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

ORBIT SYSTEMS, INC. - MARK V ESTATES
PWS ID# 0200432 , 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 the Mark V Estates PWS located in Brazoria County. The Mark V Estates PWS recorded arsenic concentrations of 22 micrograms per liter (µg/L) in May 2001 and 24.4 µg/L in June 2004. While these results were below the arsenic MCL of 50 µg/L in effect at that time, the values were above the 10 µg/L MCL for arsenic that would go into effect on January 23, 2006 (USEPA 2005a; TCEQ 2004a). Therefore, it was likely that the Mark V Estates PWS would face potential compliance issues under the new standard.

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

Table ES.1
Mark V Estates PWS
Basic System Information

Population served	285
Connections	94
Average daily flow rate	0.020 million gallons per day (mgd)
Peak demand flow rate	54.6 gallons per minute (gpm)
Water system peak capacity	0.144 mgd
Typical arsenic range	22 – 24.4 µg/L

STUDY METHODS

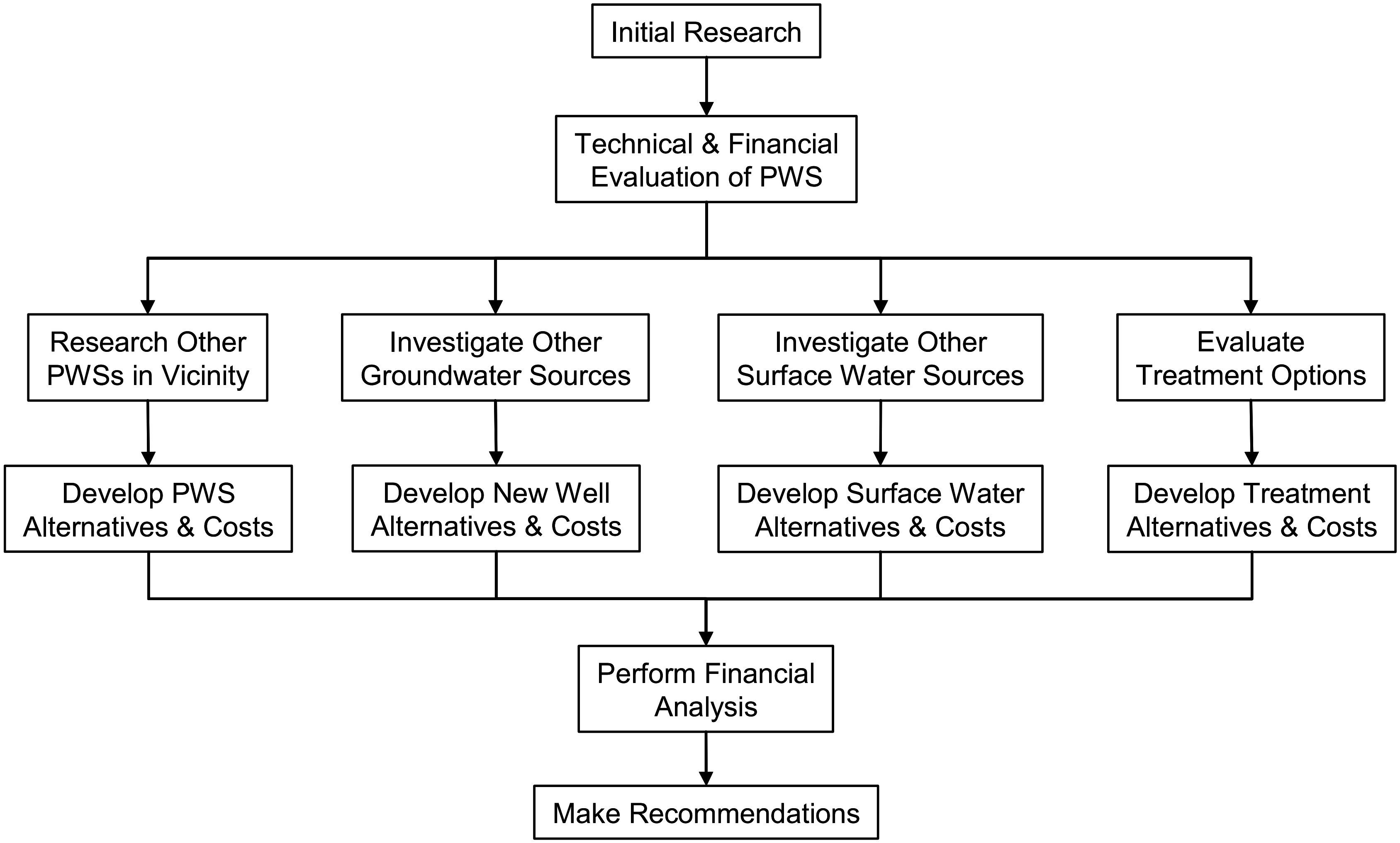
The methods used for this study were based on a pilot study performed in 2004 and 2005 by TCEQ, BEG, and Parsons. Methods for identifying and analyzing compliance options were developed in the pilot study (a decision tree approach).

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.

Figure ES-1
Summary of Project Methods



HYDROGEOLOGICAL ANALYSIS

The Mark V Estates 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 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 Mark V 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 numerous PWSs within 20 miles of Mark V Estates. 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 Mark V Estates.

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 Mark V is likely to be the best solution if compliant groundwater can be found. Having a new well close to Mark V 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 Mark V Estates PWS indicated that current water rates are under funding operations, and a rate increase of approximately 6.3 percent would be necessary to meet operating expenses. This increase would raise the average annual water bill from $381 to $405. The current average water bill represents approximately 0.8 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	$381	0.8
To meet current expenses	NA	$405	0.9
Nearby well within approximately 1 mile	100% Grant	$494	1.0
	Loan/Bond	$891	1.9
Central treatment	100% Grant	$1,582	3.5
	Loan/Bond	$2,100	4.7
Point-of-use	100% Grant	$1,641	3.7
	Loan/Bond	$1,726	3.7
Public dispenser	100% Grant	$830	1.8
	Loan/Bond	$846	1.8

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ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
µg	Microgram
AA	Activated Alumina
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
FMT	Financial, managerial, and technical
ft/mi	Feet per mile
GAM	Groundwater Availability Model
gpm	Gallons per minute
HGCSD	Houston-Galveston Subsidence District
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
NMEFC	New Mexico Environmental Financial Center
NURE	National Uranium Resource Evaluation
O&M	Operation and Maintenance
Orbit	Orbit Systems, Inc.
Parsons	Parsons Infrastructure and Technology, Inc.
POE	Point-of-entry
POU	Point-of-use
PSOC	Potential source of contamination
PVC	Polyvinyl chloride
PWS	Public water system
RO	Reverse osmosis
SCBA	Self-contained breathing apparatus
SDWA	Safe Drinking Water Act
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
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
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), were 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 Meadows 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 Mark V Estates Water System, PWS ID# 0200432, Certificate of Convenience and Necessity (CCN) # 11982, located in Brazoria County. The Mark V Estates Water System recorded arsenic concentrations of 22 micrograms per liter (µg/L) in May 2001 and 24.4 µg/L in June 2004, which is below the arsenic MCL of 50 µg/L in effect at the time of sample collection and not a violation. However, these values were above the 10 µg/L MCL for arsenic that goes into effect on January 23, 2006 (USEPA 2005a; TCEQ 2004a). Therefore, it was likely that the Mark V Estates PWS would face potential compliance issues under the new standard. The location of the Mark V Estates 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 for PWSs that supply drinking water exceeding regulatory MCLs. This project only addresses those contaminants and does not address any other violations that may exist for a PWS. As mentioned above, Mark V Estates PWS had recent sample results that exceeded 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 (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 2005c).

1.2 METHODOLOGY

The methodology for this project follows that of the pilot study performed in 2004 and 2005 by TCEQ, BEG, and Parsons. The pilot study evaluated water supply alternatives for PWSs that supply drinking water with arsenic 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.

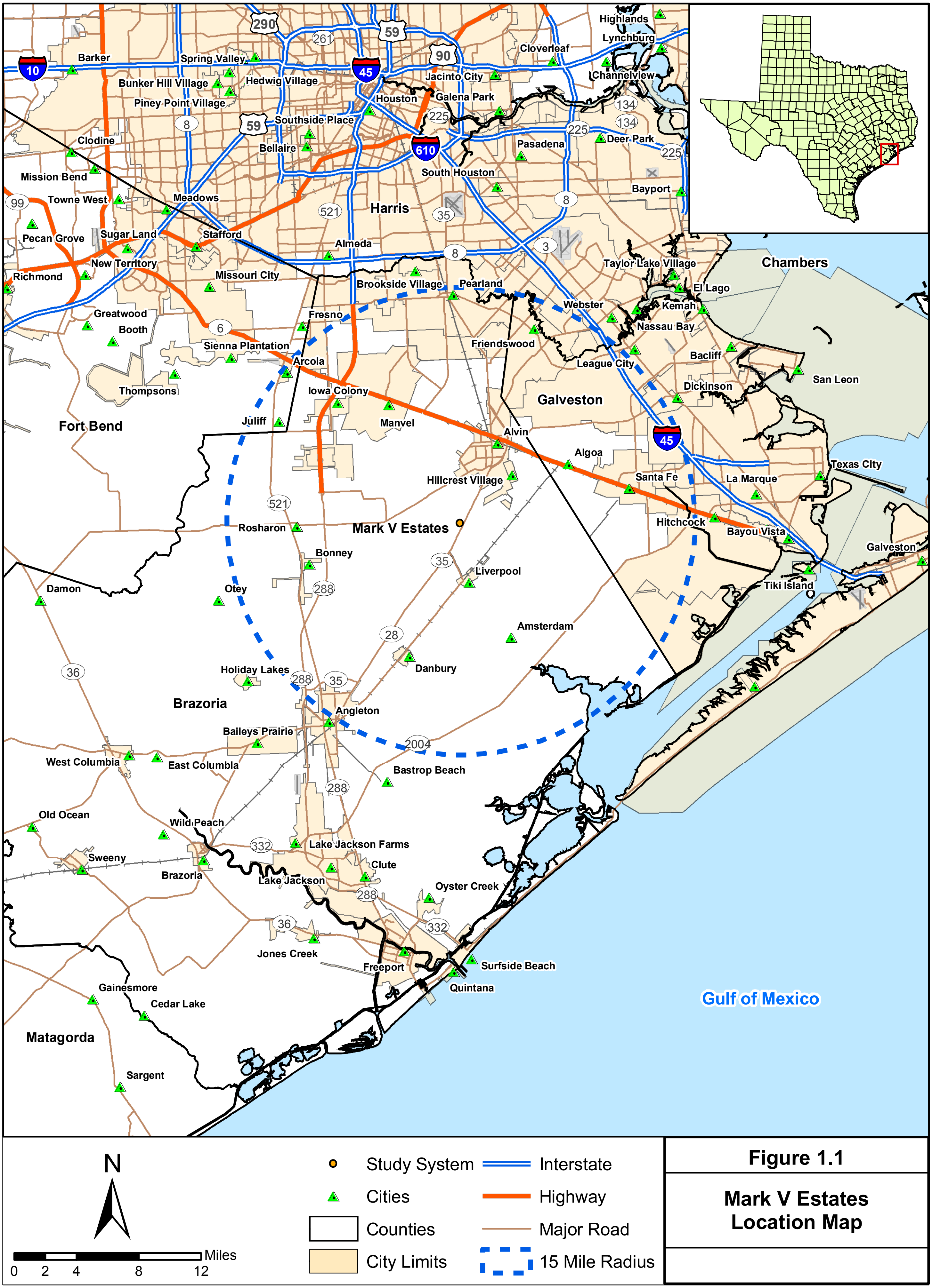


Figure 1.1

Mark V Estates Location Map

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 Mark V Estates Water System, along with compliance alternatives development and evaluation, can be found in Section 4. Section 5 references the sources used in this report.

1.3 REGULATORY PERSPECTIVE

The Utilities & Districts and Public Drinking Water Sections of the TCEQ Water Supply Division are responsible for implementing the Federal Safe Drinking Water Act (SDWA) requirements which 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 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 Mark V Estates PWS will be in violation of state and federal regulations following compliance monitoring after January 23, 2006. A PWS must take action to correct any non-compliance when it no longer meets the regulatory MCL. Corrective action is initially voluntary, but then becomes mandatory after an enforcement order. 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 achieving compliance is for the PWS to make arrangements with a neighboring PWS for water supply. For this arrangement to work, the PWS from which water is being purchased (supplier PWS) must have water in sufficient quantity and quality, the political will must exist, and it must be economically feasible.

1.4.1.1 Quantity

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

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

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

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

1.4.1.2 Quality

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

Surface water sources may offer a potential higher-quality source. Since there are significant treatment requirements, 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 the non-compliant PWS. The current use of these wells may be for irrigation, industrial purposes, domestic supply, stock watering, and other purposes. The process for investigating existing wells is as follows:

- Use existing data sources (see below) to identify wells in the area 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 0.008 milligrams per liter (mg/L) (below the MCL of 0.01 mg/L); and
  - Total dissolved solids (TDS) concentrations less than 1,000 mg/L.
- Review the recorded well information to eliminate those wells that appear to be unsuitable for the application. Often, the "Remarks" column in the Texas Water Development Board (TWDB) hard-copy database provides helpful information. Wells eliminated from consideration generally include domestic and stock wells, dug wells, test holes, observation wells, seeps and springs, destroyed wells, wells used by other communities, *etc*.

- Identify wells of sufficient size which have been used for industrial or irrigation purposes. Often the TWDB database will include well yields, which may indicate the likelihood that a particular well is a satisfactory source.
- At this point in the process, the local groundwater control district (if one exists) should be contacted to obtain information about pumping restrictions. Also, preliminary cost estimates should be made to establish the feasibility of pursuing further well development options.
- If particular wells appear to be acceptable, the owner(s) should be contacted to ascertain their willingness to work with the PWS. Once the owner agrees to participate in the program, questions should be asked about the wells. Many owners have more than one well, and would probably be the best source of information regarding the latest test dates, who tested the water, 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

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

1.4.3 Potential for Surface Water Sources

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

1.4.3.1 Existing Surface Water Sources

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

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

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

1.4.3.2 New Surface Water Sources

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

- Discussions with TCEQ to indicate the likelihood of obtaining those rights. The TCEQ may use the Water Availability Model (WAM) to assist in the determination.

- Discussions with land owners to indicate potential treatment plant locations.
- Preliminary engineering design to determine the feasibility, costs, and environmental issues of a new treatment plant.

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

1.4.4 Identification of Treatment Technologies

Various treatment technologies were also investigated as compliance alternatives for treatment of arsenic to the regulatory level (*i.e.*, MCL). Numerous options were identified by the USEPA as a best available technology (BAT) for 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 0.01 mg/L (USEPA 2001). The regulation applies to all community water systems and non-transient, non-community water systems, regardless of size.

The new arsenic MCL of 0.01 mg/L becomes effective January 23, 2006, at which time the running average annual arsenic level must be at or below 0.01 mg/L at each entry point to the distribution system, although point-of-use (POU) treatment can be instituted in place of centralized treatment. All 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);
- Activated Alumina (Adsorption); and
- Coagulation/Filtration with Iron Removal.

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

- 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 <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 follow.

1.4.5.1 Ion Exchange

<u>Process</u> – In solution, salts separate into positively-charged cations and negatively charged anions. Ion exchange is a reversible chemical process in which ions from an insoluble, permanent, solid resin bed are exchanged for ions in water. The process relies on the fact that certain ions are preferentially adsorbed on the ion exchange resin. Operation begins with a fully charged cation or anion bed, having enough positively or negatively charged ions to carry out the cation or anion exchange. Usually a polymeric resin bed is composed of millions of spherical beads about the size of medium sand grains. As water passes the resin bed, the charged ions are released into the water, being substituted or replaced with the contaminants in the water (ion exchange). When the resin becomes exhausted of positively or negatively charged ions, the bed must be regenerated by passing a strong, sodium chloride, solution over the resin bed, displacing the contaminant ions with sodium ions for cation exchange and chloride ions for anion exchange. Many different types of resins can be used to reduce dissolved contaminant concentrations. The IX treatment train for groundwater typically includes cation or anion resin beds 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 removed solids will be necessary prior to disposal. For arsenic removal, an anion exchange resin in the chloride form is used to remove arsenate [As(V)]. Because arsenite

[As(III)] occurs in water below pH 9 with no ionic charge, As(III) is not consistently removed by the anionic exchange process.

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 will 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 will 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 is 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 will 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 percent removal of As(III). The treatment process is relatively insensitive to pH. Water recovery is typically 60-80 percent, depending on the raw water characteristics. The concentrate volume for disposal can be significant.

Pretreatment – RO requires careful review of raw water characteristics and pretreatment needs to prevent membranes from fouling, scaling, or other membrane degradation. Removal or sequestering of suspended and colloidal solids is necessary to prevent fouling, and removal of sparingly soluble constituents such as calcium, magnesium, silica, sulfate, barium, *etc*., may be required to prevent scaling. Pretreatment can include media filters, 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 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). The G2 media adsorb arsenic most effectively at pH values within the 5.5 to 7.5 range, and less effectively at a higher pH value.

The Bayoxide® E33 media was developed by Bayer AG for removal of arsenic from drinking water supplies. It is a dry granular iron oxide media designed to remove dissolved arsenic via adsorption onto its ferric oxide surface. Severn Trent markets the media in the U.S. for As(III) and As(V) removal as Sorb-33, and offers several arsenic package units 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 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 GFH 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 the GFH media, thus reducing its 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 removal of arsenic from water supplies. However, it often requires pH adjustment to 5.5 to achieve optimum arsenic removal. The AAFS50 product is modified with an iron-based additive to improve its performance and increase the pH range within which it can achieve effective removal. Optimum arsenic removal efficiency is achieved with a pH of the feed water less than 7.7. Competing ions such as fluoride, sulfate, silica, and phosphate can adsorb onto the 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 recommends the system be operated in a series configuration to minimize the chance for arsenic breakthrough to impact drinking water quality.

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

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

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

<u>Waste Disposal</u> – If no pretreatment is required, there is minimal waste disposal involved with the adsorptive media system. Disposal of backwash wastewater is required, especially during startup. Regular backwash is infrequent, and disposal of the

exhausted media occurs once every 1 to 3 years, depending on operating conditions. Exhausted media are usually considered non-hazardous waste.

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

<u>Process</u> – 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 designed to allow for filtration rates up to 10 gpm per square foot (gpm/ft^2), which is a higher loading rate than commonly used for conventional filtration media.

<u>Pretreatment</u> – 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 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 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 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 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 that would largely be out of the control of the PWS, it would be 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 would 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 for regulatory compliance. The water system staff need not perform all installation, maintenance, or management functions, as these tasks may be contracted to a third party, but the final responsibility for 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 O&M of POU or POE devices installed for SDWA compliance may not be delegated to homeowners.
- POU and POE units must have mechanical warning systems to automatically notify customers of operational problems. Each POU or POE treatment device must be equipped with a warning device (*e.g.*, alarm, light) that will alert users when their unit is no longer adequately treating their water. As an alternative, units may be equipped with an automatic shut-off mechanism to meet this requirement.
- If the American National Standards Institute (ANSI) has issued product standards for a specific type of POU or POE treatment unit, only those units that are independently certified according to those 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 a SDWA compliance strategy, certain consumer behavioral changes will be necessary (*e.g.*, encouraging people to drink water only from certain treated taps) to ensure comprehensive consumer health protection.
- Although not explicitly prohibited in the 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 percent protection against inhalation or contact exposure to those contaminants at untreated taps (*e.g.*, shower heads).
- Liability – PWSs considering unconventional treatment options (POU, POE, or bottled water) must address liability issues. These could be

meeting drinking water standards, property entry and ensuing liabilities, and damage arising from improper installation or improper function of the POU and POE devices.

