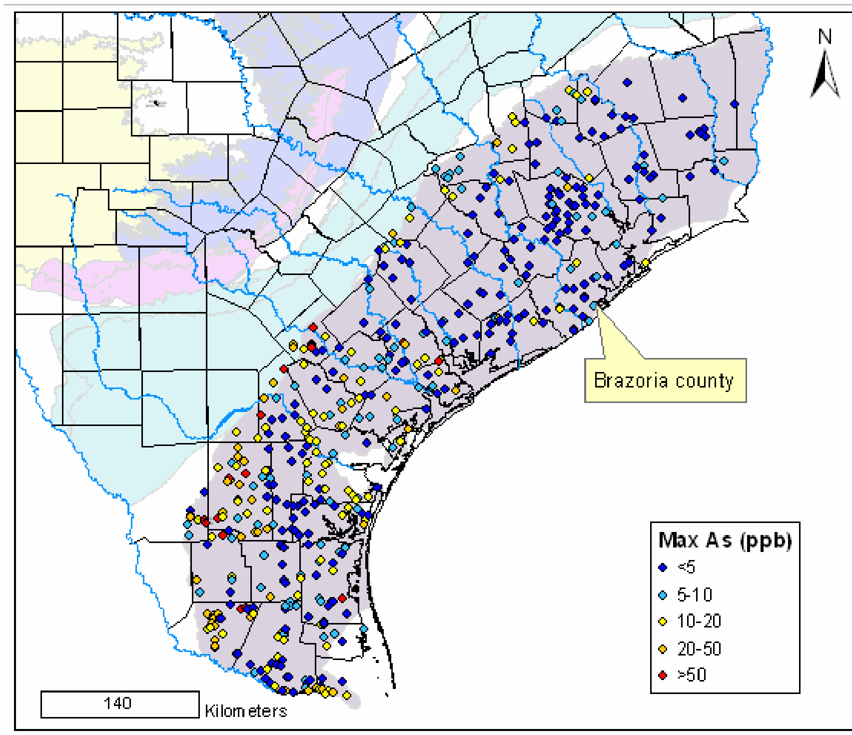
- United States Department of Agriculture, Rural Utilities Service, and
- United States Housing and Urban Development.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 ARSENIC IN THE GULF COAST AQUIFER

The Gulf Coast aquifer parallels the Texas Gulf Coast and extends from the Texas-Louisiana border to the Rio Grande. Subunits of the Gulf Coast aquifer are, from oldest to youngest, the Jasper, Evangeline, and Chicot aquifers. The aquifer is a leaky artesian system composed of middle to upper Tertiary and younger interbedded and hydrologically connected layers of clay, silt, sand, and gravel (Ashworth and Hopkins 1992). The PWS wells of concern in Brazoria County are completed in the Chicot aquifer. Figure 3.1 shows detectable arsenic concentrations in the Gulf Coast aquifer from the TWDB database, and Figure 3.2 shows arsenic concentrations from the National Geochemical Database, also known as the National Uranium Resource Evaluation (NURE) database (http://pubs.usgs.gov/of/1997/ofr-97-0492/index.html).

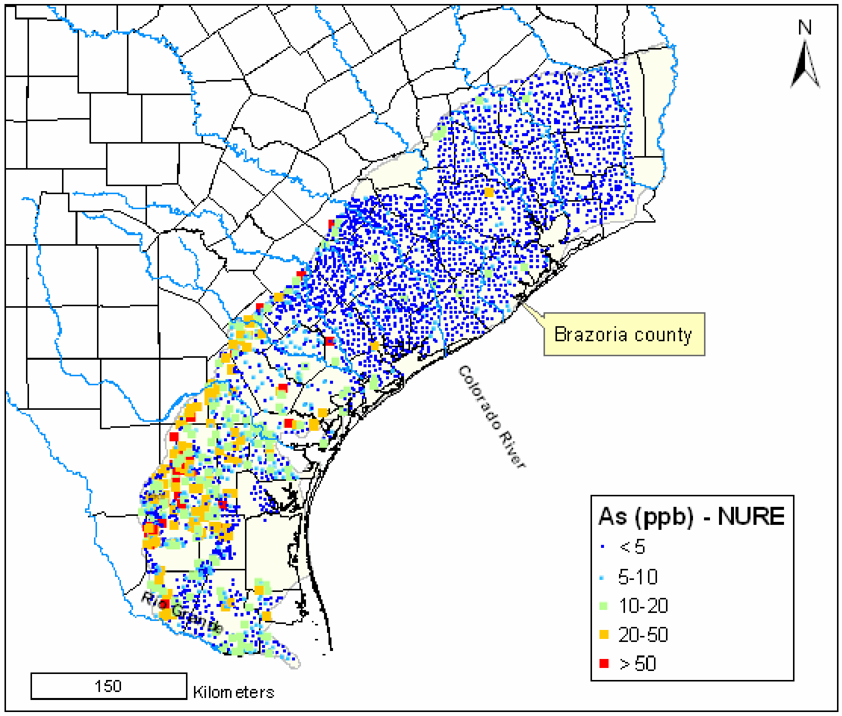
Figure 3.1 Detectable Arsenic Concentrations in Groundwater



Source: TWDB database, analyses from 1987 through 2004

The most recent value is shown for each well (number of samples shown is 503).

Figure 3.2 Detectable Arsenic Concentrations in Groundwater



Source: NURE database, analyses from 1976 through 1980

In the NURE database there is one sample per well (number of samples shown is 3,920).

3.2 GEOLOGY OF BRAZORIA COUNTY

Geologic units included in the Chicot aquifer are the Pleistocene formations, Willis, Lissie, and Beaumont (Doering 1935; Baker 1979). Since Pleistocene time, packages of fluvial sediments representing successively younger progradational cycles have been deposited along the Texas Gulf Coast (Blum 1992). The fluvial sediments, ranging in texture from gravel to clay, contain very little intergranular cement. The older parts of this depositional sequence are more coarse grained and dip 10 to 25 feet per mile (ft/mi) (Willis Formation), whereas the younger units are more fine grained and dip only approximately 1 ft/mi (Beaumont Formation) (Doering 1935).

The Willis Formation was first described as a formal stratigraphic unit by Doering (1935). It is red sand with minor amounts of coarse sand and gravel that unconformably overlie Pliocene-age clay layers of the Fleming Formation in the vicinity of Brazoria County. In this area, the Willis Formation has a 30- to 40-foot thick gravel layer at the base that can provide an ample supply of usable quality water. The Lissie Formation is finer grained than the underlying Willis Formation; it contains interbedded layers of light-colored, fine-grained sand, clayey sand, and sandy clay (Doering 1935). Although the Beaumont Formation as a whole is much more fine grained than directly underlying formations, it contains localized distributary channel deposits. The inclusive list of lithologies contained in the Beaumont Formation is clay, limey clay, sandy clay, clayey sand, and fine-grained sand (Doering 1935). Water wells completed in the Beaumont Formation section of the Chicot aquifer are usually no deeper than 75 to 100 feet and probably do not provide large quantities of water.

The lithology of geologic units within the Chicot aquifer is similar to that of the underlying Evangeline aquifer, which makes it difficult for drillers to determine in which aquifer they are completing water wells along the Texas Gulf Coast. The combined thickness of geologic units in the Chicot aquifer in the vicinity of Brazoria County varies among different researchers between 400 and 1,200 feet. The maximum thickness of the entire Gulf Coast aquifer along the northern Gulf Coast is approximately 1,300 feet (Baker 1979).

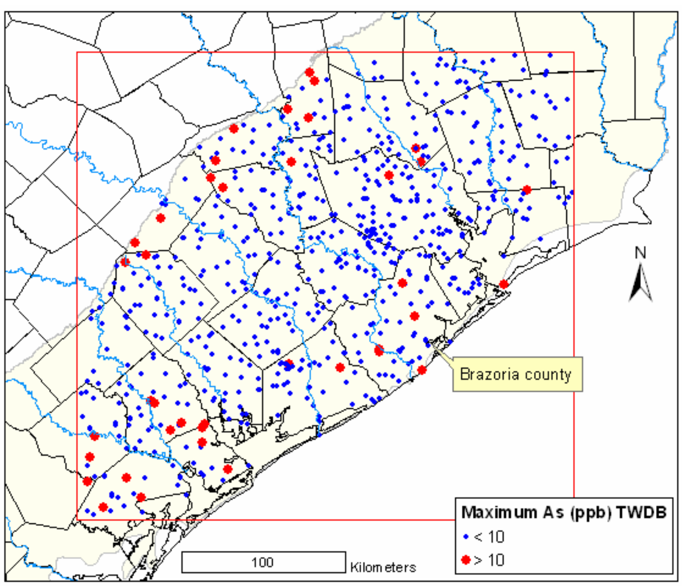
The 11 PWS wells of concern in Brazoria County are identified as being in the Chicot aquifer; completion depths are grouped around 300, 400, and 600 feet. It is possible the deeper wells are completed in the Evangeline aquifer or that screened intervals in these wells span both Chicot and Evangeline aquifers. A recognized geologic source of arsenic in groundwater is volcanic ash. Arsenic is often associated with other chemical elements such as fluoride, vanadium, molybdenum, selenium, and uranium. The association is generally seen at the subregional level, although not necessarily at the well level because of different geochemical behavior of individual elements. There are no reports of volcanic material in the geologic units that compose the Chicot aquifer. However, layers of bentonite (altered volcanic ash beds) and devitrified ash have been recognized in some parts of the Evangeline aquifer especially in South Texas. The major geologic unit of the Evangeline aquifer in South Texas is the Goliad Formation, but it is not present in outcrops north of the Colorado River (Hoel 1982). General hydrologic patterns with upward cross-formational flow along the coast support this hypothesis. However, other sources of arsenic are also possible. Arsenic hot spots exist in older formations (Catahoula and Goliad); some of those have eroded and are now part of the Chicot aquifer sediment. Additional potential sources include upwelling of highly mineralized water from salt domes. However, the spatial mismatch between salt dome distribution and areas with high arsenic concentration, as well as the lack of correlation between chloride and arsenic concentrations, precludes such an association, as discussed later.

Using uranium and radioactivity as proxies for arsenic sources, geophysical logs in Brazoria County near the PWS wells were analyzed to assess potential linkages between geologic units and elevated arsenic concentrations. Given the common association between uranium deposits and occurrences of arsenic, it was reasonable to inspect local oilfield geophysical logs for evidence of radioactive fluids in sandstone strata at depths sufficiently shallow to potentially contact fresh groundwater. A total of 40 hydrocarbon wells were identified with geophysical well logs that had (1) recorded geophysical responses within the upper 500 feet of the subsurface; and (2) latitude/longitude coordinates. Of these wells, 17 were selected on the basis of proximity to the aforementioned PWS wells. Among these 17 hydrocarbon wells, only one provided the gamma ray and resistivity logs necessary for analysis. Wells range in depth between 295 and 625 feet and are completed in the Chicot aquifer. Only one well log for the area recorded sufficiently shallow data and also showed gamma ray and resistivity responses necessary to detect radioactively elevated pore fluids in the geologic section. The well is the Kilmarovo Jamison located at west longitude 95.3483° and north latitude 29.2586°. The nearest PWS wells are operated by the City of Danbury a few miles to the south of the logged well. Elevated gamma ray values greater than 150 American Petroleum Institute units occurred in sandstone beds with resistivities greater than 10 ohms at 1,520- to 1,550-foot depths in the Jamison well. An additional bed containing fluids with elevated radioactivity occurred at the depth of approximately 177 feet. Both of these stratigraphic intervals dip toward the south and are, therefore, at greater depths in more southerly locations. The City of Danbury PWS wells are completed at depths of 295 to 304 feet. Unless groundwater flow is upward between excessively radioactive strata contacted by the Jamison well and the Danbury PWS wells, it appears unlikely that radioactive fluids and associated ionic constituents, including possible arsenic, would contact the Chicot aquifer in the Danbury area.

3.3 GENERAL TRENDS IN ARSENIC CONCENTRATIONS

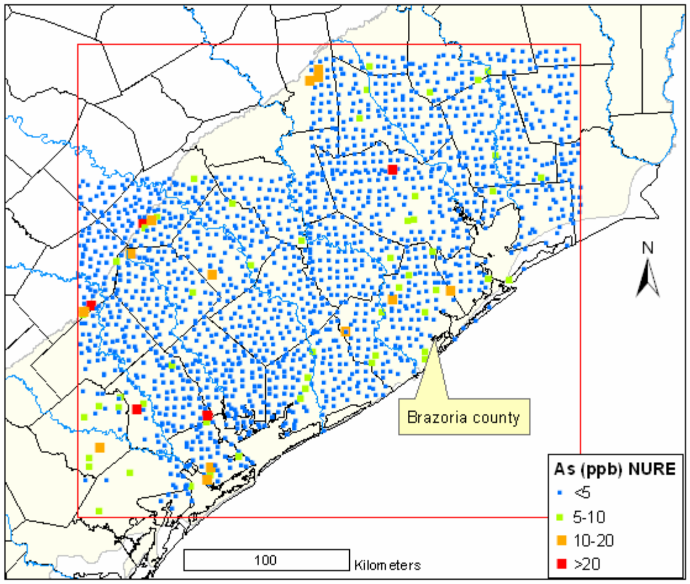
The geochemistry of arsenic is described in Appendix E. A general analysis of arsenic trends in the vicinity of Brazoria County was conducted to assess spatial trends, as well as correlations with other water quality parameters. Arsenic measurements from the TWDB database, the TCEQ database, and from a subset of the National Geochemical Database, also known as NURE (National Uranium Resource Evaluation) database, were used to assess arsenic trends. Figures 3.3 and 3.4 show the spatial distribution of arsenic concentrations from the TWDB (Figure 3.3) and the NURE (Figure 3.4) databases.

Figure 3.3 Spatial Distribution of Arsenic Concentrations



Source: TWDB database

Figure 3.4 Spatial Distribution of Arsenic Concentrations

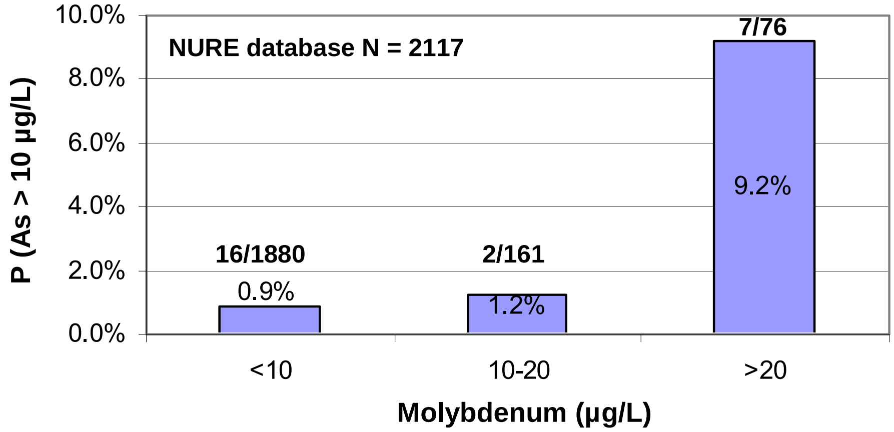


Source: NURE database

The databases were queried in an area delineated by the following coordinates: bottom left, -97.45, 28.18; top right, -94.30, 30.64. Seven hundred thirty measurements were extracted from the TWDB database. Measurements representing the most recent arsenic measurement taken at a specific well, and wells not in the Gulf Coast aquifer were excluded. The NURE database contained 2,118 groundwater (sample type 03) arsenic measurements within the defined boundary. Because the wells have no aquifer identifier, no measurements were excluded.

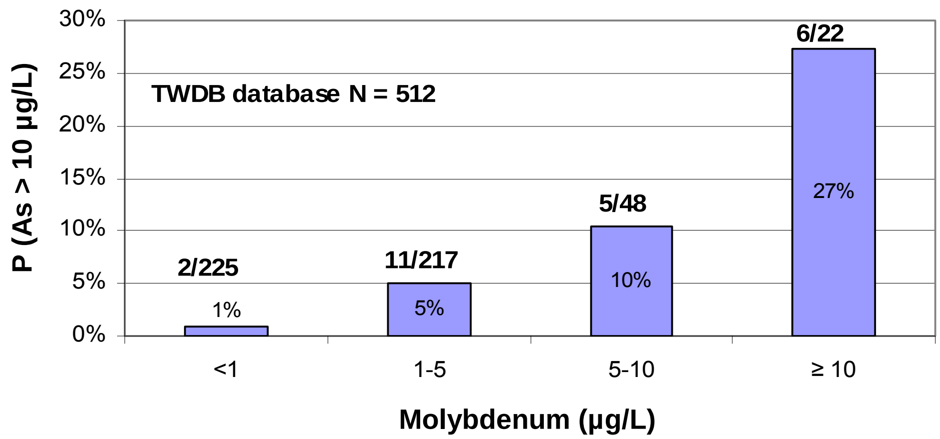
Relationships between arsenic and well depth, pH, sulfate, fluoride, chloride, TDS, dissolved oxygen, phosphorus, iron, selenium, boron, vanadium, uranium, and molybdenum, were evaluated using data separately from the NURE and TWDB databases. Correlations between arsenic concentrations and most parameters were weak (r-square values < 0.1); the highest correlation was found between arsenic and molybdenum. The relationship between the probability of arsenic > 10 µg/L and molybdenum concentration levels is shown for the NURE (Figure 3.5) and TWDB (Figure 3.6) databases.

Figure 3.5 Relationship Between Arsenic and Molybdenum



Source: NURE database

Figure 3.6 Relationship Between Arsenic and Molybdenum

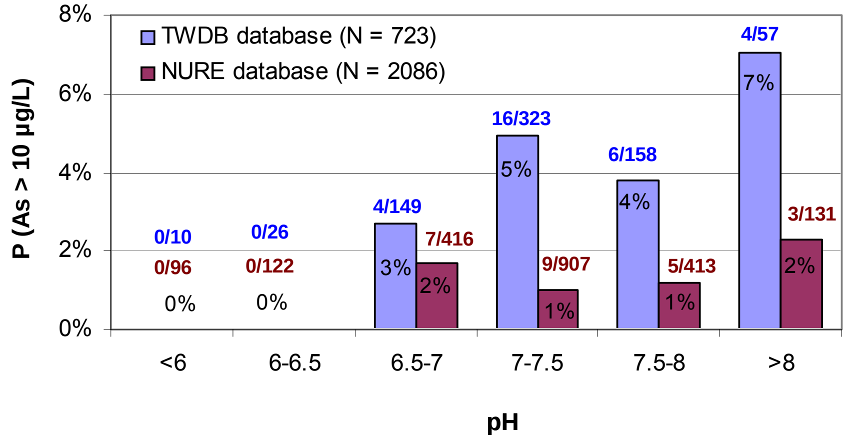


Source: TWDB database

N represents the number of measurements used from each database. Numbers on top of the graph columns show the number of arsenic measurements exceeding 10 µg/L and total number of measurements in each bin. For example, "7/76" in the bin of molybdenum > 20 means that seven of 76 arsenic measurements were greater than 10 µg/L.

Elevated arsenic concentrations and pH are also related (Figure 3.7). The absence of high arsenic concentrations (>10 µg/L) at pH less than 6.5 is notable.

Figure 3.7 Relationship Between High Arsenic Concentrations and pH

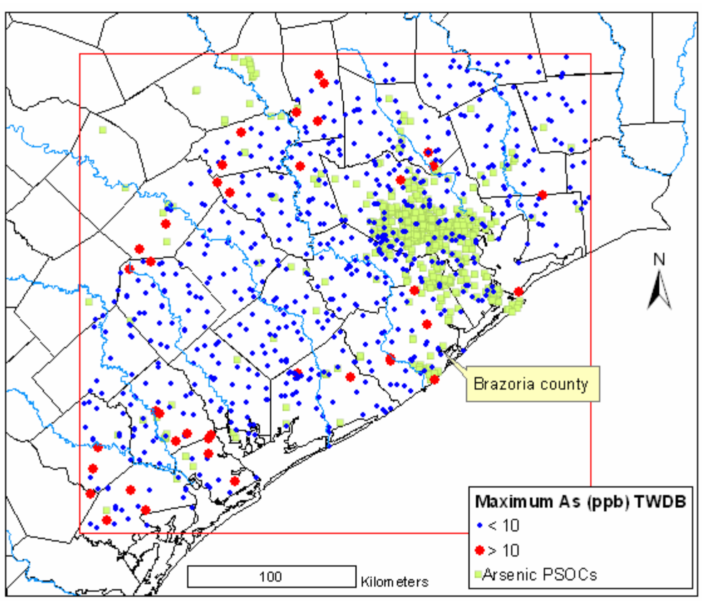


Correlations between arsenic, molybdenum, and pH suggest natural sources of elevated arsenic in Brazoria County; however, data are insufficient to make this conclusion definitively.

3.4 ARSENIC AND POINT SOURCES OF CONTAMINATION

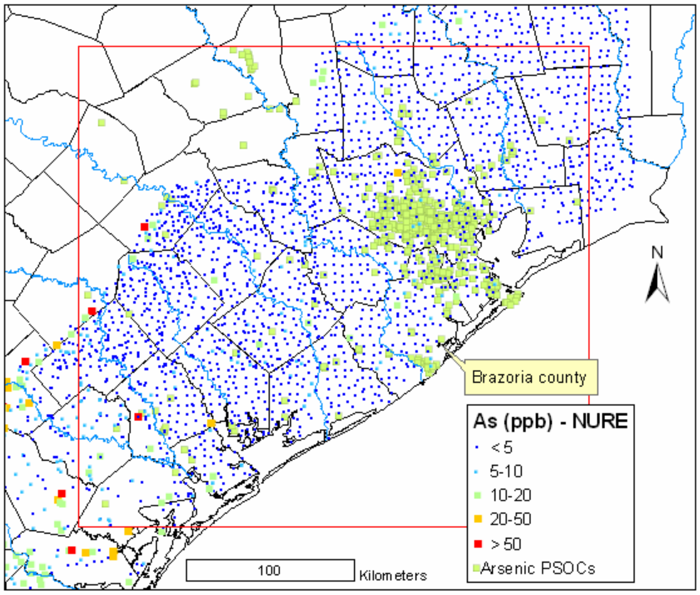
Information regarding the location of potential source of contamination (PSOC) is collected as part of the TCEQ Source Water Assessment Program. Arsenic concentrations from TWDB (Figure 3.8) and NURE (Figure 3.9) databases were compared with PSOC coverage. A density map of PSOCs was generated (number of PSOCs per square kilometer), and PSOC density values were compared with arsenic concentrations from the NURE database.

Figure 3.8 Potential Sources of Arsenic Contamination and Arsenic Concentrations



Source: TWDB database

Figure 3.9 Potential Sources of Arsenic Contamination and Arsenic Concentrations



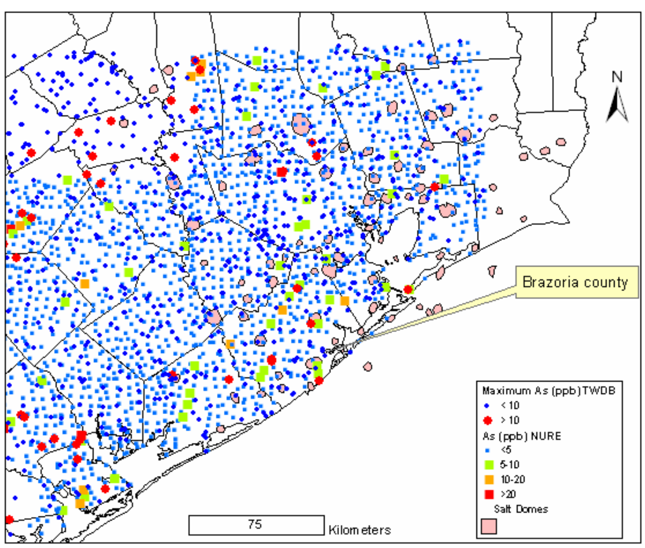
Source: NURE database

No correlation was found between high arsenic concentrations and density of potential sources of contamination, strengthening the conclusion that sources of arsenic in this area are natural.

3.5 SALT DOMES

Elevated arsenic concentrations were not correlated with salt dome locations (Figure 3.10).

Figure 3.10 Salt Dome Locations and Arsenic Concentrations

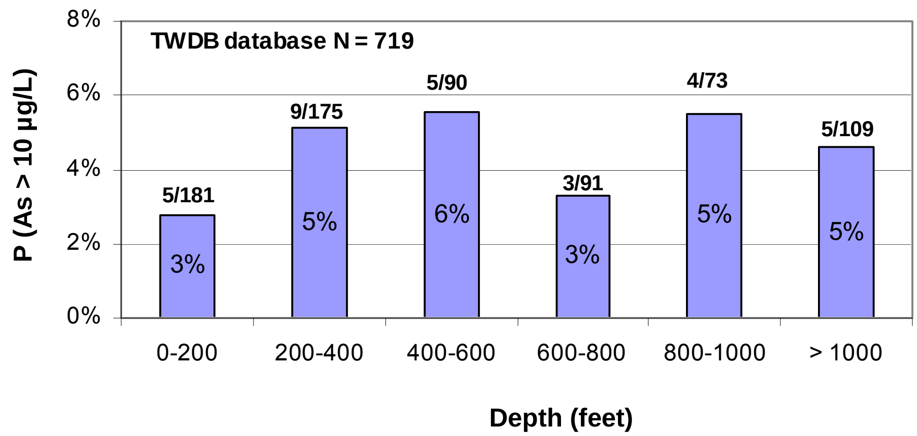


Source: TWDB and NURE databases

3.6 CORRELATION WITH DEPTH

Arsenic concentrations were compared with well depth in an attempt to assess relationships between elevated arsenic concentrations and specific stratigraphic units (Figure 3.11). Data do not show a definite correlation between arsenic levels and well depth. Lack of geologic descriptions and geophysical logs makes it difficult to further evaluate relationships between arsenic concentrations and depth distributions of geologic units.

