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

NORTH SAN SABA

PWS ID# 2060003, CCN# 11227

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 2010

EXECUTIVE SUMMARY

INTRODUCTION

The University of Texas Bureau of Economic Geology (BEG) and its subcontractor, Parsons Transportation Group Inc. (Parsons), was contracted by the Texas Commission on Environmental Quality (TCEQ) to conduct a project 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 with 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, which evaluates 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 North San Saba Water Supply Corporation; PWS ID# 2060003 and Certificate of Convenience and Necessity #11227). The North San Saba Water Supply Corporation is located approximately 8 miles northwest of Lampasas, Texas in San Saba County. The North San Saba PWS is a community water system serving a population of 909 with 303 active connections. The water source for the North San Saba PWS comes from two groundwater wells completed in the Hickory aquifer, Well #1 (G2060003A) and Well #2 (G2060003B), to depths of 3488 and 3518 feet, respectively. Well 1 is rated at 70 gallons per minute (gpm) and Well 2 is capable of 10 gpm. Recently, Well #1 was acidified which increase the capacity from approximately 15 gpm to 70 gpm. This allowed Well #2 to be taken off line since the well has high levels of combined radium and gross alpha. It is unknown how much this affected the concentrations of combined radium gross alpha particle activity (gross alpha). Nevertheless, two water samples collected from Well #1 on May 20, 2008 were compliant with the gross alpha and combined radium MCLs. Additional laboratory tests are needed to verify that Well #1 has compliant water.

During the period of July 1998 to December 2008, the North San Saba PWS recorded gross alpha (minus uranium and radon) values between 15 picocuries per liter (pCi/L) and 389.5 pCi/L and combined radium (226 and 228) values were 2.7 pCi/L to 163.5 pCi/L. These values are at or above the 15 pCi/L MCL for gross alpha and 5 pCi/L MCL for combined radium (USEPA 2010a; TCEQ 2008a). Total dissolved solids (TDS) have also been detected in concentrations of 454 mg/l to 1409 mg/l, between January 2000 and December 2008, exceeding the secondary MCL of 500 milligram per liter (mg/L) (USEPA 2010a; TCEQ 2008b). Therefore, it is likely the North San Saba PWS faces potential compliance issues under the standards.

Basic system information for the North San Saba PWS is shown in Table ES.1.

Table ES.1 North San Saba PWS Basic System Information

Population served	909
Connections	303
Average daily flow rate	0.074 million gallons per day (mgd)
Peak demand flow rate	205.5 gallons per minute
Water system peak capacity	0.201 mgd
Typical gross alpha range	15 to 389.5 pCi/L
Typical combined radium range	2.7 to 163.5 pCi/L
Typical TDS range	454 to 1409 mg/L

STUDY METHODS

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

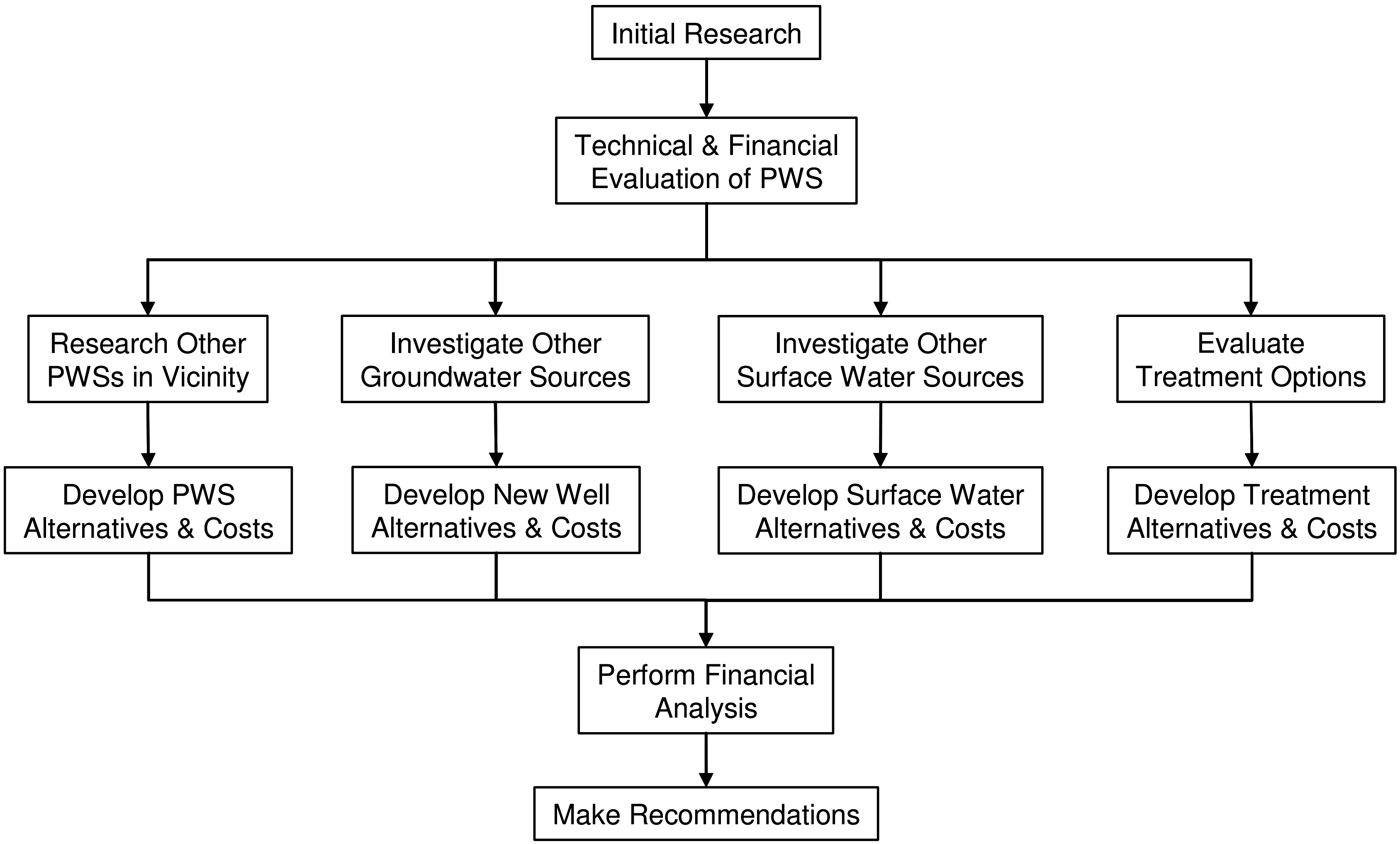
5. Assess each of the potential alternatives with respect to economic and non-economic criteria;
6. Prepare a feasibility report and present the results to the PWS.

This basic approach is summarized in Figure ES-1.

HYDROGEOLOGICAL ANALYSIS

The North San Saba PWS obtains groundwater from the Hickory aquifer. Gross alpha and combined radium are commonly found in area wells at concentrations greater than the MCLs. There are no other wells located within 6.2 miles of North San Saba PWS that have been analyzed for either gross alpha or combined radium isotope activities. There are four wells located to the east and northeast of San Saba that are compliant with the gross alpha MCL with values that range from less than 2.0 to 5.3 pCi/L. However, none of the wells have been analyzed for radium isotopes but they are likely compliant given the low gross alpha activities. Before being considered as possible alternative water sources, these wells would need to be tested for both gross alpha and combined radium as well as other constituents of concern. It may be possible to perform down-hole testing of the well to determine the source of the contaminants. If the contaminants derive primarily from a single part of the formation, that part could be excluded by modifying the existing wells, or avoided altogether by completing a new well.

Figure ES-1 Summary of Project Methods



COMPLIANCE ALTERNATIVES

The North San Saba Water Supply Corporation is governed by a seven-member Board of Directors. Overall, the system had an inadequate level of FMT capacity. There are several positive technical, managerial, and financial aspects of the water system, but there are also some areas of concern. The deficiencies noted could prevent the water system from being able to achieve compliance now or in the future and may also affect the water system's long-term sustainability. Areas of concern for the system included capacity deficiencies due to water loss, lack of redundant sources, lack of operating budget, compliance violations with combined radium and gross alpha, inadequate staffing, and lack of storage and pumping capacity.

There are several PWSs within 35 miles of North San Saba PWS. Many of these nearby systems also have water quality problems, 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. Systems within 35 miles that were identified as having good quality water and being potential water suppliers were Richland SUD, the City of Goldthwaite, and the City of San Saba.

Centralized treatment alternatives for radionuclide removal have been developed and were considered for this report, including reverse osmosis and Water Remediation Technologies, Inc. (WRT) Z-88 adsorption. 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 North San Saba PWS is likely to be the best solution if compliant groundwater can be found. Having a new well close to North San Saba PWS is likely to be one of the lower cost alternatives since the PWS already possesses the technical and managerial expertise needed to implement this option. The cost of new well alternatives quickly increases with pipeline length, making proximity of the alternate source a key concern. A new compliant well or obtaining water from a neighboring compliant PWS has the advantage of providing compliant water to all taps in the system.

Central treatment can be cost-competitive with the alternative of new nearby wells, but would require significant institutional changes to manage and operate. Similar to 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 North San Saba PWS indicated that current water rates are adequately funding current operations, but a rate increase may be necessary to undertake significant capital improvements. The current average water bill represents approximately 3.3 percent of the median household income (MHI). 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	$1021	3.4
To meet current expenses	NA	$872	2.9
Purchase water from the City of San Saba	100% Grant	$1021	3.4
	Loan/Bond	$1021	3.4
Central treatment	100% Grant	$1491	5.0
	Loan/Bond	$1621	5.4
Point-of-use	100% Grant	$1605	5.3
	Loan/Bond	$1664	5.5
Public dispenser	100% Grant	$1090	3.6
	Loan/Bond	$1099	3.7

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ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per liter
°F	Degrees Fahrenheit
AFY	Acre feet per year
ANSI	American National Standards Institute
BAT	Best available technology
BEG	Bureau of Economic Geology
bgs	Below ground surface
BWA	Brazosport Water Authority
CA	Chemical analysis
CD	Community Development
CDBG	Community Development Block Grants
CCN	Certificate of Convenience and Necessity
CFR	Code of Federal Regulations
CO	Correspondence
CR	County Road
CRMWD	Colorado River Municipal Water District
DE	Diatomaceous earth
DWSRF	Drinking Water State Revolving Fund
ED	Electrodialysis
EDAP	Economically Distressed Areas Program
EDR	Electrodialysis reversal
FMT	Financial, managerial, and technical
GAM	Groundwater Availability Model
gpd	gallons per day
gpm	Gallons per minute
gpy	Gallons per year
ISD	Independent School District
IX	Ion exchange
$KMnO_4$	Hydrous manganese oxide
MCL	Maximum contaminant level
mgd	Million gallons per day
mg/L	milligram per liter
MHI	Median household income
MnO_2	Manganese oxide
MOR	Monthly operating report
MTBE	methyl tertiary-butyl ether
NMEFC	New Mexico Environmental Financial Center

NPDWR	National Primary Drinking Water Regulations
O&M	Operation and Maintenance
Parsons	Parsons Transportation Group, Inc.
pCi/L	picoCuries per liter
POE	Point-of-entry
POU	Point-of-use
PRV	Pressure-reducing valve
PVC	Polyvinyl chloride
PWS	Public water system
RO	Reverse osmosis
RR	Ranch Road
RUS	Rural Utilities Service
SDWA	Safe Drinking Water Act
SH	State Highway
SRF	State Revolving Fund
SSCT	Small System Compliance Technology
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDRA	Texas Department of Rural Affairs
TDS	Total dissolved solids
TSS	Total suspended solids
TWDB	Texas Water Development Board
UGRA	Upper Guadalupe River Authority
USEPA	United States Environmental Protection Agency
WAM	Water Availability Model
WRT	Water Treatment Technologies, Inc.

SECTION 1
INTRODUCTION

The University of Texas Bureau of Economic Geology (BEG) and its subcontractor, Parsons Transportation 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.

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

This feasibility report provides an evaluation of water supply alternatives for the North San Saba Water Supply Corporation; PWS ID# 2060003 and Certificate of Convenience and Necessity [CCN] #11227). The North San Saba Water Supply Corporation is located approximately 8 miles northwest of Lampasas, Texas in San Saba County. The North San Saba PWS is a community water system serving a population of 909 with 303 active connections. The water source for the North San Saba PWS comes from two groundwater wells completed in the Hickory aquifer, Well #1 (G2060003A) and Well #2 (G2060003B), to depths of 3488 and 3518 feet, respectively. Well 1 is rated at 70 gallons per minute (gpm) and Well 2 is capable of 10 gpm.

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The location of the North San Saba PWS is shown on Figure 1.1. Various water supply and planning jurisdictions are shown on Figure 1.2. These water supply and planning jurisdictions are used in the evaluation of alternate water supplies that may be available in the area.

1.1 PUBLIC HEALTH AND COMPLIANCE WITH MCLs

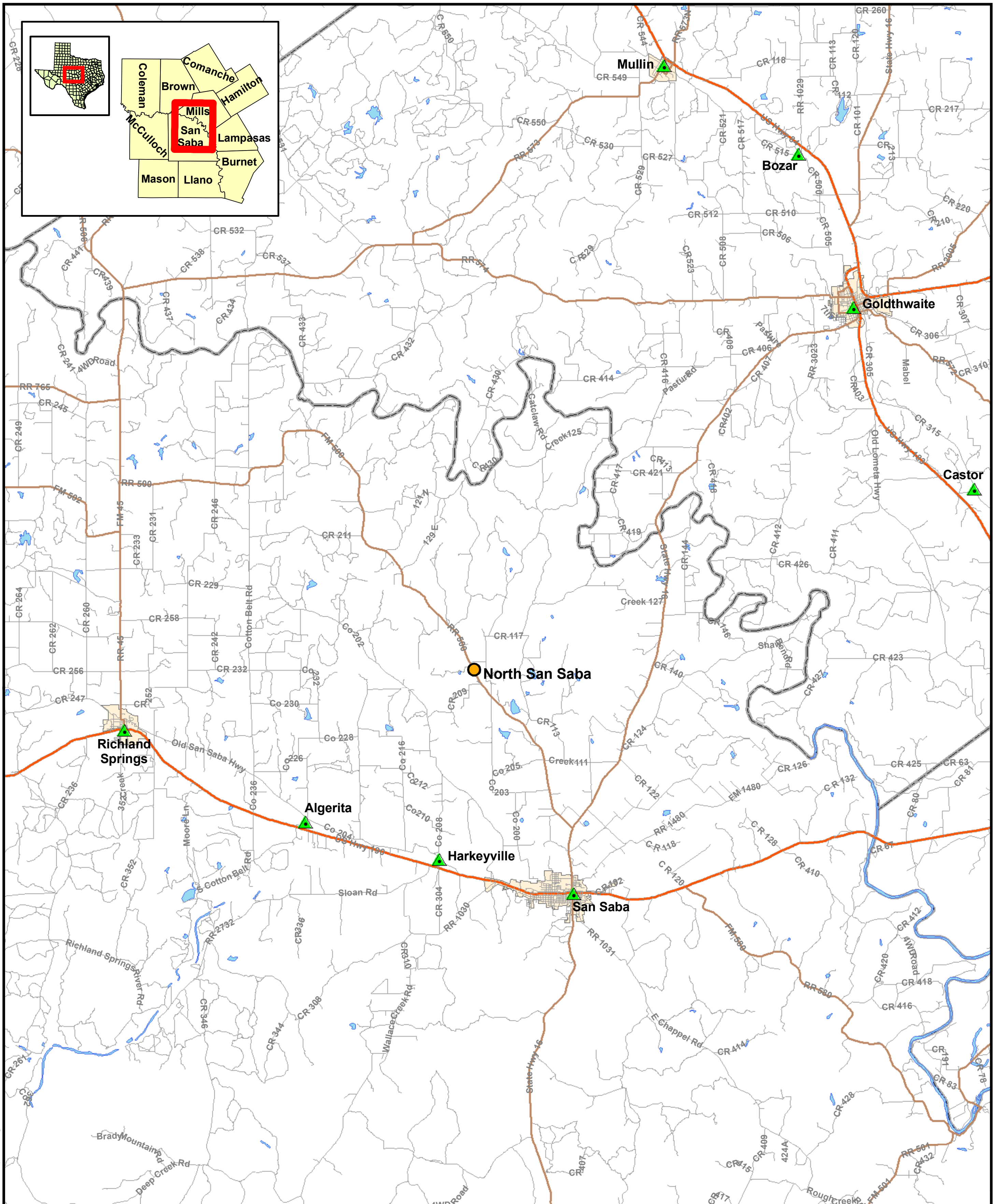
The goal of this project is to promote compliance for PWSs that supply drinking water exceeding regulatory maximum contaminant levels (MCL). This project only addresses those contaminants and does not address any other violations that may exist for a PWS. As mentioned above, the North San Saba water system had recent sample results exceeding the MCL for gross alpha and combined radium and the secondary MCL for TDS. In general, contaminant(s) in drinking water above the MCL(s) can have both short-term (acute) and long-term or lifetime (chronic) effects. Long-term ingestion of drinking water with any of the radionuclides (radium 226, radium 228, and/or gross alpha particle emitters) above the MCL may increase the risk of cancer (USEPA 2010b).

1.2 METHOD

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

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 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.



N

Miles

0 1.5 3

Legend

Study System	Interstate
Cities	Highway
City Limits	Major Road
Counties	Minor Road

Figure 1.1

NORTH SAN SABA

Location Map

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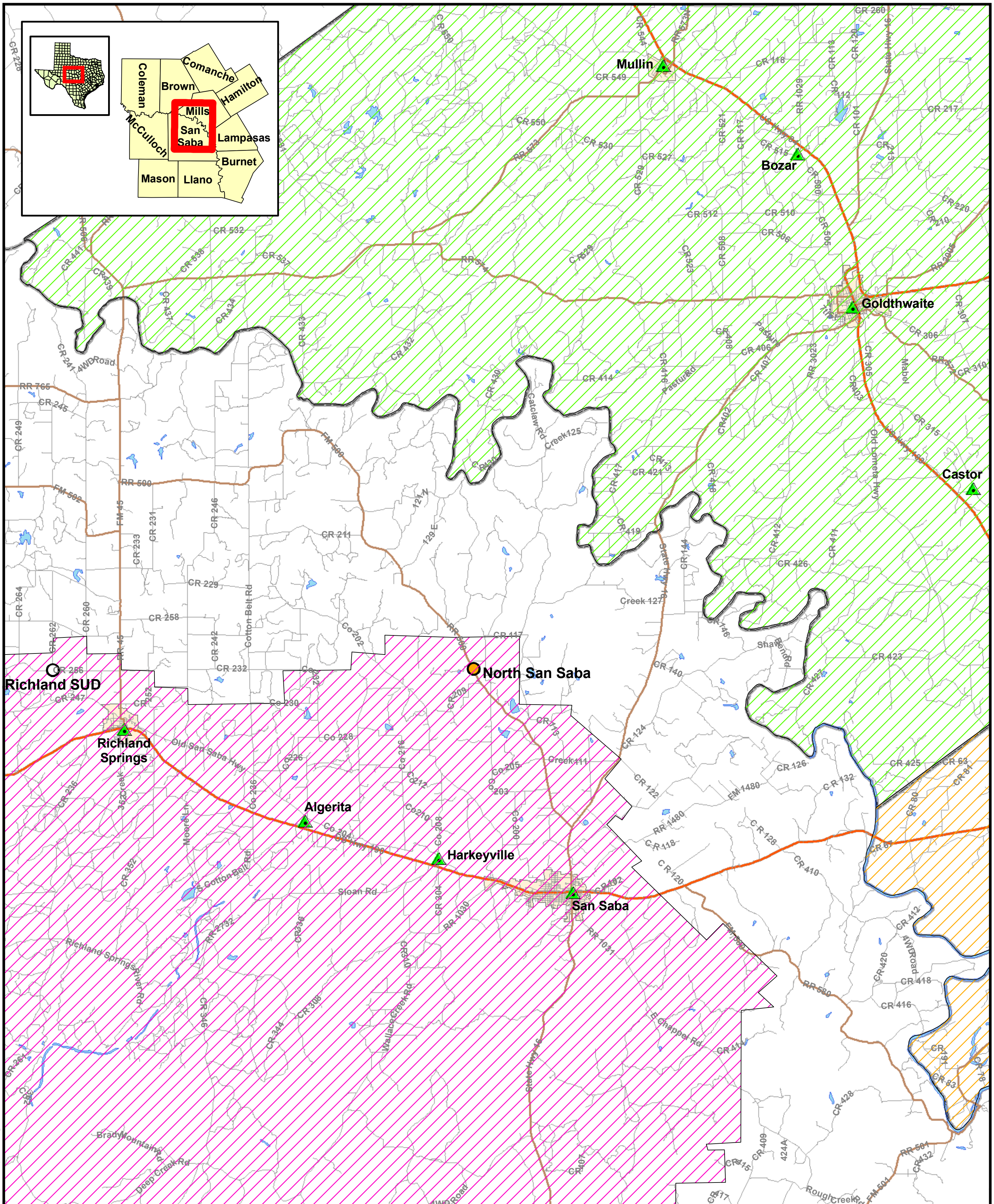


Legend

- Study System
- PWS's
- Cities
- City Limits
- Counties
- Interstate
- Highway
- Major Road
- Minor Road
- Fox Crossing Water District
- Hickory UWCD No. 1
- Saratoga UWCD

N

Miles
0 1.5 3

Figure 1.2

NORTH SAN SABA

Groundwater Conservation Districts

The remainder of Section 1 of this report addresses the regulatory background, and provides a summary of radium abatement options. Section 2 describes the method used to develop and assess compliance alternatives. The groundwater sources of combined radium and gross alpha are addressed in Section 3. Findings for the North San Saba PWS, 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 requirements of the Federal Safe Drinking Water Act (SDWA) 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

When a PWS exceeds a regulatory MCL, the PWS must take action to correct the violation. Potential MCL exceedances at the North San Saba PWS involve combined radium and gross alpha. 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 PWS as a potential supplier, 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-compliant community could pay for the facilities necessary to increase the quantity to the extent necessary to supply the needs of the non-compliant PWS. Potential improvements might include, but are not limited to:

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

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

1.4.1.2 Quality

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

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

1.4.2 Potential for New Groundwater Sources

1.4.2.1 Existing Non-Public Supply Wells

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

- Existing data sources (see below) will be used to identify wells in the areas that have satisfactory quality. For the North San Saba PWS, the following standards could be used in a rough screening to identify compliant groundwater in surrounding systems:
    - Nitrate (measured as nitrogen) concentrations less than 8 milligram per liter (mg/L) (below the MCL of 10 mg/L);
    - Fluoride concentration less than 2.0 mg/L (below the Secondary MCL of 2 mg/L);
    - Arsenic concentration less than 0.008 mg/L (below the MCL of 0.01 mg/L);
    - Uranium concentration less than 0.024 mg/L (below the MCL of 0.030 mg/L; and
    - Selenium concentration less than 0.04 mg/L (below the MCL of 0.05 mg/L).
- The recorded well information will be reviewed 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.
- Wells of sufficient size are identified. Some may be 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, additional data should be collected to characterize the quality and quantity of the well water. Many owners have more than one well, and

would probably be the best source of information regarding the latest test dates, who tested the water, flowrates, and other well characteristics.

- After collecting as much information as possible from cooperative owners, the non-compliant PWS would then narrow the selection of wells and sample and analyze them for quality. Wells with good quality water 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 that location would be suitable as a supply source.
- If financial resources allow, 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 is identified, landowners 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 landowners to indicate potential treatment plant locations.
- Coordination with U.S. Army Corps of Engineers and local river authorities.
- Preliminary engineering design to determine the feasibility, costs, and environmental issues of a new treatment plant.

Should these discussions indicate that the best option is a new surface water source, 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 reduction of radium and gross alpha to regulatory levels (*i.e.*, MCLs). The reduction of gross alpha activity typically is achieved by reducing radium, which appears to be responsible for a major part of the gross alpha activity of the groundwater. Radium-226 and Radium-228 are cations (Ra^{2+}) dissolved in water and are not removed by particle filtration. A 2002 USEPA document (*Radionuclides in Drinking Water: A Small Entity Compliance Guide, EPA 815-R-02-001*) lists a number of small system compliance technologies that can remove radium (combined radium-226 and radium-228) from water. These technologies include ion exchange, reverse osmosis (RO), electrodialysis/electrodialysis reversal (ED/EDR), lime softening, greensand filtration, re-formed hydrous manganese oxide filtration ($KMnO_4$-filtration), and co-precipitation with barium sulfate. A relatively new process using the Water Remediation Technologies, Inc. (WRT) Z-88 media that is specific for radium adsorption has been demonstrated to be an effective radium removal technology. Lime softening and co-precipitation with barium sulfate are technologies that are relatively complex and require chemistry skills that are not practical for small systems with limited resources and hence they are not evaluated further.

1.4.5 Description of Treatment Technologies

The application of radium removal treatment technologies includes ion exchange (IX), WRT-Z-88 media adsorption, RO, ED/EDR, and $KMnO_4$-greensand filtration. A description of these technologies follows.

1.4.5.1 Ion Exchange

Process – In solution, salts separate into positively charged cations and negatively charged anions. Ion exchange is a reversible chemical process in which ions from an insoluble, permanent, solid resin bed are exchanged for ions in the water. The process is based on the preferential adsorption of specific ions 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 (IX). When the resin becomes saturated with the contaminant ions, the bed must be regenerated by passing or pumping a concentrated sodium chloride solution over the resin, displacing the contaminant ions with sodium ions for cation exchange resins and chloride ions for anion exchange resins. Many different types of resins can be used depending on the specific contaminant to be removed.

The IX treatment train for groundwater typically consists of an ion exchange system containing cation or anion resin, chlorine disinfection, and clear well storage. The ion exchange system has provisions for regeneration with salt (sodium chloride) and generates approximately 2 to 4 percent of waste or "spent" regeneration solutions. Treatment trains for surface water may also include raw water pumps, debris screens, and filters for pre-treatment. Additional treatment or management of the spent regeneration salt solutions and the removed solids will be necessary prior to disposal, especially for radium removal resins that have elevated radioactivity.

For radium removal, a strong acid cation exchange resin in the sodium form can remove 95-99 percent of the radium. The strong acid resin has less capacity for radium on water with high hardness and it has the following adsorption preference: $Ra^{2+} > Ba^{2+} > Ca^{2+} > Mg^{2+} > Na^{+}$. Because of the selectivity radium and barium are much more difficult to remove from the resin during regeneration than calcium and magnesium. Economical regeneration removes most of the hardness ions, but radium and barium buildup on the resin after repeated cycles to the point where equilibrium is reached and then radium and barium will begin to breakthrough shortly after hardness. Regeneration of the sodium form strong acid resin for water with 200 mg/L of hardness with application of 6.5 lb NaCl/ft^3 resin would produce 2.4 bed volumes (BV) of 16,400 mg/L TDS brine per 100 BV of product water. This results in waste liquids equaling about 2.4% of the volume of water treated. The radium concentration in the regeneration waste would be approximately 40 times the influent radium concentration in groundwater.

The strong acid cation exchange process produces a pleasing water supply that reduces scaling in pipes. However, it increases an average daily sodium intake by 200 to 400 mg compared to an estimated average daily intake of 2,000 to 7,000 mg. Increased sodium levels from all sodium chloride regenerated ion exchange process are a concern to some people, particularly those on low salt diets, but in most cases the increase will amount to no more than approximately 10% of the average dietary intake of sodium.

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.

Maintenance – The IX resin requires regular on-site regeneration, the frequency of which depends on raw water characteristics (especially hardness), 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 with radioactivity); occasional solids waste (in the form of broken resin beads) backwashed during regeneration; and if used, spent filters and backwash wastewater.

Advantages

- Well established process for radium removal.
- Fully automated and highly reliable process.
- Suitable for small and large installations.
- Operates on demand
- Relatively insensitive to source water pH.

Disadvantages

- Requires salt storage; regular regeneration.

- Generates a brine liquid waste requiring disposal.
- Liquid spent regenerate brine can contain high levels of radium.
- Resins are sensitive to the presence of competing ions such as calcium and magnesium, which reduce the effectiveness for radium removal.

In considering application of IX for inorganic, it is important to understand what the effect of competing ions will be, and to what extent the brine can be recycled. Conventional IX cationic resin removes calcium and magnesium in addition to radium and thus the capacity for radium removal and frequency of regeneration depend on the hardness of the water to be treated. Spent regenerant is produced during IX bed regeneration, and it may have concentrations of the sorbed contaminants that would be expensive to treat and/or dispose because of hazardous waste regulations.

1.4.5.2 WRT Z-88 Media

Process – The WRT Z-88 radium treatment process is a proprietary process using a radium specific adsorption resin or zeolite supplied by WRT. The Z-88 process is similar to IX except that the radium ions are irreversibly adsorbed or attached to the Z-88 resin and no regeneration is conducted. The resin is disposed upon exhaustion. The Z-88 does not remove calcium and magnesium and thus it can last for a long time relative to conventional IX (two to three years according to WRT) before replacement is necessary. The process is operated in an upflow, fluidized mode with a surface loading rate of 10.5 gallons per minute per square foot. Pilot testing of this technology has been conducted successfully for radium removal in many locations including in the State of Texas. Seven full-scale systems with capacities of 750 to 1,200 gallons per minute (gpm) have been constructed in the Village of Oswego, Illinois since July 2005. The treatment equipment is owned by WRT and the ownership of spent media would be transferred to an approved disposal site. The customer pays WRT based on an agreed upon treated water unit cost (*e.g.,* $1.00-6.70/kgal, depending on water characteristics, flow Dow Chemical Company produces a radium selective complexer resin (DOWEX RSC) that has similar characteristics.

Pretreatment – Pretreatment may be required to reduce excess amounts of TSS, iron, and manganese that could plug the resin bed. Pretreatment typically includes media or carbon filtration. No chemical addition is required for radium removal.

Maintenance – Maintenance is relatively low for this technology as no regeneration or chemical handling is required. Periodical water quality monitoring and inspection of mechanical equipment are required.

Waste Disposal – The Z-88 media would be disposed in an approved low-level radioactive waste landfill by WRT once every two to three years. No liquid waste is generated for this process. However, if pretreatment filters are used then spent filters and backwash wastewater disposal is required. Generally since WRT owns the equipment and adsorption media, communities are not responsible for disposal of the spent media.

