

PILOT PROJECT PRELIMINARY REPORT FEASIBILITY ANALYSIS OF WATER SUPPLY FOR SMALL PUBLIC WATER SYSTEMS

NORTHSIDE WSC

PWS ID# 2440003, CCN# 10631

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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All Except Section 3

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5/19/05

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EXECUTIVE SUMMARY

The University of Texas Bureau of Economic Geology (BEG) and its subcontractor, Parsons Infrastructure and Technology Group Inc. (Parsons), were contracted by the Texas Commission on Environmental Quality (TCEQ) to conduct a pilot project to assist with identifying and analyzing alternatives for use by Public Water Systems (PWS) to meet and maintain Texas drinking water standards.

The Northside Water Supply Corporation (WSC) (PWS ID# 2240003, CCN# 10631) was identified to participate in the pilot application of a methodology (or decision tree) to analyze water supply alternatives. The location of the Northside WSC is shown in Figure 1.1.

The Northside WSC supplies drinking water with nitrate concentrations that typically vary between 15 and 20 mg/L, exceeding the maximum contaminant level (MCL) for nitrates. The MCL for nitrate (as nitrogen) has been set at 10 milligrams per liter (mg/L) by the U.S. Environmental Protection Agency (USEPA) and the TCEQ. TCEQ plans to use the decision tree developed in this study as a guide for conducting similar future studies for other non-compliant PWSs.

The decision tree is a flow chart for conducting a feasibility study for a non-compliant PWS. The decision tree flow chart is shown in Figures 2.1 through 2.4. It begins with a process for defining the operating parameters of an existing PWS. If it is determined that the PWS cannot be optimized to correct its deficiency, the process includes the investigation of other supply alternatives, such as new groundwater sources, new surface water sources, and treatment alternatives. After feasible supply alternatives are identified, conceptual designs and cost estimates are prepared for each alternative. Preferred alternatives are then selected and subjected to more detailed investigation, including an investigation into the socio-political aspects of implementing the alternatives.

The study was initiated by collecting data to define the operating parameters of the Northside WSC. Data were collected from TCEQ files, from websites operated by TCEQ, USEPA, and from the Northside WSC. A review of the existing operating parameters for the Northside WSC determined that optimization would not correct the nitrate violations. Specific data collected included:

- Groundwater data from existing wells (including quantity and quality data);
- Groundwater data from the Seymour Aquifer groundwater availability model (GAM);
- Surface water data from regional planning documents for Region B;
- Surface water data from the surface water availability model (WAM) for the Red and Pease Rivers;
- Financial data (*e.g.*, annual budget, financial statements, water rate structure, *etc.*) from the PWS;

- Demographic data from the 2000 Census and employment data from the U.S. Bureau of Labor Statistics; and
- Data on potential funding programs (*i.e.*, private, state, and federal) for compliance alternatives.

After data collection and review, a list of preliminary compliance alternatives was developed. Preliminary alternatives included connections to neighboring PWSs, development of new groundwater sources, development of new surface water sources, and treatment options for non-compliant water. The table below summarizes the compliance alternatives investigated for the Northside WSC.

Table ES.1 Summary of Preliminary Compliance Alternatives

Compliance Alternatives Considered	Northside WSC
Connection to Neighboring Public Water Systems	<ul style="list-style-type: none"> • Treated water from City of Vernon • Blended water from City of Chillicothe or Farmers' Valley
New Groundwater Sources	<ul style="list-style-type: none"> • Seymour Aquifer wells • Alluvium wells • Permian wells
New Surface Water Sources	<ul style="list-style-type: none"> • Red River - not feasible • Pease River – not feasible
Treatment of Existing Water Supply	<ul style="list-style-type: none"> • Centralized treatment of Vernon raw water • Point-of-entry treatment of Vernon raw water • Point-of-use treatment of Vernon raw water • Bottled water program (interim measure) • Treated water dispenser (interim measure)

Identification of preliminary compliance alternatives was followed by a more detailed assessment of the preferred or feasible alternatives for the Northside WSC. The detailed assessment included additional work to define the compliance alternatives (*e.g.*, identification of required components, assessment of reliability, and identification of political issues) and an analysis of cost and affordability.

The cost to implement the alternatives and an affordability analysis were developed to determine the financial impact of a compliance alternative, as measured by the fraction of median household income represented by the water bill, and the percent increase in water bills. Table 4.1 provides a summary of the detailed analysis performed for the various compliance alternatives. The analysis summarized in the table demonstrates a large range in costs for the alternatives considered. Figure 4.3 is a chart that summarizes the data from Table 4.1.

The feasibility study showed that all options are technically possible, some having more long-term reliability (*e.g.*, installation of a new compliance well) and some requiring more utility effort and customer support (*e.g.*, in-house visits and management for point-of-use treatment units). Connections to adjacent water systems or use of centralized treatments have good reliability. Providing treated bottled drinking water or water from a public dispenser are considered interim measures to be taken until a compliance alternative is implemented.

Installation of a new compliant well may be the best option. Since many systems in the region have nitrate problems, it may be possible to share the cost of this option with other PWSs, including Red River Authority (RRA). The new well or well field would need to be installed in an area where nitrate and other constituents are not above drinking water standards. To evaluate placement of a new well, existing sampling data from nearby wells can be used as indicators of groundwater conditions. Much of the existing sampling data were collected in the early 1970s and re-sampling is needed to verify the data.

The final step in evaluating feasible alternatives (although beyond the scope of this pilot project) is to consider other features of the alternatives such as socio-political issues, ease of operation, ability to reliably maintain compliance with all drinking water standards, availability and safety aspects of any needed supplies, environmental impacts, and any other factors deemed appropriate by the PWS. Once the other factors have been identified, affordability can be addressed in terms of:

- The PWS can be analyzed to determine the segment of the population that may have difficulty paying the necessary rates;
- Alternatives for addressing this segment of the population can then be considered such as: reduced fees for this segment, subsidized rates utility-wide, a voluntary good neighbor fund, connection with a charitable organization, *etc.*; and
- Rates can be structured to favor lower water users. The PWS can encourage those having trouble paying the necessary rates to use less water and thus save money.

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ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
BEG	Bureau of Economic Geology
CA	Chemical analysis
CAFO	Concentrated animal feeding operation
CCN	Certificate of Convenience and Necessity
CO	Correspondence
EDR	Electrodialysis reversal
FMT	Financial, managerial, and technical
GAM	Groundwater availability model
gpy	Gallons per year
gpm	Gallons per minute
HBR	Heterotrophic biological reduction
IX	Ion exchange
m ³ /day	Cubic meters per day
MBfR	Membrane biofilm reactor
MCL	Maximum contaminant level
MF	Micro filtration
mg/L	Milligram per liter
mgd	Million gallons per day
MHI	Median household income
MIWA	Municipal and Industrial Water Authority
MOR	Monthly quality/quantity report
NLDC	National land cover dataset
NMEFC	New Mexico Environmental Financial Center
O&M	Operation and Maintenance
psi	Pounds per square inch
PVC	Polyvinyl chloride
PWS	Public water system
RO	Reverse osmosis
RRA	Red River Authority
TCEQ	Texas Commission on Environmental Quality
TDS	Total dissolved solids
TSS	Total suspended solids
TWDB	Texas Water Development Board
USEPA	U.S. Environmental Protection Agency
WAM	Water availability model

SECTION 1 INTRODUCTION

The University of Texas Bureau of Economic Geology (BEG) and its subcontractor, Parsons Infrastructure & Technology Group Inc. (Parsons), have been contracted by the Texas Commission on Environmental Quality (TCEQ) to develop a general methodology for assisting the TCEQ and non-compliant Public Water Systems (PWS) in identifying and analyzing compliance options. The goal of the project is to provide TCEQ and Texas PWSs that exceed maximum contaminant levels (MCL) with feasibility studies to promote drinking water quality regulatory compliance using sound engineering and financial methods and data. The Northside WSC (PWS ID# 2440003, CCN# 10631) was identified as one of three subjects for the pilot application of the methodology, which also included:

- Red River Authority (RRA) Truscott-Gilliland Water System; and
- RRA Guthrie-Dumont Water System.

The location of the Northside WSC is shown in Figure 1.1 and is hereinafter collectively referred to as the “Study Area.” Various water supply and planning jurisdictions are shown in Figure 1.2.

The Northside WSC supplies drinking water with nitrate concentrations that typically vary between 15 and 20 mg/L, exceeding the MCL for nitrates. The MCL for nitrate (as nitrogen) has been set at 10 milligrams per liter (mg/L) by the U.S. Environmental Protection Agency (USEPA) and the TCEQ. Nitrate levels in excess of the MCL have caused serious illness and sometimes death (USEPA Consumer Factsheet on Nitrates/Nitrites 2004). Drinking water health publications conclude that the most susceptible population to adverse nitrate health effects includes infants less than 6 months of age; women who are pregnant or nursing; and individuals with enzyme deficiencies or a lack of free hydrochloric acid in the stomach.

A central part of the scope of the project is to develop a decision tree that can be used as a guide for analyzing alternatives for non-compliant PWSs. This decision tree can then be used as a guide for conducting similar future studies for other PWSs. Other project tasks are as follows:

- Identifying available data sources;
- Gathering and compiling data;
- Conducting financial, managerial, and technical (FMT) evaluations of the selected PWSs;
- Performing a geologic and hydrogeologic assessment of the study area;
- Developing treatment and non-treatment compliance alternatives;

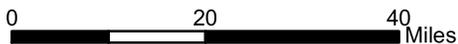
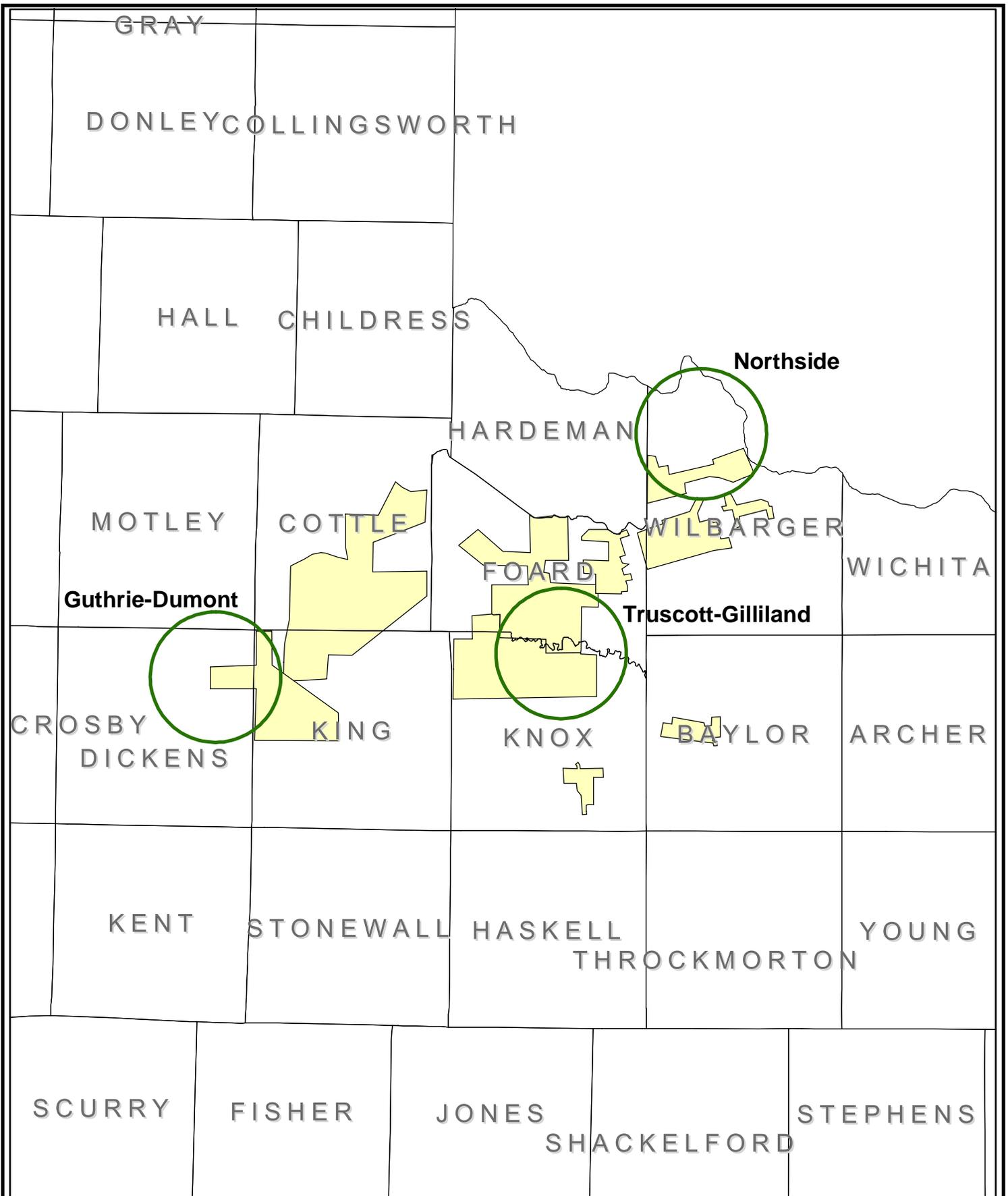


Figure 1.1

Location Map

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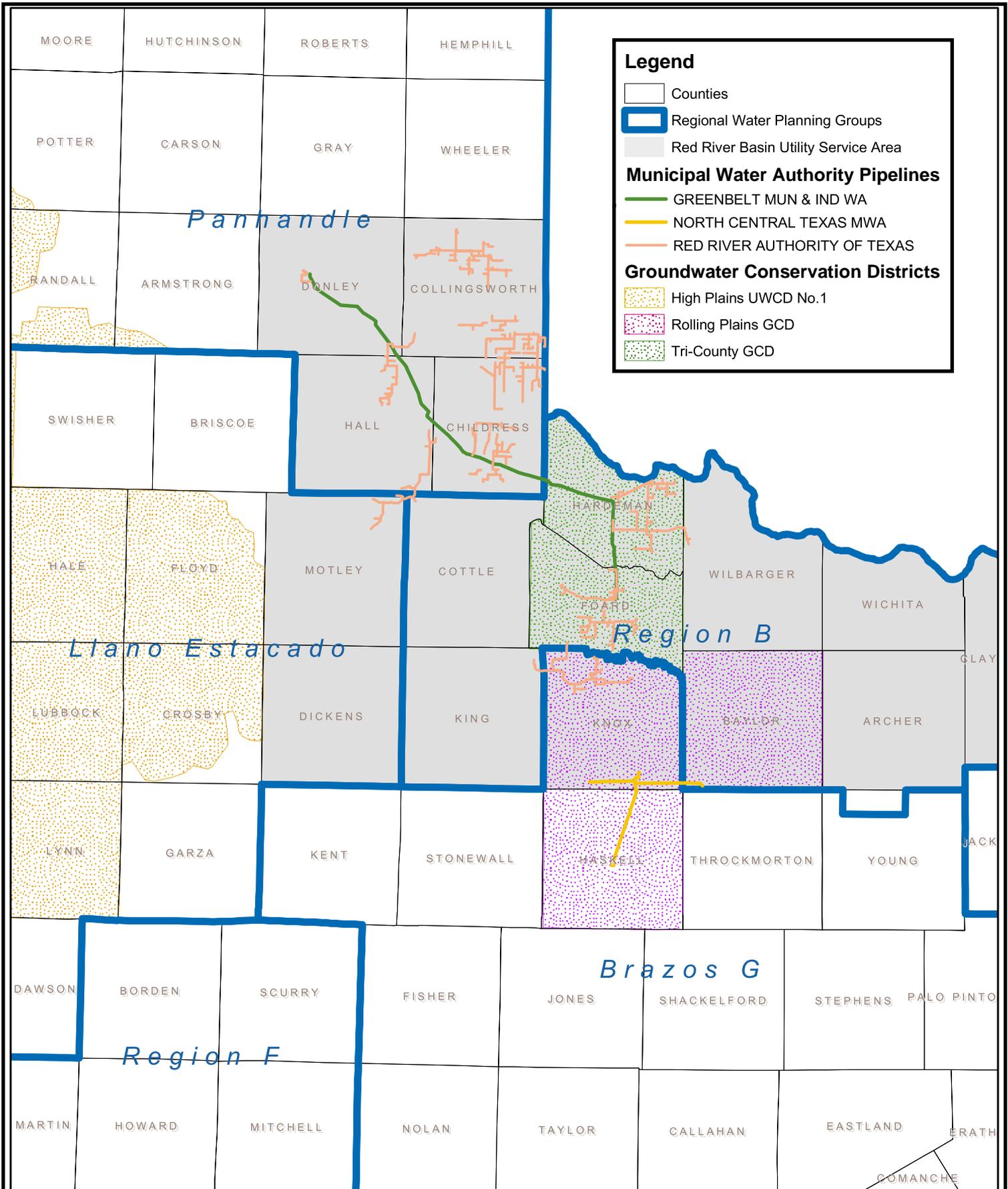
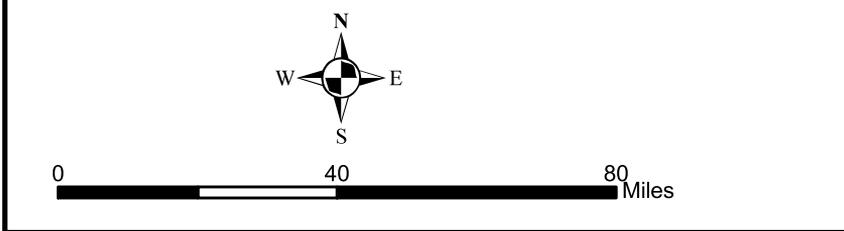


Figure 1.2
 Groundwater Districts, Conservation Areas,
 Municipal Authorities, and Planning Groups
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- Assessing potential alternatives with respect to economic and non-economic criteria;
- Preparing a feasibility report; and
- Suggesting refinements to the approach for future studies.

The remainder of Section 1 of this report addresses the regulatory background, and provides a summary of nitrate abatement options. Section 2 describes the methodology used to develop and assess compliance alternatives. The groundwater sources of nitrate are addressed in Section 3. Findings for the Northside WSC, along with compliance alternatives development and evaluation, can be found in Section 4.

1.1 REGULATORY PERSPECTIVE

The Utilities & Districts and Public Drinking Water Sections of the TCEQ Water Supply Division are responsible for implementing the federal Safe Drinking Water Act requirements that include oversight of PWSs and water utilities. These responsibilities include:

- Monitoring public drinking water quality;
- Processing enforcement referrals for MCL violators;
- Tracking and analyzing compliance options for MCL violators;
- Providing FMT assessment and assistance to PWSs;
- Participating in the Drinking Water State Revolving Fund program to assist PWSs in achieving regulatory compliance; and
- Setting of rates for privately-owned water utilities.

This pilot project was conducted to assist in achieving these responsibilities.

1.2 NITRATE ABATEMENT OPTIONS

When a PWS exceeds the regulatory MCL, the PWS must take action to correct the violation. The MCL exceedance at the Northside WSC system is for nitrates.

1.2.1 Existing Public Water Supply Systems

A common approach to achieve compliance is for the PWS to make arrangements with a neighboring PWS for water supply. For this arrangement to work, the PWS from which water is being purchased (supplier PWS) must have water in sufficient quantity and quality, the political will must exist, and it must be economically feasible.

1.2.1.1 Quantity

Quantity is used here in the sense of volume, flowrate, and pressure. Before approaching a potential supplier PWS, the non-compliant PWS should determine its water

demand on the basis of average day and maximum day. Peak instantaneous demands can be met through proper sizing of storage facilities. Further, the potential for obtaining just enough water to blend to achieve compliance should be considered. The exact blend ratio will depend on the quality of the water a potential supplier PWS can provide, and will likely vary over time.

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

- Additional wells;
- Additional or larger-diameter piping;
- Additional storage tank volume;
- Higher-pressure pumps; or
- Upsized, or additional, disinfection equipment.

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

1.2.1.2 Quality

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

A potential supplier PWS may treat non-compliant raw water, and treat it to an acceptable level. This is the situation where the City of Vernon, which recently installed an ion exchange treatment system, is a potential supplier for Northside WSC.

Surface water sources offer a potential higher-quality source. Many of the existing PWSs in the study area obtain surface water from either the Greenbelt Municipal and Industrial Water Authority (MIWA) or from North Central Texas Municipal Water Authority. Where these PWSs are neighbors, the non-compliant PWS will potentially need to deal with them as well as with the two water authorities that supply the surface water. For Northside WSC, Chillicothe and Farmers' Valley are examples of neighboring PWS that get some of their water from surface water providers.