Figure 3.11 Relationship Between Arsenic Concentrations and Well Depth

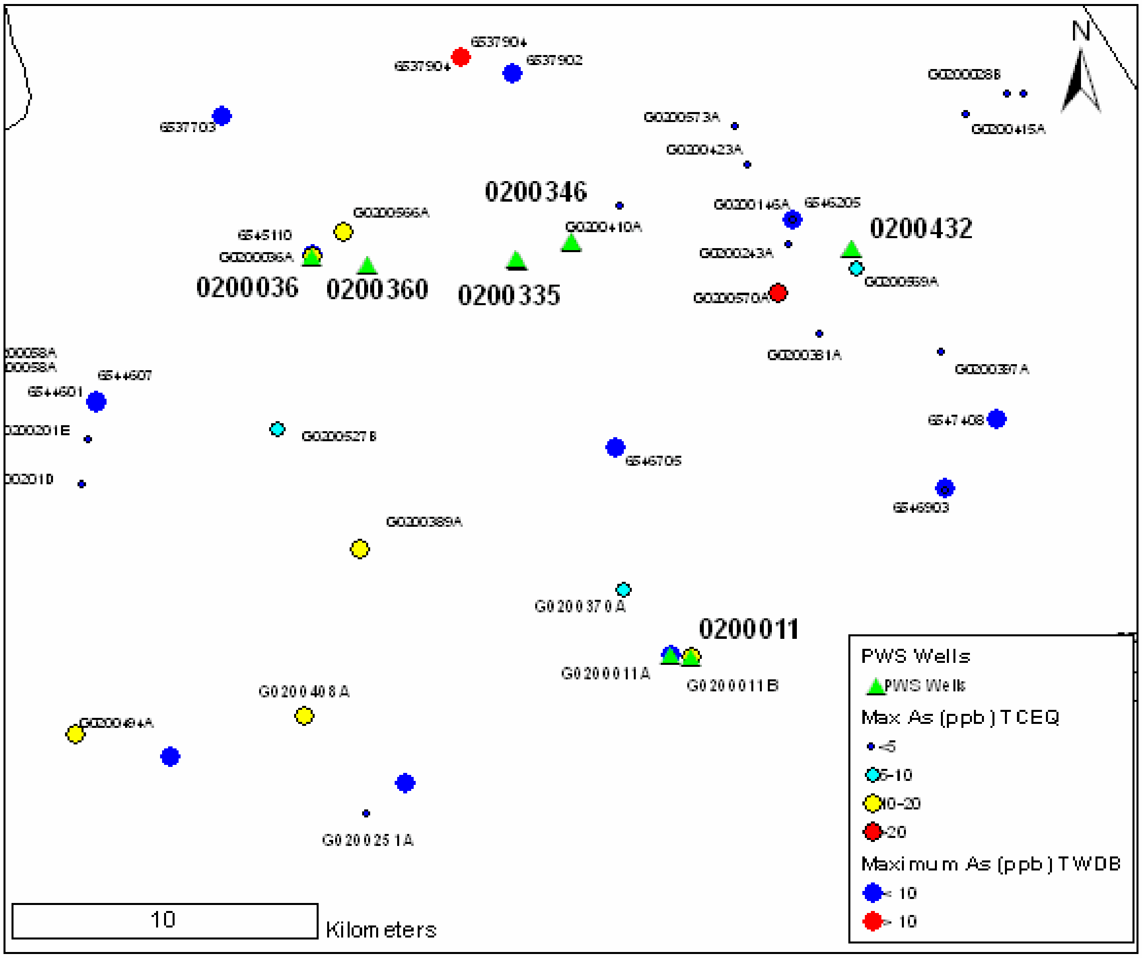


The most recent sample was used for each well. N represents total number of wells in the analysis (719), and numbers above each column represent number of arsenic measurements > 10 µg/L and total number of analyses in the bin. For example, 5/181 represents five samples > 10 µg/L out of 181 analyses at a well depth between 0 and 200 feet.

3.7 DETAILED ASSESSMENT

There are eight wells with arsenic samples > 10 µg/L near the assessed PWS wells, seven from the TCEQ database, and one from the TWDB database (Figure 3.12). Samples from the TCEQ PWS database include only those that could be related to a specific well.

Figure 3.12 Arsenic Concentrations in the Vicinity of PWS Wells



Arsenic samples are from TWDB and TCEQ databases. The maximum arsenic concentration is shown for each well. PWS wells from the TCEQ database include two types of samples: raw (related to a single well), and entry point (taken from a single entry point related to a single well). Table 3.1 details well and screen depths of PWS wells with high arsenic concentrations (> 10 μg/L).

Table 3.1 Maximum and Minimum Arsenic Concentrations

Water source	Max.-Min.-No. of As samples (μg/L)	Well depth (feet)	Screen depth (feet)	Geology	Source
G0200494A	16.7-14.2-2	419	399-419	NA	TCEQ
G0200011B	11.3 – 6.0 -2	235	160 - 230	NA	TCEQ
G0200036A	14.8 – 9.2 – 3	324	307-323	NA	TCEQ
G0200566A	10.3 - 9.4 – 4	310	NA	NA	TCEQ
G0200389A	11.7 – 8.3 – 2	374	NA	NA	TCEQ
G0200408A	10.6- 10.6 – 1	400	NA	NA	TCEQ
G0200570A	55.2-8-3	740	710-740	NA	TCEQ
6537904	16-16-1	400	NA	NA	TWDB

Well depths range from 235 to 740 feet, and wells are screened between 160 and 740 feet. These large ranges in depth make it difficult to make a definitive statement regarding local correlation of arsenic with well or screen depth. Lack of geologic descriptions of these wells also prohibits a more comprehensive evaluation of relationships between arsenic concentrations and geology.

3.7.1 Rosharon Township (PWS 0200036)

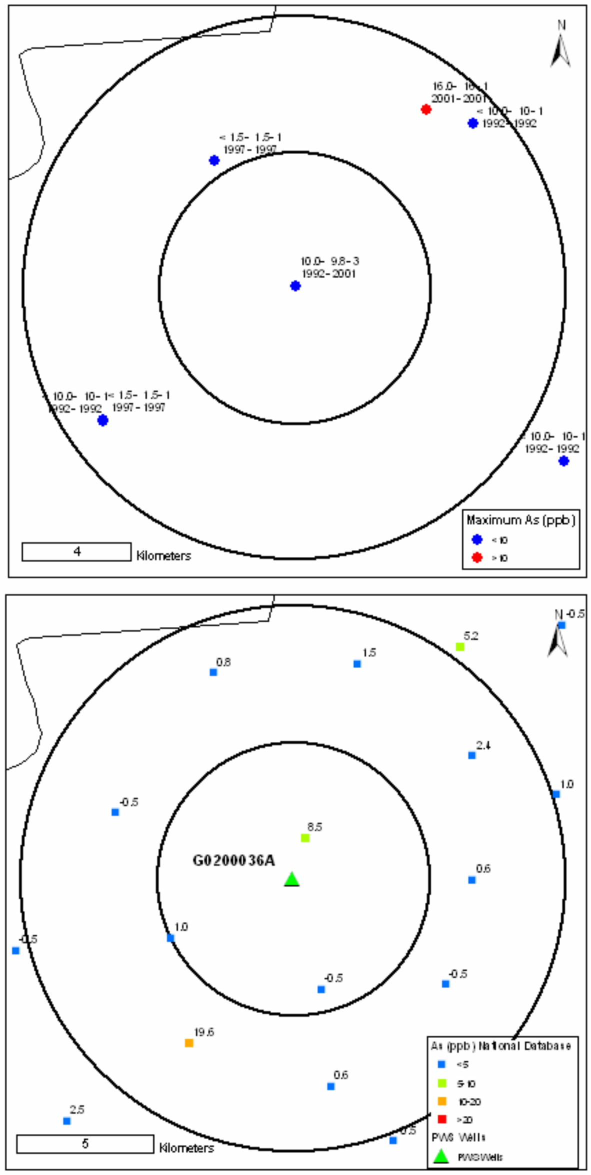
There is one well in this water supply system, well G0200036A. The depth of the well is 234 feet and it is screened between 307 and 323 feet. Table 3.2 summarizes arsenic concentrations measured at the PWS.

Table 3.2 Arsenic Concentrations in Rosharon Township PWS

Date	As (μg/L)	Source
4/20/1992	10.0	TWDB
3/13/1997	9.9	TWDB
5/16/2001	9.9	TCEQ
7/11/2001	9.8	TWDB
9/10/2003	9.2	TCEQ
2/17/2005	14.8	TCEQ

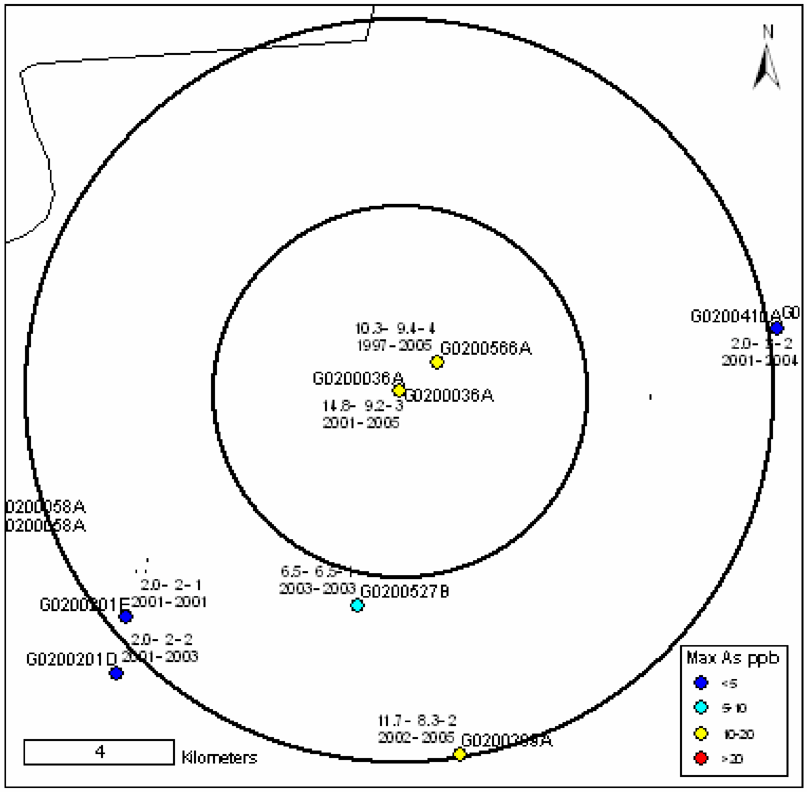
There are six water quality measurements from TCEQ and TWDB databases that were collected at the PWS between 1992 and 2005. All samples had elevated arsenic concentrations (above or near the MCL pf 10 μg/L). Figure 3.13 shows arsenic concentrations from TWDB and NURE databases measured at wells in the 5- and 10-km buffers of the PWS wells.

Figure 3.13 Arsenic Concentrations in the 5- and 10-km Buffers of Rosharon Township PWS Wells (TWDB and NURE Databases)



The top figure shows arsenic concentrations from the TWDB database. Wells are symbolized by maximum concentrations, and labels show maximum, minimum, and number of samples, as well as first and last sample year. Values from the NURE database were taken between 1976 and 1980. Negative values are less than detection limit (0.5 µg/L). One well in the 5- and 10-km buffer range from the TWDB database had high arsenic levels (16 µg/L), and one well from the NURE database (19 µg/L). In addition to TWDB and NURE databases, samples from the TCEQ PWS database were also analyzed (Figure 3.14).

Figure 3.14 Arsenic Concentrations in 5- and 10-km Buffers of Rosharon Township PWS Wells (TCEQ Database)



Samples from the TCEQ PWS database showed more wells with elevated arsenic concentrations. Two types of samples were used in the analysis: raw (related to a single well), and entry-point (taken from a single entry point and related to a single well). Table 3.3 details arsenic concentrations, well depth, and screen depths of wells in the 5- and 10-km buffers of PWS wells.

Table 3.3 Maximum and Minimum Arsenic Concentrations in the 5- and 10-km Buffers of Rosharon Township PWS

Water source	Max.-Min.-No. of As samples (μg/L)	Well depth (feet)	Screen depth (feet)
G0200036A	14.8 – 9.2 – 3	324	307-323
G0200566A	10.3 - 9.4 – 4	310	NA
G0200389A	11.7 – 8.3 - 2	374	NA
G0200527B	6.5-6.5-1	159	NA
G0200201D	2.0 - 2 -1	885	650-880
G02002015	2.0 - 2 - 2	962	770-950

There was no information on geologic units for wells in Table 3.3. In addition to the assessed PWS well (G0200036A), there are two wells (G0200566A and G0200389A) with concentrations > 10 μg/L, and one well (G0200527B) > 5 μg/L. The wells with high concentrations (> 10 μg/L) have depths between 310 and 374 feet. Wells with low arsenic concentrations (< 5 μg/L) have greater depths (885 to 962 feet). One well with high arsenic concentrations (16 μg/L) from the TWDB database has a depth of 400 feet. It is unclear whether arsenic is locally correlated with depth, and lack of geologic description of the wells precludes any analysis of relationships with geologic units.

SECTION 4
ANALYSIS OF ROSHARON TOWNSHIP PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1 Existing System

The location of the Rosharon Township PWS is shown on Figure 4.1. This PWS is operated by Orbit Systems, Inc. The PWS has one groundwater supply well. The well (Source G0200036A) is completed in the Chicot aquifer is approximately 324 feet deep, and has a rated capacity of 58 gpm. The well is located at 103 W FM 1462. Water from the well is injected with chlorine before flowing into the 40,000-gallon ground storage tank. Two booster pumps (200 gpm each) pump the water from the ground storage tank to the 5,000-gallon pressure tank that feeds the distribution system.

Arsenic concentrations detected at the point of entry were 10.5 µg/L, 9.9 µg/L, 9.2 µg/L, and 14.8 µg/L in 1998, 2001, 2003, and 2005, respectively. The treatment employed is not appropriate or effective for removal of arsenic, so optimization of the treatment system is not expected to be effective increasing arsenic removal.

Basic system information for the Rosharon Township PWS is as follows:

- Population served: 255
- Connections: 85
- Average daily flow rate: 0.022 mgd*
- Peak demand flow rate: 0.088 mgd**
- Typical arsenic range: 9.2 – 14.8 µg/L

* *Estimated based on 2004 monthly production.*
** *Estimated at 4 times average daily flow.*

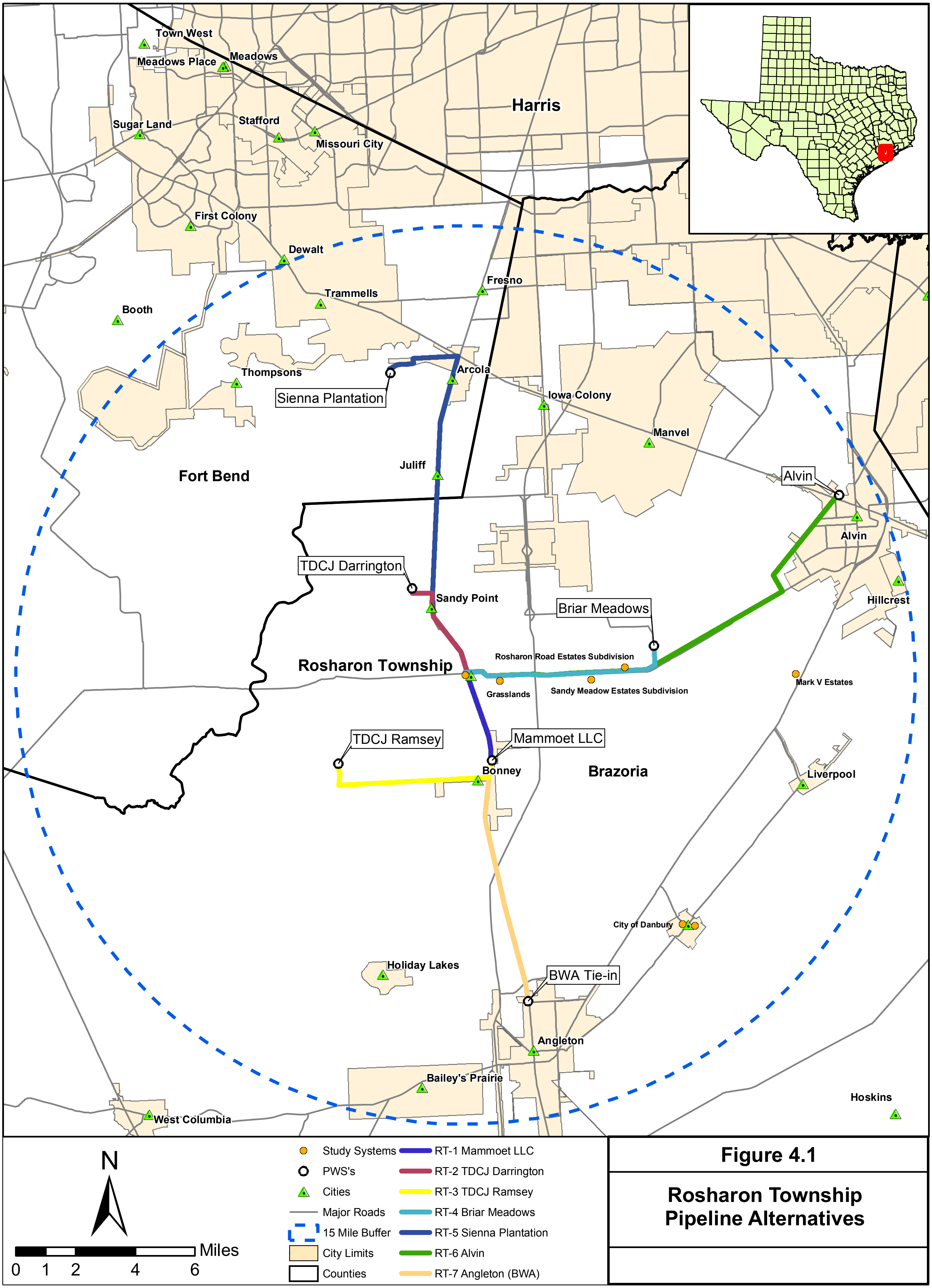


Figure 4.1

Rosharon Township Pipeline Alternatives

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4.1.2 Capacity Assessment for Rosharon Township

The following personnel involved with the Orbit Systems, Inc. (Orbit) were interviewed:

- Peggy Paul, Environmental Engineer.
- Jeff Walker, Operations Supervisor.

All interviews were conducted in person.

4.1.2.1 General Structure

Orbit is an investor-owned utility. Management includes a President, an Operations Supervisor, and an Engineer who handle all of the FMT issues for the system. These individuals also establish policies and supervise the three water operators. There is also an office worker who handles all administrative duties.

Orbit manages 33 small rural water systems. None of these systems are interconnected by pipeline. The population ranges from 170 for the smallest system to 450 for the largest system. The Orbit systems included in this study – Sandy Meadow Estates, Rosharon Township, Rosharon Road Estates, Grasslands, and Mark V Estates – had approximately 56, 85, 76, 150, and 94 connections, respectively, and populations of 170, 255, 230, 450, and 285, respectively. All of the systems are groundwater systems and all are metered.

The managerial structure of all of the water systems is the same, so only one capacity assessment was completed that covers all of the Orbit systems.

4.1.2.2 General Assessment of Capacity

Overall, the system had an adequate level of capacity. The system has some areas that needed improvement to address its future compliance issues; however, the system has many positive aspects.

4.1.2.3 Positive Aspects of Capacity

In assessing a system's overall capacity, it is important to look at all aspects – positive and negative. It is important for systems to understand those characteristics that are working well, so that those activities can be continued or strengthened. In addition, these positive aspects can assist the system in addressing the capacity deficiencies or concerns. As an example, Orbit Systems has been able to manage these 33 water systems on a regional basis so that greater efficiencies are achieved through economy of scale. The factors that were particularly important for Orbit Systems are listed below.

- Staff Longevity – The system is owned and the main managerial positions are staffed by one family. As such, the system has been able to maintain the same President, Engineer, and Operator/Operations Supervisor for over 20 years. This longevity in staff creates a long-term memory of the system components and system characteristics. The staff is very dedicated to the system. Other than the general operators, the system has experienced little turnover.

- Communication – There is excellent communication among the staff. There is also good communication between the system and the customers. Communication occurs through Consumer Confidence Reports, personal visits with customers who have a complaint, and monthly billing statements.
- In-House Expertise – The system has an engineer on staff who is able to meet the system's engineering needs. Also, the system installs many of its own lines (the lines that are less than 6-inch diameter). Part of the reason for doing this is to ensure that the lines are installed properly. In the past, the system has had problems with poorly constructed lines that were put in by private developers.
- Planning for System Growth – The systems are installed with consideration given to potential future connections. All future connections are installed initially and the lines are sized accordingly to ensure that build-out of the developments can be accommodated easily.
- Regional Nature of the System – Orbit operates 33 small rural water systems. There is a single rate structure to cover all of the systems. This combined rate allows the overall system to create an economy of scale and an efficiency that helps all of the systems. As new rules are introduced that require more complex treatment, the ability to manage several water systems on a regional basis will be critical. Orbit is willing to explore regionalization opportunities with neighboring systems that wish to work with them.
- The system maintains a good set of maps and uses them regularly. The maps are updated as the system is changed. Some private systems that were purchased did not have good mapping of the system components. Orbit is working on improving these maps over time.

4.1.2.4 Capacity Deficiencies

The following capacity deficiencies were noted in conducting the assessment.

- Training – The managerial staff does not regularly attend training. This lack of training may become a greater issue as new and more complex rules come into place. None of the staff, other than the President, are members of any water-related organization. Attendance at organization meetings could help keep the staff current on operational procedures and regulatory changes.
- Safety – The systems rely on gas chlorination. Gas chlorination has inherent dangers. The chlorination buildings do not have mechanical ventilation, no alarm systems, and no self-contained breathing apparatus

(SCBA). There are no written procedures for handling chlorination equipment and a buddy system is not used.

- Budget – Orbit does not have an official budget. Also, there are no budgets for each of the individual systems to track what is needed by each system. There is no process of preparing and approving budgets.
- Capital Improvements Planning – There is no long-term capital improvements planning done for the overall system or the individual systems. Issues are addressed as they arise, rather than planned for in advance. Needs are considered but they are not written down or included in a plan.
- Emergency Planning – The system does not have a written emergency plan, nor does it have emergency equipment such as generators or SCBAs. The lack of a generator caused a problem when an electrical storm knocked out power for 3 days and the system was not able to deliver water.
- Audited Financial Report – There is no independently audited financial report. An annual financial statement is generated in house for the facilities. However, because there is no budget, there is nothing to evaluate the annual financial statements against.

4.1.2.5 Potential Capacity Concerns

The following items were concerns regarding capacity but there are no particular operational, managerial, or financial problems that can be attributed to these items. The system should focus on the deficiencies noted above in the capacity deficiency section. Addressing the items listed below would help in further improving technical, managerial, and financial capabilities.

- Source Water Protection – The system has not implemented any type of source water protection program.
- Written Operational Procedures – There are no written operational procedures for the staff. Currently, due to the family nature of the business and the longevity of the staff, no problems are created by a lack of these procedures. However, if there is a turn-over in staff, the lack of written procedures could be a major problem for the system. In addition, written procedures would help the general operators.
- Emergency Funding – The systems should have a fund to cover emergencies. Currently, emergencies or other conditions that cause a short fall in funding are covered by private investment of the President into the system. This practice has been able to sustain the system in the past, but it may not be a sustainable practice. Orbit should consider some other means of covering these emergencies, such as reserve accounts.

4.2 ALTERNATIVE WATER SOURCE DEVELOPMENT

4.2.1 Identification of Alternative Existing Public Water Supply Sources

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

Table 4.1 is a list of the existing groundwater-supplied PWS systems within approximately 15 miles of Rosharon Township. From this list of water systems, several were selected for further evaluation based on factors such as water quality, distance from the Rosharon Township PWS, sufficient total production capacity for selling or sharing water, and willingness of the system to sell or share water or drill a new well. The wells selected for further evaluation are shown on Table 4.2.