Advantages

- Simple and fully automated process.
- No liquid waste disposal.
- No chemical handling, storage, or feed systems.
- No change in water quality except radium reduction.
- Low capital cost as WRT owns the equipment.

Disadvantages

- Relatively new technology.
- Proprietary technology without much direct competition.
- Long term contract with WRT required.

From a small utilities point of view the Z-88 process is a desirable technology for radium removal as an operation and maintenance (O&M) effort is minimal and no regular liquid waste is generated. The performance is guaranteed by WRT allowing the financial risk to a community to be minimized.

1.4.5.3 Reverse Osmosis

Process – RO is a pressure-driven membrane separation process capable of removing dissolved solutes from water by means of ion 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 and hollow fine fiber but most RO systems to date are of the spiral wound type. A typical RO installation includes a high pressure feed pump with chemical feed, parallel first and second stage membrane elements in pressure vessels, and 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 95 percent removal of radium. The treatment process is relatively insensitive to pH. Water recovery is 60-80 percent, depending on the raw water characteristics. This means that for every 100 gallons of water entering the system, 60 to 80 gallons of product water and 20 to 40 gallons of “concentrate” or waste are produced. Disposal of the concentrate can have a significant cost depending on options available.

The RO process is not selective for radium and gross alpha removal. A majority of salts and dissolved materials in the water are removed. This is an advantage if the water has high concentrations of total dissolved solids (TDS).

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. Iron and manganese must be removed prior to RO. Pretreatment can include media filters, ion exchange softening, acid and antiscalant feed, activated carbon or 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 required approved disposal methods. The disposal of the significant volume of the concentrate stream is a problem for many utilities.

Advantages

- Can remove radium effectively.
- Can remove other undesirable dissolved constituents.

Disadvantages

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

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

1.4.5.4 Electrodialysis/Electrodialysis Reversal

Process – Electrodialysis is an electrochemical separation process in which ions migrate through ion-selective semi-permeable membranes as a result of their attraction to two electrically charged electrodes. The driving force for ion transfer is direct electric current. ED is different from RO in that it removes only dissolved inorganics but not particulates, organics, and silica. Electrodialysis reversal is an improved form of ED in which the polarity of the direct current is changed approximately every 15 minutes. The change of polarity helps to reduce the formation of scale and fouling films and thus a higher water recovery can be achieved. EDR has been the dominant form of ED system used for the past 25-30 years. A typical EDR system includes a membrane stack with a number of cell pairs, each consisting of a cation transfer membrane, a demineralized water flow spacer, an anion transfer membrane, and a concentrate flow spacer. Electrode compartments are at opposite ends of the stack. The influent feed water (chemically treated to prevent precipitation) and concentrate reject flow in parallel across the membranes and through the demineralized water and concentrate flow spacers, respectively. The electrodes are continually flushed to reduce fouling or scaling. Careful consideration of flush feed water is required. Typically, the membranes are cation or anion exchange resins cast in sheet form; the spacers are high-density polyethylene; and the electrodes are inert metal. EDR stacks are tank-contained and often staged. Membrane selection is based on review of raw water characteristics. A single-stage EDR system usually removes 40-50 percent of the dissolved salts including radium, and multiple stages may be required to meet the MCL if radium concentration is high. The conventional EDR treatment train typically includes EDR membranes, chlorine disinfection, and clearwell storage.

<u>Pretreatment</u> – Guidelines are available on acceptable limits on pH, organics, turbidity, and other raw water characteristics. EDR typically requires acid and antiscalant feed to prevent scaling and a cartridge filter for prefiltration. Treatment of surface water may also require pretreatment steps such as raw water pumps, debris screens, rapid mix with addition of a coagulant, flocculation basin, sedimentation basin or clarifier, and gravity filters. Microfiltration could be used in place of flocculation, sedimentation, and filtration.

<u>Maintenance</u> – EDR membranes are durable, can tolerate pH from 1-10, and temperatures to 115°F for cleaning. The can be removed from the unit and scrubbed. Solids can be washed off by turning the power off and letting water circulate through the stack. Electrode washes flush out byproducts of electrode reaction. The byproducts are hydrogen, formed in the cathode space, and oxygen and chlorine gas, formed in the anode spacer. If the chlorine is not removed, toxic chlorine gas may form. Depending on raw water characteristics, the membranes will require regular maintenance or replacement. If used, pretreatment filter replacement and backwashing will be required. The EDR stack must be disassembled, mechanically cleaned, and reassembled at regular intervals.

<u>Waste Disposal</u> – Highly concentrated reject flows, electrode cleaning flows, and spent membranes require approved disposal methods. Pretreatment process residuals and spent materials also require approved disposal methods.

Advantages

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

Disadvantages

- Not specific to radium, also removes many TDS constituents.
- Not suitable for high levels of iron, manganese, hydrogen sulfide, and hardness.

- Relatively expensive process and high-energy consumption.
- Does not remove particulates, organics, or silica.

EDR can be quite expensive to run because of the energy it uses. If radium removal is the only purpose it is probably more expensive than other technologies. However, if nitrate and/or TDS removal is also required, then EDR is a competitive process.

1.4.5.5 Potassium Permanganate Greensand Filtration

Process – Manganese dioxide, (MnO_2) has capacity to adsorb radium from water. MnO_2 can be formed by oxidation of Mn^{2+} occurring in natural waters and/or reduction of potassium permanganate ($KMnO_4$) added to the water. The MnO_2 is in the form of colloidal MnO_2, which has a large surface area for adsorption. The MnO_2 does not adsorb calcium and magnesium so hardness is not a factor but iron and manganese and other heavy metal cations can compete strongly with radium adsorption. If these cations are present it would be necessary to install a good iron and manganese removal process before the MnO_2- filtration process to ensure that MnO_2 is still available for radium sorption. The $KMnO_4$-greensand filtration process can accomplish this purpose as the greensand is coated with MnO_2, which is regenerated by the continuous feeding of $KMnO_4$. Many operating treatment systems utilizing continuous feed $KMnO_4$, 30-minute contact time, and manganese greensand remove radium to concentrations below the MCL. The treatment system equipment includes a $KMnO_4$ feed system, a pressurized reaction tank, and a manganese greensand filter. Backwashing of the greensand filter is usually required but periodic regeneration is not required. The overall radium removal is typically 65 to 95%.

Pretreatment – The $KMnO_4$-greensand filtration process usually does not require pretreatment except if the turbidity is very high. The greensand filter usually has an anthracite layer to filter larger particles while the greensand adsorbs dissolved cations such as radium.

Maintenance – The greensand requires periodic backwashing to rid of suspended materials and metal oxides. $KMnO_4$ is usually supplied in the powder form and preparation of $KMnO_4$ solution is required. Occasional monitoring to ensure no overfeeding of $KMnO_4$ (pink water) is important to avoid problems in distribution system and household fixtures.

Waste Disposal – Approval from local authorities is usually required for the backwash wastewater. If local sewer is not available, a backwash water storage and settling tank would be required to recycle settled water to the process and disposed of the settled solids periodically.

Advantages

- Well established process for radium removal.
- No regeneration waste generated.
- Low-pressure operation and no repumping required.
- No additional process for iron and manganese removal.

Disadvantages

- Need to handle powdered KMnO4, which is an oxidant.
- Need to monitor and backwash regularly.
- Need to manage backwash
- Disposal of settled solids is required.
- Limited effectiveness if $KMnO_4$ is under dosed.

The $KMnO_4$-greensand filtration is a well-established iron and manganese removal process and is effective for radium removal. It is suitable for small and large systems and is cost competitive with other alternative technologies.

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

Point-of-entry (POE) and Point-of-use (POU) treatment devices or systems rely on many of the same treatment technologies used in central treatment plants. However, while central treatment plants treat all water distributed to consumers to the same level, POU and POE treatment devices are designed to treat only a portion of the total flow. POU devices treat only the water intended for direct consumption, typically at a single tap or limited number of taps, while POE treatment devices are typically installed to treat all water entering a single home, business, school, or facility. POU and POE treatment systems may be an option for PWSs where central treatment is not affordable. Updated USEPA guidance on use of POU and POE treatment devices is provided in "*Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems,"* EPA 815-R-06-010, April 2006 (USEPA 2006).

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

The National Primary Drinking Water Regulations (NPDWR), 40 CFR Section 141.100, covers criteria and procedures for PWSs using POE devices and sets limits on the use of these devices. According to the regulations (July 2005 Edition), the PWS must develop and obtain TCEQ approval for a monitoring plan before POE devices are installed for compliance with an MCL. Under the plan, POE devices must provide health protection equivalent to central water treatment meaning the water must meet all NPDWR and would be of acceptable quality similar to water distributed by a well-operated central treatment plant. In addition, monitoring must include physical measurements and observations such as total flow treated and mechanical condition of the treatment equipment. The system would have to track the POE flow for a given time period, such as monthly, and maintain records of device inspection. The monitoring plan should include frequency of monitoring for the contaminant of concern and number of units to be monitored. For instance, the system may propose to monitor every POE device during the first year for the contaminant of concern and then monitor one-third of the units annually, each on a rotating schedule, so each unit would be monitored every three years. To satisfy the requirement that POE devices must provide health protection, the water system may be required to conduct a pilot study to verify the POE device can provide treatment equivalent to central treatment. Every building connected to the system must have a POE device installed, maintained, and properly monitored. Additionally, TCEQ must be assured that every building is subject to treatment and monitoring, and that the rights and responsibilities of the PWS customer convey with title upon sale of property.

Effective technology for POE devices must be properly applied under the monitoring plan approved by TCEQ and the microbiological safety of the water must be maintained. TCEQ requires adequate certification of performance, field testing and, if not included in the certification process, a rigorous engineering design review of the POE devices. The design and application of the POE devices must consider the tendency for increase in heterotrophic bacteria concentrations in water treated with activated carbon. It may be necessary to use frequent backwashing, post-contactor disinfection, and Heterotrophic Plate Count monitoring to ensure that the microbiological safety of the water is not compromised.

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. The requirements associated with these regulations, relevant to MCL compliance 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 would 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 issued product standards for a specific type of POU or POE treatment unit, only those units that have been independently certified according to those standards may be used as part of a compliance strategy.

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

- If POU devices are used as an SDWA compliance strategy, certain consumer behavioral changes 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 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., showerheads).
- 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).

SECTION 2
EVALUATION METHOD

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 that 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 CCN number. The PWS identification number is used to retrieve four types of files:

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

Figure 2.1
TREE 1 – EXISTING FACILITY ANALYSIS

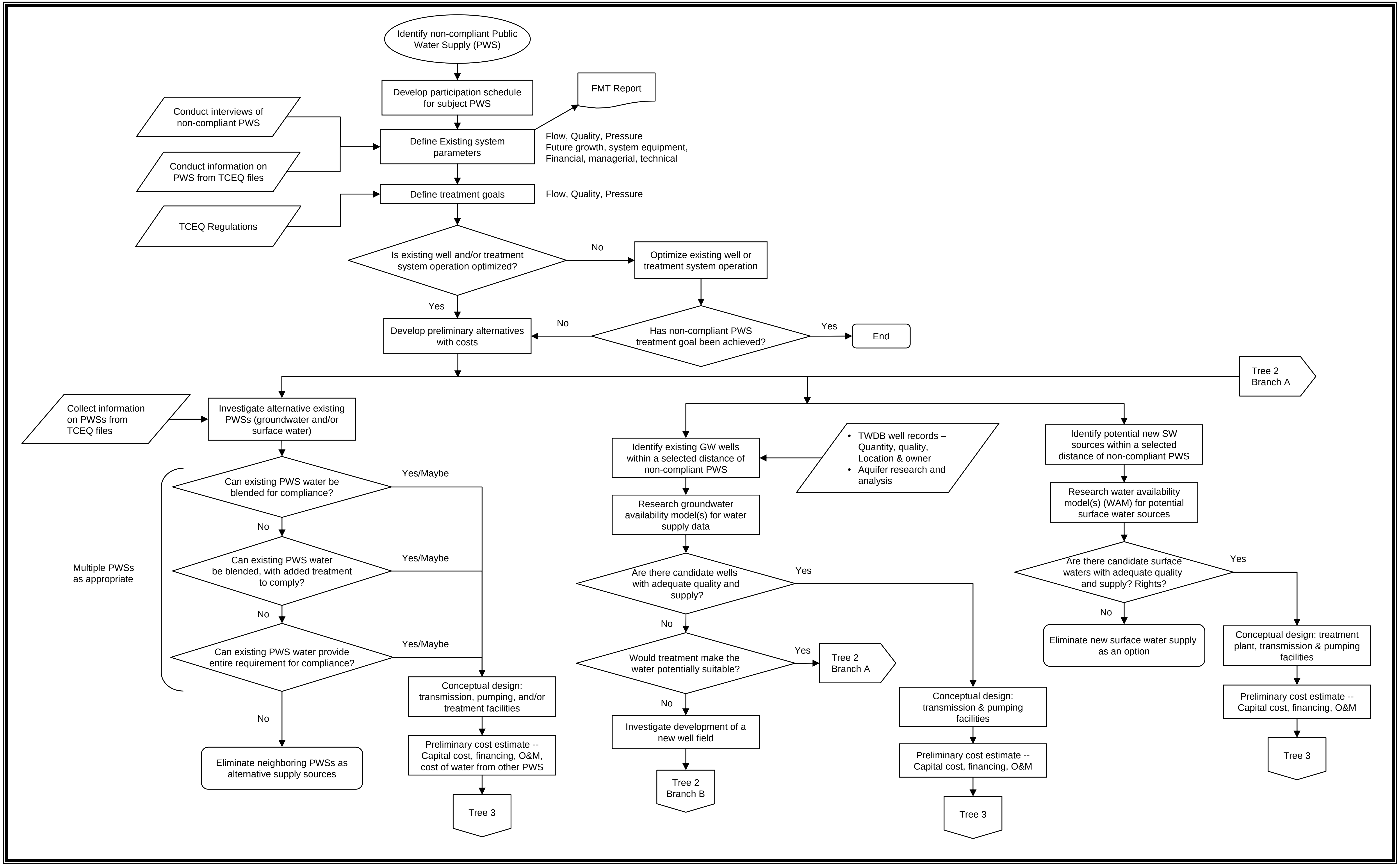
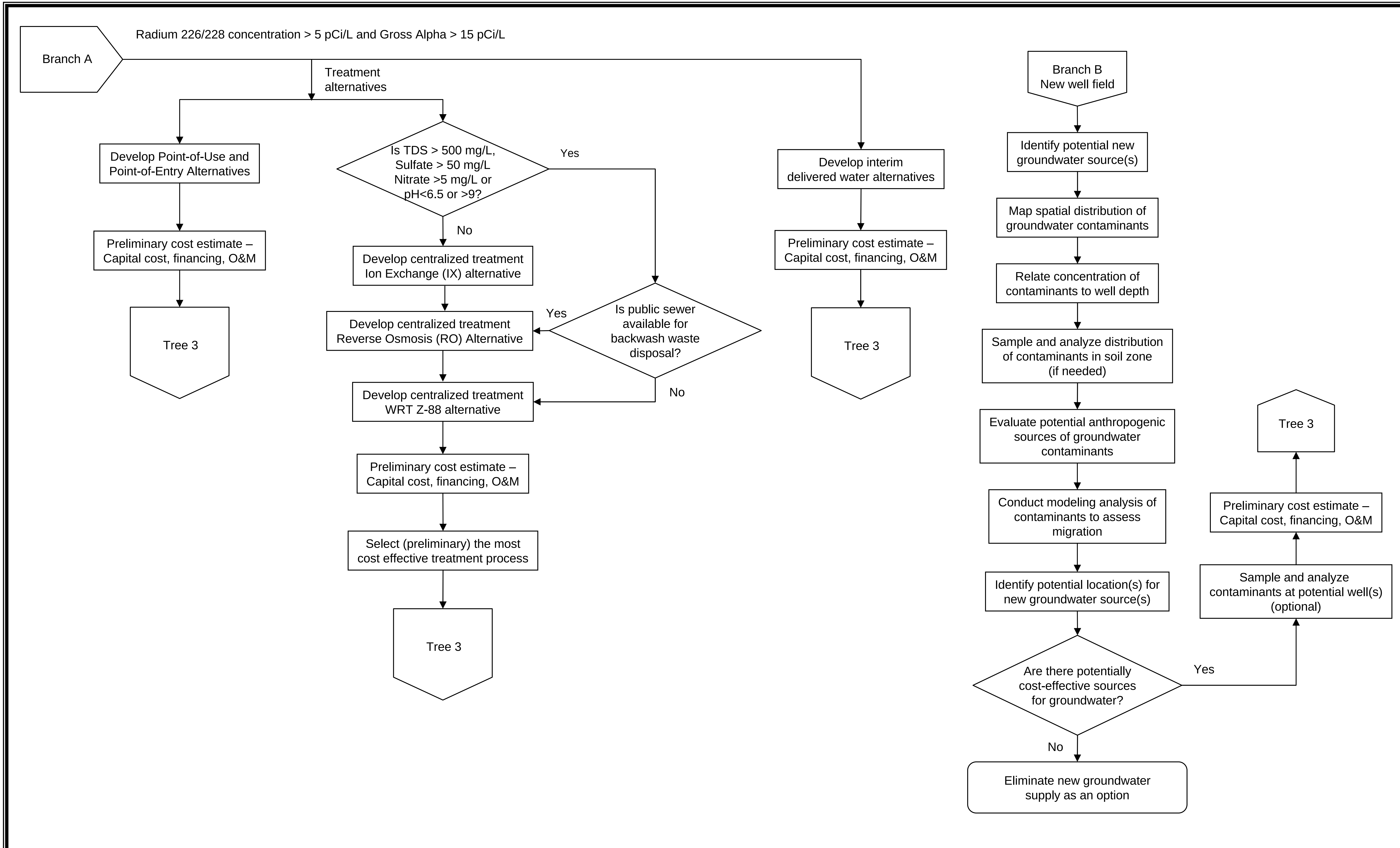


Figure 2.2
TREE 2 – DEVELOP TREATMENT ALTERNATIVES



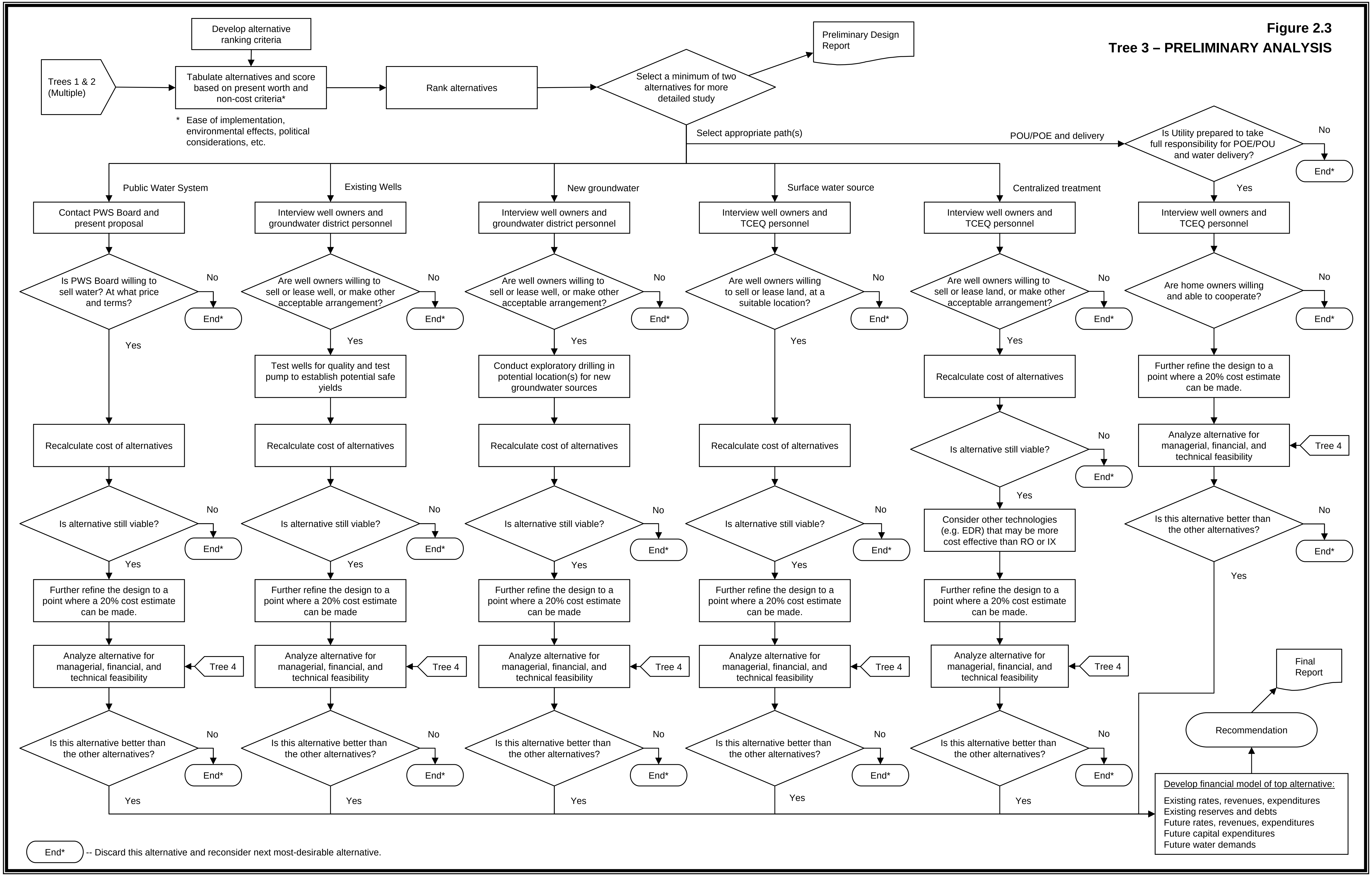
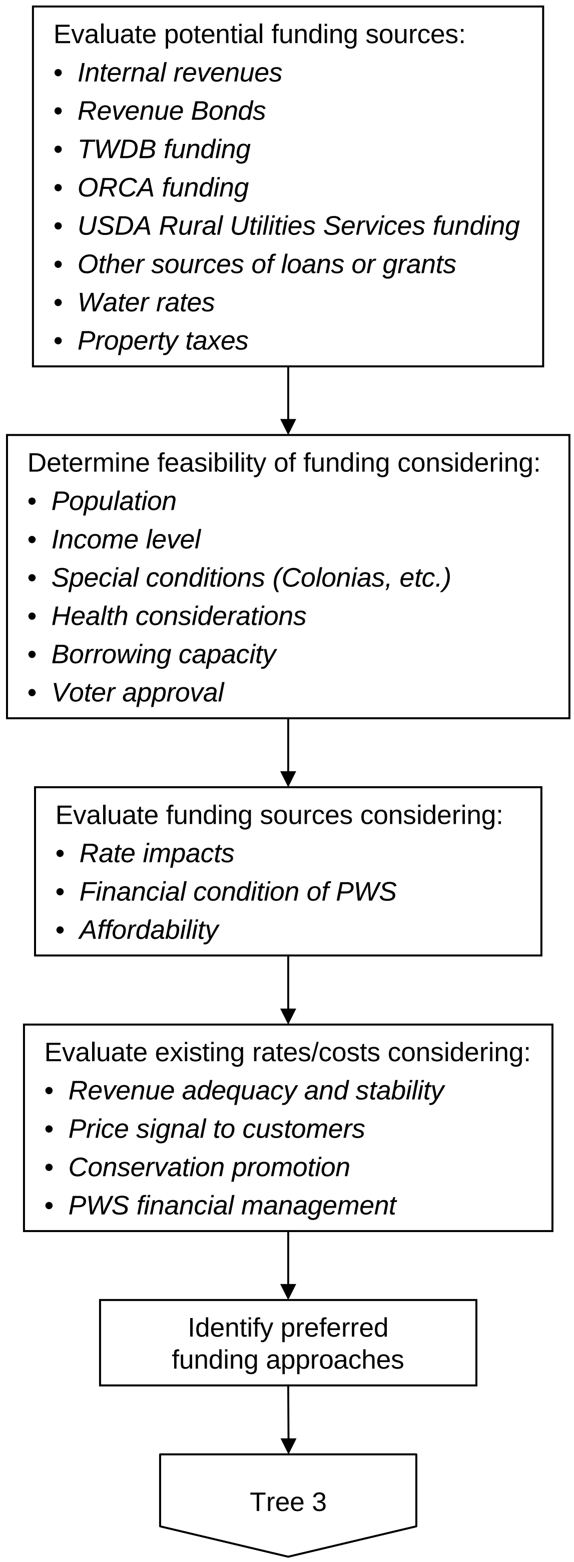


Figure 2.3
Tree 3 – PRELIMINARY ANALYSIS

Figure 2.4
TREE 4 – FINANCIAL



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

These files were reviewed for the PWS and surrounding systems.

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

- Texas Commission on Environmental Quality
  www3.tceq.state.tx.us/iwud/.
- USEPA Safe Drinking Water Information System
  www.epa.gov/safewater/data/getdata.html

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

2.2.1.2 Existing Wells

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

2.2.1.3 Surface Water Sources

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

2.2.1.4 Groundwater Availability Model

GAMs are numerical computer models of the major and minor Texas aquifers developed by the TWDB to assess groundwater availability over a 50-year planning period, and the possible effects of various proposed water management strategies on the aquifer systems. Groundwater availability data for the Hickory, Ellenburger-San Saba and Marble Falls aquifers in central Texas were used to identify potential new groundwater resources for the PWS.

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 one 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

An evaluation of existing data will yield an up-to-date assessment of the financial condition of the water system. As part of a site visit, financial data were collected in various forms such as electronic files, hard copy documents, and focused interviews. Data sought included:

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

2.2.1.7 Demographic Data

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

2.2.2 PWS Interviews

2.2.2.1 PWS Capacity Assessment Process

Capacity assessment is the industry standard term for evaluation of a water system's FMT capacity to effectively deliver safe drinking water to its customers now and in the future at a reasonable cost, and to achieve, maintain and plan for compliance with applicable regulations. The assessment process involves interviews with staff and management who have a responsibility in the operations and 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 SDWA regulations. Financial capacity refers to the financial resources of the water system, including but not limited to, revenue sufficiency, credit worthiness, and fiscal controls.

Managerial capacity is the ability of a water system to conduct its affairs so the system is able to achieve and maintain compliance with SDWA requirements. Managerial capacity refers to the management structure of the water system, including but not limited to, ownership accountability, staffing and organization, and effective relationships with 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 operation. A system that is able to meet both its immediate and long-term challenges demonstrates that it has sufficient FMT capacity.

Assessment of 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 method was developed from work the NMEFC did while assisting USEPA Region 6 in developing and piloting groundwater comprehensive performance evaluations. The NMEFC developed a standard list of questions that could be asked of water system personnel. The list was then tailored slightly to have two sets of questions – one for managerial and financial personnel, and one for operations personnel (the questions are included in Appendix A). Each person with a role in the FMT capacity of the system was asked the applicable standard set of questions individually. The interviewees were not given the questions in advance and were not told the answers others provided. Also, most of the questions are open-ended type questions so they were not asked in a fashion to indicate what would be the "right" or "wrong" answer. The interviews lasted between 45 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 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 the most promising for implementation. Once the possible alternatives are identified, they must be defined in sufficient detail so a conceptual cost estimate (capital and O&M costs) can be developed. These conceptual cost estimates are used to compare the affordability of compliance alternatives, and to give a preliminary indication of rate impacts. Consequently, these costs are pre-planning level and should not be viewed as final estimated costs for alternative implementation. The basis for the unit costs used for the compliance alternative cost estimates is summarized in Appendix B. Other non-economic factors for the alternatives, such as reliability and ease of implementation, are also addressed.

2.3.1 Existing PWS

The neighboring PWSs were identified, and the extents of their systems were investigated. PWSs farther than 35 miles from the non-compliant PWSs were not considered because the length of the pipeline required would make the alternative cost prohibitive. The quality of water provided was also investigated. For neighboring PWSs with compliant water, options for water purchase and/or expansion of existing well fields were considered. The neighboring PWSs with non-compliant water were considered as possible partners in sharing the cost for obtaining compliant water either through treatment or developing an alternate source.

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

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

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

2.3.2 New Groundwater Source

It was not possible in the scope of this project to determine conclusively whether new wells could be installed to provide compliant drinking water. To evaluate potential new groundwater source alternatives, three test cases were developed based on distance from the PWS intake point. The test cases were based on distances of 10 miles, 5 miles, and 1 mile. It was assumed 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 also considered. Availability of adequate quality water from rivers and major reservoirs in the surrounding area were investigated. TCEQ WAMs were inspected, and the WAM was run, where appropriate.

2.3.4 Treatment

Treatment technologies considered potentially applicable to radium removal are IX, WRT Z-88™ media, RO, EDR, and $KMnO_4$-greensand filtration. RO and EDR are membrane processes that produce a considerable amount of rejected liquid waste. As a result, more water needs to be pumped than that which is introduced into the distribution system. This disadvantage is somewhat offset by split treatment of the raw water wherein a fraction of the water is treated through the RO unit, and is then blended back to the raw source water. In the case of North San Saba PWS, because of the high radium concentrations, practically the entire flow must be treated through RO. The TDS can range up to 1,400 mg/L; thus adding an extra incentive for RO treatment, which would remove the TDS and improve the organoleptic properties of the water. WRT Z-88™ media is considered an alternative central treatment technology. The treatment units are 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-economical 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 is to determine the financial impact of implementing compliance alternatives, primarily by examining the required rate increases, and also the fraction of household income that water bills represent. The current financial situation of the non-compliant PWS is also reviewed to determine what rate increases are necessary to achieve or maintain long-term financial viability.

2.4.1 Financial Feasibility

A key financial metric is the comparison of average annual household water bill for a PWS customer to the MHI for the area. MHI data from the 2000 Census are used, at the most detailed level available for the community. Typically, county level data are used for small rural water utilities due to small population sizes. Annual water bills are determined for existing, base conditions, including consideration of additional rate increases needed under current conditions. Annual water bills are also calculated after adding incremental capital and operating costs for each of the alternatives to determine feasibility under several potential funding sources. It has been suggested by agencies such as USEPA that federal and state programs consider several criteria to determine "disadvantaged communities" with one based on the typical residential water bill as a percentage of MHI.