1.2.2 Potential for New Groundwater Sources

1.2.2.1 Existing Non-Public Supply Wells

Often there are wells not associated with PWSs located 10 miles or less from the non-compliant PWS. The current use of these wells may be for irrigation, industrial purposes, domestic supply, stock watering, and other purposes. The process for investigating existing wells is as follows:

- Use existing data sources (see below) to identify wells in the areas that have satisfactory quality. For this study, the standards were set as follows:
 - Nitrate (as N) concentrations less than 8 mg/L,
 - Sulfate concentrations less than 300 mg/L, and
 - Total dissolved solids concentrations less than 1,000 mg/L.
- Review the recorded information about the well 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 that were eliminated from consideration were domestic and stock wells, dug wells, test holes, observation wells, seeps and springs, destroyed wells, wells used by other communities, *etc.* Look for wells that are of sufficient size and have been used for industrial or irrigation purposes. Often the database will include well yields, which may indicate the likelihood of a particular well being a satisfactory source.
- At this point in the process, the local groundwater control district (if one exists) should be contacted to obtain information about pumping restrictions. Also, preliminary cost estimates should be made to establish the feasibility of pursuing further well development options.
- If particular wells appear to be promising, the owner(s) should be contacted to ascertain their willingness to work with the PWS. Once the owner agrees to participate with the program, questions about the wells could be posed. 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 gleaning as much information as possible from cooperative owners, the PWS would then narrow down the selection and sample selected wells and analyze for quality. Wells with good quality would then be potential candidates for test pumping. In some cases, a particular well may have to be refurbished before test pumping. Information obtained from test pumping would then be used in combination with information about the general characteristics of the aquifer to determine whether a well at this location would be suitable as a supply source.

- It is recommended that new wells be installed instead of using existing wells to ensure the well characteristics are known and the well construction meets 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.

1.2.2.2 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 may be applied to indicate potential sources. Once a general area has been identified, land owners and regulatory agencies should be contacted to determine an exact location for a new well or well field.

1.2.3 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 for nitrates, rights may not need to be 100 percent available.

1.2.3.1 Existing Sources

“Existing 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 the first course of investigation. An existing source will be limited by its water rights, the safe yield of a reservoir or river, or by its water treatment capability. The source must be able to meet the current demand and honor contracts with communities it currently supplies. In many cases, the contract amounts reflect projected future water demand based on population or industrial growth.

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

In addition to securing the water supply from a source, the non-compliant PWS would have to arrange for the transmission of the water to the PWS. In some cases, this may require negotiations with, contracts with, and payments to an intermediate PWS. (An intermediate PWS is one whose 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.) For

example, for Northside WSC to purchase surface water from Greenbelt MIWA, the water would have to pass through Crowell or through the RRA's Medicine Mound and Farmers' Valley systems. 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.

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

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

1.2.4 Treatment

Reverse Osmosis (RO), Ion Exchange (IX) and Electrodialysis Reversal (EDR) are identified by USEPA as best available technology for removal of nitrates. RO and IX are also viable options for point-of-entry and point-of-use systems. A description of these technologies and three additional technologies for the removal of nitrates follows.

1.2.4.1 Reverse Osmosis

Process - RO is a physical process in which contaminants are removed by applying pressure on the feed water to force it through a semi-permeable membrane. RO membranes reject ions based on size and electrical charge. The raw water is typically called feed; the product water is called permeate; and the concentrated reject is called concentrate. Common RO membrane materials include asymmetric cellulose acetate or polyamide thin film composite. Common membrane construction includes spiral wound or hollow fine fiber. Each material and construction method has specific benefits and limitations depending on the raw water characteristics and pre-treatment. A typical RO installation includes a high pressure feed pump; parallel first and second stage membrane elements (in pressure vessels); valving; and feed, permeate, and concentrate piping. All materials and construction methods require regular maintenance. Factors influencing membrane selection are cost, recovery, rejection, raw water characteristics, and pre-treatment. Factors influencing performance are raw water characteristics, pressure, temperature, and regular monitoring and maintenance.

The conventional RO treatment train for well water uses anti-scalant addition, micro-filtration (MF) RO membranes, chlorine disinfection, and clearwell storage. Surface water requires more intensive upstream treatment – flocculation, sedimentation, filtration. Additional treatment or management of the concentrate and the removed solids is necessary prior to off-site disposal.

Pre-treatment - RO requires careful review of raw water characteristics and pre-treatment needs to prevent membranes from fouling, scaling, or other membrane degradation. Removal or sequestering of suspended solids is necessary to prevent colloidal and bio-fouling, and removal of dissolved solids is necessary to prevent scaling and chemical attack. Pre-treatment can include media filters to remove suspended particles; ion exchange softening or anti-scalant to remove hardness; temperature and pH adjustment to maintain efficiency; acid to prevent scaling and membrane damage; activated carbon or bisulfite to remove chlorine (post-disinfection may be required); and cartridge (micro) filters to remove any remaining suspended particles to protect membranes from upsets.

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

Waste Disposal - Pre-treatment waste streams, concentrate flows, and spent filters and membrane elements all require approved disposal methods.

Advantages

- Produces highest water quality.
- Can effectively treat wide range of dissolved salts and minerals, turbidity, health and aesthetic contaminants, and certain organics; some highly-maintained units are capable of treating biological contaminants.
- Low pressure (<100 psi), compact, self-contained, single membrane units are available for small installations.

Disadvantages

- Relatively expensive to install and operate.
- Frequent membrane monitoring (for breakthrough) and maintenance; pressure, temperature, and pH requirements to meet membrane tolerances. May be chemically sensitive.
- Additional water usage depending on rejection rate.

A concern with RO for treatment of inorganics is that if the full stream is treated, then most of the alkalinity and hardness would also be removed. In that case, post-treatment may be necessary to avoid corrosion problems. If feasible, a way to avoid this issue is to treat a

slip stream of raw water and blend the slip stream back with the raw water rather than treat the full stream. The amount of water rejected is also an issue with RO. Discharge concentrate can be between 10 and 50 percent of the influent flow. If RO is to be employed, the process should first be pilot-tested. Pilot testing is needed to define design criteria, define capital and O&M costs, define the degree of pre-treatment required, obtain competitive bids, and to comply with current regulatory requirements for non-traditional treatment processes.

1.2.4.2 Ion Exchange

Process - In solution, salts separate into positively-charged cations and negatively-charged anions. Ion exchange is a reversible chemical process in which ions from an insoluble, permanent, solid resin bed are exchanged for ions in water. The process relies on the fact that certain ions are preferentially adsorbed on the ion exchange resin. Operation begins with a fully recharged cation or anion resin bed, having enough positively or negatively charged ions to carry out the cation or anion exchange. Usually a polymer resin bed is composed of millions of spherical beads about the size of medium sand grains. As water passes through the resin bed, the positively or negatively charged ions are released into the water, being substituted or replaced with the contaminant ions in the water (ion exchange). When the resin becomes exhausted of positively or negatively charged ions, the bed must be regenerated by passing a strong, usually Sodium Chloride, solution over the resin bed, displacing the contaminant ions with Sodium ions for cation exchange and Chloride ions for anion exchange. Many different types of resins can be used to reduce dissolved contaminant concentrations. The IX treatment train for groundwater typically includes cation or anion resin beds, chlorine disinfection, and clearwell storage. Treatment trains for surface water may also include raw water pumps, debris screens, and gravity filters for pre-treatment. Additional treatment or management of the concentrate and the removed solids will be necessary prior to disposal.

Pre-treatment - Guidelines are available on accepted limits for pH, organics, turbidity, and other raw water characteristics. Pre-treatment may be required to reduce excessive amounts of total suspended solids (TSS), iron, and manganese, which could plug the resin bed, and typically includes media or carbon filtration. Pre-treatment may also be required to remove sulfate that can interfere with nitrate removal.

Maintenance - The IX resin requires regular on-site regeneration, the frequency of which depends on raw water characteristics, the contaminant concentration, and the size and number of IX vessels. Many systems have undersized the IX vessels only to realize higher than necessary operating costs. Preparation of the sodium chloride solution is required. If used, filter replacement and backwashing will be required.

Waste Disposal - Approval from local authorities is usually required for disposal of concentrate from the regeneration cycle (highly concentrated salt solution); occasional solid wastes (in the form of broken resin beads) which are backwashed during regeneration; and if used, spent filters and backwash wastewater.

Advantages

- Acid addition, degasification, and repressurization are not required.

- Ease of operation; highly reliable.
- Lower initial cost; resins will not wear out with regular regeneration.
- Effective; widely used.
- Suitable for small and large installations.
- Variety of specific resins are available for removing specific contaminants.

Disadvantages

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

In considering application of IX for inorganics removal, it is important to understand what the effect of competing ions will be, and to what extent the brine can be recycled. Similar to activated alumina, IX exhibits a selectivity sequence, which refers to an order in which ions are preferred. Barium, lead, and copper are highly preferred cations. Sulfate competes with both nitrate and arsenic, but more aggressively with arsenic in anion exchange. Source waters with TDS levels above 500 mg/L and sulfate levels above 120 mg/L are not amenable to IX treatment. Spent regenerant is produced during IX bed regeneration, and this spent regenerant may have high concentrations of sorbed contaminants which can be expensive to treat and/or dispose. Research has been conducted to minimize this effect: recent research on arsenic removal shows that the brine can be reused as many as 25 times.

If IX is to be employed, the process should first be pilot-tested. Pilot testing is needed to define design criteria, define capital and O&M costs, define the degree of pre-treatment required, obtain competitive bids, and to comply with current regulatory requirements for non-traditional treatment processes.

1.2.4.3 Electrodialysis Reversal

Process - EDR is an electrochemical process in which ions migrate through ion-selective semi-permeable membranes as a result of their attraction to two electrically charged electrodes. A typical EDR system includes a membrane stack with a number of cell pairs, each consisting of a cation transfer membrane, a demineralized flow spacer, an anion transfer membrane, and a concentrate flow spacer. Electrode compartments are at opposite ends of the stack. The influent feed water (chemically treated to prevent precipitation) and concentrated reject flow in parallel across the membranes and through the demineralized and concentrate flow spacers, respectively. The electrodes are continually flushed to reduce fouling or scaling. Careful consideration of flush feed water is required. Typically, the membranes are cation or anion exchange resins cast in sheet form; the spacers are high density polyethylene; and the electrodes are inert metal. EDR stacks are tank-contained and often staged. Membrane selection is based on review of raw water characteristics. A single-stage EDR system usually removes 50 percent of the TDS; therefore, for water with more than 1,000 mg/L TDS, blending with higher quality water or a second stage is required to

meet 500 mg/L TDS. EDR uses the technique of regularly reversing the polarity of the electrodes, thereby freeing accumulated ions on the membrane surface. This process requires additional plumbing and electrical controls, but increases membrane life, does not require added chemicals, and eases cleaning. The conventional EDR treatment train typically includes EDR membranes, chlorine disinfection, and clearwell storage. Treatment of surface water may also require pre-treatment steps such as raw water pumps, debris screens, rapid mix with addition of an anti-scalant, slow mix flocculator, sedimentation basin or clarifier, and gravity filters. MF could be used in place of flocculation, sedimentation, and filtration. Additional treatment or management of the concentrate and the removed solids will be necessary prior to disposal.

Pre-treatment - Guidelines are available on acceptable limits on pH, organics, turbidity, and other raw water characteristics. EDR typically requires chemical feed to prevent scaling, acid addition for pH adjustment, and a cartridge filter for prefiltration.

Maintenance - EDR membranes are durable, can tolerate pH from 1-10, and temperatures to 115 degrees Fahrenheit (°F) for cleaning. They can be removed from the unit and scrubbed. Solids can be washed off by turning the power off and letting water circulate through the stack. Electrode washes flush out byproducts of electrode reaction. The byproducts are hydrogen, formed in the cathode space, and oxygen and chlorine gas, formed in the anode 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. EDR requires reversing the polarity. Flushing at high volume/low pressure continuously is required to clean electrodes. If used, pre-treatment filter replacement and backwashing will be required. The EDR stack must be disassembled, mechanically cleaned, and reassembled at regular intervals.

Waste Disposal - Highly concentrated reject flows, electrode cleaning flows, and spent membranes require approved disposal methods. Pre-treatment processes and spent materials also require approved disposal methods.

Advantages

- EDR can operate with minimal fouling or scaling, or chemical addition.
- Low pressure requirements; typically quieter than RO.
- Long membrane life expectancy; EDR extends membrane life and reduces maintenance.

Disadvantages

- Not suitable for high levels of Iron, Manganese, Hydrogen Sulfide, Chlorine, or hardness.
- Limited current density; current leakage; back diffusion.
- At 50 percent rejection of TDS per pass, process favors low TDS water.

EDR can be quite expensive to run because of the energy it uses. However, because it is generally automated and allows for part-time operation, it may be an appropriate technology for small systems.

If EDR is to be employed, the process should first be pilot-tested. Pilot testing is needed to define design criteria, define capital and O&M costs, define the degree of pre-treatment required, obtain competitive bids, and to comply with current regulatory requirements for non-traditional treatment processes.

1.2.4.4 Distillation

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

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

1.2.4.5 Heterotrophic Biological Reduction

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

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

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

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

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

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

1.2.4.6 Hollow-Fiber Membrane Biofilm Reactor

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

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

The biofilm on the outside of the hollow fiber develops from the indigenous bacteria present in the groundwater, and is not artificially inoculated or amended. The microorganisms in the biofilm that reduce nitrate contaminants using hydrogen gas (H₂) as their electron donor (H₂ = 2H⁺ + 2e⁻) perform the following:



Initial use and development of MBfR was conducted at Northwestern University under the direction of Bruce Rittman beginning in 2000. During the two initial steady-state denitrification studies, the influent nitrate concentrations were 10 and 12.5 mg nitrate per liter. With a liquid retention time of 40 minutes, the desired partial removals of nitrate between 76 percent and 92 percent were achieved with effluent hydrogen concentrations as low as 9 µg of hydrogen per liter. In February 2004, additional laboratory experiments with

other groundwater demonstrated MBfR's ability to reduce nitrate from 19 mg/L to below detection limit of <0.2 mg/L within the first 24 hours. Additional development work is ongoing, and it is anticipated the additional work will confirm that the MBfR process will provide drinking water denitrification at costs 25 percent to 50 percent below those of IX or HBD, and 50 percent to 75 percent less than those of RO processes.

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

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

Point-of-entry and point-of-use treatment systems can be used to provide compliant drinking water. For nitrate removal, these systems typically use small RO treatment units that are installed "under the sink" in the case of point-of-use, and where water enters a house or building in the case of point-of-entry. Point-of-entry and point-of-use treatment units would be purchased and owned by the PWS. These solutions are decentralized in nature, and require utility personnel entry into houses or at least onto private property for installation, maintenance, and testing. Due to the large number of treatment units that would be employed and would be largely out of the control of the PWS, it is very difficult to ensure 100 percent compliance. Prior to selection of a point-of-entry or point-of-use program for implementation, consultation with TCEQ will be required to address measurement and determination of level of compliance.

1.2.6 Water Delivery or Central Drinking Water Dispensers

Current USEPA regulations 40 CFR 141.101 prohibit the use of bottled water to achieve compliance with an MCL, except on a temporary basis. State regulations do not directly address the use of bottled water. Current use of bottled water in the non-compliant PWSs is on an extended temporary basis. Every 3 years the PWSs are required to present the TCEQ with estimates of the costs of piping compliant water to their systems. As long as the projected costs remain prohibitively high, the interim measure of bottled water provision 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 RO treatment units or could be compliant water that is delivered to the central point by truck.

Water delivery is currently used as an interim measure to provide the susceptible population (*e.g.*, expectant women, infant children) with water compliant with the nitrate MCL. As an interim measure for a small impacted population, providing delivered drinking water may be cost effective. If other contaminants become the subject of investigation, where the susceptible population is larger, the cost of water delivery would increase significantly.

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

The ideal system would:

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

SECTION 2 EVALUATION METHODOLOGY

2.1 DECISION TREE

The decision tree is a flow chart for conducting feasibility studies for the 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. Tree 3 starts with a comparison of the conceptual designs, selecting the two or three alternatives that appear to be most promising, and eliminating those alternatives which are obviously infeasible. 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, managerial, 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 (currently in Building E). The files are organized under two identifiers -- a PWS identification number and a "Certificate of Convenience and Necessity" (CCN) number. The PWS identification number is used to retrieve four types of files:

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

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 Northside WSC, and the surrounding systems, Greenbelt MIWA, North Central Texas Municipal Water Authority, Water Conservation and Improvement Districts, and Groundwater Control Districts.