Table 4.1 Existing Groundwater-Supplied Public Water Supply Systems

System Name	Dist. From Rosharon Township	Comments / Other Issues
OAK MEADOWS ESTATES SUBDIVISION	0.79	Small system with WQ issues: As, Fe
GRASSLANDS	1.16	Small system with WQ issues: As
SCHLUMBERGER RESERVOIR COMP	1.43	Large system (> 1mgd) with WQ issues: As, Mn
DAVENPORT MAMMOET LLC	3.03	Small system with marginal Mn exceedances. Evaluate further.
TDCJ ID DARRINGTON UNIT	3.55	Large system (> 1mgd) without identified WQ issues. Evaluate further.
SANDY MEADOW ESTATES SUBDIVISION	4.20	Small system with WQ issues: As, Mn
ROSHARON ROAD ESTATES SUBDIVISION	5.34	Small system with WQ issues: As, Mn
TDCJ RAMSEY AREA	5.57	Large system (> 1mgd) with Fe, Mn exceedances. Evaluate further.
BRIAR MEADOWS	6.37	Small system with marginal Fe exceedances. Evaluate further.
BATEMAN WATER WORKS	7.15	Small system with Mn exceedances
RIVERSIDE ESTATES	7.16	Small system with Mn exceedances
TPWD BRAZOS BEND STATE PARK 2	8.21	Small system with Fe, Mn (marginal) exceedances
BRAZORIA CNTY DETENTION CENTER 2	8.29	Large system (> 1mgd) with WQ issues: As, Fe (marginal)
JMP UTILITIES INC	9.04	Small system with Mn exceedances
ANGLECREST SUBDIVISION	9.20	Small system with Mn exceedances
TPWD BRAZOS BEND STATE PARK 1	9.23	Small system without identified WQ issues
WOLF GLEN WATER SYSTEM	9.39	Small system with WQ issues: As, Fe, Mn, TDS

System Name	Dist. From Rosharon Township	Comments / Other Issues
BAYOU SHADOWS WATER SYSTEM	9.55	Small system with WQ issues: As, Mn
BRANDI ESTATES	9.59	Small system with Mn exceedances
BEECHWOOD SUBDIVISION	9.62	Small system with Fe, Mn exceedances
SOUTHWOOD ESTATES INC	9.83	Small system with Fe, Mn exceedances
ALMEDA WATER WELL SERVICE	9.84	Small system with Fe, Mn exceedances
OAK BEND ESTATES	9.84	Small system with Mn exceedances
COLONY COVE SUBD WATER SYSTEM	9.92	Small system with Mn exceedances
OAK MANOR MUNICIPAL UTILITY DIST	10.15	Small system with WQ issues: As, Mn
SIENNA PLANTATION MUD 1	10.41	Large system (> 1mgd) with marginal Fe exceedances. Evaluate further.
CITY OF MANVEL	10.53	Small system with Mn exceedances
THE CITY OF HOLIDAY LAKE	10.55	Small system with Fe, marginal Mn exceedances
BRAZORIA CNTY PARKS BRAZOS RVR PK	10.99	Small system with WQ issues: As, Mn
BEST SEA PACK INC	11.00	Small system without identified WQ issues
MARK V ESTATES	11.03	Small system with WQ issues: As
CITY OF DANBURY	11.19	Small system with WQ issues: As, Fe, Mn, nitrate
LEE RIDGE SUBDIVISION	11.19	Small system with Mn exceedances
TELEVIEW TERRACE SUBDIVISION	11.34	Small system with Fe, Mn exceedances
COUNTRY MEADOWS	11.54	Small system with Mn exceedances
ANCHOR ROAD MOBILE HOME PARK	11.56	Small system with Fe, Mn exceedances
SCHMIDT MANUFACTURING	11.67	Small system with WQ issues: As, Fe, Mn
COUNTRY ACRES ESTATES	11.85	Small system with Mn exceedances
LIVERPOOL CITY OF	11.92	Small system with WQ issues: As
FORT BEND COUNTY MUD 23	11.94	Large system (> 1mgd) with iron exceedances
HALLIBURTON SERVICES FRESNO	12.04	Small system with Fe, Mn exceedances
NIAGRA PUBLIC WATER SUPPLY	12.29	Small system with Fe, Mn exceedances
WILLOW WOOD DUPLEX	12.38	Small system with Mn exceedances
WEYBRIDGE SUBDIVISION WATER SYSTEM	12.44	Small system with Mn and marginal TDS exceedances
FRESNO MOBILE HOME PARK	12.49	Small system with Mn exceedances
TURNER WATER SERVICE	13.04	Small system with Mn exceedances
JOHNSONS WATER SERVICE	13.40	Small system with Mn exceedances
SANDY RIDGE SUBDIVISION	13.41	Small system with Mn exceedances
CALICO FARMS SUBDIVISION	13.49	Small system with Mn exceedances
ASHLEY OAKS MOBILE HOME COMMUNITY	13.66	Small system with Mn exceedances
H L & P PARISH GAS PLANT	13.67	Large industrial system (> 1mgd) with iron exceedances
WESTWOOD SUBDIVISION	13.76	Small system with Mn exceedances
CITY OF ALVIN	13.80	Large system (> 1mgd) with marginal Mn exceedances. Evaluate further.
CITY OF LIVERPOOL	13.82	
PLEASANT MEADOWS SUBDIVISION	13.82	Small system with Mn exceedances

System Name	Dist. From Rosharon Township	Comments / Other Issues
RELIANT ENERGY	13.86	Large industrial system (> 1mgd) with Fe, Mn exceedances
PLEASANTDALE SUBD	13.93	Small system with Mn exceedances
MALLARD LAKE CLUB	13.97	Small system with Fe and marginal Mn, TDS exceedances
ANGLE ACRES WATER SYSTEM	14.03	Small system with Fe, Mn exceedances
WINDSONG SUBDIVISION	14.03	Small system with Mn exceedances
MEADOWLAND SUBDIVISION	14.09	Small system with Mn exceedances
COUNTRY CREEK ESTATES WATER SYSTEM	14.14	Small system with Mn exceedances
FORT BEND COUNTY MUD 60	14.23	Large system (> 1mgd) without identified WQ issues
HEIGHTS COUNTRY SUBDIVISION	14.40	Small system with Mn exceedances
CORONADO COUNTRY	14.60	Small system with Mn exceedances
MEADOWVIEW SUBDIVISION	14.63	Small system with Mn exceedances
FRONTIER WATER CO	14.68	Small system with Fe, Mn exceedances
CEDAR GROVE PARK	14.73	Small system with marginal Mn exceedances
CITY OF HILLCREST VILLAGE	14.74	Small system with marginal Mn and Fe exceedances
PINE COLONY MOBILE HOME PARK	14.74	Small system with Mn exceedances
PALMETTO SUBDIVISION	14.85	Small system with Mn exceedances
VILLAGE TRACE WATER SYSTEM	14.90	Small system with marginal Mn exceedances
WEST LEA WATER SYSTEM	14.92	Small system with Mn exceedances
PALMER PLANTATION MUD 1	14.93	Large system (> 1mgd) with iron exceedances
MORELAND SUBDIVISION BLOCK 3&4	14.97	Small system with Mn exceedances

Table 4.2 Existing Groundwater-Supplied Public Water Supply Systems Selected for Further Evaluation

PWS ID	System Name (PWS ID)	Pop	Conn	Total Prod, MGD	Ave Daily Usage, MGD	Approx. Dist. from RT	WQ Issues	Comments/ Other Issues
0200558	Mammoet	25	2	0.029	nd	3 miles	None	Suitable for a well
0200204	TDCJ Darrington Unit	2,037	1,250	0.900	0.500	3.5 miles	None	Consider water purchase.
0200201	TDCJ Ramsey Area	6,000	2,000	1.440	0.400	5.5 miles	None	Consider water purchase.
0200410	Briar Meadows	111	37	0.101	0.015	6.5 miles	None	Consider water purchase.
0790373	Sienna Plantation MUD 1	7455	2485	5.40	1.251	10.5 miles	None	Consider water purchase.
0200497	City of Angleton/Brazosport Water Authority	19,167[a]	6,389[a]	5.112[b]	1.910[a]	11 miles	None	Excess cap, willing to sell; 18" inch BWA main north Angleton.
0200001	City of Alvin	17,916	5,817	8.74	1.307	13.8 miles	None	Consider water purchase.

Notes: *nd – No data*
a – City of Angleton
b – Brazosport Water Authority

4.2.1.1 Mammoet USA Inc (PWS 0200558)

Mammoet USA, Inc. is located off State Hwy 288b in Bonney, Texas, approximately 3 miles south of Rosharon Township. The PWS is operated by Mammoet USA, Inc. and serves a population of 25 with two connections. The well is 270 feet deep with a rated capacity of 0.029 million gallons per day (mgd). The water is used primarily for industrial and agricultural purposes, and is hypochlorinated for disinfection before distribution. The system has one 310-gallon pressure tank. There is no information on the capacity of the booster pumps. Water consumption cannot be estimated since it is used for industrial and agricultural purposes. The water quality is good with an arsenic concentration of 0.002 mg/L based on one sample result.

The concentration of arsenic in the Rosharon Township PWS is about 0.010 mg/L. A flow of 0.034 mgd from Mammoet USA would be required to achieve a blended arsenic concentration of 0.008 mg/L at a peak consumption rate of 0.136 mgd for Rosharon Township. Thus, there is not sufficient excess capacity at Mammoet USA to supplement the Rosharon Township existing supply; however, based on available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.2 TDCJ Darrington Unit (PWS 0200204)

The Texas Department of Criminal Justice (TDCJ) operates the Darrington Unit prison located 3.6 miles north of Rosharon Township. The TDCJ Darrington Unit serves a population of 2037 with 1,250 connections. The PWS is supplied by three groundwater wells. The first two wells are completed in the Lower Chicot aquifer and the third well is completed in the Evangeline aquifer. The following table provides information about the wells and treatment processes.

Well No.	Depth	Tested	Rated	Treatment
1	595 ft	0.52 MGD	0.54 MGD	Fe, Mn Sequestration Gaseous Chlorination
2	537 ft	0.50 MGD	0.76 MGD	Fe, Mn Sequestration Gaseous Chlorination
3	1140 ft	0.86 MGD	1.08 MGD	Fe, Mn Sequestration Gaseous Chlorination

The average consumption for the system is 0.50 mgd, the maximum purchased capacity is 0.828 mgd, and the service pump capacity is 1.512 mgd. The total storage capacity is 300,000 gallons with elevated storage of 100,000 gallons. Quality of the water is good with an average arsenic concentration of 0.002 mg/L based on two sample results.

The concentration of arsenic in the Rosharon Township PWS is about 0.010 mg/L. A flow of 0.034 mgd from TDCJ Darrington Unit would be required to achieve a blended arsenic concentration of 0.008 mg/L at a peak consumption rate of 0.136 mgd for Rosharon Township. There appears to be excess capacity at TDCJ Darrington to supplement the Rosharon Township existing supply.

4.2.1.3 TDCJ Ramsey Area (PWS 0200201)

The TDCJ Ramsey Area PWS is located 5.6 miles to the southwest of the Rosharon Township. The TDCJ Ramsey Area PWS serves a population of 6,000 with 2,000 metered connections. The PWS is supplied by five groundwater wells. The following table provides information about the wells and treatment processes.

Well No.	Depth	Tested	Rated	Treatment
1	885 ft	0.32 MGD	0.65 MGD	Fe, Mn Sequestration Gaseous Chlorination
2	885 ft	0.22 MGD	0.50 MGD	Fe, Mn Sequestration Gaseous Chlorination
3	885 ft	0.68 MGD	1.01 MGD	Fe, Mn Sequestration Gaseous Chlorination
4	962 ft	0.94 MGD	0.97 MGD	Fe, Mn Sequestration Gaseous Chlorination
5	270 ft	0.94 MGD	1.44 MGD	Fe, Mn Sequestration Gaseous Chlorination

The average consumption for the system is 0.40 mgd; the maximum purchased capacity is 2.203 mgd; and the service pump capacity is 5.4 mgd. The total storage capacity is 1,350,000 gallons with elevated storage of 200,000 gallons. The quality of the water is good with an average arsenic concentration of 0.002 mg/L based on four sample results, but iron concentrations have exceeded the secondary standard MCL of 0.3 mg/L.

The concentration of arsenic in the Rosharon Township PWS is about 0.010 mg/L. A flow of 0.034 mgd from TDCJ Ramsey Area PWS would be required to achieve a blended arsenic concentration of 0.008 mg/L at a peak consumption rate of 0.136 mgd for Rosharon Township. There appears to be capacity at TDCJ Ramsey Area PWS to supplement the Rosharon Township existing supply.

4.2.1.4 Briar Meadows (PWS 0200410)

Briar Meadows is located on FM 1462, approximately 6.4 miles to the east of the Rosharon Township. The PWS is owned by Orbit Systems, Inc. and is supplied by a single groundwater well. The well, completed in the Chicot aquifer (Code 112CHCT), is 210 feet deep and rated for 0.086 mgd. The system has 5,000 gallons of storage capacity. Briar Meadows serves a population of 111 with 37 metered connections. The water delivery system has a total peak production of 0.101 mgd, and water is hypochlorinated and treated with polyphosphate for iron and manganese removal before distribution. The estimated average and maximum daily demand is 0.015 mgd and 0.059 mgd, respectively. The quality of the water is good with an arsenic concentration of 0.002 mg/L based on one sample result.

The concentration of arsenic in the Rosharon Township PWS is about 0.010 mg/L. A flow of 0.034 mgd from Briar Meadows would be required to achieve a blended arsenic concentration of 0.008 mg/L at a peak consumption rate of 0.136 mgd for Rosharon Township. It appears that there is sufficient excess capacity at Briar Meadows to supplement the Rosharon Township existing supply.

4.2.1.5 Sienna Plantation MUD 1 (PWS 0790373)

Sienna Plantation Municipal Utility District (MUD) 1 is located just west of the town of Arcola, Texas, 10.4 miles to the north of the Rosharon Township. Sienna Plantation MUD 1 serves a population of 7,455 with 2,485 metered connections. The MUD is supplied by four groundwater wells. The following table provides information about the wells and treatment processes.

Well No.	Depth	Tested	Rated	Treatment
1	940 ft	1.08 MGD	Not Rated	Gaseous Chlorination, Polyphosphate Inhibitor, Aeration
2	No Data	No Data	No Data	None
3	100 ft	2.02 MGD	Not Rated	Gaseous Chlorination, Polyphosphate Inhibitor
4	1000 ft	2.30 MGD	Not Rated	Gaseous Chlorination

Average consumption for the system is 1.251 mgd, the maximum purchased capacity is 4.932 mgd, and the service pump capacity is 14.940 mgd. The total storage capacity is

920,000 gallons and the pressure tank capacity is 50,000 gallons. Water quality is good with an average arsenic concentration of 0.0028 mg/L based on three sample results.

The concentration of arsenic in the Rosharon Township PWS is about 0.010 mg/L. A flow of 0.038 mgd from Sienna Plantation MUD 1 would be required to achieve a blended arsenic concentration of 0.008 mg/L at a peak consumption rate of 0.136 mgd for Rosharon Township. There appears to be enough excess capacity at Sienna Plantation MUD 1 to supplement the Rosharon Township existing supply.

4.2.1.6 City of Alvin (PWS 0200001)

The City of Alvin is located 13.8 miles to the northeast of Rosharon Township. The PWS is supplied by four local groundwater wells, three of which are completed in the Lower Chicot aquifer (Code 112CHCTL) and one of which is completed in the Evangeline aquifer (Code 121EVGL). The City serves a population of 17,916 and has 5,817 metered connections. The following table provides information about the wells and treatment processes.

Well No.	Depth	Tested	Rated	Treatment
1	690 ft	0	1.9 MGD	Sequestration, Hypochlorination
2	688 ft	0	1.2 MGD	Sequestration, Hypochlorination
3	702 ft	0	1.6 MGD	Sequestration, Hypochlorination
4	711 ft	0	2.2 MGD	Sequestration, Hypochlorination

Average consumption for the system is 1.307 mgd, the maximum purchased capacity is 4.75 mgd, and the service pump capacity is 7.78 mgd. Total storage capacity is 4.14 million gallons with elevated storage of 1.25 million gallons. Quality of the water is good with an average arsenic concentration of 0.002 mg/L based on five sample results.

The City of Alvin currently provides finished water to several small PWSs within its extra-territorial jurisdiction (ETJ) and is building lines towards Manvel, which is located to the west along Highway 6. The City eventually plans to build lines past Manvel. Alvin is planning to build a new WTP and storage tank in that region sometime in the next couple of years. Currently, the City has up to 4 mgd of excess capacity, and is willing to negotiate to sell water to other PWSs outside its ETJ.

4.2.1.7 Brazosport Water Authority (PWS 0200497)

The BWA currently operates a WTP in Lake Jackson, Texas. The source of the raw water is the Brazos River via the Oyster Creek Canal, and the WTP has capacity to treat up to 12.834 mgd. The current average daily consumption is 7.342 mgd resulting in an excess capacity over 5 mgd. The BWA is willing to sell water to neighboring communities subject to approval by the BWA Board of Directors. The BWA distribution system currently extends to the north side of Angleton.

4.2.2 Potential for New Groundwater Sources

4.2.2.1 Installing New Compliant Wells

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

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

The use of existing wells should probably be limited to use as indicators of groundwater quality and availability. If a new groundwater source is to be developed, it is recommended that a new well or wells be installed instead of using existing wells. This would 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 area is extensive and is likely to steadily increase over the next decades. In Brazoria County, the Chicot aquifer constitutes the primary groundwater source for public supplies. This aquifer is the upper unit of the Gulf Coast aquifer system that extends along the entire Texas coastal region. Throughout the northern part of the Gulf Coast aquifer system, large groundwater withdrawals since the 1900s have resulted in declines in the aquifer's potentiometric surface from tens to hundreds of feet. The largest declines have occurred in the Harris-Galveston Coastal Subsidence District (HGCSD), around the Houston metropolitan area, where the influence encompasses most of Brazoria County, including the Rosharon Township system.

A GAM for northern part of the Gulf Coast aquifer was recently developed by the TWDB. Modeling was performed by the U.S. Geological Survey to simulate historical conditions (Kasmerek and Robinson 2004), and to develop long-term groundwater projections (Kasmerek, *et al.* 2005). Two projections were evaluated, a TWDB scenario based on 50-year regional projections by regional user groups, and a HGCSD scenario that incorporates 30-year projections by the HGCSD for the Houston metropolitan area. Modeling of both projections anticipate extensive groundwater use and drop in aquifer levels, with far more critical groundwater availability conditions anticipated under the 30-year HGCSD scenario.

Under the HGCSD scenario, withdrawals from the Chicot aquifer and underlying Evangeline aquifer would increase by the year 2030 to an estimated 1,520 mgd, a 74 percent increase relative to 1995 conditions. Modeling of these projections indicate a significant increase in the aquifer's cone of depression by 2030, with depth increases of over 200 feet relative to current conditions (Kasmerek, *et al*. 2005). The percent of withdrawals supplied by net aquifer recharges would also steadily decrease, from an estimated 72 percent in 1995 to 43 percent projected in 2030 (Kasmerek, *et al*. 2005).

Under the TWDB scenario, long-term withdrawals from the Chicot aquifer and underlying Evangeline aquifer would moderately increase or remain level over the 50-year simulation period; the largest increase in withdrawal would occur between 2000 and 2010, with an 8 percent increase from 850 to 920 mgd (Kasmerek, *et al*. 2005). Modeling of the TWDB scenario showed relatively little change in elevation of the Chicot aquifer's potentiometric surface. In Matagorda County, however, a drop of elevation from 50 to 100 feet would occur under 2010 withdrawal conditions. The simulated net recharge of the aquifer, in contrast with the HGCSD scenario, would moderately increase under the TWDB scenario (Kasmerek, *et al*. 2005).

The GAM of the northern part of the Gulf Coast aquifer was not run for the Rosharon Township system as groundwater availability would reflect regional HGCSD conditions. Water use by the system would represent a minor addition to the regional HGCSD groundwater withdrawal, making potential changes in aquifer levels well beyond the spatial resolution of the regional GAM model.

4.2.3 Potential for New Surface Water Sources

The Gulf Coast Water Authority plans to build a 150 mgd WTP to treat Brazos River water. The new WTP may be built on 80 acres of land currently owned by the Fort Bend County Water Control & Improvement District (WC&ID) No. 2 (http://www.fortbendcountywcid2.com/WaterSource.htm). This would be a regional WTP that may serve west Harris County, the cities of Sugar Land, Missouri City, Arcola, Pearland, Alvin, Manvel, Friendswood, and the area within the boundaries of Fort Bend County WC&ID No. 2, which includes the City of Stafford. Rosharon Township may be able to connect to this regional WTP distribution system via the City of Alvin.

4.2.4 Options for Detailed Consideration

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

1. Mammoet USA, Inc. A new well would be completed in the vicinity of the well at Mammoet USA, Inc. A pipeline would be constructed and the water would be piped to Rosharon Township (Alternative RT-1).

2. TDCJ Darrington Unit. A new well would be completed in the vicinity of the wells at the TDCJ Darrington Unit. A pipeline would be constructed and the water would be piped to Rosharon Township (Alternative RT-2).

3. TDCJ Ramsey Area. A new well would be completed in the vicinity of the wells at the TDCJ Ramsey Area. A pipeline would be constructed and the water would be piped to Rosharon Township (Alternative RT-3).

4. Briar Meadows. A new well would be completed in the vicinity of the existing well at Briar Meadows. A pipeline would be constructed and the water would be piped to Rosharon Township (Alternative RT-4).

5. Sienna Plantation MUD 1. A new well would be completed in the vicinity of the wells at the Sienna Plantation MUD 1. A pipeline would be constructed and the water would be piped to Rosharon Township (Alternative RT-5).

6. City of Alvin. Treated water would be purchased from the City of Alvin to supply Rosharon Township. A pipeline would be constructed to tie into the existing City of Alvin system (Alternative RT-6).

7. Brazosport Water Authority. Treated water would be purchased from BWA to supply Rosharon Township. A pipeline would be constructed to tie into the existing main north of the City of Angleton (Alternative RT-7).

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 Rosharon Township 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 Rosharon Township. These alternatives are RT-12, RT-13, and RT-14.

4.3 TREATMENT OPTIONS

4.3.1 Blending with Other PWSs

There are opportunities to blend with other PWSs in the areas with well fields or WTPs that are producing compliant water. Blending is discussed in alternatives RT-1 through RT-7.

4.3.2 Centralized Treatment Systems

Centralized treatment of the well field water is identified as a potential option. Both adsorption and coagulation/filtration could be potentially applicable. The central adsorption treatment alternative is Alternative RT-8, and the central coagulation/filtration treatment alternative is Alternative RT-9.

4.3.3 Point-of-Use Systems / Point-of-Entry Systems

Point-of-use and point-of-entry treatment using iron-based IX technology is valid for arsenic removal. The POU treatment alternative is RT-10 and the POE alternative is RT-11.

4.3.4 New Groundwater Wells

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. New wells are discussed in alternatives RT-12 through RT-14.

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 RT-15, RT-16, and RT-17.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

A number of potential alternatives for compliance with the MCL for arsenic have been identified. Each of the potential alternatives is described in the following subsections. It should be noted that the cost information given is the capital cost and change in O&M costs associated with implementing 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. Cost analyses for shared solutions with other PWSs in the area are provided in Appendix G.

4.5.1 Alternative RT-1: Mammoet USA, Inc. (PWS 0200558)

This alternative consists of drilling a new well in the same area of the Mammoet USA well in Bonney, Texas that would be used to blend with the Rosharon Township well water. Records indicate there is no detectable amount of arsenic in the Mammoet USA well water. Sequestering may be required to treat manganese which is marginally high at times.

This alternative would require drilling a new well, installing a well pump and small ground storage tank, installing a pump station with two transfer pumps, and constructing a pipeline to the Rosharon Township system. The 4-inch polyvinyl chloride (PVC) pipeline would be approximately 3.2 miles long and would discharge into the existing Rosharon Township storage tank. One of the two pumps in the pump station is for backup in the event the other pump fails.

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 with other non-compliant PWSs in the area.

The estimated capital cost for this alternative includes a new well and small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Rosharon Township system. The estimated O&M cost for this alternative includes labor and material costs to operate the well field, maintain the pipeline, and operate the pump station. The estimated capital cost for this alternative is $928,800 and the estimated annual O&M cost for this alternative is $17,800.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair since Orbit currently operates pipelines and a pump station.

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

4.5.2 Alternative RT-2: TDCJ Darrington Unit (PWS 0200204)

While excess capacity exists at the TDCJ Darrington Unit to blend with Rosharon Township well water, it was assumed that an additional well would be drilled near the TDCJ Darrington Unit well field to supplement the existing capacity and allow for future growth. Records indicate there is no detectable amount of arsenic in the TDCJ Darringtion Unit well water.

This alternative would require drilling a new well, installing a well pump and small ground storage tank, installing a pump station with two transfer pumps, and constructing a pipeline to the Rosharon Township system. The 4-inch PVC pipeline would be approximately 4 miles long and would discharge into the existing Rosharon Township storage tank. One of the two pumps in the pump station is for backup in the event the other pump fails.

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 with other non-compliant PWSs in the area.

The estimated capital cost for this alternative includes a new well and small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Rosharon Township system. The estimated O&M cost for this alternative includes labor and material costs to operate the well field, maintain the pipeline, and operate the pump station. The estimated capital cost for this alternative is $1,029,800 and the estimated annual O&M cost for this alternative is $18,800.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair since Orbit currently operates pipelines and a pump station.

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

4.5.3 Alternative RT-3: TDCJ Ramsey Area (PWS 0200201)

While excess capacity exists at the TDCJ Ramsey Area PWS to blend with Rosharon Township well water, it was assumed that an additional well would be drilled near the TDCJ Ramsey Area well field to supplement the existing capacity and allow for future growth. Records indicate there is no detectable amount of arsenic in the TDCJ Ramsey Area well water. However, iron exceeds the secondary standard of 0.3 mg/L and would have to be removed by treatment.

This alternative would require drilling a new well, installing a well pump and small ground storage tank, installing a pump station with two transfer pumps, and constructing a pipeline to the Rosharon Township system. The 4-inch PVC pipeline would be approximately 9.5 miles long and would discharge into the existing Rosharon Township storage tank. One of the two pumps in the pump station is for backup in the event the other pump fails.

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 with other non-compliant PWSs in the area.

The estimated capital cost for this alternative includes a new well and small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Rosharon Township system. The estimated O&M cost for this alternative includes labor and material costs to operate the well field, to maintain the pipeline, and to operate the pump station. The estimated capital cost for this alternative is $2,389,200 and the estimated annual O&M cost for this alternative is $22,800.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair since Orbit currently operates pipelines and a pump station.

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

4.5.4 Alternative RT-4: Briar Meadows (PWS 0200410)

While excess capacity exists at Briar Meadows to blend with Rosharon Township well water, it was assumed that an additional well would be drilled near the Briar Meadows well field to supplement the existing capacity and allow for future growth. Records indicate there is no detectable amount of arsenic in the Briar Meadows well water. However, iron concentrations are marginally high and would have to be removed by treatment.

This alternative would require drilling a new well, installing a well pump and small ground storage tank, installing a pump station with two transfer pumps, and constructing a pipeline to the Rosharon Township system. The 4-inch PVC pipeline would be approximately 7.2 miles long and would discharge into the existing Rosharon Township storage tank. One of the two pumps in the pump station is for backup in the event the other pump fails.

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 with other non-compliant PWSs in the area.

The estimated capital cost for this alternative includes a new well and small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Rosharon Township system. The estimated O&M cost for this alternative includes labor and material costs to operate the well field, to maintain the pipeline, and to operate the pump station. The estimated capital cost for this alternative is $1,949,600 and the estimated annual O&M cost for this alternative is $20,900.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair since Orbit currently operates pipelines and a pump station.

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

4.5.5 Alternative RT-5: Sienna Plantation MUD 1 (PWS 0790373)

While excess capacity exists at Sienna Plantation MUD 1 to blend with Rosharon Township well water, it was assumed that an additional well would be drilled near the Sienna Plantation well field to supplement the existing capacity and allow for future growth. Records indicate the average and maximum concentrations of arsenic in the Sienna Plantation well water are 2.4 µg/L and 3.0 µg/L, respectively.

This alternative would require drilling a new well, installing two well pumps and two small ground storage tanks, installing two pump stations with two transfer pumps at each station, and constructing a pipeline to the Rosharon Township system. The 4-inch PVC pipeline would be approximately 13.8 miles long and would discharge to the Rosharon Township storage tank. One of the two pumps at each pump station is for backup in the event the other pump fails.

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 with other non-compliant PWSs in the area.

The estimated capital cost for this alternative includes a new well and two small ground storage tanks, two pump stations with two transfer pumps at each station, and a pipeline to the Rosharon Township system. The estimated O&M cost for this alternative includes labor and material costs to operate the well field, to maintain the pipeline, and to operate the pump stations. The estimated capital cost for this alternative is $3,363,900 and the estimated annual O&M cost for this alternative is $41,600.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair since Orbit currently operates pipelines and a pump station.

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

4.5.6 Alternative RT-6: City of Alvin (PWS 0200001)

This alternative consists of connecting directly to the City of Alvin's PWS system. The City's wells have a total capacity 8.739 mgd. The reported average daily demand is 1.307 mgd. The peak demand is estimated to be 5.228 mgd. This water would not need additional treatment.

This alternative would require installation of two pump stations with two transfer pumps at each station, and a pipeline to the Rosharon Township system. One of the two pumps at each pump station is for backup in the event the other pump fails. The 4-inch PVC pipeline would be approximately 15.6 miles long and discharge to the storage tank in Rosharon Township.