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

- Current Ratio = current assets (liquid assets that could be readily converted to cash) divided by current liabilities (accounts payable, accrued expenses, and other short-term financial obligations) provides insight into the ability to meet short-term payments. For a healthy utility, the value should be greater than 1.0.
- Debt to Net Worth Ratio = total debt (total amount of long-term debt) divided by net worth (total assets minus total liabilities) shows to what degree assets of the company have been funded through borrowing. A lower ratio indicates a healthier condition.
- Operating Ratio = total operating revenues divided by total operating expenses show the degree to which revenues cover ongoing expenses. The value is greater than 1.0 if the utility is covering its expenses.

2.4.2 Median Household Income

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

2.4.3 Annual Average Water Bill

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

2.4.4 Financial Plan Development

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

- Accounts and consumption data
- Water tariff structure
- Beginning available cash balance
- Sources of receipts:
    - Customer billings
    - Membership fees
    - Capital Funding receipts from:
        - Grants
        - Proceeds from borrowing
- Operating expenditures:
    - Water purchases
    - Utilities
    - Administrative costs
    - Salaries
- Capital expenditures
- Debt service:

    - Existing principal and interest payments
    - Future principal and interest necessary to fund viable operations
- Net cash flow
- Restricted or desired cash balances:
    - Working capital reserve (based on 1-4 months of operating expenses)
    - Replacement reserves to provide funding for planned and unplanned repairs and replacements

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

2.4.5 Financial Plan Results

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

2.4.5.1 Funding Options

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

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

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

- Grant funds for 100 percent of required capital. In this case, the PWS is only responsible for the associated O&M costs.
- Grant funds for 75 percent of required capital, with the balance treated as if revenue bond funded.
- Grant funds for 50 percent of required capital, with the balance treated as if revenue bond funded.
- State revolving fund loan at the most favorable available rates and terms applicable to the communities.

- If local MHI > 75 percent of state MHI, standard terms, currently at 3.8 percent interest for non-rated entities. Additionally:
    - If local MHI = 70-75 percent of state MHI, 1 percent interest rate on loan.
    - If local MHI = 60-70 percent of state MHI, 0 percent interest rate on loan.
    - If local MHI = 50-60 percent of state MHI, 0 percent interest and 15 percent forgiveness of principal.
    - If local MHI less than 50 percent of state MHI, 0 percent interest and 35 percent forgiveness of principal.
- Terms of revenue bonds assumed to be 25-year term at 6.0 percent interest rate.

2.4.5.2 General Assumptions Embodied in Financial Plan Results

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

- No account growth (either positive or negative).
- No change in estimate of uncollectible revenues over time.
- Average consumption per account unchanged over time.
- No change in unaccounted for water as percentage of total (more efficient water use would lower total water requirements and costs).
- No inflation included in the analyses (although the model has provisions to add escalation of O&M costs, doing so would mix water rate impacts from inflation with the impacts from the alternatives being examined).
- Minimum working capital fund established for each PWS, 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 are presented in a Table 4.4 which shows the percentage of MHI represented by the annual water bill that results 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 requires a 10 percent increase in rates and the results table shows a rate increase of 25 percent, then the impact from the alternative is 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 Water Supply Corporations, which typically provide service to less than 50,000 people. Both state and federal agencies offer grant and loan programs to assist rural communities in meeting their infrastructure needs. Most are available to "political subdivisions" such as counties, municipalities, school districts, special districts, or authorities of the state with some programs providing access to private individuals. Grant funds are made more available with demonstration of economic stress, typically indicated with MHI below 80 percent that of the state. The funds may be used for planning, design, and construction of water supply construction projects including, but not limited to, line extensions, elevated storage, purchase of well fields, and purchase or lease of rights to produce groundwater. Interim financing of water projects and water quality enhancement projects such as wastewater collection and treatment projects are also eligible. Some funds are used to enable a rural water utility to obtain water or wastewater service supplied by a larger utility or to finance the consolidation or regionalization of neighboring utilities. Three Texas agencies that offer financial assistance for water infrastructure are:

- Texas Water Development Board has several programs that offer loans at interest rates lower than the market offers to finance projects for public drinking water systems that facilitate compliance with primary drinking water regulations. Additional subsidies may be available for disadvantaged communities. Low interest rate loans with short and long-term finance options at tax exempt rates for water or water-related projects give an added benefit by making construction purchases qualify for a sales tax exemption. Generally, the program targets customers with eligible water supply projects for all political subdivisions of the state (at tax exempt rates) and Water Supply Corporations (at taxable rates) with projects.

- Texas Department of Rural Affairs is a Texas state agency with a focus on rural Texas by making state and federal resources accessible to rural communities. Funds from the U.S. Department of Housing and Urban Development Community Development Block Grants (CDBG) are administered by TDRA for small, rural communities with populations less than 50,000 that cannot directly receive federal grants. These communities are known as non-entitlement areas. One of the program objectives is to meet a need having a particular urgency, which represents an immediate threat to the health and safety of residents, principally for low- and moderate-income persons.

- U.S. Department of Agriculture Rural Development Texas (Texas Rural Development) coordinates federal assistance to rural Texas to help rural

Americans improve their quality of life. The Rural Utilities Service (RUS) programs provide funding for water and wastewater disposal systems.

The application process, eligibility requirements, and funding structure vary for each of these programs. There are many conditions that must be considered by each agency to determine eligibility and ranking of projects. The principal factors that affect this choice are population, percent of the population under the state MHI, health concerns, compliance with standards, Colonia status, and compatibility with regional and state plans. Technical assistance is available to assist local entities with the preparation of funding request applications from each agency.

SECTION 3
UNDERSTANDING SOURCES OF CONTAMINANTS

3.1 OVERVIEW OF THE STUDY AREA

Aquifers in San Saba County and the surrounding area overlie Precambrian granites and schists in the Llano Uplift and are of Paleozoic age (from oldest to youngest: Hickory, Ellenburger–San Saba, and Marble Falls aquifers) and of Cretaceous age (mainly within the Trinity Group) (Bluntzer 1992). The regional study area is defined primarily by the spatial extents of the Hickory and Ellenburger–San Saba aquifers, which are the primary aquifers in the Llano Uplift area. Additional water sources include the Trinity aquifer in the eastern and southeastern region of the study area where the Trinity overlies the Hickory and Ellenburger–San Saba aquifers. The North San Saba Public Water Supply (PWS) is located in San Saba County and operates two wells that are completed in the Hickory aquifer (Figure 3.1).

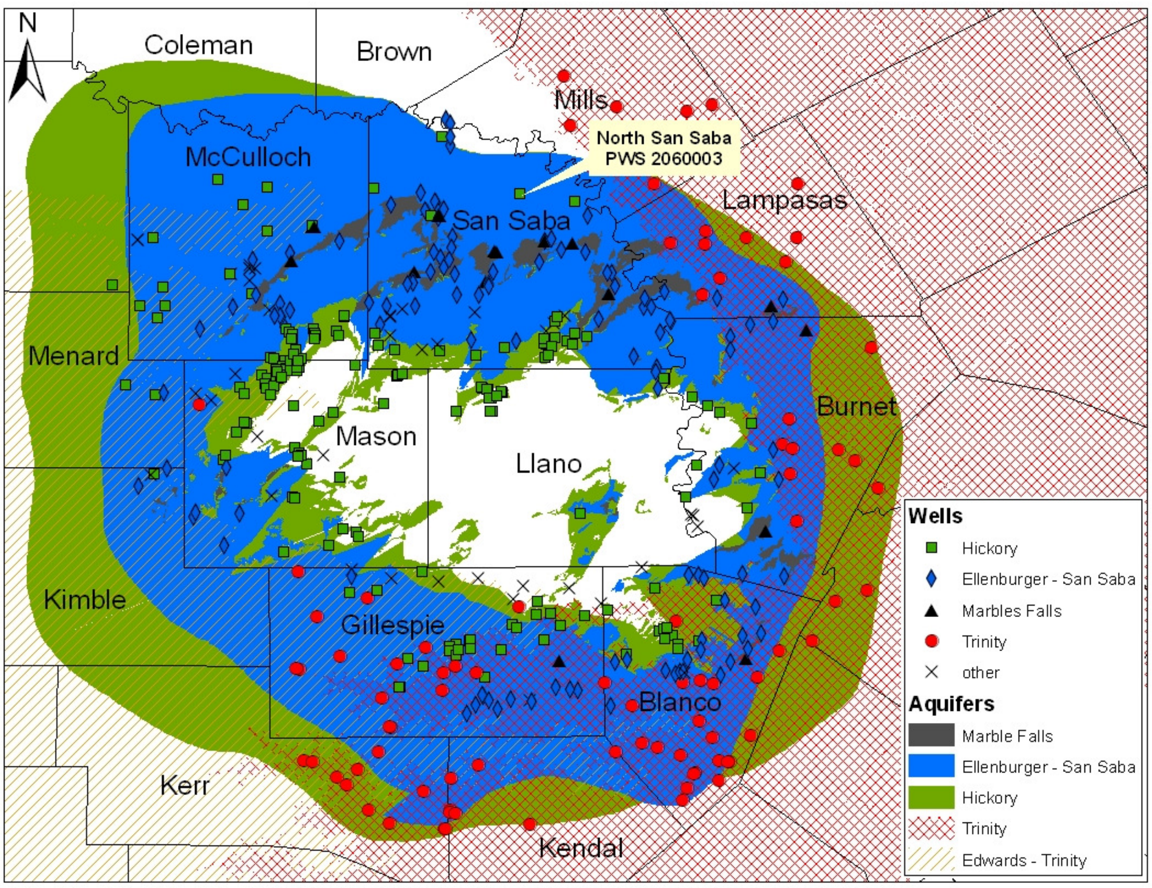


Figure 3.1 Regional Study Area, Aquifers, TWDB Database Well Locations, and Location of the North San Saba PWS.

Data used for this study include information from two sources:

- Texas Water Development Board (TWDB) groundwater database available at www.twdb.state.tx.us. The database includes information on the location and construction of wells throughout the state as well as historical measurements of water levels and chemistry in the wells.

- Texas Commission on Environmental Quality (TCEQ) Public Water Supply database (not publicly available). The database includes information on the location, type, and construction of water sources used by PWS systems in Texas, along with historical measurements of water levels and chemistry.

3.2 CONTAMINANTS OF CONCERN IN THE STUDY AREA

Contaminants of concern to North San Saba PWS include gross alpha particle activity and combined radium activity. Gross alpha and radium concentrations are expressed in units of radioactivity as picocuries per liter (pCi/L). The maximum contaminant level (MCL) allowed for public drinking water systems by the U.S. Environmental Protection Agency is 15 pCi/L for gross alpha and 5 pCi/L for combined radium, which is the sum total of both radium-226 and radium-228 isotope activity. Exposure to either contaminant is associated with an increased risk of cancer.

Alpha particles are a result of the radioactive decay of unstable isotopes. Radium-226, the most abundant isotope of radium, has a half-life of 1602 yr and is a decay-chain product of uranium-238, the most abundant isotope of uranium. Radium-228, the second-most abundant isotope of radium, has a half-life of 5.75 yr and is a decay-chain product of thorium-232, the most abundant isotope of thorium. Both uranium-238 and thorium-232 have extremely long half-lives (^{238}U: 4.5 billion yr, ^{232}Th: 14 billion yr) and thus represent persistent sources of radioactive daughter products when present in the environment. Uranium and thorium are common trace elements in granitic rock, which formed the core of the Llano Uplift region. Radium-226 and radium-228 and their decay-chain products, including radon, decay by alpha radiation. Radon is a noble gas that is chemically inert (i.e., does not combine with other elements) and thus is highly mobile in the environment. Radon also decays by alpha radiation.

3.2.1 Gross Alpha

Figure 3.2 shows the spatial distribution of gross alpha in the study area. Data from the TWDB database are summarized in Table 3.1 and represent the most recent samples for 442 wells. Most samples are relatively dated. Sample dates range from 1977 to 2009 (median 1994). Only 37 percent of samples have been analyzed since 2001. Gross alpha activity exceeded the MCL (15 pCi/L) in 77 (17%) of wells sampled and ranged from <0.9 to 605 pCi/L regionally (median 5.7 pCi/L). Gross alpha activity levels exceeded the MCL in every named aquifer sampled in the study area except for the Marble Falls aquifer.

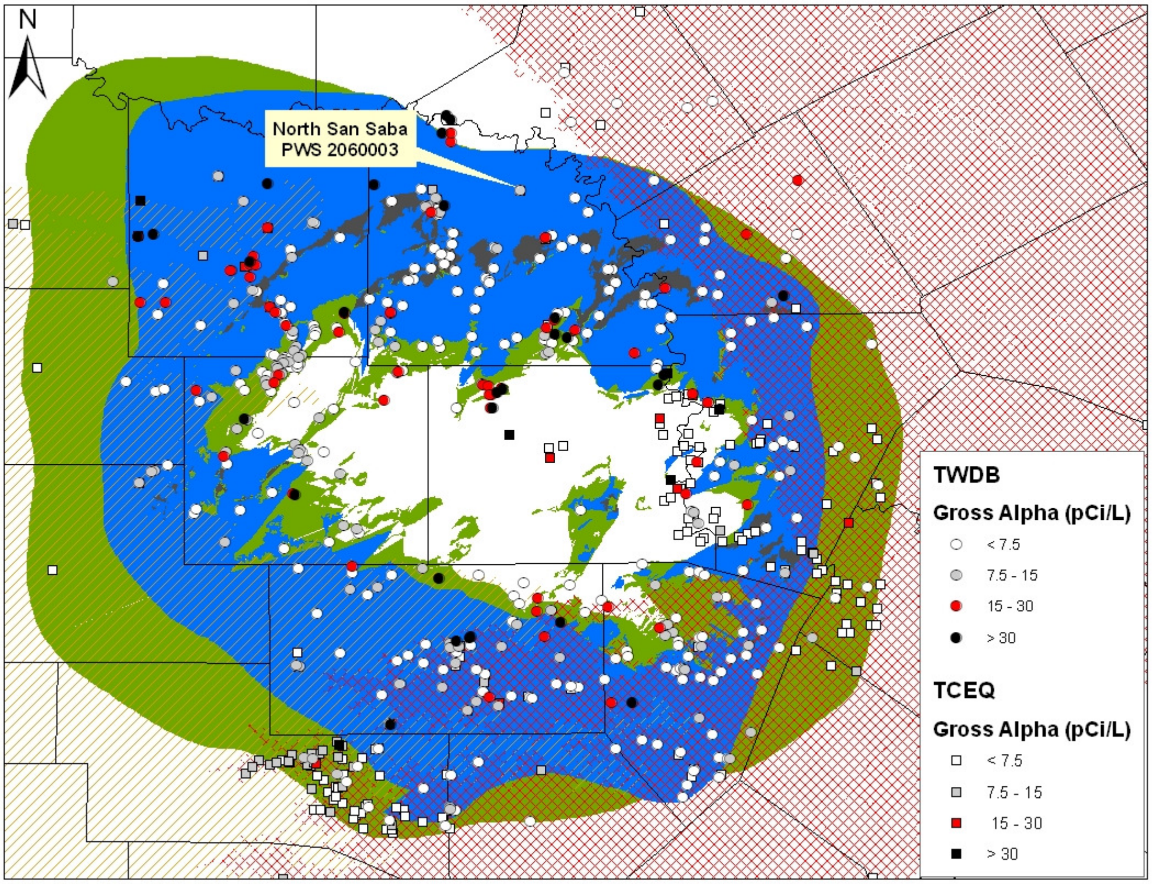


Figure 3.2 Spatial Distribution of Groundwater Gross Alpha Particle Activity in the Study Area.

Points represent locations of groundwater wells and gross alpha activity using the most recent sample data available from both the TWDB and TCEQ databases.

Table 3.1 Summary of Gross Alpha Activity in Groundwater Well Samples by Aquifer. (Based on the most recent sample data from the TWDB database).

Aquifer	Wells with measurements	Median (pCi/L)	Range (pCi/L)	Wells that exceed MCL	% of wells that exceed MCL
Hickory	179	9.9	<1.3 – 87	46	26
Ellenburger–San Saba	118	3.2	<1.1 – 605	14	12
Marble Falls	19	6.8	<0.9 – 15	0	0
Trinity	84	4.1	<1.1 – 44	2	2
Other	42	9.4	<1.4 – 82	15	36
Total	442	5.7	<0.9 – 605	77	17

Wells completed in the Hickory aquifer have the highest median gross alpha activity (9.9 pCi/L) and the highest percentage of wells that exceeded the MCL (26%) with approximately 10 percent of measurements >30 pCi/L (twice the MCL). The Ellenburger–San Saba aquifer had the lowest median gross alpha activity (3.2 pCi/L) but also had the highest measured value (605 pCi/L), although only 12 percent of wells exceeded the MCL. The Trinity aquifer had only two wells exceeding the MCL (2%) while the Marble Falls aquifer had no exceedances. Aquifers collectively classified as "Other" include several formations, including Precambrian granite, the Cambrian system, and the Welge sandstone, which are locally water-bearing and as a group had the second highest median gross alpha activity (9.4 pCi/L) with the highest percentage of wells that exceeded the MCL (36%).

Well depth information is available for a subset of 378 (86%) of the 442 wells that have had gross alpha activity analyses (Table 3.2). Both the median gross alpha activity and the percentage of wells that exceeded the gross alpha MCL for the different aquifers are very similar for the subset and the total well population and are thus considered representative of the total population. Gross alpha activities generally show trends with well depth in all of the aquifers except the Marble Falls, for which there were insufficient data (Figure 3.3). When grouped by 20th percentiles of well depth, median gross alpha activities increase overall with median well depth in the Ellenburger–San Saba, Trinity, and combined Other aquifers and decrease overall with median depth in the Hickory aquifer.

Wells completed in the Hickory aquifer at depths shallower than ~150 ft had the highest median gross alpha activity (11 pCi/L) in that aquifer, but the percentage of wells that exceed the MCL does not display a consistent trend with depth, and varies from 18 percent to 32 percent.

Median gross alpha activity increases fairly regularly with increasing well depth in the Ellenburger–San Saba aquifer, from a low of 2.4 pCi/L for wells shallower than 180 ft to a high of 7.2 pCi/L for wells between ~800 and ~3300 ft deep. Wells that exceed the MCL in the Ellenburger–San Saba are primarily completed at depths below ~800 ft where approximately 40 percent of wells are non-compliant.

Median gross alpha activity also increases fairly regularly with increasing well depth in the Trinity aquifer, from a low of 3.1 pCi/L for wells shallower than ~150 ft to a high of 6.8 pCi/L for wells between ~500 and 750 ft deep. Wells that exceed the MCL in the Trinity do not show a trend with increasing well depth and only 3 percent of wells are non-compliant.

The highest median gross alpha activities (13.5 to 17.5 pCi/L) are associated with wells completed in the combined "Other" aquifer category at depths between ~500 and 2,500 ft. Wells in this category also have the highest percentages of MCL exceedances, which increase regularly from 43 percent to 88 percent for wells completed at depths between 280 and 2,500 ft.

Table 3.2 Summary of Median Gross Alpha Activity by Groundwater Well Depth and Aquifer Based on the Most Recent Sample Data from the TWDB Database.

Percentile	Number of wells in group	Group median gross alpha (pCi/L)	Well depth (ft)		Wells > MCL	
			Median	Range	Number	%
Hickory						
0.20	35	11.0	93	21 – 151	10	29
0.40	35	10.0	232	152 – 280	9	26
0.60	34	8.7	345	284 – 400	6	18
0.80	32	7.7	463	414 – 620	9	28
1.00	34	8.4	2,227	650 – 3,520	11	32
Total	170	9.3	338	21 – 3,520	45	26
Ellenburger-San Saba						
0.20	17	2.4	109	31 – 175	1	6
0.40	18	3.2	245	180 – 304	1	6
0.60	18	4.1	364	320 – 432	1	6
0.80	18	3.6	607	442 – 765	2	11
1.00	18	7.2	1,268	780 – 3,310	7	39
Total	89	3.6	364	31 – 3,310	12	13
Trinity						
0.20	16	3.1	105	45 – 155	0	0
0.40	17	4.2	200	160 – 240	1	6
0.60	15	4.8	290	249 – 325	0	0
0.80	17	4.0	400	341 – 480	1	6
1.00	15	6.8	619	490 – 750	0	0
Total	80	4.2	290	45 – 750	2	3
Other						
0.20	8	7.4	80	30 – 115	0	0
0.40	8	5.7	162	120 – 240	1	13
0.60	7	6.6	395	280 – 470	3	43
0.80	8	13.5	705	514 – 1,230	4	50
1.00	8	17.5	2,121	2,060 – 2,500	7	88
Total	39	9.8	395	30 – 2,500	15	38
All	**378**	**6.2**	**330**	**21 – 3,520**	**74**	**20**

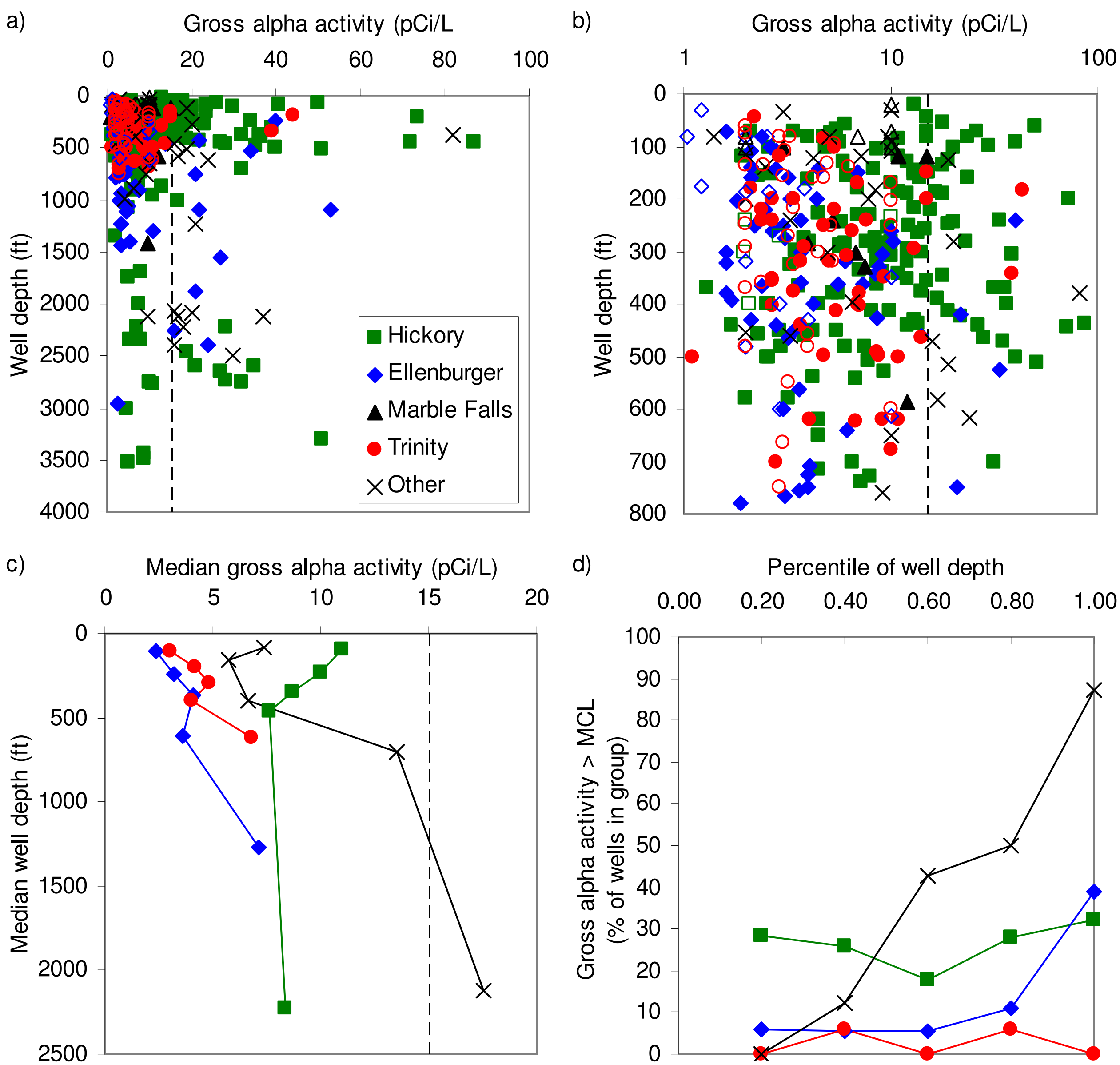


Figure 3.3 Relationship Between Gross Alpha Activity and Well Depth in the Study Area by Aquifer.

Vertical dashed lines represent the gross alpha activity MCL (15 pCi/L). Values below sample analytical detection limits are shown using open symbols. Figure b) magnifies the upper-left region of Figure a) and has a log scale to provide detail. Points in Figure c) represent median values by aquifer for groups based on the 20th percentiles of well depth. Points in Figure d) represent the percentage of wells that exceed the MCL within each group shown in c). There were insufficient data to show the Marble Falls aquifer in Figures c) and d).

3.2.2 Combined Radium

Radium in groundwater has been less frequently analyzed in the study area relative to gross alpha activity, likely due to the cost of analysis and also because guidelines provide that analyzing for radium is generally indicated only where gross alpha activity exceeds 5 pCi/L. Data from the TWDB database are summarized in Table 3.3 and represent the most recent 175 samples. Figure 3.4 shows the spatial distribution of combined radium activity measured in well samples in the study area. As with gross alpha, most samples are relatively dated. Samples for which combined radium can be calculated have a median sample date of 1994 and range from 1983 to 2009. Only 68 samples (39%) have been analyzed for combined radium since 2004. As with gross alpha activity, combined radium activity levels exceeded the MCL in every named aquifer in the study area except for the Marble Falls aquifer, for which no analysis results are reported in the database.

Table 3.3 Summary of Combined Radium Activity in Groundwater well Samples by Aquifer Based on the Most Recent Sample Data from the TWDB Database.

Aquifer	Wells with measurements	Median (pCi/L)	Range (pCi/L)	Wells that exceed MCL	% of wells that exceed MCL
Hickory	94	7.8	<0.4 – 105	61	65
Ellenburger–San Saba	30	1.9	<0.7 – 28	4	13
Trinity	34	3.1	<0.3 – 13	9	26
Other	17	10.6	2.3 – 40	13	76
Total	175	5.6	<0.3 – 105	87	50

Combined radium activity ranged from <0.3 to 105 pCi/L regionally (median 5.6 pCi/L) and exceeded the MCL (5 pCi/L) in 50 percent of wells analyzed. Most (70%) of the wells that exceed the MCL in the region are completed in the Hickory aquifer. Wells completed in the Hickory aquifer also had the highest median combined radium activity (7.8 pCi/L) and the highest percentage of wells that exceeded the MCL (65%), with approximately 37 percent of the measurements >10 pCi/L (twice the MCL).

The Ellenburger–San Saba aquifer had the lowest median combined radium activity (1.9 pCi/L) and the lowest percentage of wells exceeding the MCL (13%). The Trinity aquifer had 26 percent of wells that exceeded the MCL and also had the smallest range of combined radium activity (<0.3 to 13 pCi/L). There are no sample analyses available for the Marble Falls aquifer. Aquifers collectively classified as "Other" include several local water-bearing units, including Precambrian granite, the Cambrian system, and Welge sandstone, which as a group had the highest median combined radium activity (10.6 pCi/L) and the highest percentage of wells that exceeded the MCL (76%), with 59 percent of the measurements >10 pCi/L.

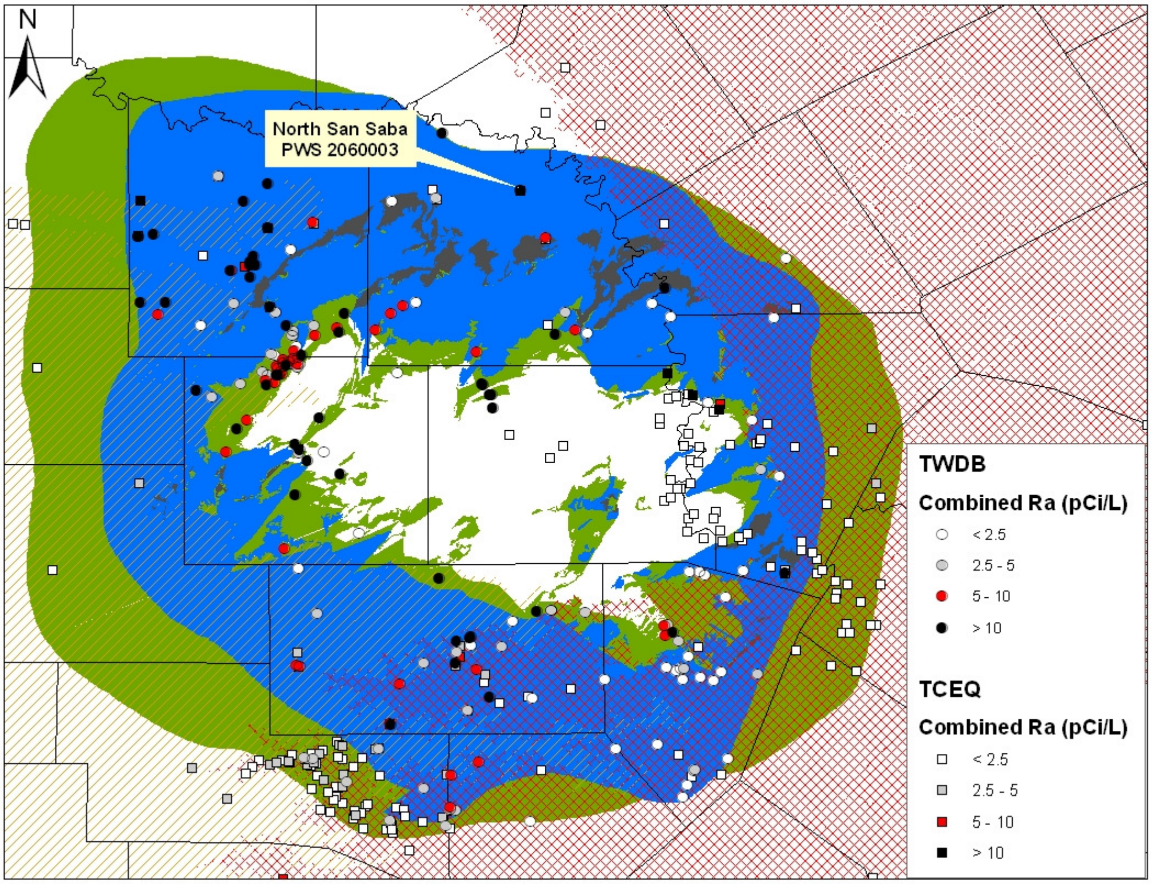


Figure 3.4 Spatial Distribution of Combined Radium Activity in the Study Area.

