2008 Regional Specific Studies

Brackish Groundwater Study

Prepared For

Region D – North East Texas Regional Water Planning Group

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EXECUTIVE SUMMARY

In June 2007, the Texas Water Development Board (TWDB) commissioned the Northeast Municipal Water District (NETMWD) to provide a study of brackish groundwater opportunities in Region D, North East Texas Regional Water Planning Area (NETRWPA).

NETRWPA anticipates a 72% increase in population during the 50-year planning period (2010 to 2060). During the planning period, water demand is estimated to increase by 50%, requiring an additional 277,900 acre-feet of water. It should also be noted that the drought cycle for North East Texas imposes peak demands which could be mitigated by developing additional water supplies. Although it is expected that some of this increased demand can be met through more aggressive water conservation and increased use of existing supplies, utilization of brackish groundwater may be an important supplemental source for the region. There were no strategies proposed in the 2006 Regional Plan involving the treatment and use of brackish groundwater.

Desalination of brackish groundwater involves additional operation and maintenance costs, and is a significant effort. For example, a brine disposal injection well can cost substantially more than the production well. Nevertheless, brackish groundwater may represent an important additional supply for NETRWPA. Municipal needs are projected to increase by 49% between 2010 and 2060, requiring an additional 58,000 acre-feet of water. Smaller municipalities have traditionally relied upon well water where it was available, because of its lower production cost and ease of maintenance when compared to treating surface water. However, some small communities in NETRWPA lack access to fresh groundwater supplies, but do have access to brackish groundwater.

The process of desalinating brackish water most frequently is reverse osmosis, although electro dialysis is also used. Both are membrane processes. In reverse osmosis, water from a pressurized saline solution is separated from the dissolved salts by flowing through a water permeable membrane. The permeable membrane allows the water to pass through, but not the dissolved salts. After reverse osmosis, the processed water requires degasification and pH adjustment to be potable. This type of water treatment is an established technology with known installation costs. Operational costs are decreasing as technology improves.

As noted above, there are potential problems with using brackish water. Brackish water removal from the water sands may impact fresh water resources. After treatment, the waste water from the desalination process contains high concentrations of dissolved solids. Discharge through land application or underground injection may eventually damage existing fresh groundwater supplies. The discharged brine waste could infiltrate

through the soil, eventually entering fresh water sands, thereby contaminating these. Discharge near surface streams and reservoirs could create a similar problem. Careful planning and research are required to mitigate this problem. Obtaining appropriate discharge permits is also a time consuming and expensive process.

Cost of desalination was also studied. Although desalination plant costs are declining, recent studies suggest capital costs of $2.76/gpd to $5.52/gpd for the desalination plant, typical capital costs for the well, higher energy costs, and significant costs of brine disposal. While significantly higher than a freshwater well, these costs may still compare favorably to costs for surface water treatment. Generally, overall total treatment costs vary from $0.98/Kgal to $3.80/Kgal in November 2008 dollars.

Recently, TWDB has published *Please Pass The Salt: Using Oil Fields For the Disposal of Concentrate From Desalination Plants*. The study demonstrates that oil fields can accommodate brine waste water, and recommends regulatory changes to improve the permitting process. Use of oil wells would be more beneficial than current methods because it is less expensive, more environmentally friendly, and because the technology for oil well injection already exists. As noted in that report, East Texas is a region which has a great many oil wells, a need for additional water supplies, and brackish water resources. As a general rule if there is oil in the area then there is also brackish water.

Information recently compiled by TWDB, “Brackish Groundwater Manual for Texas Water Planning Groups,” suggests that NETRWPA has 55,712,000 acre feet of brackish groundwater. Given the planning period additional water requirement of 277,900 acre-feet, brackish groundwater represents an important potential source. It was not a recommended strategy in the last planning cycle, primarily because of brine disposal costs, and study is now needed to determine where and how it can best be used in the Region.

Review of water system surveys from the previous planning cycle was performed in order to identify potential brackish groundwater user groups. Focus was placed on municipal and non-municipal uses. Brackish groundwater well fields have been identified and production capacities estimated.

Brackish groundwater is available in NETRWPA and desalination technologies are improving and becoming more economical. A primary cost element is the disposal of the waste concentrate. Recent studies have shown that it is feasible to inject the waste concentrate into depleted oil and gas wells. However, the most economical disposal of waste will be direct discharge to waste water treatment facilities. Published studies have shown that total treatment costs range from $0.98/Kgal to $3.80/Kgal. An actual case study in East Texas has shown the cost to be $4.89/Kgal; therefore, while the use of brackish ground water is feasible, and potential projects exist and user groups have been indentified, it is still more expensive than other current methodologies.

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1.0 INTRODUCTION

In June 2007, The Texas Water Development Board (TWDB) commissioned a study of brackish groundwater opportunities in the North East Texas Regional Water Planning Area (NETRWPA). This was done as part of the 2008 Regional Specific Studies through its administrator, the Northeast Municipal Water District (NETMWD). The inclusion of this topic was a direct result of the 2004 NETRWPG request to the TWDB for permission to investigate a potential Water Management Strategy (WMS) for the City of Kilgore utilizing treated effluent from its wastewater treatment plant for fluid injection in oil and gas reservoirs in lieu of using potable water. That study was included in the Supplemental Tasks for the 2006 North East Texas Region Plan (NETRWP). Although it was inconclusive as to the request it did generate interest in the use of brackish groundwater and its disposal to meet shortages for specific Water User Groups (WUGs) in the NETRWPA.

Therefore, the purpose of this study is to examine the potential of using brackish groundwater to meet the municipal and industrial needs of the NETRWPA along with comparing costs to other alternatives.

Expanding upon the methodology used to provide this study, the North East Texas Regional Water Planning Group (NETRWPG), through its administrator, the NETMWD, has contracted with the Consultant Group to (1) identify existing water users who have needs that could be augmented by brackish groundwater; (2) analyze which water users might potentially use brackish groundwater; (3) compare of brackish water costs to other alternatives; and, (4) prepare recommendations for incorporation into the Regional Plan.

The study and report implemented the following strategies for each of the above tasks:

1. Identification of existing water users who have needs that could be augmented by brackish groundwater was accomplished by:
    a. Review water system surveys from previous planning cycle; and,
    b. Focusing on potential use of brackish groundwater to meet municipal and industrial needs.

2. Analysis of which water users might potentially use brackish groundwater, by integrating brackish water field availability, water demand, lack of alternates and ease of brine waste disposal, by:
    a. Locating potential brackish groundwater well fields using TWDB maps and related data, including geophysical logs and well driller reports;
    b. Estimating the production capacity of wells in the brackish groundwater zone and the number of wells required to meet demands;
    c. Correlating the well field data with water users;

d. Identifying concentrate disposal options based on TWDB reports, especially by considering the 2006 TWDB Report 366 *Please Pass the Salt: Using Oil Fields for the Disposal of Concentrate from Desalination Plants*, and including more detailed data on oil wells using Railroad Commission data; and,
e. Identifying other water supply options for the selected water users.

3. Comparison of brackish water costs to other alternatives by:
    a. Developing capital cost estimates for membrane processes for desalination, pretreatment, storage, wells, and other related capital;
    b. Developing operational cost estimates for plant operation and brine disposal;
    c. Comparing the brackish groundwater costs to other available supply alternatives; and,
    d. Comparing environmental consequences of available supply alternatives and brackish groundwater use.
4. Preparation of recommendations for incorporation into the Regional Plan by:
    a. Identifying potential projects;
    b. Ranking water supply alternatives; and,
    c. Recommending specific brackish water projects as preferred supply sources, if appropriate.

To satisfy the goals above, this report will also present a brief overview of desalination, desalination projects in Texas, specific aspects related to brackish groundwater desalination and options for the disposal of desalination waste product.

2.0 Background Information

In January 2007, the Texas Water Development Board (TWDB) published the results of a multi-year, statewide water planning effort entitled *Water for Texas 2007*. The report found that the population of Texas is projected to increase from 21 million to about 46 million by the year 2060, fueling a 27 percent increase in water demand (TWDB 2007). During the same period, freshwater supplies are projected to decrease by about 18 percent, primarily because of accumulating sediments in reservoirs and depletion of aquifers (TWDB 2007).

In June 1997, Governor George W. Bush signed into law Senate Bill 1 (SB 1), comprehensive water legislation enacted by the 75th Texas Legislature. This comprehensive water legislation was an outgrowth of increased awareness of the vulnerability of Texas to drought and to the limits of existing water supplies to meet increasing demands as population grows (TWDB website, current, http://www.twdb.state.tx.us/wrpi/rwp/rwp.htm).

In April 2002 Texas Governor Rick Perry, recognizing the importance of desalination to the future of Texas, direction TWDB to develop a large-scale demonstration seawater desalination project (TWDB 2007). In 2003, the Texas Legislature passed House Bill

1370 to "… undertake or participate in research, feasibility and facility planning studies, investigations, and surveys as it considers necessary to further the development of cost-effective water supplies from seawater desalination in the state." [HB 1370 ~TWC §16.060]. In response, TWDB provided $1.5 million for three feasibility studies to assess the technical viability of proposed seawater desalination projects: Lower Rio Grande Valley (Brownsville), City of Corpus Christi, and Freeport (NRS 2008).

In 2005, TWDB expanded the scope of its desalination activities to include brackish groundwater (NRS 2008). The term "brackish" refers to the level of total dissolved solids in a water supply. Generally, supplies with a total dissolved solids (TDS) level up to 1,000 milligrams per liter (mg/l) are considered "fresh," and are suitable for most purposes, including municipal, without further treatment to remove TDS. Supplies with TDS levels above 1,000 mg/l, up to 3,000 mg/l are considered slightly saline, and from 3,000 to 10,000 mg/l are moderately saline. These mild and moderate level waters are considered "brackish." As emphasized by Mr. Jorge Arroyo, P.E., Director of Innovative Water Technologies, TWDB, in a 2005 presentation to the South Central Desalting Association, there is as much as 2.7 billion acre-feet of brackish groundwater in Texas (Guyton 2003) and there is as much as 55.7 million acre-feet in the North East Texas Region (Guyton 2003). To place this number in perspective, the largest surface water source in the region is Lake Tawakoni, which holds less than 1 million acre-feet at normal level.

According to *Water for Texas* (TWDB 2007), the 16 Texas regional planning groups have identified 4,500 water management strategies to generate the additional water supply needs for Texas during drought. The water management strategies include municipal and agriculture conservation, reservoirs, wells, water reuse, desalination plants, and other strategies. Fourteen new major reservoirs would result in about 1.1 million acre-feet per year by 2060. Additional water wells would result in about 800,000 acre-feet per year by 2060. Additional water reuse would result in about 1.3 million acre-feet per year by 2060. Desalination projects would result I about 320,000 acre-feet per year by 2060 (TWDB 2007). If implemented, desalination can significantly augment the 2060 projected water supply needs. Currently, eight of the 16 planning groups have included desalination projects as recommended strategies to meet water supply needs (TWDB 2007). The regions that have included desalination are the following: Region E - Far West Texas, Region F (includes San Angelo), Region H (includes Houston), Region K - Lower Colorado, Region L - South Central Texas, Region M - Rio Grande, Region N - Coastal Bend and Region O - Llano Estacado (see Figures 1 and 2).

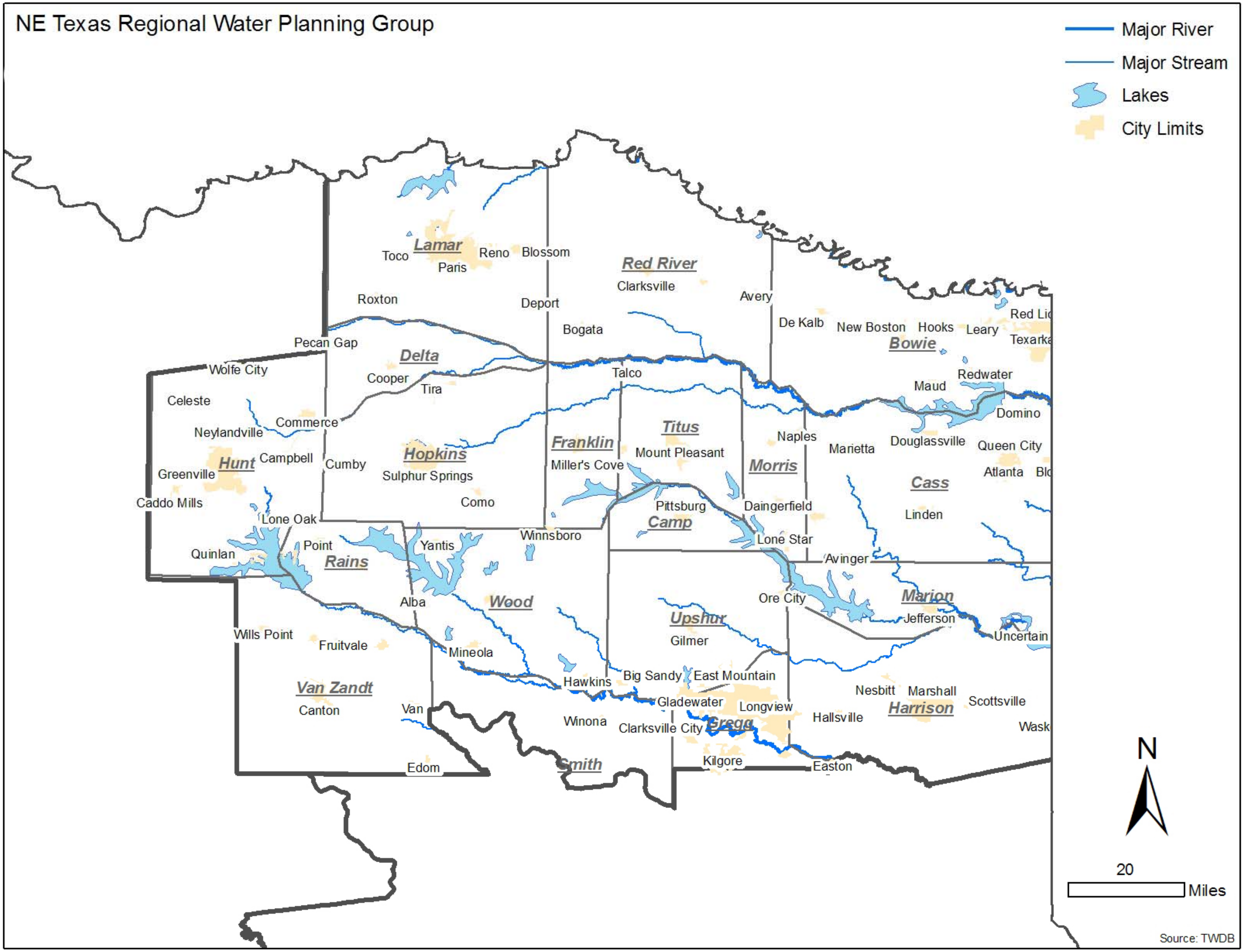


Figure 1: Region D Location Map

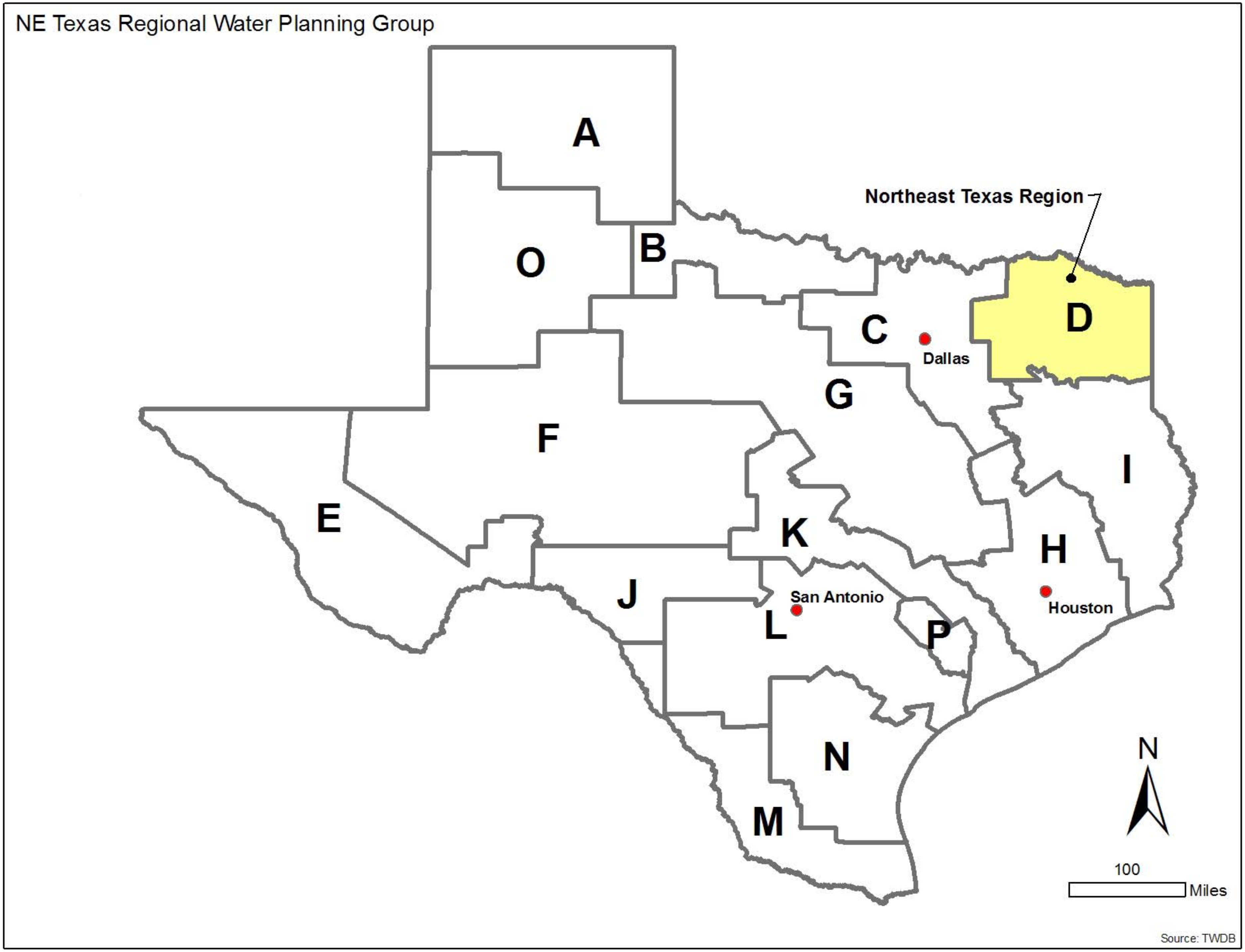


Figure 2: Planning Area Base Map

2.1 Desalination Overview

A succinct overview of the desalination process is provided in TWDB Report 360, Chapter 15 Water Desalination (TWDB 2005). The report references a number of previous reports and documents specific to desalination provided by TWDB staff, various consultants to TWDB and the U.S. Bureau of Reclamation and other agencies. These documents are referenced throughout this report. Selected passages from Arroyo 2005 are included or paraphrased below, supplemented by information from other reports and referenced as appropriate.

2.2 Desalination Technologies

Desalination is the process of removing dissolved solids, primarily salts, from water. There are a number of methods of removing salts to render it safe for human consumption. These generally include thermal technologies and membrane technologies. Thermal technologies are those that heat water and collect condensed vapor to produce pure water (distillation). These are generally used in seawater applications where the TDS level is much higher (average about 35,000 mg/l). Also, TWDB 2005 notes that thermal technologies are more economically attractive if operating in conjunction with steam power generation because the steam released from the power generation plant can be advantageously used as input into the desalination plant. Distillation technologies account for approximately one-half of the world's installed desalination capacity, and it is more commonly used in areas of the world with large supplies of fossil fuel (U.S. Bureau of Reclamation, 2003).

Membrane-based technologies utilize semi-permeable membranes to separate the salts from the water. There are two types of membrane processes: electro-dialysis reversal (EDR) process and reverse osmosis (RO) process (TWDB 2005). The EDR process utilizes electricity to energize opposing electrodes to attract and separate out positive and negative ions of the dissolved salts from a saline water supply. The ions are attracted to the electrodes and travel through semi-permeable membranes that screen the ions from the water stream. Thus, salt water flowing through an EDR unit loses dissolved salts and the resulting stream is pure water. EDR systems may be used with water containing low amounts of TDS. However, when TDS levels exceed 3,000 mg/l, RO systems are typically the preferred choice for desalination (TWDB 2005). The vast majority of brackish groundwater facilities use the RO process, often with pretreatment by micro-, nano- or ultra-filtration methods.

Osmosis is the movement of a solvent (water) through a semipermeable membrane into a solution of higher solute concentration that tends to equalize the concentrations of solute on the two sides of the membrane (Merriam-Webster website, current, http://www.merriam-webster.com/dictionary/osmosis). The reverse osmosis process uses pressure to force water through a membrane that retains impurities and allows the pure water to pass through. Typical RO operating pressures range from 200 to 450 psi for brackish groundwater plants and 800 to 1,200 psi for seawater plants (TWDB 2005). A by-product of the desalination process is brine, a highly concentrated saline stream, typically above 35,000 mg/l, which requires careful management and disposal. Methods of concentrate disposal are presented later in this report. The following photograph depicts the RO facility of the Southmost Regional Water Authority in Brownsville, Texas.