1.4.7 Water Delivery or Central Drinking Water Dispensers

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

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

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

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

The ideal system would:

- Completely identify the susceptible population. If bottled water is only provided to customers who are part of the susceptible population, the utility should have an active means of identifying the susceptible population. Problems with illiteracy, language fluency, fear of legal authority, desire for privacy, and apathy may be reasons that some members of the susceptible population do not become known to the utility, and do not take part in the water delivery program.
- Maintain customer privacy by eliminating the need for utility personnel to enter the home.

- Have buffer capacity (*e.g.*, two bottles in service, so 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 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

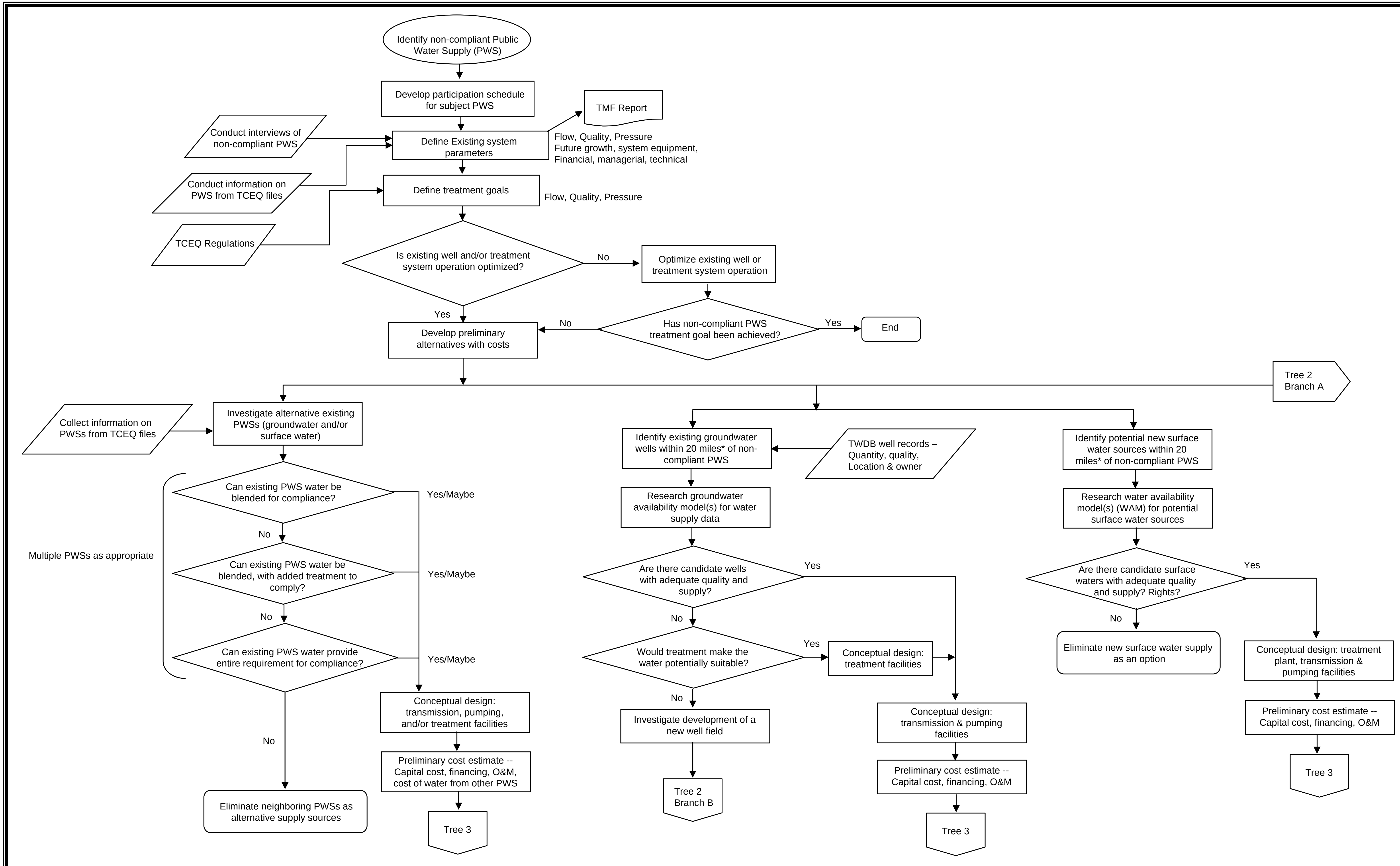
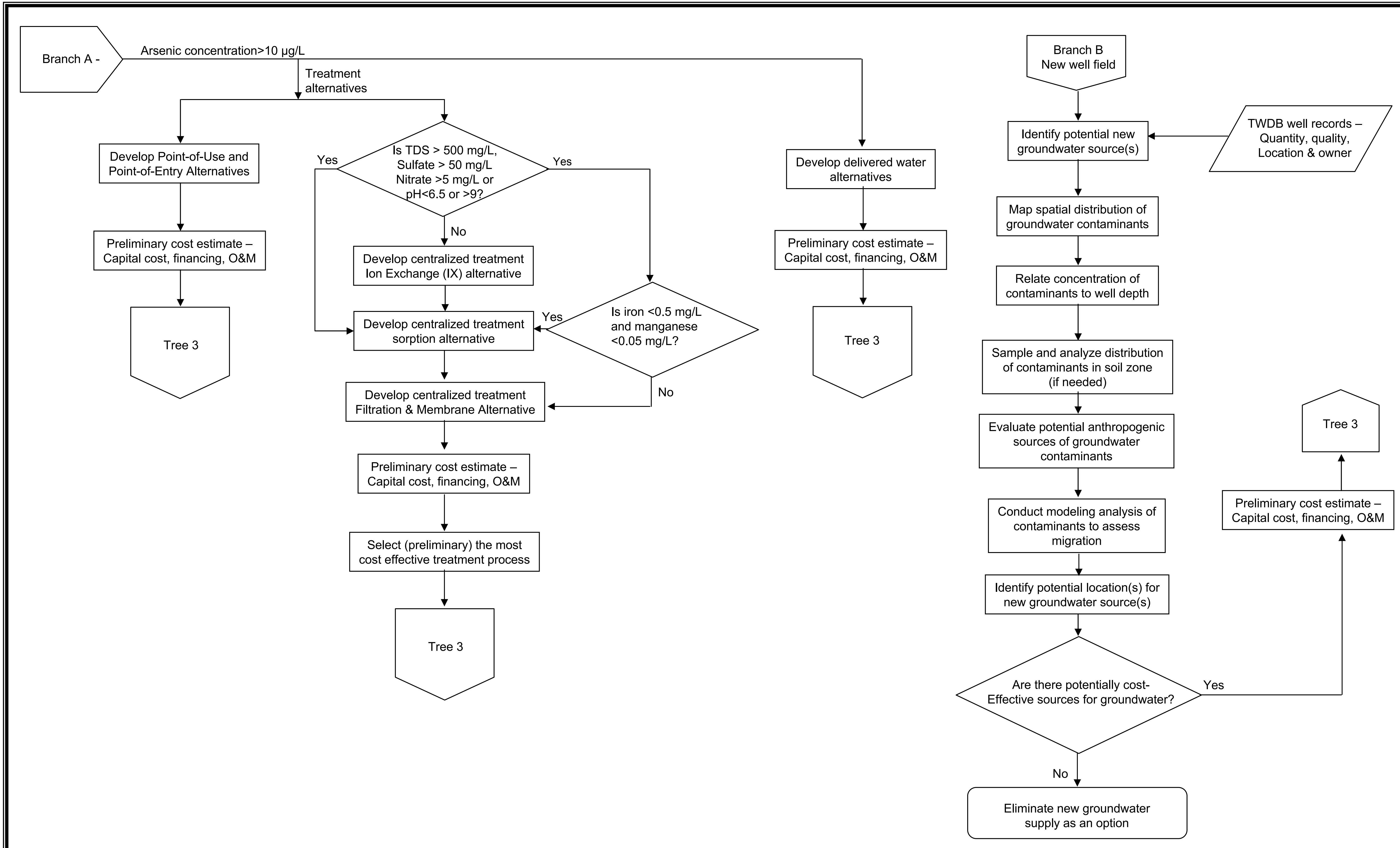


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATAIVES



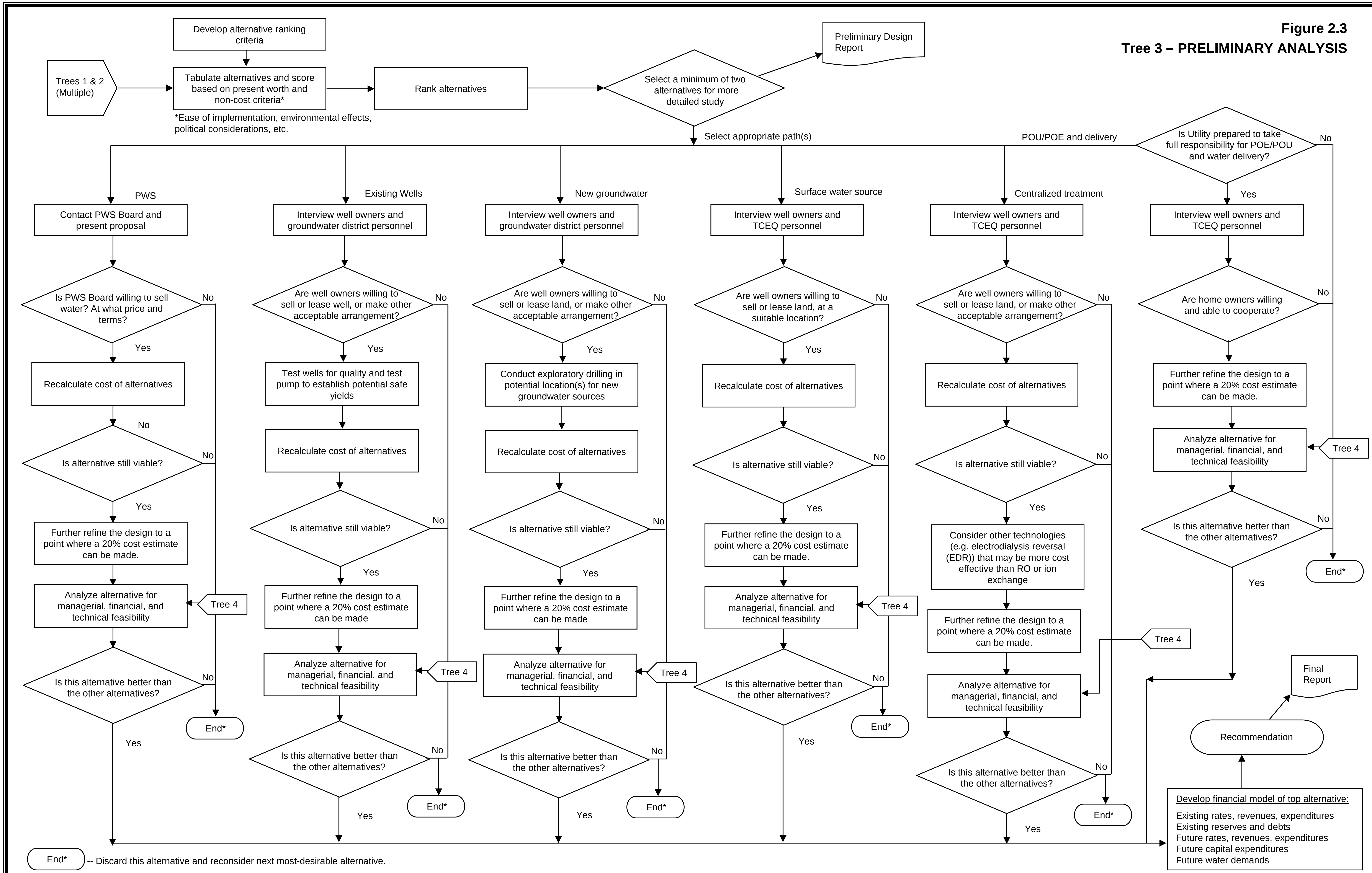
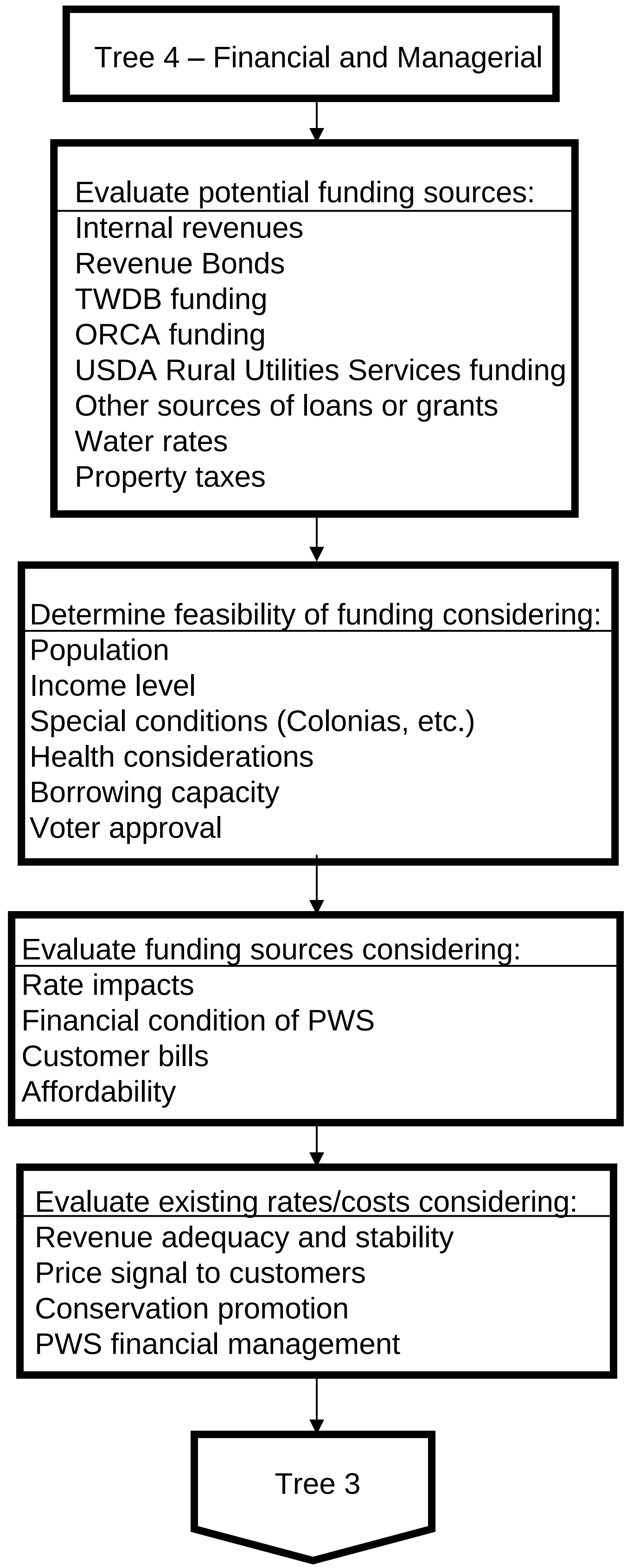


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS

Figure 2.4
TREE 4 – FINANCIAL AND MANAGERIAL



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

These files were reviewed for the PWS and surrounding systems.

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

- Texas Commission on Environmental Quality www.tnrcc.state.tx.us/iwud/pws/index.cfm. Under "Advanced Search", type in the name(s) of the county(ies) in the study area to get a listing of the public water supply systems.
- USEPA Safe Drinking Water Information System (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 flowrate, 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. The difference being that water samples analyzed for dissolved arsenic are filtered to remove suspended solids. Since 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. Mark V Estates falls within the San Jacinto-Brazos Coastal Basin. Almost all the 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 GAM for the northern part of the 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 (U.S. Census Bureau 2000) to establish incomes and eligibility for potential low cost funding for capital improvements. Median household income (MHI) and number of families below poverty level were the primary data points of significance. If available, MHI for the customers of the PWS should be used. In addition, unemployment data were collected from current U.S. Bureau of Labor Statistics. These data were collected for the following levels: national, state, and county.

2.2.2 PWS Interviews

2.2.2.1 PWS Capacity Assessment Process

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

Financial, managerial, and technical capacity are individual yet highly interrelated components of a system's capacity. A system cannot sustain capacity without maintaining adequate capability in all three components.

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

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

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

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

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

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

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

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

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

2.2.2.2 Interview Process

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

2.3 ALTERNATIVE DEVELOPMENT AND ANALYSIS

The initial objective for developing alternatives to address compliance issues 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 are 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.

2.3.1 Existing PWS

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 10 miles from the non-compliant PWS were not considered because the length of the pipeline required would make the alternative cost prohibitive. The quality of water provided was also investigated. For neighboring PWSs with compliant water, options for water purchase and/or expansion of existing well fields were considered. The neighboring PWSs with non-compliant water were considered as possible partners in sharing the cost for obtaining compliant water either through treatment or developing an alternate source.

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

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

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

2.3.2 New Groundwater Source

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

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

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

2.3.3 New Surface Water Source

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

2.3.4 Treatment

Treatment technologies considered potentially applicable 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 ion exchange were not deemed to be 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 medium solid waste stream, and both adsorption and coagulation/filtration treatment 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 provide 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 the 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 district based on specified months of O&M expenditures.

- O&M for alternatives begins 1 year after capital implementation.
- Balance of capital expenditures not funded from primary grant program is funded through debt (bond equivalent).
- Cash balance drives rate increases, unless provision chosen to override where current net cash flow is positive.

2.4.5.3 Interpretation of Financial Plan Results

Results from the financial plan model, as presented in a 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:

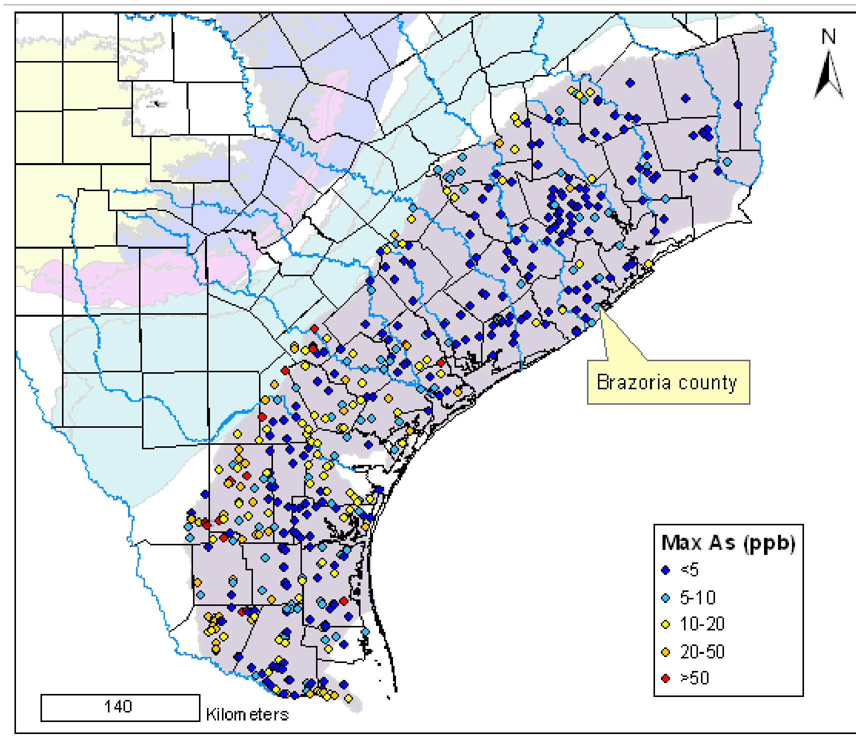
- United States Department of Agriculture, Rural Utilities Service, and
- United States Housing and Urban Development.