Points represent locations of groundwater wells and gross alpha activity using the most recent sample data available from both the TWDB and TCEQ databases.

Well depth information is available for a subset of 163 (93%) of the 175 wells that have had gross alpha activity analyses (Table 3.4). Median gross alpha activities and percentages of wells that exceeded the combined radium MCL for the different aquifers are the same or very similar for both the subsets and the larger well populations and thus the subsets are considered representative of the larger population. Combined radium activities show trends with well depth (Table 3.4, Figure 3.5), generally similar to gross alpha activities. When grouped by 25th percentiles of well depth, median combined radium activities increase overall with median depth in most of the aquifers.

Wells completed in the Hickory aquifer have median combined radium activities that exceeded the MCL at all depths, with the highest median value (9.0 pCi/L) associated with wells completed at depths <180 ft. As with gross alpha activity, there is no strong overall trend between well depth and the percentage of wells that exceeded the MCL in the Hickory, which varies from 59 percent to 82 percent at different depths.

Median activity increases systematically with increasing depth but remains less than the MCL for all depth categories in both the Ellenburger–San Saba and the Trinity aquifers. Wells that exceeded the MCL in the Ellenburger–San Saba are at least 460 ft deep, while all but one of the wells that exceeded the MCL in the Trinity are at least 295 ft deep.

Median combined radium activity also increases systematically with increasing depth for wells in the combined "Other" aquifer category. The highest median activities range from 7.5 to 13.2 pCi/L for wells completed between 400 and 2,500 ft, where 75 percent to 100 percent of wells exceeded the MCL.

Table 3.4 Summary of Median Combined Radium Activity by Groundwater Well Depth and Aquifer Based on the Most Recent Sample Data From the TWDB Database.

Percentile	**Number of wells in group**	**Group median combined radium (pCi/L)**	**Well depth (ft)**		**Wells > MCL**	
			Median	**Range**	**Number**	**%**
Hickory						
0.25	22	9.0	125	21 – 170	15	68
0.50	22	8.0	261	180 – 346	18	82
0.75	22	6.3	414	355 – 480	13	59
1.00	21	8.8	2,460	500 – 3,488	14	67
Total	87	7.9	346	21 – 3,488	60	69
Ellenburger-San Saba						
0.25	7	<1.3	23	31 – 160	0	0
0.50	6	<1.8	260	175 – 323	0	0
0.75	6	2.3	462	400 – 725	1	17
1.00	7	3.4	1,236	750 – 2,249	2	29
Total	26	1.9	362	31 – 2,249	3	12
Trinity						
0.25	9	<1.4	133	60 – 180	1	11
0.50	8	2.1	270	215 – 310	2	25
0.75	8	4.1	365	320 – 415	2	25
1.00	8	4.7	560	490 – 750	4	50
Total	33	3.1	310	60 – 750	9	27
Other						
0.25	5	4.4	200	80 – 380	2	40
0.50	4	7.5	682	395 – 1,230	3	75
0.75	4	13.2	2,097	2,060 – 2,114	4	100
1.00	4	11.5	2,313	2,127 – 2,500	4	100
Total	17	10.6	355	80 – 2,500	13	76
All	**163**	**5.6**	**355**	**21 – 3,488**	**85**	**52**

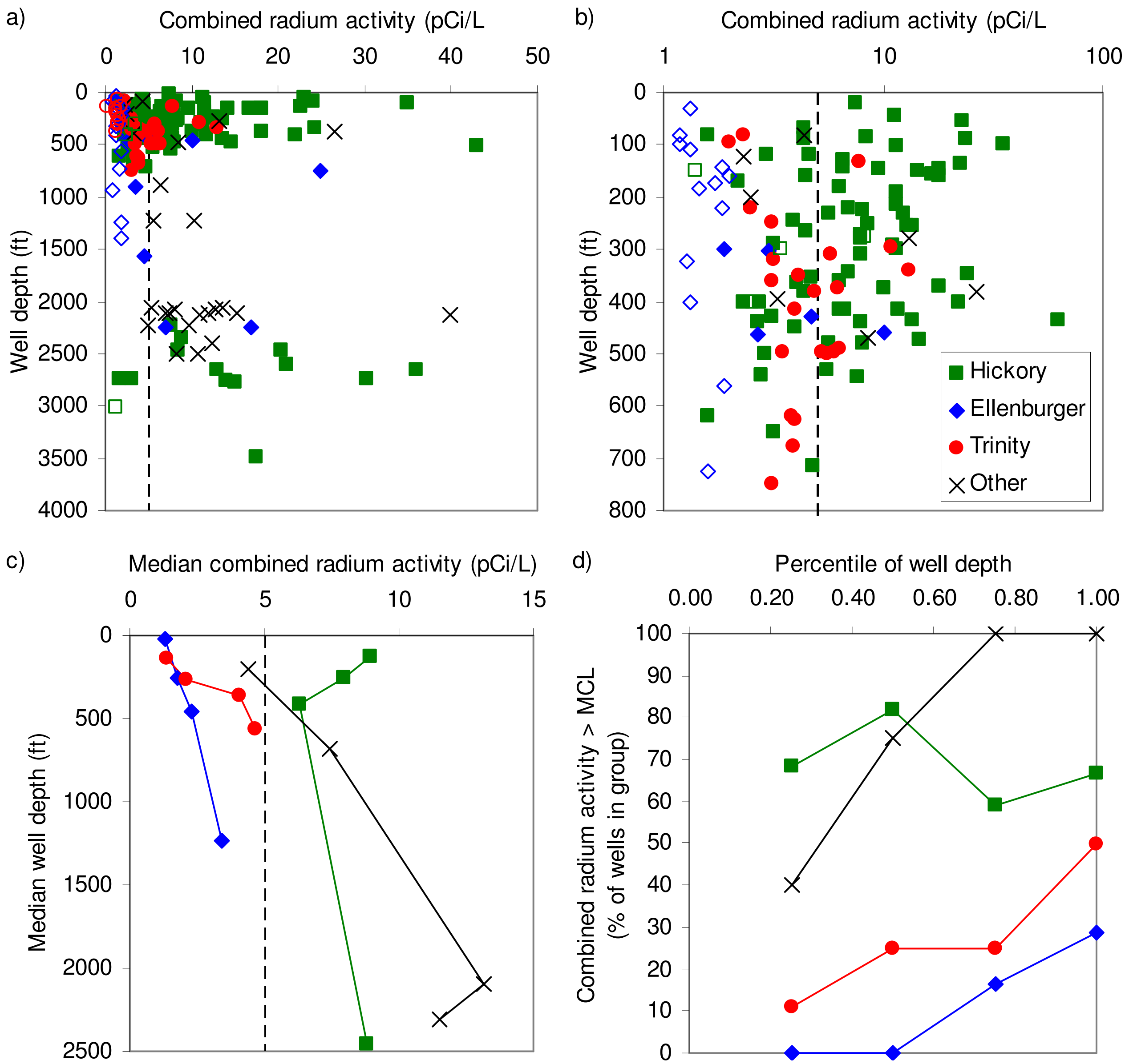


Figure 3.5 Relationship Between Combined Radium Activity and Well Depth in the Study Area.

Vertical dashed lines represent the combined radium activity MCL (5 pCi/L). Values below sample analytical detection limits are shown using open symbols. Figure b) magnifies the upper-left region of Figure a) and has a log scale to provide detail. Points in Figure c) represent median values by aquifer for groups based on the 25th percentiles of well depth. Points in Figure d) represent the percentage of wells that exceed the MCL within each group shown in c).

As expected, both radium-226 and radium-228 are both highly correlated with combined radium activity (R=0.85 and R=0.90, respectively) (Figure 3.6). Combined radium is generally dominated by radium-228 activity, which accounts for a median of 68 percent of the value (range 4% to 92%), whereas radium-226 activity accounts for a median of 32 percent of the value (range 8% to 96%).

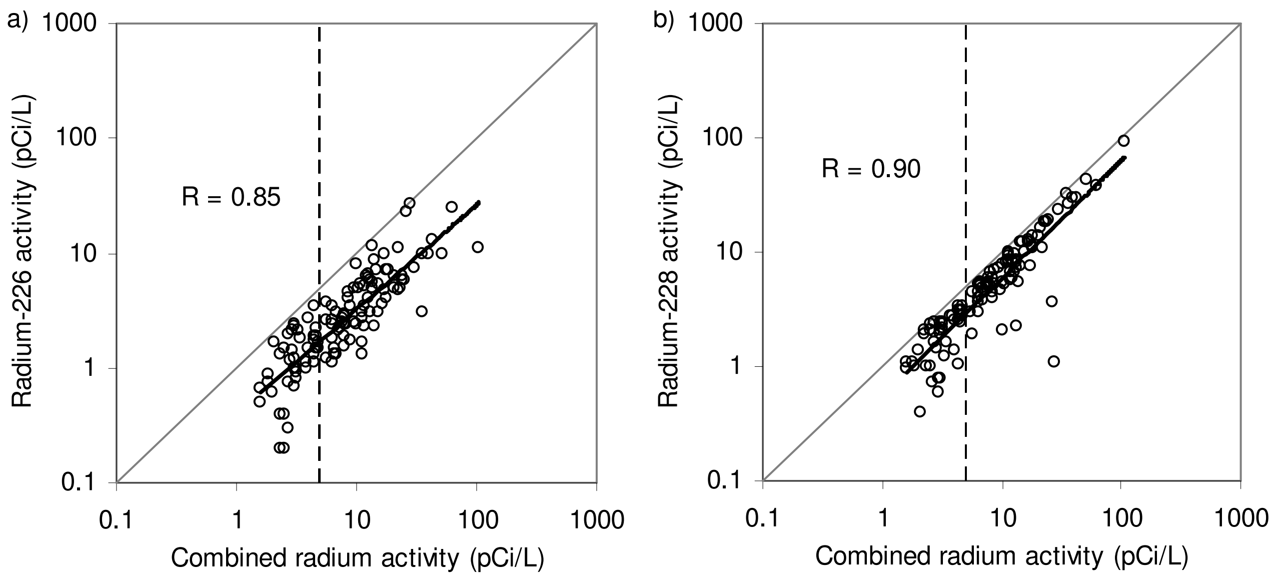


Figure 3.6 Relationships Between Combined Radium and Radium Isotope Activities in the Study Area.

Diagonal gray lines represent the 1:1 relationships. Black lines represent power-law regression fits to the data.

Gross alpha activity is also highly correlated with combined radium activity (R=0.79), though the strength of correlation is somewhat lower than with the radium isotope–combined radium relationships, reflecting other sources of alpha activity besides radium (Figure 3.7). Based on 125 samples for which both gross alpha and combined radium activities were measured, gross alpha accounted for a median of 133 percent of combined radium activity but ranged widely from 36 percent to 587 percent. Gross alpha activity should be greater than combined radium activity in all cases due to the presence of other radionuclides that also emit alpha particles, particularly radon. However, 30 percent of gross alpha activity measurements in the study area are less than the measured combined radium activity, indicating that some measurements are inaccurate.

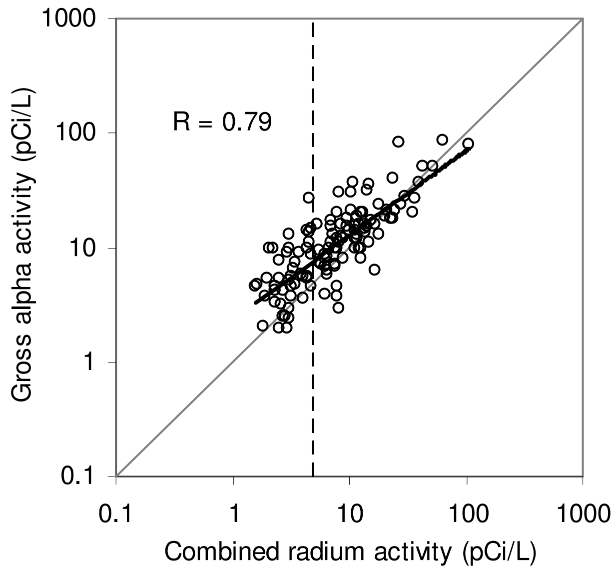


Figure 3.7 Relationship Between Combined Radium and Gross Alpha Activities in the Study Area.

Diagonal gray line represents the 1:1 relationship. Black line represents a power-law regression fit to the data.

3.3 REGIONAL GEOLOGY

San Saba County is one of several central Texas counties located on the Llano Uplift, a primarily granitic Precambrian core overlaid by Paleozoic formations that dip away in all directions around a core area formed by Llano and east Mason Counties (Bluntzer 1992). Cretaceous formations lie directly above the Paleozoic sequence and complete the stratigraphic column in west McCulloch County (Anaya and Jones 2000) and east Burnet County (RWHA 2003).

San Saba County is located in the north-central section of the Llano Uplift, where Precambrian igneous and metamorphic rocks are exposed. The geology is complex, but the details are not pertinent to this study. The Cambrian Hickory Member, consisting mainly of sandstone, represents the oldest formation overlying the Precambrian basement. The Ordovician Ellenburger Group, consisting mainly of carbonate, to which is added the San Saba Member of Upper Cambrian age, contains several hydraulically connected water bearing formations. Another water bearing formation, appropriately called the Mid-Cambrian aquifer, consisting mainly of sandstone, is present between them. The Mid-Cambrian aquifer is not recognized by the State of Texas, as opposed to the Hickory and Ellenburger–San Saba aquifers, which are classified as minor aquifers by the state (Ashworth and Hopkins 1995). A fourth unit, the Pennsylvanian age Marble Falls Formation, consisting mainly of carbonate, is also classified as a minor aquifer. The remaining Paleozoic section contains formations that are able to produce some water but not in significant quantity.

The Paleozoic aquifers are compartmentalized by faults that became inactive prior to the deposition of Cretaceous sediments. However, the stratigraphic section does not change significantly between compartments and the general dip is <2.3% (120 ft/mile) (Mason 1961). The next youngest preserved layers are of Cretaceous age located in eastern Burnet and western McCulloch Counties and were deposited on a mostly flat platform. The first described formation is the Travis Peak Formation, itself part of the Trinity Group: the Hosston Sand and Hensell Sand with intermediate confining beds. The Hosston Sand pinches out around the uplift and to the northwest and has mostly disappeared or merged with the Hensell Sand in McCulloch County. The Travis Peak Formation (also called the Twin Mountains Formation farther north) is overlain by the Glen Rose Formation, which acts as a confining unit, and then by the Paluxy Sand, which pinches out just south of Burnet County (RWHA 2003) and does not exist in McCulloch County. Toward the west, the Trinity Group is much thinner and sandier, with little or no Glen Rose Formation present, and is called the Antlers Sand (Klemt, et al. 1975; Baker, et al. 1990, p. 13). Overlying the Trinity Group, the Fredericksburg Group, which includes the Edwards Formation, completes the section. Mostly sandy units of the Trinity Group form the Trinity aquifer, classified as a major aquifer by the State of Texas (Ashworth and Hopkins 1995). The dip of the Cretaceous formations is generally small (< 0.5%) toward the south and east.

The Llano Uplift Precambrian rock does not yield significant amounts of water unless fractured or weathered (Bluntzer 1992), in which case the water is of generally good quality. Depth to the top of the Hickory aquifer ranges from zero at the outcrop to more than 2,500 ft. The Hickory varies in thickness because it was deposited on an irregular surface and ranges between 150 and 400 ft (Bluntzer 1992). The Mid-Cambrian aquifer, which can yield small quantities of water, is 50-100 ft thick and is separated from the Hickory by 400 to 600 ft of confining layers. Water quality in the Hickory (LBG-Guyton Associates 2003) and Mid-Cambrian (Mason 1961) aquifers is good. The thickness of the Ellenburger–San Saba aquifer ranges from 250 ft near the outcrop to 2,000 ft in Burnet County and 750 ft (locally >1,250 ft) in San Saba County (Core Laboratories Inc. 1972, p.26). The water is hard but otherwise of good quality (LBG-Guyton Associates 2003). More than 300 ft of limestone and shale separate the Ellenburger–San Saba aquifer from the Mid-Cambrian aquifer. The Marble Falls aquifer is about 400 ft thick and is separated from the Ellenburger–San Saba aquifer by 50 ft of confining beds. The Marble Falls aquifer has good water quality in the outcrop (mainly in San Saba County) and is also likely to have good quality water in downdip areas. Water quality in the Trinity Group is also good (LBG-Guyton Associates 2003). The uppermost water-bearing formation is the Edwards limestone under water-table conditions, unlike other aquifers that are mostly confined.

3.4 DETAILED ASSESSMENT

North San Saba (PWS 2060003)

The North San Saba PWS has two wells: G2060003A (Well A, 3488 ft deep) and G2060003B (Well B, 3518 ft deep), both completed in the Hickory aquifer. The system has 303 metered connections.

Table 3.5 Gross Alpha and Radium Isotope Concentrations in the North San Saba PWS (Data from the TCEQ PWS Database).

Sample date	Sample location	Gross alpha (pCi/L)	^{226}Ra (pCi/L)	^{228}Ra (pCi/L)	Combined Ra (pCi/L)
07/27/98	D	23.0	5.9	4.4	10.3
01/18/00	D	61.2	20.5	21.4	41.9
10/17/00	D	53.3	17.7	15.4	33.1
11/04/02	EP 1	31.5	8.9	9.5	18.4
12/09/03	EP 1	29.1	9.8	9.3	19.1
12/27/04	EP 1	47.0	12.8	10.5	23.3
01/26/05	Well B	103.5	36.7	31.0	67.7
12/06/05	EP 1	79.6	26.1	28.0	54.1
01/27/06	EP 1	22.5	7.1	6.4	13.5
06/08/06	EP 1	151.8	39.2	29.0	68.2
09/26/06	EP 1	389.5	73.8	65.0	138.8
11/21/06	EP 1	289.3	76.7	50.2	126.9
03/14/07	EP 1	247	87.8	75.7	163.5
06/21/07	EP 1	16.7	7.0	5.7	12.7
09/25/07	EP 1	122.0	46.7	29.8	76.5
12/20/07	EP 1	107.0	42.9	28.1	71.0
03/25/08	EP 1	101.0	33.3	22.7	56.0
05/20/08	Well B	60.8	21.9	14.1	36.0
05/20/08	Well A	4.0	2.0	2.3	4.3
05/20/08	EP 2	109.0	43.5	26.8	70.3
05/20/08	Well A	4.9	1.7	<1.0	<2.7
05/20/08	D	125.0	44	29.2	73.2
05/20/08	D	51.4	15.1	9.3	24.4
05/20/08	EP 1	22.5	7.2	4.9	12.1
09/17/08	EP 1	13.6	3.7	3.6	7.3
12/01/08	EP 2	10.1	2.6	<1.0	<3.6

Sample Location: EP; entry point and number, D; distribution point in system, Well A or B; raw water sample from well, Combined Ra: sum of Ra-226 and Ra-228.

Gross alpha and combined radium activities were measured in samples obtained on 20 sample dates between 1998 and 2008 (Table 3.6). Gross alpha concentrations exceeded the MCL (15 pCi/L) for all but four of the samples analyzed. Combined radium, calculated as the sum of radium-226 and radium-228 concentrations, exceeded the MCL (5 pCi/L) for all but three of the samples analyzed.

There are no other PWS system wells located within 10 km of the North San Saba PWS (Figure 3.8). The nearest system is the City of San Saba (PWS 2060001), located approximately 13 km to the southeast, which is compliant with both the gross alpha and combined radium MCLs.

The TWDB database does not list any wells located within 10 km of North San Saba PWS that have been analyzed for either gross alpha or radium isotope activities. There are four wells located to the east and northeast of San Saba compliant with the gross alpha MCL with values that range from <2.0 to 5.3 pCi/L (Figure 3.9). None of the TWDB wells were analyzed for radium isotopes but they are likely compliant given the low gross alpha activities.

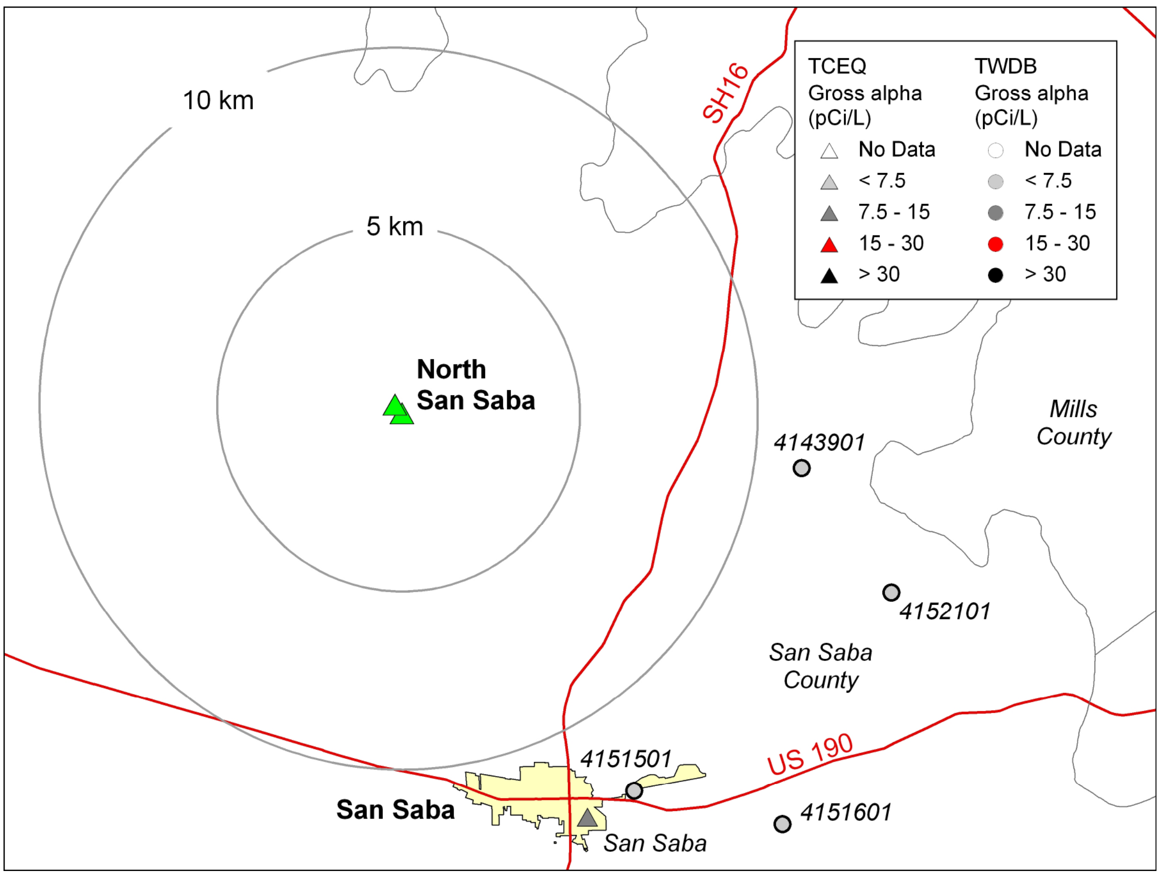


Figure 3.8 Gross alPha Activity near North San Saba PWS.

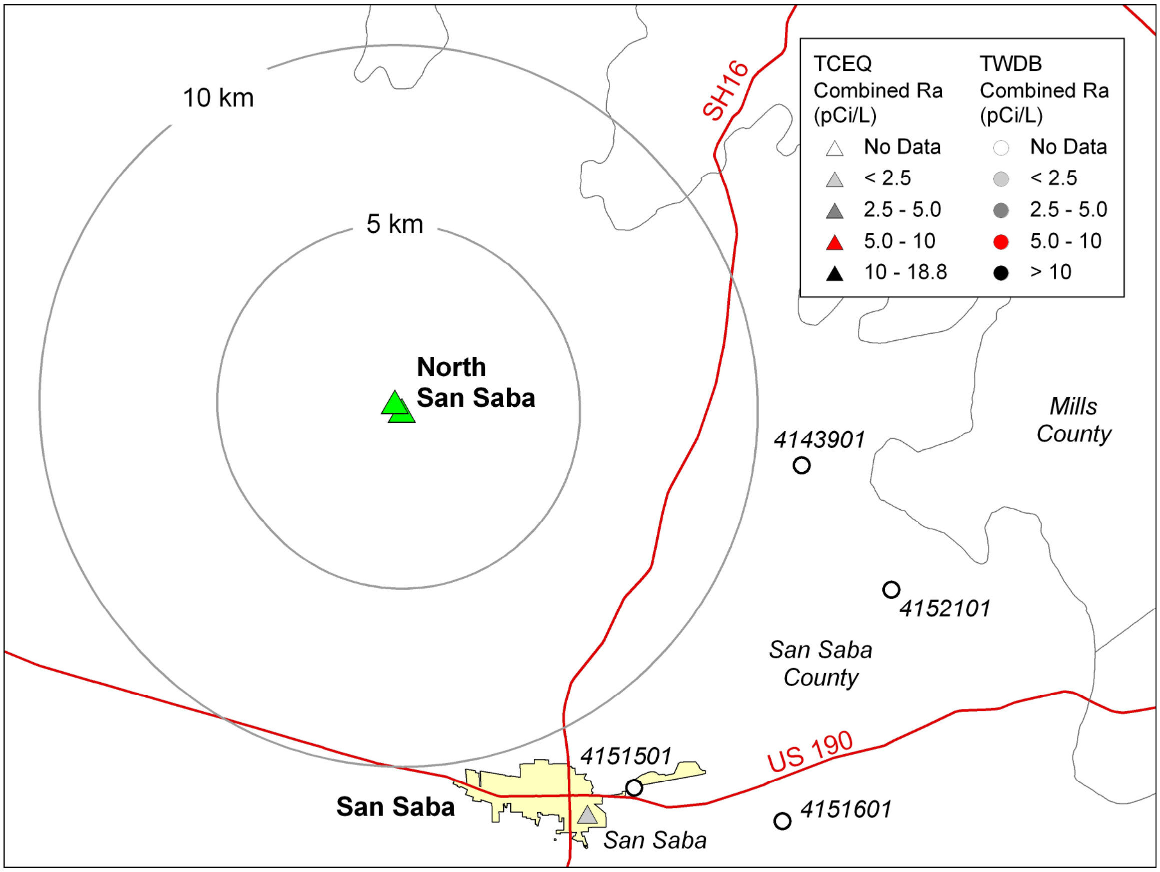


Figure 3.9 Combined Radium Activity near North San Saba PWS.

3.5 SUMMARY OF ALTERNATIVE GROUNDWATER SOURCES FOR THE NORTH SAN SABA PWS

There is no information available in either the TCEQ or the TWDB databases that reveals any alternative groundwater sources located within 10 km of the North San Saba PWS. The nearest alternative groundwater sources that are compliant are located about 12 to 15 km generally to the south and east.

SECTION 4
ANALYSIS OF THE NORTH SAN SABA PWS

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1 Existing System

The location of the North San Saba PWS is shown in Figure 4.1. North San Saba PWS is a community water system serving a population of 909 with 303 active connections. The PWS is located approximately 8 miles northwest of the City of San Saba, Texas, on Farm-to-Market Rd (FM) 500 about 0.5 mile northwest of the intersection of County Rd (CR) 209 and FM 500.

The water source for this PWS is one well, which is completed in the Hickory Aquifer (Code 391HCKR). The PWS has a second well that can be used in an emergency. The North San Saba PWS also purchases treated groundwater from the City of San Saba and is under contract to purchase between 0.10 million gallons (mg) (2.3 gpm) and 3.0 mg (69.4 gpm) per month. The North San Saba PWS contains two standpipes (capacities 0.109 mg and 0.076 mg). Two service pumps take water from the ground storage tank and pump to the distribution system with the two standpipes floating on the system. The systems two wells are located at the larger standpipe on FM 500. Groundwater is pumped into the FM 500 standpipe, which enters the distribution system, the Stingy Lane ground storage tank, and the second standpipe (Shaw Bend Tower). The Shaw Bend Tower is located near the intersection of CR 140 and CR 124 and is approximately 6.25 miles east of the FM 500 standpipe. Water purchased from the City of San Saba enters the distribution system near the intersection of State Highway 16 and FM 500.

According to the plant operator, the PWS incurred losses in the distribution system that averaged about 57 percent from March 2010 to July 2010. The losses occur in the distribution lines upstream of the customer meters.

Well #1 (G2060003A) is 3488 feet in depth and provides 70 gpm. Well #2 (G2060003B) is 3518 feet deep. Both wells are located in San Saba County. Well #2 is only used for emergencies due to high levels of combined radium in the well. Disinfection with gas chlorination is performed prior to water being pumped into the larger stand pipe and before water is pumped into the distribution system.

TCEQ identified sampling locations for the North San Saba PWS include entry point (EP) 001 (location of Wells #1 and #2) and EP 002 (purchased water location). Combined radium (226 + 228) has been detected between 2.7 pCi/L to 163.5 pCi/L between 1998 and 2008, which exceeds the MCL of 5 pCi/L. During the same period, gross alpha has been detected between 15 pCi/L to 389.5 pCi/L, which exceed the MCL of 15 pCi/L. Groundwater concentrations of combined radium and gross alpha in Well #1 are believed to be less than the concentrations in Well #2. Due to continued high contaminant concentrations in Well #2, it will only be used for emergency purposes. Typical total dissolved solids concentrations are in the range of 454 to 1409 mg/L.

The treatment employed for disinfection is not appropriate or effective for removal of combined radium or gross alpha, so optimization is not expected to be effective for increasing removal of this contaminant. However, there is a potential opportunity for system optimization to reduce the contaminant concentrations.