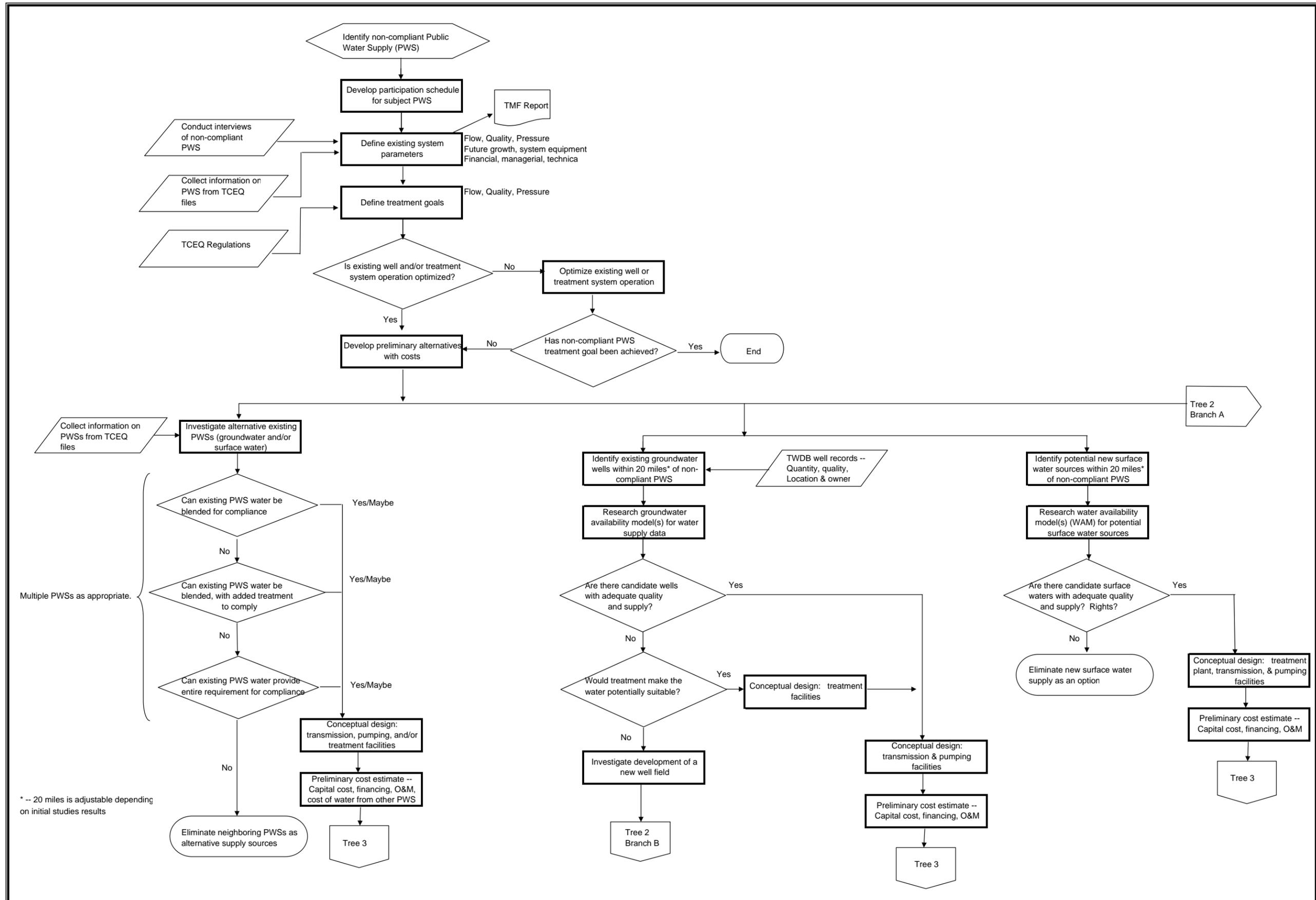


Figure 2.2
TREE 2 - DEVELOP TREATMENT ALTERNATIVES

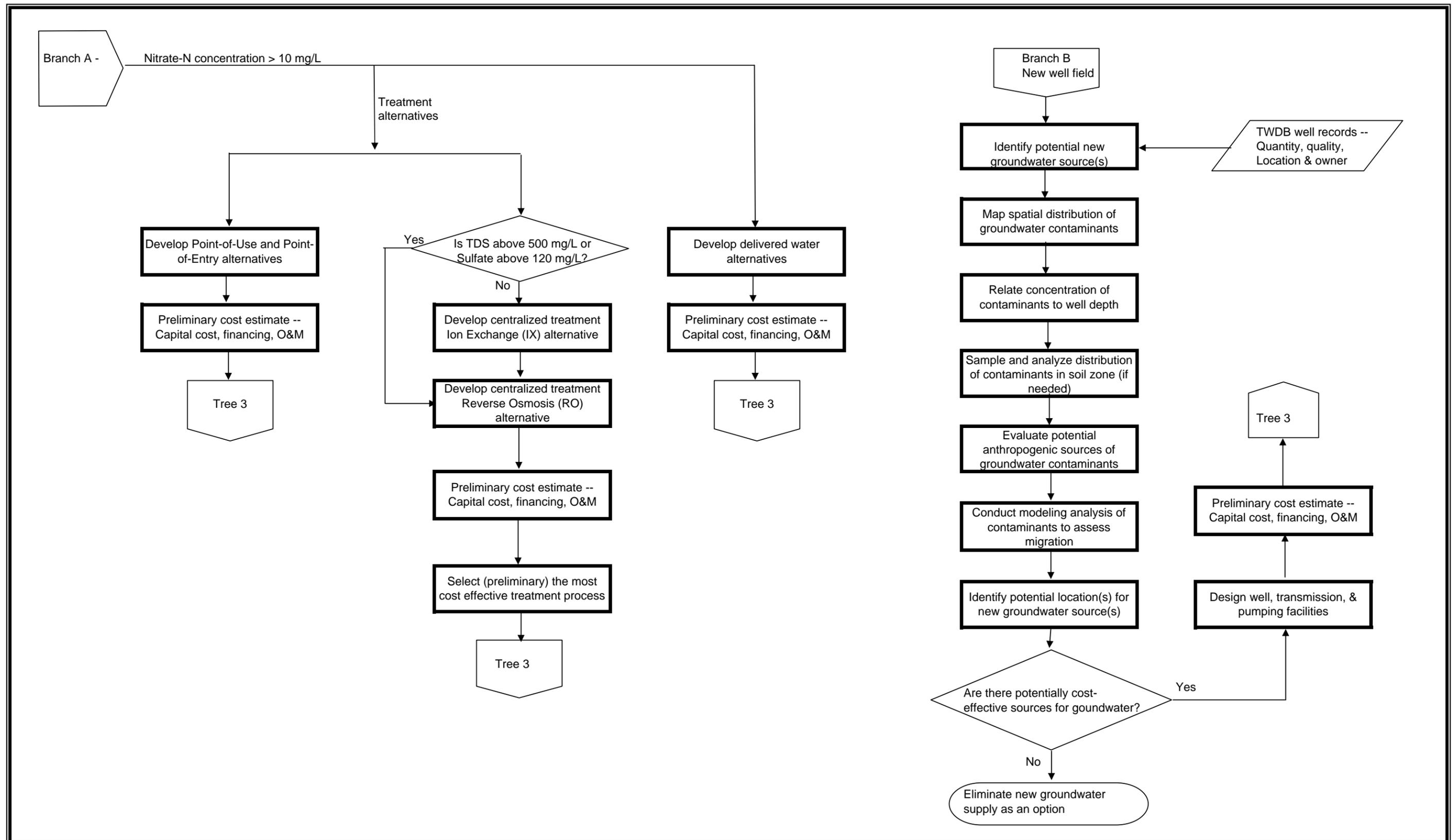


Figure 2.3
Tree 3 - PRELIMINARY ANALYSIS

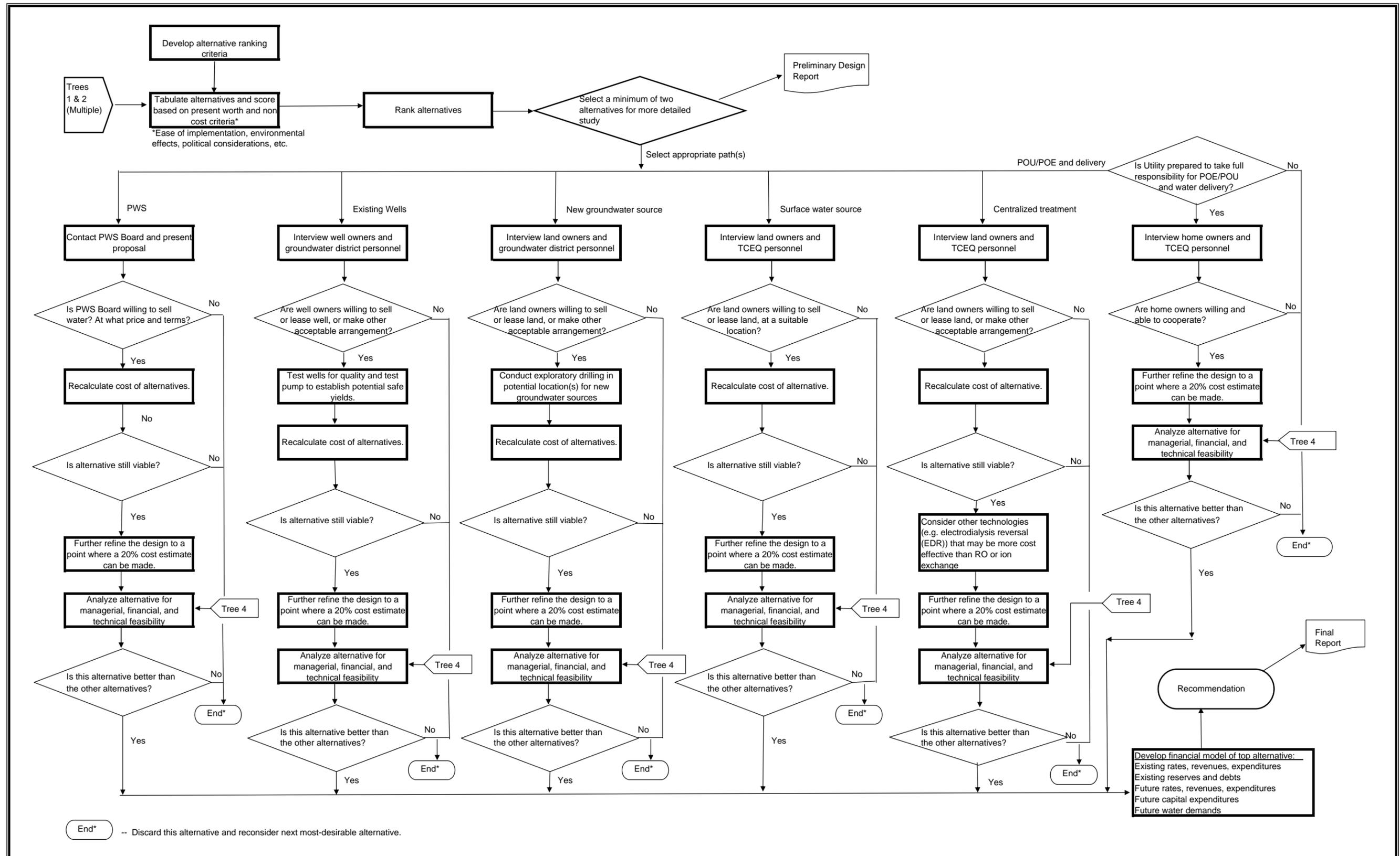
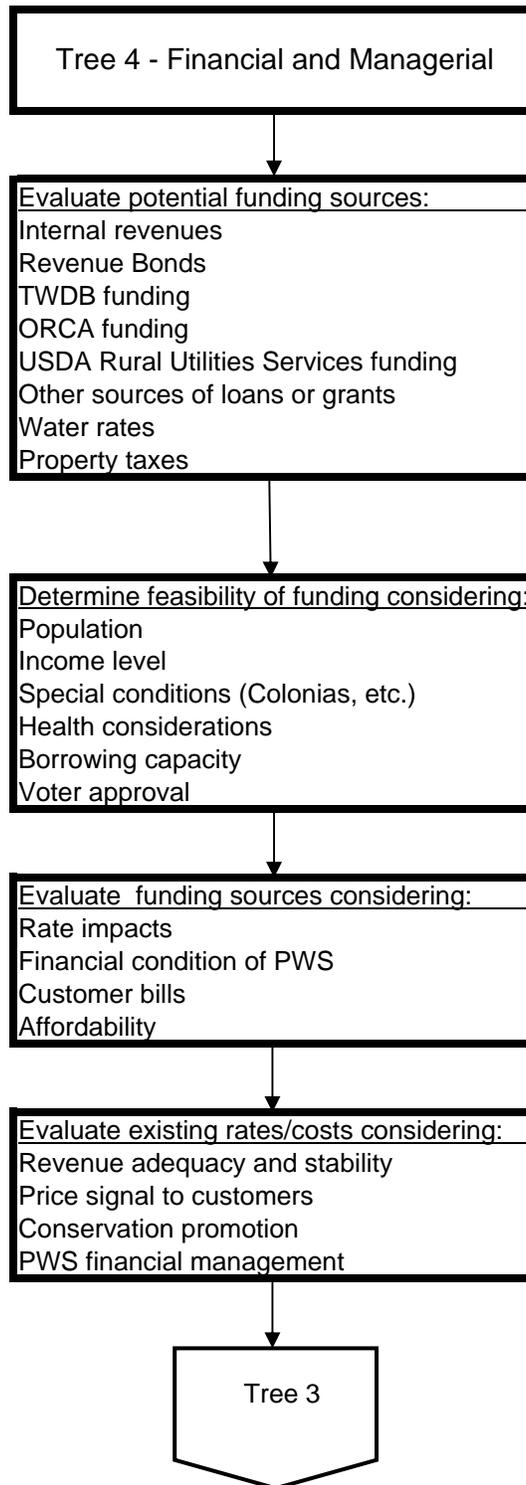


Figure 2.4
TREE 4 - FINANCIAL and MANAGERIAL



The following websites were consulted to list the water supply systems in the Study Area:

- Texas Commission on Environmental Quality
www.tnrc.state.tx.us/iwud/pws/index.cfm. Under “Advanced Search”, type in the name(s) of the County(ies) in the study area to get a listing of the public water supply systems.
- USEPA Safe Drinking Water Information System
www.epa.gov/safewater/data/getdata.html
- Red River Authority
www.rra.dst.tx.us - General Info, Regional Information Center, “click on county,” Water Systems. (Will link to a USEPA site.)

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

2.2.1.2 Existing Wells

The TWDB maintains a groundwater database available at www.twdb.state.tx.us that has two tables with helpful information. The “Well Data Table” provides a physical description of the well, owner, location in terms of latitude and longitude, current use, and for some wells, items such as flowrate, and nature of the surrounding formation. The “Water Quality Table” provides information on the aquifer and the various chemical concentrations in the water. For this study, it was assumed that the nitrate concentration given in this database was the concentration of nitrate, with a molecular weight of 62. To convert to the same basis used for the MCL (Nitrate-N), the value given in the TWDB database was divided by 4.5.

2.2.1.3 Surface Water Sources

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

2.2.1.4 Groundwater Availability Model

The TWDB has developed groundwater availability models (GAMs) for Texas. The GAMs are planning tools, and should be consulted as part of a search for new or supplementary water sources. The model most appropriate for the Study Area is the model for the Seymour Aquifer. The Seymour GAM, finalized in late 2004, was investigated as a potential tool for identifying available and suitable groundwater resources.

2.2.1.5 Water Availability Model

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

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

The water availability models provide information that assists TCEQ staff in determining whether to recommend the granting or denial of an application.

2.2.1.6 Financial Data

Financial data were collected for each of the three utilities through a site visit with each. Data sought for each 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:

- United States
- State of Texas
- Wilbarger County

2.2.2 PWS Interviews

2.2.2.1 PWS Capacity Assessment Process

Assessment of the FMT capacity of the PWS was based on an approach developed by the New Mexico Environmental Finance Center (NMEFC). This methodology was developed from work the NMEFC did while assisting USEPA Region 6 in developing and piloting groundwater comprehensive performance evaluations. The NMEFC developed a standard list of questions that could be asked of water system personnel. The list was then tailored slightly to have two sets of questions – one for managerial and financial personnel and one for operations personnel (the questions are included in Appendix A). Each person who has a role in the FMT capacity of the system is asked the applicable standard set of questions individually. The interviewees are not given the questions in advance and are not told the answers others have provided. Also, most of the questions are open ended type questions so they are not asked in a fashion to indicate what would be the “right” or “wrong” answer. The interviews last between 45 minutes to an hour and 15 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 also made. A technical information form was created to capture this information. This form is contained in Appendix A. This information was considered supplemental to the interviews because it could serve as a check on information provided in the interviews. For example, if an interviewee stated he or she had an excellent preventative maintenance schedule and the visit to the facility indicated a significant amount of deterioration – more than would be expected for the age of the facility – then the preventative maintenance program could be further investigated or the assessor could decide that the preventative maintenance program was inadequate.

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

Following the comparison of answers, the next step is to determine which items that were noted as a potential deficiency truly have a negative effect on the system’s operations. If a system has what appears to be a deficiency, but this deficiency is not creating a problem in terms of the operations or management of the system, it is not critical and may not need to be addressed as a high priority. As an example, the assessment may reveal that there appear to be insufficient staff members to operate the facility. However, it may also be revealed that

the system is able to work around this problem by receiving assistance from a neighboring system so no severe problems result from the number of staff members. Although staffing may not be ideal, the system does not need to focus on this particular issue. The system needs to focus on items that are truly affecting operations. As an example of this type of deficiency, a system may lack a reserve account which can then lead the system to delay much-needed maintenance or repair on their storage tank. In this case, the system needs to address the reserve account issue so that proper maintenance can be completed.

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

2.2.2.2 Interview Process

The project team interviewed personnel at the Northside WSC. The intent was to interview two individuals, Dan White and Beau Jones, who are the President/Manager/Operator and Board Member of the water system, respectively. However, Dan White was unable to attend the day of the scheduled interview, so only Beau Jones, Sheila White (Dan's wife), and Clint White (Dan's son and a Board Member) were available to be interviewed. Because of the unusual circumstances, all three individuals were interviewed together, rather than separately. Other than Dan White, there were no other people who had operational, managerial, or financial control of the system, so no additional interviews were held.

2.3 ALTERNATIVE DEVELOPMENT AND ANALYSIS

The initial objective for compliance alternative development is to identify a comprehensive range of possible options that can be evaluated to determine which are the most promising for implementation. Once the possible alternatives have been identified, they must be defined in sufficient detail so that a preliminary cost estimate (capital and O&M costs) can be developed. The cost estimates are used to compare the affordability of compliance alternatives. 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. In general, PWSs farther than 20 miles from the non-compliant PWSs were not considered because the length of pipelines required would make the alternative cost prohibitive. The quality of water provided was also investigated. For 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 alternative source.

The neighboring PWSs were investigated to get an idea of the water sources they use and the quantity of water they might have available for sale. They were contacted to identify

key locations in their systems where a connection might be made to obtain water, and to explore on a preliminary basis their willingness to partner or sell water. Then, the major system components that would be required to provide compliant water were identified. The major system components included treatment units, wells, storage tanks, pump stations, and pipelines.

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

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

2.3.2 New Groundwater Source

Existing non-public water supply wells with acceptable water quality within approximately 10 miles were identified. While the existing wells may or may not be appropriate for use as drinking water supply wells, they do provide information about the prevalence of compliant groundwater in the area. Also, many of the sample results in the database were from 10 or more years ago, and may not be representative of current conditions. It was not possible in the scope of this study to determine conclusively whether existing wells would be suitable or not, since sampling and test pumping would be required. In order to evaluate potential new groundwater source alternatives, three test cases were developed based on distance from the PWS intake point. The test cases were based on distances of 10 miles, 5 miles, and 1 mile. It was assumed that a pipeline would be required for all three of the test cases, and a storage tank and pump station would be required for the 10-mile and 5-mile alternatives. It was also assumed that new wells would be installed, and that their depths would be similar to the depths of the existing wells, or other existing drinking water wells in the area.

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

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

2.3.3 New Surface Water Source

New surface water sources were investigated. Availability of adequate quality water was investigated for the main rivers in the study area (Red and Pease), as well as the major reservoirs. The TCEQ Water Availability Maps for the Red River and Pease River were inspected, and the WAM was run, where appropriate. In general, it was found that surface water was not available in adequate quantities, and, even if it were, it would be of unacceptable quality, requiring extensive treatment for dissolved solids removal.

2.3.4 Treatment

Treatment technologies considered potentially applicable are RO and IX, since they are proven technologies with numerous successful installations for nitrate removal. Electrodialysis reversal was not deemed to be applicable in this study, since it is typically not applicable to waters with high TDS concentrations, and much of the groundwater in the Study Area has relatively high TDS. RO is generally more expensive than IX treatment, but is typically subject to less interference by dissolved constituents in the water.

RO treatment is considered for central treatment alternatives, as well as point-of-use and point-of-entry alternatives. IX treatment is considered for central treatment alternatives only. Both RO and IX treatment produce a liquid waste: a reject stream from RO treatment and a concentrate stream from IX treatment. As a result, the treated volume of water is less than the volume of raw water that enters the treatment system. The amount of raw water used increases to produce the same amount of treated water if RO or IX treatment is implemented. The treatment units were sized based on flow rates, and capital and annual O&M cost estimates were made based on the size of the treatment equipment required. Neighboring non-compliant PWSs were identified to look for opportunities where the costs and benefits of central treatment could be shared between systems.

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

2.4 COST OF SERVICE AND FUNDING ANALYSIS

The primary purpose of the cost of service and funding analysis is to determine the financial impact of implementing compliance alternatives, primarily by examining the required rate increases, and also the fraction of household income water bills represent. The current financial situation is also reviewed to determine what rate increases are necessary for the PWS to achieve or maintain financial viability.

2.4.1 Financial Feasibility

A key financial metric is the comparison of the average annual household water bill for a PWS customer to the median household income for the area. Median household income

data from the 2000 Census is used, at the most detailed level available for the community. Typically, county level data is 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.

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 divided by current liabilities provides insight into the ability to meet short term payments. For a healthy utility, the value should be greater than 1.0.
- Debt to Net Worth Ratio = total debt divided by net worth shows to what degree the assets of the company have been funded through borrowing. A lower ratio indicates a healthier condition.
- Operating Ratio = total operating revenues divided by total operating expenses shows the degree to which revenues cover ongoing expenses. The value is greater than 1.0 if the utility is covering its expenses.

2.4.2 Median Household Income

The 2000 Census is used as the basis for median household income. In addition to consideration of affordability, median household income 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, median household income for the State of Texas was \$39,927, compared to the U.S. level of \$41,994. With the sparse population base in the service areas, county data is the most reliable, and for many rural areas corresponds to census tract data.

2.4.3 Annual Average Water Bill

The annual average household water bill was calculated for the Northside WSC, 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 for the Northside WSC 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 Northside WSC 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 reserve 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 for the Northside WSC in a table that shows the following according to alternative and funding source:

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

Water rates resulting from the incremental capital costs of the alternative solutions 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 median household income (MHI) > 75 percent of state MHI, standard terms, currently at 3.8 percent interest for non-rated entities
 - 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 district, based on specified months of O&M expenditures
- O&M for alternatives begins 1 year after capital implementation
- Balance of capital expenditures not funded from primary grant program is funded through debt (bond equivalent)
- Cash balance drives rate increases, unless provision chosen to override where current net cash flow is positive

2.4.5.3 Interpretation of Financial Plan Results

The results from the financial plan model are presented in a table that shows the percentage of median household income that is 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 rural utilities. Both state and federal agencies offer grant and loan programs to assist rural communities in meeting their infrastructure needs.

Within Texas, the following state agencies offer financial assistance:

- Texas Water Development Board (TWDB)
- Office of Rural Community Affairs (ORCA)
- Texas Department of Health (Texas Small Towns Environment Program)

Small rural communities can also get assistance from the federal government. The primary agencies providing aid are:

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

SECTION 3 UNDERSTANDING NITRATE IN THE SEYMOUR AQUIFER

3.1 NITRATE SOURCES

The geological portion of this study indicates that the source of nitrate in groundwater is the agricultural application of fertilizers. Additionally important are several localized nitrate sources, predominantly septic tanks and barnyards near rural residences and sewers in urban areas. Groundwater nitrate concentrations in the Seymour aquifer increase with increased percentage of row crop and urban land uses within a 1,000 meter buffer surrounding each well based on the TWDB database (Figure 3-1a) and decrease with increased percentages of rangeland, forest, pasture/hay, and small grains land uses (Figure 3-1b). TDS levels are generally not related to land use (Figures 3-1a, 3-1b). Soil sampling in agricultural areas with different types of crops revealed a reservoir of nitrate in the soil zone beneath dryland and irrigated wheat and cotton (Appendix C). Nitrate levels in soil in areas of irrigated and dryland alfalfa were low. Alfalfa is a legume and can fix nitrogen; however, the data suggest that rapid growth and frequent harvesting of alfalfa may deplete all available nitrogen. An anthropogenic rather than geologic source of nitrate is indicated by a general lack of relationships between nitrate and other major inorganic anions (Figure 3-2).

Leakage from centralized sewerage systems, septic tanks, and/or barnyards may provide local sources of nitrate contamination to nearby public water supply and domestic wells as suggested by previous work conducted (Harden, *et al.* 1978). Nitrate-N concentrations in groundwater wells associated with urban areas are statistically higher than in areas not associated with urban land uses (Figure 3-3). The population of domestic wells in the TWDB database shows consistently higher nitrate-N concentrations than irrigation wells, though differences between the two in general water quality are relatively small as indicated by the distribution of TDS (Figure 3-4).