Southmost Regional Water Authority Reverse Osmosis Facility, Brownsville, Texas (photograph from NRS Consultants report by Joseph W. Norris).

2.3 Advantages/Disadvantages of Water Desalination

Water desalination, particularly membrane or filtration technologies, provide a superior quality product regardless of the source water quality. For the State of Texas, the leading advantage that water desalination offers is the ability to add drought-proof supplies to the State's water supply portfolio (TWDB 2005).

Other advantages that water desalination has over more conventional water supply sources as follows, as presented in TWDB 2005:

Sizing of facilities: Water desalination is commonly described as a "hardware technology", meaning that it is accomplished by means of pumps, membranes/filters, and other pieces of equipment. This feature results in smaller size facilities when compared with other conventional water supply alternatives, such as surface-water reservoirs and conventional water treatment plants with clarifiers, sand filters and similar structures. Also, water desalination lends itself to modular expansions, meaning that additional capacity may be added with relative ease by increasing the numbers of filtration elements. This flexibility is important when trying to minimize or optimize the initial capital investments to better match the projected water demands on the project.

Ability to incorporate technology innovations: An advantage of the hardware nature of water desalination is that it allows for new cost-saving innovations, such as foul-resistant membranes and improved energy recovery devices, to be incorporated into existing operational plants with relative ease.

Siting flexibility: In the case of brackish groundwater facilities, there is a relative advantage over conventional surface-water supply alternatives with regards to the location of the treatment plant that may be located closer to the final point of use and thus minimizing treated water transmission costs.

The most noticeable disadvantage of water desalination is its high use of energy. Approximately one third of the operational costs of a water desalination facility can be from power consumption. If the power costs increase, there is a direct impact to the cost of the desalinated water.

2.4 Desalination Funding in Texas

Currently, there are approximately 100 public water systems in Texas using desalination to treat brackish sources for a total of nearly 80 million gallons per day of installed capacity. El Paso leads this list with its flagship facility, the 27.5 million gallons per day (MGD) Kay Bailey Hutchison Brackish Groundwater Desalination Plant (Arroyo and Kalaswad, 2008).

As stated earlier, eight of 16 Water Planning Regions have indicated desalination as a strategy in their 2007 Regional Water Plans. Figure 3 shows existing desalination facilities in Texas in 2005 (NRS 2008). Many of the desalination facilities shown in Figure 2 are in regions that have not formerly indicated desalination as a strategy.

In recent years, there has been a growing interest in seawater desalination, largely due to Governor Rick Perry's vision for developing a drought-proof supply for Texas by turning seawater into potable water. In an April 29, 2002, address in San Antonio directing the TWDB to recommend a large-scale seawater desalination demonstration project, he said "To me it is not a matter of whether saltwater will one day be used as an abundant source for public use, but when and where. As a people, we must have the courage to look into the future and invest today for a better tomorrow. There is no greater untapped source of water than the ocean water that Texas can easily access." It has since become the cornerstone of Governor Perry's water policy initiative.

Thanks to a series of legislative appropriations now totaling more than $4.7 million, Texas has been methodically moving toward fulfilling Governor Perry's vision. After conducting three feasibility studies for potential seawater desalination projects, TWDB awarded a grant of $1.3 million in 2006 to the Brownsville Public Utilities Board to perform a seawater desalination pilot plant study in Brownsville (the Lower Rio Grande Regional Seawater Desalination Pilot Plant).

Concurrent with funding for seawater desalination studies, the Texas Legislature also appropriated funds to TWDB to implement a brackish groundwater desalination initiative. The goal of this initiative is to develop tangible examples or models of brackish groundwater desalination that illustrate the use of innovative, cost-effective technologies and offer solutions to practical issues. A total of $2.12 million has been awarded to nine separate entities to implement research studies and/or demonstration projects to facilitate the development of brackish groundwater supplies in the state.

All of these efforts may help explain, at least in part, the growing importance of water desalination strategies on the state water planning process. According to the 2007 State Water Plan, 3.5 percent of the new water supplies to be developed by 2060 will be provided by desalination. Although modest compared to other strategies (for example, water reuse accounts for 14 percent of the portfolio), desalination strategies increased by 74 percent from the previous State Water Plan published in 2002 (Arroyo and Kalaswad, 2008).

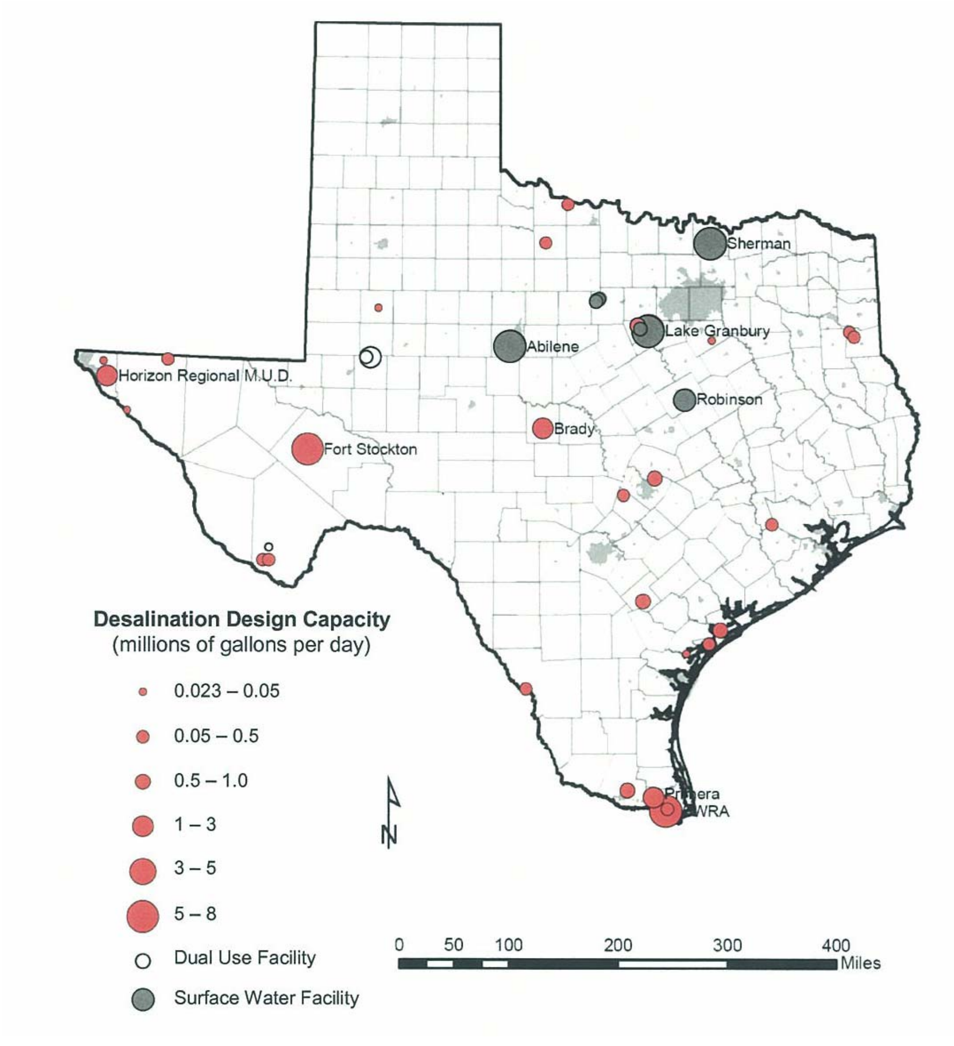


Figure 3: Desalination facilities in Texas, 2005. Facilities with a design capacity greater than 1.5 MGD are named. (NRS 2008 and TWDB 2006).

3.0 BRACKISH GROUNDWATER OPPORTUNITIES IN NETRWPA

In the 2006 Regional Water Plan for the North East Texas Region, three types of water shortages have been identified. The first, and most common, is caused by expiration of a water supply contract or permit. Most water supply contracts and permits have expiration dates, and the TWDB guidelines require that supplies based on contractual agreements should extend past the existing term of contract if the contract is renewable. In most cases, the recommended water supply strategy for these Water User Groups (WUGs) is renewal of their existing contract/permit on or before its expiration date. The second type of shortage is also contractual. These are instances where a contract expires, and the simple renewal of that contract will not adequately compensate for increased demands. In this case, an increase in the contract amount, or additional water supply sources, would be required to meet demands. The final type of shortage addressed in this region in the 2006 Regional Water Plan is the "actual" or "physical" water shortage. In this case, the entity's current water supply will not be sufficient to meet projected demands and additional water sources will be required. This type of shortage is most common among entities that utilize groundwater supplies because well capacity is held at existing development levels throughout the planning period.

3.1 Potential Water User Groups for Desalination

This study addresses WUGs that have an anticipated "actual" or "physical" shortage for which the planned strategy is new groundwater wells. There are 46 entities in the North East Texas Region with actual projected water supply shortages. Additional groundwater supply is recommended for 32 of these entities. Surface water supplies are recommended for the other 14 entities. Campbell WSC in Hunt is recommended for both surface and groundwater. Although there are more individual entities with a recommendation for groundwater, surface water is the predominant recommended supply, accounting for approximately 91 percent of the total supply required for the Region. The information contained in the 2006 Regional Water Plan is included here in its entirety (Table 1 – Table 4.42 of the 2006 NETRWP).

Table 1: Table 4.42 Recommended Strategies for Entities with Actual Shortages (BWR 2006).

	Shortage (ac-ft/yr)		Groundwater Strategy (ac-ft/yr)		Surface Water Strategy (ac-ft/yr)	
Year	**2030**	**2060**	**2030**	**2060**	**2030**	**2060**
Bowie County						
Red River Redevelopment Authority	2435	4074			2435	4074
Camp County						
BI-County WSC	299	653			299	653
Woodland Harbor	60	60	65	65		
Cass County						

Linden	101	104	215	215		
Delta County						
Ben Franklin WSC	33	36			33	36
Franklin County						
Gregg County						
Clarksville City	148	217	162	242		
Liberty City WSC	287	678	376	752		
West Gregg SUD	56	333	70	350		
Starrville-Friendship WSC	0	101	0	108		
Harrison County						
Waskom	54	151	88	176		
Blocker-Crossroads WSC	100	128	129	129		
Caddo Lake WSC	19	52	43	86		
Leigh WSC	0	36	0	43		
Scottsville	0	7	0	65		
Talley WSC	97	142	118	177		
Steam Electric	0	3184			0	3184
Hopkins County						
Miller Grove WSC	24	6	35	35		
Hunt County						
Able Springs WSC	0	171			0	171
Campbell WSC	101	762	108	108	0	665
Cash WSC	0	4152			0	4152
Celeste	0	101			0	108
Combined Consumers WSC	75	3631			75	3631
Hickory Creek SUD	270	1667	270	1882		
Wolfe City	101	195			101	195
Steam Electric	14457	23902			14457	23902
Little Creek Acres	37	153			37	153
West Leonard WSC	5	28	81	81		
Lamar County						
Petty WSC	20	20			20	20
Steam Electric	980	7474			980	7474
Marion County						
Morris County						
Rains County						
Red River County						
Smith County						
Crystal Systems Inc.	0	425	0	538		

Lindale Rural WSC	0	189	0	215		
Lindale	0	374	0	376		
Star Mountain WSC	0	83	0	108		
Titus County						
Steam Electric	0	31552			0	31552
Upshur County						
Pritchett WSC	0	51	0	54		
Van Zandt County						
Bethel Ash WSC	0	17	0	81		
Canton	217	349	291	387		
Grand Saline	143	255	323	323		
R P M WSC	30	99	37	102		
Corinth WSC	0	22	0	27		
Crooked Creek WSC	21	56	59	59		
Edom WSC	72	124	96	124		
Fruitvale WSC	119	269	129	301		
Little Hope-Moore WSC	79	162	113	188		
Wood County						
Mineola	374	360	403	403		
Yantis	20	18	38	38		
TOTALS (all counties)	**20,834**	**86,623**	**3,249**	**7,838**	**18,437**	**79,970**

As can be seen from the Table 4.42, 32 WUGs have identified groundwater strategies to supplement projected water shortages. Brackish groundwater could be used to meet a portion of the project shortages.

Pursuant to the 2006 Regional Water Plan, the development of water wells generally has minimal environmental impact, because of the limited construction disturbance, and the limited disturbance tends to be temporary. Generally, environmental issues can be easily avoided by the appropriate siting of new wells. Similarly, water management strategies that require the transmission of treated water as opposed to construction of new treatment facilities or reservoirs, typically have minimal environmental impact because the disturbances with water mains are also temporary or can be minimized in the routing of the water transmission pipelines. The development of treatment facilities may have greater environmental impact. All of these strategies should avoid, minimize, or mitigate adverse environmental impacts during project development.

3.2 Potential Water User Groups Based on Actual Shortages

Considering the information provided in the above table from the 2006 Regional Water Plan, the 32 WUGs, with their respective counties, considered in this report are as follows:

Camp County - Woodland Harbor
Cass County – Linden

Gregg County - Clarksville City, Liberty City WSC, West Gregg SUD, and Starrville-Friendship WSC

Harrison County – Waskom, Blocker-Crossroads WSC, Caddo Lake WSC, Leigh WSC, Scottsville, and Talley WSC

Hopkins County - Miller Grove WSC

Hunt County – Campbell WSC, Hickory Creek SUD, and West Leonard WSC

Smith County - Crystal Systems, Inc., Lindale Rural WSC, Lindale, and Star Mountain WSC

Upshur County - Pritchett WSC

Van Zandt County - Bethel Ash WSC, Canton, Grand Saline, R P M WSC, Corinth WSC, Crooked Creek WSC, Edom WSC, Fruitvale WSC, and Little Hope-Moore WSC

Wood County – Mineola and Yantis

Again, the recommended strategies for these WUGs with Actual Shortages are additional groundwater wells. The estimated costs to provide the additional wells are presented in the 2006 Regional Water Plan, Appendix A – Chapter 4 Appendix and are summarized in Table 2.

Table 2: Water User Groups with "Actual" or "Physical" Shortages with Existing Recommended Groundwater Strategies - Cost Estimates for Meeting Projected Supply Needs (from Region D Water Plan - Appendix A, Chapter 4 Appendix, January 5, 2006, BWR and others)

Water User Group	Population Served		Shortage (ac-ft/yr)		Groundwater Strategy (ac-ft/yr)		Firm Yield (ac-ft)	Total Capital Cost	Total Annualized Cost*	Unit Cost ($/ac-ft/yr)	Unit Cost ($/Kgal)	Environmental Impact
	2030	2060	2030	2060	2030	2060						
Camp County												
Woodland Harbor	588	588	65	65	65	65	65	$775,872	$66,928	$596	$1.83	Minimal
Cass County												
Linden	2,482	2,575	101	104	215	215	215	$340,579	$60,060	$222	$0.68	Minimal
Gregg County												
Clarksville City	1,148	1,682	148	217	162	242	217	$1,518,443	$150,043	$743	$2.28	Minimal
Liberty City WSC	5,647	8,485	287	678	376	752	753	$2,096,569	$271,451	$627	$1.92	Minimal
West Gregg SUD	4,233	6,382	56	333	70	350	350	$1,502,847	$166,524	$320	$0.98	Minimal
Starrville-Friendship WSC	1,574	2,386	0	101	0	108	108	$316,158	$39,355	$259	$0.79	Minimal
Harrison County												
Waskom	3,485	4,240	54	151	88	176	176	$455,466	$62,041	$854	$2.62	Minimal
Blocker-Crossroads WSC	1,010	1,225	100	128	129	129	129	$483,057	$57,029	$306	$0.94	Minimal
Caddo Lake WSC	1,249	1,515	19	52	43	86	86	$227,734	$30,667	$260	$0.80	Minimal
Leigh WSC	2,161	3,139	0	36	0	43	43	$139,610	$17,202	$282	$0.87	Minimal
Scottsville	871	1,057	0	7	0	65	65	$165,953	$23,173	$265	$0.81	Minimal
Talley WSC	1,664	2,020	97	142	118	177	177	$760,772	$84,382	$320	$0.98	Minimal
Hopkins County												
Miller Grove WSC	1,218	1,071	24	6	35	35	35	$479,955	$40,669	$955	$2.93	Minimal
Hunt County												
Campbell WSC	1,303	5,917	101	773	108	108	108	$618,674	$61,950	$366	$1.12	Minimal
Hickory Creek SUD	3,664	12,508	271	1,667	2,702	1,882	1,882	$6,880,290	$808,680	$909	$2.79	Minimal
West Leonard WSC	72	245	5	28	81	81	81	$890,430	$79,319	$580	$1.78	Minimal
Smith County												
Crystal Systems, Inc.	4,357	6,649	0	425	0	538	538	$992,200	$160,368	$485	$1.49	Minimal
Lindale Rural WSC	3,086	4,709	0	189	0	215	215	$316,158	$57,022	$265	$0.81	Minimal
Lindale	4,201	7,010	0	374	0	376	376	$510,648	$96,693	$257	$0.79	Minimal
Star Mountain WSC	1,516	2,313	0	83	0	108	108	$316,158	$39,987	$265	$0.81	Minimal
Upshur County												
Pritchett WSC	6,478	6,998	0	51	0	54	54	$270,925	$28,186	$341	$1.05	Minimal
Van Zandt County												
Bethel Ash WSC	617	797	0	17	0	81	81	$337,913	$37,308	$513	$1.57	Minimal
Canton	4,012	4,613	217	349	291	387	387	$1,229,656	$150,596	$365	$1.12	Minimal
Grand Saline	3,863	4,560	143	255	323	323	323	$574,243	$99,100	$232	$0.71	Minimal
R P M WSC	2,021	2,610	30	99	37	102	102	$574,243	$51,911	$491	$1.51	Minimal
Corinth WSC	1,170	1,511	0	23	0	27	27	$281,295	$24,681	$1,371	$4.21	Minimal
Crooked Creek WSC	932	1,204	21	56	59	59	59	$212,882	$24,824	$348	$1.07	Minimal
Edom WSC	1,372	1,771	34	86	43	86	86	$661,715	$61,668	$657	$2.02	Minimal
Fruitvale WSC	4,010	5,179	119	269	129	301	301	$1,944,744	$190,656	$798	$2.45	Minimal
Little Hope-Moore WSC	2,211	2,855	78	161	113	188	188	$1,395,045	$135,877	$754	$2.31	Minimal
Wood County												
Mineola	6,814	6,858	374	360	403	403	403	$243,334	$81,544	$202	$0.62	Minimal
Yantis	633	637	20	18	38	38	38	$227,734	$22,938	$603	$1.85	Minimal

* O&M Cost + Power Cost + (Total Capital Costs debt service factor, 30 yrs @ 6%)

3.3 Review of Water System Surveys from Previous Planning Cycle

Water system surveys from the 2006 Regional Water Plan (147 surveys of individual WUGs) were reviewed to identify specific potential users of brackish groundwater. Results of this review are summarized in various tables within Appendix A. The review of the water system surveys serves to identify the specific additional potential users of brackish groundwater and focused on the following areas:

- non-residential users
- users with changes in water quality or quantity
- users with average water rates above $50.00 per 10,000 gallons
- users with planned expansions

A summary of non-residential user types in Region D is as follows:

Table 3: Non-Residential Users Types in Region D
(Responses to 2006 Water Plan Survey)

User Type	Number of Users	Usage, MG/Yr.
Commercial	11	28
Institutional	6	54
Industrial	15	1,556
Livestock/Dairy	10	11
Manufacturing	23	1,871
Oil/Gas	1	20
Plant Farm	2	2
Recreational/RV Park	2	4
Wholesale/Water Supply	13	693
Totals	**83**	**4,239**

While Wholesale/Water Supply is listed above, it is assumed that the vast majority of these users are residential. Therefore, the two top non-residential uses of water are industrial and manufacturing (based on 2006 Water Plan Surveys), which constitute approximately 81% of non-residential water use in the region.

3.3.1 Non-Residential Potential Users

Major non-residential users were identified and contacted to explore the potential use of treated or non-treated brackish groundwater. Generally, the responses to using non-treated brackish groundwater were negative. Treated brackish groundwater was considered generally more expensive and, therefore, not a consideration for the respondents. Example responses are as follows:

- Steam-Electric Industry – A representative of steam-electric, and a voting member of the NETRWPG, stated that water with constituents similar to brackish groundwater, such as higher TDS levels, create significant scaling and corrosion problems, often requiring equipment to be manufactured of stainless steel or other more expensive metals. Additionally, the volume of water needed is a concern. If treated brackish groundwater is used, the cost of treatment and the volume of waste concentrate brine make brackish groundwater an unfavorable option for steam-electric power generation.