Basic system information is as follows:

- Population served: 909
- Connections: 303
- Average daily flow: 0.0.074 mgd
- Total production capacity: 0.201 mgd
- Typical combined radium range: 2.7 to 163.50 pCi/L
- Typical gross alpha range: 15 to 389.5 pCi/L
- Typical total dissolved solids range: 454 to 1409 mg/L
- Typical arsenic range: 0.0040 to 0.0051 mg/L
- Typical fluoride range: 0.98 to 2.73 mg/L
- Typical selenium range: 0.003 to 0.0047 mg/L
- Typical sulfate: 19.8 to 24 mg/L
- Typical nitrate range: 0.01 to 0.24 mg/L
- Typical bicarbonate ($CaCO_3$) range: 389 to 487 mg/L
- Typical iron range: 0.01 to 0.257 mg/L
- Typical manganese range: 0.0019 to 0.008 mg/L

The typical ranges for water quality data listed above are based on a TCEQ database that contains data updated through the beginning of 2010.

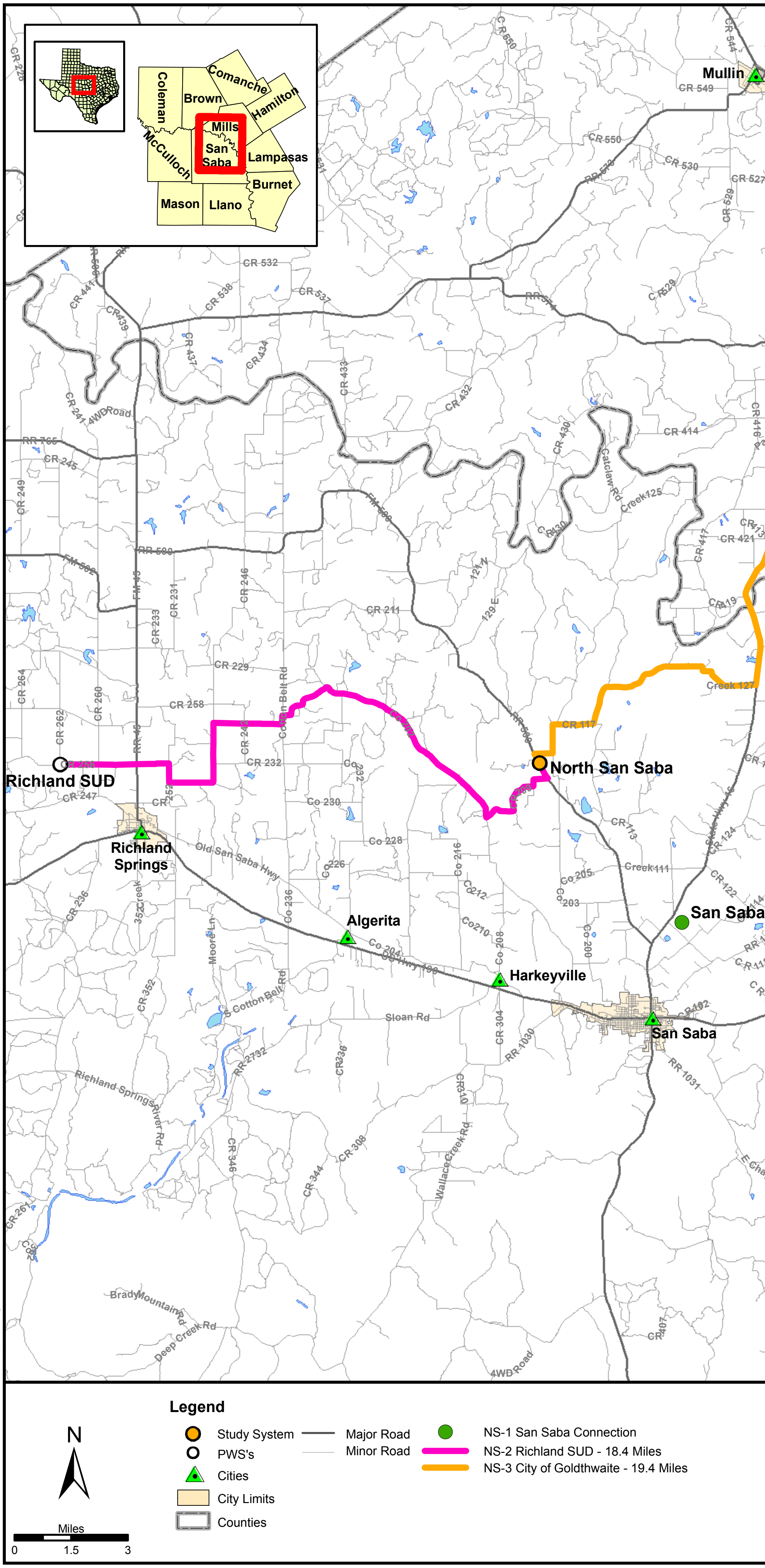


Figure 4.1

NORTH SAN SABA

Pipeline Alternative

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4.1.2 Capacity Assessment for the North San Saba PWS

The project team conducted a capacity assessment of the North San Saba PWS on June 30, 2010. Results of this evaluation are separated into four categories: general assessment of capacity, positive aspects of capacity, capacity deficiencies, and capacity concerns. The general assessment of capacity describes the overall impression of the technical, managerial, and financial capability of the water system. The positive aspects of capacity describe the strengths of the system. These factors can provide the building blocks for the system to improve capacity deficiencies. The capacity deficiencies noted are those aspects that are creating a particular problem for the system related to long-term sustainability. Primarily, these problems are related to the system's ability to meet current or future compliance, ensure proper revenue to pay the expenses of running the system, and to ensure the proper operation of the system. The last category, capacity concerns, includes items that are not causing significant problems for the system at this time. However, the system may want to address them before they become problematic.

To complete this analysis, the project team interviewed the following people:

- Wayne Blaylock, Board President
- Will Browdy, Operator
- Cindy Whitney, Office manager

4.1.2.1 General Information about the Water System

The North San Saba Water Supply Corporation is governed by a seven-member Board of Directors. The current board of directors took office in May 2009. At that time all previous board members left and an entirely new board was installed. Water service is the only service provided. The PWS does not have an office, but the previous Board President allows the system to keep records at his real estate office. The Office Manager of the PWS is also the office manager for the real estate firm. The PWS does not pay any rent for the space, but the board is considering offering him some amount for compensation. The office manager answers the phone, processes work orders, does the billing, handles complaints, and places any necessary orders. The current operator started in March 2010 and holds a TCEQ Class D license. He has 18 months to obtain a Class C license. The previous operator had been with the system for 13 years.

The system was constructed in 1973 and about 90% of it consists of inferior grade (Class 200) small diameter pipe. The water system includes one active well, 2 standpipes, a ground storage tank, serves 303 service connections, and purchases about 9% of their water from the City of San Saba.

One of the PWS customers filed a rate appeal with TCEQ alleging that the system did not conduct a rate study when they increased the rate from $42 to $59 in August of 2007. The current board believes that they could have provided justification for the increase, because the City of San Saba had increased their rates. However by the time the appeal was heard, it was too late to make the justification. As a result of the rate appeal, the system must repay $100,000 to customers on a monthly basis over 16 months. That is $336 per customer per year or $23 a month. Because this posed a hardship on the water system, the current board requested that customers not accept the refund.

In 2009 the system increased water rates to $70 base rate. Customers pay $2.70 per 1,000 gallons up to 4,000 gallons; $3.38 per 1,000 gallons from 4,001 – 8,000 gallons; $4.04 per 1,000 gallons from 8,001 – 20,000 gallons; and $4.73 per 1,000 gallons for usage over 20,000 gallons. The system had assistance from TCEQ in determining a rate structure, and was able to justify an increase to $105 base rate per month. However, because a large number of customers are elderly and on a fixed income, the board decided to increase the base rate to only $70 per month.

The system is currently repaying a FHA loan at $3,100 per month and also a bank loan at $8,900 per month. The system applied for a $1.5 million loan from the Texas Water Development Board to either raise the water tower 10 feet or install a new line with booster pumps so that they could rely solely on their own well and disconnect from San Saba. However, the loan was denied because the funder did not feel that the PWS was financially viable due to the pending rate appeal. The system is concerned that if they were to proceed with the project it will cause even more leaks in the distribution system, due to the increase in pressure. In addition, they have applied for a $300,000 grant to repair and replace old distribution lines and have spent $6,000 to install flow meters.

4.1.2.2 General Assessment of Capacity

Based on the team's assessment, this system has an inadequate level of capacity at this time. There are several positive technical, managerial, and financial aspects of the water system, but there are also some areas of concern. The deficiencies noted could prevent the water system from being able to achieve compliance now or in the future and may also impact the water system's long-term sustainability.

4.1.2.3 Positive Aspects of Capacity

In assessing a system's overall capacity, it is crucial to look at all aspects – positive and negative. It is important for systems to understand those characteristics that are working well, so that those activities can be continued or strengthened. In addition, these positive aspects can assist the system in addressing the capacity deficiencies or concerns. The factors that were particularly important for the North San Saba Water Supply Corporation are listed below.

- **Dedicated Board and Operator:** The current board members and the operator are working to ensure that safe water is provided to all their customers and to correct past problems.

- **Good Collection Rate:** The system has been able to collect fees from customers and have not had to write-off any unpaid balances. They have only had to disconnect one customer in the past year.
- **Meter Replacement:** While the system does not have a formal meter replacement program, they recognize that part of the water loss can be attributed to meters that are 35 years old. The operator has replaced 120 meters within the past 6 months. If a meter reaches 1 million gallons, it is replaced.
- **Maintenance of Residual Chlorine:** Free residual chlorine levels are monitored daily at the well, and at 7 areas throughout the distribution system. They range from 1.5 to 2.0 mg/L. This monitoring is critical to preventing contamination of the system due to the numerous leaks.
- **Increased Production:** In June of 2009, the system paid to have one of their wells acidized. Through this process they were able to increase production from 15 gpm to 70 gpm.

4.1.2.4 Capacity Deficiency

The following capacity deficiencies were noted in conducting the assessment and seriously impact the ability of the water system to meet compliance with current and future regulations and to ensure long-term sustainability.

- **Water Loss:** While the system has repaired leaks and reduced the water loss rate from 70% to 50%, water loss is still of great concern. The system has 70 miles of distribution lines and it has been difficult to locate leaks and the operator and other members have walked the lines looking for evidence of leaks. Leaks may cause the system to lose pressure, and could result in contamination of the distribution system. Low pressure is the most common complaint they receive from their customers.
- **Lack of Redundant Sources:** The system is supplied by one well which runs 24 hours a day. The amount of water purchased from the City of San Saba may not be sufficient to supply the entire system in the long term.
- **Lack of Operating Budget:** The system started tracking revenues and expenses in 2009, but does not yet have an operating budget. A budget would assist the water system with tracking necessary expenses, identifying funding shortfalls, and help plan maintenance and improvements for the system. A budget for the water system would also assist with determining the need for a future water rate increase.
- **Compliance:** The system is in violation of the Combined Radium and Gross Alpha standards and is under a Consent Order with TCEQ.
- **Storage and Pumping Capacity:** TCEQ records indicate the elevated storage capacity and service pumping capacities are inadequate for the number of service connections.

4.1.2.5 Potential Capacity Concern

The following items were a concern regarding capacity but no specific operational, managerial, or financial problems can be attributed to this item at this time. The system should consider the item listed below to further improve technical, managerial, and financial capabilities and to improve the system's long-term sustainability.

- **Inadequate Staffing:** Because the system currently requires significant leak repairs, there are times when one operator is not enough. In addition, the operator's family members are assisting with these repairs at no cost to the system. Relying on this type of assistance is probably not sustainable for the long-term, and as soon as they are financially able, the system needs to consider hiring additional staff.
- **Preventative Maintenance:** Routine and preventative maintenance of the system has been neglected in the past. The current operator has exercised every valve since he started, and of the 50 valves, only 7 operated properly.

4.2 ALTERNATIVE WATER SOURCE DEVELOPMENT

4.2.1 Identification of Alternative Existing Public Water Supply Sources

Using data drawn from the TCEQ drinking water and TWDB groundwater well databases, the PWSs surrounding the North San Saba PWS were reviewed with regard to their reported drinking water quality and production capacity. PWSs that appeared to have water supplies with water quality issues were ruled out from evaluation as alternative sources, while those without identified water quality issues were investigated further. Small systems were only considered if they were established residential or non residential systems within 5 miles of the North San Saba PWS. Large systems or systems capable of producing greater than four times the daily volume produced by the study system were considered if they were within 35 miles of the study system. A distance of 35 miles was considered to be the upper limit of economic feasibility for constructing a new water line. Table 4.1 is a list of the selected PWSs based on these criteria for large and small PWSs within 35 miles of the North San Saba PWS. If it was determined these PWSs had excess supply capacity and might be willing to sell the excess, or might be a suitable location for a new groundwater well, the system was taken forward for further consideration and identified with "EVALUATE FURTHER" in the comments column of Table 4.1.

Table 4.1 Selected Public Water Systems within 35 Miles of the North San Saba

PWS ID	PWS Name	Distance from North San Saba (miles)	Comments/Other Issues
2060001	CITY OF SAN SABA	7.84	Large GW system. WQ issues: None. **Evaluate Further**
2060002	CITY OF RICHLAND SPRINGS	10.59	Small GW and purchased water system. WQ issues: None. Systems currently purchasing water are not considered. Also, purchase water from nearby Richland SUD which is more available as a new well option or as a purchased water option.
2060012	RICHLAND SUD	11.02	Small GW water system. WQ issues: None. **Evaluate Further**.
1670009	NEW HORIZONS RANCH & CENTER	11.89	Small surface water system. WQ issues: None. Other options located closer.
1670001	CITY OF GOLDTHWAITE	13.98	Small surface water system. WQ issues: None. **Evaluate Further**.
1670005	JOE THURMAN LODGE & LIVERY INC	16.88	Small GW water system. WQ issues: Insufficient data.
1670017	MINUTE STOP	16.89	Small GW water system. WQ issues: Insufficient data.
1410002	LCRA LOMETA REGIONAL WATER SYSTEM	18.85	Small surface water and purchased water system. WQ issues: None. Systems currently purchasing water are not considered.
1670013	MULLIN ISD	18.86	Small GW water system. WQ issues: Nitrate
2060004	CHEROKEE HOME FOR CHILDREN	20	Small GW water system. WQ issues: None. Other well options located closer.
2060010	CHEROKEE ISD	22.04	Small GW water system. WQ issues: Insufficient data.
2060007	SULPHUR SPRINGS FISHING CAMP	22.14	Small GW water system. WQ issues: Insufficient data.
2060014	BAREFOOT FISHING CAMP	22.32	Small GW water system. WQ issues: Insufficient data.
2060013	TPWD COLORADO BEND STATE PARK	25.19	Small GW and surface water system. WQ issues: Insufficient data.
0250019	ZEPHYR WSC	26.31	Small purchased water system. WQ issues: None. Systems currently purchasing water are not considered.
1540004	ROCHELLE WSC	26.52	Small GW water system. WQ issues: Iron
1670016	STAR ISD	29.03	Small GW water system. WQ issues: Sulfate, TDS
1670002	PRIDDY WSC	30.26	Small GW water system. WQ issues: None. Systems currently purchasing water are not considered.
1540014	UNIMIN TEXAS COMPANY LP VOCA PLANT	30.77	Small GW system. WQ issues: Insufficient data.
1540008	RICHLAND SUD BRADY	32.37	Small GW and purchased water system. WQ issues: Iron, Gross Alpha, Total Radium, Radium 226 and 228, Gross Alpha Particle Activity
1500011	LCRA TOW WATER SYSTEM	32.61	Small GW system. WQ issues: Iron, Radium 226 and 228, Gross Alpha Particle Activity
0250004	BROOKESMITH SPECIAL UTILITY DISTRICT	34.05	Large purchased water system. WQ issues: None. Systems currently purchasing water are not considered.
0250042	DEER RUN WATER SYSTEM	34.15	Small purchased water system. WQ issues: None. Systems currently purchasing water are not considered.
0270115	CANYON OF THE EAGLES PARK	34.58	Small GW system. WQ issues: Insufficient data.
1500113	NANAS KITCHEN	34.77	Small GW system. WQ issues: Nitrate (as N)
0250015	CITY OF EARLY	34.89	Large surface water and purchased water system. WQ issues: Systems currently purchasing water are not considered.

WQ = water quality
GW = groundwater
SW= surface water
WSC = water supply corporation

After the PWSs in Table 4.1 with water quality problems were eliminated from further consideration, the remaining PWSs were screened by proximity to North San Saba PWS and sufficient total production capacity for selling or sharing water. Based on the initial screening summarized in Table 4.1, three alternatives were selected for further evaluation. These alternatives are summarized in Table 4.2. The three alternatives are connections to the City of San Saba, Richland SUD, and the City of Goldthwaite. These PWSs are described following Table 4.2.

Table 4.2 Public Water Systems Within the Vicinity of the North San Saba PWS Selected for Further Evaluation

PWS ID	PWS Name	Pop	Connections	Total Production (mgd)	Avg Daily Usage (mgd)	Approx. Dist. from North San Saba	Comments/Other Issues
2060001	CITY OF SAN SABA	2637	1623	3.607	0.656	Connection to the City located near the north side of the San Saba River	North San Saba is in a contract with City of San Saba where the North San Saba WSC must purchase 100,000 to 3,000,000 gallons/month.
2060012	RICHLAND SUD	1665	555	0.385	0.129	18.4	Small GW system. WQ issues: None.
1670001	CITY OF GOLDTHWAITE	2127	912	0.884	0.282	19.4	Small GW and surface water system. WQ issues: None.

GW = groundwater
WSC = water supply corporation

4.2.1.1 City of San Saba (2060001)

The City of San Saba is a groundwater system that has compliant water and is under contract to provide 100,000 to 3,000,000 gallons per month to North San Saba PWS. The connection to the North San Saba PWS is located about 0.25-mile south of the San Saba River at the city limits. Total groundwater production capacity is 0.656 MGD for a population of about 2640 people and 1620 connections.

4.2.1.2 Richland Special Utility District (2060012)

Richland SUD is located approximately 11 miles west from North San Saba. The SUD's Richland Springs total groundwater production capacity is 0.39 MGD for a population of about 1,665 people or 555 connections.

Richland SUD Richland Springs PWS owns two wells (250 and 750 gpm). The second well may have contaminants that exceed their respective MCLs. During the last few years, the PWS has considered constructing a pipeline to blend water from its new well with its older well water. The SUD is also looking for a source of surface water.

4.2.1.3 City of Goldthaite (1670001)

The City of Goldthwaite is located approximately 14 miles north of North San Saba PWS.

The City pumps water from the Colorado River into two surface water reservoirs with capacities of 200 acre-feet and 300 acre-feet. The water passes through a micro-filtration unit at the City water treatment plant which has a capacity of 0.8 MGD. The average usage is typically 12,000,000 gallons monthly or 0.4 MGD which indicates the treatment plant is operating at about 50% capacity. The City does have excess water available; however it is limited during the summer months when the Colorado River is at a lower stage. The population is approximately 1800 and there are 1010 connections.

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 have water quality problems, it should be possible to share in the cost and effort of identifying compliant groundwater and constructing well fields.

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

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

Some of the alternatives suggest new wells be drilled in areas where existing wells have acceptable water quality. In developing the cost estimates, Parsons assumed 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

Three overlapping, low-yield aquifers that surround the Llano uplift region of central Texas are the source for potable water wells located throughout San Saba County. Those aquifers are, from the upper hydrogeological unit to the deepest, the Marble Falls aquifer, Ellenburger-San Saba aquifer, and Hickory aquifer.

Two wells operated by the North San Saba PWS are completed in the Hickory aquifer. A search of registered wells was conducted using Public Water Supply database to assess groundwater sources utilized within a 10-mile radius of the PWS. The search indicated that a large number of domestic and public supply wells within the search area are completed in the Ellenburger-San Saba aquifer, but both the Hickory and Marble Falls aquifers are also utilized domestic and public supplies.

Key features of the two groundwater sources in the PWS vicinity are discussed below, followed by a summary of groundwater availability.

Groundwater Supply

The *Hickory aquifer*, the water source of the North San Saba PWS, is classified by the TWDB as minor on the basis of potential water production. Pockets of water-bearing rock layers of the aquifer that appear at the land surface (outcrop) are scattered mostly throughout Llano, McCulloch and San Saba counties. Deeper aquifer formations, the down dip, extend over 12 counties, including the entire San Saba County. Most of the water pumped from the Hickory aquifer is used for irrigation, although some high capacity wells are used for municipal supplies. Slight water level fluctuations occur seasonally in irrigated areas (TWDB 2007).

Wells completed in the Hickory aquifer commonly yield as much as 1,000 gallons per minute. Aquifer utilization in the previous two decades has ranged from about 17,000 to 28,000 acre-feet per year (AFY), with an estimated value of 17,634 AFY for 2000 (Mace and Angle 2004). The 2007 Texas Water Plan indicates that the groundwater supplies from the Hickory aquifer, with implementation of water management strategies, will steadily increase during the 50-year planning period, from about 50,000 AFY in 2010 to about 62,000 AFY in the year 2060.

The Marble Falls aquifer, the second source of groundwater in the PWS vicinity, is a thin hydrogeological unit overlaying the Ellenburger-San Saba and Hickory aquifers. The aquifer, that extends over eight counties, is composed of several discontinuous outcrops located mostly in the northern and eastern flanks of the Llano Uplift region (Mace and Angle 2004).

The Marble Falls aquifer is extensively utilized for livestock watering and irrigation; its use for municipal supply purposes is relatively small, and largely restricted to San Saba and Mason counties. The aquifer is capable of producing small to moderate quantities of water, with wells typically producing less than 100 gpm, although some irrigation wells produce as much as 200 gpm. Pumping from the aquifer over the two previous two decades has ranged from 700 to about 1,800 AFY, with an estimated value of 1,468 AFY for the year 2000 (Mace and Angle 2004).

Groundwater Availability

Groundwater utilization in San Saba County was estimated at 6,186 AFY for 2000, representing over 45 percent of the total water use in the county (Mace and Angle 2004). Over the 2010-2060 planning period, the 2007 Texas Water Plan indicates that the water supply will be adequate to meet the increasing water demand in San Saba County; and only a small deficit of 5 AFY is expected for municipal water supply.

In the Llano uplift area, water level declines in the Hickory aquifer have occurred in Gillespie and Mason Counties; small water declines have also been reported for the Ellenburger-San Saba Aquifer (Smith 2004). A groundwater availability model (GAM) is not currently available for aquifers of the Llano uplift region that supply groundwater in San Saba County. As a basis for future development of a combined GAM for the Ellenburger-San Saba, Hickory and Marble Falls aquifers, the TWBD has completed the evaluation of aquifer structure and water elevation contour surfaces of the Llano Uplift region (Standen and Ruggiero 2007).

4.2.3 Potential for New Surface Water Sources

There is a minimum potential for development of new surface water sources for the North San Saba Water System because water availability is very limited over the entire river basin, at the county level, and within the site vicinity.

The PWS is located in the middle reach of the Colorado Basin, within a relatively arid region of Texas that has a low surface water yield. The Texas State Water Plan, updated in 2007 by the TWDB, estimates that the average yield over the entire basin is 1.2 inches per year. Surface water rights are assigned primarily to municipal use and irrigation (66 and 25 percent, respectively). Over a 50-year planning period, the plan anticipates that availability will steadily decrease as a result of an increasing water demand. A projected 2010 surface water supply value of 1,110,000 AFY for the Colorado Basin is expected to decrease over 10 percent by the year 2060. This decrease takes into account the implementation of various long-term water management strategies proposed in the State Water Plan.

The TPWD developed a surface water availability model for the Colorado Basin as a tool to determine, at a regional level, the maximum amount of water available during the drought of record over the simulation period. For the PWS vicinity, simulation data indicate that there is a minimum availability of surface water for new uses. Surface water availability maps were developed by TCEQ illustrating percent of months of flow per year indicate that unappropriated flows for new applications are typically available less than 25 percent of the time in the site vicinity, and over the entire San Saba County. This availability is inadequate for development of new municipal water supplies as a 100 percent year-round availability is required by TCEQ for new surface water source permit applications

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. City of San Saba. Additional water would be purchased from the City of San Saba to be used by the North San Saba PWS (Alternative NS-1).

2. Richland SUD. Water would be purchased from the Richland Springs SUD to be used by the North San Saba PWS. A pipeline would be constructed to convey water from the Richland SUD and the water would be piped to North San Saba PWS (Alternative NS-2).

3. City of Goldthwaite. Water would be purchased from the City of Goldthwaite to be used by the North San Saba PWS. A pipeline would be constructed to convey water from the City of Goldthwaite and the water would be piped to the North San Saba PWS (Alternative NS-3).

4. New Wells at 10, 5, and 1 mile. Installing a new well within 10, 5, or 1 mile of the North San Saba PWS may produce compliant water in place of the water produced by the existing active well. A pipeline and pump station would be constructed to transfer the water to the North San Saba PWS (Alternatives NS-4, NS-5, and NS-6).

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of the well water is identified as a potential option. RO and WRT Z-88 are potentially applicable processes. The central RO treatment alternative is Alternative NS-7, and the central WRT Z-88 treatment alternative is Alternative NS-8.

4.3.2 Point-of-Use Systems

POU treatment using RO technology is valid for combined radium and gross alpha removal. The POU treatment alternative is NS-9.

4.3.3 Point-of-Entry Systems

POE treatment using RO technology is valid for combined radium and gross alpha removal. The POE treatment alternative is NS-10.

4.4 BOTTLED WATER

Providing bottled water is considered an interim measure to be used until a compliance alternative is implemented. Even though the community is small and people know each other; it would be reasonable to require a quarterly communication advising customers of the need to take advantage of the bottled water program. An alternative to providing delivered bottled water is to provide a central, publicly accessible dispenser for treated drinking water. Alternatives addressing bottled water are NS-11, NS-12, and NS-13.

4.5 ALTERNATIVE DEVELOPMENT AND ANALYSIS

A number of potential alternatives for compliance with the MCL for combined radium and gross alpha 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 NS-1: Purchase Water from the City of San Saba

This alternative involves purchasing additional potable water from the City of San Saba that would be used to supply water to the North San Saba PWS. The City of San Saba currently has sufficient excess capacity for this alternative to be feasible. A connection between the two systems has already been established approximately 0.25-mile south of the San Saba River at the city limits. The North San Saba PWS has a contract with the City where it must provide between 0.10 to 3.0 million gallons per month of water. For purposes of this report, to allow direct and straightforward comparison with other alternatives, this alternative assumes that water would be purchased from the City of San Saba. Also, it is assumed that North San Saba PWS would obtain all its water from the City of San Saba.

By definition this alternative involves regionalization, since North San Saba PWS would be obtaining drinking water from an existing larger supplier. Also, other PWSs near North San Saba PWS are in need of compliant drinking water and could share in implementation of this alternative.

The estimated capital cost for this alternative includes a backflow preventer. However, an hydraulic analysis of the PWS's water distribution system is needed to determine if additional infrastructure is needed, such as a storage tank and distribution pumps to assist with peak demand. The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the North San Saba PWS's wells. The estimated capital cost for this alternative is $5,900, with an estimated annual O&M savings of $39,600. 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 the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the North San Saba PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and North San Saba PWS personnel currently operate pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

The feasibility of this alternative is dependent on the continued agreement with the City of San Saba to purchase compliant drinking water.

4.5.2 Alternative NS-2: Purchase Water from the Richland SUD

This alternative involves purchasing potable water from the Richland SUD that would be used to supply water to the North San Saba PWS. Richland SUD currently has sufficient excess capacity for this alternative to be feasible, although any agreement to supply water would have to be negotiated between the Richland SUD and the North San Saba PWS. For purposes of this report, to allow direct and straightforward comparison with other alternatives, this alternative assumes that water would be purchased from Richland SUD. Also, it is assumed that North San Saba PWS would obtain all its water from Richland SUD.

This alternative would require construction of a pump station and a 5,000-gallon feed tank at a point adjacent to a Richland SUD water line near the intersection of County Road (CR) 256 and CR 262. The required pipeline would be 6-inches in diameter and approximately 18.4 miles long. The pipeline would follow east on CR 256 and south on CR 252, then east and north on CR 246 to CR 244, then continue east on CR 244 to CR 236, then north on CR 236 for approximately 0.25 miles to a dirt road, then turn east and continue on to CR 202 heading southeast to CR 209, then north on FM 500 to the North San Saba PWS. The pipeline would terminate at the existing standpipe owned by the North San Saba PWS.

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 North San Saba PWS, since the incremental cost would be relatively small, and it would provide operational flexibility.

By definition this alternative involves regionalization, since North San Saba PWS would be obtaining drinking water from an existing larger supplier. Also, other PWSs near North San Saba PWS are in need of compliant drinking water and could share in implementation of this alternative.

The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operations of the North San Saba PWS's wells. Additionally, the maintenance cost for the pipeline, pump station, electric power, and O&M are included in the cost estimate. The estimated capital cost for this alternative is $3.80 million, with an estimated annual O&M cost of $41,000. 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 the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the North San Saba PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and North San Saba PWS personnel currently operate pipelines and a pump station. If the decision was made to perform blending then the operational complexity would increase.

The feasibility of this alternative would be dependent on North San Saba PWS being able to reach an agreement with Richland SUD to purchase compliant drinking water.

4.5.3 Alternative NS-3: Purchase Treated Water from the City of Goldthwaite

This alternative involves purchasing potable water from the City of Goldthwaite that would be used to supply water to the North San Saba PWS. The City of Goldthwaite currently has sufficient excess capacity for this alternative to be feasible, although any agreement to supply water would have to be negotiated and approved by the City Council. For purposes of this report, to allow direct and straightforward comparison with other alternatives, this alternative assumes that water would be purchased from the City of Goldthwaite. Also, it is assumed that North San Saba PWS would obtain all its water from the City of Goldthwaite.

This alternative would require construction of a pump station and a 5,000 gallon feed tank at a point adjacent to a City of Goldthwaite water line near Texas Highway 16 and McIntosh Street. The required pipeline would be 6-inches in diameter, approximately 19.4 miles long. The pipeline would follow FM 500 for 0.25 miles, then east on CR 119, then north on CR 117 to Creek 127 and continuing on northeastward to State Hwy 16 and tap into the existing City of Goldthwaite distribution system on the southwest side of the city.