Previous studies suggest that the primary source of nitrate in groundwater in the Seymour Aquifer is from natural sources (Bartolino 1994). High levels of groundwater nitrate prior to widespread application of fertilizers in the mid-1960s were attributed to oxidation of nitrogen that had built up in the soil zone over long times in nearby Runnels county (Kreitler 1975) or to nitrogen fixation by legume plants such as mesquite in the Seymour Aquifer (Bartolino 1994) and subsequent flushing of this nitrate into the underlying aquifer as a result of increased recharge rates from cultivation. Groundwater data from the TWDB database indicate high nitrate levels prior to 1950; however, the number of samples is low (130). Nitrate-N concentration profiles in soil in areas of native ecosystems that has never been cultivated were low (Appendix C). However, total nitrogen was not analyzed in these samples and may be high. Nitrate profiles in soil under native settings in semiarid/arid environments in other states (Nevada and Kansas) had very high nitrate concentrations in the soil profile, and data showed that these high nitrate levels were mobilized under irrigated agriculture (Hartsough, *et al.* 2001; Stonestrom, *et al.* 2003; Walvoord, *et al.* 2003). Current estimates of recharge (0.8 to 2.5 in/yr; mean 2 in/yr) for the Seymour Aquifer from the recently developed Groundwater Availability Model (Ewing, *et al.* 2004) suggest that this original source of nitrate should be flushed through the system in areas of coarse textured soil

but could remain in areas of fine textured soil which may explain the relationship between nitrate-N concentrations in groundwater and soil texture (Figure 3-5).

3.2 PRACTICES NECESSARY TO REDUCE GROUNDWATER NITRATE CONCENTRATIONS

There are various approaches discussed in the literature for reducing nitrate derived from leaching of fertilizers. Currently fertilizers are generally applied one time prior to planting. Agricultural land uses account for 70.6 percent of the Seymour Aquifer area while irrigated areas constitute only 6.7 percent based on the National Land Cover Dataset (NLCD 1994).

To optimize fertilizer application so that crops use most of the applied fertilizers and leaching is minimized, studies suggest that fertilizer application should be split into multiple applications (2 – 4): pre-planting and post-planting. This may be a problem because the land is generally dry when fertilizers are applied prior to planting; however, precipitation after planting may make it difficult to apply fertilizers. If fertilizers are applied through irrigation water, the timing of application may not be difficult to control. The infrastructure does not seem to be available for aerial application of fertilizers in the Seymour regions. Additionally, multiple applications increase costs. The type of fertilizer applied may also influence the leaching rate. Slow release fertilizers should result in less leaching than fast release fertilizers; however, slow release fertilizers are generally more expensive. The timing of fertilizer application relative to water applications (precipitation or irrigation) may also be a critical factor in determining leaching. Although it may be difficult to control fertilizer applications relative to precipitation in dryland farming regions, irrigation applications may be controlled to minimize fertilizer leaching. The type of irrigation system plays a large role in controlling leaching: flood irrigation systems are more inefficient than center pivot systems and result in greater leaching. Subsurface drip irrigation systems are even more efficient than center pivot systems, and a study is being conducted by the Texas State Soil and Water Conservation Board to evaluate such a system in the Seymour region. Irrigating at rates determined by monitoring potential evapotranspiration or soil moisture should result in much less drainage than uniform irrigation rates and should be considered. Soil profiles in land in the Conservation Reserve Program have low nitrate levels (Appendix C), which indicate that if fertilizer is no longer applied the nitrate reservoir in the profile can be flushed out. The effects of these management practices on groundwater nitrate may take a long time to establish because of the time required for water to move through the unsaturated zone and through the groundwater system. With a recharge rate of 2 in/yr and average water content in the unsaturated zone of 10 percent by volume, the travel time through a 50-foot unsaturated zone would be 33 years.

3.3 HISTORICAL TRENDS IN NITRATE CONCENTRATIONS

Time series information from the TWDB database is limited. There are 2,283 wells in the TWDB database that are within the outcrop areas of the Seymour Aquifer. Of those, 1906 (83.5 percent) have only one water quality analysis record while only 135 (5.9 percent) have three or more nitrate-N concentrations reported through time. Most samples were collected

and analyzed in the late 1960s (Wilbarger County, Jones County) or mid-1970s (Haskell County, Knox County). Individual wells showed increasing, decreasing, and variable trends through time.

Haskell and Knox Counties account for approximately 45 percent of the Seymour Aquifer nitrate-N data. Sampling was also generally more widely spread, both spatially and temporally, relative to the other pods and provides the best overall data set for a temporal analysis of nitrate-N concentrations. Analysis for the entire well population in these counties shows a significant general increase over time in nitrate-N concentrations and median concentrations that have generally been in excess of 10 mg/L (Figure 3-6a). However, approximately 30 percent of the data used in this analysis is from domestic wells, which may be subject to local contamination. Though much of the repeat sampling of individual wells occurred for domestic wells, an analysis that excludes domestic wells and which might reflect more ambient regional conditions, also suggests increasing concentrations with time and median concentrations also generally remained greater than 10 mg/L (Figure 3-6b). However, the significance of this regression is much lower and suggests that regional temporal trends in nitrate-N concentrations may not be significant.

3.4 NITRATE STRATIFICATION

Permian age formations underlay the Seymour Aquifer and generally do not contain water that, without treatment, is of suitable quality for a public water supply system, primarily as a result of elevated sulfate and/or TDS concentrations. Groundwater nitrate-N concentrations from the TWDB database were evaluated to determine if there is any distinct stratification of water chemistry with depth in the Seymour Aquifer that would allow shallower or deeper wells to be drilled to minimize nitrate levels.

The Seymour Aquifer is relatively thin. Saturated thickness generally ranges from less than 10 feet near pod boundaries to approximately 100 feet in a few locations near pod centers, and generally ranges from 20 to 60 feet. There is no obvious relationship between nitrate-N concentration and well depth (Figure 3-7). Median nitrate-N concentrations were grouped by well depth intervals to evaluate depth trends. The analysis indicates fairly uniform median nitrate-N levels with depth, with most median values near or exceeding 10 mg/L. Additionally, the middle 50 percent of the nitrate-N concentration distributions overlapped for all intervals indicating that drilling shallower or deeper wells within the Seymour Aquifer would not likely result in acceptable nitrate-N concentrations. The uniform nitrate-N concentrations with depth may be attributed in part to the high permeability of the Seymour Aquifer throughout its thickness and particularly in the gravel layer found at the base of the aquifer in many areas.

3.5 EXPERIENCE OF OTHER STATES

Groundwater nitrate contamination in other states surrounding Texas is generally not as widespread as it is in Texas. The following summarizes the state of knowledge with respect to nitrate in Oklahoma, Louisiana, New Mexico, and Arkansas.

Oklahoma: ambient groundwater monitoring program

- Range NO₃-N: 0.0 – 19.8 mg/L; Median NO₃-N: (400 samples, time)
- High nitrate located in west and northwest areas of the state
- Potential sources: fertilizers, septic tanks, and concentrated animal feeding operation (CAFO), primarily hog CAFOs

Louisiana: ambient groundwater monitoring program

- Range NO₃-N: < 0.05 – 0.63 mg/L (2001 – 2003)

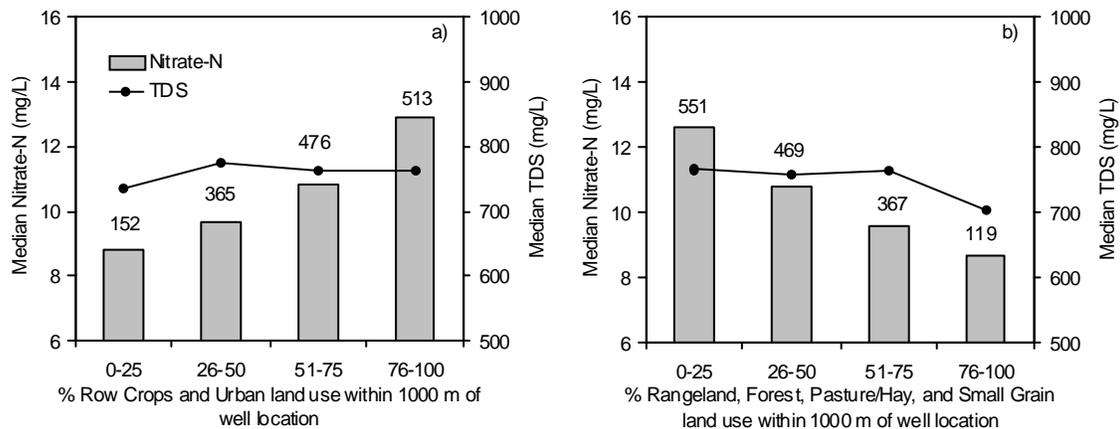
New Mexico: no ambient groundwater monitoring program

- Range NO₃-N: 0.0 - > 500 mg/L
- 200 nitrate plumes affecting 710 private and 82 public water supply wells (McQuillan, *et al.* 2004)
- Potential sources: natural, CAFOs, septic tank, and sewer systems
- USEPA study of 94 dairies: 36 percent have NO₃-N = 10 mg/L NO₃-N; waste lagoons responsible for NO₃-N = 100 mg/L NO₃-N
- Large capacity septic tank study: 50 percent = 10 mg/L NO₃-N in groundwater

Arkansas: no ambient groundwater monitoring program

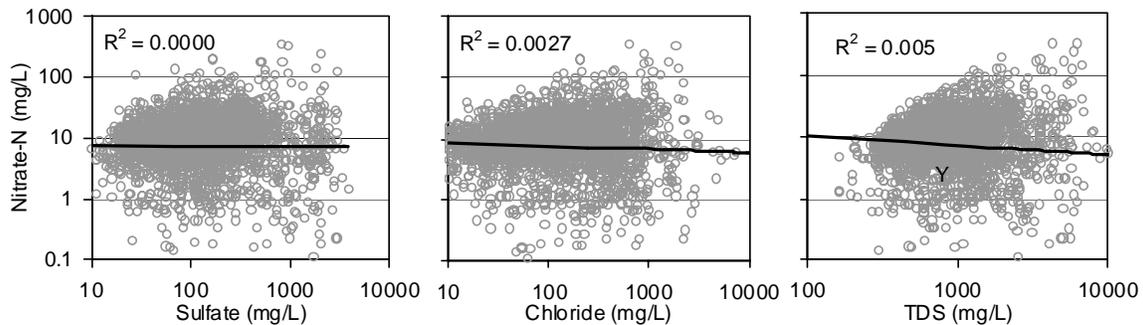
- Range NO₃-N: < 0.00 – =60 mg/L (2001 – 2003) (high in NW part of state)
- Southeast part of state mostly confined aquifers; nitrate does not reach aquifers or is denitrified in aquifers.
- Potential sources: septic systems, sewers, fertilizers, CAFOs

Figure 3-1 Nitrate Concentrations and Land Use



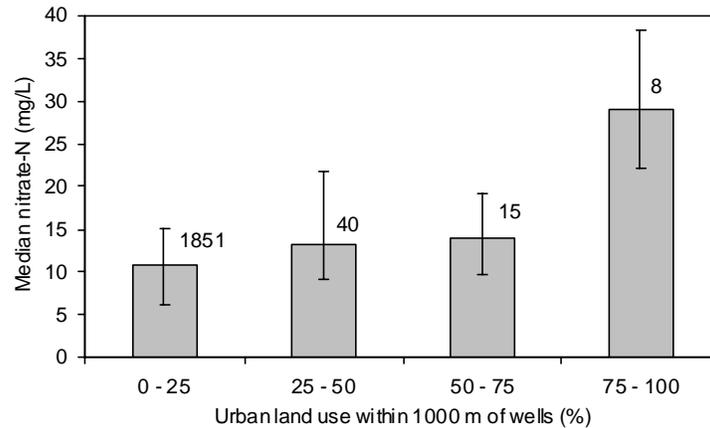
Median nitrate-N and TDS concentrations in groundwater in relation to land use within a 1,000 meter radius of well locations for a) the combined percentages of row crops (NLCD code 82) and urban (NLCD codes 21, 22, 23, 85) land use categories and (b) the combined percentages of rangeland (NLCD codes 51, 71), forest (NLCD codes 41, 42, 43) and the remaining agricultural (NLCD codes 81, 83) land use categories. The complementary analyses account for an average of 99 percent of the area within 1,000 meters of all wells. Numbers indicate the quantity of wells within each group.

Figure 3-2 Correlation of Nitrate with TDS, Chloride, and Sulfate



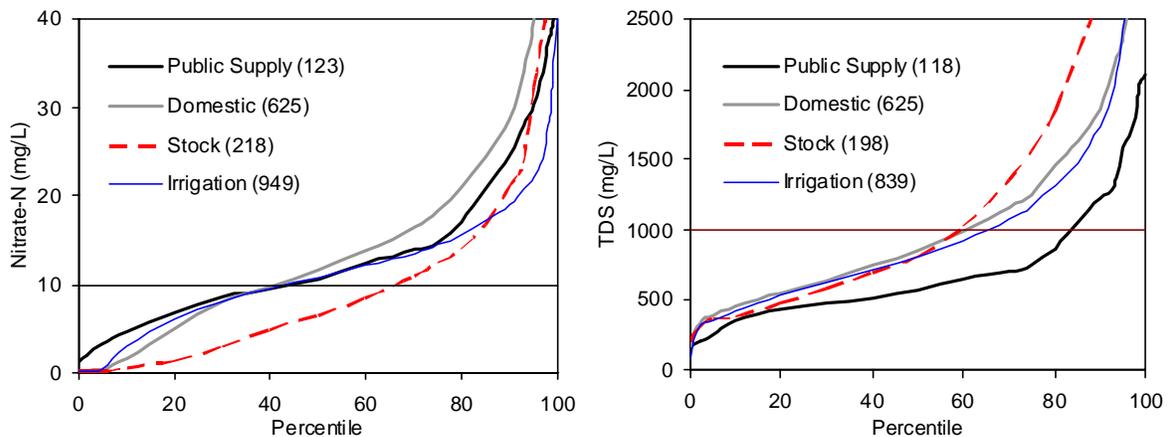
Relationship between nitrate-N and sulfate, chloride, and TDS for 3,417 groundwater samples in the Seymour Aquifer. (Source: TWDB database).

Figure 3-3 Nitrate Concentrations Related to Urban Land Use



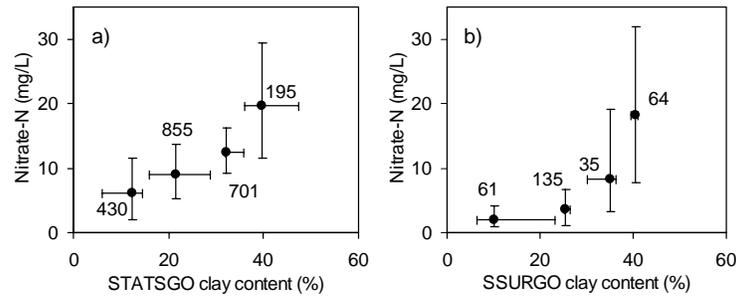
Median nitrate-N concentrations in groundwater in relation to the percentage of Urban (NLCD codes 21, 22, 23, 85) land use categories within a 1000 m radius of the well locations. Values represent the number of wells within each group. Error bars represent the middle 50 percent (*i.e.*, median \pm 25 percent) within each group. The population means are statistically different to $p < 0.01$.

Figure 3-4 Nitrate and TDS Concentrations Related to Primary Well Use



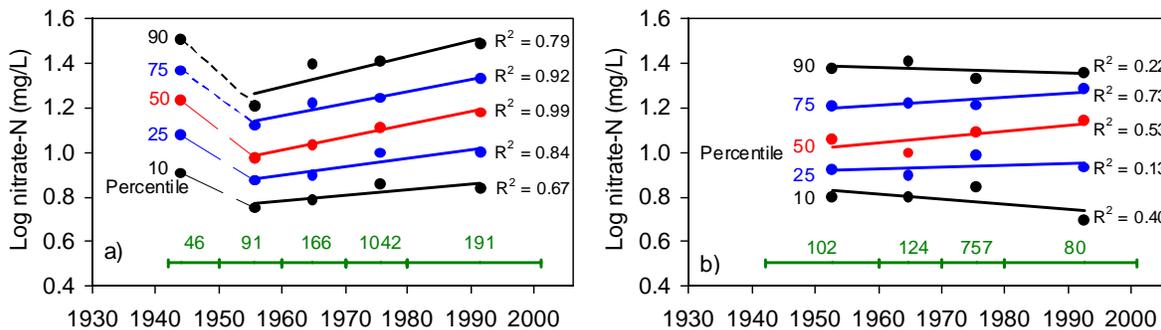
Distribution of nitrate-N and TDS concentrations in the Seymour Aquifer as a function of primary well use. Numbers in parenthesis indicate number of wells in each category. The most recent water sample for each well was used in the analysis.

Figure 3-5 Nitrate Concentrations Related to Soil Clay Content



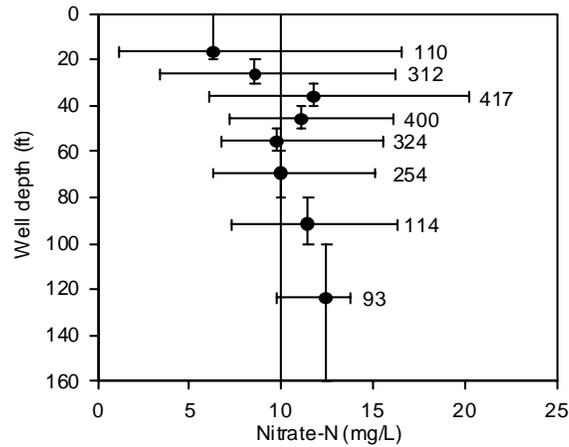
Relationship between nitrate-N concentrations in groundwater and average soil clay content at well locations in a) the entire Seymour Aquifer based on generalized soil data from the State Soil Geographic soil database and b) outcrop areas of the Seymour Aquifer in Jones County based on detailed soil data from the Soil Survey Geographic soil database. Numbers indicate quantity of wells in each group. Points are plotted at the average clay content versus median groundwater nitrate-N concentration for each group. X error bars indicate the range of clay content values for each group, and Y error bars indicate the middle 50 percent range (*i.e.*, median \pm 25 percent) of nitrate-N concentrations for each group.

Figure 3-6 Temporal Trends of Nitrate Concentrations



Temporal trends of log nitrate-N by percentile distribution for a) all wells, and b) excluding domestic wells in the Haskell and Knox Counties pod of the Seymour Aquifer. Range bars and values at the bottom of the figures, respectively, indicate the sample periods and number of samples within each period. Points are plotted at the average sample date within each range. Solid lines represent linear regression fits to the data and R^2 values are also shown. The slopes of the median (50th percentile) regression lines are significant to a) $p < 0.01$ and b) $p < 0.27$.

Figure 3-7 Relationship Between Nitrate Concentration and Depth



Relationship between nitrate-N concentrations and well depth in the Seymour Aquifer. Points are plotted at the median nitrate-N concentration and average well depth for each group. Numbers indicate the quantity of wells in each group. X error bars indicate the middle 50 percent range (*i.e.*, median \pm 25 percent) of nitrate-N concentrations in each group and Y error bars indicate the range of well depths in each group. The latest sample for each well was used in the analysis.

SECTION 4 ANALYSIS OF THE NORTHSIDE WSC

4.1 DESCRIPTION OF EXISTING SYSTEM

4.1.1 Existing System

The Northside Water Supply Corporation (WSC) is diagrammed in Figure 4.1. The system is fed from the raw water line between the Vernon well field and the City of Vernon. The feed point is located at the crossing under FM 924. The pump station includes a meter on the Vernon raw water line, ground storage tank, gas chlorinator, and one booster pump (90 gpm rated capacity) that runs continuously. The water is chlorinated before flowing into the storage tank.

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

Water is pumped eastward from the well field through a 3-inch diameter line where it intersects with the main distribution line, a 3-inch line that runs north to south along Highway 283. Northside WSC will soon move this line out of the highway right-of-way, and replace it with a 6-inch polyvinyl chloride (PVC) pipe.