This alternative presents a regional solution, since other PWSs in the area also need compliant water. The Gulf Coast Water Authority's proposed regional surface WTP would replace some of the groundwater from wells in the Alvin area in the near future.

The estimated capital cost for this alternative includes installing two ground storage tanks, two pump stations with two transfer pumps at each station, and a pipeline to the Rosharon Township system. The estimated costs for this alternative include the purchase price for treated water, pipeline maintenance, and pump station operation, minus the cost Rosharon Township currently pays to operate its well field. The estimated capital cost for this alternative is $4,155,900 and the estimated annual O&M cost for this alternative is $49,000.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair since Orbit currently operates pipelines and a pump station.

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

4.5.7 Alternative RT-7: Brazosport Water Authority (PWS 0200497)

This alternative involves the purchase of treated surface water from the BWA. BWA currently has sufficient excess capacity for this alternative to be feasible and have indicated that they would be amenable to negotiating an agreement to supply water to PWSs in the area.

This alternative would require installation of two pump stations with two transfer pumps at each station, and a pipeline to the Rosharon Township system. One of the two pumps at each pump station is for backup in the event the other pump fails. The 4-inch PVC pipeline would be approximately 11.4 miles long and discharge to a storage tank in Rosharon Township.

Each pump station would include two pumps, including one standby, and would be housed in a building. It is assumed the pumps and piping would be installed with capacity to meet all water demand for the Rosharon Township, since the incremental cost would be relatively small, and would provide operational flexibility.

The estimated costs for this alternative include the purchase price for treated water, pipeline maintenance, and pump station operation minus the cost Rosharon Township currently pays to operate its well field. The estimated capital cost for this alternative is $3,329,300, and the estimated annual O&M cost for this alternative is $45,000.

The reliability of adequate amounts of compliant water under this alternative should be good. BWA provides treated surface water on a large scale, facilitating adequate O&M resources. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair since Orbit currently operates pipelines and a pump station.

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

4.5.8 Alternative RT-8: Central Iron-Based Adsorption Treatment

Orbit would treat groundwater using an iron-based adsorption system prior to distribution. This alternative consists of constructing the adsorption treatment plant at or near the well site. The plant comprises an 400 square foot building with a paved driveway, the pre-constructed adsorption system on a skid (*e.g.*, two Model APU-300 package units from Severn Trent), and a 5,000-gallon backwash wastewater equalization tank. The entire facility would be fenced. The water would be pre-chlorinated to oxidize As(III) to As(V) and post-chlorinated for disinfection prior to flowing to the distribution system. Backwash would be required monthly with raw well water supplied directly by the well pump. The backwash wastewater would be equalized in the 5,000-gallon tank and periodically hauled to a disposal site, such as the Orbit Grasslands wastewater treatment plant. The adsorption media are expected to last approximately 2 years before replacement and disposal.

The estimated capital cost for this alternative is $376,900, and the estimated annual O&M cost is $55,700 which includes the annualized media replacement cost of $14,000.

The reliability of adequate amounts of compliant water under this alternative is good because adsorption technology has been demonstrated to be effective in full-scale and pilot-scale facilities. The technology is simple and requires minimal O&M effort.

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

4.5.9 Alternative RT-9: Central Coagulation/Filtration Treatment

Orbit would treat groundwater using a coagulation/filtration system prior to distribution. This alternative consists of constructing the coagulation/filtration plant at or near the well site. The plant comprises a 400 square foot building with a paved driveway, the pre-constructed coagulation/filtration system on a skid (*e.g.*, three Macrolite filters from Kinetico), a ferric chloride feed and storage system, and a 5,000-gallon backwash wastewater equalization tank. The entire facility would be fenced. The water would be pre-chlorinated to oxidize As(III) to As(V) and post-chlorinated for disinfection prior to flowing to the distribution system. Ferric chloride solution would be fed to the well water after pre-chlorination and before entering the filters. The filters would be backwashed once every 1 to 2 days by well water directly from the well pump. The backwash wastewater would be equalized in the 5,000-gallon tank and periodically hauled to a disposal site. The Macrolite media do not need replacement.

The estimated capital cost for this alternative is $291,600, and the estimated annual O&M cost is $125,300. This alternative requires more O&M labor cost and sewer disposal charges than the adsorption alternative.

The reliability of adequate amounts of compliant water under this alternative is good as the coagulation/filtration is a well-established technology. The technology is simple but requires significant effort for chemical handling and backwash monitoring.

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

4.5.10 Alternative RT-10: Point-of-Use Treatment

This alternative consists of the continued operation of the Rosharon Township well, plus treatment of water to be used for drinking or food preparation at POU to remove arsenic. The purchase, installation, and maintenance of POU treatment systems to be installed “under the sink” would be necessary for this alternative. The POU treatment system most applicable is the adsorption process using iron-based IX media. Blending is not an option in this case.

This alternative would require installation of the POU treatment units in residences and other buildings that provide potable water. Orbit would be responsible for purchasing and maintaining the treatment units, including media 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 would require entry by Orbit personnel or contract personnel into the houses of customers. As a result, the cooperation of customers would be important for success in implementing this alternative. The treatment units could be installed so access could be made without house entry, but that would complicate installation and increase costs.

Point-of-use arsenic treatment processes typically produce spent media that require disposal and possibly a small backwash waste stream. The backwash waste stream results in a slight increase in the overall volume of water used. POU systems have the advantage of treating a minimum volume of water for human consumption only. 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 would be insignificant in terms of supply cost, and that the backwash waste stream can be discharged to the house septic or sewer system.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the POU treatment systems. The estimated O&M cost for this alternative includes purchasing and replacing filters and media, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $56,100, and the estimated annual O&M cost for this alternative is $53,100. For the cost estimate, it is assumed that one POU treatment unit would be required for each of the 85 existing connections to the Rosharon Township 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.

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

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

4.5.11 Alternative RT-11: Point-of-Entry Treatment

This alternative consists of the continued operation of the Rosharon Township well, plus treatment of water as it enters residences to remove arsenic. The purchase, installation, and maintenance of the treatment systems at the POE to a household would be necessary for this alternative. Blending is not an option in this case.

This alternative would require installation of the POE treatment units at residences and other buildings that provide potable water. Orbit would be responsible for purchasing and maintaining the treatment units, including media and filter replacement, periodic sampling, and necessary repairs. It may also be desirable to modify piping so water for non-consumptive uses can be withdrawn upstream of the treatment unit. The POE treatment units would be installed outside the residences, so entry would not be necessary for O&M. Some cooperation from customers would be necessary for installation and maintenance of the treatment systems.

Point-of-entry arsenic treatment processes typically produce spent adsorption media as waste, as well as possibly backwash water that would require disposal. The backwash water stream results in a slight increased overall volume of water used. Point-of-entry systems treat a greater volume of water than POU systems. For this alternative, it is assumed the increase in water consumption would be insignificant in terms of supply cost, and that the backwash waste stream could be discharged to the house septic or sewer system.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the POE treatment systems. The estimated O&M cost for this alternative includes purchasing and replacing filters and media, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $981,800, and the estimated annual O&M cost for this alternative is $119,000. For the cost estimate, it is assumed that one POE treatment unit would be required for each of the 85 existing connections.

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

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

4.5.12 Alternative RT-12: New Wells at 10 Miles

This alternative consists of installing one new well within 10 miles of Rosharon Township that would produce compliant water in place of the water produced by the current well field. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed.

This alternative would require construction of one new 310-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 Rosharon Township 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 Rosharon Township storage tank. 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 another nearby system.

The estimated capital cost for this alternative includes installing the well and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing well. The estimated capital cost for this alternative is $2,628,600, and the estimated annual O&M cost for this alternative is $23,300.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From the perspective of Orbit, this alternative would be similar to operate as the existing system. Orbit has experience with O&M of wells, pipelines, and pump stations.

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

4.5.13 Alternative RT-13: New Wells at 5 Miles

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

This alternative would require constructing one new 310-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 Rosharon Township 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 Rosharon Township storage tank. 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 another nearby system.

The estimated capital cost for this alternative includes installing the well, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the O&M for the pipeline and pump station, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing wells. The estimated capital cost for this alternative is $1,337,100, and the estimated annual O&M cost for this alternative is $19,000.

The reliability of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From the perspective of Orbit, this alternative would be similar to operate as the existing system. Orbit has experience with O&M of wells, pipelines, and pump stations.

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

4.5.14 Alternative RT-14: New Wells at 1 Mile

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

This alternative would require constructing one new 310-foot well and a pipeline from the new well to the existing intake point for the Rosharon Township system. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 4-inch PVC line that discharges to the existing Rosharon Township storage tank.

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

The estimated capital cost for this alternative includes installing the well and constructing the pipeline. The estimated O&M cost for this alternative includes O&M for the pipeline, plus an amount for plugging and abandoning (in accordance with TCEQ requirements) the existing wells. The estimated capital cost for this alternative is $290,100, and the estimated annual O&M cost for this alternative is $200.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of Orbit, this alternative would be similar to operate as the existing system. Orbit has experience with O&M of wells, pipelines and pump stations.

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

4.5.15 Alternative RT-15: Public Dispenser for Treated Drinking Water

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

Orbit would be responsible for maintaining the treatment unit, including media replacement, periodic sampling, and necessary repairs. The spent media would require disposal. This alternative relies on a great deal of cooperation and action from the customers in order to be effective.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes purchasing and replacing filters and media, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is \$11,600, and the estimated annual O&M cost for this alternative is \$16, 700.

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

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

4.5.16 Alternative RT-16: 100 Percent Bottled Water Delivery

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

This alternative does not involve capital cost for construction, but would require some initial costs for system setup, and then ongoing costs to furnish bottled water. It is assumed for this alternative that bottled water would be provided to 100 percent of the Rosharon Township customers.

This alternative does not present options for a regional solution.

The estimated initial capital cost is for setting up the program. The estimated O&M cost for this alternative includes program administration and purchase of the bottled water. The estimated capital cost for this alternative is $23,900, and the estimated annual O&M cost for this alternative is $172,600. For the cost estimate, it is assumed that each person requires one gallon of bottled water per day.

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

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

4.5.17 Alternative RT-17: Public Dispenser for Trucked Drinking Water

This alternative consists of continued operation of the Rosharon Township well, plus dispensing compliant water for drinking and cooking at a publicly accessible location. The compliant water would be purchased from a nearby supplier, 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 water requires trucking, but customers would be required to pick up and deliver their own water. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

Orbit would purchase a truck suitable for hauling potable water, and install a storage tank. It is assumed the storage tank would be filled once a week, and that the chlorine residual would be tested for each truckload. The truck would need to meet requirements for potable water, and each load would be treated with chlorine. 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 purchasing a water truck and constructing the storage tank to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes O&M for the truck, maintenance for the tank, water quality testing, record keeping, and water purchase. The estimated capital cost for this alternative is $103,000, and the estimated annual O&M cost for this alternative is $15,100.

The reliability of adequate amounts of compliant water under this alternative is fair because of the large amount of effort required from the customers and the associated inconvenience. Orbit has not provided this type of service in the past. From the perspective of Orbit, this alternative would be characterized as relatively easy to operate, but water hauling and storage would need 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.

4.5.18 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for Rosharon Township.

1 **Table 4.3 Summary of Compliance Alternatives for Rosharon Township**

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost[2]	Reliability	System Impact	Remarks
RT-1	Blend with Mammoet USA well field water.	- Pump station - 3.2-mile pipeline - New well	$928,800	$17,800	$98,800	Good	N	Feasibility dependent of finding a suitable well site.
RT-2	Blend with TDCJ Darrington Unit well field water.	- Pump station - 4-mile pipeline - New well	$1,029,800	$18,800	$108,600	Good	N	Feasibility dependent of finding a suitable well site.
RT-3	Blend with TDCJ Ramsey Area well field water.	- Pump station - 9.5-mile pipeline - New well	$2,389,200	$22,800	$231,100	Good	N	Feasibility dependent of finding a suitable well site.
RT-4	Blend with Briar Meadows well field water.	- Pump station - 7.2-mile pipeline - New well	$1,949,600	$20,900	$190,800	Good	N	Feasibility dependent of finding a suitable well site.
RT-5	Blend with Sienna Plantation MUD 1 well field water.	- Pump stations - 13.8-mile pipeline - New well	$3,363,900	$41,600	$334,900	Good	N	Feasibility dependent of finding a suitable well site.
RT-6	Purchase water from City of Alvin.	- Pump stations - 15.6-mile pipeline	$4,155,900	$49,000	$411,300	Good	N	City of Alvin PWS has 3.5 mgd excess capacity.
RT-7	Purchase water from Brazosport Water Authority.	- Pump stations - 11.4-mile pipeline	$3,329,300	$45,000	$335,300	Good	N	Brazosport Water Authority has 5 mgd excess capacity.
RT-8	Continued use of existing well with central iron-based adsorption treatment	One central iron-based adsorption treatment unit	$376,900	$55,700	$88,500	Good	T	Alternative assumes no nearby PWS system to share treatment plant cost.
RT-9	Continued use of existing wells with central coagulation / filtration treatment	One central coagulation / filtration treatment unit	$291,600	$125,300	$150,700	Good	T	Alternative assumes no nearby PWS system to share treatment plant cost.
RT-10	Continued use of existing wells with point-of-use treatment	Small adsorption treatment unit for each customer	$56,100	$53,100	$58,000	Fair	T, M	Alternative assumes all the homes and businesses will cooperate. Does not provide compliant water to all taps.
RT-11	Continued use of existing wells with point-of-entry	Small adsorption treatment unit for each customer	$981,800	$119,000	$204,600	Fair	T, M	All taps compliant.

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost[2]	Reliability	System Impact	Remarks
	treatment							
RT-12	Install new compliant well within 10 miles	- New well - Storage tank - Pump station - 10-mile pipeline	$2,628,600	$23,300	$252,500	Good	N	May be difficult to find well with good water quality.
RT-13	Install new compliant well within 5 miles	- New well - Storage tank - Pump station - 5-mile pipeline	$1,337,100	$19,000	$135,600	Good	N	May be difficult to find well with good water quality.
RT-14	Install new compliant well within 1 mile	- New well - 1-mile pipeline	$290,100	$200	$25,500	Good	N	May be difficult to find well with good water quality.
RT-15	Continue operation of Rosharon Township well, but furnish public dispenser for treated drinking water	- Water treatment and dispenser unit	$11,600	$16,700	$17,700	Fair/interim measure	T	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires a lot of effort by customers.
RT-16	Continue operation of Rosharon Township well, but furnish bottled drinking water for all customers	- Set up bottled water system	$23,900	$172,600	$174,700	Fair/interim measure	M	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires customers to order and use. Management of program may be significant.
RT-17	Continue operation of Rosharon Township well, but furnish bottled drinking water for susceptible population	- Construct storage tank and dispenser - Purchase potable water truck	$103,000	$15,100	$24,100	Fair/interim measure	M	INTERIM SOLUTION: Does not provide compliant water to all taps, and requires customers to order and use. Management of program and identification

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

4.6 COST OF SERVICE AND FUNDING ANALYSIS

To evaluate the financial impact of implementing 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 typically derived from established budgets, audited financial reports, published water tariffs, and consumption data. Orbit manages 33 small rural PWSs and three wastewater treatment plants. The only financial data available was a consolidated Profit and Loss Statement and a Water and Wastewater Utilities Annual Report for 2004. The Water Utility Tariff and water usage records for all 33 Orbit PWSs were also available.

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 Rosharon Township Financial Data

Since Orbit does not keep separate financial records for each of the 33 PWSs it manages, revenues and expenses had to be estimated for Rosharon Township. Annual revenue was estimated using a base rate of $21 per month per connection plus actual usage at a rate of $1.90 per 1,000 gallons assuming a water loss of 11.4 percent. These values were plugged into the financial model resulting in 2004 revenue of $40,038 (operating revenue plus required reserve) for Rosharon Township compared to $7,780,508 total 2004 revenue for Orbit as summarized in Table 4.4.

Table 4.4 Summary of Orbit Systems 2004 Water Revenues

PWS Name	2004 Water Usage (gallons)	No. Connections	2004 Water Revenue
Rosharon Township	8,055,400	85	$40,038
Rosharon Roads Estates	5,455,900	76	$29,870
Sandy Meadow	3,735,400	56	$24,456
Mark V Estates	7,178,900	94	$37,858
Grasslands	12,465,400	150	$67,595
Other Systems - Water	88,671,400	1,236	$503,096
Other Systems - Sewer	125,562,400	---	$77,595
Total		**1,697**	**$780,508**

Annual expenses for Rosharon Township were estimated based on its percentage water usage of 6.4 percent as shown in Appendix F. This resulted in 2004 expenses of $48,917 (including depreciation) compared to $770,256 total expenses for Orbit as summarized in Table 4.5.

Table 4.5 Summary of Orbit Systems 2004 Expenses

PWS Name	2004 Water Usage (gallons)	% Water Usage	2004 Water Expenses
Rosharon Township	8,055,400	6.4	$ 48,917
Rosharon Roads Estates	5,455,900	4.3	$ 32,866
Sandy Meadow	3,735,400	3.0	$ 22,930
Mark V Estates	7,178,900	5.7	$ 43,566
Grasslands	12,465,400	10.3	$ 79,317
Other Systems	88,671,400	70.3	$542,660
Total	**125,562,400**	**100.0**	**$770,256**

4.6.1.2 Current Financial Condition

4.6.1.2.1 Cash Flow Needs

Table 4.6 shows the 2004 revenues and expenses for Rosharon Township compared to other Orbit PWSs included in this study. The shortfall for Rosharon Township of $8,879 is based on current operations without any capital expenditures to address the arsenic problem. This means that Orbit Systems is not currently charging its Rosharon Township customers enough for water usage to sustain this portion of the operation.

Table 4.6 Summary of Orbit Systems 2004 Operations

PWS Name	2004 Water Expenses	2004 Water Revenue	Over / (Under)
Rosharon Township	$ 48,917	$ 40,038	($ 8,879)
Rosharon Roads Estates	$ 32,866	$ 29,870	($ 2,996)
Sandy Meadow	$ 22,930	$ 24,456	$1,526
Mark V Estates	$ 43,566	$ 37,858	($ 5,708)
Grasslands	$ 79,317	$ 67,595	($11,722)

Analysis of the long-term financial plan indicates that Rosharon Township will need to increase rates over the next few years in order to maintain financial viability even without considering any possible solutions for the arsenic problem. The average annual bill for Rosharon Township customers must be increased by 71.4 percent just to meet operating expenses for this system based on the assumptions used in this analysis.

Table 4.7 shows how a 71.4 percent increase would impact the average annual bill for Rosharon Township customers as a percent of the MHI for Brazoria County compared to other Orbit PWSs included in this study. The average annual bill in Rosharon Township would increase from $252 to $432 based on the no action alternative.

Table 4.7 Summary of Orbit Systems Required Revenue Increases

PWS Name	Current Average Annual Bill	Current % MHI	% Increase Needed	New Average Annual Bill	New % MHI
Rosharon Township	$ 252	0.52 %	71.4 %	$ 432	0.89 %
Rosharon Roads Estates	$ 373	0.77 %	1.3 %	$ 378	0.81 %
Sandy Meadow	$ 344	0.86 %	None	$ 295	0.74 %
Mark V Estates	$ 381	0.78 %	16.3 %	$ 405	0.90 %
Grasslands	$ 375	0.77 %	8.8 %	$ 408	0.87 %

4.6.1.2.2 Ratio Analysis

There is not enough financial information available for Orbits or Rosharon Township to calculate the Current Ratio or the Debt to Net Worth Ratio. However, an Operating Ratio of 0.82 was calculated from available financial information. An Operating Ratio of 1.0 means that a utility is collecting just enough money to meet expenses; thus, an Operating Ratio of 0.82 is just another indication that Orbit must raise its water rates for its Rosharon Township customers in the future.

4.6.1.3 Financial Plan Results

Each compliance alternative for Rosharon Township was evaluated using the financial model to determine the overall increase in water rates that would be necessary to pay for the improvements. Each alternative was examined under the various funding options described in Section 2.4.

The financial model results for all the alternatives are summarized in Table 4.8 and Figure 4.2. Figure 4.3 shows the current average annual bill for Rosharon Township of $252, and the average annual bill of $432 needed to fully fund existing operations. There are two bars shown for each alternative. The lowest bar is based on 100 percent grant funding of capital improvements for the compliance alternative. Thus, the higher average annual water bill reflects only higher O&M costs associated with the compliance alternative. The highest bar is based on entirely funding capital requirements with either loans or bonds, which represents the highest cost scenario. Therefore, the higher average annual water bill in this case reflects both higher O&M costs and the principal and interests costs to service debt associated with the compliance alternative. Figure 4.2 also shows the annual residential water bill as a percent of MHI for Brazoria County.

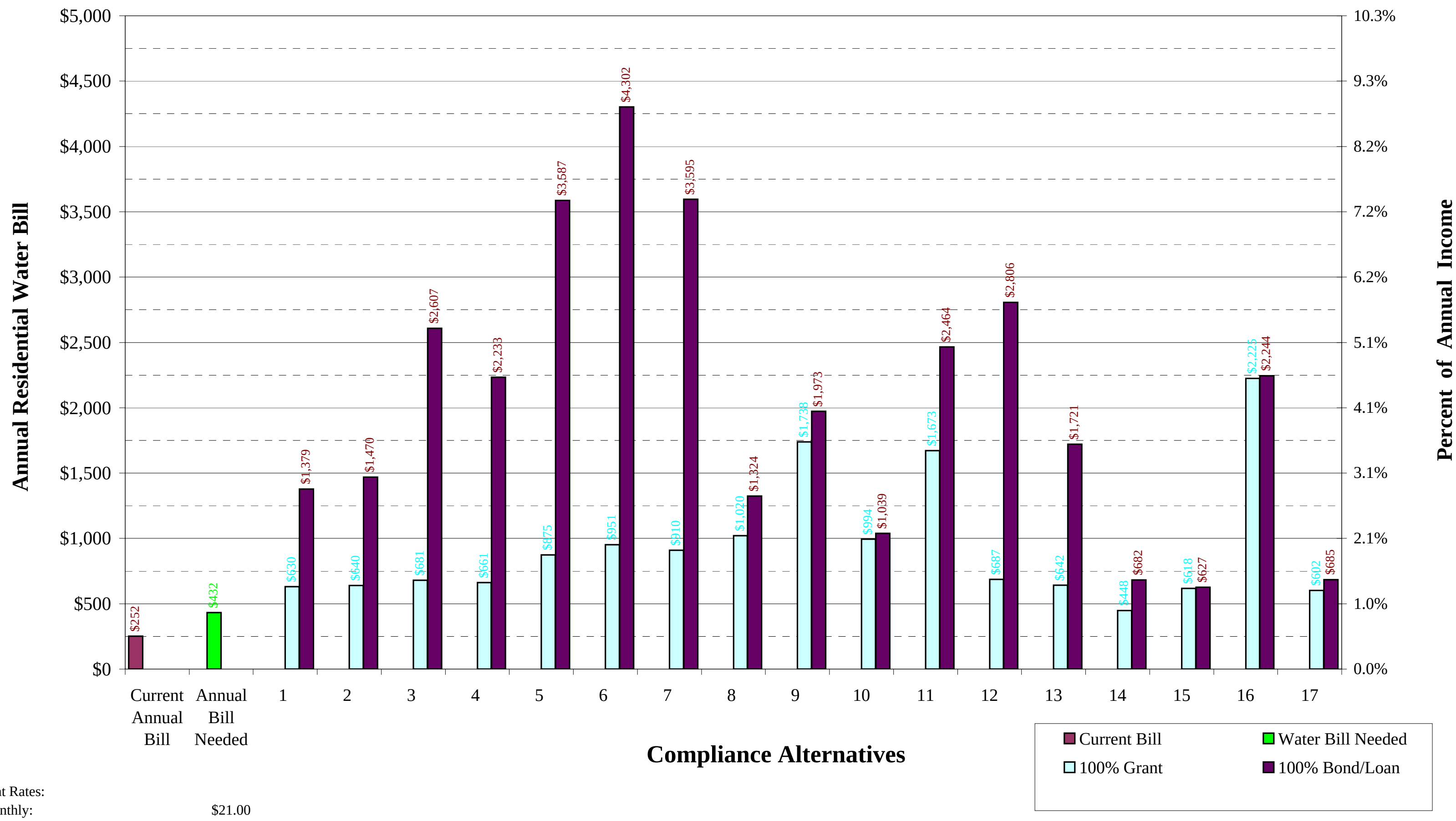
1 **Table 4.8 Financial Impact on Households for Rosharon Township**

		Funding Source #	0	1	2	3	4	5
#	ALTERNATIVES		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Loan/Bond
RT-1	Mammoet LLC	Average Annual Water Bill	$ 9,984.43	$ 1,029.01	$ 1,373.25	$ 1,717.48	$ 2,239.66	$ 2,405.96
		Maximum % of HH Income	22%	2%	3%	4%	5%	5%
		Percentage Rate Increase Compared to Current	4134%	335%	484%	632%	858%	930%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-2	TDCJ Darrington	Average Annual Water Bill	$ 10,967.42	$ 1,037.98	$ 1,419.66	$ 1,801.34	$ 2,380.31	$ 2,564.69
		Maximum % of HH Income	24%	2%	3%	4%	5%	6%
		Percentage Rate Increase Compared to Current	4551%	339%	504%	669%	919%	998%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-3	TDCJ Ramsey	Average Annual Water Bill	$ 24,111.78	$ 1,097.33	$ 1,982.83	$ 2,868.34	$ 4,211.56	$ 4,639.35
		Maximum % of HH Income	53%	2%	4%	6%	9%	10%
		Percentage Rate Increase Compared to Current	10127%	366%	748%	1130%	1710%	1894%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-4	Briar Meadows	Average Annual Water Bill	$19,855.80	$1,062.45	$1,785.05	$2,507.64	$3,603.74	$3,952.82
		Maximum % of HH Income	44%	2%	4%	6%	8%	9%
		Percentage Rate Increase Compared to Current	8322%	350%	662%	974%	1447%	1598%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-5	Sienna Plantation	Average Annual Water Bill	$33,685.98	$1,441.19	$2,687.99	$3,934.79	$5,826.06	$6,428.39
		Maximum % of HH Income	74%	3%	6%	9%	13%	14%
		Percentage Rate Increase Compared to Current	14191%	519%	1058%	1596%	2412%	2672%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-6	Alvin	Average Annual Water Bill	$41,391.23	$1,576.64	$3,116.97	$4,657.30	$6,993.83	$7,737.96
		Maximum % of HH Income	91%	4%	7%	10%	16%	17%
		Percentage Rate Increase Compared to Current	17461%	580%	1245%	1910%	2918%	3239%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-7	Brazos Water Auth	Average Annual Water Bill	$33,384.02	$1,504.63	$2,738.58	$3,972.53	$5,844.31	$6,440.43
		Maximum % of HH Income	73%	3%	6%	9%	13%	14%
		Percentage Rate Increase Compared to Current	14064%	548%	1080%	1613%	2421%	2678%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005