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 North San Saba PWS, since the incremental cost would be relatively small, and would provide operational flexibility.

By definition this alternative involves regionalization, since North San Saba PWS would be obtaining drinking water from an existing larger supplier. Also, other PWSs near North San Saba PWS are in need of compliant drinking water and could share in implementation of this alternative.

The estimated O&M cost for this alternative includes the purchase price for the treated water minus the cost related to current operation of the North San Saba PWS wells. Additionally, the maintenance cost for the pipeline, pump station, electric power and O&M are included in the cost estimate. The estimated capital cost for this alternative is $3.93 million, with an estimated annual O&M cost of $6,700. 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 the finished water is compliant.

The reliability of adequate amounts of compliant water under this alternative should be good. From the perspective of the North San Saba PWS, this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood. If the decision was made to perform blending then the operational complexity would increase.

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

4.5.4 Alternative NS-4: New Well at 10 miles

This alternative consists of installing two new wells within 10 miles of the North San Saba PWS that would produce compliant water in place of the water produced by existing wells. At this level of study, it is not possible to positively identify existing wells or the location where new wells could be installed.

This alternative would require constructing two new 3,518-foot wells, a new pump station with a 5,000-gallon feed tank near the new wells, and a pipeline from the new well/feed tank to the existing intake point for the North San Saba PWS system. The pump station and feed 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 6-inches in diameter and discharge to the existing standpipe at the North San Saba PWS. The pump station would include a feed tank, two transfer 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 wells, constructing the pipeline, the pump station, the feed tank, service pumps and pump house. The estimated O&M cost for this alternative includes O&M for the pipeline and pump stations. The estimated capital cost for this alternative is $3.68 million, and the estimated annual O&M cost for this alternative is $40,200.

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

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

4.5.5 Alternative NS-5: New Well at 5 miles

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

This alternative would require constructing two new 3,518-foot wells, a new pump station with 5,000-gallon feed tank near the new well, and a pipeline from the new well/feed tank to the existing intake point for the North San Saba PWS system. The pump station and feed tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be 6-inches in diameter, approximately 5 miles long, and would discharge to the existing standpipe at the North San Saba PWS. The pump station near the well would include two transfer 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 wells, and constructing the pipeline and pump station. The estimated O&M cost for this alternative includes O&M for the pipeline and pump station. The estimated capital cost for this alternative is $2.67 million, and the estimated annual O&M cost for this alternative is $38,700.

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

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

4.5.6 Alternative NS-6: New Well at 1 mile

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

This alternative would require constructing two new 3,518-foot wells and a pipeline from the new well to the existing standpipe with two service pumps installed within a pump house near the existing intake point for the North San Saba PWS system. Since the new wells are relatively close, a pump station would not be necessary. For this alternative, the pipeline is assumed to be 6-inches in diameter, approximately 1 mile long, and would discharge to the existing storage tank at the North San Saba PWS.

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

The estimated capital cost for this alternative includes installing the wells, and constructing the pipeline. The estimated O&M cost for this alternative includes O&M for the pipeline. The estimated capital cost for this alternative is $1.74 million, and the estimated annual O&M cost for this alternative is $12,400.

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

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

4.5.7 Alternative NS-7: Central RO Treatment

This system would continue to pump water from both existing wells, and would treat the water through an RO system prior to distribution. Because of the relatively high radium concentrations, 100 percent of the raw water would be treated to obtain compliant water. The RO process concentrates impurities in the reject stream which would require disposal. It is estimated the RO reject generation would be approximately 32,000 gallons per day (gpd) when the system is operated at the average daily consumption of 87,000 gpd. It is assumed that the brine reject could be gradually released to the San Saba wastewater treatment system. Should this not be the case, the cost of the alternative would rise due to trucking and liquid disposal costs.

This alternative consists of constructing the RO treatment plant near the existing well. The plant comprises a 900 square foot building with a paved driveway; a skid with the pre-constructed RO plant; transfer pumps, a 39,000-gallon tank for storing the treated water, and a 227,000-gallon tank for storing reject water. The treated water would be chlorinated prior to being pumped into the distribution system. The entire facility would be fenced.

The estimated capital cost for this alternative is $1.1 million, and the estimated annual O&M cost is $143,700. This estimate is based on the assumption that the reject can be piped directly to a local sewer leading to a sewage treatment plant.

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

4.5.8 Alternative NS-8: Central WRT Z-88 Treatment

The system would continue to pump water from the North San Saba PWS wells, and would treat the water through the Z-88 adsorption system prior to distribution. The full flow of raw water would be treated by the Z-88 system as the media specifically adsorb radium and do not affect other constituents. There is no liquid waste generated in this process, other than the occasional backwash for the media. The Z-88 media would be replaced and disposed by WRT in an approved low-level radioactive waste landfill after 2-3 years of operation.

This alternative consists of constructing the Z-88 treatment system at the existing North San Saba PWS well field. WRT owns the Z-88 equipment and the Subdivision would pay for construction for the treatment unit and auxiliary facilities. The plant is composed of a 960 square foot building with a paved driveway; the pre-fabricated Z-88 adsorption system owned by WRT; and piping system. The entire facility would be fenced. The treated water would be chlorinated prior to distribution. It is assumed the well pumps would have adequate pressure to pump the water through the Z-88 system to the ground storage tanks without requiring new pumps.

The estimated capital cost for this alternative is $503,100, and the estimated annual O&M cost is $187,600.

Based on many pilot testing results and some full-scale plant data, this technology appears to be reliable. It is very simple to operate and the media replacement and disposal would be handled by WRT. Because WRT owns the equipment, the capital cost is relatively low. The main operating cost would be WRT's fee for the treated water. One concern with this technology is the potential health effect on O&M personnel because of the level of radioactivity accumulated in the Z-88 vessel after the media have been operating for a long time.

4.5.9 Alternative NS-9: Point-of-Use Treatment

This alternative consists of the continued operation of the North San Saba PWS well field, plus treatment of water to be used for drinking or food preparation at the point of use to remove combined radium and gross alpha. The purchase, installation, and maintenance of POU treatment systems to be installed "under the sink" would be necessary for this alternative. Blending is not an option in this case.

This alternative would require installing the POU treatment units in residences and other buildings that provide drinking or cooking water. North San Saba PWS staff would be responsible for purchase and maintenance of the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. In houses, the most convenient point for installation of the treatment units is typically under the kitchen sink, with a separate tap installed for dispensing treated water. Installation of the treatment units in kitchens will require the entry of North San Saba or contract personnel into the houses of customers. As a result, cooperation of customers would be important for success implementing this alternative. The treatment units could be installed for access without house entry, but that would complicate the installation and increase costs.

Treatment processes would involve RO. Treatment processes produce a reject waste stream. The reject waste streams result 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 the increase in water consumption is insignificant in terms of supply cost, and that the reject 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 membranes, as well as periodic sampling and record keeping as required by the Texas Administrative Code (Title 30, Part I, Chapter 290, Subchapter F, Rule 290.106). The estimated capital cost for this alternative is $230,000, and the estimated annual O&M cost for this alternative is $222,100. For the cost estimate, it is assumed that one POU treatment unit will be required for each of the 303 connections in the North San Saba 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. Additionally, capital cost would increase if POU treatment units are placed at other taps within a home, such as refrigerator water dispensers, ice makers, and bathroom sinks. In school settings, all taps where children and faculty receive water may need POU treatment units or clearly mark those taps suitable for human consumption. Additional considerations may be necessary for preschools or other establishments where individuals cannot read.

The reliability of adequate amounts of compliant water under this alternative is fair, since it relies on the active cooperation of the customers for system installation, use, and maintenance, and only provides compliant water to single tap within a house. Additionally, the O&M efforts (including monitoring of the devices to ensure adequate performance) required for the POU systems will be significant, and the current personnel are inexperienced in this type of work. From the perspective of the North San Saba PWS, this alternative would be characterized as more difficult to operate owing to the in-home requirements and the large number of individual units.

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

4.5.10 Alternative NS-10: Point-of-Entry Treatment

This alternative consists of the continued operation of the North San Saba PWS well field, plus treatment of water as it enters residences to remove combined radium and gross alpha.

The purchase, installation, and maintenance of the treatment systems at the point of entry to a household would be necessary for this alternative. Blending is not an option in this case.

This alternative would require the installation of the POE treatment units at houses and other buildings that provide drinking or cooking water. Every building connected to the system must have a POE device installed, maintained, and adequately monitored. TCEQ must be assured the system has 100 percent participation of all property and or building owners. A way to achieve 100 percent participation is through a public announcement and education program. Example public programs are provided in the document "*Point-of-Use or Point-of-Entry" Treatment Options for Small Drinking Water Systems*" published by USEPA. The property owner's responsibilities for the POE device must also be contained in the title to the property and "run with the land" so subsequent property owners understand their responsibilities (USEPA 2006).

North San Saba PWS would be responsible for purchase, operation, and maintenance of the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. It may also be desirable to modify piping so water for non-consumptive uses can be withdrawn upstream of the treatment unit. The POE treatment units would be installed outside the residences, so entry would not be necessary for O&M. Some cooperation from customers would be necessary for installation and maintenance of the treatment systems.

POE treatment for combined radium and gross alpha would involve RO. Treatment processes produce a reject stream that requires disposal. The reject water stream results in a slight increase in overall volume of water used. POE systems treat a greater volume of water than POU systems. For this alternative, it is assumed the increase in water consumption is insignificant in terms of supply cost, and that the backwash reject 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 membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $4.75 million, and the estimated annual O&M cost for this alternative is $671,100. For the cost estimate, it is assumed that one POE treatment unit will be required for each of the 303 existing connections to the North San Saba PWS system.

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

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

4.5.11 Alternative NS-11: Public Dispenser for Treated Drinking Water

This alternative consists of the continued operation of the North San Saba PWS well, plus dispensing treated water for drinking and cooking at a publicly accessible location. Implementing this alternative would require purchasing and installing two treatment units where customers would be able to come and 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.

North San Saba PWS personnel would be responsible for maintenance of the treatment unit, including media or membrane replacement, periodic sampling, and necessary repairs. The spent media or membranes will require disposal. This alternative relies on a great deal of cooperation and action from the customers in order to be effective.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes purchasing and installing the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes purchasing and replacing filters and media or membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is $36,700, and the estimated annual O&M cost for this alternative is $66,200.

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

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

4.5.12 Alternative NS-12: 100 Percent Bottled Water Delivery

This alternative consists of the continued operation of the North San Saba PWS wells, but compliant drinking water will be delivered to customers in containers. This alternative involves setting up and operating a bottled water delivery program to serve all customers in the system. It is expected that North San Saba would find it most convenient and economical to contract a bottled water service. The bottle delivery program would have to be flexible enough to allow the delivery of smaller containers should customers be incapable of lifting and manipulating 5-

gallon bottles. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

This alternative does not involve capital cost for construction, but would require some initial costs for system setup, and then ongoing costs to have the bottled water furnished. It is assumed for this alternative that bottled water is provided to 100 percent of the North San Saba PWS 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 $27,600, and the estimated annual O&M cost for this alternative is $524,500. For the cost estimate, it is assumed that each person requires one gallon of bottled water per day.

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

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

4.5.13 Alternative NS-13: Public Dispenser for Trucked Drinking Water

This alternative consists of continued operation of the North San Saba PWS wells, plus dispensing compliant water for drinking and cooking at a publicly accessible location. The compliant water would be purchased from the City of Richland Springs, 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 treatment, 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.

North San Saba PWS 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 bleach. This alternative relies on a great deal of cooperation and action from the customers for it to be effective.

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

The estimated capital cost for this alternative includes purchasing a water truck and 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 $203,800, and the estimated annual O&M cost for this alternative is $29,400.

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

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

4.5.14 Summary of Alternatives

Table 4.3 provides a summary of the key features of each alternative for North San Saba PWS.

Table 4.3 Summary of Compliance Alternatives for North San Saba PWS

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
NS-1	Purchase water from City of San Saba	- Backflow preventer	$5,900	$(39,600)	$(39,100)	Good	N	Continue contract agreement with City of San Saba. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
NS-2	Purchase water from Richland SUD	- Pump station/feed tank - 18.4-mile pipeline	$3,804,000	$41,000	$372,700	Good	N	Agreement must be successfully negotiated with Richland SUD. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
NS-3	Purchase water from City of Goldthwaite	- Pump station/feed tank - 19.4-mile pipeline	$3,933,500	$6,700	$349,600	Good	N	Agreement must be successfully negotiated with the City of Goldthwaite. Blending may be possible. Costs could possibly be shared with small systems along pipeline route.
NS-4	Install new compliant well within 10 miles	- 2 New wells - Pump station/feed tank - 10-mile pipeline	$3,677,200	$40,200	$360,800	Good	N	May be difficult to find well with good water quality. Costs could possibly be shared with small systems along pipeline route.
NS-5	Install new compliant well within 5 miles	- 2 New wells - Pump station/feed tank - 5-mile pipeline	$2,674,000	$38,700	$271,800	Good	N	May be difficult to find well with good water quality. Costs could possibly be shared with small systems along pipeline route.
NS-6	Install new compliant well within 1 mile	- 2 New wells - 1-mile pipeline	$1,740,100	$12,400	$164,100	Good	N	May be difficult to find well with good water quality.
NS-7	Continue operation of North San Saba well field with central RO treatment	- Central RO treatment plant	$1,115,600	$143,700	$241,000	Good	T	Costs could possibly be shared with nearby small systems.
NS-8	Continue operation of North San Saba well field with central WRT Z-88 treatment	- Central WRT Z-88 treatment plant	$503,100	$187,600	$231,500	Good	T	Costs could possibly be shared with nearby small systems.
NS-9	Continue operation of North San Saba well field, and POU treatment	- POU treatment units.	$230,000	$222,100	$242,100	Fair	T, M	Only one compliant tap in home. Cooperation of residents required for installation, maintenance, and testing.
NS-10	Continue operation of North San Saba well field, and POE treatment	- POE treatment units.	$4,747,000	$671,100	$1,085,000	Fair (*better than POU*)	T, M	All home taps compliant and less resident cooperation required.
NS-11	Continue operation of North San Saba well field, but furnish public dispenser for treated drinking water	- Water treatment and dispenser unit	$36,700	$66,200	$69,400	Fair/interim measure	T	Does not provide compliant water to all taps, and requires a lot of effort by customers.

Alt No.	Alternative Description	Major Components	Capital Cost[1]	Annual O&M Cost	Total Annualized Cost	Reliability	System Impact	Remarks
NS-12	Continue operation of North San Saba well field, but furnish bottled drinking water for all customers	- Set up bottled water system	$27,600	$524,500	$526,900	Fair/interim measure	M	Does not provide compliant water to all taps, and requires customers to order and use. Management of program may be significant.
NS-13	Continue operation of North San Saba well field, but furnish public dispenser for trucked drinking water.	- Construct storage tank and dispenser - Purchase potable water truck	$203,800	$29,400	$47,200	Fair/interim measure	M	Does not provide compliant water to all taps, and requires a lot of effort by customers.

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

4.6 COST OF SERVICE AND FUNDING ANALYSIS

To evaluate the financial impact of implementing the compliance alternatives, a 30-year financial planning model was developed. This model can be found in Appendix D. The financial model is based on estimated cash flows, with and without implementation of the compliance alternatives. Data for such models are typically derived from established budgets, audited financial reports, published water tariffs, and consumption data. North San Saba PWS serves a population of 909 and has 303 connections. Information that was available to complete the financial analysis was the balance sheet for the system dated May 31, 2010, and the profit and loss statement for 2009. The water usage rate for North San Saba PWS was estimated to be 81 gpd per capita based on average daily use and current population.

This analysis will need to be performed in a more detailed fashion and applied to alternatives 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

Expenses for the North San Saba PWS were derived from the 2009 Profit and Loss Statement. A total of 27 million gallons of water were sold in FY2009, with water sales revenues of $303,236. Direct water services expenses were $264,066. These values as well as other financial data were entered into the financial model.

The average annual water bill was $1001 or approximately 3.3 percent of the median annual household income of $30,104. The North San Saba PWS MHI may be greater than 75% of the median state household income, which may reduce eligibility for some grants and low interest rate loans. It may be advisable to perform a study to definitively determine the MHI for the water system.

4.6.2 Current Financial Condition

4.6.2.1 Cash Flow Needs

The current rate appears to be adequate for funding current operations. North San Saba PWS may need to raise rates in the future to service the debt associated with capital improvements.

4.6.2.2 Ratio Analysis

Current Ratio = 6.34

The Current Ratio is a measure of liquidity. It is defined as the ratio of current assets to current liabilities. Current liabilities are defined as all debt due within 1 year. A Current Ratio of 6.34 indicates that the North San Saba PWS would be able to meet all its current obligations, with total current assets of $68,569 exceeding the current liabilities of $10,808.

Debt to Net Worth Ratio = 0.93

A Debt to Net Worth ratio is another measure of financial liquidity and stability. The North San Saba PWS has a net worth of $463,525, and a total debt of $497,864, resulting in a debt to net worth ratio of 0.93. Ratios less than 1.25 are indicative of financial stability, with lower ratios indicating greater financial stability and better credit risks for future borrowings. Based on the present ratio, North San Saba PWS meets the suggested threshold for financially stability.

Operating Ratio = 1.15

The Operating Ratio is a financial term defined as a company's revenues divided by the operating expenses. For this calculation water service related revenues and expenses, including interest income, connections fees, debt service, and other sources (uses) for sustained operations. An operating ratio of 1.0 means that a utility is collecting just enough money to meet expenses. In general, an operating ratio of 1.25 or higher is desirable. An operating ratio of 1.15 indicates that North San Saba PWS may need to raise water rates for its customers to be able to make capital improvements.

4.6.3 Financial Plan Results

Each of the compliance alternatives for the North San Saba PWS 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.Results of the financial impact analysis are provided in Table 4.4 and Figure 4.2. Table 4.4 and Figure 4.2 present rate impacts assuming that revenues match expenses, without funding reserve accounts, and that operations and implementation of compliance alternatives are funded with revenue and are not paid for from reserve accounts. Figure 4.2 provides a bar chart that, in terms of the yearly billing to an average customer, shows the following:

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

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

4.6.4 Evaluation of Potential Funding Options

There are a variety of funding programs available to entities as described in Section 2.4. North Saba PWS is most likely to obtain funding from programs administered by the TWDB, TDRA, and Rural Development. This report contains information that would be used for an application for funding. Information such as financial analyses, water supply assessment, and records demonstrating health concerns, failing infrastructure, and financial need, may be required by these agencies. This section describes the candidate funding agencies and their appropriate programs as well as information and steps needed to begin the application process.

This report should serve to document the existing water quality issues, infrastructure need and costs, and water system information needed to begin the application process. Although this report is at the conceptual level, it demonstrates that significant funding will be needed to meet Safe Drinking Water Standards. The information provided in this report may serve as the needed documentation to justify a project that may only be possible with significant financial assistance.

4.6.4.1 TWDB Funding Options

TWDB programs include the Drinking Water State Revolving Fund (DWSRF), Rural Water Assistance Fund, State Loan Program (Development Fund II), and Economically Distressed Areas Program (EDAP). Additional information on these programs can be found online at the TWDB website under the Assistance tab, Financial Assistance section, under the Public Works Infrastructure Construction subsection.

Drinking Water State Revolving Fund

The DWSRF offers net long-term interest lending rates below the rate the borrower would receive on the open market for a period no longer than 20 years. A cost-recovery loan origination charge is imposed to cover the administrative costs of operating the DWSRF, but an additional interest rate subsidy is offered to offset the charge. The terms of the loan typically require a revenue or tax pledge. The DWSRF program can provide funds from State sources or Federal capitalization grants. State loans provide a net long-term interest rate of 0.7 percentage points below the rate the borrower would receive on the open market at the time of loan closing and Federal Capitalization Grants provide a lower net long-term interest rate of 1.2 percentage points. “Disadvantaged communities” may obtain loans at even greater subsidies and up to a 30-year loan term.

The loan application process has several steps: pre-application, application and commitment, loan closing, funding and construction monitoring, and any other special requirements. In the pre-application phase, prospective loan applicants are asked to submit a brief DWSRF Information Form to the TWDB that describes the applicant's existing water facilities, additional facility needs and the nature of projects being considered for meeting those needs, project cost estimates, and "disadvantaged community" status. The TCEQ assigns a priority rating that includes an applicant's readiness to proceed. TWDB staff notifies prospective applicants of their priority rating and encourage them to schedule a pre-planning conference for guidance in preparing the engineering, planning, environmental, financial, and water conservation portions of the DWSRF application.

Rural Water Assistance Fund

Small rural water utilities can finance water projects with attractive interest rate loans with short and long-term finance options at tax exempt rates. Funding through this program gives an added benefit to nonprofit water supply corporations as construction purchases qualify for a sales tax exemption. Rural Political Subdivisions are eligible (non-profit water supply corporations; water districts or municipalities serving a population of up to 10,000; and counties in which no urban area has a population exceeding 50,000). A non-profit water supply corporation is eligible to apply these funds for design and construction of water projects. Projects can include line extensions, elevated storage, the purchase of well fields, the purchase or lease of rights to produce groundwater, and interim financing of construction projects. The fund may also be used to enable a rural water utility to obtain water service supplied by a larger utility or to finance the consolidation or regionalization of a neighboring utility.

A maximum financing life is 50 years for projects. The average financing period is 20 to 23 years. System revenues and/or tax pledges are typically required. The lending rate is set in accordance with the TWDB rules in 31 Texas Administrative Code (TAC) 384.5 and the scale varies according to the length of the loan and several factors. The TWDB seeks to provide reasonable rates for its customers with minimal risk to the state. The TWDB posts rates for comparison for applicants, and in August 2010 the TWDB showed its rates for a 22-year, taxable loan at 7.07 percent, where the market was at 8.47 percent. Funds in this program are not restricted.

The TWDB's Office of Project Finance and Construction Assistance staff can discuss the terms of the loan and assist applicants during preparation of the application, and this is encouraged. The application materials must include an engineering feasibility report, environmental information, rates and customer base, operating budgets, financial statements, and project information. The TWDB considers the needs of the area; benefits of the project; the relationship of the project to the overall state water needs; relationship of the project to the State Water Plan; and availability of all sources of revenue to the rural utility for the ultimate repayment of the water supply project cost. The board considers applications monthly.

State Loan Program (Development Fund II)

The State Loan Program is a diverse lending program directly from state funding sources. As it does not receive federal subsidies, it is more streamlined. The loans can incorporate more than one project under the umbrella of one loan. Water supply corporations are eligible, but will have taxable rates. Projects can include purchase of water rights, treatment plants, storage and pumping facilities, transmission lines, well development, and acquisitions.

The loan requires that the applicant pledge revenue or taxes, as well as some collateral for North Saba PWS. The maximum financing life is 50 years. The average financing period is 20 to 23 years. The interest rate is set in accordance with the TWDB rules in 31 TAC 363.33(a). The TWDB seeks to provide reasonable rates with minimal risk to the state. The TWDB post rates for comparison for applicants and in August 2010, the TWDB showed their rates for a 22-year, taxable loan at 7.07 percent where the market was at 8.47 percent.

The TWDB staff can discuss the terms of the loan and assist applicants during preparation of the application, and a preapplication conference is encouraged. The application materials must include an engineering feasibility report, environmental information, rates and customer base, operating budgets, financial statements, and project information. The board considers applications monthly.

Economically Distressed Areas Program

The EDAP was designed to assist areas along the U.S./Mexico border in areas that were economically distressed. In 2008, this program was extended to apply to the entire state so long as requirements are met. This program provides financial assistance through the provision of grants and loans to communities where present facilities are inadequate to meet minimal residential needs. Eligible communities are those that have median household income less than 75 percent of the state household income. The applicant must be capable of maintaining and operating the completed system, and hold or be in the process of obtaining a Certificate of Convenience and Necessity. The county where the project is located must adopt model rules for the regulation of subdivisions prior to application for financial assistance. If the applicant is a city, the city must also adopt Model Subdivision Rules of TWDB (31 TAC Chapter 364). The program funds planning, design, construction, and acquisition. Up to 75 percent funding is available for facility plans with certain hardship cases 100 percent funding may be available. Projects must complete the planning, acquisition, and design phase before applying for second phase construction funds. The TWDB works with the applicant to find ways to leverage other state and federal financial resources. For grant fund above 50 percent, the Texas Department of State Health Services must determine if there is a health and safety nuisance.

The loan requires that the applicant pledge revenue or taxes, as well as some collateral for North Saba PWS. The maximum financing life is 50 years. The average financing period is 20 to 23 years. The lending rate scale varies according to several factors but is set by the TWDB in accordance with the TWDB rules in 31 TAC 363.33(a). The TWDB seeks to provide reasonable rates with minimal loss to the state. The TWDB posts rates for comparison for applicants and in August 2010 the TWDB showed its rates for a 22-year, tax exempt loan at 5.05 percent where the market was at 6.05 percent. Most projects have a financial package with the majority of the project financed with grants. Many have received 100 percent grants.

The first step in the application process is to meet with TWDB staff to discuss the terms of the loan and assist applicants during preparation of the application. Major components of the application materials must include an engineering feasibility report, environmental information, rates and customer base, operating budgets, financial statements, community information, project information, and other legal information.

4.6.4.2 TDRA Funding Options

Created in 2001, TDRA seeks to strengthen rural communities and assist them with community and economic development and healthcare by providing a variety of rural programs, services, and activities. Of their many programs and funds, the most appropriate programs related to drinking water are the Community Development (CD) Fund and the Texas Small Towns Environment Program. These programs offer attractive funding packages to help make improvements to potable water systems to mitigate potential health concerns. These programs are available to counties and cities, which have to submit a TDRA application on behalf of the PWS. All program requirements would have to be met by the benefiting community receiving services by the PWS.

Community Development Fund

The CD Fund is a competitive grant program for water system improvements as well as other utility services (wastewater, drainage improvements, and housing activities). Funds are distributed between 24 state planning regions where funds are allocated to address each region's utility priorities. Funds can be used for various types of public works projects, including water system improvements. Communities with a population of less than 50,000 that are not eligible for direct CDBG funding from the U.S. Department of Housing and Urban Development are eligible. Funds are awarded on a competitive basis decided twice a year in each region by local elected officials, appointed by the Governor using a defined scoring system (past performance with CDBG is a factor). Awards are no less than $75,000 and cannot exceed $800,000. More information can be found at the Office of Community Affairs website under Community Development Fund.

Texas Small Towns Environment Program

Under special occasions some communities are invited to participate in grant programs when self-help is a feasible method for completing a water project, the community is committed to self-help, and the community has the capacity to complete the project. The purpose is to significantly reduce the cost of the project by using the communities' own human, material, and financial capital. Communities with a population of less than 50,000 that are not eligible for direct CDBG funding from the U.S. Department of Housing and Urban Development are eligible. Projects typically are repair, rehabilitation, improvements, service connections, and yard services. Reasonable associated administration and engineering cost can be funded. A letter of interest is first submitted, community meetings are held, and after CDBG staff determines eligibility with a written invitation to apply, an application may be submitted. Awards are only given twice per year on a priority basis so long as the project can be fully funded ($350,000 maximum award). Ranking criteria are project impact, local effort, past performance, percent of savings, and benefit to low to medium-income persons.

4.6.4.3 Rural Development

The Rural Utilities Service's (RUS) agency of Rural Development established Water and Waste Disposal Program for public entities administered by the staff of the Water and Environment Program to assist communities with water and wastewater systems. The purpose is to fund technical assistance and projects to help communities bring safe drinking water and sanitary, environmentally sound, waste disposal facilities to rural Americans in greatest need.

The Water and Waste Disposal Program provides loans, grants, and loan guarantees for drinking water, sanitary sewer, solid waste, and storm drainage facilities in rural areas and cities and towns with a population of 10,000 people and rural areas with no population limits. Recipients must be public entities such as municipalities, counties, special purpose districts, Indian tribes, and non-profit corporations. RUS has set aside direct loans and grants for several areas (e.g., empowerment zones). Projects include all forms of infrastructure improvement, acquisition of land and water rights, and design fees. Funds are provided on a first come, first serve basis; however, staff do evaluate need and assign priorities as funds are limited. Grant/loan mixes vary on a case by case basis and some communities may have to wait though several funding cycles until funds become available.

Entities must demonstrate that they cannot obtain reasonable loans at market rates, but have the capacity to repay loans, pledge security, and operate the facilities. Grants can be up to 75 percent of the project costs, and loan guarantees can be up to 90 percent of eligible loss. Loans are not to exceed a 40-year repayment period, require tax or revenue pledges, and are offered at three rates:

- Poverty Rate - The lowest rate is the poverty interest rate of 4.5 percent. Loans must be used to upgrade or construct new facilities to meet health standards, and the MHI in the service area must be below the poverty line for a family of four or below 80 percent of the statewide MHI for non-metropolitan communities.

- Market Rate – Where the MHI in the service exceeds the state MHI, the rate is based on the average of the "Bond Buyer" 11-Bond Index over a four week period.