Basic system information is as follows:

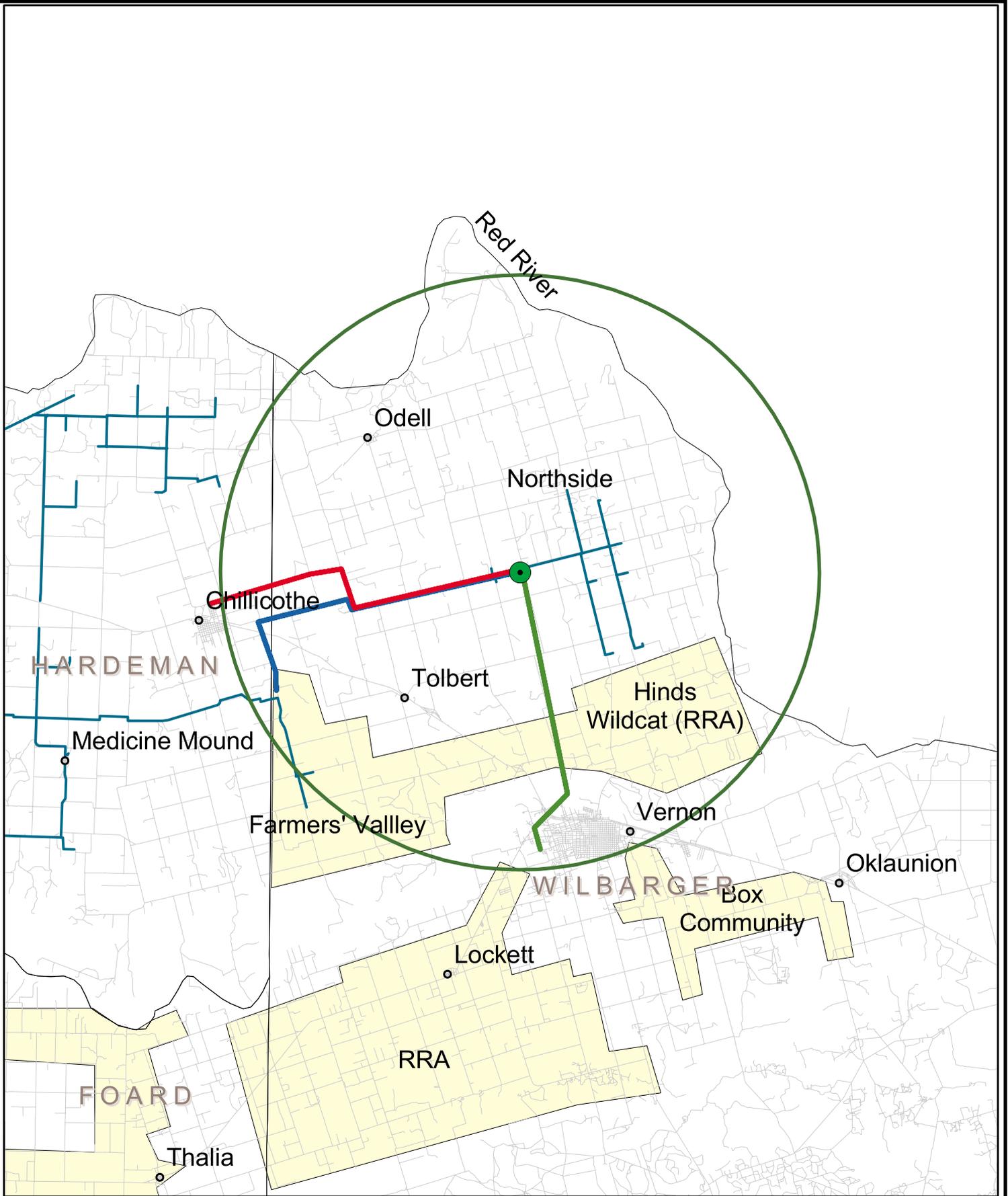
- Population served: 250
- Connections: 66
- Average daily flow: 53,000 gpd
- Maximum daily flow: 97,000 gpd
- Production capability: 0.130 million gallons per day (mgd)
- Typical nitrate range: 15 to 20 mg/L

More detailed information on the system is in *Public Water Supply Regulatory Program, Regulated Entity Data* (included in Appendix D).

The Northside WSC currently notifies customers that expectant and nursing mothers should drink bottled water and use bottled water for infants.

4.1.2 Capacity Assessment for Northside WSC

The Northside WSC is a membership-type organization run by a board. The system is a primarily volunteer organization, with only one paid position for the part-time meter reader.



- System Intake Point (with 10 mile radius)
- Towns

- Existing Distribution Line
- Vernon Treated Water Alternative
- Chillicothe Blended Water Alternative
- Farmers' Valley Blended Water Alternative



Figure 4.1

Northside

PARSONS

4.1.2.1 General Structure

The Northside WSC has a volunteer board that oversees the water system operations. The Board President, Mr. Dan White, is also the Chief Operator. The system employs one part-time employee to read meters and prepare bills.

4.1.2.2 General Assessment of Capacity

The Northside WSC has a dedicated Board and Board President/Operator and is able to overcome some of its capacity deficiencies. Overall the capacity is considered marginal to acceptable, but this rating is extremely dependent on the current President/Operator. If this system were to lose its current operator, the system would probably have significant capacity problems.

4.1.2.3 Positive Aspects of Capacity

In assessing capacity, it is as important to note the positive aspects of capacity as the deficiencies related to capacity. It is important for systems to be aware of the characteristics that either make them a well-run system or that lead them towards being a well-run system so that they can continue to do these activities or increase them. The factors below are positive aspects of the Northside WSC.

- Communications – There are a small number of individuals involved in the system and it is a fairly small system which allows the key individuals to communicate about the system on a regular basis.
- Dedicated Volunteers – The Northside WSC has extremely dedicated volunteers who are willing and able to do whatever is needed or asked of them to keep the system going. The dedication of these individuals is exhibited in the fact that President will send his own workers to fix water line problems, at no expense to the water system. The Board members will also volunteer time to make repairs or do whatever is asked of them. This volunteerism also allows the system to maintain a very low budget, as much of the activities that systems normally have to pay for are provided by volunteer efforts.
- Supportive Customers – The customers on the system understand what it was like for them before the system was started. They realize that it is being run by volunteers and are appreciative of the service they get. There are few complaints. This supportive customer base may allow the system to raise rates if needed to pay for a system upgrade to include nitrate removal.

4.1.2.4 Capacity Deficiencies

The following capacity deficiencies were noted in conducting the assessment.

- Budget Process – The Northside WSC does not have a budget process to examine needed revenues. Rates are not based on a budget. The lack of a budget reduces the system's ability to raise revenues for the installation and operation of nitrate treatment.

- **Rate Process** – Rates are not reviewed on a periodic basis. Rates are set based on the City of Vernon. Rates have not been raised since approximately 1987, when the volume charge was raised. Base rate has never been raised. The rates have been sufficient to cover expenses given the heavy use of volunteer labor and the lack of needing complex treatment. However, the rates will be insufficient to support a nitrate treatment system and may not be adequately covering all current, non-labor, operation and maintenance expenses.
- **Insufficient Reserves** – There is some money in the bank at the end of each month (a few thousand dollars.) However, there is not a sufficient reserve account to pay for major expenses. Because of this lack of reserve account, money has not been collected in a fund that could have been used to pay for the needed nitrate removal system or an alternative method of addressing the nitrate issue. Reserve accounts also reduce the need to borrow money for system upgrades and help cover other needed repairs or replacements.
- **Planning** – There is no official short-term capital improvement planning process, and no long range process (e.g., 20-year process) to fully examine the “big picture” in terms of needs. The lack of long-term planning may have limited the systems’ ability to address the nitrate compliance issue.
- **Certified Operator** – There currently is no certified operator at the system. The President is in the process of certification, but has not yet completed the process. Although the president of the board/chief operator is extremely familiar with the system and has been operating it for a long time, it is important that he receive sufficient training and certification to be able to operate the more complex nitrate system, if a treatment alternative is chosen.
- **Water Quality Goals** – The Northside WSC does not have clear water quality goals for the water system, such as maintenance of a specific chlorine residual. The major aspect of this lack of goals, however, is that the water system does not have clear goals for meeting the nitrate standard. This lack of goals on this parameter may be impacting the system’s ability or willingness to consider alternatives to meeting this standard (alternatives other than bottled water). Also, these goals can be used to communicate with the customers exactly what the system is trying to accomplish.
- **Unaccounted for Water** – Unaccounted for water represents 43 percent of the water produced by the Northside WSC. This unaccounted for water rate is considered high. A reduction in this rate would reduce significantly the amount of water that must be purchased, pumped, and/or treated, depending on the compliance alternative implemented.

4.1.2.5 Potential Capacity Concerns

The following items were concerns regarding capacity but there are no particular operational, managerial, or financial problems that can be attributed to these items. The main areas to concentrate on are listed above in the capacity deficiency section. Addressing these items may assist the system in further improving the system’s overall operation.

- Disinfectant Residual Monitoring – Disinfectant residuals are checked on a weekly basis. For maximum public health protection it would be best to check residuals daily. A clear policy in this area would be helpful. In this case, there have not been coliform violations, but if residuals are not checked daily, the chlorination system can go out without the operator being aware. If this occurs at the same time as a line break or some other condition, there is the potential for contamination.
- Water Conservation Program – The Northside WSC does not currently have a water conservation plan in place for its system. Given the drought issues in Texas, it is important to consider instituting some type of program. In addition, the system could use this program to address unaccounted for water issues.

4.2 ALTERNATIVE WATER SOURCE DEVELOPMENT

4.2.1 Identification of Alternative Existing Public Water Supply Systems

4.2.1.1 City of Vernon

The City of Vernon obtains its well water from 21 wells in the Odell and Winston Well Fields located approximately 16 miles north of Vernon and west of Highway 283. The pipeline from the well fields to the treatment plant in Vernon and passes through the Northside WSC service area. Other communities in the area receive groundwater from the City of Vernon, either as raw water from the Vernon well field, or treated from the City Water Treatment Plant. The City of Vernon has recently installed an ion exchange plant to reduce the nitrate concentration to within regulated limits. Communities receiving raw water are:

- Northside WSC
- Hinds Wildcat (RRA)

Communities receiving treated water are:

- Box Community (RRA)
- City of Oklaunion
- Lockett WSC (treated water to meet peak demand) – As of 3/16/2004, the Lockett Water System was still producing water with nitrate concentrations substantially in excess of 10 mg/L (20.5 mg/L). Based on this analysis, it appears as though Lockett is not using City of Vernon water to blend to reduce nitrates.

Previous studies have investigated pumping treated water back from the City of Vernon to Northside. The line could also serve the Hinds Wildcat System. Those studies concluded that the construction and operation of such a line would be too expensive in the absence of grants.

If the City of Vernon were to be connected to Northside WSC, approximately 10 miles of pipe would be required. The routing is shown in Figure 4.1. The pipe would pass through the Hinds-Wildcat system; thus, it is reasonable to consider inviting the Red River Authority, owner of the Hinds-Wildcat system, to share in the cost of the line.

4.2.1.2 City of Chillicothe

The City of Chillicothe operates 4 wells, completed in the Seymour Aquifer (Code 112SYMR). These wells produce water with nitrates in excess of 10 mg/L, with a TDS concentration of approximately 500 mg/L. The production rate is 75 gpm from each well. The City blends surface water from Greenbelt MIWA, through the RRA's Medicine Mound system, to reduce nitrate concentrations to below 10 mg/L. The average daily use is approximately 0.09 mgd well water and 0.03 mgd surface water (purchased). Maximum daily use is 0.2 mgd well water and 0.072 mgd purchased water. It should be noted that at the date of this report, the City of Chillicothe had not been successful in adjusting the blending process to reliably produce compliant water.

A connection between Chillicothe and Northside WSC would require a pipe approximately 11 miles long. The routing is shown in Figure 4.1.

4.2.1.3 Farmers' Valley

Farmers' Valley (RRA) operates 2 wells completed in the Blaine Aquifer approximately 2 miles south of Chillicothe. These wells produce water with nitrate concentrations in excess of 10 mg/L and a TDS concentration of approximately 500 mg/L. The production rate is 20 gpm from each well. The City blends surface water from Greenbelt MIWA, through the Red River Authority's Medicine Mound system, to reduce nitrate concentrations to below 10 mg/L. The average daily use is approximately 0.02 mgd. Maximum daily use is 0.09 mgd.

A connection between Farmers' Valley and Northside WSC would require a pipe approximately 12 miles long, about the same as the distance from Chillicothe. A disadvantage to this route is that the pipe installation would have to pass below a major highway (U.S. 287). The routing is shown in Figure 4.1.

4.2.1.4 Medicine Mound

Medicine Mound (RRA) is the only community within 20 miles of Northside receiving all its water as surface water obtained from the Greenbelt MIWA. Medicine Mound is a small community of 65 people with 54 metered connections.

A connection to Medicine Mound would have to be made through either the Chillicothe pipe system or through the Farmers' Valley pipe system as described above. The Chillicothe and Farmers' Valley systems already obtain water through the Medicine Mound system, this alternative duplicates the previous two alternatives.

4.2.2 Potential for New Groundwater Sources

4.2.2.1 Existing Non-Public Supply Wells

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

There are approximately 90 wells not associated with public supply systems located within approximately 10 miles of the Northside WSC that have nitrate concentrations less than 8 mg/L, sulfate concentrations less than 300 mg/L, and total dissolved solids concentrations less than 1000 mg/L. These wells are primarily used for irrigation, domestic supply, and stock watering. The majority of the nitrate samples were taken in the early 1970s, and the water quality may have changed since then. The well locations are shown in Figure 4.2.

Installation of a new well within 1, 5 or 10 miles of the system intake point is likely to be the best option for obtaining compliant water. As a result, existing wells with good water quality should be investigated, even though water quality data for these wells are dated and need to be verified.

For examination of these wells as potential sources, it is suggested that the owners first be contacted to ascertain their willingness to work with the utility. Once the owner is on board with the program, questions about the wells could be posed. 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 gleaning as much information as possible from cooperative owners, the Utility would then narrow down the selection and sample selected wells and analyze for quality. Wells with good quality would then be potential candidates for test pumping. Alternatives that address new groundwater sources are NS-8, NS-9, and NS-10.

4.2.2.2 Results of Groundwater Availability Modeling

The Seymour Aquifer is discontinuous and exists as a series of “pods” that may or may not be interconnected. The pod sizes are small in comparison to the GAM grid size. As a result, the Seymour GAM is not suitable for predicting aquifer responses at specific points such as a selected well at a particular municipality. As a result, the GAM was not run to assist in locating groundwater sources for Northside WSC. The Draft Seymour GAM report was consulted to provide basic information about groundwater resources in the Northside WSC area.

4.2.2.3 General Aquifer Indications

The majority of the wells in the area are completed in the Seymour aquifer. There are 209 wells listed in the TWDB water quality database within approximately a 10-mile radius

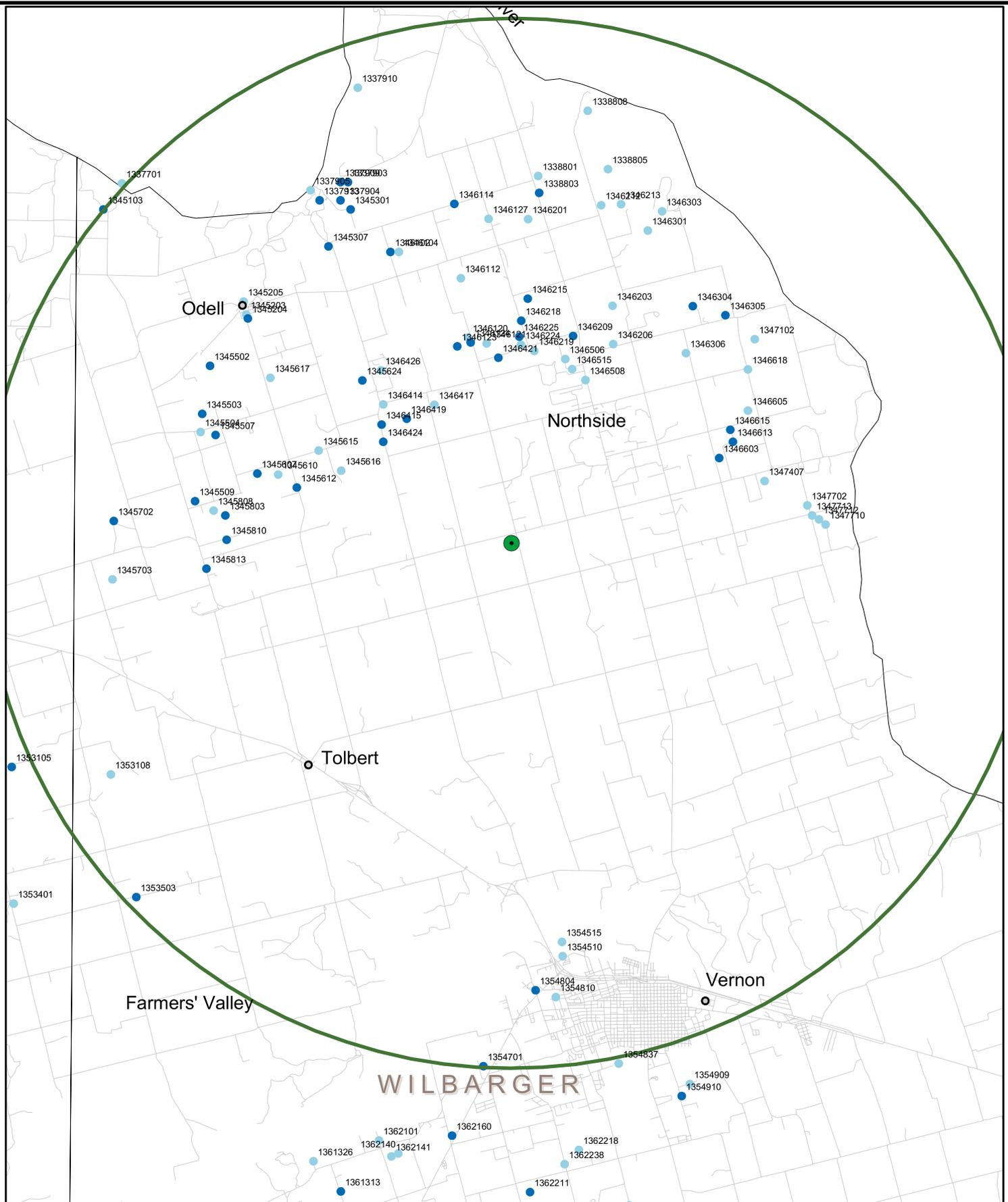
of the Northside WSC that include analyses for nitrate, sulfate, and TDS concentrations. Of these wells, 78 percent are completed in the Seymour while 17 percent are completed in alluvium (also considered part of the Seymour Aquifer system in the GAM) and 5 percent are completed in older Permian formations. Using prioritized screening criteria indicated in Section 4.2.2.1, only 41 percent of all wells provide acceptable quality water. Most of the Seymour aquifer well failures are due to high nitrate-N concentrations while wells completed in other formations generally fail due to elevated sulfate and/or TDS concentrations. However, most (78 percent) of the water quality analyses were performed between 1969 and 1971 and may not reflect current conditions. Wells located in areas to the northeast and west of the Northside WSC (that are dominated by rangeland land use categories as indicated by both National Land Cover Dataset (NLCD) and aerial photograph) displayed generally lower values of nitrate-N and also have acceptable levels of sulfate and TDS. These wells should be resampled and further evaluated as a potential alternative water source for the Northside WSC.

Aquifer	Number of Wells	Passing	Nitrate-N >8 mg/L	Sulfate >300 mg/L or TDS >1000 mg/L
Seymour	163	73	75	15
Alluvium	35	11	3	21
Permian	11	3	7	1
Total	209	87	85	37

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

4.2.3 Potential for New Surface Water Sources

The Texas Commission on Environmental Quality's Red River Water Availability Map indicates that surface water is available from the Red River and from the Pease River over 75 percent of the time. The surface water availability model (WAM) was run for a supply from the Red River and resulted in water available less than 85 percent of the time. The TCEQ requires 100 percent supply availability for a municipal water supply, so the Red River is not a potential surface water source. Even if the water were available 100 percent of the time, the use of the surface water from this river is restricted because of the high total dissolved solids concentrations which exceed the MCL.



- Northside Intake Point (with 10 mile buffer)
- Towns
- Water Wells**
- 0.0 - 5.0 Nitrate-N (mg/L)
- 5.0 - 8.0 Nitrate-N (mg/L)



0 4 8 Miles

Figure 4.2
 Northside
 Non-Public Supply Wells
PARSONS

4.2.4 Options for Detailed Consideration

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

1. City of Vernon (Alternative NS-1)
 - a) Construct pipeline along Highway 283, between the new Vernon WTP and Northside WSC.
 - b) Since the pipe passes through the Hinds-Wildcat (RRA) system, consider sharing the pipeline and the cost with that system.
2. Greenbelt MIWA, through Medicine Mound, and in parallel with Farmers' Valley (Alternative NS-2)
3. Greenbelt MIWA, through Medicine Mound, and Chillicothe (Alternative NS-3)

4.3 TREATMENT OPTIONS

4.3.1 Centralized Treatment Systems

Centralized treatment of the raw water purchased from the City of Vernon is identified as a potential option for Northside WSC. It may be possible to share the cost for a treatment plant, since the Hinds-Wildcat system is relatively close, and has similar water quality problems. Both RO and IX could be potentially applicable, and in fact, the City of Vernon has recently installed an IX treatment plant to treat the same raw groundwater as Northside purchases. The central RO treatment alternative is Alternative NS-6, and the central IX treatment alternative is Alternative NS-7.

4.3.2 Point-of-Entry Treatment Systems

Point-of-entry treatment using RO technology is valid for nitrate removal. The point-of-entry RO treatment alternative is NS-5.

4.3.3 Point-of-Use Treatment Systems

Point-of-use treatment using RO technology is valid for nitrate removal. The point-of-use RO treatment alternative is NS-4.

4.3.4 Bottled water

Northside WSC currently instructs expectant mothers to drink bottled water and to use bottled water for infant children. A modification to this system would be to have Northside WSC pay for the bottled water and to have Northside WSC or contract personnel deliver bottled water. The community is small and people know each other; however, 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, NS-13, and NS-14. It should be noted that provision of bottled water is considered an interim measure to be used until a compliance alternative is implemented.

4.4 ALTERNATIVE DEVELOPMENT AND ANALYSIS

A number of potential alternatives for compliance with the MCL for nitrate have been identified. Each of the potential alternatives is described in the following subsections. It should be noted that the cost information given is the capital cost and change in O&M costs associated with implementing the particular alternative. In some cases, alternative implementation will reduce overall O&M cost. Appendix E contains cost estimates for the compliance alternatives.