- Food and Beverage Processing – A representative of Ocean Spray in Hopkins County, who currently receives treated surface water from the City of Sulphur Springs, stated water is the essential ingredient of their product and they use additional treatment/purification methods. The representative stated that his business was far too particular about water quality to entertain the idea of using brackish water.

- Manufacturing – Rubbermaid in Hunt County receives Lake Tawakoni water via the City of Greenville. The facilities manager stated that water quality is a significant factor of the injection mold process and was emphatically opposed to the idea of using non-treated brackish groundwater.

- Manufacturing – Air Liquide in Gregg County receives City of Longview water. The water quality concerns of Air Liquide are very similar to those of the steam-electric industry. The representative stated "we have to watch our solids very closely" and was not interested in brackish water due to the boiler feed water quality specifications and the cooling tower characteristics.

- Manufacturing – A representative of Rexam, a manufacturer of beverage cans and plastic packaging, stated that "entertaining different water would not make a significant difference in our bottom-line, therefore, we would not be interested." Rexam is also in Gregg County and receives treated surface water from the City of Longview.

- Manufacturing - A facilities manager from Eastman in Longview stated that they are not interested in using treated or non-treated brackish groundwater. Their processes and equipment are too sensitive to TDS. The representative stated that treated brackish groundwater is not cost effective.

- Food and Beverage Processing – A consultant for Pilgrim's Pride (poultry processing) stated that because of water quality and current abundance of water there would be no interest on their part to use untreated or treated brackish groundwater.

Representatives from the livestock, dairy, institutional or other non-residential users could not be reached for this survey. The survey summaries with contact information are included at the end of Appendix A.

3.3.2 Users with Changes in Water Quality or Quantity

Nine WUGs using well water in Region D identified a change in water quality and/or quantity in the surveys from the previous planning cycle. Two of these entities indentified an increase in sodium or TDS levels and seven identified a decrease in quantity (a drop in static ground water levels or lower gpm production).

These include the following systems:

- Redwater Water and Sewer Co., Bowie County
- City of Bogata, Red River County
- City of Clarksville, Red River County
- Red River County WSC, Red River County
- City of Gilmer, Upshur County
- Rosewood, Upshur County
- City of Canton, Van Zandt County
- New Hope WSC, Wood County
- Yantis WSC, Wood County

Notably, these water suppliers' costs per 10,000 gallons ranged between a low of $33.00 to a high of $43.50, which are on the higher end of overall rates in Region D.

The City of Clarksville has expressed a desire to implement RO treatment of its groundwater. Clarksville gets up to 1 million gallons per day from Langford Lake and supplements it with three groundwater wells. The well water contains higher than desired levels of TDS (~1,083 mg/l) and other constituents, such as sodium (~300 mg/l) and chloride (~ 233 to 300 mg/l, but often over 300 mg/l). The City's blending operations allow them to use this water to supplement the surface water. However, on peak days the water quality becomes more of a concern. The City's Director of Water and Wastewater Plants, Mr. Daniel Rapien, expressly stated that the City is very interested in adding an RO system. However, their constraint is funding. The City of Clarksville is the one WUG this report specifically recommends for a brackish groundwater project. If Clarksville transferred completely to groundwater, they would need five wells, at approximately 335 gpm per well. While this is not necessarily their desire, their intent is to continue to supplement the lake water albeit with a higher quality groundwater, the calculation would be as follows:

- 1,440 connections x 0.6 gpm / connection x 60 min / hr x 24 hrs / day = 1.24 MGD

- Their current wells range between 320 and 350 gpm, therefore, 335 gpm is used as an average. The RO system will produce approximately 80% of each well capacity; therefore, 335 gpm becomes 268 gpm. Using the minimum requirements (0.6 gpm) and multiplying by a factor of safety of 1.5, results in 0.9 gpm, 1.24 MGD becomes 1.86 MGD. During peak days a few times a year each well could yield 385,920 gallons after RO treatment. Therefore, five wells producing an average of at least 335 gpm would be required.

3.3.3 Users with Average Water Rates above $50 per 10,000 Gallons

Review of the water surveys from the last 2006 planning cycle identified sixteen WUGs with rates greater than $50 per 10,000 gallons (five entities were above $60 per 10,000 gallons). Fifty dollars per 10,000 gallons was used as a threshold rate where the treatment of brackish groundwater may become financially viable, as this is currently the approximate cost of providing treated brackish groundwater.

The systems, with their respective rates, above $50/10,000 gallons are as follows:

- City of Reno, Lamar County, $50.07
- Tryon Road SUD, Gregg County, $51.00
- City of Quitman, Wood County, $51.46
- City of Caddo Mills, Hunt County, $51.84
- Central Bowie Co. WSC, Bowie County, $52.00
- Mims WSC, Marion County, $52.26
- City of Edgewood, Van Zandt County, $57.31
- City of Deport, Lamar County, $57.50
- MACBEE SUD, Van Zandt County, $57.99
- South Tawakoni WSC, Van Zandt County, $58.79
- Woodland Estates, Bowie County, $59.99
- 410 WSC, Red River County, $61.29
- City of Lone Oak, Hunt County, $61.94
- Pritchett WSC, Upshur County, $63.32
- City of Hallsville, Harrison County, $65.00
- Combined Consumers WSC, Hunt County, $65.48

These 16 represent an even split of entities that treat water and those that purchase water. Three of the entities currently use groundwater and the remaining 13 use surface water. Ten of the Region's 19 counties are represented in this group and are geographically well distributed throughout the North East Region. All of the WUGs listed in sections 3.3.2 and 3.3.3 should be considered as WUGS with potential brackish groundwater projects that could be incorporated into the Regional Plan.

3.4 Brackish Groundwater in Texas and in the North East Texas Region

The following map (Figure 4) from Guyton 2003 illustrates the known occurrence of brackish groundwater in Texas. The results of Guyton's study have been obtained from TWDB and overlaid with the regional map and with the county maps that contain the WUGs indicated above that have groundwater strategies for projected actual shortages. The maps are included on the following pages. The one regional map (Figure 5) and ten county maps (Figure 6 - 15) presented contain the 32 WUGs with "actual" shortages that have identified groundwater as a strategy and indicate the proximity of the WUGs to the water quality data obtained from TWDB's Guyton 2003 study.

Mr. Stan Hayes, P.E., of Hayes Engineering, Inc., consultant for the 2006 Regional Water Plan and the 2008 Specific Studies, who primarily consults in the southern portion of Region D, reports most of the brackish water is from the Wilcox that intermingles with the Carrizo. The Queen City is at a depth of 300 to 400 feet and it is potable water. The Carrizo is 500 to 700 feet and it is for the most part potable especially at the shallower depths (as it mingles with the Wilcox its salinity increases). The Wilcox is from 700 feet and deeper, but does migrate up to the Carrizo. Mr. Hayes stated the counties that have brackish water are generally south and east of Interstate Highway 30 (IH-30). The counties where he is working on water supply are Harrison, Gregg, Marion, Cass, Camp, Morris and Upshur. As a general rule if there is oil in the area then there is also brackish water.

Examples of brackish groundwater wells for which Hayes Engineering is familiar are as follows:

East Mt. WSC	Upshur County	300+ gpm
Harleton WSC	Harrison County	300+ gpm
West Harrison WSC	Harrison county	300+ gpm

Hayes also reports that brackish groundwater generally exists in the Bi-County WSC WUG (Camp, Upshur and Morris counties) and in Marion County.

Mr. Reeves Hayter, P.E., of Hayter Engineering, Inc., also consultant for the 2006 Regional Water Plan and the 2008 Specific Studies, primarily consults in the northern portion of Region D. He reports that generally groundwater wells are not drilled north of IH-30 due to low production rates and the prevalence of surface water. Most of the wells north of IH-30 produce 100 to 150 gpm wells. Also, there are few oil wells in which to dispose the brine. The water systems in Lamar County where the cost of water is above $50 for 10,000 gallons per month mostly purchase from Lamar County WSC. The WSCs in Lamar County once had wells but gave them up due to poor quality or lack of production of potable water. Delta County is one area where they do not consider drilling due to groundwater is typically 2000 feet deep and is brackish.

LBG-Guyton Associates, Inc. has performed an evaluation of the brackish groundwater supply in the Region D area for this report. The TWDB data was searched and parsed for relevant information on brackish groundwater. Information in this database is populated from data obtained by well driller reports, pumping test results, water quality analyses and other pertinent information obtained by TWDB through reliable sources.

In general, brackish groundwater is found in the down-dip limits of the aquifers in the region. Aquifers with brackish water include the Cretaceous aquifers of Nacatoch, Blossom, Woodbine and the Paluxy and Twin Mountain of the Trinity Aquifer (Figure 16). Brackish water can also be found in some of the deeper Wilcox portion of the Carrizo-Wilcox aquifer (Figure 16). Most wells found in the southeastern portion of the Region D area are completed into the Tertiary age, Carrizo and Queen City Sands that generally produce freshwater.

Six geophysical logs were obtained from the Surface Casing Division of the Texas Commission of Environmental Quality representing the different aquifers with known brackish water. These logs are made from oil field test wells that span a number of the shallower aquifers. The state identification numbers for those wells are: 17-29-202, 17-21-807, 17-22-404, 16-33-601, 34-02-702, and 35-33-602 (Figure 16). Logs found in the northern portion of Region D show the Cretaceous aquifers and logs in the southern area show the Carrizo-Wilcox Aquifer. Based on review of geophysical logs in the area, brackish water is generally found in strata at depths less than 2,000 feet.

An evaluation of these logs indicates only a portion of each geologic unit is capable of producing significant water. The Cretaceous aquifers only have small footage intervals of sand or limestone that can actually produce water. The Wilcox aquifer generally has a variety of sandy layers that can produce water. Throughout the total thickness of the geologic unit, a variety of water quality can be interpreted from any particular sand interval on the geophysical log. Depending on the interval that is screened and open to produce water to the well will determine the overall average chemistry from a particular well. Generally, deeper sands have lower resistivities on the geophysical log, which correspond to higher TDS content of the water produced from those intervals.

Based on these logs and other wells completion information, wells completed in the Cretaceous aquifers (Nacatoch, Blossom, Woodbine and the Paluxy and Twin Mountain of the Trinity Aquifer) generally produce lower volumes often less than 50 gallons per minute (gpm) with one reported as high as 120 gpm completed into the Blossom Aquifer. Wells completed into the Wilcox generally have higher reported yields ranging up to about 600 gpm. However, a practical expectation for Wilcox brackish wells is about 100 to 300 gpm.

Brackish wells could be developed in the Woodbine and Trinity aquifers in Lamar and Red River Counties. Experience in Texas indicates that each brackish groundwater wellfield needs to be evaluated individually to identify specific water quality characteristics and well production capacity. It is possible to find brackish groundwater in most of the down-dip sections of the Nacatoch aquifer, but especially in Hunt, Hopkins, and Bowie Counties. In the Carrizo and Wilcox aquifers, there are zones of brackish groundwater in many Region D counties where the aquifers exists. Generally, the brackish groundwater will be found in the deeper section of the aquifers, but there are exceptions to this general rule.

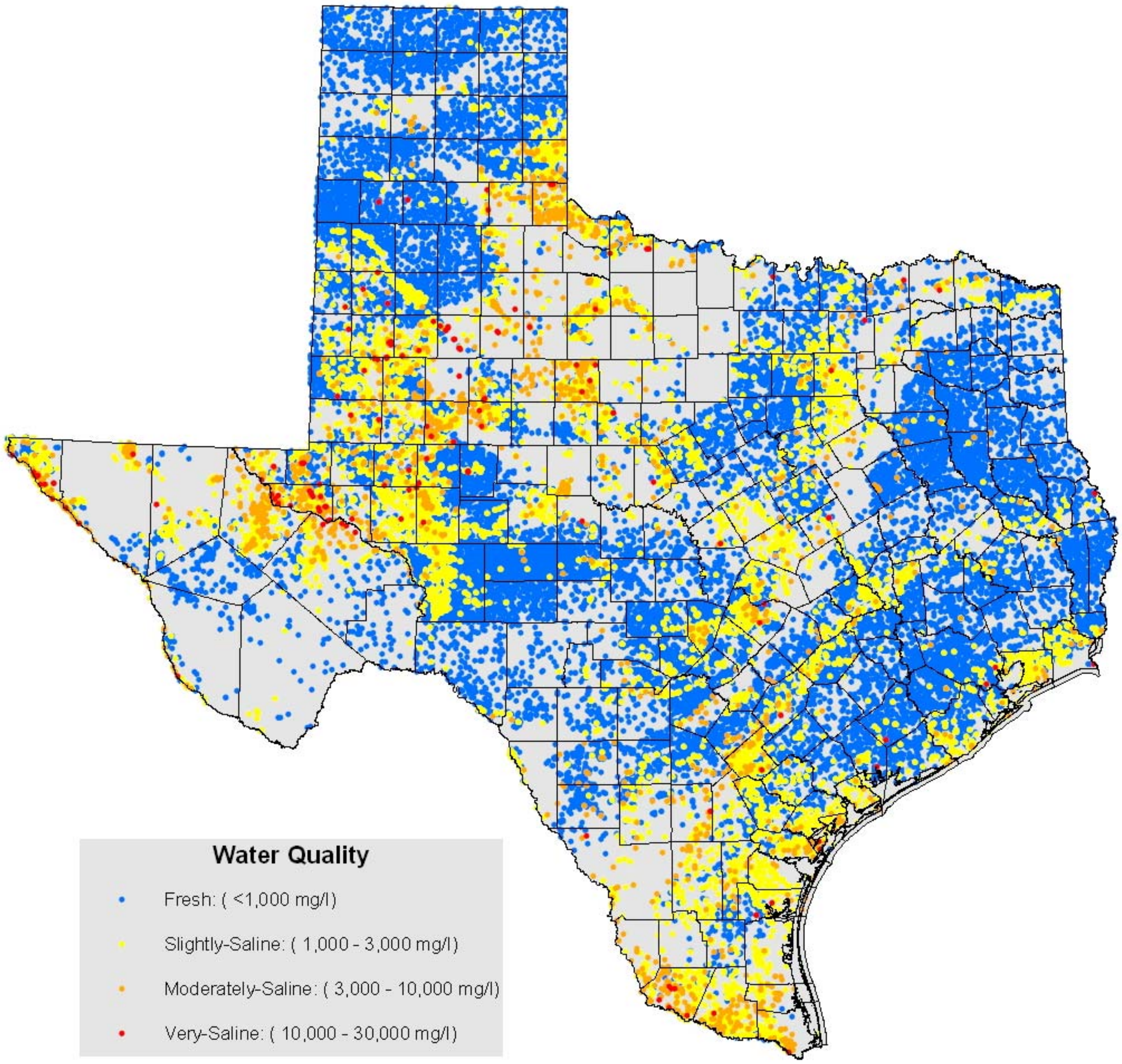


Figure 4: Distribution of Brackish Groundwater in Texas (Guyton 2003)

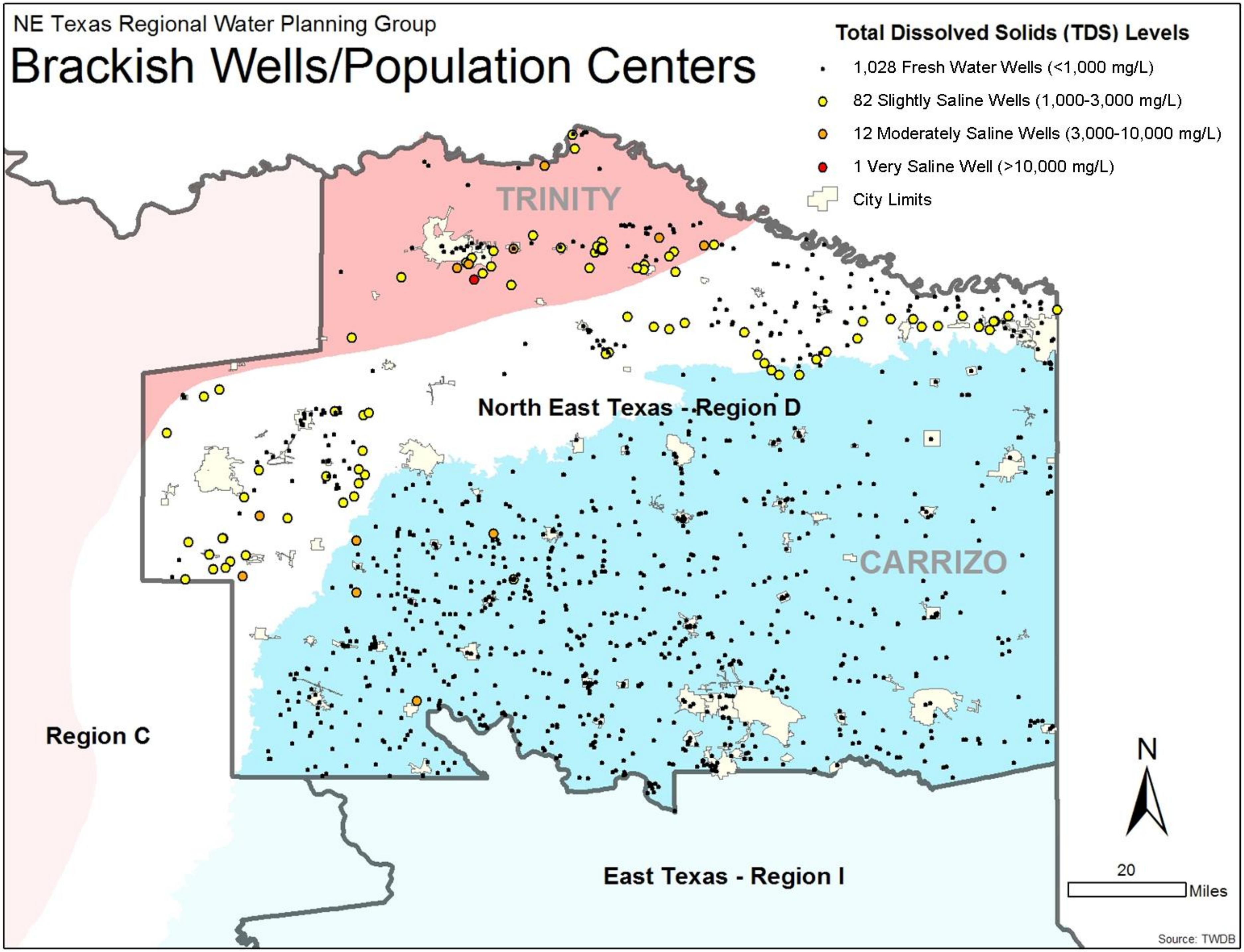
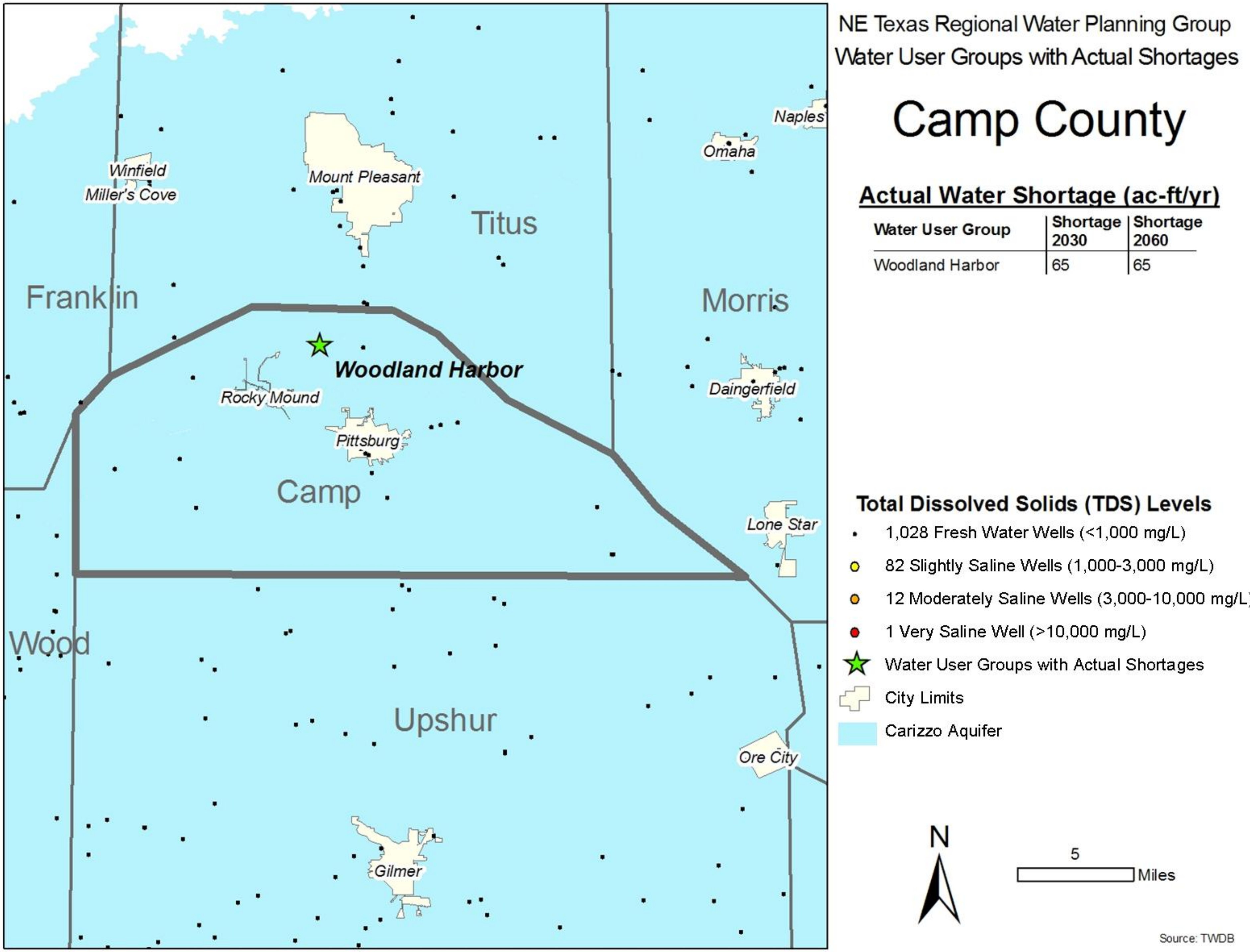
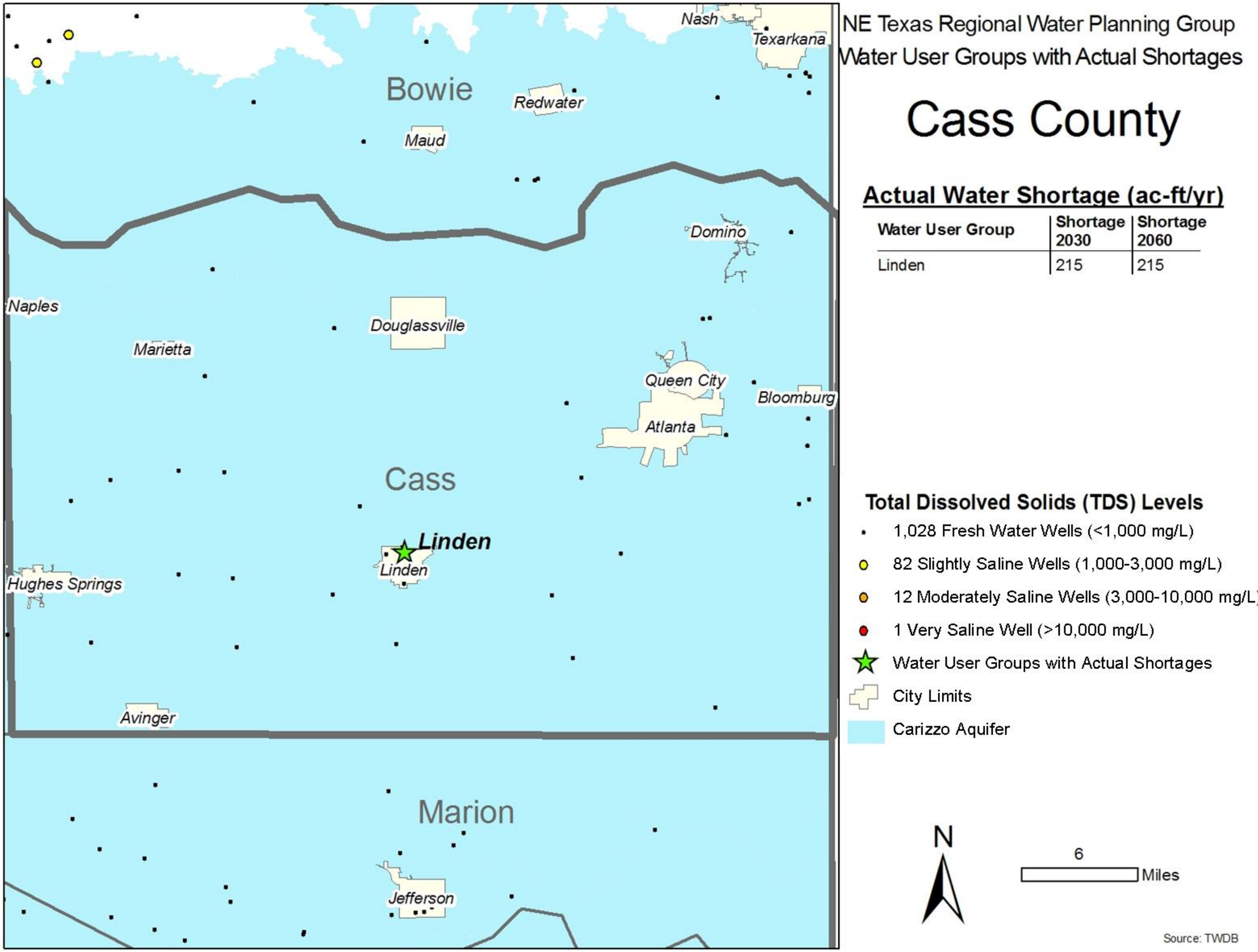