		Funding Source #	0	1	2	3	4	5
#	**ALTERNATIVES**		**All Revenue**	**100% Grant**	**75% Grant**	**50% Grant**	**SRF**	**Loan/Bond**
RT-8	Central Adsorption	Average Annual Water Bill	$5,015.36	$1,699.39	$1,839.06	$1,978.74	$2,190.61	$2,258.09
		Maximum % of HH Income	11%	4%	4%	4%	5%	5%
		Percentage Rate Increase Compared to Current	2032%	635%	695%	755%	847%	876%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-9	Central Coagulation	Average Annual Water Bill	$4,841.60	$2,972.89	$3,080.96	$3,189.04	$3,352.98	$3,405.19
		Maximum % of HH Income	11%	7%	7%	7%	8%	8%
		Percentage Rate Increase Compared to Current	1968%	1205%	1251%	1298%	1369%	1391%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-10	POU-Adsorption	Average Annual Water Bill	$1,898.74	$1,652.54	$1,673.33	$1,694.12	$1,725.66	$1,735.71
		Maximum % of HH Income	4%	4%	4%	4%	4%	4%
		Percentage Rate Increase Compared to Current	709%	614%	623%	632%	646%	650%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-11	POE-Adsorption	Average Annual Water Bill	$11,437.29	$2,857.18	$3,221.06	$3,584.93	$4,136.88	$4,312.67
		Maximum % of HH Income	25%	6%	7%	8%	9%	10%
		Percentage Rate Increase Compared to Current	4765%	1153%	1310%	1467%	1705%	1781%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-12	New Well 10 mi	Average Annual Water Bill	$26,425.43	$1,107.55	$2,081.79	$3,056.03	$4,533.85	$5,004.50
		Maximum % of HH Income	58%	2%	5%	7%	10%	11%
		Percentage Rate Increase Compared to Current	11109%	370%	791%	1211%	1849%	2052%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-13	New Well 5 mi	Average Annual Water Bill	$13,932.90	$1,040.48	$1,536.05	$2,031.62	$2,783.35	$3,022.77
		Maximum % of HH Income	31%	2%	3%	4%	6%	7%
		Percentage Rate Increase Compared to Current	5809%	340%	554%	768%	1093%	1196%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-14	New Well 1 mi	Average Annual Water Bill	$3,661.81	$865.09	$972.60	$1,080.10	$1,243.17	$1,295.11
		Maximum % of HH Income	8%	2%	2%	2%	3%	3%
		Percentage Rate Increase Compared to Current	1450%	263%	310%	356%	426%	449%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-15	Dispenser	Average Annual Water Bill	$1,130.09	$1,018.24	$1,022.54	$1,026.84	$1,033.36	$1,035.44
		Maximum % of HH Income	2%	2%	2%	2%	2%	2%
		Percentage Rate Increase Compared to Current	378%	330%	332%	334%	337%	338%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005

		Funding Source #	**0**	**1**	**2**	**3**	**4**	**5**
#	**ALTERNATIVES**		**All Revenue**	**100% Grant**	**75% Grant**	**50% Grant**	**SRF**	**Loan/Bond**
RT-16	100% Bottled	Average Annual Water Bill	$3,853.15	$3,837.23	$3,846.11	$3,854.98	$3,868.44	$3,872.73
		Maximum % of HH Income	9%	9%	9%	9%	9%	9%
		Percentage Rate Increase Compared to Current	1591%	1591%	1595%	1599%	1605%	1607%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
RT-17	Central Trucked	Average Annual Water Bill	$1,996.74	$1,003.73	$1,041.90	$1,080.07	$1,137.97	$1,156.41
		Maximum % of HH Income	4%	2%	2%	2%	2%	3%
		Percentage Rate Increase Compared to Current	745%	324%	341%	357%	382%	390%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005

Figure 4-2 Alternative Cost Summary



Current Rates:

Monthly:	$21.00
Median Household Income	$48,632
Average Monthly Residential Usage	6,008 gallons

SECTION 5
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APPENDIX A
PWS INTERVIEW FORM

CAPACITY DEVELOPMENT ASSESSMENT FORM

*Prepared By*___________________________________ *Date*___________________________

Section 1. Public Water System Information

1. PWS ID # 2. Water System Name

3. County

4. Owner Address

Tele. E-mail

Fax Message

5. Admin Address

Tele. E-mail

Fax Message

6. Operator Address

Tele. E-mail

Fax Message

7. Population Served 8. No. of Service Connections

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

11. Source Type

12. Total PWS Annual Water Used

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

Total Coliform Chemical/Radiological

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

A. Basic Information

1. Name of Water System:

2. Name of Person Interviewed:

3. Position:

4. Number of years at job:

5. Number of years experience with drinking water systems:

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

7. Certified Water Operator (Yes or No):

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

   7b. How long have you been certified?

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

B. Organization and Structure

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

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

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

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

    3b. May we see a copy?

C. Personnel

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

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

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

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

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

D. Communication

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

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

3. How are your work priorities set?

4. How are work tasks delegated to staff?

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

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

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

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

9. Describe communication between utility and customers.

E. Planning and Funding

1. Describe the rate structure for the utility.

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

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

3. How often are the rates reviewed?

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

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

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

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

8. How is the budget approved or adopted?

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

    9a. How are budget shortfalls handled?

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

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

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

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

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

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

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

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

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

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

F. Policies, Procedures, and Programs

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

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

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

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

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

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

7. Approximately how many complaints are there per month?

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

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

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

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

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

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

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

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

G. Operations and Maintenance

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

    a. Process Control

    b. Purchases of supplies or small equipment

    c. Compliance sampling/reporting

    d. Staff scheduling

2. Describe your utility's preventative maintenance program.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

H. SDWA Compliance

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

2. How were the violations handled?

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

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

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

I. Emergency Planning

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

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

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

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

Attachment A

A. Technical Capacity Assessment Questions

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

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

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

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

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

   YES ☐ NO ☐

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

   _____NM Small System _____Class 2

   _____NM Small System Advanced _____Class 3

   _____Class 1 _____Class 4

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

   YES ☐ NO ☐ No Deficiencies ☐

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

   Source ☐ Storage ☐

   Treatment ☐ Distribution ☐

   Other _____

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

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

   Radionuclides YES ☐ NO ☐ Doesn't Apply ☐

   Arsenic YES ☐ NO ☐ Doesn't Apply ☐

   Stage 1 Disinfectants and Disinfection By-Product (DBP)

   YES ☐ NO ☐ Doesn't Apply ☐

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

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

   YES ☐ NO ☐

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

YES ☐ NO ☐

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

Drought _____ Limited Supply _____

System Failure _____ Other _____

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

YES ☐ NO ☐ Don’t Know ☐

If YES, please complete the following table.

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

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

YES ☐ NO ☐

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

Source ☐ Storage ☐

Treatment ☐ Distribution ☐

Other ☐ _____

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

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

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

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

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

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

YES ☐ NO ☐

14. Does the system have a flushing program?

YES ☐ NO ☐

If YES, please describe.

15. Are there any pressure problems within the system?

YES ☐ NO ☐

If YES, please describe.

16. Does the system disinfect the finished water?

YES ☐ NO ☐

If yes, which disinfectant product is used? ______

Interviewer Comments on Technical Capacity:

B. Managerial Capacity Assessment Questions

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

YES ☐ NO ☐

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

YES ☐ NO ☐

18. Does the system have written operating procedures?

YES ☐ NO ☐

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

YES ☐ NO ☐

20. Does the system have:

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

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

Water quality violations
YES ☐ NO ☐

Public notification
YES ☐ NO ☐

Sampling exemptions
YES ☐ NO ☐

22. Please describe how the above records are maintained:

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

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

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

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

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

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

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

If yes, from which agency and how much?

Describe the project?

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

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

YES ☐ NO ☐

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

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

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

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

Interviewer Comments on Managerial Capacity:

C. Financial Capacity Assessment

30. Does the system have a budget?

YES ☐ NO ☐

If YES, what type of budget?

Operating Budget ☐

Capital Budget ☐

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

34. Are rates reviewed annually?

YES ☐ NO ☐

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

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

Operation & Maintenance ☐

Infrastructure Repair & replacement ☐

Staffing ☐

Emergency/Reserve fund ☐

Debt payment ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, is this policy implemented?

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

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

[Convert to % of active connections

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

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

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

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

YES ☐ NO ☐

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

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

YES ☐ NO ☐

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

YES ☐ NO ☐

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

YES ☐ NO ☐

If yes, please describe.

41. Has the system ever had a financial audit?

YES ☐ NO ☐

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

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

Interviewer Comments on Financial Assessment:

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

APPENDIX B
COST BASIS

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

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

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

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

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

Electrical power cost is estimated to be \$0.136 per kWH, as supplied by Reliant Energy, Houston, Texas. 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 is from a USEPA arsenic removal demonstration project (USEPA 2004).

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

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

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

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

Table B.1
Summary of General Data
Orbit Systems, Inc. - Rosharon Township
PWS #0200036
General PWS Information

Service Population	255	**Number of Connections**	85
Total PWS Daily Water Usage	0.022 (mgd)	**Source**	2005 Report

Unit Cost Data
East Texas

General Items	**Unit**	**Unit Cost**
Treated water purchase cost	*See alternative*	
Water purchase cost (trucked)	$/1,000 gals	$ 1.80
Contingency	20%	n/a
Engineering & Constr. Management	25%	n/a
Procurement/admin (POU/POE)	20%	n/a

Pipeline Unit Costs	**Unit**	**Unit Cost**
PVC water line, Class 200, 04"	LF	$ 27
Bore and encasement, 10"	LF	$ 60
Open cut and encasement, 10"	LF	$ 35
Gate valve and box, 04"	EA	$ 370
Air valve	EA	$ 1,000
Flush valve	EA	$ 750
Metal detectable tape	LF	$ 0.15
Bore and encasement, length	Feet	200
Open cut and encasement, length	Feet	50

Pump Station Unit Costs	**Unit**	**Unit Cost**
Pump	EA	$ 7,500
Pump Station Piping, 04"	EA	$ 4,000
Gate valve, 04"	EA	$ 405
Check valve, 04"	EA	$ 595
Electrical/Instrumentation	EA	$ 10,000
Site work	EA	$ 2,000
Building pad	EA	$ 4,000
Pump Building	EA	$ 10,000
Fence	EA	$ 5,870
Tools	EA	$ 1,000

Well Installation Unit Costs	**Unit**	**Unit Cost**
Well installation	*See alternative*	
Water quality testing	EA	$ 1,500
Well pump	EA	$ 7,500
Well electrical/instrumentation	EA	$ 5,000
Well cover and base	EA	$ 3,000
Piping	EA	$ 2,500
Storage Tank - 5,000 gals	EA	$ 7,025
Electrical Power	$/kWH	$ 0.136
Building Power	kWH	11,800
Labor	$/hr	$ 30
Materials	EA	$ 1,200
Transmission main O&M	$/mile	$ 200
Tank O&M	EA	$ 1,000

POU/POE Unit Costs		
POU treatment unit purchase	EA	$ 250
POU treatment unit installation	EA	$ 150
POE treatment unit purchase	EA	$ 3,000
POE - pad and shed, per unit	EA	$ 2,000
POE - piping connection, per unit	EA	$ 1,000
POE - electrical hook-up, per unit	EA	$ 1,000
POU treatment O&M, per unit	$/year	$ 225
POE treatment O&M, per unit	$/year	$ 1,000
Contaminant analysis	$/year	$ 100
POU/POE labor support	$/hr	$ 30

Dispenser/Bottled Water Unit Costs		
Treatment unit purchase	EA	$ 3,000
Treatment unit installation	EA	$ 5,000
Treatment unit O&M	EA	$ 500
Administrative labor	hr	$ 40
Bottled water cost (inc. delivery)	gallon	$ 1.60
Water use, per capita per day	gpcd	1.0
Bottled water program materials	EA	$ 5,000
Storage Tank - 5,000 gals	EA	$ 7,025
Site improvements	EA	$ 4,000
Potable water truck	EA	$ 60,000
Water analysis, per sample	EA	$ 100
Potable water truck O&M costs	$/mile	$ 1.00

Central Treatment Unit Costs	**Unit**	**Unit Cost**
Site preparation	acre	$ 4,000
Slab	CY	$ 1,000
Building	SF	$ 60
Building electrical	SF	$ 8
Building plumbing	SF	$ 8
Heating and ventilation	SF	$ 7
Fence	LF	$ 15
Paving	SF	$ 2
Electrical, Adsorption	JOB	$ 50,000
Electrical, Coagulation	JOB	$ 30,000
Piping, Adsorption	JOB	$ 20,000
Piping, Coagulation	JOB	$ 10,000
Adsorption package	UNIT	$ 115,000
Coagulation package	UNIT	$ 89,700
Sewer connection fee	EA	$ 15,000
Chlorination point	EA	$ 2,000
Backwash recycle pumpset	EA	$ 5,000
Coagulant tank	GAL	$ 3.00
Backwash tank	GAL	$ 2.00
Tank, 20,000 GAL	GAL	$ 1.00
Tank, 10,000 GAL	GAL	$ 1.50
Excavation	CYD	$ 3.00
Compacted fill	CYD	$ 7.00
Lining	SF	$ 0.50
Vegetation	SY	$ 1.00
Access road	LF	$ 30
Building Power	kwh/yr	$ 0.136
Equipment power	kwh/yr	$ 0.136
Labor	hr	$ 40
Adsorption Materials	year	$ 14,000
Coagulation/Filtration Materials	year	$ 2,000
Backwash discharge to sewer	MG/year	$ 2,000
Chemicals, Coagulation	year	$ 2,000
Analyses	test	$ 200
Spent media disposal	CY	$ 20
Truck rental	day	$ 700
Mileage	mile	$ 1.00
Disposal fee	kgal	$ 5.00

APPENDIX C
COMPLIANCE ALTERNATIVE CONCEPTUAL COST ESTIMATES

This appendix presents the conceptual cost estimates developed for the compliance alternatives. The conceptual cost estimates are given in Tables C.1 through C.17. The cost estimates are conceptual in nature (+50%/-30%), and are intended for making comparisons between compliance options and to provide a preliminary indication of possible water rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation.

Table C.1

PWS Name *Orbit Systems, Inc. - Rosharon Township*
Alternative Name *New Well at Mammoet LLC*
Alternative Number *RT-1*

Distance from PWS to new well location	3.17	miles
Estimated well depth	270	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	8	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	16,725	LF	$ 27.00	$ 451,575
Bore and encasement, 10"	1,600	LF	$ 60.00	$ 96,000
Open cut and encasement, 10"	50	LF	$ 35.00	$ 1,750
Gate valve and box, 04"	3	EA	$ 370.00	$ 1,238
Air valve	3	EA	$ 1,000.00	$ 3,000
Flush valve	3	EA	$ 750.00	$ 2,509
Metal detectable tape	16,725	LF	$ 0.15	$ 2,509
Subtotal				**$ 558,580**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Well Installation				
Well installation	270	LF	$ 25	$ 6,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 27,750**
Subtotal of Component Costs				**$ 640,535**
Contingency	20%			$ 128,107
Design & Constr Management	25%			$ 160,134
TOTAL CAPITAL COSTS				**$ 928,776**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	3.2	mile	$ 200	$ 634
Subtotal				**$ 634**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	17,900	kWH	$ 0.136	$ 2,434
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 17,189**
Well O&M				
Pump power	761	kWH	$ 0.136	$ 103
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,703**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 17,807**

Table C.2

PWS Name *Orbit Systems, Inc. - Rosharon Township*
Alternative Name *New Well at TCDJ Darrington Unit*
Alternative Number *RT-2*

Distance from PWS to new well location	3.99	miles
Estimated well depth	600	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	3	n/a	n/a	n/a
Number of Crossings, open cut	2	n/a	n/a	n/a
PVC water line, Class 200, 04"	21,060	LF	$ 27.00	$ 568,620
Bore and encasement, 10"	600	LF	$ 60.00	$ 36,000
Open cut and encasement, 10"	100	LF	$ 35.00	$ 3,500
Gate valve and box, 04"	4	EA	$ 370.00	$ 1,558
Air valve	4	EA	$ 1,000.00	$ 4,000
Flush valve	4	EA	$ 750.00	$ 3,159
Metal detectable tape	21,060	LF	$ 0.15	$ 3,159
Subtotal				**$ 619,996**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Well Installation				
Well installation	600	LF	$ 25	$ 15,000
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				**$ 36,000**
Subtotal of Component Costs				**$ 710,201**
Contingency	20%			$ 142,040
Design & Constr Management	25%			$ 177,550
TOTAL CAPITAL COSTS				**$ 1,029,792**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	4.0	mile	$ 200	$ 798
Subtotal				**$ 798**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	22,850	kWH	$ 0.136	$ 3,108
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 17,862**
Well O&M				
Pump power	1,690	kWH	$ 0.136	$ 230
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,830**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 18,771**

Table C.3

PWS Name *Orbit Systems, Inc. - Rosharon Township*
Alternative Name *New Well at TCDJ Ramsey*
Alternative Number *RT-3*

Distance from PWS to new well location	9.45	miles
Estimated well depth	270	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	15	n/a	n/a	n/a
Number of Crossings, open cut	6	n/a	n/a	n/a
PVC water line, Class 200, 04"	49,910	LF	$ 27.00	$ 1,347,570
Bore and encasement, 10"	3,000	LF	$ 60.00	$ 180,000
Open cut and encasement, 10"	300	LF	$ 35.00	$ 10,500
Gate valve and box, 04"	10	EA	$ 370.00	$ 3,693
Air valve	9	EA	$ 1,000.00	$ 9,000
Flush valve	10	EA	$ 750.00	$ 7,487
Metal detectable tape	49,910	LF	$ 0.15	$ 7,487
Subtotal				**$ 1,565,736**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Well Installation				
Well installation	270	LF	$ 25	$ 6,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 27,750**
Subtotal of Component Costs				**$ 1,647,691**
Contingency	20%			$ 329,538
Design & Constr Management	25%			$ 411,923
TOTAL CAPITAL COSTS				**$ 2,389,152**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	9.5	mile	$ 200	$ 1,891
Subtotal				**$ 1,891**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	45,100	kWH	$ 0.136	$ 6,134
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 20,888**
Well O&M				
Pump power	761	kWH	$ 0.136	$ 103
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,703**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 22,764**

Table C.4

PWS Name *Orbit Systems, Inc. - Rosharon Township*
Alternative Name *New Well at Briar Meadows*
Alternative Number *RT-4*

Distance from PWS to new well location	7.17	miles
Estimated well depth	215	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	18	n/a	n/a	n/a
Number of Crossings, open cut	3	n/a	n/a	n/a
PVC water line, Class 200, 04"	37,836	LF	$ 27.00	$ 1,021,572
Bore and encasement, 10"	3,600	LF	$ 60.00	$ 216,000
Open cut and encasement, 10"	150	LF	$ 35.00	$ 5,250
Gate valve and box, 04"	8	EA	$ 370.00	$ 2,800
Air valve	7	EA	$ 1,000.00	$ 7,000
Flush valve	8	EA	$ 750.00	$ 5,675
Metal detectable tape	37,836	LF	$ 0.15	$ 5,675
Subtotal				**$ 1,263,973**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Well Installation				
Well installation	215	LF	$ 25	$ 5,375
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				**$ 26,375**
Subtotal of Component Costs				**$ 1,344,553**
Contingency	20%			$ 268,911
Design & Constr Management	25%			$ 336,138
TOTAL CAPITAL COSTS				**$ 1,949,601**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	7.2	mile	$ 200	$ 1,433
Subtotal				**$ 1,433**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	34,600	kWH	$ 0.136	$ 4,706
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 19,460**
Well O&M				
Pump power	606	kWH	$ 0.136	$ 82
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,682**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 20,857**

Table C.5

PWS Name *Orbit Systems, Inc. - Rosharon Township*
Alternative Name *New Well at Sienna Plantation*
Alternative Number *RT-5*

Distance from PWS to new well location	13.81	miles
Estimated well depth	950	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	2	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	11	n/a	n/a	n/a
Number of Crossings, open cut	14	n/a	n/a	n/a
PVC water line, Class 200, 04"	72,927	LF	$ 27.00	$ 1,969,029
Bore and encasement, 10"	2,200	LF	$ 60.00	$ 132,000
Open cut and encasement, 10"	700	LF	$ 35.00	$ 24,500
Gate valve and box, 04"	15	EA	$ 370.00	$ 5,397
Air valve	14	EA	$ 1,000.00	$ 14,000
Flush valve	15	EA	$ 750.00	$ 10,939
Metal detectable tape	72,927	LF	$ 0.15	$ 10,939
Subtotal				**$ 2,166,804**
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	$ 405	$ 3,240
Check valve, 04"	4	EA	$ 595	$ 2,380
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				**$ 108,410**
Well Installation				
Well installation	950	LF	$ 25	$ 23,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 44,750**
Subtotal of Component Costs				**$ 2,319,964**
Contingency	20%			$ 463,993
Design & Constr Management	25%			$ 579,991
TOTAL CAPITAL COSTS				**$ 3,363,947**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	13.8	mile	$ 200	$ 2,762
Subtotal				**$ 2,762**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.136	$ 3,210
Pump Power	66,550	kWH	$ 0.136	$ 9,051
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 30	$ 21,900
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 38,560**
Well O&M				
Pump power	2,677	kWH	$ 0.136	$ 364
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,964**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 41,568**

Table C.6

PWS Name	***Orbit Systems, Inc. - Rosharon Township***
Alternative Name	***Purchase Water from City of Alvin***
Alternative Number	***RT-6***

Distance from Alternative to PWS (along pipe)		15.6	miles
Total PWS annual water usage		8.030	MG
Treated water purchase cost	$	1.65	per 1,000 gals
Number of Pump Stations Needed		2	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	40	n/a	n/a	n/a
Number of Crossings, open cut	6	n/a	n/a	n/a
PVC water line, Class 200, 04"	82,240	LF	$ 27.00	$ 2,220,480
Bore and encasement, 10"	8,000	LF	$ 60.00	$ 480,000
Open cut and encasement, 10"	300	LF	$ 35.00	$ 10,500
Gate valve and box, 04"	16	EA	$ 370.00	$ 6,086
Air valve	16	EA	$ 1,000.00	$ 16,000
Flush valve	16	EA	$ 750.00	$ 12,336
Metal detectable tape	82,240	LF	$ 0.15	$ 12,336
Subtotal				**$ 2,757,738**
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	$ 405	$ 3,240
Check valve, 04"	4	EA	$ 595	$ 2,380
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				**$ 108,410**
Subtotal of Component Costs				**$ 2,866,148**
Contingency	20%			$ 573,230
Design & Constr Management	25%			$ 716,537
TOTAL CAPITAL COSTS				**$ 4,155,914**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	15.6	mile	$ 200	$ 3,115
Subtotal				**$ 3,115**
Water Purchase Cost				
From BWA	8,030	1,000 gal	$ 1.65	$ 13,250
Subtotal				**$ 13,250**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.136	$ 3,210
Pump Power	72,200	kWH	$ 0.136	$ 9,819
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 30	$ 21,900
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 39,329**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 48,975**

Table C.7

PWS Name *Orbit Systems, Inc. - Rosharon Township*
Alternative Name *Purchase Water from BWA*
Alternative Number *RT-7*

Distance from Alternative to PWS (along pipe)		11.4	miles
Total PWS annual water usage		8.030	MG
Treated water purchase cost	$	1.60	per 1,000 gals
Number of Pump Stations Needed		2	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	44	n/a	n/a	n/a
Number of Crossings, open cut	4	n/a	n/a	n/a
PVC water line, Class 200, 04"	59,971	LF	$ 27.00	$ 1,619,217
Bore and encasement, 10"	8,800	LF	$ 60.00	$ 528,000
Open cut and encasement, 10"	200	LF	$ 35.00	$ 7,000
Gate valve and box, 04"	12	EA	$ 370.00	$ 4,438
Air valve	11	EA	$ 1,000.00	$ 11,000
Flush valve	12	EA	$ 750.00	$ 8,996
Metal detectable tape	59,971	LF	$ 0.15	$ 8,996
Subtotal				**$ 2,187,646**
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	$ 405	$ 3,240
Check valve, 04"	4	EA	$ 595	$ 2,380
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				**$ 108,410**
Subtotal of Component Costs				**$ 2,296,056**
Contingency	20%			$ 459,211
Design & Constr Management	25%			$ 574,014
TOTAL CAPITAL COSTS				**$ 3,329,281**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	11.4	mile	$ 200	$ 2,272
Subtotal				**$ 2,272**
Water Purchase Cost				
From BWA	8,030	1,000 gal	$ 1.60	$ 12,848
Subtotal				**$ 12,848**
Pump Station(s) O&M				
Building Power	23,600	kWH	$ 0.136	$ 3,210
Pump Power	52,400	kWH	$ 0.136	$ 7,126
Materials	2	EA	$ 1,200	$ 2,400
Labor	730	Hrs	$ 30	$ 21,900
Tank O&M	2	EA	$ 1,000	$ 2,000
Subtotal				**$ 36,636**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 45,037**

Table C.8

PWS Name ***Orbit Systems, Inc. - Rosharon Township***
Alternative Name ***Central Treatment - Adsorption***
Alternative Number ***RT-8***

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Adsorption				
Site preparation	0.50	acre	$ 4,000	$ 2,000
Slab	15	CY	$ 1,000	$ 15,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8	$ 3,200
Building plumbing	400	SF	$ 8	$ 3,200
Heating and ventilation	400	SF	$ 7	$ 2,800
Fence	300	LF	$ 15	$ 4,500
Paving	1,600	SF	$ 2	$ 3,200
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 20,000	$ 20,000
Adsorption package including:				
4 Adsorption vessels				
E33 Iron oxide media				
Controls & instruments	1	UNIT	$ 115,000	$ 115,000
Backwash Tank	5,000	GAL	$ 2.00	$ 10,000
Chlorination Point	1	EA	$ 2,000	$ 2,000
Backwask Recycle Pumpset	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 259,900**
Contingency	20%			51,980
Design & CM	25%			64,975
Total				**$ 376,855**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
Building Power	6,000	kwh/yr	$ 0.136	$ 816
Equipment power	1000	kwh/yr	$ 0.136	$ 136
Labor	500	hrs/yr	$ 40	$ 20,000
Materials	1	year	$ 14,000	$ 14,000
Analyses	24	test	$ 200	$ 4,800
Spent Media Disposal	6	CY	$ 20	$ 120
Total				**$ 39,872**
Backwash Disposal				
Truck rental	21	days	$ 700	14700
Mileage	800	miles	$ 1.00	800
Disposal fee	63	kgal/yr	$ 5.00	315
Subtotal				**$ 15,815**
Total				**$ 55,687**