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).

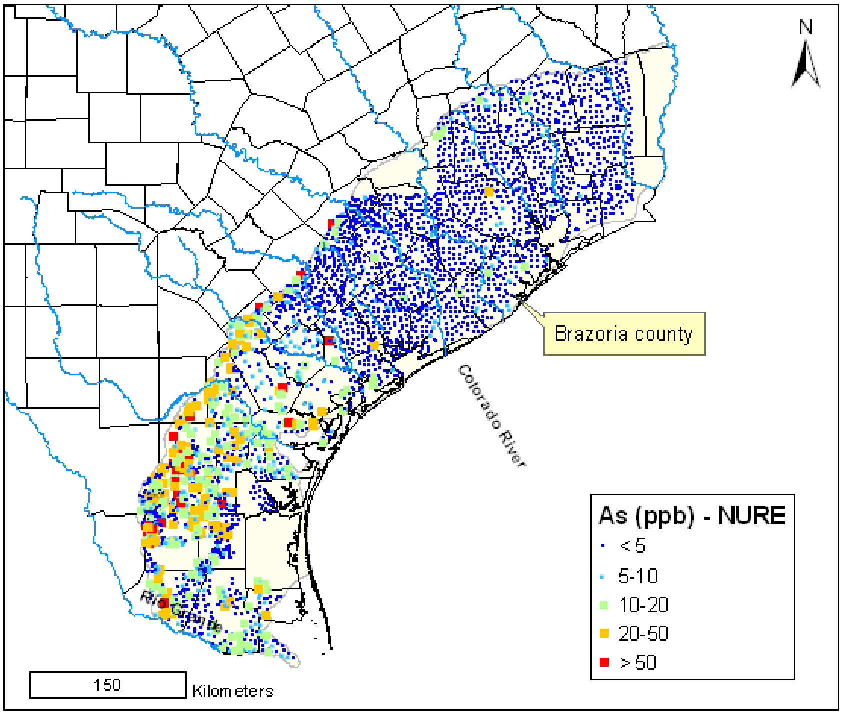
Figure 3.1 Detectable Arsenic Concentrations in Groundwater



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. According to Baker (1979), the maximum thickness of the entire Gulf Coast aquifer along the northern Gulf Coast is approximately 1,300 feet.

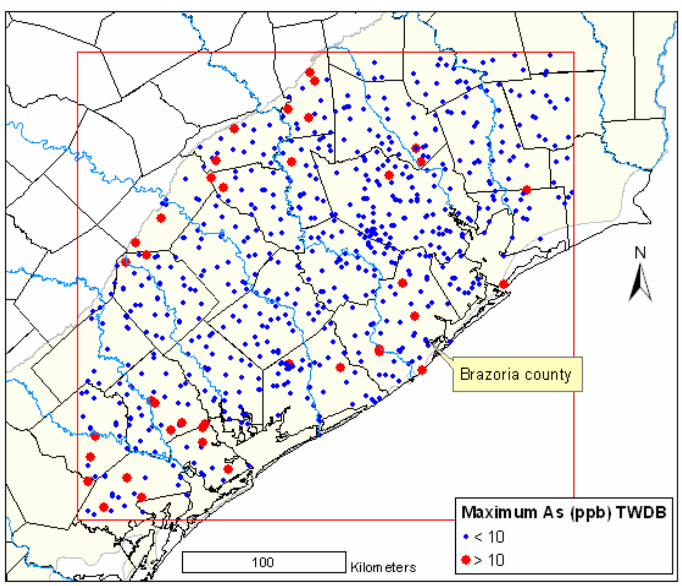
The 11 PWS wells of concern in Brazoria County are identified as being in the Chicot aquifer; completion depths are grouped around 300, 400, and 600 feet. It is possible the deeper wells are completed in the Evangeline aquifer or that screened intervals in these wells span both Chicot and Evangeline 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

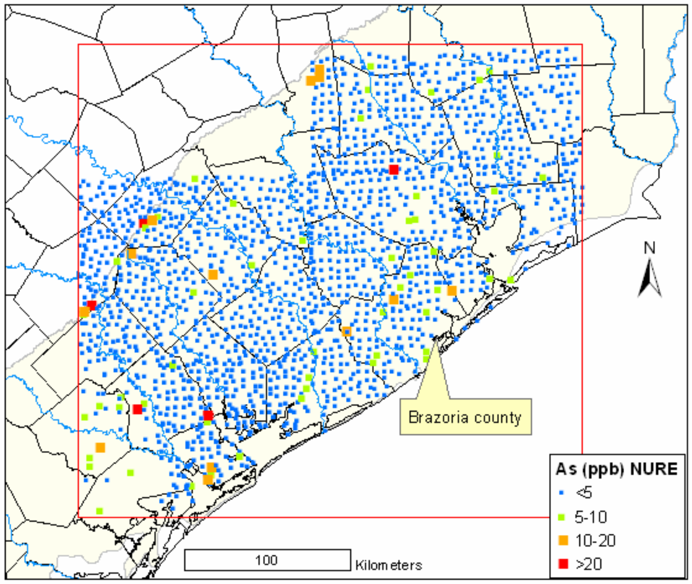
The geochemistry of arsenic is described in Appendix E. A general analysis of arsenic trends in the vicinity of Brazoria County was conducted to assess spatial trends, as well as correlations with other water quality parameters. Arsenic measurements from the TWDB database, the TCEQ database, and from 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 spatial distribution of arsenic concentrations from TWDB (Figure 3.3) and NURE (Figure 3.4) databases.

Figure 3.3 Spatial Distribution of Arsenic Concentrations



Source: TWDB database

Figure 3.4 Spatial Distribution of Arsenic Concentrations

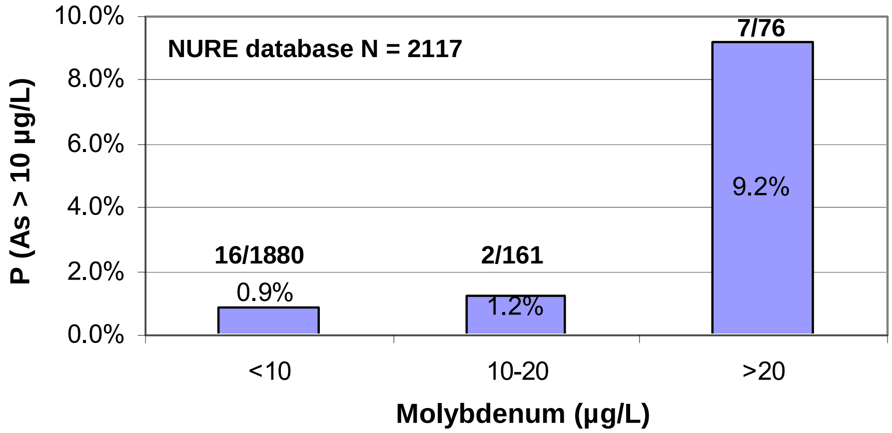


Source: NURE database

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.

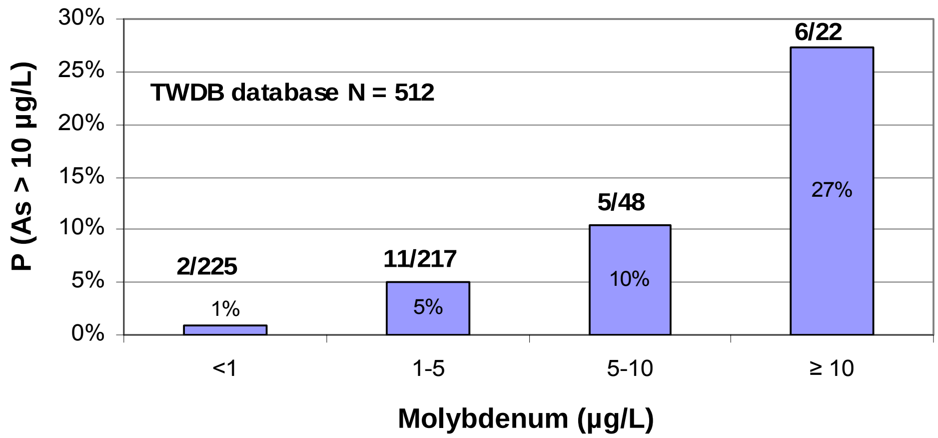
Relationships between arsenic and well depth, pH, SO_4, fluoride, chloride, TDS, dissolved oxygen, phosphorus, iron, selenium, boron, vanadium, uranium, and molybdenum, were evaluated using data separately from the NURE and TWDB databases. Correlations between arsenic concentrations and most parameters 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

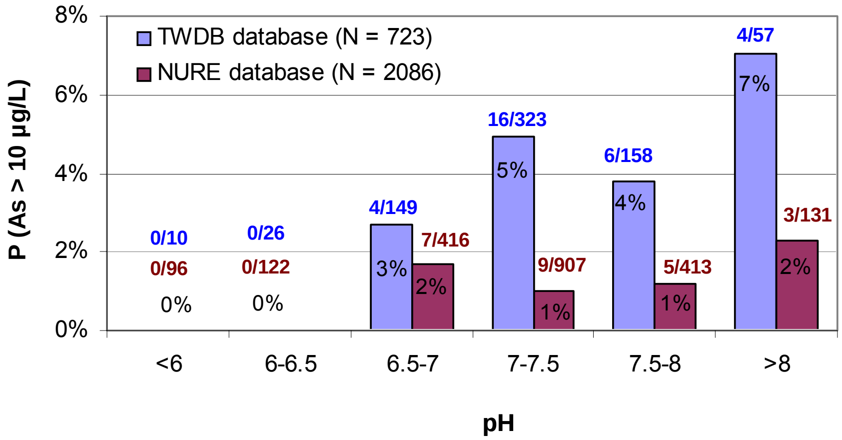


Source: TWDB database

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

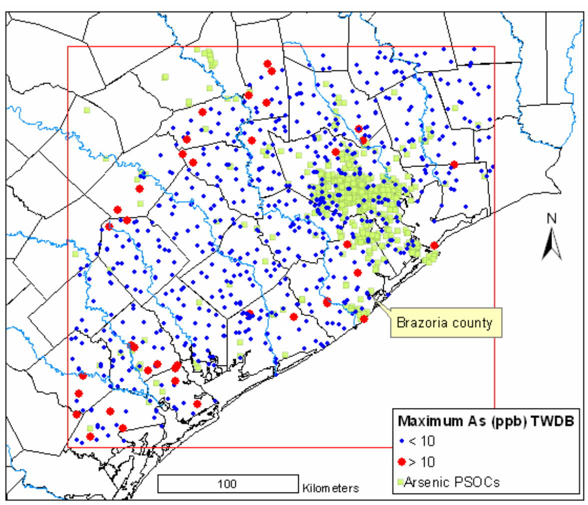


Correlations between arsenic, molybdenum, and pH suggest natural sources of elevated arsenic in Brazoria County; however, data are insufficient to make this conclusion definitively.

3.4 ARSENIC AND POINT SOURCES OF CONTAMINATION

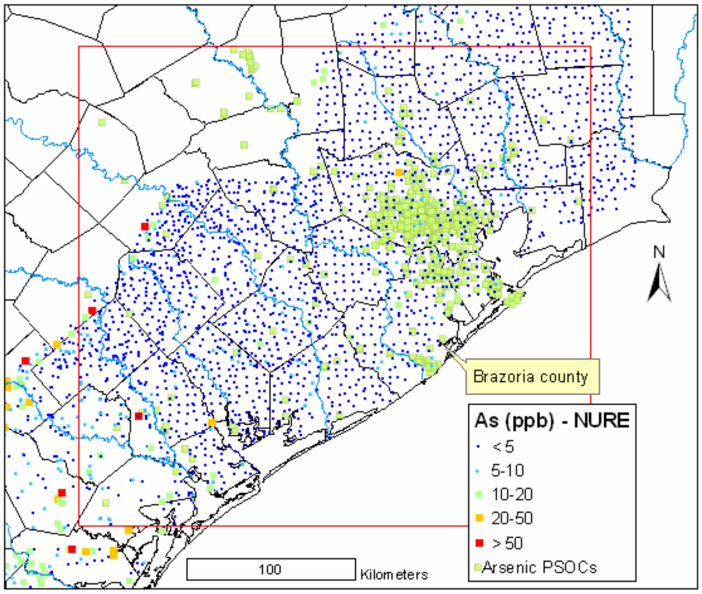
Information regarding the location of potential source of contamination (PSOC) is collected as part of the TCEQ Source Water Assessment Program. Arsenic concentrations from TWDB (Figure 3.8) and NURE (Figure 3.9) databases were compared with PSOC coverage. A density map of PSOCs was generated (number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



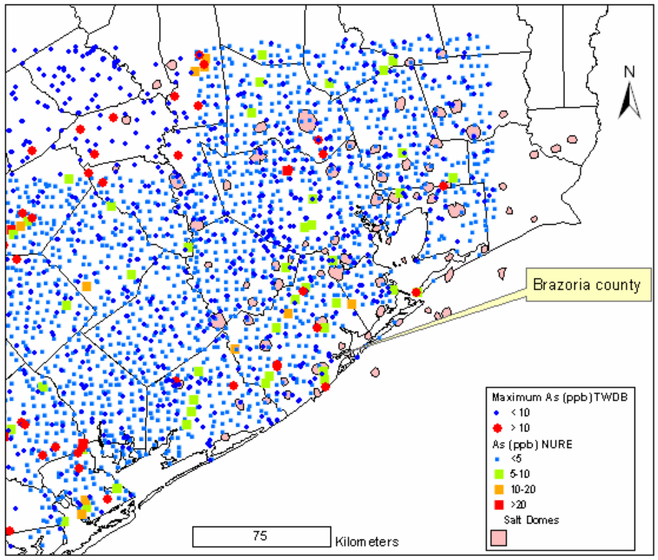
Source: NURE database

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

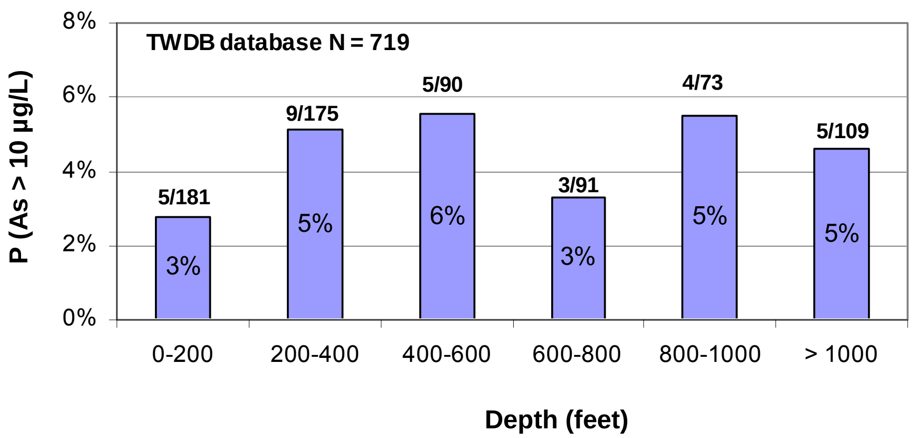


Source: TWDB and NURE databases

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

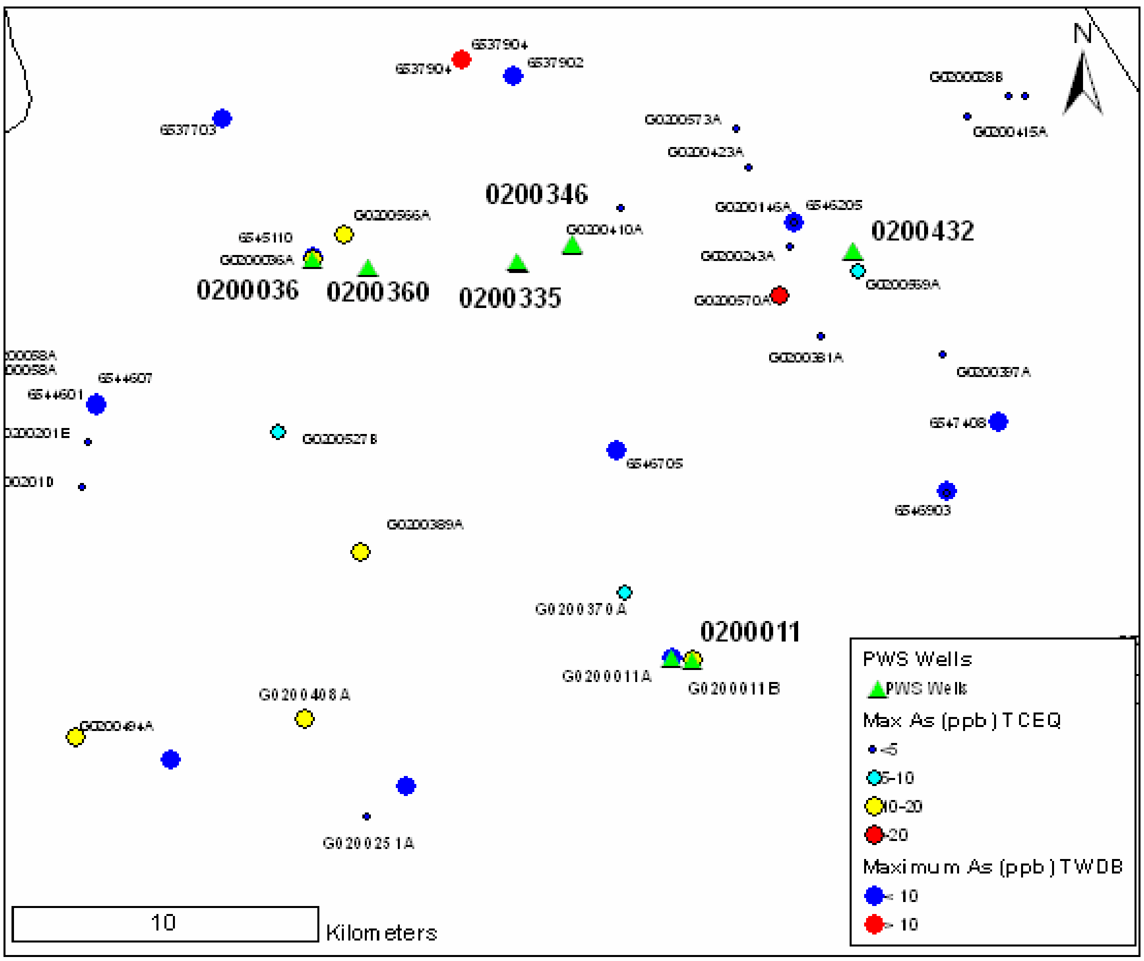


The most recent sample was used for each well. N represents total number of wells in the analysis (719), and numbers above each column represent number of arsenic measurements > 10 µg/L and total number of analyses in the bin. For example, 5/181 represents five samples > 10 µg/L out of 181 analyses at 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 (g/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 Mark V Estates (PWS 0200432)

Three wells are in the Mark V Estates PWS (G0200432A, G0200432B, and G0200346C). The depth of Well A, 400 feet, is screened between 336 and 400 feet. Well B has a depth of 318 feet and is screened between 304 and 318 feet. Well C, 500 feet deep, is screened between 460 and 500 feet. All three wells are related to the same entry point of the water supply, thus making it difficult to separate the source of arsenic. Table 3.2 summarizes arsenic concentrations from the TCEQ database measured at the PWS (there are no samples in the TWDB database).