Figure 5: Brackish Wells/Population Centers



Water User Group	Shortage 2030	Shortage 2060
Woodland Harbor	65	65

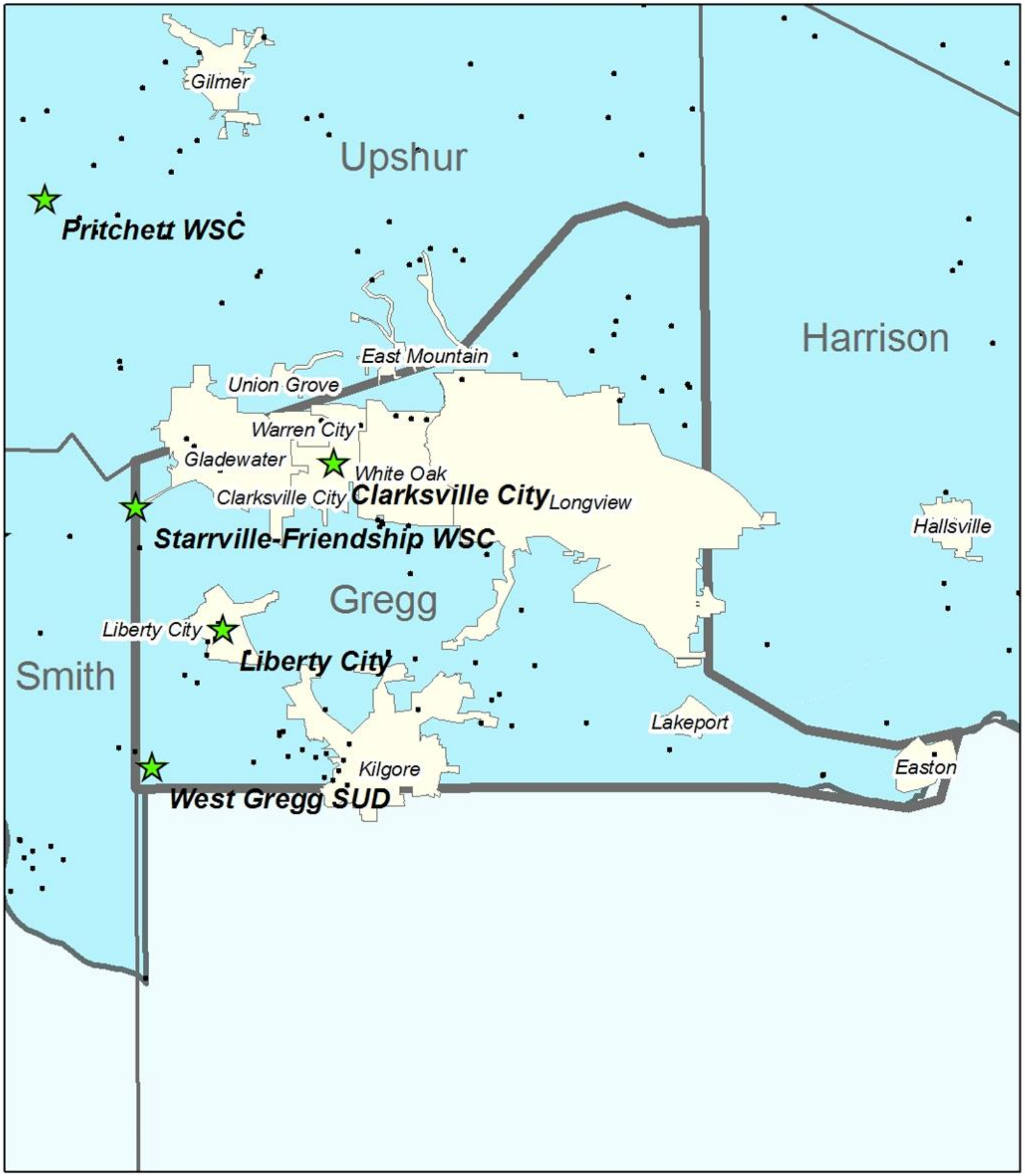
Figure 6: Camp County



Actual Water Shortage (ac-ft/yr)

Water User Group	Shortage 2030	Shortage 2060
Linden	215	215

Figure 7: Cass County



NE Texas Regional Water Planning Group
Water User Groups with Actual Shortages

Gregg County

Actual Water Shortage (ac-ft/yr)

Water User Group	Shortage 2030	Shortage 2060
Clarksville City	162	242
Liberty City WSC	376	752
West Gregg SUD	70	350
Starrville-Friendship WSC	0	108

Total Dissolved Solids (TDS) Levels

- 1,028 Fresh Water Wells (<1,000 mg/L)
- 82 Slightly Saline Wells (1,000-3,000 mg/L)
- 12 Moderately Saline Wells (3,000-10,000 mg/L)
- 1 Very Saline Well (>10,000 mg/L)
- Water User Groups with Actual Shortages
- City Limits
- Carizzo Aquifer

Figure 8: Gregg County

NE Texas Regional Water Planning Group
Water User Groups with Actual Shortages

Harrison County

Actual Water Shortage (ac-ft/yr)

Water User Group	Shortage 2030	Shortage 2060
Blocker-Crossroads WSC	129	129
Caddo Lake WSC	43	86
Leigh WSC	0	43
Scottsville	0	65
Talley WSC	118	177
Waskom	88	176

Total Dissolved Solids (TDS) Levels

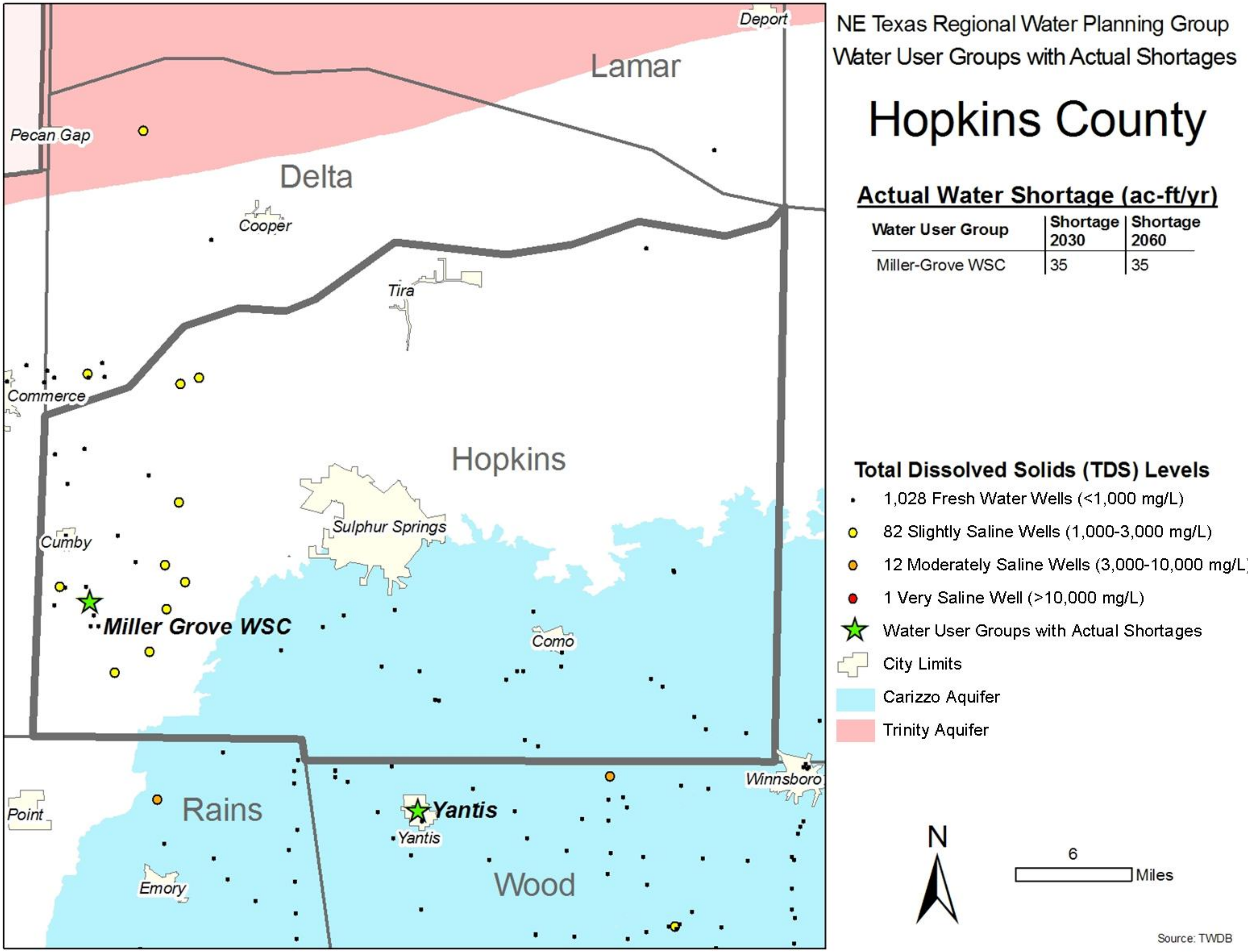
- 1,028 Fresh Water Wells (<1,000 mg/L)
- 82 Slightly Saline Wells (1,000-3,000 mg/L)
- 12 Moderately Saline Wells (3,000-10,000 mg/L)
- 1 Very Saline Well (>10,000 mg/L)
- Water User Groups with Actual Shortages
- City Limits
- Carizzo Aquifer

N

7 Miles

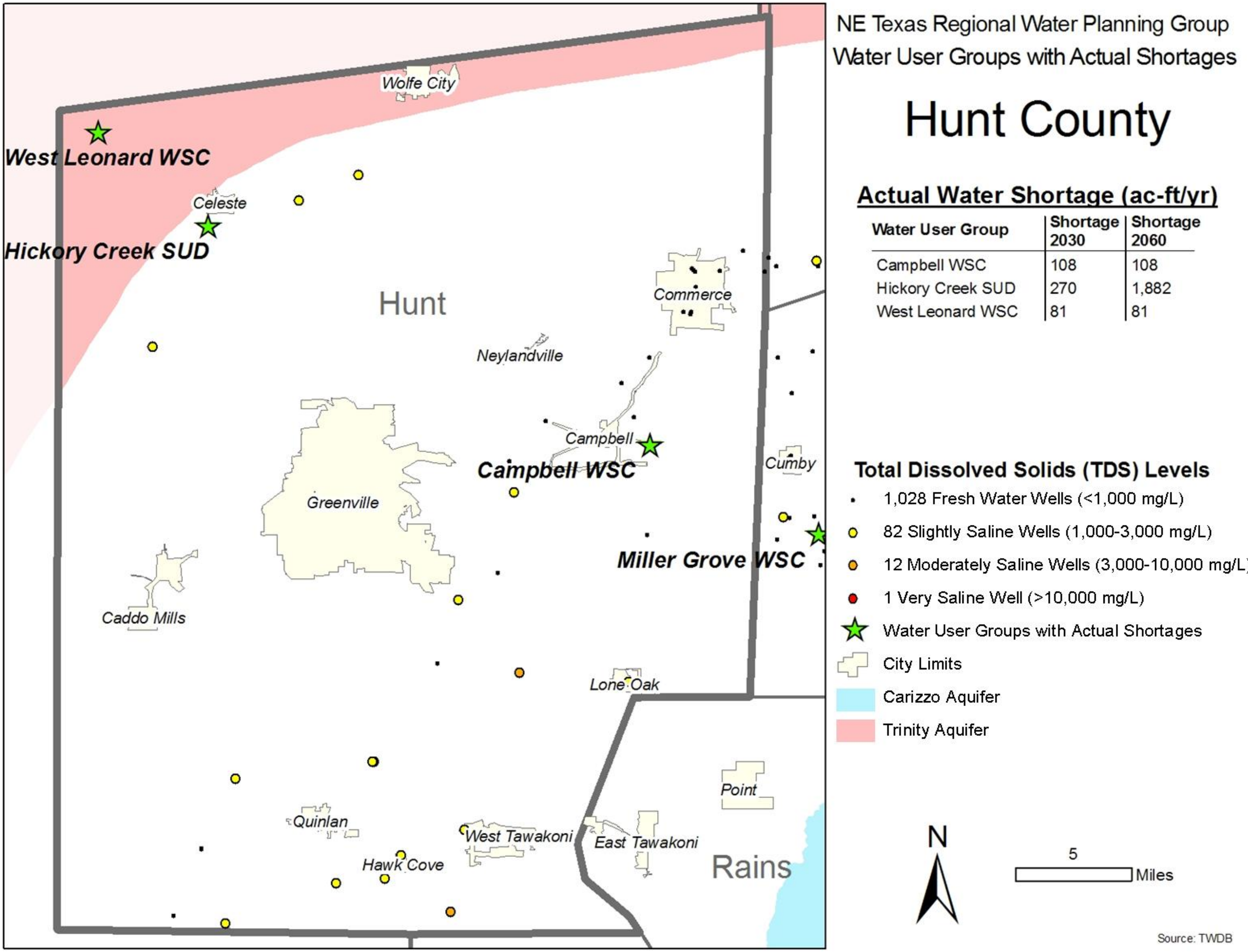
Source: TWDB

Figure 9: Harrison County



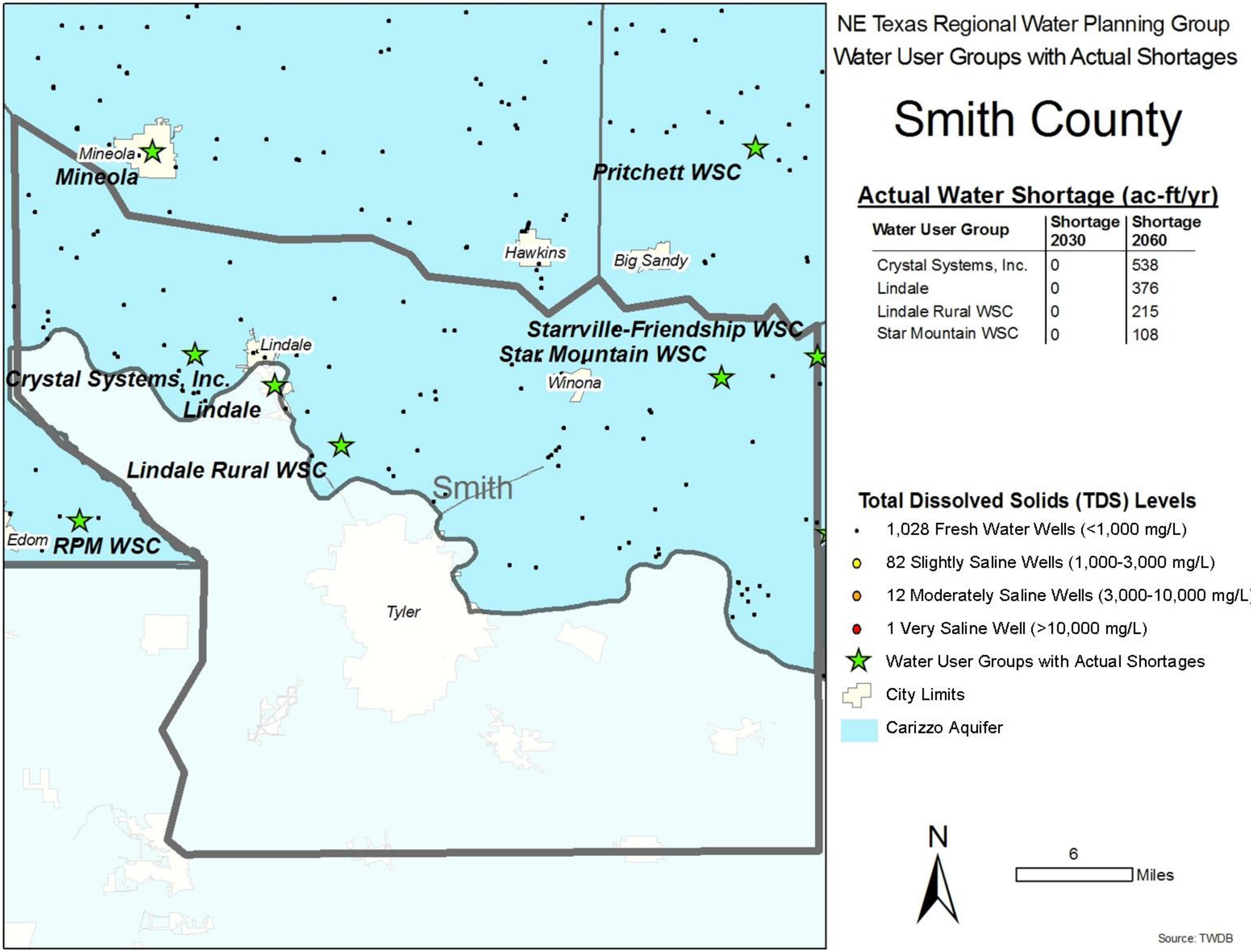
Water User Group	Shortage 2030	Shortage 2060
Miller-Grove WSC	35	35