Table C.9

PWS Name *Orbit Systems, Inc. - Rosharon Township*
Alternative Name *Central Treatment - Coag-Filt*
Alternative Number *RT-9*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Central-Coag-Filt				
Site preparation	0.50	acre	$ 4,000	$ 2,000
Slab	15	CY	$ 1,000	$ 15,000
Building	400	SF	$ 60	$ 24,000
Building electrical	400	SF	$ 8	$ 3,200
Building plumbing	400	SF	$ 8	$ 3,200
Heating and ventilation	400	SF	$ 7	$ 2,800
Fence	300	LF	$ 15	$ 4,500
Paving	1,600	SF	$ 2	$ 3,200
Electrical	1	JOB	$ 30,000	$ 30,000
Piping	1	JOB	$ 10,000	$ 10,000
Coagulant/Filter package including:				
Chemical feed system				
Pressure ceramic filters				
Controls & Instruments	1	UNIT	$ 89,700	$ 89,700
Backwash Tank	5,000	GAL	$ 2.00	$ 10,000
Chlorination Point	1	EA	$ 2,000	$ 2,000
Coagulant Tank	500	GAL	$ 3	$ 1,500
Subtotal				**$ 201,100**
Contingency	20%			40,220
Design & CM	25%			50,275
Total				**$ 291,595**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
Building Po	6,000	kwh/yr	$ 0.136	$ 816
Equipment	1000	kwh/yr	$ 0.136	$ 136
Labor	1,000	hrs/yr	$ 40	$ 40,000
Materials	1	year	$ 2,000	$ 2,000
Chemicals	1	year	$ 2,000	$ 2,000
Analyses	24	test	$ 200	$ 4,800
Total				**$ 49,752**
Backwash Disposal				
Truck renta	100	days	$ 700	$ 70,000
Mileage	4000	miles	$ 1.00	$ 4,000
Disposal fe	315	kgal/yr	$ 5.00	$ 1,575
Subtotal				**$ 75,575**
Total				**$ 125,327**

Table C.10

PWS Name ***Orbit Systems, Inc. - Rosharon Township***
Alternative Name ***Point-of-Use Treatment***
Alternative Number ***RT-10***

Number of Connections for POU Unit Installation 85

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POU-Treatment - Purchase/Installation				
POU treatment unit purchase	85	EA	$ 250	$ 21,250
POU treatment unit installation	85	EA	$ 150	$ 12,750
Subtotal				**$ 34,000**
Subtotal of Component Costs				**$ 34,000**
Contingency	20%			$ 6,800
Design & Constr Management	25%			$ 8,500
Procurement & Administration	20%			$ 6,800
TOTAL CAPITAL COSTS				**$ 56,100**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POU materials, per unit	85	EA	$ 225	$ 19,125
Contaminant analysis, 1/yr per unit	85	EA	$ 100	$ 8,500
Program labor, 10 hrs/unit	850	hrs	$ 30	$ 25,500
Subtotal				**$ 53,125**
TOTAL ANNUAL O&M COSTS				**$ 53,125**

Table C.11

PWS Name ***Orbit Systems, Inc. - Rosharon Township***
Alternative Name ***Point-of-Entry Treatment***
Alternative Number ***RT-11***

Number of Connections for POE Unit Installation 85

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POE-Treatment - Purchase/Installation				
POE treatment unit purchase	85	EA	$ 3,000	$ 255,000
Pad and shed, per unit	85	EA	$ 2,000	$ 170,000
Piping connection, per unit	85	EA	$ 1,000	$ 85,000
Electrical hook-up, per unit	85	EA	$ 1,000	$ 85,000
Subtotal				**$ 595,000**
Subtotal of Component Costs				**$ 595,000**
Contingency	20%			$ 119,000
Design & Constr Management	25%			$ 148,750
Procurement & Administration	20%			$ 119,000
TOTAL CAPITAL COSTS				**$ 981,750**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POE materials, per unit	85	EA	$ 1,000	$ 85,000
Contaminant analysis, 1/yr per unit	85	EA	$ 100	$ 8,500
Program labor, 10 hrs/unit	850	hrs	$ 30	$ 25,500
Subtotal				**$ 119,000**
TOTAL ANNUAL O&M COSTS				**$ 119,000**

Table C.12

PWS Name *Orbit Systems, Inc. - Rosharon Township*
Alternative Name *New Well at 10 Miles*
Alternative Number *RT-12*

Distance from PWS to new well location	10.0 miles
Estimated well depth	310 feet
Number of wells required	1
Well installation cost (location specific)	$25 per foot
Number of pump stations needed	1

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	22	n/a	n/a	n/a
Number of Crossings, open cut	6	n/a	n/a	n/a
PVC water line, Class 200, 04"	52,800	LF	$ 27.00	$ 1,425,600
Bore and encasement, 10"	4,400	LF	$ 60.00	$ 264,000
Open cut and encasement, 10"	300	LF	$ 35.00	$ 10,500
Gate valve and box, 04"	11	EA	$ 370.00	$ 3,907
Air valve	10	EA	$ 1,000.00	$ 10,000
Flush valve	11	EA	$ 750.00	$ 7,920
Metal detectable tape	52,800	LF	$ 0.15	$ 7,920
Subtotal				**$ 1,729,847**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Well Installation				
Well installation	310	LF	$ 25	$ 7,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 28,750**
Subtotal of Component Costs				**$ 1,812,802**
Contingency	20%			$ 362,560
Design & Constr Management	25%			$ 453,201
TOTAL CAPITAL COSTS				**$ 2,628,563**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	10.0	mile	$ 200	$ 2,000
Subtotal				**$ 2,000**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	48,295	kWH	$ 0.136	$ 6,568
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 21,323**
Well O&M				
Pump power	873	kWH	$ 0.136	$ 119
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,719**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 23,323**

Table C.13

PWS Name *Orbit Systems, Inc. - Rosharon Township*
Alternative Name *New Well at 5 Miles*
Alternative Number *RT-13*

Distance from PWS to new well location	5.0 miles
Estimated well depth	310 feet
Number of wells required	1
Well installation cost (location specific)	$25 per foot
Number of pump stations needed	1

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	11	n/a	n/a	n/a
Number of Crossings, open cut	3	n/a	n/a	n/a
PVC water line, Class 200, 04"	26,400	LF	$ 27.00	$ 712,800
Bore and encasement, 10"	1,800	LF	$ 60.00	$ 108,000
Open cut and encasement, 10"	100	LF	$ 35.00	$ 3,500
Gate valve and box, 04"	5	EA	$ 370.00	$ 1,954
Air valve	5	EA	$ 1,000.00	$ 5,000
Flush valve	5	EA	$ 750.00	$ 3,960
Metal detectable tape	26,400	LF	$ 0.15	$ 3,960
Subtotal				**$ 839,174**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Well Installation				
Well installation	310	LF	$ 25	$ 7,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 28,750**
Subtotal of Component Costs				**$ 922,129**
Contingency	20%			$ 184,426
Design & Constr Management	25%			$ 230,532
TOTAL CAPITAL COSTS				**$ 1,337,086**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	5.0	mile	$ 200	$ 1,000
Subtotal				**$ 1,000**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	24,147	kWH	$ 0.136	$ 3,284
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 18,039**
Well O&M				
Pump power	873	kWH	$ 0.136	$ 119
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,719**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 19,039**

Table C.14

PWS Name ***Orbit Systems, Inc. - Rosharon Township***
Alternative Name ***New Well at 1 Mile***
Alternative Number ***RT-14***

Distance from PWS to new well location	1.0	miles
Estimated well depth	310	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	2	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	5,280	LF	$ 27.00	$ 142,560
Bore and encasement, 10"	400	LF	$ 60.00	$ 24,000
Open cut and encasement, 10"	50	LF	$ 35.00	$ 1,750
Gate valve and box, 04"	1	EA	$ 370.00	$ 391
Air valve	1.00	EA	$ 1,000.00	$ 1,000
Flush valve	1	EA	$ 750.00	$ 792
Metal detectable tape	5,280	LF	$ 0.15	$ 792
Subtotal				**$ 171,285**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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	310	LF	$ 25	$ 7,750
Water quality testing	2	EA	$ 1,500	$ 3,000
Well pump	1	EA	$ 7,500	$ 7,500
Well electrical/instrumentation	1	EA	$ 5,000	$ 5,000
Well cover and base	1	EA	$ 3,000	$ 3,000
Piping	1	EA	$ 2,500	$ 2,500
Subtotal				**$ 28,750**
Subtotal of Component Costs				**$ 200,035**
Contingency	20%			$ 40,007
Design & Constr Management	25%			$ 50,009
TOTAL CAPITAL COSTS				**$ 290,050**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	1.0	mile	$ 200	$ 200
Subtotal				**$ 200**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.136	$ -
Pump Power	-	kWH	$ 0.136	$ -
Materials	-	EA	$ 1,200	$ -
Labor	-	Hrs	$ 30	$ -
Tank O&M	-	EA	$ 1,000	$ -
Subtotal				**$ -**
Well O&M				
Pump power	873	kWH	$ 0.136	$ 119
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,719**
O&M Credit for Existing Well Closure				
Pump power	873	kWH	$ 0.136	$ (119)
Well O&M matl	1	EA	$ 1,200	$ (1,200)
Well O&M labor	180	Hrs	$ 30	$ (5,400)
Subtotal				**$ (6,719)**
TOTAL ANNUAL O&M COSTS				**$ 200**

Table C.15

PWS Name ***Orbit Systems, Inc. - Rosharon Township***
Alternative Name ***Public Dispenser for Treated Drinking Water***
Alternative Number ***RT-15***

Number of Treatment Units Recommended 1

Capital Costs

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

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Treatment unit O&M, 1 per unit	1	EA	$ 500	$ 500
Contaminant analysis, 1/wk per unit	52	EA	$ 100	$ 5,200
Sampling/reporting, 1 hr/day	365	HRS	$ 30	$ 10,950
Subtotal				**$ 16,650**
TOTAL ANNUAL O&M COSTS				**$ 16,650**

Table C.16

PWS Name	***Orbit Systems, Inc. - Rosharon Township***
Alternative Name	***Supply Bottled Water to Population***
Alternative Number	***RT-16***

Service Population	255	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	93,075	gallons

Capital Costs

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

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water purchase costs	93,075	gals	$ 1.60	$ 148,920
Program admin, 9 hrs/wk	468	hours	$ 40	$ 18,673
Program materials	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 172,593**
TOTAL ANNUAL O&M COSTS				**$ 172,593**

Table C.17

PWS Name ***Orbit Systems, Inc. - Rosharon Township***
Alternative Name ***Central Trucked Drinking Water***
Alternative Number ***RT-17***

Service Population	255	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	93,075	gallons
Travel distance to compliant water source (roundtrip)	7	miles

Capital Costs

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

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water delivery labor, 4 hrs/wk	208	hrs	$ 30	$ 6,240
Truck operation, 1 round trip/wk	364	miles	$ 1.00	$ 364
Water purchase	93	1,000 ga	$ 1.80	$ 168
Water testing, 1 test/wk	52	EA	$ 100	$ 5,200
Sampling/reporting, 2 hrs/wk	104	hrs	$ 30	$ 3,120
Subtotal				**$ 15,092**
TOTAL ANNUAL O&M COSTS				**$ 15,092**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Table D.1 Example Financial Model

Step 1

Water System: Rosharon Township

Step 2

Click Here to Update Verification and Raw

Water System	Rosharon Township		
Alternative Description	Point-of-Use Treatment		
Sum of Amount		Year	Funding Alternative
		2007	
Group	Type	100% Grant	Bond
Capital Expenditures	Capital Expenditures-Funded from Bonds	$ 500	$ 56,600
	Capital Expenditures-Funded from Grants	$ 56,100	$ -
	Capital Expenditures-Funded from Revenue/Reserves	$ -	$ -
	Capital Expenditures-Funded from SRF Loans	$ -	$ -
Capital Expenditures Sum		$ 56,600	$ 56,600
Debt Service	Revenue Bonds	$ 39	$ 4,428
	State Revolving Funds	$ -	$ -
Debt Service Sum		$ 39	$ 4,428
Operating Expenditures	Administrative Expenses	$ 4,377	$ 4,377
	Chemicals, Treatment	$ 1,297	$ 1,297
	Contract Labor	$ 1,526	$ 1,526
	Insurance	$ 889	$ 889
	Other Operating Expenditures 1	$ 1,023	$ 1,023
	Other Operating Expenditures 2	$ 12,449	$ 12,449
	Professional and Directors Fees	$ 192	$ 192
	Repairs	$ 1,038	$ 1,038
	Salaries & Benefits	$ 12,544	$ 12,544
	Supplies	$ 1,038	$ 1,038
	Utilities	$ 5,253	$ 5,253
	Maintenance	$ 1,038	$ 1,038
	Accounting and Legal Fees	$ 75	$ 75
	Auto and Travel	$ 16	$ 16
Operating Expenditures Sum		$ 42,756	$ 42,756
Residential Operating Rever	Residential Base Monthly Rate	$ 24,449	$ 24,449
	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		$ 24,449	$ 24,449

Location_Name	Rosharon Township	
Alt_Desc	Point-of-Use Treatment	
		Current_Year
Funding_Alt	Data	2007
100% Grant	Sum of Beginning_Cash_Bal	$ (20,294)
	Sum of Total_Expenditures	$ 99,395
	Sum of Total_Receipts	$ 80,549
	Sum of Net_Cash_Flow	$ (18,846)
	Sum of Ending_Cash_Bal	$ (39,141)
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ 3,081
	Sum of Total_Reqd_Resv	$ 3,081
	Sum of Net_Avail_Bal	$ (42,221)
	Sum of Add_Resv_Needed	$ (42,221)
	Sum of Rate_Inc_Needed	173%
	Sum of Percent_Rate_Increase	0%
Bond	Sum of Beginning_Cash_Bal	$ (20,294)
	Sum of Total_Expenditures	$ 103,784
	Sum of Total_Receipts	$ 80,549
	Sum of Net_Cash_Flow	$ (23,235)
	Sum of Ending_Cash_Bal	$ (43,529)
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ 3,081
	Sum of Total_Reqd_Resv	$ 3,081
	Sum of Net_Avail_Bal	$ (46,610)
	Sum of Add_Resv_Needed	$ (46,610)
	Sum of Rate_Inc_Needed	191%
	Sum of Percent_Rate_Increase	0%

APPENDIX E
GENERAL ARSENIC GEOCHEMISTRY

Geochemistry of arsenic is complex because of (1) the possible coexistence of two or even three redox states, (2) the complex chemistry of organo-arsenicals, and (3) the strong interaction of most arsenic compounds with soil particles, particularly iron oxides (and to a lesser degree, aluminum and manganese oxides). Fully deprotonated arsenate AsO_4^{-3} is the expected form of arsenic in most soil under aerobic conditions only at high pH (Figure E.1). At more neutral and acid pHs, $HAsO_4^{-2}$ and $H_2AsO_4^{-1}$ forms, respectively, are dominant. General understanding of arsenic mobility in soil and aquifers is that it increases with increasing pH and phosphate concentration and with decreasing clay and iron oxide content. As pH increases, the negative charge of the arsenate ion increases, making it less likely to sorb on negatively charged soil particles. Phosphates have a chemical structure similar to that of arsenates and sorb to soil preferentially in some conditions. Nitrogen also belongs to the same group in the periodic table but does not show the same competing behavior as phosphate. Other structurally similar oxyanions, sulfate and selenate, are also weak sorbers. Under less oxidizing conditions, arsenite ion H_3AsO_3 is most stable. Lack of charge renders the ion more mobile and less likely to sorb to soil particles. Its pH stability spread ranges from acid to alkaline. The first deprotonated form, $H_2AsO_3^{-1}$, exists at significant concentrations only above a pH of approximately 9. Redox processes seem to be mediated by microorganisms (Welch, *et al.* 2000) and to take place next to mineral surfaces.

Under even more reducing conditions, arsenide is the stable ionic form of arsenic. Arsenic has a complex geochemistry with sulfur, both in solution where several thioarsenic ions can form and in associated minerals. Arsenic metal –As(0)- rarely occurs. Methylated arsenic compounds are generally present at low aqueous concentrations (<1ppb), if at all, except perhaps when there is an abundance of organic matter (Welch, *et al*., 2000).

As(V) and As(III) minerals are fairly soluble and do not control arsenic solubility in oxidizing or mildly reducing conditions, except, perhaps, if barium is present (Henry, *et al*. 1982). This situation is in contrast to that of other companion oxyanions which are not as mobile under reducing conditions, except vanadium. In reducing conditions, arsenic precipitates as arsenopyrite (FeAsS), although more commonly in solid solution with pyrite. Realgar (AsS) and orpiment (As_2S_3) require high sulfur activity and are unlikely in the southern Gulf Coast.

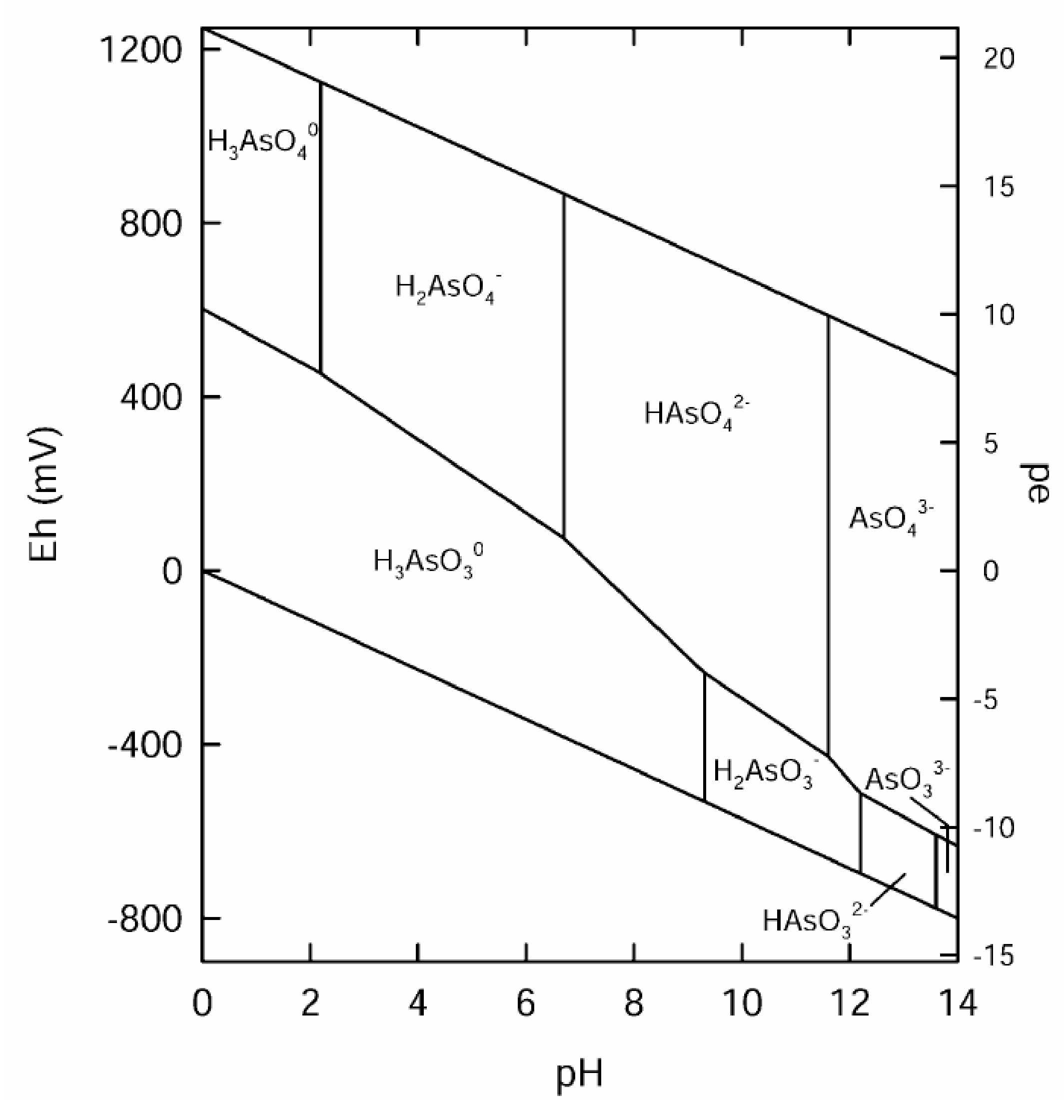

Figure E.1
Eh-pH Diagram for Arsenic Aqueous Species in the As-O_2-H_2O System at 25°C and 1 bar (Smedley and Kinniburgh 2002)

APPENDIX F
ORBIT SYSTEMS WATER USAGE

Orbit Systems, Inc.
2004 Water Usage

No.	System Name	2004 Water Usage (gal/yr)	% Water Usage %	No. Connections #	Usage Per Connection (gal/yr)	No. Customers #	Annual Usage Per Customer (gal/yr)	Daily Usage Per Customer (gpcd)
1	Coronado Country	2,083,300	1.7	44	47,348	132	15,783	43.2
2	Country Acres	6,766,800	5.4	88	76,895	264	25,632	70.2
3	Colony Cove	4,239,800	3.4	48	88,329	144	29,443	80.7
4	Country Meadows	3,446,900	2.7	48	71,810	144	23,937	65.6
5	Blue Sage Gardens	2,976,800	2.4	43	69,228	129	23,076	63.2
6	Brandi Estates	3,524,700	2.8	43	81,970	129	27,323	74.9
7	Sandy Meadows	3,735,400	3.0	68	54,932	204	18,311	50.2
8	Rosharon Road Estates	5,455,900	4.3	76	71,788	228	23,929	65.6
9	Grasslands	12,465,400	9.9	171	72,897	513	24,299	66.6
10	Rosharon Township	8,055,400	6.4	99	81,368	297	27,123	74.3
11	Demi-John Island	3,973,000	3.2	99	40,131	297	13,377	36.6
12	San Bernard River	4,595,500	3.7	49	93,786	147	31,262	85.6
13	Angle Acres	3,330,500	2.7	44	75,693	132	25,231	69.1
14	Spanish Bait	672,000	0.5	8	84,000	24	28,000	76.7
15	Briarmeadow	5,231,700	4.2	41	127,602	123	42,534	116.5
16	Mooreland	4,605,600	3.7	48	95,950	144	31,983	87.6
17	Raynlong	2,736,600	2.2	32	85,519	96	28,506	78.1
18	Snug Harbor	2,030,600	1.6	33	61,533	99	20,511	56.2
19	Bernard Oaks	4,280,000	3.4	71	60,282	213	20,094	55.1
20	Demi-John Place	2,844,500	2.3	88	32,324	264	10,775	29.5
21	Teleview Terrace	5,997,600	4.8	47	127,609	141	42,536	116.5
22	Wolf Glen	2,809,900	2.2	35	80,283	105	26,761	73.3
23	Larkspur	420,000	0.3	5	84,000	15	28,000	76.7
24	Wilco Water	4,037,100	3.2	49	82,390	147	27,463	75.2
25	Beechwood	5,655,000	4.5	73	77,466	219	25,822	70.7
26	Oak Meadows	1,542,000	1.2	33	46,727	99	15,576	42.7
27	Mark V	7,178,900	5.7	94	76,371	282	25,457	69.7
28	Riverside Estates	3,695,400	2.9	48	76,988	144	25,663	70.3
29	Lee Ridge	1,926,900	1.5	22	87,586	66	29,195	80.0
30	Quail Valley Ranches IV	785,600	0.6	8	98,200	24	32,733	89.7
31	Paloma Acres	1,484,500	1.2	25	59,380	75	19,793	54.2
32	Colony Trails	2,254,100	1.8	45	50,091	135	16,697	45.7
33	Other	725,000	0.6	19	38,158	57	12,719	34.8
	TOTAL	**125,562,400**	**100**	**1,744**		**5,232**		
	AVERAGE				**74,504**		**24,835**	**68.0**

APPENDIX G
ANALYSIS OF SHARED SOLUTIONS FOR OBTAINING WATER FROM BWA AND CITY OF ALVIN

G.1 Overview of Method

There are a number of small PWSs with water quality problems located in the vicinity of the Oak Meadows Estates PWS that could benefit from joining together and cooperating to share the cost for obtaining compliant drinking water. This cooperation could involve creating a formal organization of individual PWSs to address obtaining compliant drinking water, consolidating to form a single PWS, or having the individual PWSs be taken over or bought out by a larger regional entity.

The small PWSs with water quality problems near the Oak Meadows Estates PWS are summarized in Table G.1. Most of them are owned by Orbit. It is assumed for this analysis that all of the systems would participate in a shared solution.

This analysis focuses on compliance alternatives related to obtaining water from large water providers that are interested in providing water outside their current area, either by wholesaling to PWSs, or by expanding their service areas. This type of solution is most likely to have the best prospects for sustainability, and a reliable provision of compliant drinking water.

The purpose of this analysis is to approximate the level of capital cost savings that could be expected from pursuing a shared solution versus a solution where the study PWS obtains compliant drinking water on its own. Regardless of the form a group solution would take, one way or another the water consumers would have to pay for the infrastructure needed for obtaining compliant water. In order to keep this analysis as straightforward and realistic as possible, it is assumed the individual PWSs would remain independent, and would share the capital cost for the infrastructure required. Also, to maintain simplicity this analysis is limited to estimating capital cost savings. A shared solution could also produce savings in O&M expenses as a result of reduction in redundant facilities and the potential for shared O&M resources, and these savings would have to be evaluated if the PWSs are interested in implementing a shared solution.

There are many ways capital costs could be divided between participating PWSs and the final apportioning of costs would likely be based on negotiation between the participating entities. At this preliminary stage of analysis it is not possible to project results from negotiations regarding cost sharing. For this reason, two methods are used to allocate cost between PWSs in an effort to give an approximation of the range of savings that might be attainable for an individual PWS. This range is considered to be representative of possible savings that could result from an agreement that should be fair and equitable to all parties involved.

Method A is based on allocating capital cost of the shared solution proportionate to the amount of water used by the PWSs. In this case, the total capital cost for the pipeline and the necessary pump stations is estimated, and then capital cost for each component is allocated based on the fraction of the total water used by each PWS. This method is a reasonable method for allocating cost when all of the PWSs are different in size but are relatively equidistant from the shared water source.