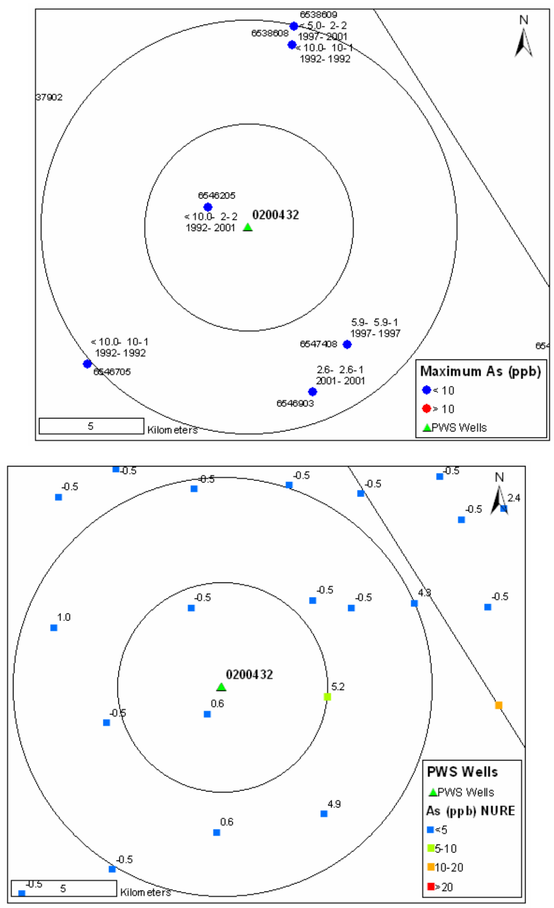
Groundwater arsenic concentrations can have a high degree of spatial variability. Because of this variability, an investigation of the existing wells should be conducted to determine whether all or only some produce non-compliant water. If one or more wells is found to produce compliant water, as much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

Table 3.2 Arsenic Concentrations in Mark V Estates PWS

Date	As (µg/L)	Source
4/28/1999	19.5	TCEQ
5/16/2001	22	TCEQ
6/1/2004	24.4	TCEQ
2/17/2005	21.8	TCEQ

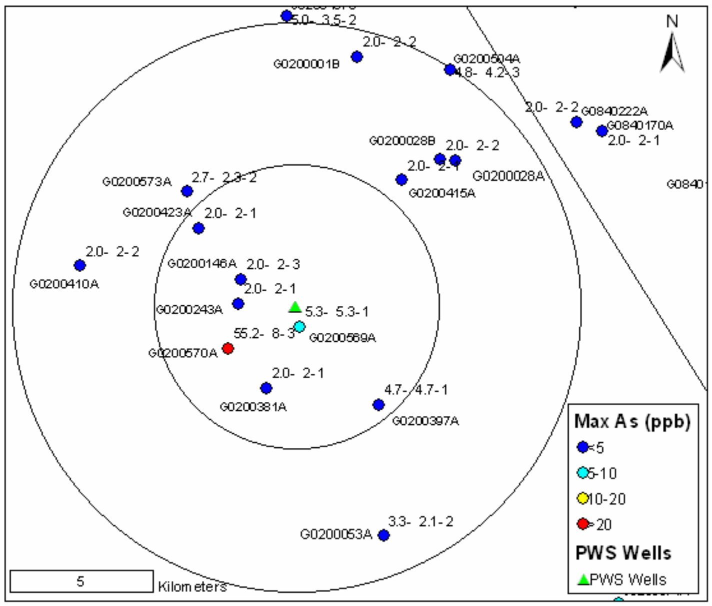
Four water quality measurements from the TCEQ database were collected at the PWS between 1999 and 2005. All samples had elevated arsenic (>10 µg/L). Figure 3.13 shows arsenic concentrations from TWDB and NURE databases measured at wells in 5- and 10-km buffers of PWS wells.

Figure 3.13 Arsenic Concentrations in 5- and 10-km Buffers of Mark V Estates 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). No wells have elevated arsenic samples (10 µg/L) within 5- and 10-km buffers, and only one well from the NURE database had concentrations greater than 5 μg/L. In addition to TWDB and NURE databases, samples from the TCEQ PWS database were analyzed (Figure 3.14).

Figure 3.14 Arsenic Concentrations in 5- and 10-km Buffers of Mark V Estates PWS Wells (TCEQ Database)



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

Table 3.3 Maximum and Minimum Arsenic Concentrations in the 5- and 10-km Buffers of Mark V Estates PWS

Water source	Max.-Min.-No. of As samples (µg/L)	Well depth (feet)	Screen depth (feet)	Geology
G0200432A	21.8 -19.5 - 4	400	336-400	NA
G0200432B		318	304-318	NA
G0200432C		500	460-500	Description of geology to depth of 367 feet
G0200410A	2.0 -2 - 2	210	NA	NA
G0200573A	2.7-2.3-2	510	NA	NA
G0200423A	2.0-2-1	166	NA	NA
G0200146A	2.0-2-3	147	NA	NA
G0200243A	2.0-2-1	400	NA	NA
G0200570A	55.2-8-3	740	710-740	NA
G0200569A	5.3 – 5.3 - 1	550	NA	NA
G0200381A	2.0-2 -1	132	NA	NA
G0200001B	2.0-2-2	690	546-666	Yes. Sand in the screen depth
G0200028B	2.0-2-2	728	NA	NA
G0200028A	2.0-2-2	730	NA	NA
G0200415A	2.0-2-1	160	NA	NA
G0200397A	4.7-4.7-1	750	NA	NA
G0200053A	3.3-2.1-2	221	101-111	NA

In addition to assessed PWS wells (G0200432A, G0200432B, and G0200432C), one well (G0200570A) has concentrations greater than 10 µg/L, and one well (G0200569A) has concentrations above 5 µg/L within 5- and 10-km buffers. Wells with high concentrations have depths between 318 and 740 feet, and known screens have depths of 304 to 740 feet.

SECTION 4
ANALYSIS OF THE MARK V ESTATES PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1 Existing System

The location of the Mark V Estates PWS is shown on Figure 4.1. The PWS has three wells (Wells 1, 2, and 3). Well #1 has been plugged and abandoned. The two remaining wells (Grid #65-46-3, Sources G0200432B and G0200432C) are completed in the Lower Chicot aquifer (Code 112CHCT), approximately 318 to 500 feet deep, respectively. These wells are located at 16802 Keith Circle. Well #3 (80 gpm) is the primary well. Well #2 (20 gpm) may be used during peak use or as a backup. The wells feed into a storage tank adjacent to Well #3. Water from the wells is injected with polyphosphate then chlorine before flowing into the 20,000-gallon ground storage tank. Two booster pumps (200 gpm each) pump the water from the ground storage tank to the 5,000-gallon pressure tanks that feed the distribution system.

Arsenic concentrations detected at the POE were 22 µg/L and 24.4 µg/L on May 16, 2001 and June 16, 2004, respectively. The concentration of TDS on June 3, 2004 was 543 mg/L. Sulfate averaged 1 mg/L for water samples taken in 1999 and 2004. The treatment employed is not appropriate or effective for removal of arsenic so optimization of the treatment system is not expected to be effective for increasing arsenic removal.

There is, however, a potential opportunity for system optimization to reduce arsenic concentration. The system has more than one well and, since arsenic concentrations can vary significantly between wells, arsenic concentrations should be determined for each well. If one or more wells are found to produce water with acceptable arsenic levels, as much production as possible should be shifted to that well. It may also be possible to identify arsenic-producing strata through comparison of well logs or through sampling of water produced by various strata intercepted by the well screen.

Basic system information is as follows:

- Population served: 285
- Connections: 94
- Average daily flow rate: 0.020 mgd
- Peak demand flow rate: 54.6 gpm
- Water system peak capacity: 0.144 mgd
- Typical arsenic range: 22 – 24.4 µg/L
- Typical manganese range: 33.4 µg/L to 37 µg/L

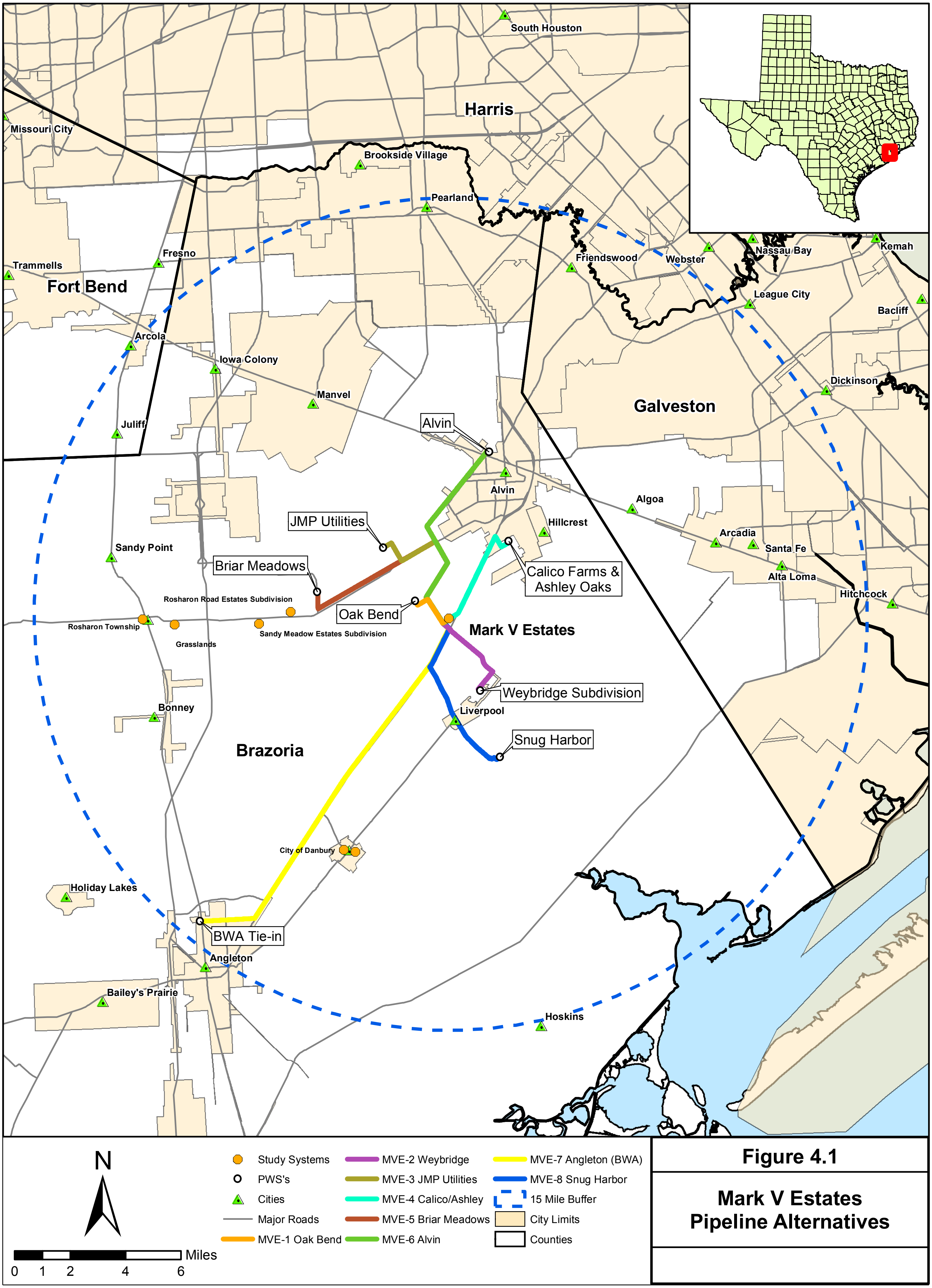


Figure 4.1

Mark V Estates Pipeline Alternatives

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4.1.2 Capacity Assessment for Orbit Systems, Inc.

The following personnel associated with 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 financial, management and technical (FMT) issues for the system. These individuals also establish policies and supervise the three water operators. There is also an office worker who handles administrative duties.

Orbit manages 33 regional water systems. 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 are metered groundwater systems.

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

4.1.2.2 General Assessment of Capacity

Overall, the system had an adequate level of capacity. The system had some areas that needed improvement to be able to address 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 what those positive characteristics are so they can be continued or strengthened. These positive aspects assist the system in addressing capacity deficiencies or concerns. For example, this particular system has been able to manage 33 small regional water systems so that greater efficiencies are achieved through economy of scale. The factors that are particularly important for Orbit are listed below.

- Staff Longevity – The system is owned and the main managerial positions are staffed by one family. As such, the system has had the same President, Engineer, and Operator/Operations Supervisor for over 20 years. This longevity in staff creates a long-term memory of system components and system characteristics. The staff is very dedicated, and other than general operators, 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 systems engineering needs. Also, the system installs many of its own lines (less than 6 inches in diameter). Part of the reason for doing so is to ensure that the lines are installed properly. In the past, the system had problems with poorly constructed lines installed by private developers.

- Planning for System Growth – The systems are installed with consideration given to potential future connections. All connections for future use are initially installed and the lines sized accordingly to ensure that build-out of the developments can be accommodated easily.

- Regional Nature of the System – There is a single rate structure to cover all the systems operated by Orbit. This combined rate allows the overall system to create an economy of scale and an efficiency that helps all the systems. As new rules that will require more complex treatment are introduced, the ability to take advantage of this regional approach 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 purchased by Orbit did not have good mapping of system components, and it 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 are established. None of the staff, other than the President, are members of any water-related organization. Attendance at organization meetings could help keep staff members current on operational procedures and regulatory changes.

- Safety – The systems rely on gas chlorination which 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 chlorine gas, 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 absence of a back-up 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 will help in further improving FMT 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. 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 – Orbit should have a fund to cover emergencies. Currently, emergencies or other conditions that cause a short fall in funding are covered by private investment by the President. This practice has been able to sustain the system in the past, but it may not be a sustainable practice in the future. 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

Table 4.1 is a list of the existing groundwater-supplied PWS systems within approximately 20 miles of the Mark V Estates. From this list of water systems, several were selected for further evaluation based on factors such as water quality, distance from the Mark V 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

Dist (miles)	PWS Name	Capacity Screen	Issues / Comments
0.45	Red Oak 102 Chevron	<1	WQ issues: Mn
1.28	Monsanto Park Chocolate Bayou	<1	WQ issues: Fe, Mn
1.36	Oak Bend Estates	<1	WQ issues: Mn
1.58	Oak Manor Municipal Utility Dist	<1	WQ issues: As, Mn
1.76	Bayou Shadows Water System	<1	WQ issues: As, Mn
1.89	Alvin Food Mart 2	<1	WQ issues: Mn (marginal)
2.74	Sams Country Store	<1	WQ issues: Mn
2.82	Wee Mart	<1	WQ issues: Mn (marginal)
2.86	Weybridge Subdivision Water System	<1	WQ issues: Mn,TDS
3.46	JMP Utilities, Inc.	<1	WQ issues: Mn
3.51	Calico Farms Subdivision	<1	WQ issues: Mn
3.59	Liverpool City Of	<1	WQ issues: As, Mn
3.61	Ashley Oaks Mobile Home Community	<1	WQ issues: Mn
4.61	City Of Hillcrest Village	<1	WQ issues: Mn, Fe (marginal)
4.82	Briar Meadows	<1	WQ issues: Fe (marginal)
5.35	City Of Liverpool	<1	WQ issues: Mn, Fe (marginal)
5.43	Country Acres Estates	<1	WQ issues: Mn
5.70	Rosharon Road Estates Subdivision	<1	WQ issues: As, Mn
5.81	City Of Alvin	6.41	>1 mgd system with marginal manganese exceedances. Evaluate further
6.14	Malt N Burger	<1	WQ issues: Mn
6.15	Willow Wood Duplex	<1	WQ issues: Mn
6.17	Custom Food Group	<1	WQ issues: Mn (marginal)
6.25	Hot Market	<1	WQ issues: Fe, Mn
6.68	Country Meadows	<1	WQ issues: Mn
6.84	Sandy Meadow Estates Subdivision	<1	WQ issues: As, Mn
6.90	Columbus Club Association Of Alvin	<1	WQ issues: Mn
7.21	Alvin Country Club	<1	WQ issues: Fe, Mn
7.29	Best Sea Pack Inc	<1	Small capacity system without identified water quality issues

Dist (miles)	PWS Name	Capacity Screen	Issues / Comments
7.51	Coastal Mini Mart 335	<1	WQ issues: Mn
7.73	Rozis Mini Mart 3	<1	WQ issues: Mn
8.18	Lee Ridge Subdivision	<1	WQ issues: Mn
8.23	Pleasantdale Subd	<1	WQ issues: Mn
8.37	Country Creek Estates Water System	<1	WQ issues: Mn
8.42	Heights Country Subdivision	<1	WQ issues: Mn
8.45	Pleasant Meadows Subdivision	<1	WQ issues: Mn
8.46	Wolf Glen Water System	<1	WQ issues: As, Fe, Mn, TDS
8.48	Meadowland Subdivision	<1	WQ issues: Mn
8.58	Moreland Subdivision Block 3&4	<1	WQ issues: Mn
8.60	Brandi Estates	<1	WQ issues: Mn
8.67	Moreland Subdivision Block 1&2	<1	WQ issues: Fe
8.75	City Of Manvel	<1	WQ issues: Mn
8.85	Pine Colony Mobile Home Park	<1	WQ issues: Mn
8.92	Spin In Market 11	<1	WQ issues: Mn
8.93	Pt Food Mart	<1	WQ issues: Fe, Mn, TDS
8.99	Mooreland Subdivision Water System	<1	WQ issues: Mn
9.00	Brazoria Co Parks - Resoft Pk	<1	WQ issues: Mn (marginal)
9.04	Camp Wind A Mere	<1	WQ issues: Mn
9.12	City Of Danbury	<1	WQ issues: Fe, Mn, nitrate, TDS
9.33	Coastal Mini Mart 338	<1	Small system without identified water quality issues
9.58	Salt Grass Kountry 1	<1	WQ issues: As, TDS
9.68	Arcadia Baptist Church	<1	WQ issues: Mn
9.70	Chocolate Bayou Marina	<1	WQ issues: TDS (marginal)
9.77	Runge Park	<1	WQ issues: Mn
9.83	Equistar Chemicals LP Chocolate Ba	<1	WQ issues: Fe, Mn, TDS
9.88	Grasslands	<1	WQ issues: As
9.91	Easy Stop	<1	Small system without identified water quality issues
9.93	W Galvest Cnty Interfaith Ministry	<1	Small system without identified water quality issues
9.94	Santa Fe Community Center	<1	WQ issues: Fe, Mn
9.97	Amigo Mart	<1	WQ issues: Fe, Mn
10.01	Hastings Homeowners Water System	<1	Small system without identified water quality issues
10.12	Schlumberger Reservoir Comp	1.21	WQ issues: As, Fe, Mn, nitrate, TDS
10.20	Wolfe Air Park	<1	WQ issues: Mn (marginal)
10.22	Brazoria Cnty Detention Center 2	1.008	WQ issues: As, Fe
10.27	Almeda Water Well Service	<1	WQ issues: Fe, Mn
10.33	Ryan Long Subd 2 Water System	<1	WQ issues: Mn
10.37	K & B Waterworks	<1	WQ issues: Mn
10.42	Oak Meadows Estates Subdivision	<1	WQ issues: As, Mn
10.42	Alvin Pantry 261 Citgo	<1	Small system without identified water quality issues