Figure 10: Hopkins County



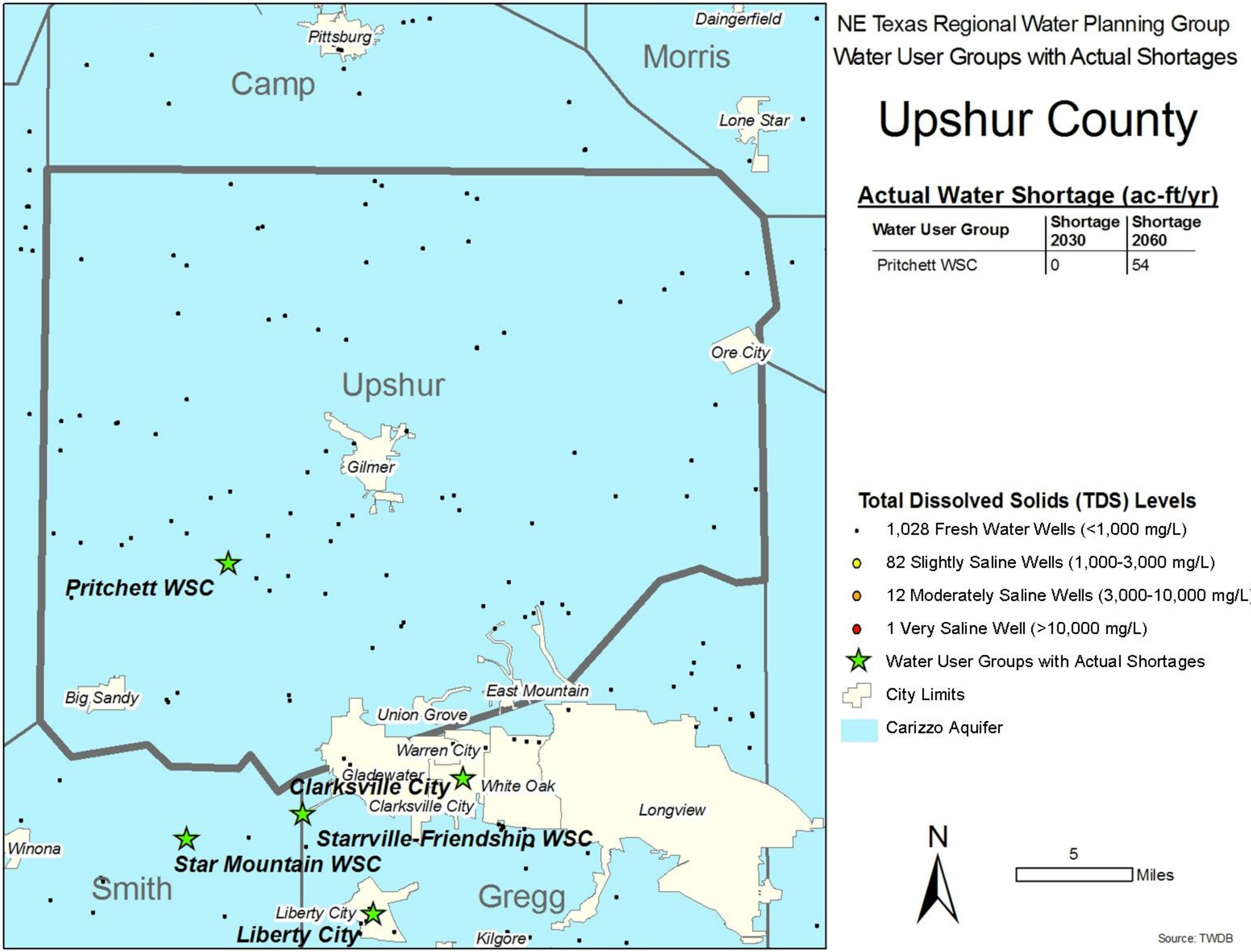
Water User Group	Shortage 2030	Shortage 2060
Campbell WSC	108	108
Hickory Creek SUD	270	1,882
West Leonard WSC	81	81

Figure 11: Hunt County



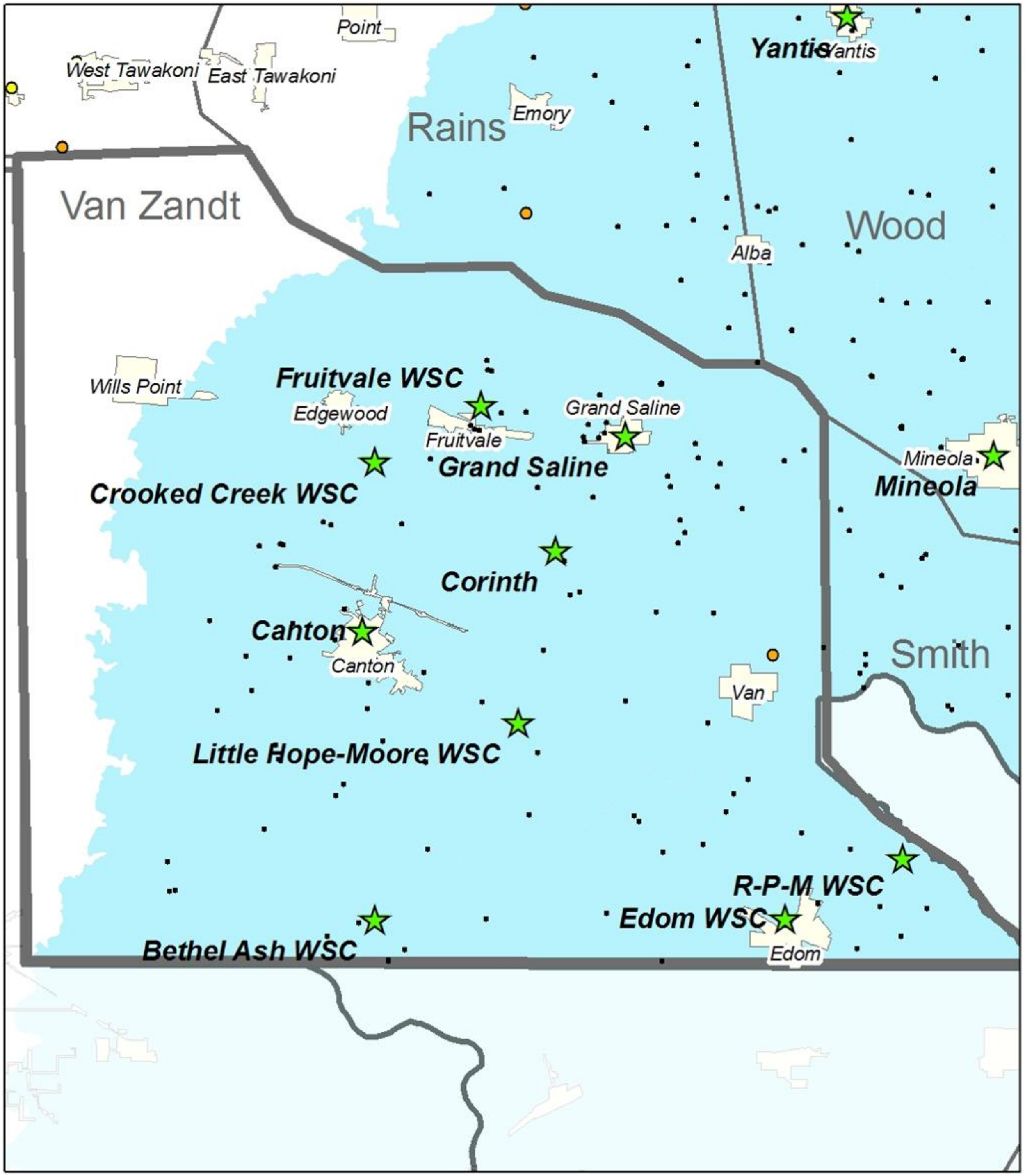
Water User Group	Shortage 2030	Shortage 2060
Crystal Systems, Inc.	0	538
Lindale	0	376
Lindale Rural WSC	0	215
Star Mountain WSC	0	108

Figure 12: Smith County



Water User Group	Shortage 2030	Shortage 2060
Pritchett WSC	0	54

Figure 13: Upshur County



NE Texas Regional Water Planning Group
Water User Groups with Actual Shortages

Van Zandt County

Actual Water Shortage (ac-ft/yr)

Water User Group	Shortage 2030	Shortage 2060
Bethel Ash WSC	0	81
Canton	291	387
Corinth WSC	0	27
Crooked Creek WSC	59	59
Edom WSC	96	124
Fruitvale WSC	129	301
Grand Saline	323	323
Llittle Hope-Moore WSC	113	188
R-P-M WSC	37	102

Total Dissolved Solids (TDS) Levels

- 1,028 Fresh Water Wells (<1,000 mg/L)
- 82 Slightly Saline Wells (1,000-3,000 mg/L)
- 12 Moderately Saline Wells (3,000-10,000 mg/L)
- 1 Very Saline Well (>10,000 mg/L)
- Water User Groups with Actual Shortages
- City Limits
- Carizzo Aquifer

N

6 Miles

Source: TWDB

Figure 14: Van Zandt County

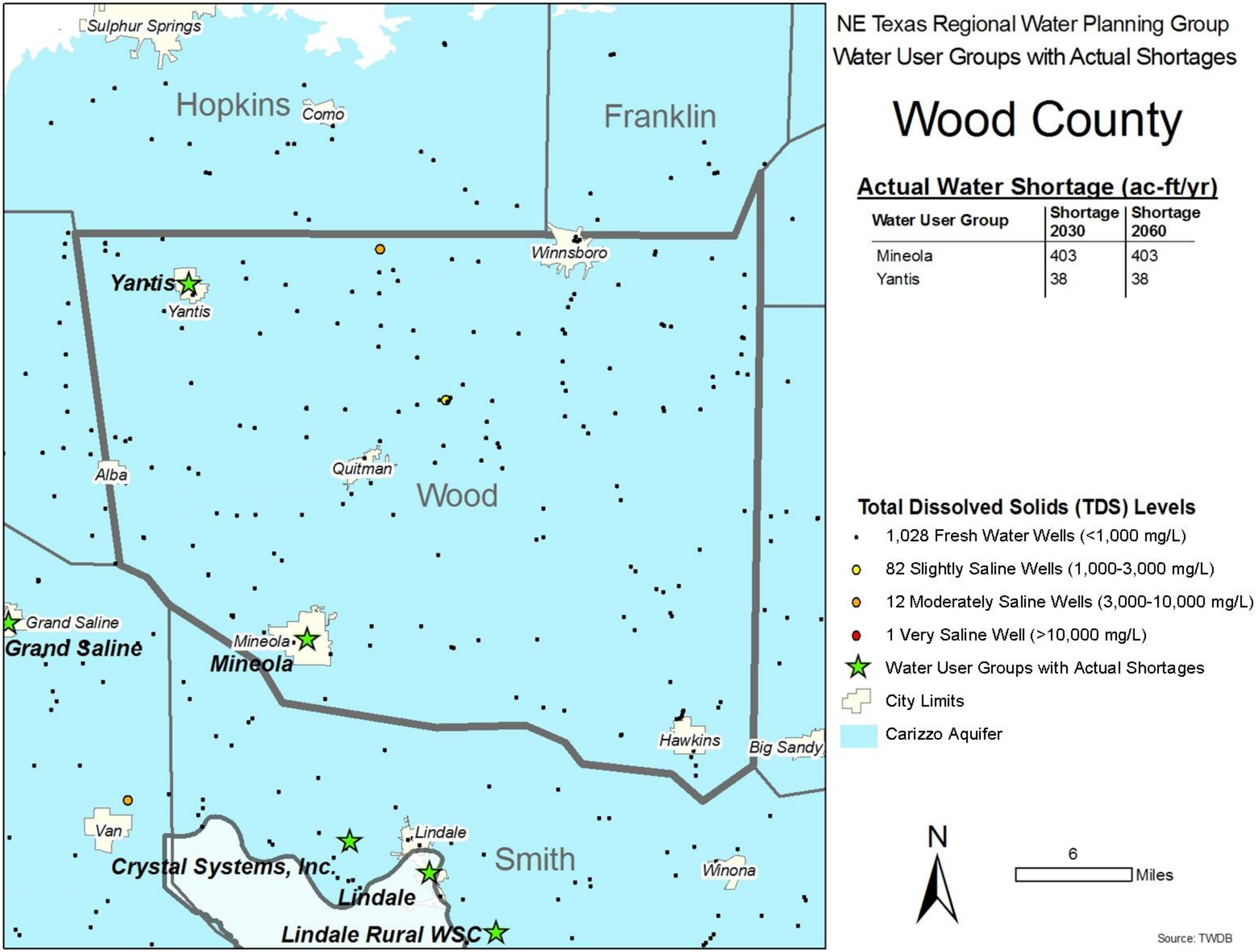
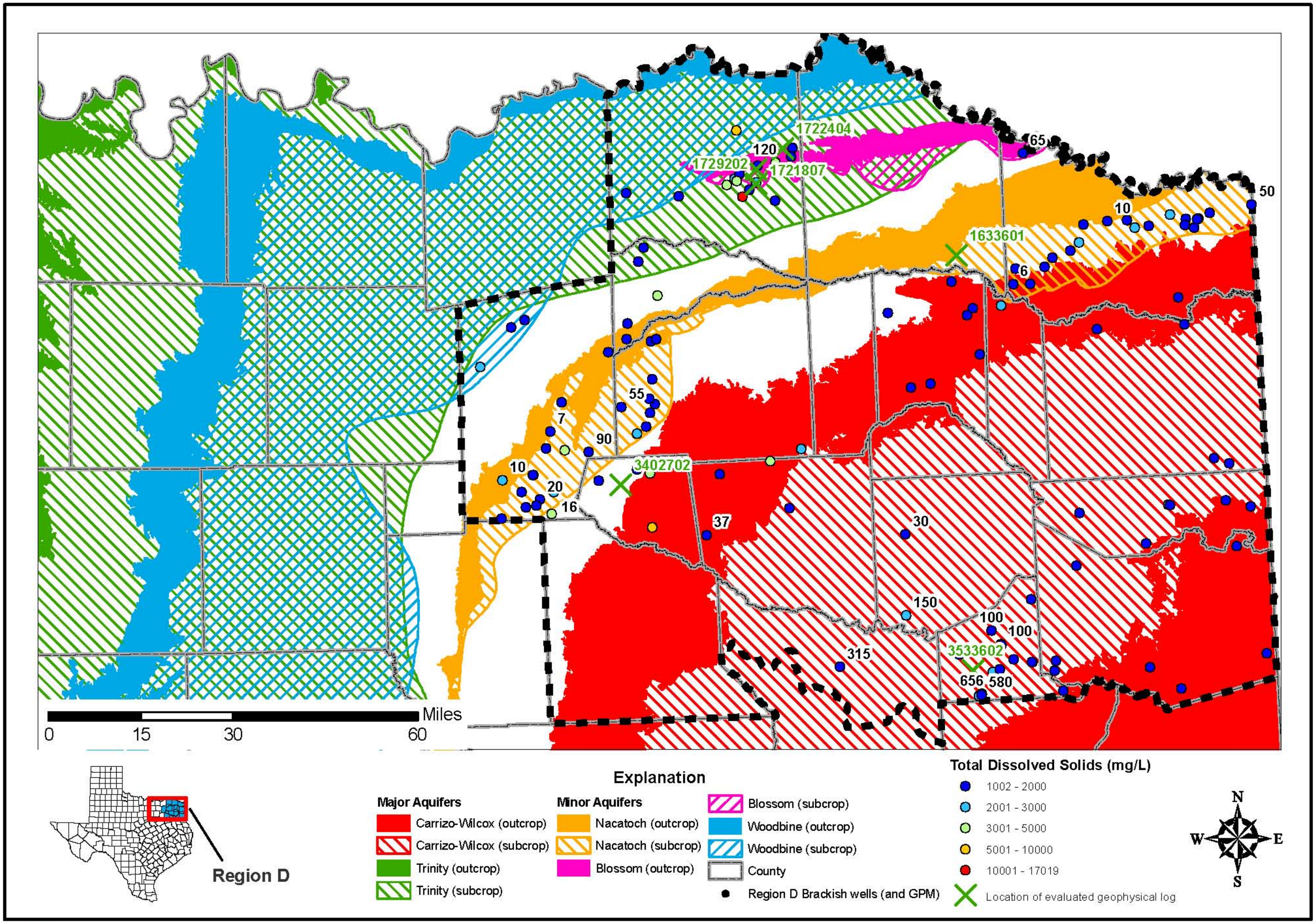


Figure 15: Wood County



REGION D BRACKISH WELLS AND CAPACITIES

FIG

LBG-GUYTON ASSOCIATES

Figure 16: Region D Brackish Wells and Capacities

3.5 Disposal of Desalination Concentrate

Concentrate disposal can represent a primary cost item of utilizing brackish groundwater. There are often environmental and legal constraints against discharging liquid wastes from a desalting plant into surface waters or underground (USBOR 2003). There are five major methods of concentrate disposal: 1) disposal to wastewater treatment plants, 2) disposal to surface waters, 3) deep-well injection, 4) evaporation ponds and 5) evaporation to dryness (crystallization). Others methods that have been utilized but are less attractive include land application, including treatment wetlands, and other developing technologies. TWDB reports that of based on information collected from 38 public drinking water facilities that desalinate brackish groundwater, about 37% of the plants discharge to a surface water body, 24% to a municipal sewer, 21% discharge to an evaporation pond, about 13% utilize land application and about 5% remain unknown. At least one facility, the Kay Bailey Hutchinson (El Paso-Fort Bliss) Desalination Facility is using deep well injection (USEPA Class V injection well) to dispose of concentrates from desalination. The plant came online on August 8, 2007 and it is the first such plant in Texas to use this disposal option.

3.6 *Please Pass the Salt* Study

Of the various disposal options, this study specifically investigated the potential of deep-well injection by reviewing the TWDB report *Please Pass the Salt: Using Oil Fields for the Disposal of Concentrate from Desalination Plants*, *TWDB Report 366*, by Robert E. Mace, Ph.D., P.G. and others. Dr. Mace, Director of the Groundwater Resources Division of TWDB, and others provide an in-depth investigation of the possibility of injecting concentrate into oil and gas fields where formation pressures have been greatly lowered due to past oil and gas production. The authors believe that the cost of concentrate disposal could be reduced if water users could dispose of concentrate down the same or similarly equipped wells that accept oil field brines (TWDB 2006). However, the report highlights the fact that Texas permitting does not specifically allow for desalination disposal via deep-well injection. Instead, desalination plant operators are expected to apply for a Class I permit, which can require millions of dollars and years to permit, instead of using a Class II permitted well, which only requires thousands of dollars and months to permit (TWDB 2006). Class I wells are designed to inject fluids of hazardous, industrial or other domestic wastes beneath the lowermost formation containing an underground source of drinking water that lies within a ¼ mile of the well bore. Class II wells are designed to inject fluids that are brought to the surface in connection with oil and gas exploration or the storage of hydrocarbons (TWDB 2006).

Oil and gas fields exist in much of Texas requiring disposal of brine. Producers need to dispose of the brine that is associated with oil and gas production and therefore inject it back into the field (TWDB 2006). In Texas, there are over 31,000 active permitted injection wells in oil and gas fields and these fields are likely to be near sources of brackish water.

The East Texas Basin was one of six analysis areas of the *Please Pass the Salt* study (Figure 17). The authors (Mace and others, 2006) state that the selection of the analysis areas was based on the location of (1) mature oil and gas fields (Figure 18), (2) oil and gas fields from various geological basins (Figure 19), (3) Class II injection wells (Figure 20), (4) areas with unmet water needs (Figure 21) or an interest in desalination to meet future water needs, and (5) available brackish groundwater resources (Figures 4 and 17). Based on these maps and additional criteria, such as available brackish groundwater resources and general characterization, the authors identified the six analysis areas from different basins across the state. The basins considered include the Anadarko basin, the East Texas basin, the Permian basin, the Gulf Coast basin, the Fort Worth basin, and the Maverick basin. These analysis areas are representative of Texas basins; reservoirs; and brackish and formation waters; and are representative of typical scenarios in the rest of the State (TWDB 2006).