4.4.1 Alternative NS-1: Vernon Treated Water

This alternative consists of the purchase of treated water from the City of Vernon in place of the raw water that Northside WSC currently purchases from the City of Vernon. Blending is not an option since the City of Vernon would provide treated water with nitrate concentrations less than the 10 mg/L limit, but not low enough to be feasible for blending with the raw water. For this alternative to be feasible, the City of Vernon water treatment plant must have enough capacity to accommodate the additional water demand.

This alternative would require the construction of a pipeline from the City of Vernon water treatment plant to the existing intake point for the Northside WSC system. A pump station would also be required to overcome pipe friction and the elevation difference between Vernon and Northside WSC. The pipeline would be approximately 10 miles long, and would be a 4 inch PVC line that discharges to the existing storage tank at the Northside WSC intake point. The pipeline would have to cross a river, several smaller streams, a major highway, and several secondary roads. The pump station would include two pumps, including one standby, and would be housed in a building.

This alternative presents some options for a more regional solution. The RRA Hinds-Wildcat system also currently purchases raw water from the City of Vernon, and has similar nitrate problems. The RRA Hinds-Wildcat system has a water demand similar to Northside WSC, and the pipeline to Northside WSC would pass through the Hinds-Wildcat system. As a result, it would appear that the pipeline could serve both systems. The Hinds-Wildcat system is about 2.5 miles north of Vernon, so they would only be expected to share in the cost for about 25 percent of the cost for the 10-mile pipeline. The portion of the line that serves both Hinds-Wildcat and Northside would likely need to be 6 inches instead of 4 inches, which would increase the construction cost for this portion of the line. The Hinds-Wildcat system could be expected to share evenly in the cost for the pump station.

An additional opportunity for regionalization would be to combine the Hinds-Wildcat and Northside WSC. This could reduce the overall cost for management and administration of two systems. This would also increase the overall customer base, strengthening the financial capability.

The estimated capital cost for this alternative includes cost to construct the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for treated water minus the cost Northside WSC currently pays for raw water, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. This analysis does not consider the potential economic benefits of regionalization. The estimated capital cost for this alternative is \$432,000, and the estimated annual O&M cost for this alternative is \$26,000.

Reliability of supply of adequate amounts of compliant water under this alternative should be good. Vernon has a well field with a number of wells and water treatment is performed on a relatively large scale, facilitating the provision of adequate O&M resources. From Northside WSC's perspective this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and Northside WSC currently operates pipelines and a pump station.

The feasibility of this alternative is dependant on the capability and willingness of the City of Vernon to sell treated drinking water, and to a lesser extent the willingness of the Hinds-Wildcat system to share in the cost of the pump station and pipeline.

4.4.2 Alternative NS-2: Farmers' Valley Blended Water

This alternative consists of the purchase of blended water from the RRA Farmers' Valley system in place of the raw water that Northside WSC currently purchases from the City of Vernon. Farmers' Valley blends well water with surface water from Greenbelt MIWA to obtain water that is compliant for nitrate. Blending is not an option in this case for Northside WSC since the Farmers' Valley water is already blended and would not have nitrate concentrations low enough to make blending feasible.

This alternative would require the construction of a pipeline from the Farmers' Valley system to the existing intake point for the Northside WSC system. A pump station would also be required to overcome pipe friction and elevation differences between Farmers' Valley and Northside. The pipeline would be approximately 12 miles long, and would be a 4-inch PVC line that discharges to the existing storage tank at the Northside WSC intake point. The pipeline would have to cross a highway and railroad, several streams, and several secondary roads. The pump station would include two pumps, including one standby, and would be housed in a building.

This alternative presents limited options for a regional solution, since the Farmers' Valley system already produces compliant water. Some regionalization could be accomplished by combining Farmers' Valley and Northside WSC. This could reduce the overall cost for management and administration of the two systems. This would also increase the overall customer base, strengthening financial capability. A combined system would also result in shared cost for pipelines and other common/shared infrastructure. It should be noted that even without combining the systems, the cost for the infrastructure to deliver water through the Farmers' Valley system would be shared through the rates Northside WSC would pay for obtaining the water.

The estimated capital cost for this alternative includes the cost to construct the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for treated water minus the cost Northside WSC currently pays for raw water, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is \$474,000, and the estimated annual O&M cost for this alternative is \$16,000.

Reliability of supply of adequate amounts of compliant water under this alternative should be good. Farmers' Valley has two wells and Greenbelt MIWA supplies water on a relatively large scale, facilitating adequate O&M resources. From Northside WSC's perspective this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and Northside WSC currently operates pipelines and a pump station.

The feasibility of this alternative is dependant on the capability and willingness of RRA (Farmers' Valley) and Greenbelt MIWA to sell and convey water.

4.4.3 Alternative NS-3: Chillicothe Blended Water

This alternative consists of the purchase of blended water from the City of Chillicothe in place of the raw water that Northside WSC currently purchases from the City of Vernon. The City of Chillicothe blends well water with surface water from Greenbelt MIWA to obtain water that is compliant for nitrate. Blending is not an option in this case for Northside WSC since the Chillicothe water is already blended and would not have nitrate concentrations low enough to make blending feasible. It should be noted that at the date of this report, the City of Chillicothe had not been successful in adjusting the blending process to reliably produce compliant water.

This alternative would require the construction of a pipeline from the City of Chillicothe system to the existing intake point for the Northside WSC system. A pump station would also be required to overcome pipe friction and elevation differences between Chillicothe and Northside WSC. The pipeline would be approximately 11 miles long, and would be a 4-inch PVC line that discharges to the existing storage tank at the Northside WSC intake point. The pipeline would have to cross a number of streams and roads. The pump station would include two pumps, including one standby, and would be housed in a building.

This alternative presents limited options for a regional solution, since the Chillicothe system should produce compliant water. Some regionalization could be accomplished by combining the City of Chillicothe and Northside WSC. This could reduce the overall cost for management and administration of the two systems. This would also increase the overall customer base, strengthening financial capability. A combined system would also result in shared cost for pipelines and other common/shared infrastructure. It should be noted that even without combining the systems, the cost for the infrastructure to deliver water through the City of Chillicothe system would be shared through the rates Northside WSC would pay for obtaining the water.

The estimated capital cost for this alternative includes cost to construct the pipeline and pump station. The estimated O&M cost for this alternative includes the purchase price for treated water minus the cost Northside WSC currently pays for raw water, plus maintenance cost for the pipeline, and power and O&M labor and materials for the pump station. The estimated capital cost for this alternative is \$462,000, and the estimated annual O&M cost for this alternative is \$16,000.

Reliability of supply of adequate amounts of compliant water under this alternative should be good, provided the City of Chillicothe resolves the blending problems. The City of Chillicothe has four wells and Greenbelt MIWA supplies water on a relatively large scale, facilitating adequate O&M resources. From Northside WSC's perspective this alternative would be characterized as easy to operate and repair, since O&M and repair of pipelines and pump stations is well understood, and Northside WSC currently operates pipelines and a pump station.

The feasibility of this alternative is dependant on the capability and willingness of City of Chillicothe and Greenbelt MIWA to sell water.

4.4.4 Alternative NS-4: Point-of-Use Treatment

This alternative consists of the continued purchase of raw water from the City of Vernon, and treatment of water to be used for drinking or food preparation at the point of use to remove nitrate. The purchase, installation, and maintenance of point-of-use 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 the installation of the point-of-use treatment units in houses and other buildings that provide drinking or cooking water. The Northside WSC 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 Northside WSC or contract personnel into the houses of customers. As a result, the cooperation of customers will be important for success in implementation of this alternative. The treatment units could be installed so that they could be accessed without house entry, but that would complicate the installation and increase costs.

Point-of-use nitrate treatment processes typically produce liquid waste streams that are equal in volume to the treated water and require disposal. These waste streams result in an increased overall volume of water used. Point-of-use systems have the advantage that a minimum volume of water (only that for human consumption) is treated. This minimizes the size of the treatment units, the increase in water required, and the waste for disposal. For this alternative, it is assumed that the increase in water consumption is insignificant in terms of supply cost, and that the waste stream can be recovered for reuse or discharged to the house septic system.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes cost to purchase and install the point-of-use 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 \$77,000, and the estimated annual O&M cost for this alternative is \$28,000. For the cost estimate, it is assumed that one point-of-use treatment unit will be required for each of the 66 existing connections to the Northside WSC.

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

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

4.4.5 Alternative NS-5: Point-of-Entry Treatment

This alternative consists of the continued purchase of raw water from the City of Vernon, and treatment of water as it enters residences to remove nitrate. 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 point-of-entry treatment units at houses and other buildings that provide drinking or cooking water. The Northside WSC would be responsible for purchase and maintenance of the treatment units, including membrane and filter replacement, periodic sampling, and necessary repairs. The plumbing in homes should be investigated to ensure that the aggressive water that will result from RO treatment will not cause damage. It may also be desirable to modify piping so that water for non-consumptive uses can be withdrawn upstream of the treatment unit. The point-of-entry treatment units will be installed outside of the houses, so that entry will not be necessary for O&M. Some cooperation from customers will be necessary for installation and maintenance of the treatment systems.

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

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes cost to purchase and install the point-of-entry 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 \$1.2 million, and the estimated annual O&M cost for this alternative is \$49,000. For the cost estimate, it is assumed that one point-of-entry treatment unit will be required for each of the 66 existing connections to the Northside WSC.

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

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

4.4.6 Alternative NS-6: Central RO Treatment

Northside WSC would continue to purchase raw water from the City of Vernon, and would treat the water through a reverse osmosis system prior to distribution. For this option, a fraction of the raw water will be treated and then combined with the untreated stream to obtain overall compliant water. The RO process concentrates impurities in the reject stream. This stream must be disposed. As a result, 11 percent more raw water will be required to produce the same amount of finished water.

This alternative consists of constructing the RO treatment plant at or near the intake point to the Northside system. The plant comprises a 400 square foot building with a paved driveway, the pre-constructed RO plant on a skid, two transfer pumps, a 20,000-gallon tank for storing the treated water, and a 260,000-gallon pond for storing reject water. The treated water would be chlorinated and stored in the new treated-water tank prior to being pumped into the distribution system. The existing above-grade storage tank would continue to be used to accumulate feed water. The entire facility is fenced. The capital cost includes purchase of a water truck-trailer to periodically haul reject water to an offsite disposal point 10 miles from the plant site.

The estimated capital cost for this alternative is \$450,000, and the estimated annual O&M cost is \$62,000.

Reliability of supply of adequate amounts of compliant water under this alternative is good, since RO treatment is a common and well-understood treatment technology. However, the O&M efforts required for the central RO treatment plant may be significant, and Northside WSC personnel are inexperienced with RO. The feasibility of this alternative is not dependant on the cooperation, willingness, or capability of other water supply entities.

Regionalization possibilities associated with this option include constructing a common treatment plant that could also serve the Hinds-Wildcat system.

4.4.7 Alternative NS-7: Central Ion Exchange Treatment

Northside WSC would continue to purchase raw water from the City of Vernon, and would treat the water through an IX system prior to distribution. Water would be blended, in a manner similar to that of RO, as a means of extending the time between regenerations of the IX resin beds. Water in excess of that currently purchased (400,000 gallons per year [gpy]) will be required for backwashing the resin beds.

The IX treatment plant, located at or near the intake point to the Northside system, features a 400 square foot building with a paved driveway, the pre-constructed IX plant on a skid, two transfer pumps, a 20,000-gallon tank for storing the treated water, a 10,000-gallon tank for storing spent backwash water, and a 10,000-gallon tank for storing regenerant. The regenerant tank would be fitted with a dry-salt feeder and a mixer to allow the addition and dissolution of dry sodium chloride regenerant. The treated water would be chlorinated and stored in the new treated water tank prior to being pumped into the distribution system. The existing above-grade storage tank would continue to be used to accumulate feed water. The entire facility is fenced.

The City of Vernon has recently constructed an IX treatment plant to treat the same raw water as that which Northside WSC receives; however, pilot testing should be conducted to ensure the raw water can be reliably treated.

The estimated capital cost for this alternative is \$370,000, and the estimated annual O&M cost is \$65,000. The difference in capital cost between this alternative and the RO alternative is primarily due to the purchase of a water truck for hauling wastewater under the RO alternative. The purchase of a truck under the Central IX alternative was not considered necessary because the volume of wastewater to be hauled appears to be more economically handled by periodic truck rental. The estimates assume that spent regenerant could be disposed in the Truscott Brine Reservoir. Backwash water would be hauled to either the same reservoir or to a local treatment plant.

Reliability of supply of adequate amounts of compliant water under this alternative is good, since IX treatment is a common and well-understood treatment technology. IX treatment does not require high pressures, but can be affected by interfering constituents in the water. The O&M efforts required for the central IX treatment plant may be significant, and Northside WSC personnel are inexperienced in this type of work. The feasibility of this alternative is not dependent on the cooperation, willingness, or capability of other water supply entities.

Regionalization possibilities associated with this option include constructing a common treatment plant that could also serve the Hinds-Wildcat system.

4.4.8 Alternative NS-8: New Well at 10 miles

This alternative consists of the installation of a new well within 10 miles of the Northside WSC that would produce compliant water in place of purchasing raw water from the City of Vernon. Blending is not considered to be an option since the new well is expected to be installed in the Seymour aquifer, which is characterized by relatively high nitrate concentrations, and would not be feasible for blending with the raw water currently purchased from the City of Vernon. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed. In order to address a range of solutions, three different well alternatives are developed, assuming the new well is located within 10 miles, 5 miles, and 1 mile from the existing intake point.

This alternative would require the construction of a new 60-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the Northside WSC system. The pump station and storage tank would be necessary to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 10 miles long, and would be a 4-inch PVC line that discharges to the existing storage tank at the Northside WSC intake point. The pump station would include two pumps, including one standby, and would be housed in a building.

Depending on well location and capacity, this alternative could present some options for a more regional solution. It may be possible to share water and costs with another nearby system such as RRA Hinds-Wildcat, which has similar nitrate problems.

The estimated capital cost for this alternative includes cost to install the well, and construct the pipeline and pump station. The estimated O&M cost for this alternative includes the cost for O&M for the new well, pipeline, and pump station, minus the amount Northside pays the City of Vernon for raw water. The estimated capital cost for this alternative is \$509,000, and the estimated annual impact on O&M cost for this alternative is a reduction of \$11,000.

Reliability of supply of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From Northside WSC's perspective, this alternative would be more difficult to operate than their current system since a water well would be added. Northside WSC has experience with O&M and repair of pipelines and pump stations, but does not have previous experience with water wells.

The feasibility of this alternative is dependant on the ability to find an adequate existing well or success in installing a well that produces an adequate supply of compliant water. It is likely that the alternate groundwater source will not be found on Northside WSC controlled land, so landowner cooperation will be required.

4.4.9 Alternative NS-9: New Well at 5 miles

This alternative consists of the installation of a new well within 5 miles of the Northside WSC that would produce compliant water in place of purchasing raw water from the City of Vernon. Blending is not considered to be an option since the new well is expected to be installed in the Seymour aquifer, which is characterized by relatively high nitrate concentrations, and would not be feasible for blending with the raw water currently purchased from the City of Vernon. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed.

This alternative would require the construction of a new 60-foot well, a new pump station with storage tank near the new well, and a pipeline from the new well/tank to the existing intake point for the Northside WSC system. The pump station would be necessary to overcome pipe friction and changes in land elevation. The storage tank at the pump station is mainly to equalize pumping rates, and has a capacity of 20,000 gallons. For this alternative, the pipeline is assumed to be approximately 5 miles long, and would be a 4-inch PVC line that discharges to the existing storage tank at the Northside WSC intake point. The pump station would include two pumps, including one standby, and would be housed in a building.

Depending on well location and capacity, this alternative could present some options for a more regional solution. It may be possible to share water and costs with another nearby system such as RRA Hinds-Wildcat, which has similar nitrate problems.

The estimated capital cost for this alternative includes cost to install the well, and construct the pipeline and pump station. The estimated O&M cost for this alternative includes the cost for O&M for the new well, pipeline, and pump station, minus the amount Northside pays the City of Vernon for raw water. The estimated capital cost for this alternative is \$346,000, and the estimated annual impact on O&M cost for this alternative is a reduction of \$13,000.

Reliability of supply of adequate amounts of compliant water under this alternative should be good, since water wells, pump stations and pipelines are commonly employed. From Northside WSC's perspective, this alternative would be more difficult to operate than their current system since a water well would be added. Northside WSC has experience with O&M and repair of pipelines and pump stations, but does not have previous experience with water wells.

The feasibility of this alternative is dependant on the ability to find an adequate existing well or success in installing a well that produces an adequate supply of compliant water. It is likely that the alternate groundwater source will not be found on Northside WSC controlled land, so landowner cooperation will be required.

4.4.10 Alternative NS-10: New Well at 1 mile

This alternative consists of the installation of a new well within 1 mile of the Northside WSC that would produce compliant water in place of purchasing raw water from the City of Vernon. Blending is not considered to be an option since the new well is expected to be

installed in the Seymour aquifer, which is characterized by relatively high nitrate concentrations, and would not be feasible for blending with the raw water currently purchased from the City of Vernon. At this level of study, it is not possible to positively identify an existing well or the location where a new well could be installed.

This alternative would require the construction of a new 60- foot well and a pipeline from the new well to the existing intake point for the Northside WSC system. The well pump would be used to overcome pipe friction and changes in land elevation. For this alternative, the pipeline is assumed to be approximately 1 mile long, and would be a 4-inch PVC line that discharges to the existing storage tank at the Northside WSC intake point.

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 such as RRA Hinds-Wildcat, which has similar nitrate problems.

The estimated capital cost for this alternative includes cost to install the well and construct the pipeline. The estimated O&M cost for this alternative includes the cost for O&M for the new well and pipeline, minus the amount Northside pays the City of Vernon for raw water. The estimated capital cost for this alternative is \$114,000, and the estimated annual impact on O&M cost for this alternative is a reduction of \$24,000.

Reliability of supply of adequate amounts of compliant water under this alternative should be good, since water wells and pipelines are commonly employed. From Northside WSC's perspective, this alternative would be more difficult to operate than their current system since a water well would be added. Northside WSC has experience with O&M and repair of pipelines, but does not have previous experience with water wells.

The feasibility of this alternative is dependant on the ability to find an adequate existing well or success in installing a well that produces an adequate supply of compliant water. It is likely that the alternate groundwater source will not be found on Northside WSC controlled land, so landowner cooperation will be required.

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

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

The Northside WSC would be responsible for maintenance of the treatment unit, including membrane and filter replacement, periodic sampling, and necessary repairs. A method for disposal of the reject waste stream produced by the treatment system will have to

be found. This alternative relies on a great deal of cooperation and action from the customers in order to be effective.

This alternative does not present options for a regional solution.

The estimated capital cost for this alternative includes cost to purchase and install the treatment system to be used for the drinking water dispenser. The estimated O&M cost for this alternative includes the purchase and replacement of filters and membranes, as well as periodic sampling and record keeping. The estimated capital cost for this alternative is \$22,000, and the estimated annual O&M cost for this alternative is \$7,000.

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

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

4.4.12 Alternative NS-12: 100 Percent Bottled Water Delivery

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

This alternative does not involve capital cost for construction, but would require some initial costs for system setup, and then ongoing costs to have the bottled water furnished. It is assumed for this alternative that bottled water is provided to 100 percent of the Northside WSC 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 \$4,000, and the estimated annual O&M cost for this alternative is \$330,000. For the cost estimate, it is assumed that each person requires 2.5 gallons of bottled water per day.

Reliability of supply of adequate amounts of compliant water under this alternative is fair, since it relies on the active cooperation of customers to order and utilize the water.

Management and administration of the bottled water delivery program will require attention from Northside WSC.

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

4.4.13 Alternative NS-13: 25 Percent Bottled Water Delivery

For this alternative, raw water will continue to be purchased from the City of Vernon, but compliant drinking water will be delivered to customers in containers. This alternative consists of setting up and operating a bottled water delivery program to serve only the susceptible population in the system. For this alternative, it is assumed that serving the susceptible population will result in the provision of bottled drinking water to 25 percent of the served population. It is expected that Northside WSC will find it most convenient and economical to contract a bottled water service. The bottle delivery program will have to be flexible enough to allow the delivery of smaller containers should customers be incapable of lifting and manipulating 5-gallon bottles. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

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

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 \$4,000, and the estimated annual O&M cost for this alternative is \$86,000. For the cost estimate, it is assumed that each person requires 2.5 gallons of bottled water per day.

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

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

4.4.14 Alternative NS-14: Public Dispenser for Trucked Drinking Water

This alternative consists of the continued purchase of raw water from the City of Vernon, and dispensing compliant water for drinking and cooking at a publicly accessible location. The compliant water would be purchased from the City of Vernon, and delivered by truck to a tank at a central location where customers would be able to come and fill their own containers. This alternative also includes notifying the customers of the importance of obtaining drinking water from the dispenser. In this way, only a relatively small volume of

water requires treatment, but customers are required to pickup and deliver their own water. Blending is not an option in this case. It should be noted that this alternative would be considered an interim measure until a compliance alternative is implemented.