Dist (miles)	PWS Name	Capacity Screen	Issues / Comments
10.54	Davenport Mammoet Llc	<1	WQ issues: Mn (marginal)
10.63	Village Trace Water System	<1	WQ issues: Mn (marginal)
10.71	Meadowview Subdivision	<1	WQ issues: Mn
10.72	Palmetto Subdivision	<1	WQ issues: Mn
10.76	Cedar Grove Park	<1	WQ issues: Mn (marginal)
11.03	Rosharon Township	<1	WQ issues: As, Mn
11.39	Krayola Kastle	<1	WQ issues: Fe, Mn
11.47	Kickin Up At Eddies	<1	WQ issues: Fe, Mn
11.58	Cricketts	<1	WQ issues: Mn, TDS
11.73	Genes Country Store	<1	WQ issues: Fe, Mn, TDS
11.78	Coastal Mini Mart 337	<1	Small system without identified water quality issues
11.79	Handi Plus 42	<1	WQ issues: Mn
11.82	Diamond Mini Mart 316	<1	WQ issues: As, Mn
11.85	End Of The Trail	<1	WQ issues: Mn
11.86	Oil Field Fabricating And Machine	<1	WQ issues: Fe, Mn
11.90	Friendswood Industrial Park	<1	WQ issues: Mn
11.97	Galveston County WCID 8	<1	Small system with marginal water quality issues
12.02	Frontier Water Co	<1	WQ issues: Fe, Mn
12.03	The Bend At Brazoria Golf Course	<1	WQ issues: Mn
12.03	A & A Stop And Shop	<1	WQ issues: Mn
12.10	Shooters	<1	WQ issues: fe, TDS
12.11	Foe 3789	<1	Small system with marginal water quality issues
12.12	Grab All	<1	WQ issues: As, Fe, Mn, TDS
12.13	La Casita Restaurant	<1	WQ issues: Mn (marginal)
12.16	Sandy Ridge Subdivision	<1	WQ issues: Mn
12.26	Flora 7	<1	WQ issues: Mn
12.26	Wellborn Acres	<1	WQ issues: Fe, Mn
12.27	Flora 6	<1	WQ issues: Fe, Mn
12.33	Susies Corner	<1	WQ issues: Fe, Mn
12.36	Friendswood City Of	8.244	WQ issues: Fe, Mn
12.40	Windsong Mobile Home Park	<1	WQ issues: Fe, Mn
12.47	Chaplines Mobile Home Development	<1	WQ issues: Fe, Mn, TDS
12.47	Oak Hollow Mobile Home Park	<1	WQ issues: Fe, Mn
12.56	A Place To Grow Day Care Center	<1	WQ issues: Mn
12.59	Westwood Subdivision	<1	WQ issues: Mn
12.59	Super Food Country Store	<1	WQ issues: Fe, Mn, TDS
12.59	Bateman Water Works	<1	WQ issues: Mn
12.62	Windsong Subdivision	<1	WQ issues: Mn
12.66	Meadowlark Subdivision	<1	WQ issues: Mn
12.72	Rush N Grocery	<1	Small system without identified water quality issues
12.80	Centennial Place	<1	WQ issues: Mn (marginal)

Dist (miles)	PWS Name	Capacity Screen	Issues / Comments
12.83	John's Countryette	<1	Small system without identified water quality issues
12.84	Colony Cove Subd Water System	<1	WQ issues: Mn
12.85	VFW Post 5400	<1	WQ issues: Fe, Mn
12.85	Maryland Day Care Center	<1	WQ issues: Mn, TDS (marginal)
12.92	Behavior Training Research Inc	<1	Small system without identified water quality issues
12.93	Sharondale Subdivision	<1	WQ issues: Mn
12.98	Almost Heaven Campground	<1	WQ issues: Fe, Mn
13.14	H_2O Tech Inc	<1	WQ issues: Mn
13.18	Southwood Estates Inc	<1	WQ issues: Fe, Mn
13.18	TDCJ Id Darrington Unit	1.886	>1 mgd system without identified water quality issues.
13.22	West Lea Water System	<1	WQ issues: Mn
13.30	Wagon Wheel Utility Co	<1	WQ issues: Mn
13.44	Beechwood Subdivision	<1	WQ issues: Fe, Mn
13.52	Country Oaks Arbor MHP	<1	WQ issues: Fe, Mn
13.55	Coronado Country	<1	WQ issues: Mn
13.56	Quail Meadows Subdivision	<1	WQ issues: Mn
13.63	Buffalo Springfield Ice Hse & Res	<1	WQ issues: Mn, TDS
13.63	Chaparrel Recreational Assn Inc	<1	Small system without identified water quality issues
13.74	Clear Creek Shores I	<1	WQ issues: Mn (marginal)
13.77	Blue Sage Gardens Subdivision	<1	WQ issues: Mn
13.89	Marguerites	<1	WQ issues: Fe, Mn, TDS
13.95	Manvel Road Terrace Subdivision	<1	WQ issues: Mn
14.27	Harris Cnty Pct 1 Challenger 7 Mem	<1	WQ issues: Mn (marginal)
14.45	Harris Cnty Mud 55	4.262	>1 mgd system without identified water quality issues.
14.52	Beacon Lakes Golf Club	<1	WQ issues: Fe, Mn, TDS
14.60	Roger Lewis Water System	<1	WQ issues: Fe, Mn
14.61	Pearland City Of	10.152	>1 mgd system with marginal Fe, Mn exceedances.
14.62	Rudys Tavern Inc	<1	WQ issues: Fe, Mn
14.78	Cross Country Stores	<1	WQ issues: As, Mn
14.79	Bill Holley Centre	<1	WQ issues: Fe, Mn
14.83	Back To Basic Christian Day Care	<1	WQ issues: Mn
14.86	Brazoria Cnty Mud 2	5.472	>1 mgd system without identified water quality issues.
14.90	Angle Acres Water System	<1	WQ issues: Fe, Mn
15.01	Anglecrest Subdivision	<1	WQ issues: Mn
15.06	Market Square Food Mart	<1	WQ issues: Mn
15.12	Bedrock Cafe	<1	WQ issues: Fe, Mn
15.27	Galveston County WCID 1	4.233	>1 mgd system with marginal nitrate exceedances.
15.32	Old Place The	<1	WQ issues: Mn

Dist (miles)	PWS Name	Capacity Screen	Issues / Comments
15.34	Anchor Road Mobile Home Park	<1	WQ issues: Fe, Mn
15.42	Hitchcock City Of	1.879	>1 mgd system without identified water quality issues.
15.54	Houston Southwest Airport	<1	WQ issues: Fe, Mn
15.58	Teleview Terrace Subdivision	<1	WQ issues: Fe, Mn
15.67	Racetrac Petroleum 527	<1	WQ issues: Mn
15.83	Arcola Food Market	<1	WQ issues: Fe, Mn
15.84	TDCJ Ramsey Area	1.919	WQ issues: Fe
15.85	Johnsons Water Service	<1	WQ issues: Mn
15.89	Sterling Estates	<1	WQ issues: Fe, Mn
15.96	Fresno Food Market	<1	WQ issues: Mn (marginal)
15.99	League City, City of	3.427	>1 mgd system without identified water quality issues.
16.01	Niagra Public Water Supply	<1	WQ issues: Fe, Mn
16.20	Halliburton Services Fresno	<1	WQ issues: Fe, Mn
16.30	Turner Water Service	<1	WQ issues: Mn
16.51	Wilco	<1	WQ issues: Fe, Mn
16.72	Champion Technologies Inc	<1	WQ issues: Mn (marginal)
16.86	Fresno Mobile Home Park	<1	WQ issues: Mn
16.87	Sienna Plantation Mud 1	1.188	>1 mgd system with marginal Fe, Mn exceedances.
16.97	Fort Bend County Mud 23	3.6	WQ issues: Mn
17.07	The City Of Holiday Lake	<1	WQ issues: Fe, Mn, TDS
17.20	Schmidt Manufacturing	<1	WQ issues: As, Fe, Mn
17.44	Crossroad Market	<1	WQ issues: Fe, Mn
17.80	Marlin Marina Water System	<1	WQ issues: Fe, Mn, TDS
18.00	Riverside Estates	<1	WQ issues: Mn
18.04	Demi John Place Water System	<1	WQ issues: Fe, Mn, TDS
18.08	Demi John I S Water System	<1	WQ issues: Fe, TDS
18.76	Brazoria Cnty Parks Brazos Rvr Pk	<1	WQ issues: As, Mn
19.17	TPWD Brazos Bend State Park 2	<1	WQ issues: Fe, Mn
19.54	Wood Oaks Water Works Inc	<1	WQ issues: Mn
19.55	Exxon Mobil-Thompson Field	<1	Small system without identified water quality issues
19.58	Fort Bend County Mud 60	1.296	>1 mgd system without identified water quality issues.
19.59	Brazoria Cnty Airport North	<1	WQ issues: Mn, TDS
19.64	3 Bridges RV Park	<1	WQ issues: Fe, Mn

Table 4.2 Investigated PWS Systems

Oak Bend Estates
Weybridge Subdivision
J M P Utilities
Calico Farms Subdivision
Briar Meadows
Snug Harbor Subdivision
City of Alvin
Brazosport Water Authority

4.2.1.1 Oak Bend Estates

Oak Bend Estates is located on County Road 864A off of County Road 172, approximately 1.4 miles northwest of Mark V Estates. The PWS is operated by Southwest Utilities, Inc. in El Campo, Texas. Oak Bend Estates has a population of 114 serving 38 connections. The well is 145 feet deep with a rated capacity of 0.050 mgd. The water is hypochlorinated and treated with polyphosphate (for iron and manganese) before distribution. The system has a 21,000-gallon ground storage tank, two 125 gpm service pumps, and one 2,500-gallon pressure tank. The water delivery system has a total peak production of 0.055 mgd. The estimated average and maximum daily demand is 0.015 mgd and 0.060 mgd, respectively. The well has no excess capacity.

There is no excess capacity at Oak Bend Estates to supplement the existing supply of the Mark V Estates; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.2 Weybridge Subdivision

The Weybridge Subdivision is located approximately 2.9 miles from Mark V Estates. The well is located near Bayou Road a short distance northeast of Liverpool, Texas. The PWS is managed by Walker Water Works, Inc. The PWS is supplied by a single groundwater well, completed in the Chicot aquifer (Code 112CHCTU), which is 130 feet deep with a rated capacity of 0.086 mgd. Well water is treated with hypochlorite and polyphosphate before being discharged to a 2,000-gallon pressure tank. The water delivery system has a total peak production of 0.101 mgd. The PWS serves a population of 108 and has 36 metered connections.

The estimated average and maximum daily demand is 0.014 mgd and 0.057 mgd, respectively. The well does not have enough capacity to meet the peak demand flow rate of Mark V Estates. The location may be a suitable point for a new groundwater well.

4.2.1.3 J M P Utilities

J M P Utilities serves a mobile home park located adjacent to County Road 184 approximately 1 mile north of Farm to Market Road 1462. The PWS is approximately

3.5 miles from Mark V Estates, and is operated by J M P Utilities in Manvel, Texas. The PWS serves a population of 57 (19 metered connections) with one well with a total capacity of 0.288 mgd and a 3,000-gallon pressure tank. The water delivery system has a total peak production of 0.086 mgd. The well, completed in the Chicot aquifer (Code 112CHCT), is 510 feet deep.

The estimated average and maximum daily demand is 0.008 mgd and 0.030 mgd, respectively. The PWS's 200 gpm (0.288 mgd) well pump is large enough to also provide water to Mark V Estates.

4.2.1.4 Calico Farms Subdivision

The Calico Farms Subdivision is adjacent and south of Alvin and east of County Road 2403 on County Road 424. The subdivision's population is 69 (23 connections). The PWS is 3.5 miles from Mark V Estates and operates one well with a rated capacity of 0.063 mgd. The PWS is operated by Walker Water Works, Inc. in El Campo, Texas. The well, completed in the Chicot aquifer (Code 112CHCT), is 154 feet deep. Water from the well is pumped to a 2,000-gallon pressure tank. The water delivery system has a total peak production of 0.063 mgd. The location may be a suitable point for a new groundwater well.

The estimated average and maximum daily demand is 0.009 mgd and 0.036 mgd, respectively. The well does not have enough capacity to meet the peak demand flow rate of Mark V Estates.

4.2.1.5 Briar Meadows

Briar Meadows is located on Farm to Market 1462, approximately 4.8 miles to the north of the Mark V Estates. The PWS is owned by Orbit 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 PWS system has a 5,000 gallon pressure tank. 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) before distribution.

The estimated average and maximum daily demand is 0.015 mgd and 0.059 mgd, respectively. The well does not have enough capacity to meet the peak demand flow rate of Mark V Estates. The location may be a suitable point for a new groundwater well.

4.2.1.6 Snug Harbor Subdivision

Snug Harbor Subdivision is a mobile home park located approximately 5.25 miles to the southeast of the Mark V Estates. The PWS is supplied by a single groundwater well, completed in the Upper Chicot aquifer (Code 112CHCTU), which is 245 feet deep with a total production of 0.077 mgd. Well water is treated with hypochlorite and polyphosphate before being discharged to a pressure tank. Snug Harbor serves a population of 84 and has 28 metered connections.

The estimated average and maximum daily demand is 0.011 mgd and 0.044 mgd, respectively. There is not sufficient excess capacity at Snug Harbor to supplement existing supply of the Mark V Estates; however, based on the available water quality data, the location may be a suitable point for a new groundwater well.

4.2.1.7 City of Alvin

The City of Alvin is located approximately 5.8 miles north of the Mark V Estates. 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 four wells are between 688 and 711 feet deep, and have a total production of 8.739 mgd. Well water is treated with polyphosphate and hypochlorite before being discharged to several ground and elevated storage tanks. The City serves a population of 17,916 and has 5,817 metered connections. The reported average daily demand is 1.307 mgd. The peak demand is estimated to be 5.228 mgd.

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

4.2.1.8 Brazosport Water Authority

The Gulf Coast Water Authority plans build a 150 mgd water treatment plant (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 and 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. Mark V Estates may be able to connect to this regional WTP's distribution system within the City of Alvin.

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.

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

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

Some of the alternatives suggest new wells be drilled in areas where existing wells are compliant with the future arsenic MCL of 10 µg/L. In developing the cost estimates, Parsons assumed that the aquifer in these areas would produce the required amount of water with only one well. Site investigations and geological research, which are beyond the scope of this study, could indicate whether the aquifer at a particular site and depth would provide the amount of water needed or if more than one well would need to be drilled in separate areas.

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 occurred in the Houston-Galveston Coastal Subsidence District (HGCSD), around the Houston metropolitan area, whose area of influence encompasses most of Brazoria County, including the Mark V Estates system.

A GAM for the 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 anticipates extensive groundwater use and a 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 2,030 to an estimated 1,520 mgd, a 74 percent increase from 1995 conditions. Modeling of these projections indicates 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 a projected 43 percent 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 Mark V Estates 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

There is low potential for development of new surface water sources for the Mark V Estates system as indicated by limited water availability within the site vicinity. The system is located within the San Jacinto-Brazos Basin where surface water availability is expected to remain at current levels over the next 50 years according to the TWDB's 2002 Water Plan (approximately 47,692 available for use during drought conditions). Approximately 17 miles west of the site, the San Jacinto-Brazos Basin transitions into the Brazos River Basin where water availability is expected to decrease by 17 percent over the next 50 years.

The vicinity of the Mark V Estates system has a minimum availability of surface water for new uses. The TCEQ availability map for the San Jacinto-Brazos Basin and Brazos Basin indicates that unappropriated flows for new uses are typically available less than 50 percent of the time. This supply is inadequate as the TCEQ requires 100 percent supply availability for a municipal water supply.

4.2.4 Options for Detailed Consideration

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

1. Drill a new well near Oak Bend Estates and install a storage tank, pump station, and pipeline (Alternative MVE-1).

2. Drill a new well near Weybridge Subdivision and install a storage tank, pump station, and pipeline (Alternative MVE-2).

3. Purchase water from J M P Utilities and install a storage tank, pump station, and pipeline (Alternative MVE-3).

4. Drill a new well near Calico Farms Subdivision and install a storage tank, pump station, and pipeline (Alternative MVE-4).

5. Drill a new well near Briar Meadows and install a storage tank, pump station, and pipeline (Alternative MVE-5).

6. Purchase water from the City of Alvin and install a storage tank, pump station, and pipeline (Alternative MVE-6).

7. Purchase water from the Brazosport Water Authority and install a storage tank, pump station, and pipeline (Alternative MVE-7).

8. Drill a new well near Snug Harbor and install a storage tank, pump station, and pipeline (Alternative MVE-8).

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 Mark V Estates PWS. Under each of these alternatives, it is assumed that a source of compliant water can be located and then a new well would be completed and a pipeline would be constructed to transfer the compliant water to Mark V Estates. These alternatives are MVE-13, MVE-14, and MVE-15.

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of well water is identified as a potential option for the Mark V Estates. It may be possible to treat groundwater from both wells at the Well #3 site with a combined capacity of 100 gpm (210 gpm and 400 gpm) and water from Well #2 may be used for peak demand or as a backup. Both iron-based adsorption and coagulation/filtration are potentially applicable technologies for removal of arsenic from groundwater. The central iron-based adsorption treatment alternative is Alternative MVE-9, and the central coagulation/filtration alternative is Alternative MVE-10.

4.3.2 Point-of-Use Systems

Point-of-use treatment using iron-based adsorption technology is valid for arsenic removal. The POU adsorption treatment alternative is MVE-11.

4.3.3 Point-of-Entry Systems

Point-of-entry treatment using iron-based adsorption technology is valid for arsenic removal. The POE adsorption treatment alternative is MVE-12.

4.4 BOTTLED WATER

Providing bottled water is considered an interim measure to be used until a compliance alternative is implemented. Even though the community is small and people know each other, it would be reasonable to require 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. The alternatives addressing bottled water are MVE-16, MVE-17, and MVE-18.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

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

4.5.1 Alternative MVE-1: Oak Bend Estates

This alternative consists of drilling a new well in the Oak Bend Estates area that would replace the wells in the Mark V Estates. Records indicate no detectable amount of arsenic in the Oak Bend Estates well water; however, manganese is sometimes above 50 µg/L, which requires sequestering. Blending is a marginal option since the Mark V Estates well water has an arsenic concentration of 22 µg/L and would require more than a 3:1 ratio to achieve a reasonable factor of safety.

This alternative would require drilling a new well and installing a well pump, small ground storage tank, pump station with two transfer pumps, and a pipeline to the Mark V Estates system. One of the two pumps in the pump station is for backup in the event the other pump fails. The pipeline would be approximately 1.9 miles long, and would be a 4-inch polyvinyl chloride (PVC) line that discharges to the existing storage tank in the Mark V Estates.

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

The estimated capital cost for this alternative includes the cost of drilling a new well and installing a small ground storage tank, pump station with two transfer pumps, and a 4-inch PVC pipeline to the Mark V Estates system. The estimated O&M cost for this alternative includes pipeline maintenance and power and O&M labor and materials for the pump station minus the reduction in the cost Mark V Estates could realize from not operating its well field. The estimated capital cost for this alternative is $660,000, and the estimated annual O&M cost for this alternative is $10,200.

The reliability of adequate amounts of compliant water under this alternative should be good. Mark V Estates has a well field where manganese sequestering is performed. From the perspective of Orbit, this alternative is characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations are well understood, and 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 MVE-2: Weybridge Subdivision

This alternative consists of drilling a new well in the Weybridge Subdivision area that would replace the Mark V Estates wells. Records indicate there is 3 to 4 µg/L of arsenic in the Weybridge Subdivision well water. Manganese concentrations range between 60 µg/L and 90 µg/L, which requires sequestering. Blending is a marginal option since well water in the Mark V Estates has an arsenic concentration of 22 µg/L and would require more than an 8:1 ratio to achieve a reasonable factor of safety.