In the NETRWPA there are locations where brackish water samples were tested by TWDB 2006. These show there is a good supply of brackish water in the NETRWPA. The locations of these samples are shown in Figure 22.

The conclusions of *Please Pass the Salt* are summarized in the Figure 23 along with the locations of identified major oil and gas reserves in NETRWPA. In the table included in Figure 23 (*Pass the Salt* Summary of Conclusions), the East Texas study area received "High" relative scores in the categories of injection rate and pressure depletion, a "Medium" relative score for scaling and a "Low" relative score for water sensitivity. The East Texas study area had the highest median injection rate at approximately 466 gallons per minute (gpm). The low relative score for water sensitivity rating indicates concentrate injection in the East Texas Basin could present a challenge. However, the report concludes that with careful analysis and pretreatment of the concentrate, if necessary, injection into the North East Region is very feasible.

Table 4 demonstrates the relative proximity of WUGs to oil and gas fields. Nineteen of the 32 WUGs with actual shortages are within five miles of oil and gas fields and received a "High" rating for Relative Estimated Likelihood of Use for well injection. This suggests that siting of wells or transportation of concentrate would be less expensive and therefore more likely for these WUGs. These include WUGs in the counties of Cass, Gregg, Harrison, Smith, Upshur and Van Zandt (see Table 4).

Please Pass the Salt concludes by stating that injection of desalination concentrate into oil and gas field is technically feasible and recommends several options for making the permitting process easier and more affordable.

An update to this aspect is that the TCEQ is proposing to issue a general permit (Proposed General Permit No. WDWG010000) authorizing the use of a Class I injection well to dispose of nonhazardous brine from a desalination operation or nonhazardous drinking water treatment residuals. It is unclear to what level of improvement this will afford, but Mace in TWDB 2006 states, "A general permit would greatly simplify and decrease the time to attain a Class I permit. A general permit would involve getting a permit for a general class of injection wells. In this case, the general class of wells would be concentrate injection wells. Approval of the general permit requires going through the full approval process of a Class I injection well. Once a general permit is attained, anyone can apply for a permit under the general permit. If those permits meet the requirements set forth in the general permit, then the permit is granted. The advantage of the general permit is that it reduces the permitting process to an administrative review. If the application meets the requirements set forth in the general permit, the permit is granted. Therefore, instead of taking one to three years to attain a Class I permit, it might take as little as 60 days for a complete application. Implementation of a general permit would require approval of the concept of general permitting by TCEQ." The notice for public comment on the proposed general permit is attached in Appendix D. More information can be found at http://www.tceq.state.tx.us/permitting/waste_permits/advgroups/uicgp.html

3.7 WUG Proximity to Oil/Gas Reserves and Known Brackish Groundwater Study

The prevalence of oil and gas well fields was examined by referencing information contained in TWDB 2006 and Guyton 2003. The proximity of oil and gas fields in relation to WUGs with Actual Shortages was analyzed with results presented in Table 4 (page 46). This listing indicates the relative feasibility – high, moderate, or low - of a WUG using depleted or non-producing oil or gas wells for the injection of brine concentrate, based on physical distance. Eighteen of the 32 WUGs with Actual Shortages appear to existing within five miles of oil or gas reserves. This analysis assumes that regulations pertaining to the injection of brine concrete become less onerous in the future.

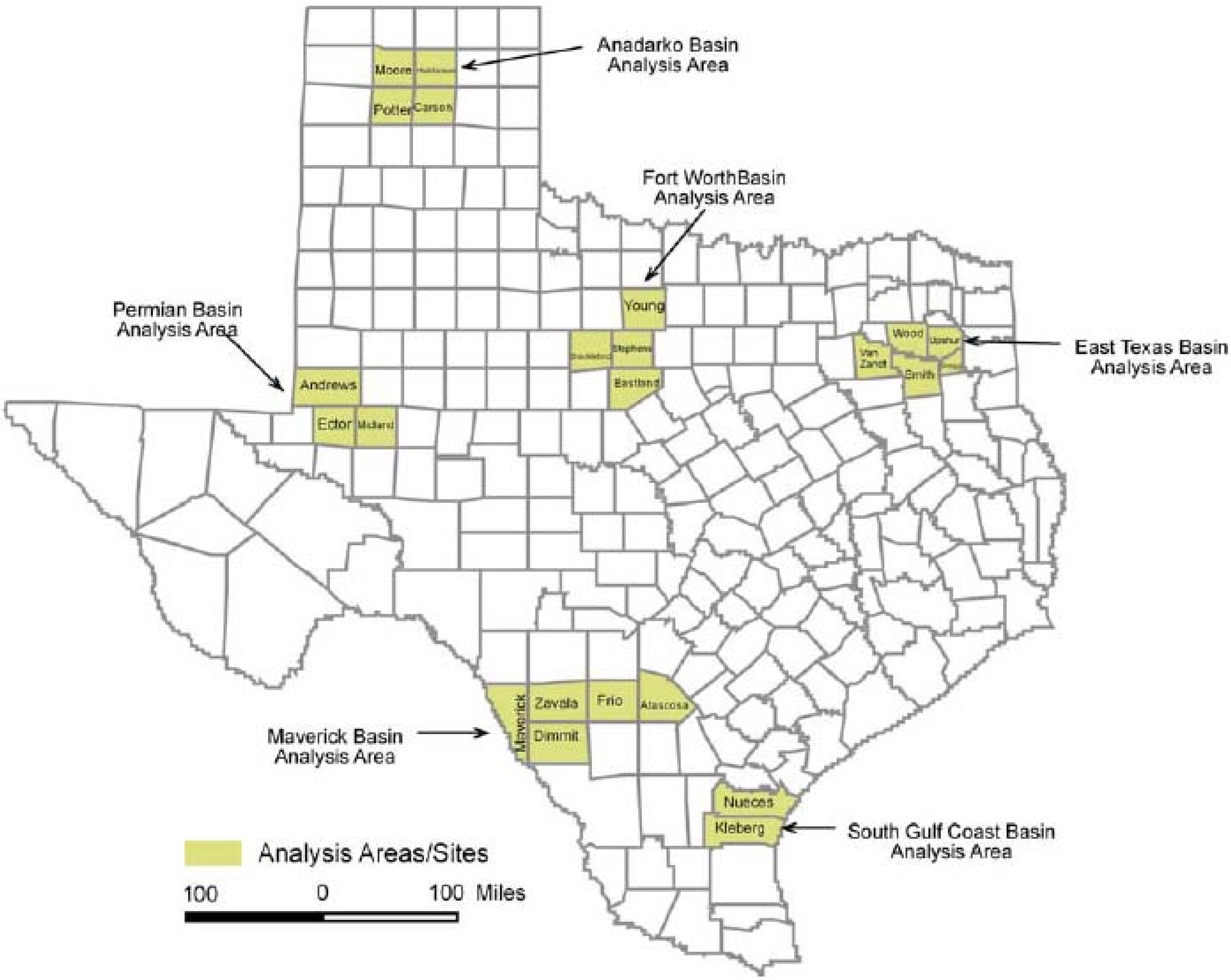


Figure 17: Locations of analysis areas (TWDB 2006)

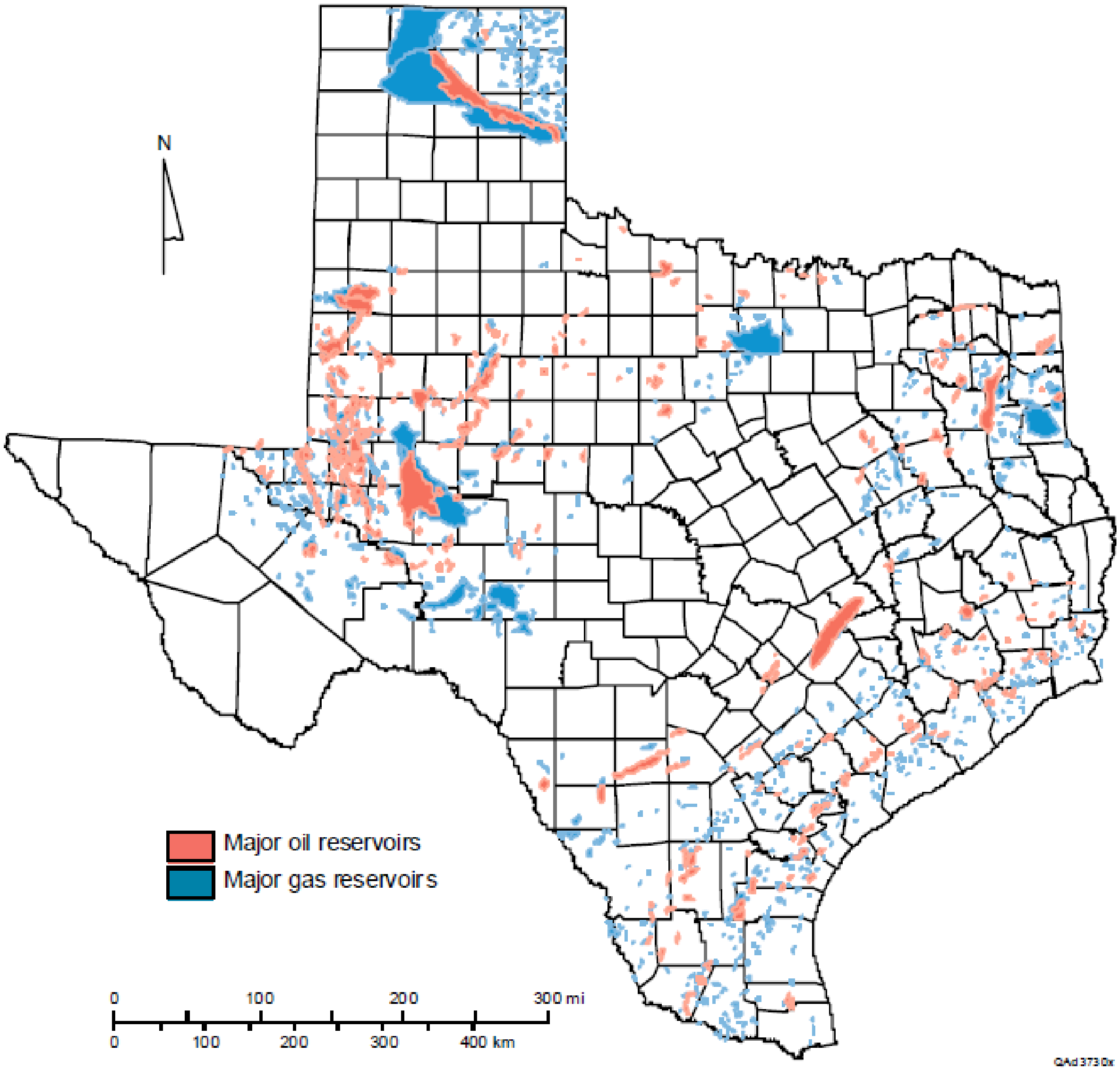


Figure 18: Location of major oil and gas reservoirs in Texas. (TWDB 2006)

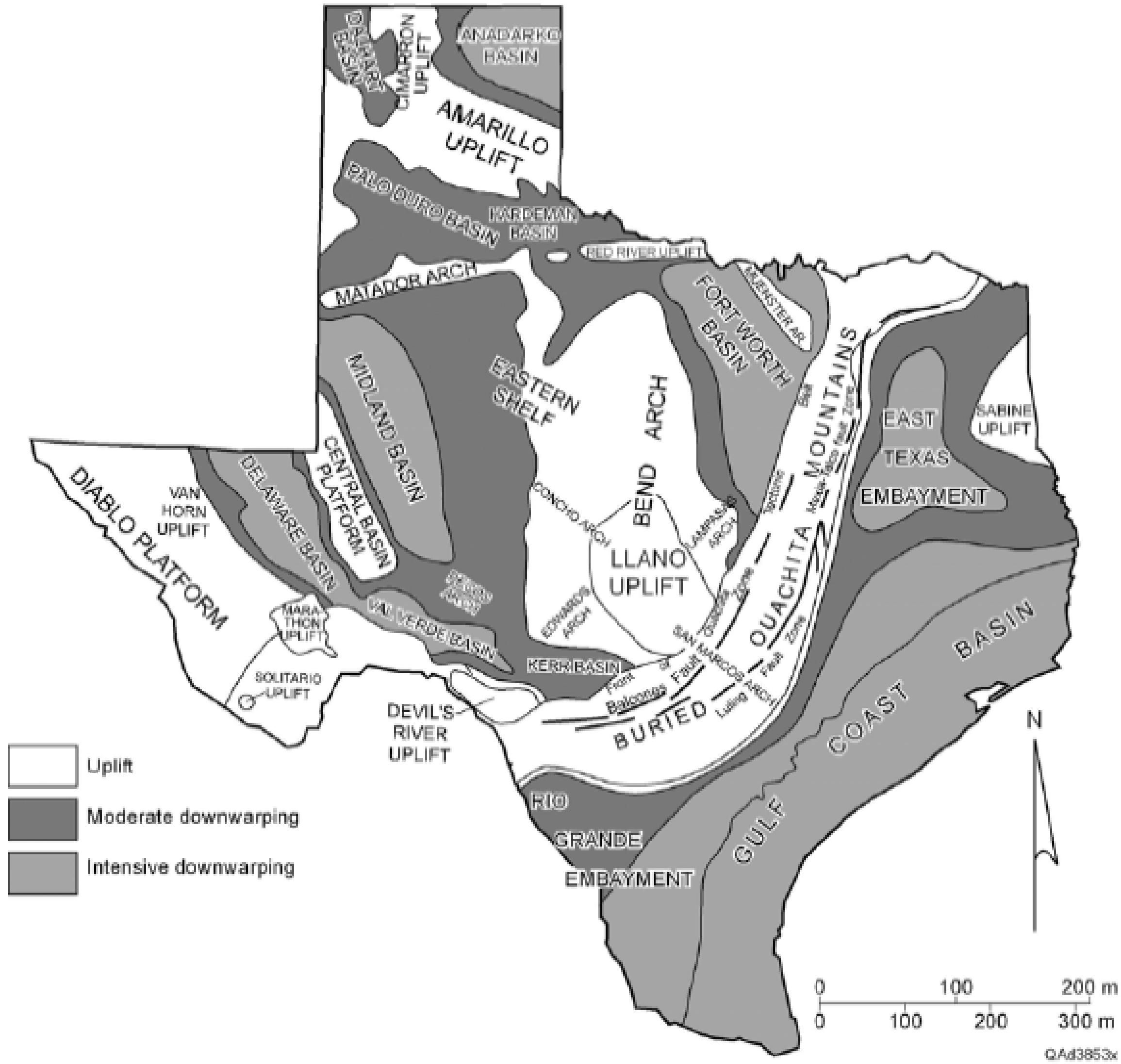
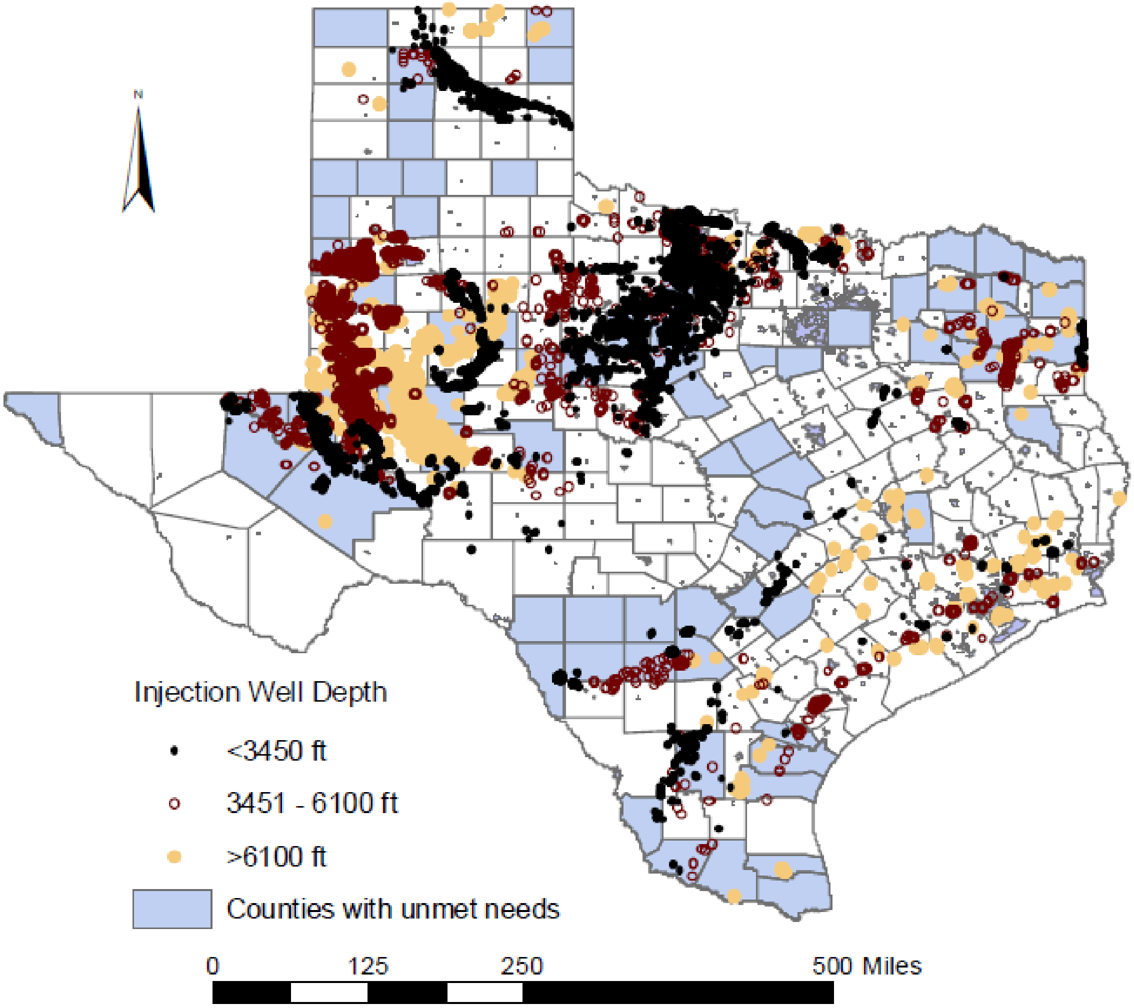


Figure 19: Generalized tectonic map of Texas showing location of sedimentary basins (TWDB 2006)



Note: Class II injection wells split into 3 depth groups of equivalent size (~25,000 points with depth information ou of ~30,000 active injection wells).