Method B is based on allocating capital cost of the shared solution proportionate to the cost each PWS would have to pay to obtain compliant water if it were to implement an individual solution. In this case, the total capital cost for the shared pipeline and the necessary pump stations is estimated as well as the capital cost each PWS would have for obtaining its own pipeline. The total capital cost for the shared solution is then allocated between the participating PWSs based on what each PWS would have to pay to construct its own pipeline. This method is a reasonable method for allocating cost when the PWS are not equidistant from the water source.

G.2 Shared Solution for Obtaining Water from City of Alvin

This alternative would consist of constructing a main pipeline from the southwest part of the City of Alvin that would run southwest and west along FM 1462 to Rosharon Township. Each PWS would connect to this main with a spur line. Spur lines would convey the water from the main line to the storage tanks of each PWS. The main pipeline would start out as 6 inches in diameter, and reduce to 4 inches in diameter at the end. All of the spur pipelines would be 4 inches in diameter. It is assumed two pump stations would be required to transfer the water from the City of Alvin to the end of the pipeline. The pipeline routing is shown in Figure G.1.

The capital costs for each pipe segment and the total capital cost for the shared pipeline are summarized in Table G.2. Tables G.3, G.4 and G.5 show the capital costs allocated to each PWS using Methods A, B and C respectively while Table G.6 compares the found values from each method. More detailed cost estimates for the pipe segments are shown in Tables G.12 through G.22 and G.35 through G.40.

Based on these estimates, the range of capital cost savings to the Rosharon Township PWS could be between \$2.12 million and \$2.68 million, or 76 and 94 percent if it implemented a shared solution like this. These estimates are hypothetical and are only provided to approximate the magnitude of potential savings if this shared solution is implemented as described.

G.3 Group Solution for Obtaining Water from Brazosport Water Authority

This alternative would consist of constructing a main pipeline that starts at the north part of the City of Angleton where the Brazosport Water Authority line currently terminates. The line would run north along Highway 288 to Rosharon Township and turn to run east along FM 1462 to Rosharon Road Estates. Spur lines would convey the water from the main line to the storage tanks. The main pipeline would start out as 6 inches in diameter, and reduce to 4 inches in diameter at the end. All of the spur pipelines would be 4 inches in diameter. It is assumed three pump stations would be required to transfer the water from the Brazosport Water Authority line to the end of the pipeline. The pipeline routing is shown in Figure G.2.

The capital costs for each pipe segment and the total capital cost for the shared pipeline are summarized in Table G.7. Table G.8, G.9 and G.10 show the capital costs allocated to each PWS using Methods A, B and C respectively while Table G.11 compares the found values from each method. More detailed cost estimates for the pipe segments are shown in Tables G.23 through G.17 and G.41 through G.46.

Based on these estimates, the range of capital cost savings to the Rosharon Township PWS could be between \$2.20 million and \$2.70 million, or 65 and 80 percent, if they were to implement a shared solution like this. These estimates are hypothetical and are only provided to approximate the magnitude of potential savings if this shared solution is implemented as described.

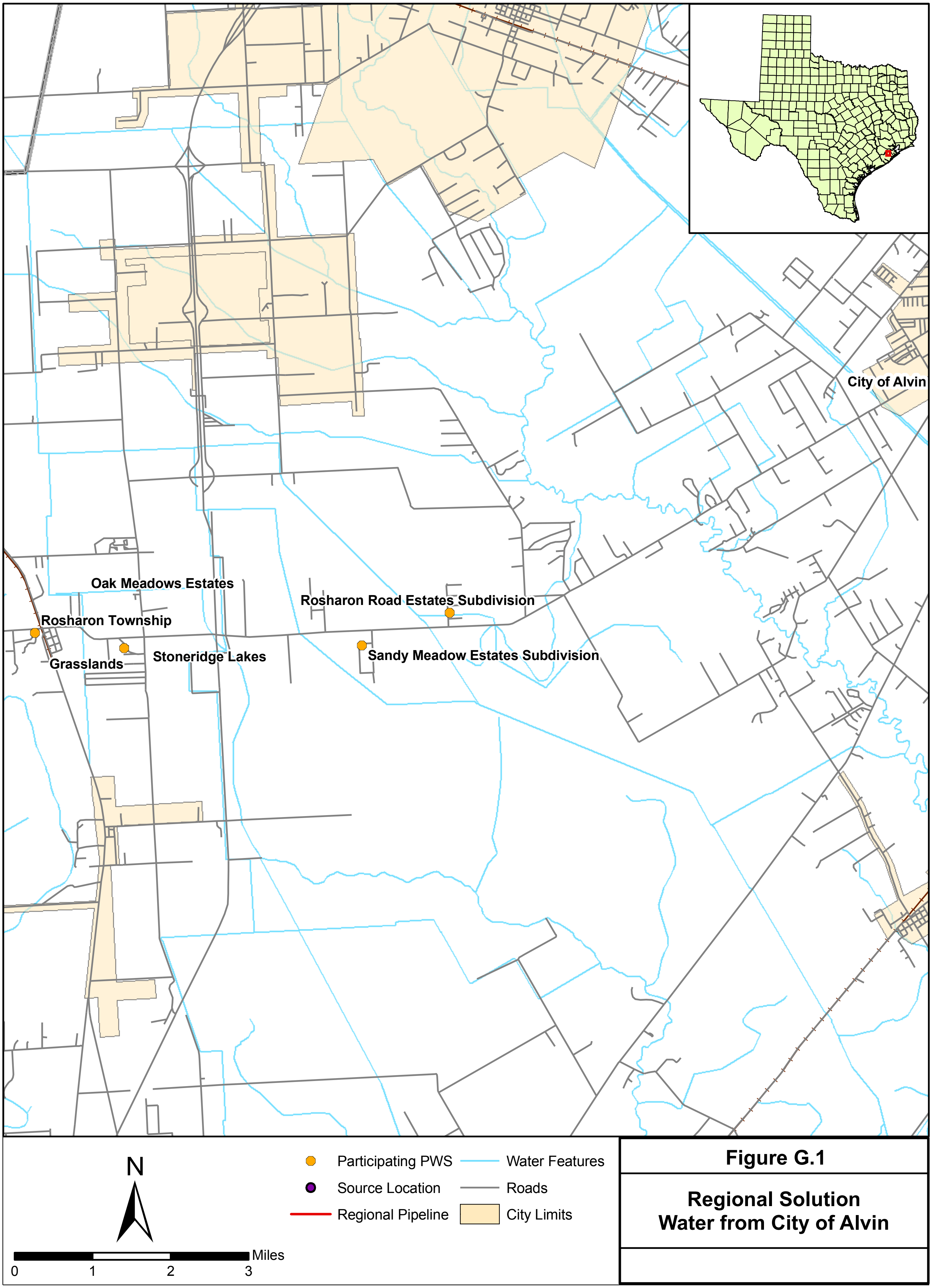

Figure G.1

Regional Solution
Water from City of Alvin

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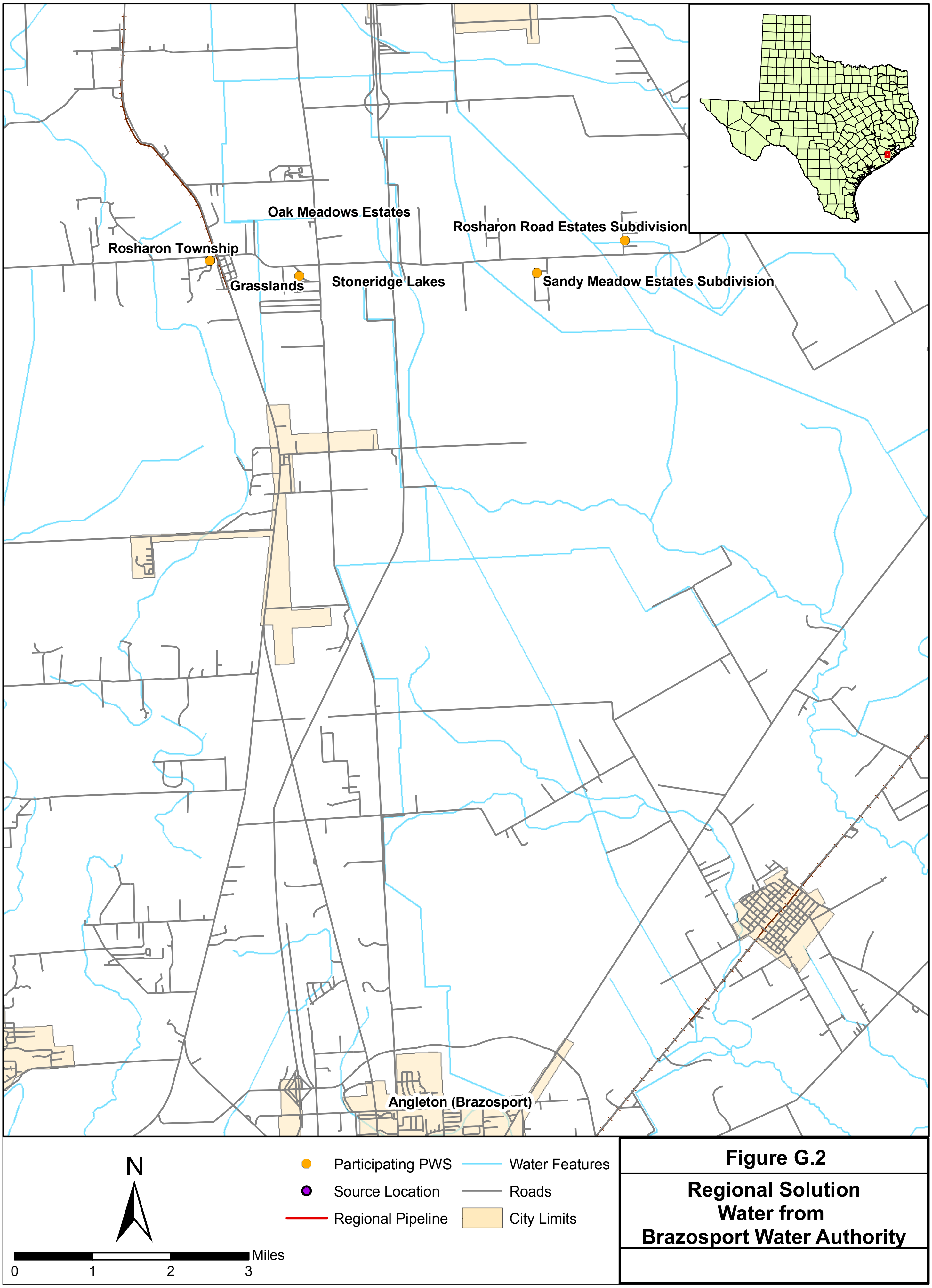

Figure G.2

**Regional Solution
Water from
Brazosport Water Authority**

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Table G.1

PWS	Average Water Demand (mgd)	Water Demand as Percent of Total
Rosharon Road Estates Subdivision	0.10443	28%
Sandy Meadows Estates Subdivision	0.08943	24%
Stoneridge Lakes	0.07343	19%
Grasslands	0.06485	17%
Oak Meadows	0.02585	7%
Rosharon Township	0.0191	5%
0	0	0%
0	0	0%
0	0	0%

Table G.2
Capital Cost for Shared Pipeline from the City of Alvin

Pipe Segment	Capital Cost
Pipe 1	$ 1,867,972
Pipe 2	$ 231,354
Pipe 3	$ 771,954
Pipe 4	$ 66,985
Pipe 5	$ 110,723
Pipe 6	$ -
Pipe 7	$ -
Pipe 8	$ -
Pipe 9	$ -
Pipe A	$ 83,183
Pipe B	$ 56,081
Pipe C	$ 28,781
Pipe D	$ 20,947
Pipe E	$ 121,746
Pipe F	$ 81,115
Pipe G	$ -
Pipe H	$ -
Pipe I	$ -
Total	**$ 3,440,840**

Table G.3
Cost Solution A

PWS	Percentage Based On Flow	Total Costs
Rosharon Road Estates Subdivision	28%	$ 952,894
Sandy Meadows Estates Subdivision	24%	$ 816,024
Stoneridge Lakes	19%	$ 670,028
Grasslands	17%	$ 591,738
Oak Meadows	7%	$ 235,874
Rosharon Township	5%	$ 174,282
0	0%	$ -
0	0%	$ -
0	0%	$ -
Total	**100%**	**$ 3,440,840**

Table G.4
Cost Solution B

PWS	Costs Incurred due to Shared Pipeline	Costs Incurred due to Personal Pipeline	Total Costs
Rosharon Road Estates Subdivision	$ 517,310	$ 83,183	$ 600,493
Sandy Meadows Estates Subdivision	$ 518,887	$ 56,081	$ 574,968
Stoneridge Lakes	$ 735,416	$ 28,781	$ 764,196
Grasslands	$ 689,048	$ 20,947	$ 709,995
Oak Meadows	$ 338,338	$ 121,746	$ 460,083
Rosharon Township	$ 249,990	$ 81,115	$ 331,105
0	$ -	$ -	$ -
0	$ -	$ -	$ -
0	$ -	$ -	$ -
Total	**$ 3,048,988**	**$ 391,852**	**$ 3,440,840**

Table G.5
Cost Solution C

PWS	Percentage based on Individual Solutions	Total Costs
Rosharon Road Estates Subdivision	12%	$ 397,613
Sandy Meadows Estates Subdivision	13%	$ 449,660
Stoneridge Lakes	18%	$ 614,387
Grasslands	18%	$ 623,111
Oak Meadows	20%	$ 673,214
Rosharon Township	20%	$ 682,855
0	0%	$ -
0	0%	$ -
0	0%	$ -
Total	**100%**	**$ 3,440,840**

Table G.6
Summation Table

PWS	Individual Pipeline Cost	Capital Cost Option A	Capital Cost Option B	Capital Cost Option C	Percent Savings A	Percent Savings B	Percent Savings C
Rosharon Road Estates Subdivision	$ 1,660,177	$ 952,894	$ 600,493	$ 397,613	43%	64%	76%
Sandy Meadows Estates Subdivision	$ 1,877,491	$ 816,024	$ 574,968	$ 449,660	57%	69%	76%
Stoneridge Lakes	$ 2,565,286	$ 670,028	$ 764,196	$ 614,387	74%	70%	76%
Grasslands	$ 2,601,709	$ 591,738	$ 709,995	$ 623,111	77%	73%	76%
Oak Meadows	$ 2,810,908	$ 235,874	$ 460,083	$ 673,214	92%	84%	76%
Rosharon Township	$ 2,851,163	$ 174,282	$ 331,105	$ 682,855	94%	88%	76%
0	$ -	$ -	$ -	$ -	false	false	false
0	$ -	$ -	$ -	$ -	false	false	false
0	$ -	$ -	$ -	$ -	false	false	false
Total	**$ 14,366,734**	**$ 3,440,840**	**$ 3,440,840**	**$ 3,440,840**	**73%**	**75%**	**76%**

Table G.7
Capital Cost for Shared Pipeline from BWA

Pipe Segment	Capital Cost
Pipe 1	$ 2,988,751
Pipe 2	$ 92,141
Pipe 3	$ 110,723
Pipe 4	$ 66,985
Pipe 5	$ 786,817
Pipe 6	$ 231,354
Pipe 7	$ -
Pipe 8	$ -
Pipe 9	$ -
Pipe A	$ 74,108
Pipe B	$ 121,746
Pipe C	$ 20,947
Pipe D	$ 28,769
Pipe E	$ 56,085
Pipe F	$ 83,254
Pipe G	$ -
Pipe H	$ -
Pipe I	$ -
Total	**$ 4,661,678**

Table G.8
Cost Solution A

PWS	Percentage Based On Flow	Total Costs
Rosharon Township	18%	$ 852,611
Oak Meadows	6%	$ 301,315
Grasslands	37%	$ 1,740,934
Stoneridge Lakes	8%	$ 383,005
Sandy Meadows Estates Subdivision	15%	$ 714,222
Rosharon Road Estates Subdivision	14%	$ 669,590
0	0%	$ -
0	0%	$ -
0	0%	$ -
Total	**100%**	**$ 4,661,678**

Table G.9
Cost Solution B

PWS	Costs Incurred due to Shared Pipeline	Costs Incurred due to Personal Pipeline	Total Costs
Rosharon Township	$ 546,636	$ 74,108	$ 620,744
Oak Meadows	$ 200,472	$ 121,746	$ 322,217
Grasslands	$ 1,213,235	$ 20,947	$ 1,234,181
Stoneridge Lakes	$ 281,432	$ 28,769	$ 310,202
Sandy Meadows Estates Subdivision	$ 930,908	$ 56,085	$ 986,992
Rosharon Road Estates Subdivision	$ 1,104,088	$ 83,254	$ 1,187,342
0	$ -	$ -	$ -
0	$ -	$ -	$ -
0	$ -	$ -	$ -
Total	**$ 4,276,771**	**$ 384,908**	**$ 4,661,678**

Table G.10
Cost Solution C

PWS	Percentage based on Individual Solutions	Total Costs
Rosharon Township	15%	$ 699,159
Oak Meadows	16%	$ 744,220
Grasslands	15%	$ 703,840
Stoneridge Lakes	15%	$ 698,313
Sandy Meadows Estates Subdivision	19%	$ 891,538
Rosharon Road Estates Subdivision	20%	$ 924,609
0	0%	$ -
0	0%	$ -
0	0%	$ -
Total	**100%**	**$ 4,661,678**

Table G.11
Summation Table

PWS	Individual Pipeline Cost	Capital Cost Option A	Capital Cost Option B	Capital Cost Option C	Percent Savings A	Percent Savings B	Percent Savings C
Rosharon Township	$ 2,540,184	$ 852,611	$ 620,744	$ 699,159	66%	76%	72%
Oak Meadows	$ 2,703,899	$ 301,315	$ 322,217	$ 744,220	89%	88%	72%
Grasslands	$ 2,557,190	$ 1,740,934	$ 1,234,181	$ 703,840	32%	52%	72%
Stoneridge Lakes	$ 2,537,109	$ 383,005	$ 310,202	$ 698,313	85%	88%	72%
Sandy Meadows Estates Subdivision	$ 3,239,135	$ 714,222	$ 986,992	$ 891,538	78%	70%	72%
Rosharon Road Estates Subdivision	$ 3,359,289	$ 669,590	$ 1,187,342	$ 924,609	80%	65%	72%
0	$ -	$ -	$ -	$ -	false	false	false
0	$ -	$ -	$ -	$ -	false	false	false
0	$ -	$ -	$ -	$ -	false	false	false
Total	**$ 16,936,806**	**$ 4,661,678**	**$ 4,661,678**	**$ 4,661,678**	**72%**	**73%**	**72%**

Table G.12

Obtain Water From the City of Alvin
Main Link # 1

Total Pipe Length	6.67	miles
Number of Pump Stations Needed	1	
Pipe Size	06"	inches

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	4	n/a	n/a	n/a
Number of Crossings, open cut	14	n/a	n/a	n/a
PVC water line, Class 200, 06"	35,210	LF	$ 32	$ 1,126,720
Bore and encasement, 10"	800	LF	$ 60	$ 48,000
Open cut and encasement, 10"	700	LF	$ 35	$ 24,500
Gate valve and box, 06"	8	EA	$ 465	$ 3,720
Air valve	7	EA	$ 1,000	$ 7,000
Flush valve	8	EA	$ 750	$ 6,000
Metal detectable tape	35,210	LF	$ 0.15	$ 5,282
Subtotal				**$ 1,221,222**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 06"	2	EA	$ 4,000	$ 8,000
Gate valve, 06"	4	EA	$ 590	$ 2,360
Check valve, 06"	2	EA	$ 890	$ 1,780
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 - 5000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 67,035**
Subtotal of Component Costs				**$ 1,288,257**
Contingency	20%			$ 257,651
Design & Constr Management	25%			$ 322,064
TOTAL CAPITAL COSTS				**$ 1,867,972**

Table G.13

Obtain Water From the City of Alvin
Main Link # 2

Total Pipe Length	0.99	miles
Number of Pump Stations Needed	0	
Pipe Size	04"	inches

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	5,251	LF	$ 27	$ 141,777
Bore and encasement, 10"	200	LF	$ 60	$ 12,000
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	2	EA	$ 370	$ 740
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	2	EA	$ 750	$ 1,500
Metal detectable tape	5,251	LF	$ 0.15	$ 788
Subtotal				**$ 159,555**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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 - 5000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Subtotal of Component Costs				**$ 159,555**
Contingency	20%			$ 31,911
Design & Constr Management	25%			$ 39,889
TOTAL CAPITAL COSTS				**$ 231,354**

Table G.14

Obtain Water From the City of Alvin
Main Link # 3

Total Pipe Length	2.92	miles
Number of Pump Stations Needed	1	
Pipe Size	04"	inches

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	3	n/a	n/a	n/a
Number of Crossings, open cut	3	n/a	n/a	n/a
PVC water line, Class 200, 04"	15,394	LF	$ 27	$ 415,638
Bore and encasement, 10"	600	LF	$ 60	$ 36,000
Open cut and encasement, 10"	150	LF	$ 35	$ 5,250
Gate valve and box, 04"	4	EA	$ 370	$ 1,480
Air valve	3	EA	$ 1,000	$ 3,000
Flush valve	4	EA	$ 750	$ 3,000
Metal detectable tape	15,394	LF	$ 0.15	$ 2,309
Subtotal				**$ 466,677**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	2	EA	$ 4,000	$ 8,000
Gate valve, 04"	4	EA	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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 - 5000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 65,705**
Subtotal of Component Costs				**$ 532,382**
Contingency	20%			$ 106,476
Design & Constr Management	25%			$ 133,096
TOTAL CAPITAL COSTS				**$ 771,954**

Table G.15

Obtain Water From the City of Alvin
Main Link # 4

Total Pipe Length	0.30	miles
Number of Pump Stations Needed	0	
Pipe Size	04"	inches

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	1,559	LF	$ 27	$ 42,093
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	1,559	LF	$ 0.15	$ 234
Subtotal				**$ 46,197**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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 - 5000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Subtotal of Component Costs				**$ 46,197**
Contingency	20%			$ 9,239
Design & Constr Management	25%			$ 11,549
TOTAL CAPITAL COSTS				**$ 66,985**

Table G.16

Obtain Water From the City of Alvin
Main Link # 5

Total Pipe Length	0.51	miles
Number of Pump Stations Needed	0	
Pipe Size	04"	inches

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	2,670	LF	$ 27	$ 72,090
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	2,670	LF	$ 0.15	$ 401
Subtotal				**$ 76,361**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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 - 5000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Subtotal of Component Costs				**$ 76,361**
Contingency	20%			$ 15,272
Design & Constr Management	25%			$ 19,090
TOTAL CAPITAL COSTS				**$ 110,723**

Table G.17

Segment A
Obtain Water From the City of Alvin
Rosharon Road Estates Subdivision

Private Pipe Size	04"	
Total Pipe Length	0.28	miles
Total PWS annual water usage	38.1	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	2	n/a	n/a	n/a
PVC water line, Class 200, 04"	1,464	LF	$ 27	$ 39,528
Bore and encasement, 10"	200	LF	$ 60	$ 12,000
Open cut and encasement, 10"	100	LF	$ 35	$ 3,500
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	1,464	LF	$ 0.15	$ 220
Subtotal				**$ 57,368**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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				**$ -**
Subtotal of Component Costs				**$ 57,368**
Contingency	20%			$ 11,474
Design & Constr Management	25%			$ 14,342
TOTAL CAPITAL COSTS				**$ 83,183**

Table G.18

Segment B
Obtain Water From the City of Alvin
Sandy Meadows Estates Subdivision

Private Pipe Size	04"	
Total Pipe Length	0.24	miles
Total PWS annual water usage	32.6	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	1,282	LF	$ 27	$ 34,614
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	1,282	LF	$ 0.15	$ 192
Subtotal				**$ 38,676**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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				**$ -**
Subtotal of Component Costs				**$ 38,676**
Contingency	20%			$ 7,735
Design & Constr Management	25%			$ 9,669
TOTAL CAPITAL COSTS				**$ 56,081**

Table G.19

Segment C
Obtain Water From the City of Alvin
Stoneridge Lakes

Private Pipe Size		04"	
Total Pipe Length		0.12	miles
Total PWS annual water usage		26.8	MG
Treated water purchase cost	$	1.25	per 1,000 gals
Number of Pump Stations Needed		0	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	-	n/a	n/a	n/a
PVC water line, Class 200, 04"	653	LF	$ 27	$ 17,631
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	-	LF	$ 35	$ -
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	653	LF	$ 0.15	$ 98
Subtotal				**$ 19,849**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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				**$ -**
Subtotal of Component Costs				**$ 19,849**
Contingency	20%			$ 3,970
Design & Constr Management	25%			$ 4,962
TOTAL CAPITAL COSTS				**$ 28,781**

Table G.20

Segment D
Obtain Water From the City of Alvin
Grasslands

Private Pipe Size	04"	
Total Pipe Length	0.09	miles
Total PWS annual water usage	23.7	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item		**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction					
	Number of Crossings, bore	-	n/a	n/a	n/a
	Number of Crossings, open cut	-	n/a	n/a	n/a
	PVC water line, Class 200, 04"	454	LF	$ 27	$ 12,258
	Bore and encasement, 10"	-	LF	$ 60	$ -
	Open cut and encasement, 10"	-	LF	$ 35	$ -
	Gate valve and box, 04"	1	EA	$ 370	$ 370
	Air valve	1	EA	$ 1,000	$ 1,000
	Flush valve	1	EA	$ 750	$ 750
	Metal detectable tape	454	LF	$ 0.15	$ 68
	Subtotal				**$ 14,446**
Pump Station(s) Installation					
	Pump	-	EA	$ 7,500	$ -
	Pump Station Piping, 04"	-	EA	$ 4,000	$ -
	Gate valve, 04"	-	EA	$ 405	$ -
	Check valve, 04"	-	EA	$ 595	$ -
	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				**$ -**
	Subtotal of Component Costs				**$ 14,446**
	Contingency	20%			$ 2,889
	Design & Constr Management	25%			$ 3,612
	TOTAL CAPITAL COSTS				**$ 20,947**