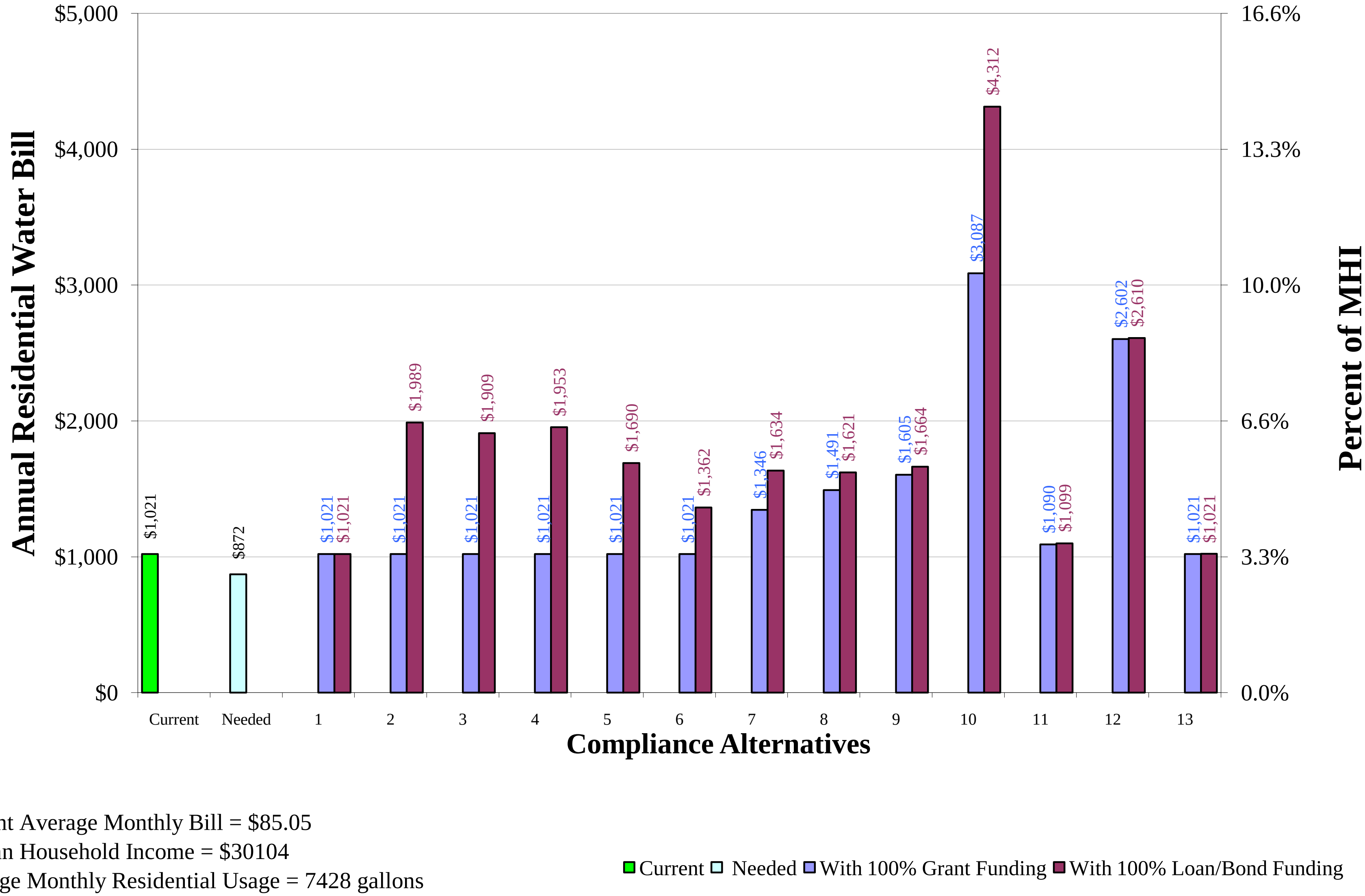
- Intermediate Rate – the average of the Poverty Rate and the Market Rate, but not to exceed seven percent.

North San Saba WSC

Table 4.4 Financial Impact on Households

Alternative	Description		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Bond
1	Purchase water from City of San Saba	Maximum % of MHI	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%
		Percentage Rate Increase Compared to Current	0%	0%	0%	0%	0%	0%
		Average Annual Water Bill	$1,021	$1,021	$1,021	$1,021	$1,021	$1,021
2	Purchase water from Richland SUD	Maximum % of MHI	44.6%	3.4%	4.2%	5.0%	6.1%	6.6%
		Percentage Rate Increase Compared to Current	1216%	0%	23%	47%	81%	95%
		Average Annual Water Bill	$13,426	$1,021	$1,252	$1,498	$1,843	$1,989
3	Purchase water from City of Goldthwaite	Maximum % of MHI	46.0%	3.4%	3.8%	4.7%	5.8%	6.3%
		Percentage Rate Increase Compared to Current	1257%	0%	12%	37%	72%	87%
		Average Annual Water Bill	$13,853	$1,021	$1,147	$1,401	$1,758	$1,909
4	Install new compliant well within 10 miles	Maximum % of MHI	43.2%	3.4%	4.1%	4.9%	6.0%	6.5%
		Percentage Rate Increase Compared to Current	1174%	0%	22%	45%	78%	91%
		Average Annual Water Bill	$13,007	$1,021	$1,241	$1,479	$1,812	$1,953
5	Install new compliant well within 5 miles	Maximum % of MHI	32.2%	3.4%	3.9%	4.5%	5.3%	5.6%
		Percentage Rate Increase Compared to Current	850%	0%	15%	32%	55%	66%
		Average Annual Water Bill	$9,697	$1,021	$1,172	$1,344	$1,587	$1,690
6	Install new compliant well within 1 mile	Maximum % of MHI	22.0%	3.4%	3.4%	3.8%	4.3%	4.5%
		Percentage Rate Increase Compared to Current	548%	0%	0%	11%	27%	33%
		Average Annual Water Bill	$6,615	$1,021	$1,025	$1,137	$1,295	$1,362
7	Continue operation of North San Saba well field with cen	Maximum % of MHI	15.1%	4.5%	4.7%	4.9%	5.3%	5.4%
		Percentage Rate Increase Compared to Current	346%	32%	39%	46%	56%	60%
		Average Annual Water Bill	$4,553	$1,346	$1,418	$1,490	$1,591	$1,634
8	Continue operation of North San Saba well field with cen	Maximum % of MHI	8.4%	5.0%	5.1%	5.2%	5.3%	5.4%
		Percentage Rate Increase Compared to Current	148%	46%	49%	52%	57%	59%
		Average Annual Water Bill	$2,532	$1,491	$1,523	$1,556	$1,601	$1,621
9	Continue operation of North San Saba well field, and PO	Maximum % of MHI	5.4%	5.3%	5.4%	5.4%	5.5%	5.5%
		Percentage Rate Increase Compared to Current	60%	57%	59%	60%	62%	63%
		Average Annual Water Bill	$1,631	$1,605	$1,619	$1,634	$1,655	$1,664
10	Continue operation of North San Saba well field, and PO	Maximum % of MHI	54.9%	10.3%	11.3%	12.3%	13.7%	14.3%
		Percentage Rate Increase Compared to Current	1520%	202%	232%	262%	305%	322%
		Average Annual Water Bill	$16,538	$3,087	$3,393	$3,699	$4,130	$4,312
11	Continue operation of North San Saba well field, but furn	Maximum % of MHI	3.6%	3.6%	3.6%	3.6%	3.6%	3.7%
		Percentage Rate Increase Compared to Current	7%	7%	7%	7%	8%	8%
		Average Annual Water Bill	$1,090	$1,090	$1,092	$1,095	$1,098	$1,099
12	Continue operation of North San Saba well field, but furn	Maximum % of MHI	8.6%	8.6%	8.7%	8.7%	8.7%	8.7%
		Percentage Rate Increase Compared to Current	155%	155%	155%	155%	156%	156%
		Average Annual Water Bill	$2,602	$2,602	$2,604	$2,606	$2,609	$2,610
13	Continue operation of North San Saba well field, but furn	Maximum % of MHI	5.1%	3.4%	3.4%	3.4%	3.4%	3.4%
		Percentage Rate Increase Compared to Current	51%	0%	0%	0%	0%	0%
		Average Annual Water Bill	$1,544	$1,021	$1,021	$1,021	$1,021	$1,021

Figure 4.2
Alternative Cost Summary: North San Saba WSC



Current Average Monthly Bill = $85.05
Median Household Income = $30104
Average Monthly Residential Usage = 7428 gallons

SECTION 5
REFERENCES

Ashworth, J.B., and Janie Hopkins. 1995. Major and Minor Aquifers of Texas: Texas Water Development Board, Report 345, 69p. http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/GWreports.asp

Baker, Bernard, Gail Duffin, Robert Flores, and Tad Lynch. 1990. Evaluation of Water Resources in Part of Central Texas. Texas Water Development Board, Report 319, 67p. http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/GWreports.asp

Bluntzer, Robert L., 1992. Evaluation of Ground-Water Resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas, Texas Water Development Board Report 339, 130 p. + Appendices http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/GWreports.asp

Core Laboratories Inc., 1972. A survey of the subsurface saline water of Texas, Vol. 3, Aquifer Rock Properties, Texas Water Development Board, Report 157, 364p.Klemt, William B., Robert D. Perkins and Henry J. Alvarez, 1975. Ground-Water Resources of Part of Central Texas with Emphasis on the Antlers and Travis Peak Formations, Volume 1. Texas Water Development Board, Report 195, 63p. http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/GWreports.asp

LBG-Guyton Associates, 2003. Brackish groundwater manual for Texas Regional Water Planning Groups, Report prepared for the Texas Water Development Board, 188p.

Mason, C. C., 1961, Ground-water geology of the Hickory sandstone member of the Riley Formation, McCulloch County, Texas: Texas Water Development Board Bulletin 6017, 84 p.

http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/bulletins/Bull.htm/B6017.htm Mace, R.E. and E.S. Angle 2004. Aquifers of the Edwards Plateau: Chapter 1 in R.E. Mace, E.S. Angle and W.F. Mullican (eds.) *Aquifers of the Edwards Plateau*. Texas Water Development Board Report 360. Available online at: *http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/R360AEPC/AEPCindex.htm*

RWHA (R.W. Harden & Associates, Inc), 2004. Northern Trinity / Woodbine Aquifer Groundwater Availability Model. Report prepared for the Texas Water Development Board, variously paginated. http://www.twdb.state.tx.us/gam/trnt_n/trnt_n.htm Raucher, Robert S., *et al*. 2004. Conventional and Unconventional Approaches to Water Service Provision. AWWA Research Foundation and American Water Works Association.

Smith, R. 2004. Palaeozoic aquifers of the Llano Uplift: Chapter 9 in R.E. Mace, E.S. Angle and W.F. Mullican (eds.) *Aquifers of the Edwards Plateau*. Texas Water Development Board Report 360. Available online at:

http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/R360AEPC/AEPCindex.htm

Standen, A. and R. Ruggiero, 2007. Llano Uplift Aquifers: Structure and Stratigraphy. Prepared for the Texas Water Development Board, November 5, 2007. Available online at: *http://www.twdb.state.tx.us/GAM/Llano/Llano.htm*.Texas Commission on Environmental Quality (TCEQ) 2004. How to Conduct Radionuclide Testing for Well Completion Interim Approval available at: http://www.tceq.state.tx.us/permitting/water_supply/pdw/chemicals/radionuclides/pdw_rad.html

TCEQ. 2008a. Drinking Water Standards Governing Drinking Water Quality and Reporting Requirements for Public Water Systems: 30 TAC 290 Subchapter F (290.108. Radionuclides Other than Radon). RG-346, May 2008.

TCEQ. 2008b. Drinking Water Standards Governing Drinking Quality and Reporting Requirements for Public Water Systems: 30 TAC 290 Subchapter F (290.105. Summary of Secondary Standards). RG-346, May 2008.

Texas Administrative Code. Title 30, Part I, Chapter 290, Subchapter F, Rule 290.106.Can be viewed at: http://info.sos.state.tx.us/pls/pub/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=290&rl=106

TWDB. 2007. Water for Texas 2007, State Water Plan. Texas Water Development Board. Available online at: http://www.twdb.state.tx.us/wrpi/swp/swp.htm

USEPA 2006. United States Environmental Protection Agency, Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems, EPA 815-R-06-010, April 2006.

USEPA. 2010a. United States Environmental Protection Agency List of Drinking Water Contaminants & MCLs. Online. Last updated on Wednesday, June 23, 2010. Web accessed June 28, 2010. http://www.epa.gov/safewater/mcl.html.

USEPA. 2010b. United States Environmental Protection Agency Drinking Water Contaminants for Radionuclides. Last updated on Monday, June 28, 2010. Website accessed on June 28, 2010, *http://www.epa.gov/safewater/contaminants/index.html#rads*

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 2009 RS Means Site Work & Landscape Cost Data. The number of borings and encasements and open cuts and encasements is 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 that gate valves and flush valves would be installed, on average, every 5,000 feet along the pipeline. Pipeline cost estimates are based on the 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, fence and building, and tools. The number of pump stations is based on calculations of pressure losses in the proposed pipeline for each alternative. Back-flow prevention is required in cases where pressure losses are negligible, and pump stations are not needed. Construction cost of a storage tank is based on consultations with vendors and 2007 RS Means Site Work & Landscape Cost Data.

Labor costs are estimated based on 2009 RS Means Site Work & Landscape Cost Data specific to the Lubbock County region.

Electrical power cost is estimated to be $0.11 per kWH, as supplied by the City of Richland Springs. 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 2010 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 2010 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 2010 dollars based on the ENR construction cost index.

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

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

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

Well installation costs are based on quotations from drillers for installation of similar depth wells in the area. Well installation costs include drilling, a well pump, electrical and instrumentation installation, well finishing, piping, and water quality testing. O&M costs for water wells include power, materials, and labor. It is assumed that new wells located more than

1 mile from the intake point of an existing system would require a storage tank and pump station.

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

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

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

Table B.1
Summary of General Data
North San Saba PWS
2060003
General PWS Information

Service Population 909 **Number of Connections** 303
Total PWS Daily Water Usage 0.074 (mgd)

Unit Cost Data

General Items	**Unit**	**Unit Cost**
Treated water purchase cost	*See alternative*	
Water purchase cost (trucked)	$/1,000 gals	$ 1.79
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, 06"	LF	$ 21
Bore and encasement, 10"	LF	$ 235
Open cut and encasement, 10"	LF	$ 127
Gate valve and box, 06"	EA	$ 1,125
Air valve	EA	$ 2,079
Flush valve	EA	$ 1,700
Metal detectable tape	LF	$ 0.05
Bore and encasement, length	Feet	200
Open cut and encasement, length	Feet	50
Pump Station Unit Costs	**Unit**	**Unit Cost**
Pump	EA	$ 8,230
Pump Station Piping, 06"	EA	$ 817
Gate valve, 06"	EA	$ 1,125
Check valve, 06"	EA	$ 1,223
Electrical/Instrumentation	EA	$ 10,550
Site work	EA	$ 2,635
Building pad	EA	$ 5,275
Pump Building	EA	$ 10,550
Fence	EA	$ 6,330
Tools	EA	$ 1,055
5,000 gal feed tank	EA	$ 12,487
Backflow preventer, 6"	EA	$ 4,059
Backflow Testing/Certification	EA	$ 110
Well Installation Unit Costs	**Unit**	**Unit Cost**
Well installation	*See alternative*	
Water quality testing	EA	$ 1,320
25 HP Well Pump	EA	$ 7,702
Well electrical/instrumentation	EA	$ 5,800
Well cover and base	EA	$ 3,165
Piping	EA	$ 3,165
50,000 gal ground storage tank	EA	$ 101,655
Electrical Power	$/kWH	$ 0.11
Building Power	kWH	11,800
Labor	$/hr	$ 55
Materials	EA	$ 1,585
Transmission main O&M	$/mile	$ 285
Tank O&M	EA	$ 1,055
POU/POE Unit Costs		
POU treatment unit purchase	EA	$ 300
POU treatment unit installation	EA	$ 160
POE treatment unit purchase	EA	$ 5,275
POE - pad and shed, per unit	EA	$ 2,110
POE - piping connection, per unit	EA	$ 1,055
POE - electrical hook-up, per unit	EA	$ 1,055
POU Treatment O&M, per unit	$/year	$ 103
POE Treatment O&M, per unit	$/year	$ 1,585
Treatment analysis	$/year	$ 210
POU/POE labor support	$/hr	$ 42
Dispenser/Bottled Water Unit Costs		
POE-Treatment unit purchase	EA	$ 7,385
POE-Treatment unit installation	EA	$ 5,275
Treatment unit O&M	EA	$ 2,110
Administrative labor	hr	$ 46
Bottled water cost (inc. delivery)	gallon	$ 1.50
Water use, per capita per day	gpcd	1.0
Bottled water program materials	EA	$ 5,275
10,000 gal ground storage tank	EA	$ 22,395
Site improvements	EA	$ 3,165
Potable water truck	EA	$115,000.00
Water analysis, per sample	EA	$ 210
Potable water truck O&M costs	$/mile	$ 2

Central Treatment Unit Costs	**Unit**	**Unit Cost**
General		
Site preparation	acre	$ 4,000
Slab	CY	$ 1,000
Building	SF	$ 60
Building electrical	SF	$ 8.00
Building plumbing	SF	$ 8.00
Heating and ventilation	SF	$ 7.00
Fence	LF	$ 15
Paving	SF	$ 2.00
Chlorination point	EA	$ 4,000
Building power	kwh/yr	$ 0.110
Equipment power	kwh/yr	$ 0.110
Labor, O&M	hr	$ 40
Analyses	test	$ 200
Reject Pond		
Reject pond, excavation	CYD	$ 3
Reject pond, compacted fill	CYD	$ 4
Reject pond, lining	SF	$ 0.50
Reject pond, vegetation	SY	$ 1.50
Reject pond, access road	LF	$ 30
Reject water haulage truck	EA	$ 100,000
Reverse Osmosis		
Electrical	JOB	$ 100,000
Piping	JOB	$ 50,000
RO package plant	UNIT	$ 304,000
Transfer pumps (5 hp)	EA	$ 5,000
Permeate tank	gal	$ 3
RO materials and chemicals	kgal	$ 0.43
RO chemicals	year	$ 2,000
Backwash disposal mileage cost	miles	$ 1.50
Backwash disposal fee	1,000 gal/yr	$ 5.00
Backwash discharge to sewer	MG/year	$ 5,000
WRT Z-88 package		
Electrical	JOB	$ 50,000
Piping	JOB	$ 40,000
WRT Z-88 package plant	UNIT	$ 66,160
WRT treated water charge	1,000 gal/yr	$ 3.00
Backwash tank	GAL	$ 2.00
Sewer connection fee	EA	$ 15,000
Spent media disposal	CY	$ 20
Backwash discharge to sewer	MG/year	$ 5,000

APPENDIX C
COMPLIANCE ALTERNATIVE CONCEPTUAL COST ESTIMATES

This appendix presents the conceptual cost estimates developed for the compliance alternatives. The conceptual cost estimates are given in Tables C.1 through C-13. 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 ***North San Saba PWS***
Alternative Name ***Purchase Water from City of San Saba***
Alternative Number ***NS-1***

Distance from Alternative to PWS (along pipe)	-	miles
Total PWS annual water usage	27.010	MG
Treated water purchase cost	$ 1.79	per 1,000 gals
Pump Stations needed w/ 1 feed tank each	0	
On site storage tanks / pump sets needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	-	n/a	n/a	n/a
PVC water line, Class 200, 06"	-	LF	$ 21	$ -
Bore and encasement, 10"	-	LF	$ 235	$ -
Open cut and encasement, 10"	-	LF	$ 127	$ -
Gate valve and box, 06"	-	EA	$ 1,125	$ -
Air valve	-	EA	$ 2,079	$ -
Flush valve	-	EA	$ 1,700	$ -
Metal detectable tape	-	LF	$ 0	$ -
Subtotal				**$ -**
Pump Station(s) Installation				
Pump	-	EA	$ 8,230	$ -
Pump Station Piping, 06"	-	EA	$ 817	$ -
Gate valve, 06"	-	EA	$ 1,125	$ -
Check valve, 06"	-	EA	$ 1,223	$ -
Electrical/Instrumentation	-	EA	$ 10,550	$ -
Site work	-	EA	$ 2,635	$ -
Building pad	-	EA	$ 5,275	$ -
Pump Building	-	EA	$ 10,550	$ -
Fence	-	EA	$ 6,330	$ -
Tools	-	EA	$ 1,055	$ -
5,000 gal feed tank	-	EA	$ 12,487	$ -
50,000 gal ground storage tank	-	EA	$ 101,655	$ -
Backflow Preventor	1	EA	$ 4,059	$ 4,059
Subtotal				**$ 4,059**
Subtotal of Component Costs				**$ 4,059**
Contingency	20%			$ 812
Design & Constr Management	25%			$ 1,015
TOTAL CAPITAL COSTS				**$ 5,885**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	0.0	mile	$ 285	$ -
Subtotal				**$ -**
Water Purchase Cost				
From PWS	27,010	1,000 gal	$ 1.79	$ 48,348
Subtotal				**$ 48,348**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.110	$ -
Pump Power	-	kWH	$ 0.110	$ -
Materials	-	EA	$ 1,585	$ -
Labor	-	Hrs	$ 55.00	$ -
Tank O&M	-	EA	$ 1,055	$ -
Backflow Test/Cert	1	EA	$ 110	$ 110
Subtotal				**$ 110**
O&M Credit for Existing Well Closure				
Pump power	695,992	kWH	$ 0.110	$ (76,559)
Well O&M matl	1	EA	$ 1,585	$ (1,585)
Well O&M labor	180	Hrs	$ 55.00	$ (9,900)
Subtotal				**$ (88,044)**
TOTAL ANNUAL O&M COSTS				**$ (39,586)**

Table C.2

PWS Name ***North San Saba PWS***
Alternative Name ***Purchase Water from Richland SUD***
Alternative Number ***NS-2***

Distance from Alternative to PWS (along pipe)	18.4	miles
Total PWS annual water usage	27.010	MG
Treated water purchase cost	$ 3.50	per 1,000 gals
Pump Stations needed w/ 1 feed tank each	1	
On site storage tanks / pump sets needed	0	

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	18	n/a	n/a	n/a
PVC water line, Class 200, 06"	97,214	LF	$ 21	$ 2,010,136
Bore and encasement, 10"	1,400	LF	$ 235	$ 328,608
Open cut and encasement, 10"	900	LF	$ 127	$ 114,426
Gate valve and box, 06"	19	EA	$ 1,125	$ 21,867
Air valve	18	EA	$ 2,079	$ 37,422
Flush valve	19	EA	$ 1,700	$ 33,053
Metal detectable tape	97,214	LF	$ 0	$ 4,861
Subtotal				**$ 2,550,373**
Pump Station(s) Installation				
Pump	2	EA	$ 8,230	$ 16,460
Pump Station Piping, 06"	1	EA	$ 817	$ 817
Gate valve, 06"	4	EA	$ 1,125	$ 4,499
Check valve, 06"	2	EA	$ 1,223	$ 2,445
Electrical/Instrumentation	1	EA	$ 10,550	$ 10,550
Site work	1	EA	$ 2,635	$ 2,635
Building pad	1	EA	$ 5,275	$ 5,275
Pump Building	1	EA	$ 10,550	$ 10,550
Fence	1	EA	$ 6,330	$ 6,330
Tools	1	EA	$ 1,055	$ 1,055
5,000 gal feed tank	1	EA	$ 12,487	$ 12,487
50,000 gal ground storage tank	-	EA	$ 101,655	$ -
Backflow Preventor	-	EA	$ 4,059	$ -
Subtotal				**$ 73,102**
Subtotal of Component Costs				**$ 2,623,475**
Contingency	20%			$ 524,695
Design & Constr Management	25%			$ 655,869
TOTAL CAPITAL COSTS				**$ 3,804,039**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	18.4	mile	$ 285	$ 5,247
Subtotal				**$ 5,247**
Water Purchase Cost				
From PWS	27,010	1,000 gal	$ 3.50	$ 94,535
Subtotal				**$ 94,535**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.110	$ 1,298
Pump Power	47,985	kWH	$ 0.110	$ 5,278
Materials	1	EA	$ 1,585	$ 1,585
Labor	365	Hrs	$ 55.00	$ 20,075
Tank O&M	1	EA	$ 1,055	$ 1,055
Backflow Test/Cert	0	EA	$ 110	$ -
Subtotal				**$ 29,291**
O&M Credit for Existing Well Closure				
Pump power	695,992	kWH	$ 0.110	$ (76,559)
Well O&M matl	1	EA	$ 1,585	$ (1,585)
Well O&M labor	180	Hrs	$ 55	$ (9,900)
Subtotal				**$ (88,044)**
TOTAL ANNUAL O&M COSTS				**$ 41,030**

Table C.3

PWS Name ***North San Saba PWS***
Alternative Name ***Purchase Water from City of Goldthwaite***
Alternative Number ***NS-3***

Distance from Alternative to PWS (along pipe)	19.4	miles
Total PWS annual water usage	27.010	MG
Treated water purchase cost	$ 2.30	per 1,000 gals
Pump Stations needed w/ 1 feed tank each	1	
On site storage tanks / pump sets needed	0	

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	14	n/a	n/a	n/a
PVC water line, Class 200, 06"	102,503	LF	$ 21	$ 2,119,499
Bore and encasement, 10"	1,400	LF	$ 235	$ 328,608
Open cut and encasement, 10"	700	LF	$ 127	$ 88,998
Gate valve and box, 06"	21	EA	$ 1,125	$ 23,057
Air valve	19	EA	$ 2,079	$ 39,501
Flush valve	21	EA	$ 1,700	$ 34,851
Metal detectable tape	102,503	LF	$ 0	$ 5,125
Subtotal				**$ 2,639,639**
Pump Station(s) Installation				
Pump	2	EA	$ 8,230	$ 16,460
Pump Station Piping, 06"	1	EA	$ 817	$ 817
Gate valve, 06"	4	EA	$ 1,125	$ 4,499
Check valve, 06"	2	EA	$ 1,223	$ 2,445
Electrical/Instrumentation	1	EA	$ 10,550	$ 10,550
Site work	1	EA	$ 2,635	$ 2,635
Building pad	1	EA	$ 5,275	$ 5,275
Pump Building	1	EA	$ 10,550	$ 10,550
Fence	1	EA	$ 6,330	$ 6,330
Tools	1	EA	$ 1,055	$ 1,055
5,000 gal feed tank	1	EA	$ 12,487	$ 12,487
50,000 gal ground storage tank	-	EA	$ 101,655	$ -
Backflow Preventor	0	EA	$ 4,059	$ -
Subtotal				**$ 73,102**
Subtotal of Component Costs				**$ 2,712,742**
Contingency	20%			$ 542,548
Design & Constr Management	25%			$ 678,185
TOTAL CAPITAL COSTS				**$ 3,933,476**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	19.4	mile	$ 285	$ 5,533
Subtotal				**$ 5,533**
Water Purchase Cost				
From PWS	27,010	1,000 gal	$ 2.30	$ 62,123
Subtotal				**$ 62,123**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.110	$ 1,298
Pump Power	27,912	kWH	$ 0.110	$ 3,070
Materials	1	EA	$ 1,585	$ 1,585
Labor	365	Hrs	$ 55.00	$ 20,075
Tank O&M	1	EA	$ 1,055	$ 1,055
Backflow Test/Cert	0	EA	$ 110	$ -
Subtotal				**$ 27,083**
O&M Credit for Existing Well Closure				
Pump power	695,992	kWH	$ 0.110	$ (76,559)
Well O&M matl	1	EA	$ 1,585	$ (1,585)
Well O&M labor	180	Hrs	$ 55	$ (9,900)
Subtotal				**$ (88,044)**
TOTAL ANNUAL O&M COSTS				**$ 6,695**

Table C.4

PWS Name	***North San Saba PWS***
Alternative Name	***New Well at 10 Miles***
Alternative Number	***NS-4***

Distance from PWS to new well location	10.0	miles
Estimated well depth	3518	feet
Number of wells required	2	
Well installation cost (location specific)	$147	per foot
Pump Stations needed w/ 1 feed tank each	1	
On site storage tanks / pump sets needed	0	

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	4	n/a	n/a	n/a
Number of Crossings, open cut	8	n/a	n/a	n/a
PVC water line, Class 200, 06"	52,800	LF	$ 21	$ 1,091,769
Bore and encasement, 10"	800	LF	$ 235	$ 187,776
Open cut and encasement, 10"	400	LF	$ 127	$ 50,856
Gate valve and box, 06"	11	EA	$ 1,125	$ 11,877
Air valve	10	EA	$ 2,079	$ 20,790
Flush valve	11	EA	$ 1,700	$ 17,952
Metal detectable tape	52,800	LF	$ 0	$ 2,640
Subtotal				**$ 1,383,659**
Pump Station(s) Installation				
Pump	2	EA	$ 8,230	$ 16,460
Pump Station Piping, 06"	1	EA	$ 817	$ 817
Gate valve, 06"	4	EA	$ 1,125	$ 4,499
Check valve, 06"	2	EA	$ 1,223	$ 2,445
Electrical/Instrumentation	1	EA	$ 10,550	$ 10,550
Site work	1	EA	$ 2,635	$ 2,635
Building pad	1	EA	$ 5,275	$ 5,275
Pump Building	1	EA	$ 10,550	$ 10,550
Fence	1	EA	$ 6,330	$ 6,330
Tools	1	EA	$ 1,055	$ 1,055
5,000 gal feed tank	1	EA	$ 12,487	$ 12,487
50,000 gal ground storage tank	-	EA	$ 101,655	$ -
Subtotal				**$ 73,102**
Well Installation				
Well installation	7,036	LF	$ 147	$ 1,034,292
Water quality testing	4	EA	$ 1,320	$ 5,280
Well pump	2	EA	$ 7,702	$ 15,404
Well electrical/instrumentation	2	EA	$ 5,800	$ 11,600
Well cover and base	2	EA	$ 3,165	$ 6,330
Piping	2	EA	$ 3,165	$ 6,330
Subtotal				**$ 1,079,236**
Subtotal of Component Costs				**$ 2,535,997**
Contingency	20%			$ 507,199
Design & Constr Management	25%			$ 633,999
TOTAL CAPITAL COSTS				**$ 3,677,196**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	10.0	mile	$ 285	$ 2,850
Subtotal				**$ 2,850**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.110	$ 1,298
Pump Power	20,065	kWH	$ 0.110	$ 2,207
Materials	1	EA	$ 1,585	$ 1,585
Labor	365	Hrs	$ 55.00	$ 20,075
Tank O&M	-	EA	$ 1,055	$ -
Subtotal				**$ 25,165**
Well O&M				
Pump power	701,979	kWH	$ 0.110	$ 77,218
Well O&M matl	2	EA	$ 1,585	$ 3,170
Well O&M labor	360	Hrs	$ 55	$ 19,800
Subtotal				**$ 100,188**
O&M Credit for Existing Well Closure				
Pump power	695,992	kWH	$ 0.110	$ (76,559)
Well O&M matl	1	EA	$ 1,585	$ (1,585)
Well O&M labor	180	Hrs	$ 55	$ (9,900)
Subtotal				**$ (88,044)**
TOTAL ANNUAL O&M COSTS				**$ 40,159**

Table C.5

PWS Name ***North San Saba PWS***
Alternative Name ***New Well at 5 Miles***
Alternative Number ***NS-5***