This alternative would require drilling a new well and installing a well pump, small ground storage tank, pump station with two transfer pumps, and a 4-inch PVC pipeline to the Mark V Estates system. One of the two pumps in the pump station is for backup in the event the other pump fails. The pipeline would be approximately 3.8 miles long, and would discharge to the existing storage tank in the Mark V Estates.

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

The estimated capital cost for this alternative includes drilling a new well, a small ground storage tank, pump station with two transfer pumps, and a pipeline to the Mark V Estates system. The estimated O&M cost for this alternative includes pipeline maintenance and power and O&M labor and materials for the pump station minus the reduction in the cost Mark V Estates could realize from not operating its well field. The estimated capital cost for this alternative is $1.1 million, and the estimated annual O&M cost for this alternative is $11,700.

The reliability of adequate amounts of compliant water under this alternative should be good. Mark V Estates has a well field where manganese sequestering is performed. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations are well understood, and 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 MVE-3: J M P Utilities

The alternative consists of connecting directly to the J M P Utilities PWS well. The well capacity is 0.288 mgd. The estimated peak demand is 0.030 mgd (57 people) providing an excess capacity of 0.258 mgd. Its water would need to be sequestered for manganese, which averages 128 µg/L.

This alternative would require installing a small ground storage tank, pump station with two transfer pumps, and a 4-inch PVC pipeline to the Mark V Estates system. One of the two pumps in the pump station is for backup in the event the other pump fails. The pipeline would be approximately 6.3 miles long, and would discharge to the existing storage tank in the Mark V Estates.

This alternative presents a limited regional solution, since other PWSs in the area also need compliant water. Regional facilities serving 250 connections or more require at least two wells.

The estimated capital cost for this alternative includes the cost of installing a ground storage tank, a pump station with two transfer pumps, and a pipeline to the Mark V Estates system. The estimated O&M cost for this alternative includes the purchase price for treated water, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station minus the reduction in cost the Mark V Estates could realize from not operating its well field. The estimated capital cost for this alternative is $1.64 million, and the estimated annual O&M cost for this alternative is $19,200.

The reliability of adequate amounts of compliant water under this alternative should be good. Mark V Estates has a well field where manganese sequestering is performed. From the perspective of Orbit, this alternative is characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations are well understood, and Orbit currently operates pipelines and a pump station.

4.5.4 Alternative MVE-4: Calico Farms Subdivision

This alternative consists of drilling a new well in the Calico Farms Subdivision area to replace the wells in the Mark V Estates. Records indicate manganese concentrations range between 95 µg/L and 117 µg/L, which requires sequestering. Blending is a marginal option since well water in the Mark V Estates has an arsenic concentration of 22 µg/L and would require more than a 3:1 ratio to achieve a reasonable factor of safety.

This alternative would require drilling a new well and installing a well pump, small ground storage tank, pump station with two transfer pumps, and a pipeline to the Mark V Estates system. One of the two pumps in the pump station is for backup in the event the other pump fails. The pipeline would be approximately 4.3 miles long, and would be a 4-inch PVC pipeline that discharges to the existing storage tank in the Mark V Estates.

This alternative presents a limited regional solution, since 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 drilling a new well and installing a well pump, small ground storage tank, pump station with two transfer pumps, and a pipeline to the Mark V Estates system. The estimated O&M cost for this alternative includes maintenance cost for the pipeline, and power and O&M labor and materials for the pump station minus the reduction in cost Mark V Estates could realize from not operating its well field. The estimated capital cost for this alternative is $1.14 million, and the estimated annual O&M cost for this alternative is $12,200.

The reliability of adequate amounts of compliant water under this alternative should be good. Mark V Estates has a well field where manganese sequestering is performed. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations are well understood, and 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 MVE-5: Briar Meadows

Briar Meadows PWS is also owned and operated by Orbit. This alternative consists of drilling a new well in the Briar Meadows area to replace wells in the Mark V Estates. Records indicate the PWS is meeting MCLs for arsenic, iron, and manganese. Blending is a marginal option since the well water in the Mark V Estates has an arsenic concentration of 22 µg/L and would require more than a 3:1 ratio to achieve a reasonable factor of safety.

This alternative would require drilling a new well and installing a well pump, ground storage tank, pump station with two transfer pumps, and a pipeline to the Mark V Estates system. One of the two pumps in the pump station is for backup in the event the other pump fails. The pipeline would be approximately 9.3 miles long, and would be a 4-inch PVC pipeline that discharges to the existing storage tank in Mark V Estates.

This alternative presents a good opportunity for a regional solution, since there are other Orbit PWSs in the area that would need compliant water. Regionalization would allow the sharing of the cost of drilling the well(s) with other non-compliant PWSs in the area. According to 30 TAC Chapter 290, Subchapter D, §290.45(b)(D), a regional PWS system serving 250 connections or more must have two or more wells or an interconnection with another PWS.

The estimated capital cost for this alternative includes drilling a new well and installing a well pump, small ground storage tank, pump station with two transfer pumps, and a pipeline to the Mark V Estates system. The estimated O&M cost for this alternative includes maintenance cost for the pipeline, and power and O&M labor and materials for the pump station minus the reduction in cost Mark V Estates could realize from not operating its well field. The estimated capital cost for this alternative is $2.36 million, and the estimated annual O&M cost for this alternative is $16,200.

The reliability of adequate amounts of compliant water under this alternative should be good. Mark V Estates has a well field with adequate capacity and manganese sequestering is performed. From the perspective of Orbit, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations are well understood, and 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 MVE-6: City of Alvin

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. Its water would not need additional treatment.

This alternative would require installing a small ground storage tank, a pump station with two transfer pumps, and a pipeline to the Mark V Estates system. One of the two pumps in the pump station is for backup in the event the other pump fails. The pipeline would be a maximum 8 miles long, and would be a 4-inch PVC line that discharges to the existing storage tank in Mark-V Estates. There may be a closer connection point that can be tapped into, which would help reduce the length of the transfer pipeline.

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 will replace some groundwater from wells in the Alvin area in the near future.

The estimated capital cost for this alternative includes installing a ground storage tank, pump station with two transfer pumps, and a pipeline to the Mark V Estates system. The estimated O&M cost for this alternative includes the purchase price for treated water plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station minus the cost Mark V Estates currently pays to operate its well field. The estimated capital cost for this alternative is $2.27 million, and the estimated annual O&M cost for this alternative is $20,600.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of Orbit, this alternative is characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations are well understood, and Orbit currently operates pipelines and a pump station.

4.5.7 Alternative MVE-7: Brazosport Water Authority

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 has indicated it would be amenable to negotiating an agreement to supply water to PWSs in the area.

This alternative would require installation of a small tank, pump station and a pipeline from the BWA 18-inch water main located adjacent to State Highway 227 in the City of Angleton to the existing intake point for the Mark V Estates system. A pump station would also be required to overcome pipe friction and elevation differences between Angleton and Mark V Estates. The required pipeline would follow Route 171, be approximately 15 miles long, and constructed of 4-inch PVC pipe. The pipeline would terminate at the existing Mark V Estates storage tank.

The 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 Mark V Estates, since the incremental cost would be relatively small, and would provide operational flexibility.

The estimated capital cost for this alternative includes constructing the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for the treated water plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station minus the cost that Mark V Estates currently pays to operate its well field. The estimated capital cost for this alternative is $3.83 million, and the estimated annual O&M cost is $25,800. If the purchased water was used for blending rather than for the full water supply, the annual O&M cost for this alternative could be reduced because of reduced pumping costs and reduced water purchase costs. However, additional costs would be incurred for equipment to ensure proper blending, and additional monitoring to ensure compliance of the finished water.

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 O&M and repair of pipelines and pump stations are well understood, and Orbit currently operates pipelines and a pump station. If the decision to perform blending is made, then the operational complexity would increase.

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

4.5.8 Alternative MVE-8: Snug Harbor

This alternative involves completion of a new well in the vicinity of Snug Harbor, a mobile home park located 5.25 miles to the southeast of Mark V Estates, and construction of a pump station and pipeline to transfer the pumped groundwater to the Mark V Estates. Based on the water quality data in the TCEQ database, it is expected that groundwater from this well would be compliant with drinking water MCLs. An agreement would need to be negotiated with Snug Harbor to expand its well field.

This alternative would require completion of one new well at Snug Harbor and installation of a small tank, pump station and a pipeline from the new well to the existing intake point at the Mark V Estates. The required pipeline would be constructed of 4-inch PVC pipe and would be approximately 6.6 miles in length. The pipeline would terminate at the existing Mark V Estates storage tanks owned by Orbit.

The pipeline would need to make several crossings on its route, three of which would be open cut and 20 that would require boring. The 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 a capacity to meet all water demand for the Mark V Estates, since the incremental cost would be relatively small, and it would provide operational flexibility.

The estimated capital cost for this alternative includes completing the new well and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes maintenance cost for the pipeline, and power and O&M labor and materials for the pump station minus the cost the Mark V Estates currently pays to operate its well field. The estimated capital cost for this alternative is $1.88 million, and the alternative's estimated annual O&M cost is $13,900.

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

This alternative also presents opportunity for a shared solution, since expansion of the Snug Harbor well field could also be used to supply the City of Danbury, about 6½ miles to the southwest. However, this would require construction of a separate pipeline.

The feasibility of this alternative is dependent on Orbit being able to reach an agreement with Snug Harbor to complete a new groundwater well.

4.5.9 Alternative MVE-9: Central Iron-Based Adsorption Treatment

Orbit would treat groundwater from both Wells #1 and #2 using an iron-based adsorption system prior to distribution. This alternative consists of constructing the adsorption treatment plant at or near the Well #2 site. The plant comprises a 400 ft^2 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 Orbit's

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 as the adsorption technology has been demonstrated effective in full-scale and pilot-scale facilities. The technology is simple and requires minimal O&M effort.

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

4.5.10 Alternative MVE-10: Central Coagulation/Filtration Treatment

Orbit would treat groundwater from both Wells #1 and #2 using a coagulation/filtration system prior to distribution. This alternative consists of constructing the coagulation/filtration plant at or near the Well #2 site. The plant comprises a 400 ft^2 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 medium does 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.

4.5.11 Alternative MVE-11: Point-of-Use Treatment

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

This alternative would require installation of the POU treatment units in houses and other buildings that provide water for drinking or cooking. Orbit would be responsible for purchase and maintenance of 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 of Orbit personnel or contract personnel into the houses of customers. As a result, the cooperation of customers would be important for success in implementation of this alternative. The treatment units could be installed access without house entry, but that would complicate the installation and increase costs.

POU 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 that only a minimum volume of water is treated (only that for human consumption). This minimizes the size of the treatment units, the increase in water required, and the waste for disposal. For this alternative, it is assumed that the increase in water consumption 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 the purchase and replacement of filters and media, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $62,000, and the estimated annual O&M cost for this alternative is $58,800. For the cost estimate, it is assumed that one POU treatment unit would be required for each of the 94 existing connections to the Mark V Estates system. It should be noted that the POU treatment units would need to be more complex than units typically found in commercial retail outlets in order to meet regulatory requirements, making purchase and installation more expensive.

The reliability of adequate amounts of compliant water under this alternative is fair, since it relies on active cooperation of the customers for system installation, use, and maintenance, and only provides compliant water to single tap within a house. Additionally, the O&M efforts required for the POU systems would be significant, and Orbit personnel are inexperienced in this type of work. From Orbit’s perspective 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 PWS entities.

4.5.12 Alternative MVE-12: Point-of-Entry Treatment

This alternative consists of the continued operation of the Mark V Estates well field, plus treatment of water to remove arsenic as it enters the residence. The purchase, installation, and maintenance of the treatment systems at the POE would be necessary for this alternative. Blending is not an option in this case.

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

Point-of-entry arsenic treatment processes typically produce spent adsorption media as waste, as well as possibly backwash water that requires disposal. The backwash water stream results in a slight increase in the overall volume of water used. POE systems treat a greater volume of water than POU systems. For this alternative, it is assumed that the increase in water consumption 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 POE treatment systems. The estimated O&M cost for this alternative includes the purchase and replacement of filters and media, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $1.1 million, and the estimated annual O&M cost for this alternative is $131,600. For the cost estimate, it is assumed that one POE treatment unit would be required for each of the 94 existing connections in the Mark V Estates.

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 customers for system installation, use, and maintenance, and compliant water is supplied to all taps within a house. Additionally, the O&M efforts required for the POE systems 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 PWS entities.

4.5.13 Alternative MVE-13: New Well at 10 Miles

This alternative consists of installing one new well within 10 miles of the Mark V Estates which would produce compliant water in place of the water produced by the current well field. Blending is not considered an option since the current arsenic concentrations in the existing wells are too high. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed. In order to address a range of solutions, three different well alternatives are developed, assuming the new well is located within 10 miles, 5 miles, and 1 mile from the existing intake point.

This alternative would require 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 Mark V Estates system. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 10 miles long, and would be a 4-inch PVC line that discharges to the existing Mark V Estates 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 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 $2.66 million, and the estimated annual O&M cost for this alternative is $17,000.

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 operating the existing system. Orbit personnel are experienced 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 an alternate groundwater source may not be found on Mark V Estates or Orbit-controlled land, so landowner cooperation would be required.

4.5.14 Alternative MVE-14: New Well at 5 Miles

This alternative consists of installing one new well within 5 miles of Mark V Estates that would produce compliant water in place of the water produced by the current well field. Blending is not considered an option since the current arsenic concentrations in the existing wells are too high. 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, 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 Mark V Estates system. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 5 miles long, and would be a 4-inch PVC line that discharges to the existing Mark V Estates 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 PWS 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 cost for 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 $1.35 million, and the estimated annual O&M cost for this alternative is $12,600.

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 operating the existing system. Orbit personnel have 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 the alternate groundwater source may not be found on Mark V Estates or Orbit-controlled land, so landowner cooperation would be required.

4.5.15 Alternative MVE-15: New Well at 1 Mile

This alternative consists of installing one new well within 1 mile of Mark V Estates that would produce compliant water in place of the water produced by the current well field. Blending is not considered an option since the current arsenic concentrations in the existing wells are too high. 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, and a pipeline from the new well to the existing intake point for the Mark V Estates system. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 4-inch PVC line that discharges to the existing Mark V Estates storage tank.

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. 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 $6,400 less than current costs.

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 operating the existing system. Orbit personnel have 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 Mark V Estates or Orbit-controlled land, so landowner cooperation would be required.

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

This alternative consists of the continued operation of the Mark V Estates well field, 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 maintenance of 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 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 purchase and replacement of 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 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 is only one unit.

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

4.5.17 Alternative MVE-17: 100 Percent Bottled Water Delivery

This alternative consists of the continued operation of the Mark V Estates well field, but compliant drinking water would be delivered to customers in containers. 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 convenient and economical to contract a bottled water service. The bottle delivery program would have to be flexible enough to allow for delivery of smaller containers should customers be incapable of lifting and manipulating 5-gallon bottles. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

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

This alternative does not present options for a regional solution.

The estimated initial capital cost is for setting up the program. The estimated O&M cost for this alternative includes program administration and purchase of the bottled water. The estimated capital cost for this alternative is $23,900, and the estimated annual O&M cost for this alternative is $190,100. For the cost estimate, it is assumed that each person requires 1 gallon of bottled water per day.

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

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

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

This alternative consists of continued operation of the Mark V Estates well field, 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 are required to pick up and deliver their own water. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

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 have to meet requirements for potable water, and each load would be treated with chlorine. This alternative relies on cooperation and action from 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 purchase of a water truck and construction of 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 $15,000.

The reliability of adequate amounts of compliant water under this alternative is fair because of the large amount of effort required from 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 the 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 PWS entities.

4.5.19 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for Mark V Estates.

1 **Table 4.3 Summary of Compliance Alternatives for Mark V Estates**

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
MVE-1	New well near Oak Bend Estates	Well, pump station, and 1.9 mile pipeline	$660,000	$10,200	$67,700	Good	N	Alternative assumes adequate quantity of compliant water is available from this part of the Chicot aquifer, and land is available.
MVE-2	New well near Weybridge Subdivision	Well, pump station, and 3.8 mile pipeline	$1,075,300	$11,700	$105,400	Good	N	Alternative assumes adequate quantity of compliant water is available from this part of the Chicot aquifer, and land is available.
MVE-3	Purchase groundwater from J M P Utilities	Pump station and 6.3 mile pipeline	$1,643,600	$19,200	$162,500	Good	N	Alternative assumes J M P Utilities is willing to sell water.
MVE-4	New well near Calico Farms Subdivision	Well, pump station, and 4.4 mile pipeline	$1,142,100	$12,200	$111,800	Good	N	Alternative assumes adequate quantity of compliant water is available from this part of the Chicot aquifer, and land is available.
MVE-5	New well near Briar Meadows	Well, pump station, and 9.3 mile pipeline	$2,363,700	$16,200	$222,300	Good	N	Alternative assumes adequate quantity of compliant water is available from this part of the Chicot aquifer, and land is available.
MVE-6	Purchase groundwater from City of Alvin	Pump station and 8 mile pipeline	$2,267,000	$20,600	$218,300	Good	N	Alternative assumes City of Alvin will sell water.
MVE-7	Purchase surface water from Brazosport Water Authority	Pump station and 15.2 mile pipeline	$3,825,300	$25,800	$359,300	Good	N	BWA expects to sell all excess capacity within the next 5 years.
MVE-8	New well near Snug Harbor	Well, pump station, and 6.6 mile pipeline	$1,883,700	$13,900	$178,100	Good	N	Alternative assumes adequate quantity of compliant water is available from this part of the Chicot aquifer, and land is available.
MVE-9	Continued use of existing wells with central iron-based adsorption treatment	One central iron-based adsorption treatment unit	$376,900	$55,700	$88,500	Good	T, M	Alternative assumes no nearby PWS system to share treatment plant cost.
MVE-10	Continued use of existing wells with central coagulation / filtration treatment	One central coagulation / filtration treatment unit	$291,600	$125,300	$150,700	Good	T, M	Alternative assumes no nearby PWS system to share treatment plant cost.

o.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
MVE-11	Continued use of existing wells with point-of-use treatment	Small adsorption treatment unit for each customer	$62,000	$58,800	$64,200	Fair	T, M	Alternative assumes all the homes and businesses will cooperate. Does not provide compliant water to all taps.
MVE-12	Continued use of existing wells with point-of-entry treatment	Small adsorption treatment unit for each customer	$1,085,700	$131,600	$226,300	Good	T, M	All taps compliant.
MVE-13	Install new compliant well within 10 miles	Well, pump station, and 10 mile pipeline	$2,659,400	$17,000	$248,900	Good	N	Alternative assumes adequate quantity of compliant water is available from this part of the Chicot aquifer
MVE-14	Install new compliant well within 5 miles	Well, pump station, and 5 mile pipeline	$1,348,000	$12,600	$130,100	Good	N	Alternative assumes adequate quantity of compliant water is available from this part of the Chicot aquifer
MVE-15	Install new compliant well within 1 miles	Well and 1 mile pipeline	$290,100	$(6,400)	$18,900	Good	N	Alternative assumes adequate quantity of compliant water is available from this part of the Chicot aquifer
MVE-16	Continued use of existing wells with public dispenser of treated drinking water	Install medium size iron-based adsorption treatment system, storage tank, and public dispenser	$11,600	$16,700	$17,700	Fair / interim measure	T	INTERIM SOLUTION: Does not provide compliant water to building taps; requires a lot of effort by customers.
MVE-17	Continued use of existing wells with bottled water deliver	Set up bottled water delivery system	$23,900	$190,100	$192,200	Fair / interim measure	M	INTERIM SOLUTION: Does not provide compliant water to building taps; requires customers to order and use delivery water.
MVE-18	Continued use of existing wells with public dispenser of trucked drinking water	Install storage tank and public dispenser. Buy delivery truck	$103,000	$15,000	$23,900	Fair / interim measure	M	INTERIM SOLUTION: Does not provide compliant water to building taps; requires a lot of effort by customers.