The Northside WSC would purchase a truck suitable for hauling potable water, and install a storage tank. It is assumed that 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 in order to be effective.

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

The estimated capital cost for this alternative includes cost to purchase a water truck and to construct 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 was \$103,000, and the estimated annual O&M cost for this alternative was \$8,000.

Reliability of supply of adequate amounts of compliant water under this alternative is fair, because of the large amount of effort required from the customers and the associated inconvenience. Northside WSC has not provided this type of service in the past. From Northside WSC's perspective this alternative would be characterized as relatively easy to operate, but the water hauling and storage will have to be done with care to ensure sanitary conditions.

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

4.4.15 Summary of Alternatives

Table 4.1 provides a summary of the key features of each alternative for Northside WSC.

Table 4.1 Summary of Compliance Alternatives for Northside WSC

Alt. No.	Alternative Description	Major Components	Capital Cost ¹	Annual O&M Cost ¹	Annualized Cost ²	Reliability	System Impact	Remarks
NS-1	Purchase treated Vernon water instead of raw water	- Pump station - 10-mile pipeline	\$432,000	\$30,000	\$75,000	Good	N	City of Vernon must be willing to sell treated water. May be able to share cost with Hinds-Wildcat.
NS-2	Purchase blended water from Farmers Valley WSC	- Pump station - 12-mile pipeline	\$474,000	\$20,000	\$69,000	Good	N	Farmers' Valley and Greenbelt MIWA must be willing to sell water. Possibility to join with Farmers' Valley.
NS-3	Purchase blended water from C. of Chillicothe	- Pump station - 11-mile pipeline	\$462,000	\$20,000	\$68,000	Good	N	Chillicothe and Greenbelt MIWA must be willing to sell water. Possibility to join with Chillicothe.
NS-4	Continue raw water purchase from Vernon, and point-of-use treatment	- Point-of-use treatment units.	\$77,000	\$28,000	\$36,000	Fair	T, M	Only one compliant tap in house. Cooperation required for installation, maintenance, and testing.
NS-5	Continue raw water purchase from Vernon, and point-of-entry treatment	- Point-of-entry treatment units.	\$1.2 million	\$49,000	\$173,000	Good	T, M	All home taps compliant and less customer cooperation required.
NS-6	Continue raw water purchase from Vernon with central RO treatment	- Central RO treatment plant	\$450,000	\$61,000	\$107,000	Good	T	May be able to share cost of treatment plant with Hinds-Wildcat.
NS-7	Continue raw water purchase from Vernon with central IX treatment	- Central IX treatment plant	\$370,000	\$62,000	\$100,000	Good	T	May be able to share cost of treatment plant with Hinds-Wildcat.
NS-8	Install new compliant well within 10 miles	- New well, storage tank, pump station and 10-mile pipeline	\$509,000	(\$7,000)	\$45,000	Good	T	May be difficult to find well with good water quality. Northside does not currently operate a well.
NS-9	Install new compliant well within 5 miles	- New well, storage tank, pump station and 5-mile pipeline	\$346,000	(\$9,000)	\$27,000	Good	T	May be difficult to find well with good water quality. Northside does not currently operate a well.
NS-10	Install new compliant well within 1 mile	- New well and 1-mile pipeline	\$114,000	(\$20,000)	(\$8,000)	Good	T	May be difficult to find well with good water quality. Northside does not currently operate a well.
NS-11	Continue raw water purchase from Vernon, but furnish public dispenser for treated drinking water	- Water treatment and dispenser unit	\$22,000	\$7,000	\$9,000	Fair/interim measure	T	Does not provide compliant water to all taps, and requires a lot of effort by customers.
NS-12	Continue raw water purchase from Vernon, but furnish bottled drinking water for all customers	- Set up bottled water system	\$4,000	\$334,000	\$334,000	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 raw water purchase from Vernon, but furnish bottled drinking water for susceptible population	- Set up bottled water system	\$4,000	\$86,000	\$87,000	Fair/interim measure	M	Does not provide compliant water to all taps, and requires customers to order and use. Management of program and identification of susceptible population may be significant.
NS-14	Continue raw water purchase from Vernon, but furnish public dispenser for trucked drinking water	- New storage tank, dispenser and potable water truck	\$103,000	\$8,000	\$19,000	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 E
2 – 15-year return period and 6 percent interest

4.5 COST OF SERVICE AND FUNDING ANALYSIS

To evaluate the financial impact of implementing the compliance alternatives for Northside WSC, a 30-year financial planning model was developed. This model can be found in Appendix F. The financial model is based on estimated cash flows for the Northside PWS, with and without implementation of the compliance alternatives. Generally, data for such models are derived from established budgets, audited financial reports, and published water tariffs, and consumption data. However, Northside WSC operates on a strictly cash flow basis. The only financial data compiled by Northside WSC is a check register that records deposits and withdrawals from the Northside WSC bank account.

4.5.1 Financial Plan Development

4.5.1.1 Northside WSC Financial Data

Since Northside WSC does not produce any of the standard accounting documents, the bank register for January 2003 through June 2004 was analyzed to develop a summary of cash receipts, primarily from customer payment of water bills, and of cash expenditures for operating and maintaining the system. Expenditures were summarized by category, including:

- Water purchases
- Utilities
- Chemicals
- Repairs
- Office Supplies
- Salaries
- Insurance

Expenditures were summarized for the 18-month period, and monthly averages calculated. These monthly averages became the input to the financial planning model as the estimate for annual expenditures. Customer receipts were also summarized and an annual amount was estimated based on the average for the period.

4.5.1.2 Current Financial Condition

4.5.1.2.1 Cash Flow Needs

Northside WSC currently charges all customer classes a base rate of \$14.00 a month, which includes the first 3,000 gallons of water usage per month. All water consumption over 3,000 gallons is billed at \$2.40 per thousand gallons. The 62 residential customers use on average just over 12,000 gallons per month. Based on these rates and consumption levels, the current average annual water bill for Northside WSC customers is estimated at \$437.00, or about 1.5 percent of the median annual household income of

\$29,500 for Wilbarger County. The 12 commercial customers have an average consumption of about 17,400 gallons per month.

The long-term financial plan analysis indicates that Northside WSC will need to increase rates over the next few years in order to maintain financial viability, without consideration for any of the possible solutions for the nitrate issue. Current revenues average about \$31,200 per year, while expenditures average about \$38,700. Northside has sufficient cash in the bank to absorb the expenses for a year to 2 years, under current conditions. Based on current revenue and expenditure patterns, it appears that Northside WSC will need to raise water rates by about 19 percent over the next 2 years to meet current cash flow needs and to maintain prudent reserve levels. This would increase the annual water bill for residential customers to \$508, or 1.7 percent of annual income.

4.5.1.2.2 Ratio Analysis

Current Ratio = Not Available

Since Northside WSC produces no financial reports, the data necessary to calculate the current ratio are not available. However, with over \$11,000 in its checking account as of June 30, 2004 with no short term liabilities other than a month's payments for water purchases and power, it is estimated that Northside WSC would have quite a high Current Ratio, indicating that Northside WSC would have no problem meeting its short term obligations.

Debt to Net Worth Ratio = Not Available

Again without a financial report, there are no data to calculate this ratio. While Northside WSC's net worth cannot be determined, it has no long term debt. Consequently, the ratio would equal zero, which is a strong financial indicator. While net worth cannot be determined, it is likely a positive number.

Operating Ratio = 0.79

Based on data from Northside WSC's check register, estimates for annual operating expenses and operating revenues can be made. Operating revenues average about \$2,450 per month while operating expenses average about \$3,100 per month, for an operating ratio estimated to be 0.79, indicating that Northside WSC is not currently collecting enough to remain viable over the long term.

4.5.1.3 Financial Plan Results

Each of the compliance alternatives for Northside WSC was evaluated, with emphasis on the impact on affordability (expressed as a percentage of household income), and 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.

For SRF funding options, customer MHI compared to the state average determines the availability of subsidized loans. Since the MHI for the customers of Northside WSC was not available, county-wide data were used. Wilbarger County, in which Northside WSC is located, has a household income of \$29,500 according to the 2000 U.S. Census compared to a statewide average of \$39,927. Northside WSC would qualify for an interest rate of 1 percent since incomes are at 73.9 percent of the state average. Repayment over 20 years is standard for Drinking Water State Revolving Fund (SRF) loans.

The financial plan results are summarized in Table 4.2, and Figure 4.3. The bar chart in Figure 4.3 provides yearly billing to an average customer (12,054 gallons per month consumption), illustrating the following:

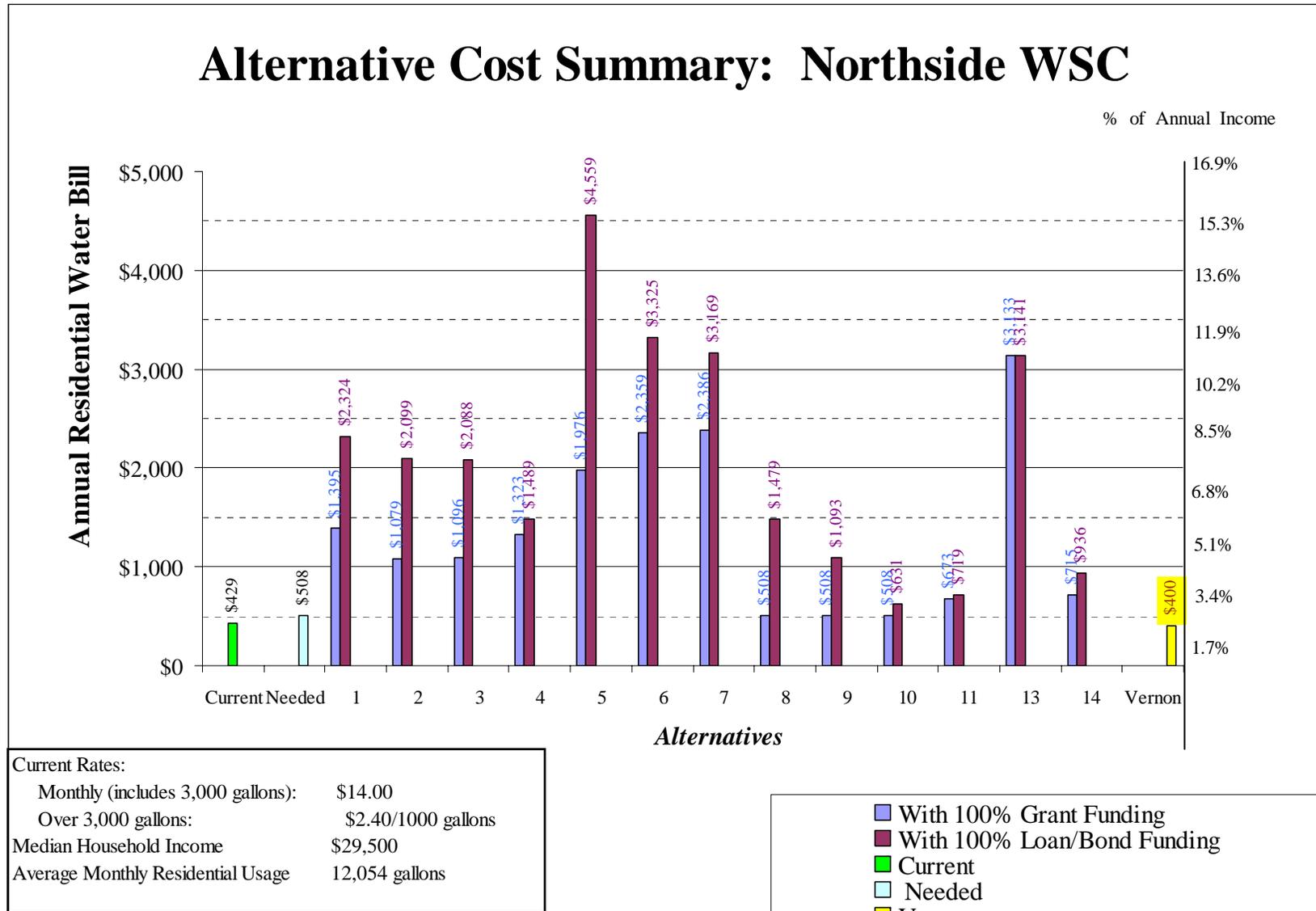
- Current yearly billing,
- Projected yearly billing including a rate increase necessary to maintain financial viability without implementation of compliance alternatives, and
- Projected yearly billing including rate increases to maintain financial viability and also for implementing the various compliance alternatives.

The two bars shown for each compliance alternative represent the maximum rate increases necessary assuming 100 percent grant funding and 100 percent loan/bond funding. Most funding options will fall between 100 percent grant and 100 percent loan/bond funding, with the exception of 100 percent revenue financing. If existing reserves are insufficient to fund a compliance alternative, rates would have to be raised ahead of implementation of the compliance alternative to allow the accumulation of sufficient reserves, in order to avoid larger but temporary rate increases during the years the compliance alternative is implemented.

Table 4.2 Financial Impact on Households for Northside WSC

	Funding Source #	0	1	2	3	4	5
ALTERNATIVES		All Revenue	100% Grant	75% Grant	50% Grant	SRF	Loan/Bond
Vernon	Maximum % of HH Income	23.6%	4.7%	5.5%	6.3%	7.0%	7.9%
	Maximum Rate %	1522.6%	225.4%	279.5%	333.7%	378.8%	442.0%
	Year Needed	2005	2005	2005	2005	2005	2005
Farmers Valley	Maximum % of HH Income	25.0%	3.7%	4.5%	5.4%	6.1%	7.1%
	Maximum Rate %	1618.2%	151.6%	211.0%	270.5%	320.1%	389.5%
	Year Needed	2005	2005	2005	2005	2005	2005
Chillicothe	Maximum % of HH Income	24.4%	3.7%	4.6%	5.4%	6.1%	7.1%
	Maximum Rate %	1579.0%	155.6%	213.5%	271.4%	319.6%	387.1%
	Year Needed	2005	2005	2005	2005	2005	2005
POU-RO	Maximum % of HH Income	6.9%	4.5%	4.6%	4.8%	4.9%	5.0%
	Maximum Rate %	376.5%	208.6%	218.3%	228.0%	236.0%	247.3%
	Year Needed	2005	2005	2005	2005	2005	2005
POE-RO	Maximum % of HH Income	60.5%	6.7%	8.9%	11.1%	12.9%	15.5%
	Maximum Rate %	4063.8%	360.9%	511.5%	662.1%	787.6%	963.3%
	Year Needed	2005	2005	2005	2005	2005	2005
Central RO	Maximum % of HH Income	26.2%	8.0%	8.8%	9.6%	10.3%	11.3%
	Maximum Rate %	1702.5%	450.3%	506.6%	562.9%	609.8%	675.4%
	Year Needed	2005	2005	2005	2005	2005	2005
Central IX	Maximum % of HH Income	22.3%	8.1%	8.8%	9.4%	10.0%	10.7%
	Maximum Rate %	1435.1%	456.4%	502.1%	547.8%	585.9%	639.2%
	Year Needed	2005	2005	2005	2005	2005	2005
New well 10 mi	Maximum % of HH Income	25.4%	1.7%	2.2%	3.2%	3.9%	5.0%
	Maximum Rate %	1650.3%	18.6%	53.6%	117.4%	170.6%	245.1%
	Year Needed	2005	2005	2005	2005	2005	2005
New well 5 mi	Maximum % of HH Income	17.8%	1.7%	2.0%	2.4%	3.0%	3.7%
	Maximum Rate %	1127.7%	18.6%	40.2%	68.1%	104.3%	154.9%
	Year Needed	2005	2005	2005	2005	2005	2005
New well 1 mi	Maximum % of HH Income	7.0%	1.7%	1.8%	1.9%	2.0%	2.1%
	Maximum Rate %	383.2%	18.6%	25.7%	32.8%	38.8%	47.1%
	Year Needed	2005	2005	2005	2005	2005	2005
Dispenser	Maximum % of HH Income	3.1%	2.3%	2.3%	2.4%	2.4%	2.4%
	Maximum Rate %	114.4%	56.9%	59.6%	62.3%	64.6%	67.8%
	Year Needed	2005	2005	2005	2005	2005	2005
100% Bottled	Maximum % of HH Income	36.5%	36.5%	36.6%	36.6%	36.6%	36.6%
	Maximum Rate %	2414.4%	2414.4%	2414.9%	2415.3%	2415.7%	2416.2%
	Year Needed	2005	2005	2005	2005	2005	2005
25% Bottled	Maximum % of HH Income	10.6%	10.6%	10.6%	10.6%	10.6%	10.6%
	Maximum Rate %	630.7%	630.7%	631.1%	631.6%	631.9%	632.5%
	Year Needed	2005	2005	2005	2005	2005	2005
Central Trucked	Maximum % of HH Income	7.0%	2.4%	2.6%	2.8%	3.0%	3.2%
	Maximum Rate %	380.2%	66.7%	79.6%	92.5%	103.3%	118.4%
	Year Needed	2005	2005	2005	2005	2005	2005

Figure 4.3 Alternative cost Summary: Northside WSC



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**APPENDIX A
PWS INTERVIEW FORMS**

APPENDIX B COST BASIS

This section presents the basis for the unit costs used to develop the conceptual cost estimates for the compliance alternatives. The cost estimates are conceptual in nature, and are intended for making comparisons between compliance options. It is assumed that adequate electrical power is available near the site. The cost estimates specifically do not include the following:

- Costs for obtaining land or easements.
- Costs for surveying.
- Mobilization/demobilization for construction.
- Insurance and bonds

In general, unit costs were based on recent construction bids for similar work in North Central Texas when possible, consultations with vendors or other suppliers, published construction and O&M cost data, and EPA cost guidance. The unit costs used for the cost estimates are summarized in Table B.1.

The unit costs for the pipeline components are based on a construction bid tabulation for a water pipeline project for Baylor WSC. The amounts of boring and encasement and open cut and encasement were estimated by counting the road, highway, railroad, stream, and river crossings for a conceptual routing for the pipeline. The number of air release valves was estimated by examining the land surface profile along the conceptual pipeline route. It was assumed that gate valves and flush valves would be installed on average every 5000 feet along the pipeline.

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

Northside WSC purchases raw groundwater from the City of Vernon for \$1.29 per 1000 gallons. It was assumed that purchase of treated drinking water from the City of Vernon would cost \$2.25 per 1000 gallons, based on discussion with Utility Director Bob Cochran.

Electrical power cost was estimated to be \$0.08 per kilowatt-hour. The estimate was based on consultation with Southwest Rural Electric. Annual cost for pump station power is calculated based on the pumping head and volume, and includes 36,500 kilowatt-hours 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 keeping the pumps operating and for minor repairs; maintenance vehicle purchase, 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 were estimated based on the USEPA publication, *Standardized Costs for Water Supply Distribution Systems* (1992), which provides cost curves for O&M components. The costs from the 1992 report were adjusted to 2004 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 was calculated based on the USEPA technical report, *Innovative and Alternate Technology Assessment Manual MCD 53* (1978). The costs from the 1978 report were adjusted to 2004 dollars based on the ENR construction cost index.

Storage tank maintenance cost includes cleaning and renewal of interior lining and exterior coating. Unit cost for storage tank O&M were based on USEPA publication *Standardized Costs for Water Supply Distribution Systems* (1992). The costs from the 1992 report were adjusted to 2004 dollars based on the ENR construction cost index.

Purchase price for point-of-use water treatment units was based on vendor price lists for RO units, plus installation. Point-of-use treatment unit O&M costs were based on vendor price lists for replacement filters and RO membranes. It was assumed that the filters and membranes would be replaced once per year. It was also assumed that a water sample would be analyzed for nitrate-N on a yearly basis.

Purchase price for point-of-entry water treatment units was based on vendor price lists for RO units, plus an allowance for installation including a concrete pad and shed, piping modifications, and electrical connection. Point-of-entry treatment unit O&M costs were based on vendor price lists for replacement filters and RO membranes. It was assumed that the filters and membranes would be replaced once per year. It was also assumed that a water sample would be analyzed for nitrate-N on a yearly basis.

Central treatment plant costs, for both RO and IX, included pricing for buildings, utilities, and sitework. The prices are based on pricing given in the various R.S. Means Construction Cost Data References, as well as on prices obtained on similar work on other projects. Treatment equipment pricing was obtained from two vendors – GE Water and Process Technologies and Ionics Ahlfinger Water Company. For the Northside WSC, the operating cost includes additional water purchase to make up for RO membrane reject water and for IX backwash water.

Well installation costs were based on bid tabs for installation of similar depth wells in the area. Well installation cost includes 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 was assumed that the new wells located more than a mile from the existing system intake point would require a storage tank and pump station.

Purchase price for the RO treatment unit for the dispenser was based on vendor price lists for RO units, plus an allowance for installation at a central public location. The O&M costs were based on vendor price lists for replacement filters and RO membranes. It was assumed that the filters and membranes would be replaced once per year. It was also assumed that weekly water samples would be analyzed for nitrate-N.

The costs for the bottled water delivery alternatives were based on consultation with vendors that provide residential bottled water delivery. 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 the construction of a storage tank. Annual costs include labor for purchase of water, picking up and delivering the water, truck maintenance, and water sampling and testing. It was assumed that one trip with the water truck would be required each week, and the chlorine residual would be determined with each truck load.