Distance from PWS to new well location	5.0	miles
Estimated well depth	3518	feet
Number of wells required	2	
Well installation cost (location specific)	$147	per foot
Pump Stations needed w/ 1 feed tank each	1	
On site storage tanks / pump sets 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	4	n/a	n/a	n/a
PVC water line, Class 200, 06"	26,400	LF	$ 21	$ 545,884
Bore and encasement, 10"	400	LF	$ 235	$ 93,888
Open cut and encasement, 10"	200	LF	$ 127	$ 25,428
Gate valve and box, 06"	5	EA	$ 1,125	$ 5,938
Air valve	5	EA	$ 2,079	$ 10,395
Flush valve	5	EA	$ 1,700	$ 8,976
Metal detectable tape	26,400	LF	$ 0	$ 1,320
Subtotal				**$ 691,830**
Pump Station(s) Installation				
Pump	2	EA	$ 8,230	$ 16,460
Pump Station Piping, 06"	1	EA	$ 817	$ 817
Gate valve, 06"	4	EA	$ 1,125	$ 4,499
Check valve, 06"	2	EA	$ 1,223	$ 2,445
Electrical/Instrumentation	1	EA	$ 10,550	$ 10,550
Site work	1	EA	$ 2,635	$ 2,635
Building pad	1	EA	$ 5,275	$ 5,275
Pump Building	1	EA	$ 10,550	$ 10,550
Fence	1	EA	$ 6,330	$ 6,330
Tools	1	EA	$ 1,055	$ 1,055
5,000 gal feed tank	1	EA	$ 12,487	$ 12,487
50,000 gal ground storage tank	-	EA	$ 101,655	$ -
Subtotal				**$ 73,102**
Well Installation				
Well installation	7,036	LF	$ 147	$ 1,034,292
Water quality testing	4	EA	$ 1,320	$ 5,280
Well pump	2	EA	$ 7,702	$ 15,404
Well electrical/instrumentation	2	EA	$ 5,800	$ 11,600
Well cover and base	2	EA	$ 3,165	$ 6,330
Piping	2	EA	$ 3,165	$ 6,330
Subtotal				**$ 1,079,236**
Subtotal of Component Costs				**$ 1,844,168**
Contingency	20%			$ 368,834
Design & Constr Management	25%			$ 461,042
TOTAL CAPITAL COSTS				**$ 2,674,043**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	5.0	mile	$ 285	$ 1,425
Subtotal				**$ 1,425**
Pump Station(s) O&M				
Building Power	11,800	kWH	$ 0.110	$ 1,298
Pump Power	10,033	kWH	$ 0.110	$ 1,104
Materials	1	EA	$ 1,585	$ 1,585
Labor	365	Hrs	$ 55.00	$ 20,075
Tank O&M	1	EA	$ 1,055	$ 1,055
Subtotal				**$ 25,117**
Well O&M				
Pump power	701,979	kWH	$ 0.110	$ 77,218
Well O&M matl	2	EA	$ 1,585	$ 3,170
Well O&M labor	360	Hrs	$ 55	$ 19,800
Subtotal				**$ 100,188**
O&M Credit for Existing Well Closure				
Pump power	695,992	kWH	$ 0.110	$ (76,559)
Well O&M matl	1	EA	$ 1,585	$ (1,585)
Well O&M labor	180	Hrs	$ 55	$ (9,900)
Subtotal				**$ (88,044)**
TOTAL ANNUAL O&M COSTS				**$ 38,685**

Table C.6

PWS Name *North San Saba PWS*
Alternative Name *New Well at 1 Mile*
Alternative Number *NS-6*

Distance from PWS to new well location	1.0 miles
Estimated well depth	3518 feet
Number of wells required	2
Well installation cost (location specific)	$147 per foot
Pump Stations needed w/ 1 feed tank each	0
On site storage tanks / pump sets needed	0

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline Construction				
Number of Crossings, bore	-	n/a	n/a	n/a
Number of Crossings, open cut	1	n/a	n/a	n/a
PVC water line, Class 200, 06"	5,280	LF	$ 21	$ 109,177
Bore and encasement, 10"	-	LF	$ 235	$ -
Open cut and encasement, 10"	50	LF	$ 127	$ 6,357
Gate valve and box, 06"	1	EA	$ 1,125	$ 1,188
Air valve	1	EA	$ 2,079	$ 2,079
Flush valve	1	EA	$ 1,700	$ 1,795
Metal detectable tape	5,280	LF	$ 0	$ 264
Subtotal				**$ 120,860**
Pump Station(s) Installation				
Pump	-	EA	$ 8,230	$ -
Pump Station Piping, 06"	-	EA	$ 817	$ -
Gate valve, 06"	-	EA	$ 1,125	$ -
Check valve, 06"	-	EA	$ 1,223	$ -
Electrical/Instrumentation	-	EA	$ 10,550	$ -
Site work	-	EA	$ 2,635	$ -
Building pad	-	EA	$ 5,275	$ -
Pump Building	-	EA	$ 10,550	$ -
Fence	-	EA	$ 6,330	$ -
Tools	-	EA	$ 1,055	$ -
5,000 gal feed tank	-	EA	$ 12,487	$ -
50,000 gal ground storage tank	-	EA	$ 101,655	$ -
Subtotal				**$ -**
Well Installation				
Well installation	7,036	LF	$ 147	$ 1,034,292
Water quality testing	4	EA	$ 1,320	$ 5,280
Well pump	2	EA	$ 7,702	$ 15,404
Well electrical/instrumentation	2	EA	$ 5,800	$ 11,600
Well cover and base	2	EA	$ 3,165	$ 6,330
Piping	2	EA	$ 3,165	$ 6,330
Subtotal				**$ 1,079,236**
Subtotal of Component Costs				**$ 1,200,095**
Contingency	20%			$ 240,019
Design & Constr Management	25%			$ 300,024
TOTAL CAPITAL COSTS				**$ 1,740,138**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Pipeline O&M				
Pipeline O&M	1.0	mile	$ 285	$ 285
Subtotal				**$ 285**
Pump Station(s) O&M				
Building Power	-	kWH	$ 0.110	$ -
Pump Power	-	kWH	$ 0.110	$ -
Materials	-	EA	$ 1,585	$ -
Labor	-	Hrs	$ 55.00	$ -
Tank O&M	-	EA	$ 1,055	$ -
Subtotal				**$ -**
Well O&M				
Pump power	701,979	kWH	$ 0.110	$ 77,218
Well O&M matl	2	EA	$ 1,585	$ 3,170
Well O&M labor	360	Hrs	$ 55	$ 19,800
Subtotal				**$ 100,188**
O&M Credit for Existing Well Closure				
Pump power	695,992	kWH	$ 0.110	$ (76,559)
Well O&M matl	1	EA	$ 1,585	$ (1,585)
Well O&M labor	180	Hrs	$ 55	$ (9,900)
Subtotal				**$ (88,044)**
TOTAL ANNUAL O&M COSTS				**$ 12,429**

Table C.7

PWS Name ***North San Saba PWS***
Alternative Name ***Central Treatment - RO***
Alternative Number ***NS-7***

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Reverse Osmosis Unit Purchase/Installation				
Site preparation	0.36	acre	$ 4,000	$ 1,440
Slab	36	CY	$ 1,000	$ 36,000
Building	960	SF	$ 60	$ 57,600
Building electrical	960	SF	$ 8	$ 7,680
Building plumbing	960	SF	$ 8	$ 7,680
Heating and ventilation	960	SF	$ 7	$ 6,720
Fence	448	LF	$ 15	$ 6,720
Paving	4,760	SF	$ 2	$ 9,520
Electrical	1	JOB	$ 100,000	$ 100,000
Piping	1	JOB	$ 50,000	$ 50,000
Reverse osmosis package including:				
High pressure pumps - 10hp				
Cartridge filters and vessels				
RO membranes and vessels				
Control system				
Chemical feed systems				
Freight cost				
Vendor start-up services	1	UNIT	$ 304,000	$ 304,000
Transfer pumps	3	EA	$ 5,000	$ 15,000
Permeate tank	39,000	gal	$ 3	$ 117,000
Brine Pipeline to Sewer	1	EA	$ 35,000	$ 35,000
Sewer connection feee	1	EA	$ 15,000	$ 15,000
Reject pond:				
Excavation	-	CYD	$ 3.00	$ -
Compacted fill	-	CYD	$ 4.00	$ -
Lining	-	SF	$ 0.50	$ -
Vegetation	-	SY	$ 1.50	$ -
Fence around pond	-	LF	$ 15.00	$ -
Access road	-	LF	$ 30.00	$ -
Subtotal of Design/Construction Costs				**$ 769,360**
Contingency	20%			$ 153,872
Design & Constr Management	25%			$ 192,340
Reject water haulage truck	-	EA	$ 100,000	$ -
TOTAL CAPITAL COSTS				**$ 1,115,572**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Reverse Osmosis Unit O&M				
Building Power	10,074	kwh/yr	$ 0.110	$ 1,108
Equipment Power	180,777	kwh/yr	$ 0.110	$ 19,885
Labor	1,000	hrs/yr	$ 40	$ 40,000
RO Materials and Chemicals	47,336	year	$ 0.43	$ 20,354
Analyses	12	test	$ 200	$ 2,400
Reject discharge to sewer	12	MG/yr	$ 5,000	$ 60,000
Subtotal				**$ 143,748**
Backwash Disposal				
Disposal truck mileage	-	miles	$ 1.50	$ -
Backwash disposal fee	-	kgal/yr	$ 5.00	$ -
Subtotal				**$ -**
TOTAL ANNUAL O&M COSTS				**$ 143,748**

Table C.8

PWS Name *Council Creek*
Alternative Name *Central Treatment - WRT Z-88*
Alternative Number *NS-8*

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Adsorption Unit Purchase/Installation				
Site preparation	0.36	acre	$ 4,000	$ 1,440
Slab	36	CY	$ 1,000	$ 36,000
Building	960	SF	$ 60	$ 57,600
Building electrical	960	SF	$ 8	$ 7,680
Building plumbing	960	SF	$ 8	$ 7,680
Heating and ventilation	960	SF	$ 7	$ 6,720
Fence	448	LF	$ 15	$ 6,720
Paving	4,760	SF	$ 2	$ 9,520
Electrical	1	JOB	$ 50,000	$ 50,000
Piping	1	JOB	$ 40,000	$ 40,000
WTR-Z88 installation	1	UNIT	$ 66,160	$ 66,160
Backwash Tank	1,723	GAL	$ 2	$ 3,446
Brine Pipeline to Sewer	1	EA	$ 35,000	$ 35,000
Sewer connection fee	1	EA	$ 15,000	$ 15,000
Chlorination Point	1	EA	$ 4,000	$ 4,000
Backwash evap pond				
Excavation	-	CYD	$ 3.00	$ -
Compacted fill	-	CYD	$ 4.00	$ -
Lining	-	SF	$ 0.50	$ -
Vegetation	-	SY	$ 1.50	$ -
Fence around pond	-	LF	$ 15.00	$ -
Access road	-	LF	$ 30.00	$ -
Subtotal of Component Costs				**$ 346,966**
Contingency	20%			$ 69,393
Design & Constr Management	25%			$ 86,742
TOTAL CAPITAL COSTS				**$ 503,101**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
WTR-Z88 Unit O&M				
Building Power	10,100	kwh/yr	$ 0.110	$ 1,111
Equipment power	57,594	kwh/yr	$ 0.110	$ 6,335
Labor	800	hrs/yr	$ 40	$ 32,000
Company provided service	48,545	MG/yr	$ 3.00	$ 145,635
Analyses	12	test	$ 200	$ 2,400
Backwash discharge to sewer	0.030	MG/yr	$ 5,000	$ 150
Spent Media Disposal	NA	CY	$ 20	NA
Subtotal				**$ 187,631**
Backwash Disposal				
Disposal truck mileage	0	miles	$ 1.50	$0
Backwash disposal fee	0	kgal/yr	$ 5.00	$0
Subtotal				**$0**
TOTAL ANNUAL O&M COSTS				**$ 187,631**

Table C.9

PWS Name ***North San Saba PWS***
Alternative Name ***Point-of-Use Treatment***
Alternative Number ***NS-9***

Number of Connections for POU Unit Installation 303 connections

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POU-Treatment - Purchase/Installation				
POU treatment unit purchase	303	EA	$ 300	$ 90,900
POU treatment unit installation	303	EA	$ 160	$ 48,480
Subtotal				**$ 139,380**
Subtotal of Component Costs				**$ 139,380**
Contingency	20%			$ 27,876
Design & Constr Management	25%			$ 34,845
Procurement & Administration	20%			$ 27,876
TOTAL CAPITAL COSTS				**$ 229,977**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POU materials, per unit	303	EA	$ 103	$ 31,209
Contaminant analysis, 1/yr per unit	303	EA	$ 210	$ 63,630
Program labor, 10 hrs/unit	3,030	hrs	$ 42	$ 127,260
Subtotal				**$ 222,099**
TOTAL ANNUAL O&M COSTS				**$ 222,099**

Table C.10

PWS Name ***North San Saba PWS***
Alternative Name ***Point-of-Entry Treatment***
Alternative Number ***NS-10***

Number of Connections for POE Unit Installation 303 connections

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
POE-Treatment - Purchase/Installat				
POE treatment unit purchase	303	EA	$ 5,275	$ 1,598,325
Pad and shed, per unit	303	EA	$ 2,110	$ 639,330
Piping connection, per unit	303	EA	$ 1,055	$ 319,665
Electrical hook-up, per unit	303	EA	$ 1,055	$ 319,665
Subtotal				**$ 2,876,985**
Subtotal of Component Costs				**$ 2,876,985**
Contingency	20%			$ 575,397
Design & Constr Management	25%			$ 719,246
Procurement & Administration	20%			$ 575,397
TOTAL CAPITAL COSTS				**$ 4,747,025**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
O&M				
POE materials, per unit	303	EA	$ 1,585	$ 480,255
Contaminant analysis, 1/yr per uni	303	EA	$ 210	$ 63,630
Program labor, 10 hrs/unit	3,030	hrs	$ 42	$ 127,260
Subtotal				**$ 671,145**
TOTAL ANNUAL O&M COSTS				**$ 671,145**

Table C.11

PWS Name ***North San Saba PWS***
Alternative Name ***Public Dispenser for Treated Drinking Water***
Alternative Number ***NS-11***

Number of Treatment Units Recommended 2

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Public Dispenser Unit Installation				
POE-Treatment unit(s)	2	EA	$ 7,385	$ 14,770
Unit installation costs	2	EA	$ 5,275	$ 10,550
Subtotal				**$ 25,320**
Subtotal of Component Costs				**$ 25,320**
Contingency	20%			$ 5,064
Design & Constr Management	25%			$ 6,330
TOTAL CAPITAL COSTS				**36,714**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Treatment unit O&M, 1 per unit	2	EA	$ 2,110	$ 4,220
Contaminant analysis, 1/wk per ui	104	EA	$ 210	$ 21,840
Sampling/reporting, 1 hr/day	730	HRS	$ 55	$ 40,150
Subtotal				**$ 66,210**
TOTAL ANNUAL O&M COSTS				**$ 66,210**

Table C.12

PWS Name ***North San Saba PWS***
Alternative Name ***Supply Bottled Water to 100% of Population***
Alternative Number ***NS-12***

Service Population	909	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	331,785	gallons

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Implementation				
Initial program set-up	500	hours	$ 46	$ 23,000
Subtotal				**$ 23,000**
Subtotal of Component Costs				**$ 23,000**
Contingency	20%			$ 4,600
TOTAL CAPITAL COSTS				**$ 27,600**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water purchase costs	331,785	gals	$ 1.50	$ 497,678
Program admin, 9 hrs/wk	468	hours	$ 46	$ 21,528
Program materials	1	EA	$ 5,275	$ 5,275
Subtotal				**$ 524,481**
TOTAL ANNUAL O&M COSTS				**$ 524,481**

Table C.13

PWS Name ***North San Saba PWS***
Alternative Name ***Central Trucked Drinking Water - Richland Springs***
Alternative Number ***NS-13***

Service Population	909	
Percentage of population requiring supply	100%	
Water consumption per person	1.00	gpcd
Calculated annual potable water needs	331,785	gallons
Travel distance to compliant water source	4	miles

Capital Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Storage Tank Installation				
10,000 gal ground storage tank	1	EA	$ 22,395	$ 22,395
Site improvements	1	EA	$ 3,165	$ 3,165
Potable water truck	1	EA	$115,000	$ 115,000
Subtotal				**$ 140,560**
Subtotal of Component Costs				**$ 140,560**
Contingency	20%			$ 28,112
Design & Constr Management	25%			$ 35,140
TOTAL CAPITAL COSTS				**$ 203,811**

Annual Operations and Maintenance Costs

Cost Item	Quantity	Unit	Unit Cost	Total Cost
Program Operation				
Water delivery labor, 4 hrs/wk	208	hrs	$ 55	$ 11,440
Truck operation, 1 round trip/wk	364	miles	$ 2.00	$ 728
Water purchase	332	1,000 gals	$ 1.79	$ 594
Water testing, 1 test/wk	52	EA	$ 210	$ 10,920
Sampling/reporting, 2 hrs/wk	104	hrs	$ 55	$ 5,720
Subtotal				**$ 29,402**
TOTAL ANNUAL O&M COSTS				**$ 29,402**

APPENDIX D
EXAMPLE FINANCIAL MODEL

Appendix D
General Inputs

North San Saba WSC

Number of Alternatives 13 Selected from Results Sheet

Input Fields are Indicated by:

General Inputs		
Implementation Year	2011	
Months of Working Capital	0	
Depreciation	$ -	
Percent of Depreciation for Replacement Fund	0%	
Allow Negative Cash Balance (yes or no)	No	
Median Household Income	$ 30,104	North San Saba WSC
Median HH Income -- Texas	$ 39,927	
Grant Funded Percentage	0%	Selected from Results
Capital Funded from Revenues	$ -	

	Base Year Growth/Escalation	2009
Accounts & Consumption		
Metered Residential Accounts		
Number of Accounts	0.0%	303
Number of Bills Per Year		12
Annual Billed Consumption		27,010,000
Consumption per Account Per Pay Period	0.0%	7,428
Consumption Allowance in Rates		-
Total Allowance		-
Net Consumption Billed		27,010,000
Percentage Collected		100.0%
Unmetered Residential Accounts		
Number of Accounts	0.0%	0
Number of Bills Per Year		12
Percentage Collected		100.0%
Metered Non-Residential Accounts		
Number of Accounts	0.0%	0
Number of Bills Per Year		12
Non-Residential Consumption		-
Consumption per Account	0.0%	-
Consumption Allowance in Rates		-
Total Allowance		-
Net Consumption Billed		-
Percentage Collected		0.0%
Unmetered Non-Residential Accounts		
Number of Accounts	0.0%	0
Number of Bills Per Year		12
Percentage Collected		100.0%
Water Purchase & Production		
Water Purchased (gallons)	0.0%	
Average Cost Per Unit Purchased (per 1000 gallon)	0.0%	
Bulk Water Purchases	0.0%	
Water Production	0.0%	27,010,000
Unaccounted for Water		-
Percentage Unaccounted for Water		0.0%

Appendix D
General Inputs

North San Saba WSC

Number of Alternatives 13 Selected from Results Sheet

Input Fields are Indicated by:

Residential Rate Structure	Allowance within Tier	
	-	
Estimated Average Water Rate ($/1000gallons)		$ 11.45
Non-Residential Rate Structure		
	-	
Estimated Average Water Rate ($/1000gallons)		$ -
INITIAL YEAR EXPENDITURES	Inflation	Initial Year
Operating Expenditures:		
Salaries & Benefits	0.0%	-
Contract Labor	0.0%	-
Water Purchases	0.0%	-
Chemicals, Treatment	0.0%	-
Utilities	0.0%	-
Repairs, Maintenance, Supplies	0.0%	-
Repairs	0.0%	-
Maintenance	0.0%	-
Supplies	0.0%	-
Administrative Expenses	0.0%	
Accounting and Legal Fees	0.0%	-
Insurance	0.0%	-
Automotive and Travel	0.0%	-
Professional and Directors Fees	0.0%	-
Bad Debts	0.0%	-
Garbage Pick-up	0.0%	-
Miscellaneous	0.0%	-
Other 3	0.0%	264,066
Other 4	0.0%	-
Incremental O&M for Alternative	0.0%	-
Total Operating Expenses		264,066
Non-Operating Income/Expenditures		
Interest Income	0.0%	-
Other Income	0.0%	-
Other Expense	0.0%	-
Transfers In (Out)	0.0%	-
Net Non-Operating		-

Esisting Debt Service		
Bonds Payable, Less Current Maturities		$ -
Bonds Payable, Current		$ -
Interest Expense		$ -

Debt Service for North San Saba WSC
Alternative Number = 13
Funding Source = Loan/Bond

		2009 0	2010 1	2011 2	2012 3	2013 4	2014 5	2015 6	2016 7	2017 8	2018 9	2019 10	2020 11	2021 12	2022 13	2023 14	2024 15	2025 16	2026 17	2027 18	2028 19	2029 20	2030 21	2031 22	2032 23	2033 24	2034 25	2035 26	2036 27	2037 28	2038 29	2039 30
Existing Debt Service	$ -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Principal Payments		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interest Payment	0.00%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Debt Service			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Balance		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Term	25																															
Revenue Bonds		-	-	203,811	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Forgiveness	0.00%	-	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Balance		-	-	203,811	200,097	196,159	191,985	187,560	182,871	177,899	172,630	167,044	161,123	154,847	148,194	141,143	133,668	125,744	117,345	108,443	99,006	89,003	78,399	67,160	55,246	42,617	29,231	15,041	0	0	0	0
Principal		-	-	3,715	3,938	4,174	4,424	4,690	4,971	5,270	5,586	5,921	6,276	6,653	7,052	7,475	7,923	8,399	8,903	9,437	10,003	10,603	11,240	11,914	12,629	13,386	14,190	15,041	-	-	-	-
Interest	6.00%	-	-	12,229	12,006	11,770	11,519	11,254	10,972	10,674	10,358	10,023	9,667	9,291	8,892	8,469	8,020	7,545	7,041	6,507	5,940	5,340	4,704	4,030	3,315	2,557	1,754	0	0	0	0	0
Total Debt Service		-	-	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,943	15,041	0	0	0	0
New Balance		-	-	200,097	196,159	191,985	187,560	182,871	177,899	172,630	167,044	161,123	154,847	148,194	141,143	133,668	125,744	117,345	108,443	99,006	89,003	78,399	67,160	55,246	42,617	29,231	15,041	0	0	0	0	0
Term	20																															
State Revolving Fund		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Forgiveness	0.00%	-	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Balance		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Principal		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interest	2.90%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Debt Service		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Balance		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Term	10																															
Bank/Interfund Loan				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Forgiveness	0.00%	-	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Balance		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Principal		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interest	8.00%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Debt Service		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Balance		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Term	25																															
RUS Loan			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Forgiveness	0.00%		-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Balance		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Principal		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Interest	5.00%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Debt Service		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Balance		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E
RADIONUCLIDE GEOCHEMISTRY

Radionuclide impact on water quality is measured according to two scales: intrinsic measurement of radioactivity and impact on human beings. Activity or number of disintegrations per unit time is typically measured in pico Curies (pCi), whereas impact on living organisms is measured in millirem (mrem). Radioactive decay can generate alpha or beta particles, as well as gamma rays. Two radioactive elements with the same activity may have vastly different impacts on life, depending on the energy released during decay. Each radionuclide has a conversion factor from pCi to mrem as a function of exposure pathway. Activity is related to contaminant concentration and half-life. A higher concentration and a shorter half-life lead to increased activity. Given the ratio of the half-life of each (Table E.1), it is apparent that radium is approximately 1 million times more radioactive than uranium. Concentrations of gross alpha and beta emitters take into account the whole decay series and not just uranium and radium, as well as other elements such as K 40.

Uranium and thorium (atomic numbers 92 and 90, respectively), both radium sources, are common trace elements and have a crustal abundance of 2.6 and 10 parts per million (ppm), respectively. They are abundant in acidic rocks. A study of the Cambrian aquifers in the Llano Uplift area suggests an average whole-rock concentration of 4 and 14 ppm for uranium and thorium, respectively (Kim, *et al*. 1995). Uranium and thorium do not fit readily into the structure of rock-forming minerals and are concentrated in melt during the series of fractionations leading to major rock types (acidic, intermediate, basic). Intrusive rocks such as granites will partly sequester uranium and thorium in erosion-resistant accessory minerals (*e.g.*, monazite, thorite), whereas uranium in volcanic rocks is much more labile and can be leached by surface and groundwater. Lattice substitution in minerals (*e.g.,* Ca^{+2} and U^{+4}, have almost the same ionic radius), as well as micrograins of uranium and thorium minerals, are other possibilities. In sedimentary rocks, uranium and thorium aqueous concentrations are controlled mainly by the sorbing potential of the rocks (metal oxides, clays, and organic matter). In the Cambrian aquifers of Central Texas, uranium concentrations are high in accessory minerals and cannot readily be mobilized. Uranium is also present in phosphatic and hematitic cements (Kim, *et al.* 1995), with which the aqueous concentration is most likely in equilibrium.

The geochemistry of uranium is complicated but can be summarized by the following. Uranium(VI) in oxidizing conditions exists as the soluble positively charged uranyl UO_2^{+2}. Solubility is higher at acid pHs, decreases at neutral pHs, and increases at alkaline pHs. The uranyl ion can easily form aqueous complexes, including with hydroxyl, fluoride, carbonate, and phosphate ligands. Hence, in the presence of carbonates, uranium solubility is considerably enhanced in the form of uranyl-carbonate (UO_2CO_3) and other higher order carbonate complexes: uranyl-di-carbonate ($UO_2(CO_3)_2^{-2}$ and uranyl-tri-carbonates $UO_2(CO_3)_3^{-4}$). Adsorption of uranium is inversely related to its solubility and is highest at neutral pH's (De Soto 1978). Uranium sorbs strongly to metal oxides and clays. Uranium(IV) is the other commonly found redox state. In that state, however, uranium is not very soluble and precipitates as uraninite, UO_2, coffinite, $USiO_4.nH_2O$ (if SiO_2>60 mg/L, Henry, *et al*. 1982, p.18), or related minerals. In most aquifers, no mineral controls uranium solubility in oxidizing conditions. However, uranite and coffinite are the controlling minerals if Eh drops below 0-100 mV.

Thorium exists naturally only in one redox state Th(IV). Th^{+4} forms complexes with most common aqueous anions. However, thorium solubility remains low except perhaps at higher pH when complexed by carbonate ions (USEPA 1999). Thorium sorbs strongly to metal oxides in a way similar to uranium.

Radium has an atomic number of 88. Radium originates from the radioactive decay of uranium and thorium. Ra226 is an intermediate product of U238 (the most common uranium isotope >99%, Table A-1) decay, whereas Ra228 belongs to the Th232 (~100% of natural thorium) decay series. Both radium isotopes further decay to radon and, ultimately, to lead. Radon is a gas and tends to volatilize from shallower units. Ra223 and Ra224 isotopes are also naturally present but in minute quantities. Ra224 belongs to the thorium decay series, whereas Ra223 derives from the much rarer U235 (~0.7%). Radium is an alkaline Earth element and belongs to the same group (2A in periodic table) as magnesium, calcium, strontium, and barium. It most resembles barium chemically, as evidenced by removal technologies such as ion exchange with Na and lime softening. Sorption on iron and manganese oxides is also a common trait of alkaline Earth elements. Radium exists only under one oxidation state, the divalent cation Ra^{+2}, similar to other alkaline Earth elements (Ca^{+2}, Mg^{+2}, Sr^{+2}, and Ba^{+2}). $RaSO_4$ is extremely insoluble (more so than barium sulfate), with a log K solubility product of -10.5, compared to that of barium sulfate at ~-10. Radium solubility is mostly controlled by sulfate activity.

Table E.1 Uranium, Thorium, and Radium Abundance and Half-lives

Decay series	Uranium/thorium	Radium	Radon
U238	U238 – ~99.3% (4.47×10^9 yrs)	Ra226 - (1,599 yrs)	Rn222 - (3.8 days)
	U234 – 0.0055% (0.246×10^9 yrs)	Intermediate product of U238 decay	
U235	U235 - ~0.7% (0.72×10^9 yrs)	Ra223 – (11.4 days)	Rn219 - (4 seconds)
Th232	Th232 – ~100% (14.0×10^9 yrs)	Ra228 - (5.76 yrs) Ra224 - (3.7 days)	Rn220 - (~1 min)

NOTE: half-life from Parrington et al. (1996)

USEPA Maximum Contaminant Levels

- Uranium: 30 ppb
- Gross alpha : 15 pCi/L
- Beta particles and photon emitters: 4 mrem/yr
- Radium 226 and radium 228: 5 pCi/L

Appendix References:

Bluntzer R. L., 1992, Evaluation of ground-water resources of the Paleozoic and Cretaceous Aquifers in the Hill Country of Central Texas: Texas Water Development Board Report 339, 130 p.

De Soto, R. H., 1978. Uranium geology and exploration: lecture notes and references: Golden, CO, Colorado School of Mines, March, 396 p.

USEPA, 1999, Understanding variations in partition coefficients, Kd, values: Environment Protection Agency report EPA-402-R-99-004A, August, Volume II: Review of geochemistry and available Kd values for cadmium, cesium, chromium, lead, plutonium, radon, strontium, thorium, tritium (^{3}H), and uranium. Variously paginated.

Henry, C. D., Galloway, W. E., and Smith, G. E., Ho, C. L., Morton, J. P., and Gluck, J. K., 1982, Geochemistry of groundwater in the Miocene Oakville sandstone—a major aquifer and uranium host of the Texas coastal plain: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 118, 63 p.

Kim, Y, Tieh, T. T., and Ledger, E. B., 1995, Aquifer mineralogy and natural radionuclides in groundwater—the lower Paleozoic of Central Texas: Gulf Coast Association of Geological Societies Transactions, Vol. XLV.

Parrington, J. R., Knox, H. D., Breneman, S. L., Baum, E. M., and Feiner, F., 1996, Nuclides and isotopes, chart of the nuclides: San Jose, California, General Electric Company and KAPL, Inc., 15th edition.