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

4.6 COST OF SERVICE AND FUNDING ANALYSIS

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 Mark V Estates 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 Mark V Estates. 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 $37,858 (operating revenue plus required reserve) for Mark V Estates compared to $7,780,508 total 2004 revenue for Orbit Systems as summarized in Table 4.4.

Table 4.4 Summary of Orbit Systems 2004 Water Revenues

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

Annual expenses for Mark V Estates were estimated based on its percentage water usage of 5.7 percent as shown by Appendix F. This resulted in 2004 expenses of $43,566 (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 Road 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 Mark V Estates compared to other Orbit PWSs included in this study. The shortfall for Mark V Estates of $5,708 is based on current operations without any capital expenditures to address the arsenic problem. This means that Orbit is not currently charging its Mark V Estates 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 Road 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 Mark V Estates would need to increase rates over the next few years to maintain financial viability, even without considering any possible solutions for the arsenic problem. The average annual bill for Mark V Estates customers must be increased by 6.3 percent just to meet operating expenses for this system based on the assumptions used in this analysis.

Table 4.7 shows how a 6.3 percent increase would impact the average annual bill for Mark V Estates customers as a percent of the MHI for Brazoria County compared to other Orbit PWSs included in this study. The average annual bill in Mark V Estates would increase from $381 to $405 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 Road Estates	$ 373	0.77 %	1.3 %	$ 378	0.81 %
Sandy Meadow	$ 344	0.86 %	None	$ 295	0.74 %
Mark V Estates	$ 381	0.78 %	6.3 %	$ 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 Mark V Estates to calculate the Current Ratio or the Debt to Net Worth Ratio. However, an Operating Ratio of 0.87 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 0.87 is just another indication that Orbit must raise its water rates for its Mark V Estates customers in the future.

4.6.1.3 Financial Plan Results

Each compliance alternative for Mark V Estates 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 4.2 shows the current average annual bill for Mark V Estates of $381 and the average annual bill of $405, 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 entirely on 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.

Table 4.8 Financial Impact on Households for Mark V Estates Alternatives

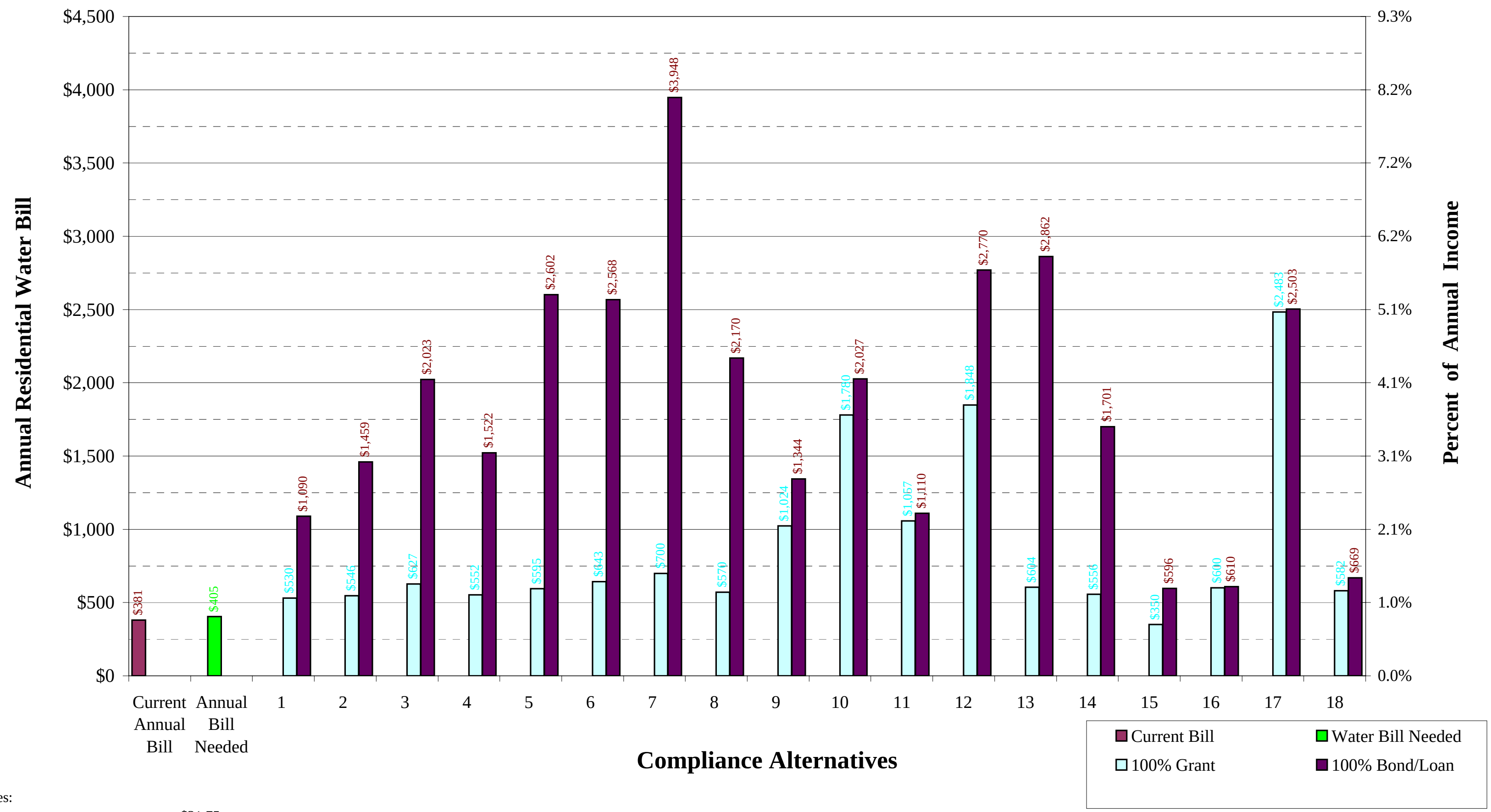
		Funding Source #	0	1	2	3	4	5
#	ALTERNATIVES		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Loan/Bond
MVE-1	Oak Bend Estates	Average Annual Water Bill	$ 7,525	$ 873	$1,131	$1,389	$1,780	$1,904
		Maximum % of HH Income	17%	2%	2%	3%	4%	4%
		Percentage Rate Increase Compared to Current	2009%	142%	216%	289%	401%	436%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-2	Weybridge Subdivision	Average Annual Water Bill	$11,590	$734	$1,154	$1,574	$2,211	$2,413
		Maximum % of HH Income	25%	2%	3%	3%	5%	5%
		Percentage Rate Increase Compared to Current	3150%	103%	222%	342%	524%	582%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-3	JMP Utilities	Average Annual Water Bill	$17,514	$885	$1,526	$2,168	$3,141	$3,451
		Maximum % of HH Income	38%	2%	3%	5%	7%	8%
		Percentage Rate Increase Compared to Current	4815%	145%	329%	512%	790%	879%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-4	Calico Farms/Ashley Oaks	Average Annual Water Bill	$2,274	$745	$1,191	$1,637	$2,313	$2,528
		Maximum % of HH Income	27%	2%	3%	4%	5%	6%
		Percentage Rate Increase Compared to Current	3342%	106%	233%	360%	554%	615%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005

MVE-5	Briar Meadows	Average Annual Water Bill	$24,718	$822	$1,744	$2,667	$4,066	$4,512
		Maximum % of HH Income	54%	2%	4%	6%	9%	10%
		Percentage Rate Increase Compared to Current	6838%	128%	392%	656%	1056%	1183%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-6	City of Alvin	Average Annual Water Bill	$23,779	$ 907	$1,792	$ 2,677	$ 4,019	$4,447
		Maximum % of HH Income	52%	2%	4%	6%	9%	10%
		Percentage Rate Increase Compared to Current	6575%	154%	407%	660%	1043%	1165%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-7	Brazosport Water Authority	Average Annual Water Bill	$39,655	$1,007	$2,501	$3,994	$6,259	$6,980
		Maximum % of HH Income	87%	2%	6%	9%	14%	16%
		Percentage Rate Increase Compared to Current	11035%	183%	610%	1037%	1684%	1890%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-8	Snug Harbor	Average Annual Water Bill	$19,821	$ 778	$1,513	$2,248	$3,364	$ 3,719
		Maximum % of HH Income	44%	2%	3%	5%	7%	8%
		Percentage Rate Increase Compared to Current	5463%	115%	325%	536%	854%	956%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-9	Central Adsorption	Average Annual Water Bill	$4,929	$1,582	$1,729	$1,876	$2,100	$2,171
		Maximum % of HH Income	11%	4%	4%	4%	5%	5%
		Percentage Rate Increase Compared to Current	1284%	354%	396%	438%	502%	522%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005

MVE-10	Central Coagulation	Average Annual Water Bill	$4,745	$2,923	$3,037	$3,151	$3,324	$3,379
		Maximum % of HH Income	10%	7%	7%	7%	8%	8%
		Percentage Rate Increase Compared to Current	1239%	751%	783%	816%	865%	881%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-11	POU-Adsorption	Average Annual Water Bill	$1,762	$1,641	$1,665	$1,690	$1,726	$1,738
		Maximum % of HH Income	4%	4%	4%	4%	4%	4%
		Percentage Rate Increase Compared to Current	394%	371%	378%	385%	395%	399%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-12	POE-Adsorption	Average Annual Water Bill	$2,871	$3,044	$3,468	$3,892	$4,535	$4,740
		Maximum % of HH Income	28%	7%	8%	9%	10%	11%
		Percentage Rate Increase Compared to Current	3522%	787%	908%	1029%	1213%	1271%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-13	New well 10 mi	Average Annual Water Bill	$27,729	$838	$1,876	$2,914	$4,489	$4,990
		Maximum % of HH Income	61%	2%	4%	6%	10%	11%
		Percentage Rate Increase Compared to Current	7684%	133%	430%	727%	1177%	1320%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-14	New well 5 mi	Average Annual Water Bill	$4,368	$752	$1,279	$1,805	$2,603	$2,857
		Maximum % of HH Income	32%	2%	3%	4%	6%	6%
		Percentage Rate Increase Compared to Current	3931%	108%	258%	409%	637%	709%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005

MVE-15	New well 1 mi	Average Annual Water Bill	$3,439	$494	$606	$719	$891	$946
		Maximum % of HH Income	8%	1%	1%	2%	2%	2%
		Percentage Rate Increase Compared to Current	859%	32%	64%	96%	145%	161%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-16	Public Dispenser	Average Annual Water Bill	$839	$830	$835	$839	$846	$849
		Maximum % of HH Income	2%	2%	2%	2%	2%	2%
		Percentage Rate Increase Compared to Current	131%	131%	132%	134%	135%	136%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-17	100% Bottled	Average Annual Water Bill	$4,188	$4,171	$4,181	$4,190	$4,204	$4,209
		Maximum % of HH Income	10%	10%	10%	10%	10%	10%
		Percentage Rate Increase Compared to Current	1121%	1121%	1123%	1126%	1130%	1131%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005
MVE-18	Central Trucked	Average Annual Water Bill	$1,748	$798	$838	$878	$939	$959
		Maximum % of HH Income	4%	2%	2%	2%	2%	2%
		Percentage Rate Increase Compared to Current	386%	121%	133%	144%	162%	167%
		Year First Rate Increase Needed	2005	2005	2005	2005	2005	2005

Figure 4-2 Alternative Cost Summary



Current Rates:

Monthly:	$31.75
Median Household Income	$48,632
Average Monthly Residential Usage	5,639 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
Mark V Estates
PWS #0200432
General PWS Information

Service Population 285 | **Number of Connections** 94
Total PWS Daily Water Usage 0.02 (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

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

Table C.1

PWS Name *Mark V Estates*
Alternative Name *New Well at Oak Bend Estates*
Alternative Number *MVE-1*

Distance from PWS to new well location	1.91	miles
Estimated well depth	150	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	7	n/a	n/a	n/a
Number of Crossings, open cut	4	n/a	n/a	n/a
PVC water line, Class 200, 04"	10,072	LF	$ 27	$ 271,944
Bore and encasement, 10"	1,400	LF	$ 60	$ 84,000
Open cut and encasement, 10"	200	LF	$ 35	$ 7,000
Gate valve and box, 04"	2	EA	$ 370	$ 745
Air valve	2	EA	$ 1,000	$ 2,000
Flush valve	2	EA	$ 750	$ 1,511
Metal detectable tape	10,072	LF	$ 0.15	$ 1,511
Subtotal				**$ 368,711**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 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				**$ 61,705**
Well Installation				
Well installation	150	LF	$ 25	$ 3,750
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				**$ 24,750**
Subtotal of Component Costs				**$ 455,166**
Contingency	20%			$ 91,033
Design & Constr Management	25%			$ 113,791
TOTAL CAPITAL COSTS				**$ 659,991**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	1.9	mile	$ 200	$ 382
Subtotal				**$ 382**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	12,550	kWH	$ 0.136	$ 1,707
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 16,462**
Well O&M				
Pump power	384	kWH	$ 0.136	$ 52
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,652**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ 10,187**

Table C.2

PWS Name *Mark V Estates*
Alternative Name *New Well at Weybridge Subdivision*
Alternative Number *MVE-2*

Distance from PWS to new well location	3.80	miles
Estimated well depth	150	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	3	n/a	n/a	n/a
PVC water line, Class 200, 04"	20,088	LF	$ 27	$ 542,376
Bore and encasement, 10"	1,600	LF	$ 60	$ 96,000
Open cut and encasement, 10"	150	LF	$ 35	$ 5,250
Gate valve and box, 04"	4	EA	$ 370	$ 1,487
Air valve	4	EA	$ 1,000	$ 4,000
Flush valve	4	EA	$ 750	$ 3,013
Metal detectable tape	20,088	LF	$ 0.15	$ 3,013
Subtotal				**$ 655,139**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 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				**$ 61,705**
Well Installation				
Well installation	150	LF	$ 25	$ 3,750
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				**$ 24,750**
Subtotal of Component Costs				**$ 741,594**
Contingency	20%			$ 148,319
Design & Constr Management	25%			$ 185,398
TOTAL CAPITAL COSTS				**$ 1,075,311**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	3.8	mile	$ 200	$ 761
Subtotal				**$ 761**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	20,650	kWH	$ 0.136	$ 2,808
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 17,563**
Well O&M				
Pump power	384	kWH	$ 0.136	$ 52
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,652**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ 11,668**

Table C.3

PWS Name *Mark V Estates*
Alternative Name *Purchase Water from JMP Utilities*
Alternative Number *MVE-3*

Distance from Alternative to PWS (along pipe)	6.3	miles
Total PWS annual water usage	7.300	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	13	n/a	n/a	n/a
Number of Crossings, open cut	6	n/a	n/a	n/a
PVC water line, Class 200, 04"	33,127	LF	$ 27.00	$ 894,429
Bore and encasement, 10"	2,600	LF	$ 60.00	$ 156,000
Open cut and encasement, 10"	300	LF	$ 35.00	$ 10,500
Gate valve and box, 04"	7	EA	$ 370.00	$ 2,451
Air valve	6	EA	$ 1,000.00	$ 6,000
Flush valve	7	EA	$ 750.00	$ 4,969
Metal detectable tape	33,127	LF	$ 0.15	$ 4,969
Subtotal				**$ 1,079,318**
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				**$ 1,133,523**
Contingency	20%			$ 226,705
Design & Constr Management	25%			$ 283,381
TOTAL CAPITAL COSTS				**$ 1,643,609**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	6.3	mile	$ 200	$ 1,255
Subtotal				**$ 1,255**
Water Purchase Cost				
From Source	7,300	1,000 gal	$ 1.65	$ 12,045
Subtotal				**$ 12,045**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	32,650	kWH	$ 0.136	$ 4,440
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 19,195**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ 19,187**

Table C.4

PWS Name *Mark V Estates*
Alternative Name *New Well at Calico Farms/Ashley Oaks*
Alternative Number *MVE-4*

Distance from PWS to new well location	4.31	miles
Estimated well depth	150	feet
Number of wells required	1	
Well installation cost (location specific)	$25	per foot
Number of pump stations needed	1	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	6	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 04"	22,776	LF	$ 27	$ 614,952
Bore and encasement, 10"	1,200	LF	$ 60	$ 72,000
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	5	EA	$ 370	$ 1,685
Air valve	4	EA	$ 1,000	$ 4,000
Flush valve	5	EA	$ 750	$ 3,416
Metal detectable tape	22,776	LF	$ 0.15	$ 3,416
Subtotal				**$ 701,220**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 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				**$ 61,705**
Well Installation				
Well installation	150	LF	$ 25	$ 3,750
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				**$ 24,750**
Subtotal of Component Costs				**$ 787,675**
Contingency	20%			$ 157,535
Design & Constr Management	25%			$ 196,919
TOTAL CAPITAL COSTS				**$ 1,142,129**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	4.3	mile	$ 200	$ 863
Subtotal				**$ 863**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	23,900	kWH	$ 0.136	$ 3,250
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 18,005**
Well O&M				
Pump power	384	kWH	$ 0.136	$ 52
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,652**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$(10,800)
Subtotal				**$(13,308)**
TOTAL ANNUAL O&M COSTS				**$ 12,212**

Table C.5

PWS Name *Mark V Estates*
Alternative Name *New Well at Briar Meadows*
Alternative Number *MVE-5*

Distance from PWS to new well location	9.26	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	15	n/a	n/a	n/a
Number of Crossings, open cut	8	n/a	n/a	n/a
PVC water line, Class 200, 04"	48,917	LF	$ 27	$ 1,320,759
Bore and encasement, 10"	3,000	LF	$ 60	$ 180,000
Open cut and encasement, 10"	400	LF	$ 35	$ 14,000
Gate valve and box, 04"	10	EA	$ 370	$ 3,620
Air valve	9	EA	$ 1,000	$ 9,000
Flush valve	10	EA	$ 750	$ 7,338
Metal detectable tape	48,917	LF	$ 0.15	$ 7,338
Subtotal				**$ 1,542,054**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 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				**$ 61,705**
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				**$ 1,630,134**
Contingency	20%			$ 326,027
Design & Constr Management	25%			$ 407,533
TOTAL CAPITAL COSTS				**$ 2,363,694**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	9.3	mile	$ 200	$ 1,853
Subtotal				**$ 1,853**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	45,750	kWH	$ 0.136	$ 6,222
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 20,977**
Well O&M				
Pump power	551	kWH	$ 0.136	$ 75
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,675**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ 16,197**

Table C.6

PWS Name *Mark V Estates*
Alternative Name *Purchase Water from City of Alvin*
Alternative Number *MVE-6*