APPENDIX C NITRATE FIELD INVESTIGATION RESULTS

Figure C-1. Soil water content, chloride, and nitrate-N concentration profiles for boreholes in native vegetation areas.

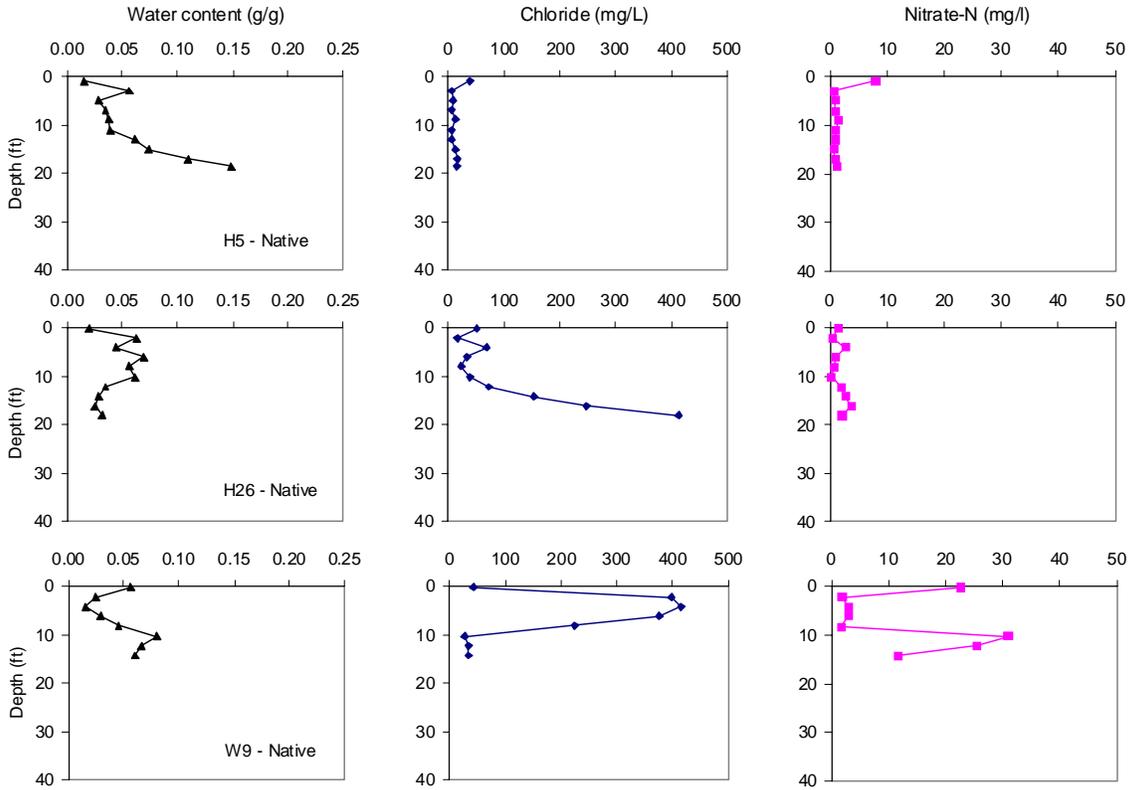


Figure C-2 Soil water content, chloride, and nitrate-N concentration profiles for boreholes in Conservation Reserve Program (CRP) areas.

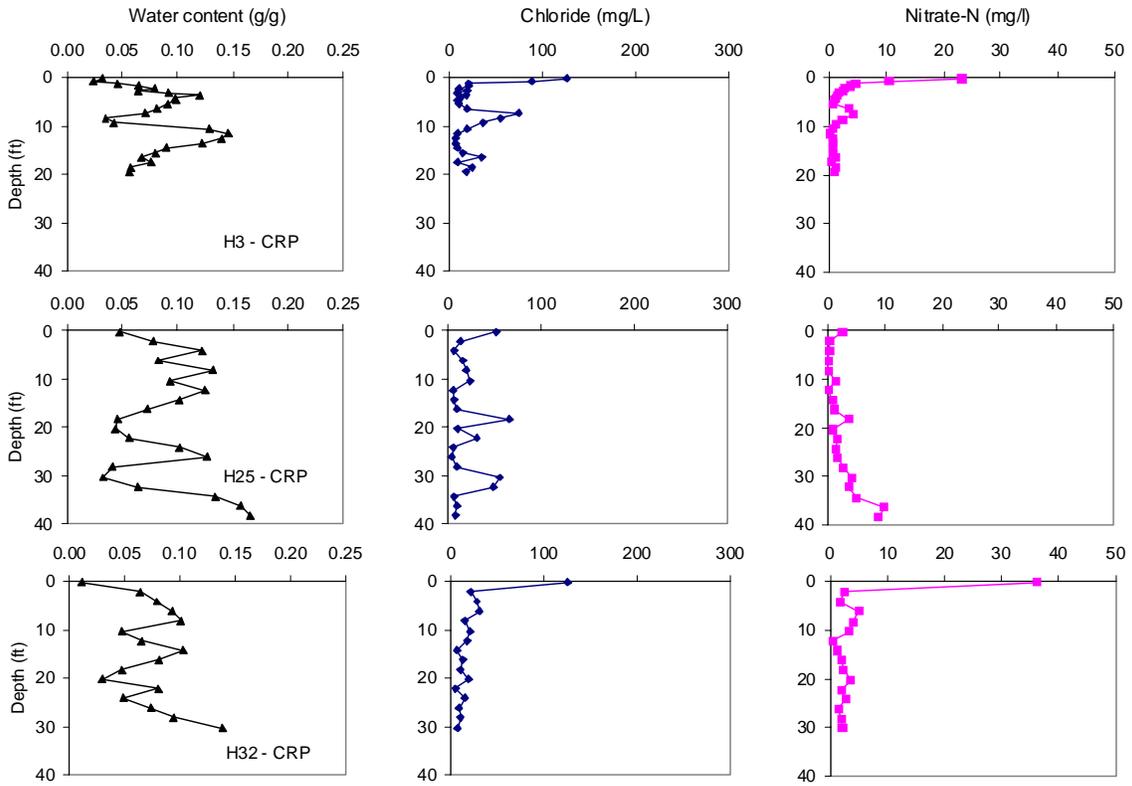


Figure C-3 Soil water content, chloride, and nitrate-N concentration profiles for boreholes in dryland agricultural areas.

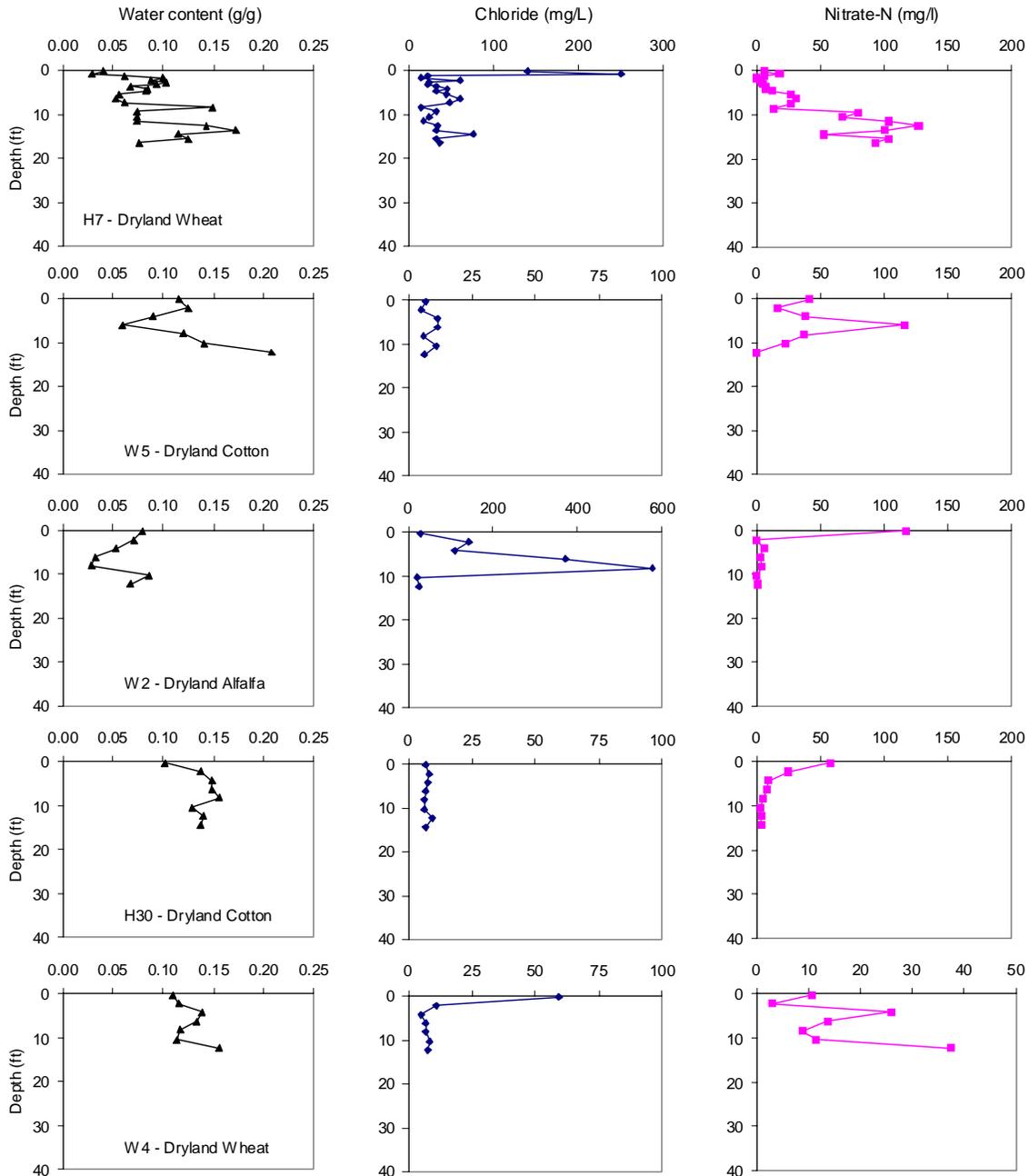


Figure C-3 (cont.). Soil water content, chloride, and nitrate-N concentration profiles for boreholes in dryland agricultural areas.

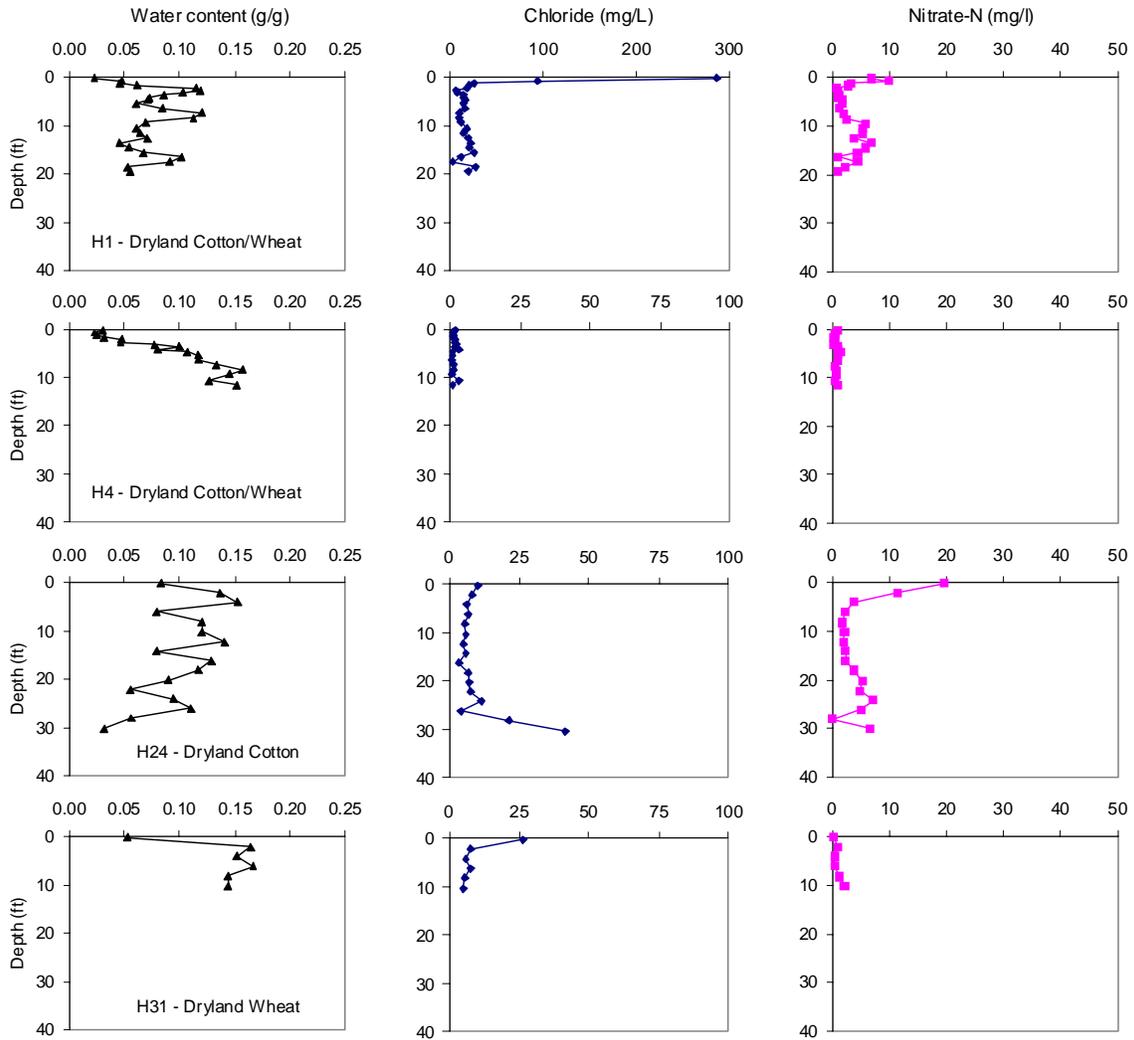


Figure C-4. Soil water content, chloride, and nitrate-N concentration profiles for boreholes in irrigated agricultural areas.

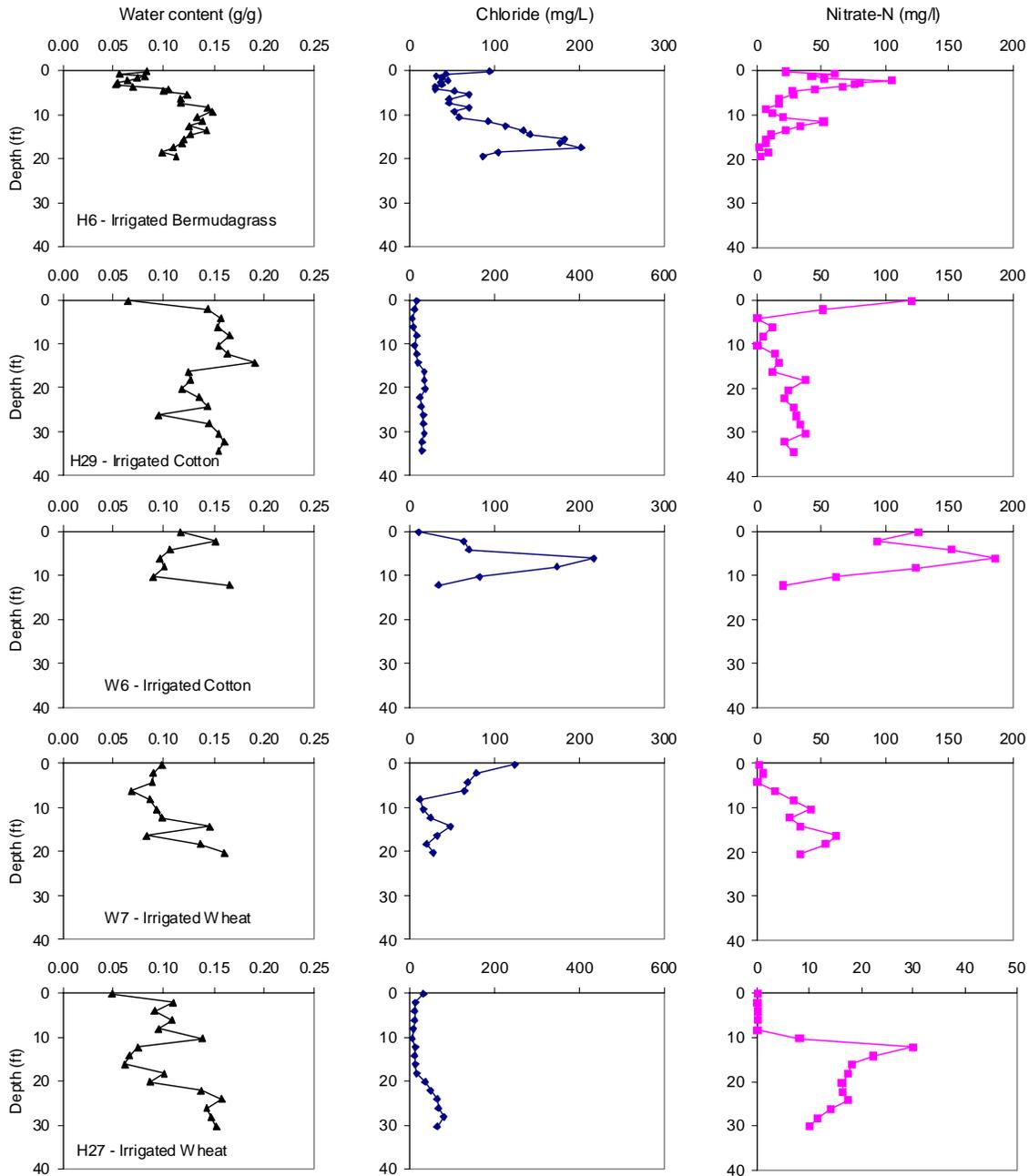
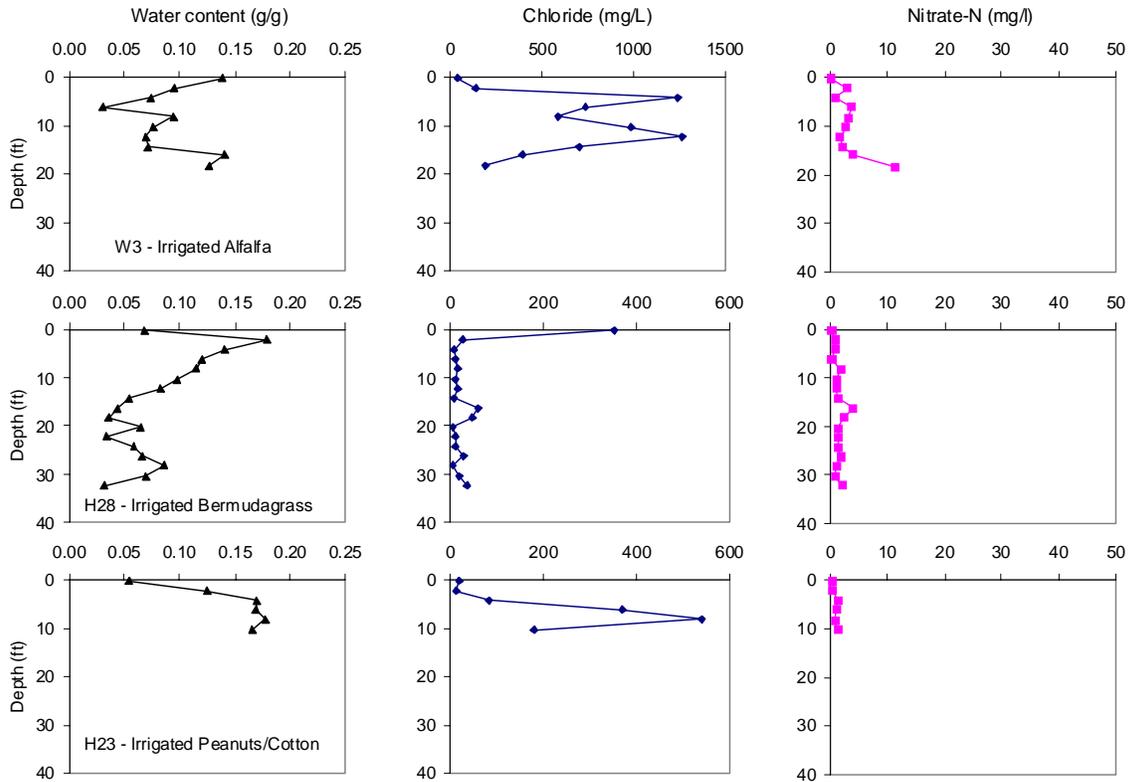


Figure C-4 (cont.). Soil water content, chloride, and nitrate-N concentration profiles for boreholes in irrigated agricultural areas.



**APPENDIX D
PWS BACKGROUND INFORMATION**

APPENDIX E COMPLIANCE ALTERNATIVE CONCEPTUAL COST ESTIMATES

This appendix presents the conceptual cost estimates developed for the compliance alternatives for Northside WSC. The conceptual cost estimates are given in Tables E.1 through E.14. The cost estimates are conceptual in nature, and are intended for making comparisons between compliance options.

**APPENDIX F
EXAMPLE FINANCIAL MODEL**