Figure 20: Locations of Class II injection wells in Texas with corresponding completion depths. Counties with water-supply needs are shown in blue. (TWDB 2006)

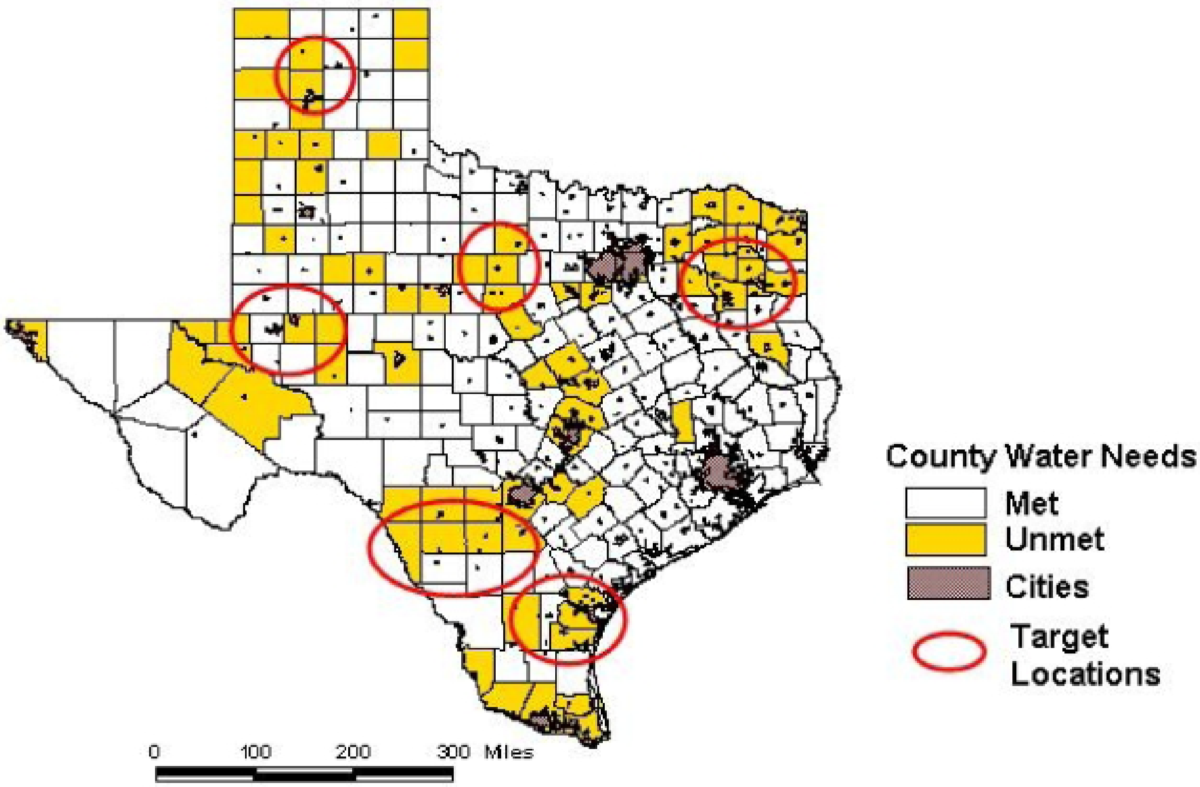


Figure 21: Texas counties with water-supply needs in 2050 (TWDB 2006)

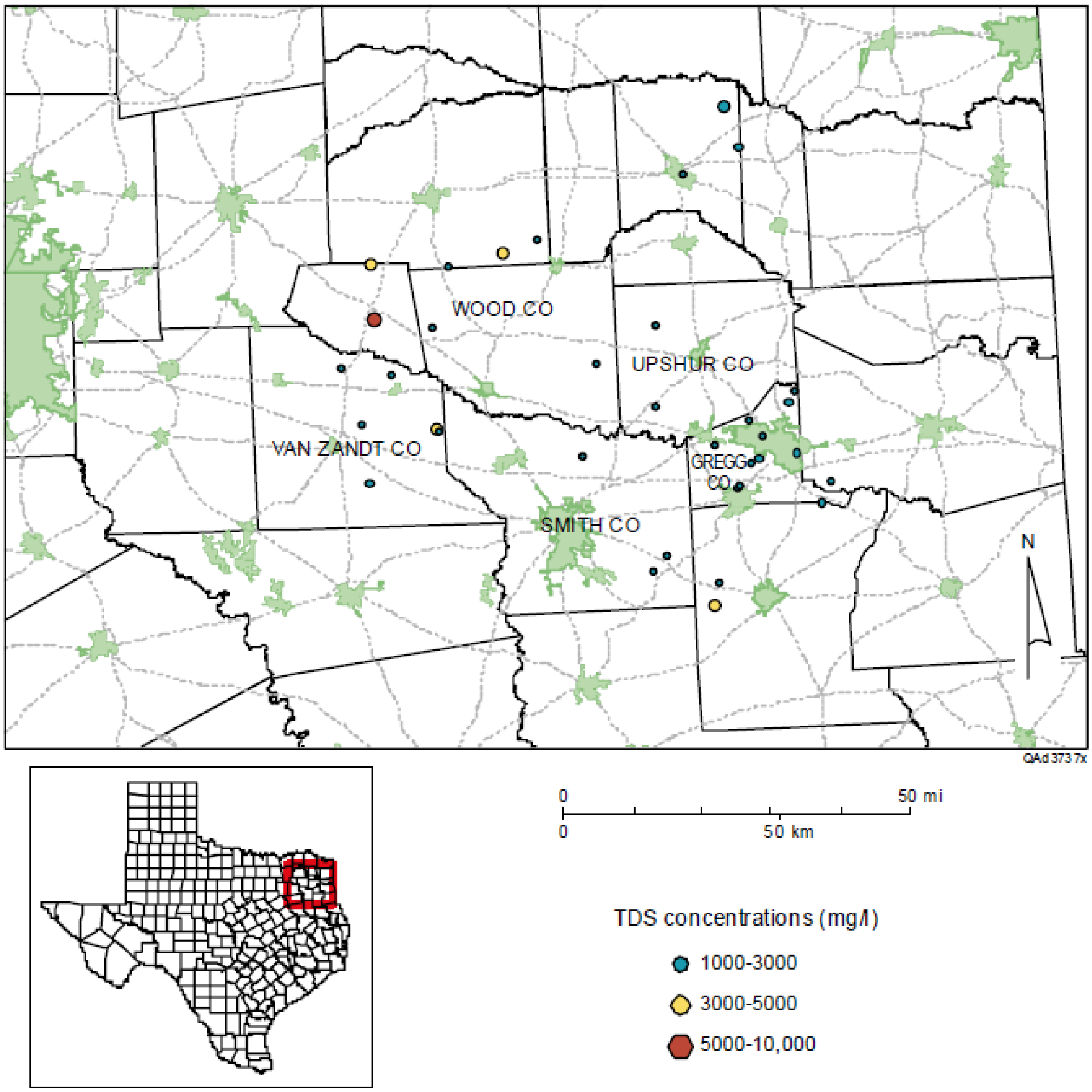


Figure 22: Location of brackish water samples with TDS concentrations (TWDB 2006)

Please Pass the Salt Summary of Conclusions

Basin	Score relative to scaling	Score relative to water sensitivity	Score relative to injection rate	Score relative to pressure depletion
Anadarko				
	Medium	High	Low	Very High
Permian				
	Medium	High	Low	High
East Texas				
	Medium	Low	High	High
Fort Worth				
	Medium	Medium	Low	High
Maverick				
	Medium	Medium	Low	High
Southern Gulf Coast				
	Medium	Low-Medium	High	High

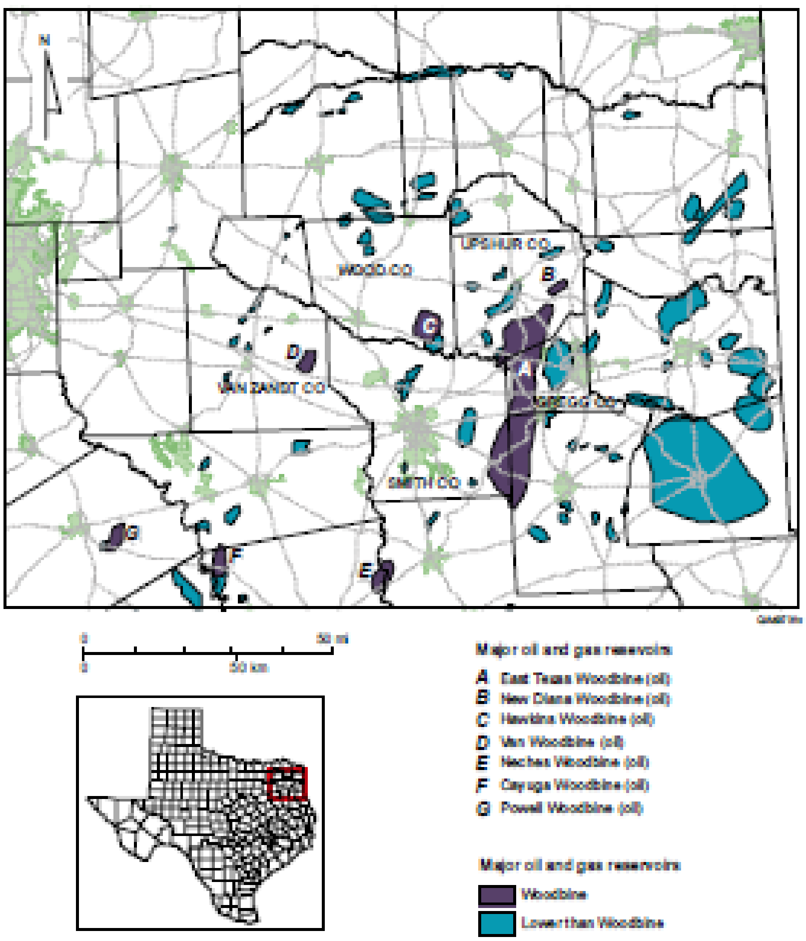


Figure 23: Please Pass the Salt Summary of Conclusions and Major Oil and Gas Reserves in the East Texas Analysis Area (TWDB 2006)

Table 4: Water User Groups with "Actual" or "Physical" Shortages with Existing Recommended Groundwater Strategies - Proximity to Oil/Gas Reserves and to Known Brackish Groundwater (BGW); Relative Estimated Likelihood to Use Deep-Well Injection Concentrate Disposal Based on Proximity to Oil/Gas Reserves (analysis from information obtained from Guyton 2003 and TWDB 2006)

Water User Group	Population Served		Shortage (ac-ft/yr)		Groundwater Strategy (ac-ft/yr)		Proximity to known Oil & Gas Reserves, approx. miles	Proximity to known BGW Wells/Samples, approx. miles	Relative Estimated Likelihood of Use*
	2030	2060	2030	2060	2030	2060			
Camp County									
Woodland Harbor	588	588	65	65	65	65	10	20	Moderate
Cass County									
Linden	2,482	2,575	101	104	215	215	5	+20	High
Gregg County									
Clarksville City	1,148	1,682	148	217	162	242	<1	<5	High
Liberty City WSC	5,647	8,485	287	678	376	752	<1	<5	High
West Gregg SUD	4,233	6,382	56	333	70	350	<1	<5	High
Starrville-Friendship WSC	1,574	2,386	0	101	0	108	<1	<5	High
Harrison County									
Waskom	3,485	4,240	54	151	88	176	2	+20	High
Blocker-Crossroads WSC	1,010	1,225	100	128	129	129	7	+20	Moderate
Caddo Lake WSC	1,249	1,515	19	52	43	86	5	+20	High
Leigh WSC	2,161	3,139	0	36	0	43	1	+20	High
Scottsville	871	1,057	0	7	0	65	2	+20	High
Talley WSC	1,664	2,020	97	142	118	177	1	+20	High
Hopkins County									
Miller Grove WSC	1,218	1,071	24	6	35	35	20	<1	Low
Hunt County									
Campbell WSC	1,303	5,917	101	773	108	108	+20	5	Low
Hickory Creek SUD	3,664	12,508	271	1,667	2,702	1,882	+40	5	Low
West Leonard WSC	72	245	5	28	81	81	+40	10	Low
Smith County									
Crystal Systems, Inc.	4,357	6,649	0	425	0	538	8	15	Moderate
Lindale Rural WSC	3,086	4,709	0	189	0	215	<1	10	High
Lindale	4,201	7,010	0	374	0	376	5	8	High
Star Mountain WSC	1,516	2,313	0	83	0	108	10	12	Moderate
Upshur County									
Pritchett WSC	6,478	6,998	0	51	0	54	2	5	High
Van Zandt County									
Bethel Ash WSC	617	797	0	17	0	81	6	10	Moderate
Canton	4,012	4,613	217	349	291	387	2	2	High
Grand Saline	3,863	4,560	143	255	323	323	5	2	High
R P M WSC	2,021	2,610	30	99	37	102	8	15	Low
Corinth WSC	1,170	1,511	0	23	0	27	2	6	High
Crooked Creek WSC	932	1,204	21	56	59	59	5	6	High
Edom WSC	1,372	1,771	34	86	43	86	4	15	High
Fruitvale WSC	4,010	5,179	119	269	129	301	5	3	High
Little Hope-Moore WSC	2,211	2,855	78	161	113	188	7	3	Moderate
Wood County									
Mineola	6,814	6,858	374	360	403	403	15	15	Low
Yantis	633	637	20	18	38	38	6	3	Moderate

* Ratings for Relative Estimated Likelihood to Use Deep-Well Injection Concentrate Disposal Based on Proximity to Oil/Gas Reserves is based on the following:
High: 0 - 5 miles; Moderate: 5 - 10 miles; and Low: >10 miles, from known oil and gas reserves.

4.0 COMPARISONS OF BRACKISH WATER COSTS

This section will discuss typical capital and annual operations and maintenance costs of treating brackish groundwater. Comparisons to other alternatives will be discussed within the case studies and current national average water rates will be presented. Most desalination costs presented herein are specific to the reverse osmosis (RO) process of treatment as the vast majority of brackish groundwater is treated in this manner. Primary cost constituents will be evident in the cost comparisons.

4.1 TWDB Commissioned Reports

First to be considered in this section is the cost analysis of groundwater desalination methodology of LBG-Guyton Associates report Brackish Groundwater Manual for Texas Regional Water Planning Groups, February 2003, to the TWDB. The methodology in the Guyton report is largely supported by Desalination for Texas Water Supply, by HDR and others, August 2000, also a TWDB commissioned report. Findings of NRS Consulting Engineers work in the Rio Grande Valley supplements the Guyton report.

A costs overview and general estimated range of costs based on the Guidance Manual for Reverse Osmosis Desalination Facility Permitting Requirements in Texas, by R.W. Beck, Inc., from November 2004 will be included. Additionally, information from Guidance Manual for Brackish Groundwater Desalination in Texas, an NRS authored report to TWDB from April 2008. This report presents cost data from the North Cameron Regional Water Supply Corporation RO project 2007 completed project. Reference was also made to Desalination Handbook for Planners, 3rd edition, U.S. Department of the Interior Bureau of Reclamation, July 2003.

Case studies from the City of Clarksville City, City of Tatum and the Southmost Regional Water Authority will be examined. Information for these entities was obtained by personal communications and published reports.

4.2 Cost Analysis for Treatment of Brackish Groundwater – Methodologies from Guyton 2003 and HDR 2000 Reports

HDR 2000 presents detailed information about capital and construction and operation and maintenance (O&M) costs for brackish groundwater desalination facilities. The report gives costs estimates for essential elements of a desalination system. Referenced figures from HDR 2000 and Guyton 2003 are included herein. Additional information may be gained by reviewing the reports in their entirety, especially HDR Section 6 – Costs of Water Desalination Using Membranes and Guyton Section 4.0 Cost Analysis of Groundwater Desalination.

HDR survey responses to reasons for constructing membrane facilities included the following as reasons that desalination was used (specific response numbers are shown in parentheses): TDS (11); TDS and hardness (3); arsenic (1); and, sulfate and radionuclides (1).

Survey responses to concentrate disposal methods included the following: ocean outfall (5); surface water discharge (3); groundwater injection (1); discharge to sanitary sewer (3); and, percolation plus evaporation (4).

Capital and O&M costs are aggregated into one cost curve representing total treated water unit cost for membrane desalination. This is shown in Figure 24 on the following page. The total capital cost was divided by the present plant capacity to yield the unit cost for plant construction in dollars per gallon per day ($/gpd). Annual debt service was computed using 8 percent over a 20-year period.

The Guyton 2003 report provided simple formulas for the calculation of the data found in the HDR report. The formula for total treatment cost (TTC) based on plant capacity, for year 2000 US dollars, is shown in Equation 1 below, by Guyton 2003, based on HDR 2000 (Figure 1 in this report):

Equation 1: $TTC = -0.071C + 2.43$
where:
TTC = total treatment cost in $/Kgal
C = plant capacity in MGD

Their total treated water cost are the sum of the amortize capital costs and the O&M costs. Capital was amortized over 20 years at 8% interest. The above relationship was developed without consideration of TDS concentration in the brackish groundwater and was based on 2000 dollars.

In 2000, two relevant costs indices were:

Engineering News Record Construction Cost Index:	6221
Engineering News Record Building Cost Index:	3539

The same indices for November 2008 are estimated to be:

Engineering News Record Construction Cost Index:	8602
Engineering News Record Building Cost Index:	4847

The average factor of these two national indices is 1.38. Therefore, a factor of 1.38 has been applied to the surveyed costs compiled in the HDR report. The HDR survey consisted of 11 desalination plants, ten of which use the RO process and one using the electrodialysis reversal (EDR) process. It gives an approximate range of total treated water costs of $1.50/Kgal to $2.75/Kgal (2000 U.S. dollars). In 2008 US dollars this equates to $2.07/Kgal to $3.80/Kgal.

Using Equation 1 methodology for a system with 1 MGD capacity yields a TTC of $2.36/Kgal. Multiplying $2.36 by 1.38 to adjust for 2008 dollars equates to $3.26/Kgal. One MGD equates 365 MG/year, or 365,000 1000 gallon units. Therefore, TTC for one year equals $3.26/Kgal multiplied by 365,000 Kgal equaling $1,189,900 in annual costs. Using Figure 1 below one would extrapolate approximately the $2.36/Kgal figure above and then convert it to 2008 dollars.

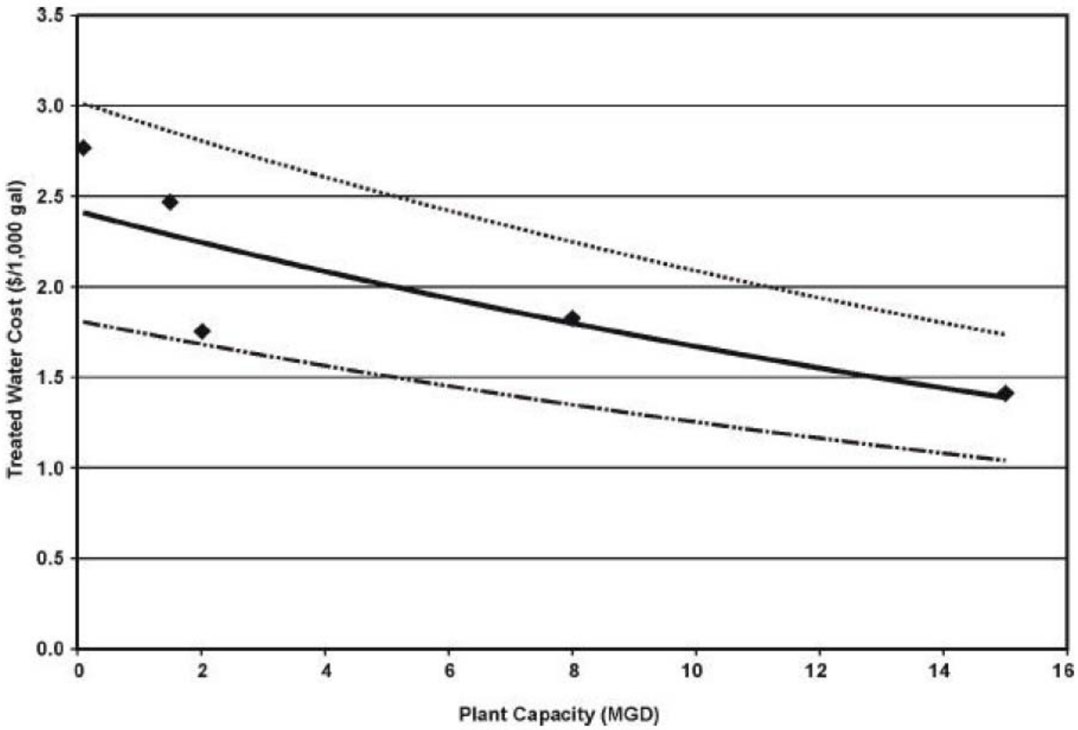


Figure 24: Total Treatment Cost for Brackish Groundwater Desalination (HDR 2000)

A more complete picture of cost may be gained by referring to the original reports for complete discussions of the assumptions incorporated into the above and forthcoming analyses. Additionally, TDS levels, operating pressures, site specific conditions, technological advances, disposal options, regulations and fluctuating energy and construction costs will greatly influence the approximate estimation tools presented in this section.

A table presented in HDR 2000 is shown below (Table 5) varies slightly from the above discussion in that its range of total treatment costs is $0.71/Kgal to $2.37/Kgal, which equate to $0.98/Kgal to $3.27/Kgal in November 2008 dollars.

Therefore, combining the HDR 2000 and Guyton 2003 methodologies the NETRWPG should expect that the range of total treatment cost would be $0.98/Kgal to 3.80/Kgal in November 2008 dollars. Considering increasing construction costs and this current economic period, costs should be in the upper reaches of this range. As will be discussed later, the City of Clarksville City is experiencing costs above this range for an entirely new facility.

Brackish Water Treatment Costs
for Water Needing Minimal Pre-Treatment

Item	*Estimated Costs 0.1 MGD*	*Estimated Costs 0.5 MGD*	*Estimated Costs 1 MGD*	*Estimated Costs 3 MGD*	*Estimated Costs 5 MGD*	*Estimated Costs 10 MGD*
Water Treatment Plant	$478,000	$1,077,000	$1,823,000	$3,946,000	$5,718,000	$9,097,000
Engineering, Legal Costs and Contingencies (35%)	167,000	377,000	638,000	1,381,000	2,001,000	3,184,000
Interest During Construction (1 years)	29,000	65,000	109,000	237,000	343,000	546,000
Total Project Cost	**$674,000**	**$1,519,000**	**$2,570,000**	**$5,564,000**	**$8,062,000**	**$12,827,000**
Annual Costs						
Debt Service (6 percent for 30 years)	$49,000	$110,000	$187,000	$404,000	$586,000	$932,000
O&M - Water Treatment Plant	37,544	112,103	209,522	541,840	864,519	1,647,977
Total Annual Cost	**$86,544**	**$222,103**	**$396,522**	**$945,840**	**$1,450,519**	**$2,579,977**
Available Project Yield (acft/yr)	**112**	**560**	**1,120**	**3,360**	**5,601**	**11,202**
Annual Cost of Water ($ per acft)	**$773**	**$397**	**$354**	**$281**	**$259**	**$230**
Annual Cost of Water ($ per 1,000 gallons)	**$2.37**	**$1.22**	**$1.09**	**$0.86**	**$0.79**	**$0.71**

Notes:

TDS range from 1,000 mg/L to 3,000 mg/L, Feedwater pressure 300 psi, Recovery Rate 80%, Power cost $0.06 per kWh.