Distance from Alternative to PWS (along pipe)	8.0	miles
Total PWS annual water usage	7.300	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	28	n/a	n/a	n/a
Number of Crossings, open cut	6	n/a	n/a	n/a
PVC water line, Class 200, 04"	42,184	LF	$ 27.00	$ 1,138,968
Bore and encasement, 10"	5,600	LF	$ 60.00	$ 336,000
Open cut and encasement, 10"	300	LF	$ 35.00	$ 10,500
Gate valve and box, 04"	8	EA	$ 370.00	$ 3,122
Air valve	8	EA	$ 1,000.00	$ 8,000
Flush valve	8	EA	$ 750.00	$ 6,328
Metal detectable tape	42,184	LF	$ 0.15	$ 6,328
Subtotal				**$ 1,509,245**
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				**$ 1,563,450**
Contingency	20%			$ 312,690
Design & Constr Management	25%			$ 390,862
TOTAL CAPITAL COSTS				**$ 2,267,002**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	8.0	mile	$ 200	$ 1,598
Subtotal				**$ 1,598**
Water Purchase Cost				
From Source	7,300	1,000 gal	$ 1.65	$ 12,045
Subtotal				**$ 12,045**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	40,800	kWH	$ 0.136	$ 5,549
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 20,304**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ 20,638**

Table C.7

PWS Name *Mark V Estates*
Alternative Name *Purchase Water from Brazosport Water Authority*
Alternative Number *MVE-7*

Distance from Alternative to PWS (along pipe)	15.2	miles
Total PWS annual water usage	7.300	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	30	n/a	n/a	n/a
Number of Crossings, open cut	8	n/a	n/a	n/a
PVC water line, Class 200, 04"	80,182	LF	$ 27.00	$ 2,164,914
Bore and encasement, 10"	6,000	LF	$ 60.00	$ 360,000
Open cut and encasement, 10"	400	LF	$ 35.00	$ 14,000
Gate valve and box, 04"	16	EA	$ 370.00	$ 5,933
Air valve	15	EA	$ 1,000.00	$ 15,000
Flush valve	16	EA	$ 750.00	$ 12,027
Metal detectable tape	80,182	LF	$ 0.15	$ 12,027
Subtotal				**$ 2,583,902**
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				**$ 2,638,107**
Contingency	20%			$ 527,621
Design & Constr Management	25%			$ 659,527
TOTAL CAPITAL COSTS				**$ 3,825,255**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	15.2	mile	$ 200	$ 3,037
Subtotal				**$ 3,037**
Water Purchase Cost				
From Source	7,300	1,000 gal	$ 1.60	$ 11,680
Subtotal				**$ 11,680**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	71,150	kWH	$ 0.136	$ 9,676
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 24,431**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ 25,840**

Table C.8

PWS Name *Mark V Estates*
Alternative Name *New Well at Snug Harbor*
Alternative Number *MVE-8*

Distance from PWS to new well location	6.63	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	20	n/a	n/a	n/a
Number of Crossings, open cut	3	n/a	n/a	n/a
PVC water line, Class 200, 04"	35,025	LF	$ 27	$ 945,675
Bore and encasement, 10"	4,000	LF	$ 60	$ 240,000
Open cut and encasement, 10"	150	LF	$ 35	$ 5,250
Gate valve and box, 04"	7	EA	$ 370	$ 2,592
Air valve	7	EA	$ 1,000	$ 7,000
Flush valve	7	EA	$ 750	$ 5,254
Metal detectable tape	35,025	LF	$ 0.15	$ 5,254
Subtotal				**$ 1,211,024**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 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				**$ 61,705**
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				**$ 1,299,104**
Contingency	20%			$ 259,821
Design & Constr Management	25%			$ 324,776
TOTAL CAPITAL COSTS				**$ 1,883,701**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	6.6	mile	$ 200	$ 1,327
Subtotal				**$ 1,327**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.136	$ 1,605
Pump Power	32,850	kWH	$ 0.136	$ 4,468
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 19,222**
Well O&M				
Pump power	551	kWH	$ 0.136	$ 75
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,675**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ 13,916**

Table C.9

PWS Name ***Mark V Estates***
Alternative Name ***Central Treatment - Adsorption***
Alternative Number ***MVE-9***

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:				
Regenerant pumps				
Prefilter & vessels				
IX resins & vessels	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.10

PWS Name *Mark V Estates*
Alternative Name *Central Treatment - Coag-Filt*
Alternative Number *MVE-10*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Central-Coagulation/Filtration				
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:				
Regenerant pumps				
Prefilter & vessels				
IX resins & vessels	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 Power	6,000	kwh/yr	$ 0.136	$ 816
Equipment power	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 rental	100	days	$ 700	70000
Mileage	4000	miles	$ 1.00	4000
Disposal fee	315	kgal/yr	$ 5.00	1575
Subtotal				**$ 75,575**
Total				**$ 125,327**

Table C.11

PWS Name ***Mark V Estates***
Alternative Name ***Point-of-Use Treatment***
Alternative Number ***MVE-11***

Number of Connections for POU Unit Installation 94

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POU-Treatment - Purchase/Installation				
POU treatment unit purchase	94	EA	$ 250	$ 23,500
POU treatment unit installation	94	EA	$ 150	$ 14,100
Subtotal				**$ 37,600**
Subtotal of Component Costs				**$ 37,600**
Contingency	20%			$ 7,520
Design & Constr Management	25%			$ 9,400
Procurement & Administration	20%			$ 7,520
TOTAL CAPITAL COSTS				**$ 62,040**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POU materials, per unit	94	EA	$ 225	$ 21,150
Contaminant analysis, 1/yr per unit	94	EA	$ 100	$ 9,400
Program labor, 10 hrs/unit	940	hrs	$ 30	$ 28,200
Subtotal				**$ 58,750**
TOTAL ANNUAL O&M COSTS				**$ 58,750**

Table C.12

PWS Name *Mark V Estates*
Alternative Name *Point-of-Entry Treatment*
Alternative Number *MVE-12*

Number of Connections for POE Unit Installation 94

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POE-Treatment - Purchase/Installation				
POE treatment unit purchase	94	EA	$ 3,000	$ 282,000
Pad and shed, per unit	94	EA	$ 2,000	$ 188,000
Piping connection, per unit	94	EA	$ 1,000	$ 94,000
Electrical hook-up, per unit	94	EA	$ 1,000	$ 94,000
Subtotal				**$ 658,000**
Subtotal of Component Costs				**$ 658,000**
Contingency	20%			$ 131,600
Design & Constr Management	25%			$ 164,500
Procurement & Administration	20%			$ 131,600
TOTAL CAPITAL COSTS				**$ 1,085,700**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POE materials, per unit	94	EA	$ 1,000	$ 94,000
Contaminant analysis, 1/yr per unit	94	EA	$ 100	$ 9,400
Program labor, 10 hrs/unit	940	hrs	$ 30	$ 28,200
Subtotal				**$ 131,600**
TOTAL ANNUAL O&M COSTS				**$ 131,600**

Table C.13

PWS Name ***Mark V Estates***
Alternative Name ***New Well at 10 Miles***
Alternative Number ***MVE-13***

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	23	n/a	n/a	n/a
Number of Crossings, open cut	7	n/a	n/a	n/a
PVC water line, Class 200, 04"	52,800	LF	$ 27	$ 1,425,600
Bore and encasement, 10"	4,600	LF	$ 60	$ 276,000
Open cut and encasement, 10"	350	LF	$ 35	$ 12,250
Gate valve and box, 04"	11	EA	$ 370	$ 3,907
Air valve	10	EA	$ 1,000	$ 10,000
Flush valve	11	EA	$ 750	$ 7,920
Metal detectable tape	52,800	LF	$ 0.15	$ 7,920
Subtotal				**$ 1,743,597**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 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				**$ 61,705**
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				**$ 1,834,052**
Contingency	20%			$ 366,810
Design & Constr Management	25%			$ 458,513
TOTAL CAPITAL COSTS				**$ 2,659,376**

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	50,620	kWH	$ 0.136	$ 6,884
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 21,639**
Well O&M				
Pump power	794	kWH	$ 0.136	$ 108
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,708**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ 17,039**

Table C.14

PWS Name ***Mark V Estates***
Alternative Name ***New Well at 5 Miles***
Alternative Number ***MVE-14***

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	4	n/a	n/a	n/a
PVC water line, Class 200, 04"	26,400	LF	$ 27	$ 712,800
Bore and encasement, 10"	1,800	LF	$ 60	$ 108,000
Open cut and encasement, 10"	100	LF	$ 35	$ 3,500
Gate valve and box, 04"	5	EA	$ 370	$ 1,954
Air valve	5	EA	$ 1,000	$ 5,000
Flush valve	5	EA	$ 750	$ 3,960
Metal detectable tape	26,400	LF	$ 0.15	$ 3,960
Subtotal				**$ 839,174**
Pump Station(s) Installation				
Pump	2	EA	$ 7,500	$ 15,000
Pump Station Piping, 04"	1	EA	$ 4,000	$ 4,000
Gate valve, 04"	4	EA	$ 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				**$ 61,705**
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				**$ 929,629**
Contingency	20%			$ 185,926
Design & Constr Management	25%			$ 232,407
TOTAL CAPITAL COSTS				**$ 1,347,961**

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	25,310	kWH	$ 0.136	$ 3,442
Materials	1	EA	$ 1,200	$ 1,200
Labor	365	Hrs	$ 30	$ 10,950
Tank O&M	1	EA	$ 1,000	$ 1,000
Subtotal				**$ 18,197**
Well O&M				
Pump power	794	kWH	$ 0.136	$ 108
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,708**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ 12,597**

Table C.15

PWS Name *Mark V Estates*
Alternative Name *New Well at 1 Mile*
Alternative Number *MVE-15*

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	$ 142,560
Bore and encasement, 10"	400	LF	$ 60	$ 24,000
Open cut and encasement, 10"	50	LF	$ 35	$ 1,750
Gate valve and box, 04"	1	EA	$ 370	$ 391
Air valve	1.00	EA	$ 1,000	$ 1,000
Flush valve	1	EA	$ 750	$ 792
Metal detectable tape	5,280	LF	$ 0.15	$ 792
Subtotal				**$ 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	794	kWH	$ 0.136	$ 108
Well O&M matl	1	EA	$ 1,200	$ 1,200
Well O&M labor	180	Hrs	$ 30	$ 5,400
Subtotal				**$ 6,708**
O&M Credit for Existing Well Closure				
Pump power	794	kWH	$ 0.136	$ (108)
Well O&M matl	2	EA	$ 1,200	$ (2,400)
Well O&M labor	360	Hrs	$ 30	$ (10,800)
Subtotal				**$ (13,308)**
TOTAL ANNUAL O&M COSTS				**$ (6,400)**

Table C.16

PWS Name ***Mark V Estates***
Alternative Name ***Public Dispenser for Treated Drinking Water***
Alternative Number ***MVE-16***

Number of Treatment Units Recommended 1

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Public Dispenser Unit Installation				
POE-Treatment unit(s)	1	EA	$ 3,000	$ 3,000
Unit installation costs	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 8,000**
Subtotal of Component Costs				**$ 8,000**
Contingency	20%			$ 1,600
Design & Constr Managem	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.17

PWS Name *Mark V Estates*

Alternative Name *Supply Bottled Water to Population*

Alternative Number *MVE-17*

Service Population	285	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	104,025	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	104,025	gals	$ 1.60	$ 166,440
Program admin, 9 hrs/wk	468	hours	$ 40	$ 18,673
Program materials	1	EA	$ 5,000	$ 5,000
Subtotal				**$ 190,113**
TOTAL ANNUAL O&M COSTS				**$ 190,113**

Table C.18

PWS Name ***Mark V Estates***
Alternative Name ***Central Trucked Drinking Water***
Alternative Number ***MVE-18***

Service Population	285	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	104,025	gallons
Travel distance to compliant water source (roundtrip	4	miles

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Storage Tank Installation				
Storage Tank - 5,000 gals	1	EA	$ 7,025	$ 7,025
Site improvements	1	EA	$ 4,000	$ 4,000
Potable water truck	1	EA	$ 60,000	$ 60,000
Subtotal				**$ 71,025**
Subtotal of Component Costs				**$ 71,025**
Contingency	20%			$ 14,205
Design & Constr 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	208	miles	$ 1.00	$ 208
Water purchase	104	1,000 gals	$ 1.80	$ 187
Water testing, 1 test/wk	52	EA	$ 100	$ 5,200
Sampling/reporting, 2 hrs/wk	104	hrs	$ 30	$ 3,120
Subtotal				**$ 14,955**
TOTAL ANNUAL O&M COSTS				**$ 14,955**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Table D.1 Example Financial Model

Step 1

Water System: Mark V Estates

Step 2

Click Here to Update Verification and Raw

Water System	Mark V Estates
Alternative Description	New Well at 5 Miles

Sum of Amount		Year	Funding Alternative
		2007	
Group	Type	100% Grant	Bond
Capital Expenditures	Capital Expenditures-Funded from Bonds	$ 500	$ 1,348,461
	Capital Expenditures-Funded from Grants	$ 1,347,961	$ -
	Capital Expenditures-Funded from Revenue/Reserves	$ -	$ -
	Capital Expenditures-Funded from SRF Loans	$ -	$ -
Capital Expenditures Sum		$ 1,348,461	$ 1,348,461
Debt Service	Revenue Bonds	$ 39	$ 105,486
	State Revolving Funds	$ -	$ -
Debt Service Sum		$ 39	$ 105,486
Operating Expenditures	Administrative Expenses	$ 3,898	$ 3,898
	Chemicals, Treatment	$ 1,155	$ 1,155
	Contract Labor	$ 1,359	$ 1,359
	Insurance	$ 792	$ 792
	Other Operating Expenditures 1	$ 911	$ 911
	Other Operating Expenditures 2	$ 11,087	$ 11,087
	Professional and Directors Fees	$ 171	$ 171
	Repairs	$ 925	$ 925
	Salaries & Benefits	$ 11,172	$ 11,172
	Supplies	$ 925	$ 925
	Utilities	$ 4,678	$ 4,678
	Maintenance	$ 925	$ 925
	Accounting and Legal Fees	$ 66	$ 66
	Auto and Travel	$ 14	$ 14
Operating Expenditures Sum		$ 38,078	$ 38,078
Residential Operating Revenu	Residential Base Monthly Rate	$ 23,214	$ 23,214
	Residential Tier 1 Monthly Rate	$ 11,843	$ 11,843
	Residential Tier2 Monthly Rate	$ -	$ -
	Residential Tier3 Monthly Rate	$ -	$ -
	Residential Tier4 Monthly Rate	$ -	$ -
	Residential Unmetered Monthly Rate	$ -	$ -
Residential Operating Revenues Sum		$ 35,058	$ 35,058

Location_Name	Mark V Estates
Alt_Desc	New Well at 5 Miles

		Current_Year
Funding_Alt	Data	2007
100% Grant	Sum of Beginning_Cash_Bal	$ (4,845)
	Sum of Total_Expenditures	$ 1,386,578
	Sum of Total_Receipts	$ 1,383,019
	Sum of Net_Cash_Flow	$ (3,560)
	Sum of Ending_Cash_Bal	$ (8,405)
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ 2,744
	Sum of Total_Reqd_Resv	$ 2,744
	Sum of Net_Avail_Bal	$ (11,148)
	Sum of Add_Resv_Needed	$ (11,148)
	Sum of Rate_Inc_Needed	32%
	Sum of Percent_Rate_Increase	0%
Bond	Sum of Beginning_Cash_Bal	$ (4,845)
	Sum of Total_Expenditures	$ 1,492,025
	Sum of Total_Receipts	$ 1,383,019
	Sum of Net_Cash_Flow	$ (109,006)
	Sum of Ending_Cash_Bal	$ (113,851)
	Sum of Working_Cap	$ -
	Sum of Repl_Resv	$ 2,744
	Sum of Total_Reqd_Resv	$ 2,744
	Sum of Net_Avail_Bal	$ (116,595)
	Sum of Add_Resv_Needed	$ (116,595)
	Sum of Rate_Inc_Needed	333%
	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.

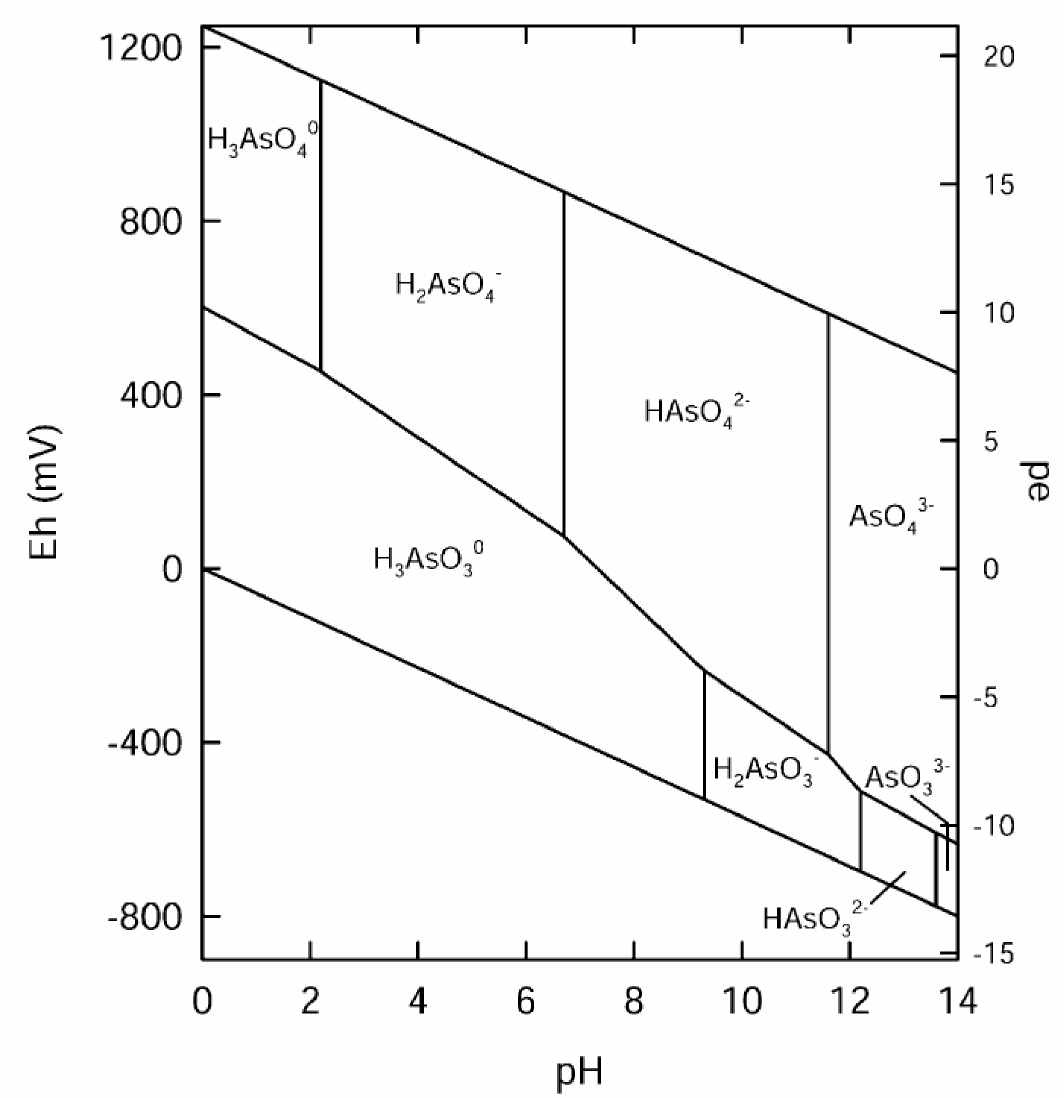

Figure E.1
Eh-pH Diagram for Arsenic Aqueous Species in the As-O_2-H_2O System at 25°C and 1 bar (Smedley and Kinniburgh 2002)

APPENDIX F
ORBIT SYSTEMS WATER USAGE

APPENDIX F
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**