Table G.21

Segment E
Obtain Water From the City of Alvin
Oak Meadows

Private Pipe Size	04"	
Total Pipe Length	0.56	miles
Total PWS annual water usage	9.4	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item		**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction					
	Number of Crossings, bore	-	n/a	n/a	n/a
	Number of Crossings, open cut	1	n/a	n/a	n/a
	PVC water line, Class 200, 04"	2,950	LF	$ 27	$ 79,650
	Bore and encasement, 10"	-	LF	$ 60	$ -
	Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
	Gate valve and box, 04"	1	EA	$ 370	$ 370
	Air valve	1	EA	$ 1,000	$ 1,000
	Flush valve	1	EA	$ 750	$ 750
	Metal detectable tape	2,950	LF	$ 0.15	$ 443
	Subtotal				**$ 83,963**
Pump Station(s) Installation					
	Pump	-	EA	$ 7,500	$ -
	Pump Station Piping, 04"	-	EA	$ 4,000	$ -
	Gate valve, 04"	-	EA	$ 405	$ -
	Check valve, 04"	-	EA	$ 595	$ -
	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				**$ -**
	Subtotal of Component Costs				**$ 83,963**
	Contingency	20%			$ 16,793
	Design & Constr Management	25%			$ 20,991
	TOTAL CAPITAL COSTS				**$ 121,746**

Table G.22

Segment F
Obtain Water From the City of Alvin
Rosharon Township

Private Pipe Size	04"	
Total Pipe Length	0.34	miles
Total PWS annual water usage	7.0	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	3	n/a	n/a	n/a
PVC water line, Class 200, 04"	1,789	LF	$ 27	$ 48,303
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	150	LF	$ 35	$ 5,250
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	1,789	LF	$ 0.15	$ 268
Subtotal				**$ 55,941**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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				**$ -**
Subtotal of Component Costs				**$ 55,941**
Contingency	20%			$ 11,188
Design & Constr Management	25%			$ 13,985
TOTAL CAPITAL COSTS				**$ 81,115**

Table G.23

Obtain Water From the City of Alvin
Main Link # 1

Total Pipe Length	11.36	miles
Number of Pump Stations Needed	1	
Pipe Size	06"	inches

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	2	n/a	n/a	n/a
Number of Crossings, open cut	9	n/a	n/a	n/a
PVC water line, Class 200, 06"	59,964	LF	$ 32	$ 1,918,848
Bore and encasement, 10"	400	LF	$ 60	$ 24,000
Open cut and encasement, 10"	450	LF	$ 35	$ 15,750
Gate valve and box, 06"	12	EA	$ 465	$ 5,580
Air valve	12	EA	$ 1,000	$ 12,000
Flush valve	12	EA	$ 750	$ 9,000
Metal detectable tape	59,964	LF	$ 0.15	$ 8,995
Subtotal				**$ 1,994,173**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 06"	2	EA	$ 4,000	$ 8,000
Gate valve, 06"	4	EA	$ 590	$ 2,360
Check valve, 06"	2	EA	$ 890	$ 1,780
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 - 5000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 67,035**
Subtotal of Component Costs				**$ 2,061,208**
Contingency	20%			$ 412,242
Design & Constr Management	25%			$ 515,302
TOTAL CAPITAL COSTS				**$ 2,988,751**

Table G.24

Obtain Water From the City of Alvin
Main Link # 2

Total Pipe Length	0.33	miles
Number of Pump Stations Needed	0	
Pipe Size	04"	inches

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	1,756	LF	$ 27	$ 47,412
Bore and encasement, 10"	200	LF	$ 60	$ 12,000
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	1,756	LF	$ 0.15	$ 263
Subtotal				**$ 63,545**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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 - 5000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Subtotal of Component Costs				**$ 63,545**
Contingency	20%			$ 12,709
Design & Constr Management	25%			$ 15,886
TOTAL CAPITAL COSTS				**$ 92,141**

Table G.25

Obtain Water From the City of Alvin
Main Link # 3

Total Pipe Length	0.51	miles
Number of Pump Stations Needed	0	
Pipe Size	04"	inches

Capital Costs

Cost Item		**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction					
	Number of Crossings, bore	-	n/a	n/a	n/a
	Number of Crossings, open cut	1	n/a	n/a	n/a
	PVC water line, Class 200, 04"	2,670	LF	$ 27	$ 72,090
	Bore and encasement, 10"	-	LF	$ 60	$ -
	Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
	Gate valve and box, 04"	1	EA	$ 370	$ 370
	Air valve	1	EA	$ 1,000	$ 1,000
	Flush valve	1	EA	$ 750	$ 750
	Metal detectable tape	2,670	LF	$ 0.15	$ 401
	Subtotal				**$ 76,361**
Pump Station(s) Installation					
	Pump	-	EA	$ 7,500	$ -
	Pump Station Piping, 04"	-	EA	$ 4,000	$ -
	Gate valve, 04"	-	EA	$ 405	$ -
	Check valve, 04"	-	EA	$ 595	$ -
	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 - 5000 gals	-	EA	$ 7,025	$ -
	Subtotal				**$ -**
	Subtotal of Component Costs				**$ 76,361**
	Contingency	20%			$ 15,272
	Design & Constr Management	25%			$ 19,090
	TOTAL CAPITAL COSTS				**$ 110,723**

Table G.26

Obtain Water From the City of Alvin
Main Link # 4

Total Pipe Length	0.30	miles
Number of Pump Stations Needed	0	
Pipe Size	04"	inches

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	1,559	LF	$ 27	$ 42,093
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	1,559	LF	$ 0.15	$ 234
Subtotal				**$ 46,197**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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 - 5000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Subtotal of Component Costs				**$ 46,197**
Contingency	20%			$ 9,239
Design & Constr Management	25%			$ 11,549
TOTAL CAPITAL COSTS				**$ 66,985**

Table G.27

Obtain Water From the City of Alvin
Main Link # 5

Total Pipe Length	2.92	miles
Number of Pump Stations Needed	1	
Pipe Size	04"	inches

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	4	n/a	n/a	n/a
Number of Crossings, open cut	2	n/a	n/a	n/a
PVC water line, Class 200, 04"	15,394	LF	$ 27	$ 415,638
Bore and encasement, 10"	800	LF	$ 60	$ 48,000
Open cut and encasement, 10"	100	LF	$ 35	$ 3,500
Gate valve and box, 04"	4	EA	$ 370	$ 1,480
Air valve	3	EA	$ 1,000	$ 3,000
Flush valve	4	EA	$ 750	$ 3,000
Metal detectable tape	15,394	LF	$ 0.15	$ 2,309
Subtotal				**$ 476,927**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	2	EA	$ 4,000	$ 8,000
Gate valve, 04"	4	EA	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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 - 5000 gals	1	EA	$ 7,025	$ 7,025
Subtotal				**$ 65,705**
Subtotal of Component Costs				**$ 542,632**
Contingency	20%			$ 108,526
Design & Constr Management	25%			$ 135,658
TOTAL CAPITAL COSTS				**$ 786,817**

Table G.28

Obtain Water From the City of Alvin
Main Link # 6

Total Pipe Length	0.99	miles
Number of Pump Stations Needed	0	
Pipe Size	04"	inches

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	1	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	5,251	LF	$ 27	$ 141,777
Bore and encasement, 10"	200	LF	$ 60	$ 12,000
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	2	EA	$ 370	$ 740
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	2	EA	$ 750	$ 1,500
Metal detectable tape	5,251	LF	$ 0.15	$ 788
Subtotal				**$ 159,555**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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 - 5000 gals	-	EA	$ 7,025	$ -
Subtotal				**$ -**
Subtotal of Component Costs				**$ 159,555**
Contingency	20%			$ 31,911
Design & Constr Management	25%			$ 39,889
TOTAL CAPITAL COSTS				**$ 231,354**

Table G.29

Segment A
Obtain Water From the City of Alvin
Rosharon Township

Private Pipe Size	04"	
Total Pipe Length	0.31	miles
Total PWS annual water usage	4,841.3	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	3	n/a	n/a	n/a
PVC water line, Class 200, 04"	1,611	LF	$ 27	$ 43,497
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	150	LF	$ 35	$ 5,250
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	1,611	LF	$ 0.15	$ 242
Subtotal				**$ 51,109**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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				**$ -**
Subtotal of Component Costs				**$ 51,109**
Contingency	20%			$ 10,222
Design & Constr Management	25%			$ 12,777
TOTAL CAPITAL COSTS				**$ 74,108**

Table G.30

Segment B
Obtain Water From the City of Alvin
Oak Meadows

Private Pipe Size	04"	
Total Pipe Length	0.56	miles
Total PWS annual water usage	1,710.9	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item		Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction					
	Number of Crossings, bore	-	n/a	n/a	n/a
	Number of Crossings, open cut	1	n/a	n/a	n/a
	PVC water line, Class 200, 04"	2,950	LF	$ 27	$ 79,650
	Bore and encasement, 10"	-	LF	$ 60	$ -
	Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
	Gate valve and box, 04"	1	EA	$ 370	$ 370
	Air valve	1	EA	$ 1,000	$ 1,000
	Flush valve	1	EA	$ 750	$ 750
	Metal detectable tape	2,950	LF	$ 0.15	$ 443
	Subtotal				**$ 83,963**
Pump Station(s) Installation					
	Pump	-	EA	$ 7,500	$ -
	Pump Station Piping, 04"	-	EA	$ 4,000	$ -
	Gate valve, 04"	-	EA	$ 405	$ -
	Check valve, 04"	-	EA	$ 595	$ -
	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				**$ -**
	Subtotal of Component Costs				**$ 83,963**
	Contingency	20%			$ 16,793
	Design & Constr Management	25%			$ 20,991
	TOTAL CAPITAL COSTS				**$ 121,746**

Table G.31

Segment C
Obtain Water From the City of Alvin
Grasslands

Private Pipe Size	04"	
Total Pipe Length	0.09	miles
Total PWS annual water usage	9,885.4	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	-	n/a	n/a	n/a
PVC water line, Class 200, 04"	454	LF	$ 27	$ 12,258
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	-	LF	$ 35	$ -
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	454	LF	$ 0.15	$ 68
Subtotal				**$ 14,446**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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				**$ -**
Subtotal of Component Costs				**$ 14,446**
Contingency	20%			$ 2,889
Design & Constr Management	25%			$ 3,612
TOTAL CAPITAL COSTS				**$ 20,947**

Table G.32

Segment D
Obtain Water From the City of Alvin
Stoneridge Lakes

Private Pipe Size	04"	
Total Pipe Length	0.12	miles
Total PWS annual water usage	2,174.8	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item		**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction					
	Number of Crossings, bore	-	n/a	n/a	n/a
	Number of Crossings, open cut	-	n/a	n/a	n/a
	PVC water line, Class 200, 04"	653	LF	$ 27	$ 17,623
	Bore and encasement, 10"	-	LF	$ 60	$ -
	Open cut and encasement, 10"	-	LF	$ 35	$ -
	Gate valve and box, 04"	1	EA	$ 370	$ 370
	Air valve	1	EA	$ 1,000	$ 1,000
	Flush valve	1	EA	$ 750	$ 750
	Metal detectable tape	653	LF	$ 0.15	$ 98
	Subtotal				**$ 19,841**
Pump Station(s) Installation					
	Pump	-	EA	$ 7,500	$ -
	Pump Station Piping, 04"	-	EA	$ 4,000	$ -
	Gate valve, 04"	-	EA	$ 405	$ -
	Check valve, 04"	-	EA	$ 595	$ -
	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				**$ -**
	Subtotal of Component Costs				**$ 19,841**
	Contingency	20%			$ 3,968
	Design & Constr Management	25%			$ 4,960
	TOTAL CAPITAL COSTS				**$ 28,769**

Table G.33

Segment E
Obtain Water From the City of Alvin

Sandy Meadows Estates Subdivision

Private Pipe Size	04"	
Total Pipe Length	0.24	miles
Total PWS annual water usage	4,055.5	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	1,282	LF	$ 27	$ 34,617
Bore and encasement, 10"	-	LF	$ 60	$ -
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	1	EA	$ 370	$ 370
Air valve	1	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 750
Metal detectable tape	1,282	LF	$ 0.15	$ 192
Subtotal				**$ 38,679**
Pump Station(s) Installation				
Pump	-	EA	$ 7,500	$ -
Pump Station Piping, 04"	-	EA	$ 4,000	$ -
Gate valve, 04"	-	EA	$ 405	$ -
Check valve, 04"	-	EA	$ 595	$ -
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				**$ -**
Subtotal of Component Costs				**$ 38,679**
Contingency	20%			$ 7,736
Design & Constr Management	25%			$ 9,670
TOTAL CAPITAL COSTS				**$ 56,085**

Table G.34

Segment F
Obtain Water From the City of Alvin
Rosharon Road Estates Subdivision

Private Pipe Size	04"	
Total Pipe Length	0.28	miles
Total PWS annual water usage	3,802.1	MG
Treated water purchase cost	$ 1.25	per 1,000 gals
Number of Pump Stations Needed	0	

Capital Costs

Cost Item		Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction					
	Number of Crossings, bore	1	n/a	n/a	n/a
	Number of Crossings, open cut	2	n/a	n/a	n/a
	PVC water line, Class 200, 04"	1,466	LF	$ 27	$ 39,577
	Bore and encasement, 10"	200	LF	$ 60	$ 12,000
	Open cut and encasement, 10"	100	LF	$ 35	$ 3,500
	Gate valve and box, 04"	1	EA	$ 370	$ 370
	Air valve	1	EA	$ 1,000	$ 1,000
	Flush valve	1	EA	$ 750	$ 750
	Metal detectable tape	1,466	LF	$ 0.15	$ 220
	Subtotal				**$ 57,416**
Pump Station(s) Installation					
	Pump	-	EA	$ 7,500	$ -
	Pump Station Piping, 04"	-	EA	$ 4,000	$ -
	Gate valve, 04"	-	EA	$ 405	$ -
	Check valve, 04"	-	EA	$ 595	$ -
	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				**$ -**
	Subtotal of Component Costs				**$ 57,416**
	Contingency	20%			$ 11,483
	Design & Constr Management	25%			$ 14,354
	TOTAL CAPITAL COSTS				**$ 83,254**

Table G.35

	Alvin to each PWS
Alternative Name	***Purchase Water from Alvin to Rosharon Road***
Alternative Number	***RR***

Distance from Alternative to PWS (along pipe)	7.0	miles
Total PWS annual water usage	5.475	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	4	n/a	n/a	n/a
Number of Crossings, open cut	17	n/a	n/a	n/a
PVC water line, Class 200, 04"	36,750	LF	$ 27.00	$ 992,250
Bore and encasement, 10"	800	LF	$ 60.00	$ 48,000
Open cut and encasement, 10"	850	LF	$ 35.00	$ 29,750
Gate valve and box, 04"	7	EA	$ 370.00	$ 2,720
Air valve	7	EA	$ 1,000.00	$ 7,000
Flush valve	7	EA	$ 750.00	$ 5,513
Metal detectable tape	36,750	LF	$ 0.15	$ 5,513
Subtotal				**$ 1,090,745**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,144,950**
Contingency	20%			$ 228,990
Design & Constr Management	25%			$ 286,237
TOTAL CAPITAL COSTS				**$ 1,660,177**

Table G.36

	Alvin to each PWS
Alternative Name	***Purchase Water from Alvin to Sandy Meadow***
Alternative Number	***SM***

Distance from Alternative to PWS (along pipe)	7.9	miles
Total PWS annual water usage	5.840	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	5	n/a	n/a	n/a
Number of Crossings, open cut	16	n/a	n/a	n/a
PVC water line, Class 200, 04"	41,814	LF	$ 27.00	$ 1,128,978
Bore and encasement, 10"	1,000	LF	$ 60.00	$ 60,000
Open cut and encasement, 10"	800	LF	$ 35.00	$ 28,000
Gate valve and box, 04"	8	EA	$ 370.00	$ 3,094
Air valve	8	EA	$ 1,000.00	$ 8,000
Flush valve	8	EA	$ 750.00	$ 6,272
Metal detectable tape	41,814	LF	$ 0.15	$ 6,272
Subtotal				**$ 1,240,616**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,294,821**
Contingency	20%			$ 258,964
Design & Constr Management	25%			$ 323,705
TOTAL CAPITAL COSTS				**$ 1,877,491**

Table G.37

	Alvin to each PWS
Alternative Name	***Purchase Water from Alvin to Stoneridge***
Alternative Number	***SR***

Distance from Alternative to PWS (along pipe)	10.7	miles
Total PWS annual water usage	3.132	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	10	n/a	n/a	n/a
Number of Crossings, open cut	20	n/a	n/a	n/a
PVC water line, Class 200, 04"	56,585	LF	$ 27.00	$ 1,527,795
Bore and encasement, 10"	2,000	LF	$ 60.00	$ 120,000
Open cut and encasement, 10"	1,000	LF	$ 35.00	$ 35,000
Gate valve and box, 04"	11	EA	$ 370.00	$ 4,187
Air valve	11	EA	$ 1,000.00	$ 11,000
Flush valve	11	EA	$ 750.00	$ 8,488
Metal detectable tape	56,585	LF	$ 0.15	$ 8,488
Subtotal				**$ 1,714,958**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,769,163**
Contingency	20%			$ 353,833
Design & Constr Management	25%			$ 442,291
TOTAL CAPITAL COSTS				**$ 2,565,286**

Table G.38

	Alvin to each PWS
Alternative Name	***Purchase Water from Alvin to Grasslands***
Alternative Number	***Grass***

Distance from Alternative to PWS (along pipe)	11.0	miles
Total PWS annual water usage	14.235	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	9	n/a	n/a	n/a
Number of Crossings, open cut	20	n/a	n/a	n/a
PVC water line, Class 200, 04"	57,941	LF	$ 27.00	$ 1,564,407
Bore and encasement, 10"	1,800	LF	$ 60.00	$ 108,000
Open cut and encasement, 10"	1,000	LF	$ 35.00	$ 35,000
Gate valve and box, 04"	12	EA	$ 370.00	$ 4,288
Air valve	11	EA	$ 1,000.00	$ 11,000
Flush valve	12	EA	$ 750.00	$ 8,691
Metal detectable tape	57,941	LF	$ 0.15	$ 8,691
Subtotal				**$ 1,740,077**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,794,282**
Contingency	20%			$ 358,856
Design & Constr Management	25%			$ 448,570
TOTAL CAPITAL COSTS				**$ 2,601,709**

Table G.39

	Alvin to each PWS
Alternative Name	***Purchase Water from Alvin to Oak Meadows***
Alternative Number	***OM***

Distance from Alternative to PWS (along pipe)	12.0	miles
Total PWS annual water usage	5.475	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	9	n/a	n/a	n/a
Number of Crossings, open cut	20	n/a	n/a	n/a
PVC water line, Class 200, 04"	63,175	LF	$ 27.00	$ 1,705,725
Bore and encasement, 10"	1,800	LF	$ 60.00	$ 108,000
Open cut and encasement, 10"	1,000	LF	$ 35.00	$ 35,000
Gate valve and box, 04"	13	EA	$ 370.00	$ 4,675
Air valve	12	EA	$ 1,000.00	$ 12,000
Flush valve	13	EA	$ 750.00	$ 9,476
Metal detectable tape	63,175	LF	$ 0.15	$ 9,476
Subtotal				**$ 1,884,352**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,938,557**
Contingency	20%			$ 387,711
Design & Constr Management	25%			$ 484,639
TOTAL CAPITAL COSTS				**$ 2,810,908**

Table G.40

	Alvin to each PWS
Alternative Name	***Purchase Water from Alvin to RosharonTownship***
Alternative Number	***RT***

Distance from Alternative to PWS (along pipe)	12.0	miles
Total PWS annual water usage	6.972	MG
Treated water purchase cost	$ 1.65	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	10	n/a	n/a	n/a
Number of Crossings, open cut	23	n/a	n/a	n/a
PVC water line, Class 200, 04"	63,559	LF	$ 27.00	$ 1,716,093
Bore and encasement, 10"	2,000	LF	$ 60.00	$ 120,000
Open cut and encasement, 10"	1,150	LF	$ 35.00	$ 40,250
Gate valve and box, 04"	13	EA	$ 370.00	$ 4,703
Air valve	12	EA	$ 1,000.00	$ 12,000
Flush valve	13	EA	$ 750.00	$ 9,534
Metal detectable tape	63,559	LF	$ 0.15	$ 9,534
Subtotal				**$ 1,912,114**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,966,319**
Contingency	20%			$ 393,264
Design & Constr Management	25%			$ 491,580
TOTAL CAPITAL COSTS				**$ 2,851,163**

Table G.41

	Angleton to each PWS
Alternative Name	***Purchase Water from Angleton to RoshTownship***
Alternative Number	***RT***

Distance from Alternative to PWS (along pipe)	11.4	miles
Total PWS annual water usage	6.972	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	2	n/a	n/a	n/a
Number of Crossings, open cut	12	n/a	n/a	n/a
PVC water line, Class 200, 04"	59,971	LF	$ 27.00	$ 1,619,217
Bore and encasement, 10"	400	LF	$ 60.00	$ 24,000
Open cut and encasement, 10"	600	LF	$ 35.00	$ 21,000
Gate valve and box, 04"	12	EA	$ 370.00	$ 4,438
Air valve	11	EA	$ 1,000.00	$ 11,000
Flush valve	12	EA	$ 750.00	$ 8,996
Metal detectable tape	59,971	LF	$ 0.15	$ 8,996
Subtotal				**$ 1,697,646**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,751,851**
Contingency	20%			$ 350,370
Design & Constr Management	25%			$ 437,963
TOTAL CAPITAL COSTS				**$ 2,540,184**

Table G.42

	Angleton to each PWS
Alternative Name	***Purchase Water from Angleton to Oak Meadow***
Alternative Number	***OM***

Distance from Alternative to PWS (along pipe)	12.1	miles
Total PWS annual water usage	2.464	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	2	n/a	n/a	n/a
Number of Crossings, open cut	11	n/a	n/a	n/a
PVC water line, Class 200, 04"	64,123	LF	$ 27.00	$ 1,731,321
Bore and encasement, 10"	400	LF	$ 60.00	$ 24,000
Open cut and encasement, 10"	550	LF	$ 35.00	$ 19,250
Gate valve and box, 04"	13	EA	$ 370.00	$ 4,745
Air valve	12	EA	$ 1,000.00	$ 12,000
Flush valve	13	EA	$ 750.00	$ 9,618
Metal detectable tape	64,123	LF	$ 0.15	$ 9,618
Subtotal				**$ 1,810,553**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,864,758**
Contingency	20%			$ 372,952
Design & Constr Management	25%			$ 466,190
TOTAL CAPITAL COSTS				**$ 2,703,899**

Table G.43

	Angleton to each PWS
Alternative Name	***Purchase Water from Angleton to Grasslands***
Alternative Number	***Grass***

Distance from Alternative to PWS (along pipe)	11.4	miles
Total PWS annual water usage	14.235	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	3	n/a	n/a	n/a
Number of Crossings, open cut	11	n/a	n/a	n/a
PVC water line, Class 200, 04"	60,025	LF	$ 27.00	$ 1,620,675
Bore and encasement, 10"	600	LF	$ 60.00	$ 36,000
Open cut and encasement, 10"	550	LF	$ 35.00	$ 19,250
Gate valve and box, 04"	12	EA	$ 370.00	$ 4,442
Air valve	11	EA	$ 1,000.00	$ 11,000
Flush valve	12	EA	$ 750.00	$ 9,004
Metal detectable tape	60,025	LF	$ 0.15	$ 9,004
Subtotal				**$ 1,709,374**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,763,579**
Contingency	20%			$ 352,716
Design & Constr Management	25%			$ 440,895
TOTAL CAPITAL COSTS				**$ 2,557,190**

Table G.44

	Angleton to each PWS
Alternative Name	***Purchase Water from Angleton to Stoneridge***
Alternative Number	***SR***

Distance from Alternative to PWS (along pipe)	11.1	miles
Total PWS annual water usage	3.132	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Pipeline Construction				
Number of Crossings, bore	4	n/a	n/a	n/a
Number of Crossings, open cut	15	n/a	n/a	n/a
PVC water line, Class 200, 04"	58,825	LF	$ 27.00	$ 1,588,275
Bore and encasement, 10"	800	LF	$ 60.00	$ 48,000
Open cut and encasement, 10"	750	LF	$ 35.00	$ 26,250
Gate valve and box, 04"	12	EA	$ 370.00	$ 4,353
Air valve	11	EA	$ 1,000.00	$ 11,000
Flush valve	12	EA	$ 750.00	$ 8,824
Metal detectable tape	58,825	LF	$ 0.15	$ 8,824
Subtotal				**$ 1,695,526**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 1,749,731**
Contingency	20%			$ 349,946
Design & Constr Management	25%			$ 437,433
TOTAL CAPITAL COSTS				**$ 2,537,109**

Table G.45

	Angleton to each PWS
Alternative Name	***Purchase Water from Ang to Sandy Meadow***
Alternative Number	***SM***

Distance from Alternative to PWS (along pipe)	14.2	miles
Total PWS annual water usage	5.840	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	7	n/a	n/a	n/a
Number of Crossings, open cut	15	n/a	n/a	n/a
PVC water line, Class 200, 04"	75,087	LF	$ 27.00	$ 2,027,349
Bore and encasement, 10"	1,400	LF	$ 60.00	$ 84,000
Open cut and encasement, 10"	750	LF	$ 35.00	$ 26,250
Gate valve and box, 04"	15	EA	$ 370.00	$ 5,556
Air valve	14	EA	$ 1,000.00	$ 14,000
Flush valve	15	EA	$ 750.00	$ 11,263
Metal detectable tape	75,087	LF	$ 0.15	$ 11,263
Subtotal				**$ 2,179,682**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 2,233,887**
Contingency	20%			$ 446,777
Design & Constr Management	25%			$ 558,472
TOTAL CAPITAL COSTS				**$ 3,239,135**

Table G.46

	Angleton to each PWS
Alternative Name	***Purchase Water from Ang to Roasharon Road***
Alternative Number	***RR***

Distance from Alternative to PWS (along pipe)	14.6	miles
Total PWS annual water usage	5.475	MG
Treated water purchase cost	$ 1.60	per 1,000 gals
Number of Pump Stations Needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	9	n/a	n/a	n/a
Number of Crossings, open cut	17	n/a	n/a	n/a
PVC water line, Class 200, 04"	77,073	LF	$ 27.00	$ 2,080,971
Bore and encasement, 10"	1,800	LF	$ 60.00	$ 108,000
Open cut and encasement, 10"	850	LF	$ 35.00	$ 29,750
Gate valve and box, 04"	15	EA	$ 370.00	$ 5,703
Air valve	15	EA	$ 1,000.00	$ 15,000
Flush valve	15	EA	$ 750.00	$ 11,561
Metal detectable tape	77,073	LF	$ 0.15	$ 11,561
Subtotal				**$ 2,262,546**
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	$ 405	$ 1,620
Check valve, 04"	2	EA	$ 595	$ 1,190
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				**$ 54,205**
Subtotal of Component Costs				**$ 2,316,751**
Contingency	20%			$ 463,350
Design & Constr Management	25%			$ 579,188
TOTAL CAPITAL COSTS				**$ 3,359,289**