Costs Not Included: Source Water Development, Concentrate Disposal, Finished Water Storage and Pumping, Distribution, Environmental/Archaeology, Land Acquisition, and Surveying

Table 5: Brackish Water Treatment Costs (HDR 2000)

4.2.1 Capital Costs

Figure 25 is presented in the HDR and Guyton reports. It illustrates the estimated capital costs associated with brackish groundwater desalination in year 2000 dollars. A comparative range of values in 2008 dollars is approximately $2.76/gpd to $5.52/gpd. Again, it should be noted that the Figure 25 represents 11 desalination facility respondents.

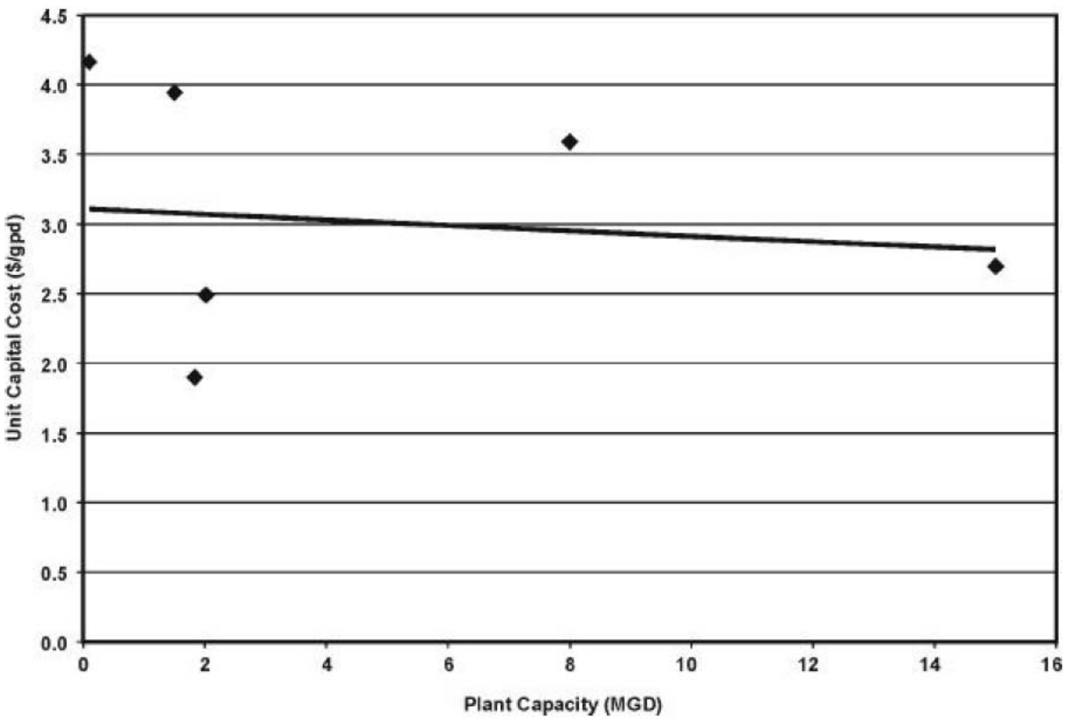


Figure 25: Capital Costs Associated with Brackish Groundwater Desalination (HDR 2000)

4.2.2 Operation and Maintenance Costs

Figure 26 (HDR 2000) illustrates the estimated O&M costs associated with brackish groundwater desalination in 2000 dollars. In 2008 dollars this represents a range of $0.83/Kgal to $2.21/Kgal. The estimate of operation and maintenance costs includes the cost of personnel, chemicals, power, membrane parts replacement, and concentrate disposal. Again, TDS concentration will be a primary determinate of O&M costs.

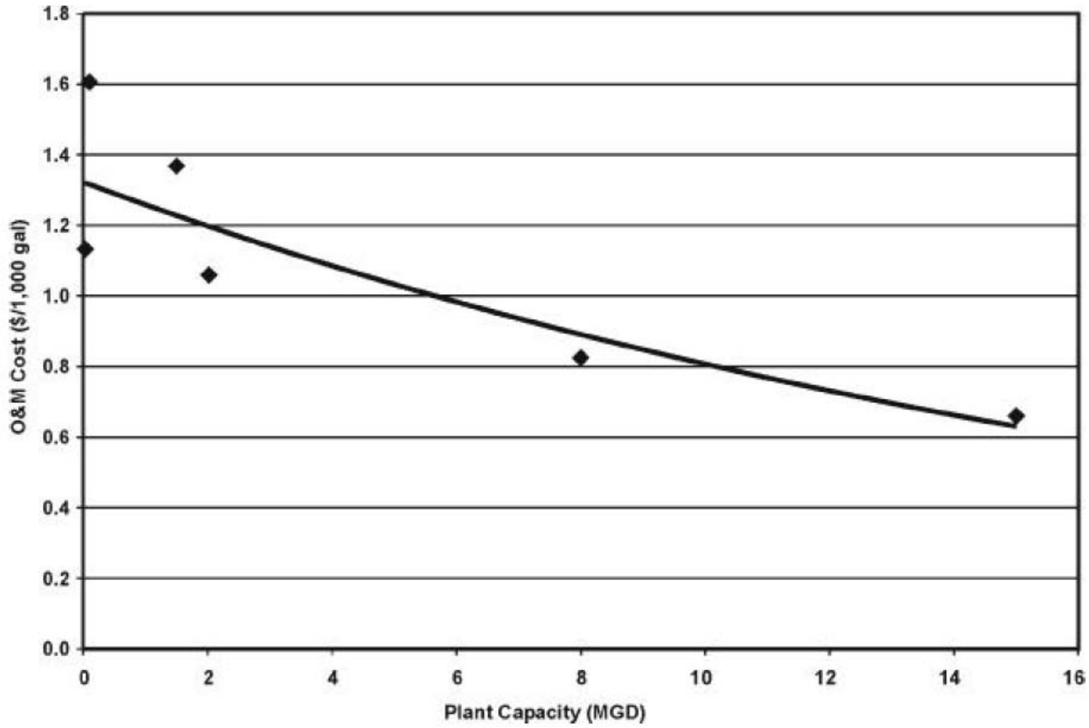


Figure 26: O&M costs for Brackish Groundwater Desalination (HDR 2000)

4.2.3 Energy Costs

Guyton 2003 and other reports indicate that one of the most significant cost factors for brackish groundwater desalination is the cost of energy to force brackish groundwater through the membranes. The higher the TDS level the higher the energy costs. Figure 27 shows circa 2003 data compiled by NRS Consulting Engineers indicating the effect of variable power costs on the total energy costs required to treat 3,000 mg/L TDS source water. Recent advances in energy recovery of these systems can lower the power cost of the facility. In addition, energy deregulation allows for shopping of power for lower costs (Guyton 2003).

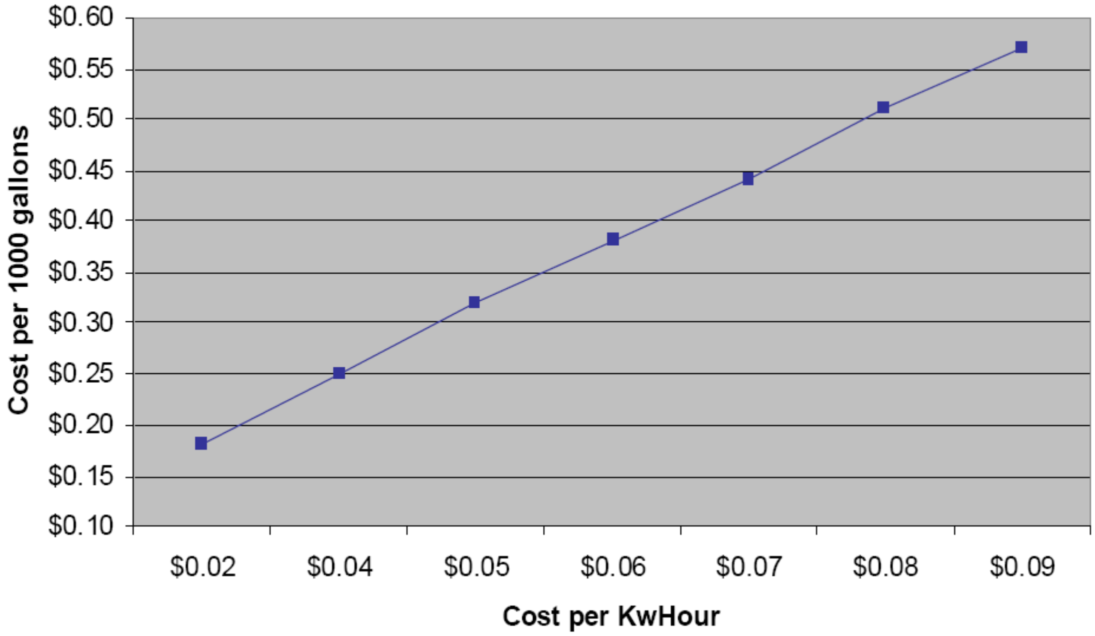


Figure 27: Recent Data (circa 2003) indicating the Effect of Power Costs for Treating 3,000 mg/L Brackish Groundwater (Guyton 2003; Data Compiled by NRS Consulting Engineers)

4.2.4 Cost of Wells for Source Water

In their February 2003 study, LBG-Guyton Associates created a table to roughly estimate the costs associated with additional wells or well field development (Table 6). Pursuant to the Guyton 2003 report, these cost relationships are "rule-of-thumb" in nature and they represent construction methods required for public water supply wells. As Guyton states, "The cost relationships do not include engineering, contingency, financial and legal services, land costs, or permits. A more detailed cost analysis should be completed prior to developing a project."

Additionally, Guyton reported, "The generic cost relationships are developed for wells of different well casing diameter. A cost relationship was developed for wells ranging from 6 to 16 inches in diameter and each relationship includes the variables for discharge and well depth. The pump costs assume that the pump is set at 300 feet below ground surface and that the lift is 300 feet. Pump depth and lift requirements will vary in each situation and may need to be adjusted for individual projects."

Table 6: Estimated Well Costs for Brackish Water Production Wells (Guyton 2003)

Well Diameter (inches)	Typical Production Range (gpm)	Estimated Cost (2002 $) a=production rate (gpm), b= well depth (feet)
6	25-150	7000 + 68a + 60b
8	150-300	10000 + 65a + 140b
10	300-500	15000 + 63a + 180b
12	500-800	20000 + 60a + 225b
16	800-2000	22000 + 60a + 320b

Using the cost relationships in Table 6, a 700 gpm well with a total depth of 1,000 feet would cost approximately $287,000 in 2002 dollars. The Engineering News Record Construction Cost 2002 index was 6538, divided into 8602 (2008 index) gives the factor of 1.32. Multiply $287,000 by 1.32 to obtain a 2008 dollars estimate of $378,840.

The costs associated with conveyance systems for multi-well systems can vary widely based on the distance between wells, terrain characteristics, well production, and distance to the treatment or brine disposal facility. These costs should be estimated using standard engineering approaches and site-specific information.

4.2.5 Concentrate Disposal

Concentrate, brine or waste product is a primarily concern and cost factor for groundwater desalination. Concentrate disposal options include the following:

- Direct surface water discharge
- Pre-discharge mixing
- Disposal to wastewater treatment
- Deep-well injection
- Land application
- Evaporation ponds

and innovative and emerging technologies such as,

- Zero Liquid Discharge (ZLD)
- Vibratory Separation Enhanced Process (VSEP)
- Treatment wetlands
- Other hybrid approaches

The estimated costs of some brine disposal options are highlighted below.

The following sections 4.2.6, 4.2.7, and 4.2.8 on brine disposal and concentrate management are excerpted from Guyton 2003, for completeness.

4.2.6 Cost Estimates for Brine Disposal Methods

USBOR 2001 documented membrane concentrate disposal practices and the regulations that impact disposal systems and techniques. This report was based on the findings from a detailed survey of 149 membrane plants that included 84% of the utility desalting plants (RO, EDR, and nanofiltration) built in the United States between 1993 and 1999. The survey also included 44% of the utility low-pressure membrane (microfiltration and ultrafiltration) plants built during the same period. The report describes cost considerations for concentrate disposal to deep well injection, evaporation ponds, spray irrigation, and zero liquid discharge. Findings of the report regarding disposal via deep-well injection and evaporation ponds are included here as a reference for planners who need to complete preliminary cost analysis. For more details on cost estimation of spray irrigation and zero liquid discharge, please see USBOR 2001.

4.2.7 Deep Well Injection Cost Estimates

The costs of disposal by deep-well injection are subject to many site-specific circumstances – perhaps more so than those of any other disposal method (USBOR 2001).

Potential costs variables include those associated with site terrain, availability of water for drilling and injection testing, subcontractors, geology, drilling difficulty, regulatory issues, and others. USBOR 2001 describes a regression cost model to determine the total capital cost for injection wells based on 35 case studies. It should be noted that most of these wells are located in Florida, and the reader should be aware of any differences which may affect these estimates by referring to the original USBOR 2001 report. The simple formulation for estimating total capital cost for deep-well disposal is shown in Equation 2 below:

$$CC = -288 + 145.9(TD) + 0.754(D) \quad \text{(Equation 2)}$$

where:

CC = total capital cost (x \$1,000)
TD = tubing diameter (inches)
D = depth (feet)

Please note, 2001 Engineering News Record Construction Cost Index for 2001 was 6334. Adjusting to 2008 requires multiplying by 1.36 (2008 index of 8602 divided by 6334 equals 1.36).

Figure 5 shows the relationship between total capital cost for deep-well disposal, well depth, and tubing diameter. For most cost models, the size of the disposal option is based on flow rate of concentrate. For deep-well disposal this is not always the case. Because the material costs are not the major cost factor for the deep injection wells, there is relatively little penalty or additional cost for designing and building a well capable of receiving larger flows. This might be done to allow for future plant expansion or for future shared use of the well. If the tubing and packer requirements were not necessary for disposal of membrane concentrate, the tubing could be removed, resulting in a much larger capacity deep injection well – limited by the diameter of the final casing string (USBOR 2001).

It should be noted that the cost model and regression cost equation are provided only to obtain a preliminary level cost estimate. Site-specific conditions might significantly change estimates for the injection well disposal costs. The availability of suitable subsurface injection zones is a critical issue to be evaluated if deep well disposal is anticipated for a desalination plant.

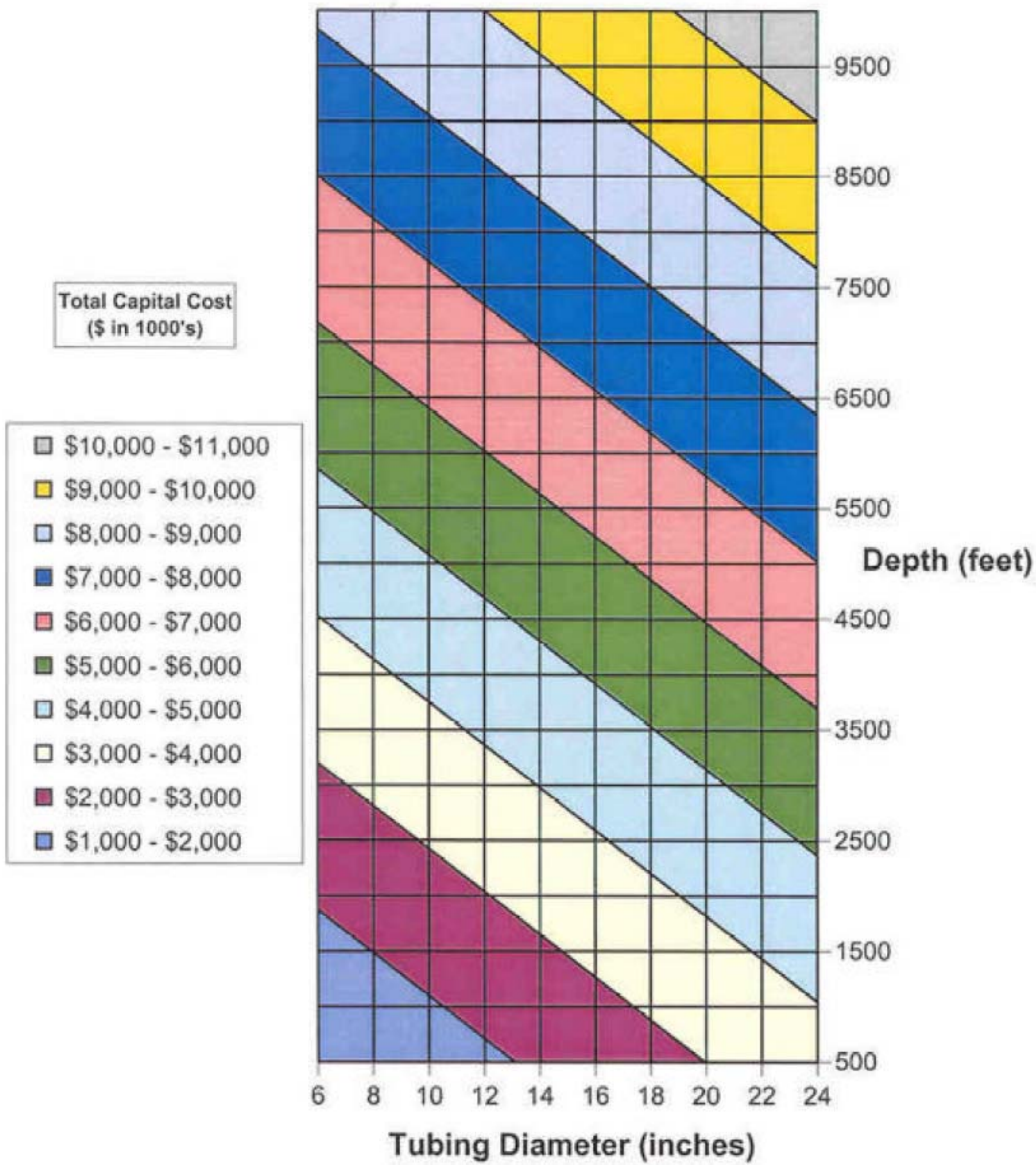


Figure 28: Total Concentrate Disposal Cost as a Function of Tubing Diameter and Well Depth (USBOR 2001)

4.2.8 Evaporation Pond Cost Estimates

Evaporation ponds are a well established method for removing water from a concentrate solution, especially in arid climates. Evaporation ponds for membrane concentrate disposal are most appropriate for smaller volume flows and for regions with relatively high evaporation rates, level topography, and low land costs.

Advantages of evaporation ponds include (USBOR 2001):

- Relatively easy to design and construct.
- Properly constructed evaporation ponds are low maintenance and require little operator attention compared to mechanical equipment and approaches.
- Very little mechanical equipment is required except for pumps to convey concentrate to the evaporation ponds.
- For small volumes of concentrate, evaporation ponds are often the least expensive means of disposal.

Disadvantages may include:

- Requirement for large tracts of land to facilitate evaporation ponds.
- Requirement for clay or synthetic liners, which may increase the construction costs. Leaking ponds can cause groundwater contamination.
- There is little economy of scale due to the nature of the evaporation process, and thus, large flows, expensive land, or uneven terrain can increase the total concentrate disposal costs.

The criteria for high evaporation rates are better met in the western half of Texas than in the eastern portion of the state. Design and cost considerations for evaporation ponds include determination of the evaporation rate, pond depth, land clearing, dike construction, liner materials and construction, miscellaneous costs (fencing, roads, seepage monitoring, etc.), operations, pond maintenance, and potential sludge removal. Of course, the first variable to be determined for proper sizing of evaporation ponds is the evaporation rate at the proposed facility location. The TWDB maintains an historical database of evaporation estimates for the entire state of Texas since 1940. Design and cost calculations should consider these data when making estimates of the pond area that will be required to use evaporation as the concentrate disposal method. After the appropriate pond area has been determined, the following formulas can be used to estimate capital cost for constructing an evaporation pond disposal system. If there are significant seasonal changes in evaporation rates, this variation would need to be incorporated into the design.

USBOR 2001 developed a simple formulation for estimating the total area (TA) required for the operation (with 20% contingency incorporated) can be estimated by:

$$TA = 1.2(EA)[1 + 0.155(DH)/\mathrm{sqrt}(EA)] \quad \text{(Equation 3)}$$

where:

TA = total area (acres)
EA = evaporation area (acres)

DH = dike height (feet)

The total unit area capital cost for evaporation pond disposal is shown in Equation 4:

UC = 5406 + 465(LT) + 1.07(LC) + 0.93(CC) + 217.5(DH) (Equation 4)
where:
UC = total unit area capital cost ($/acre)
LT = liner thickness (millimeters)
LC = land cost ($/acre)
CC = land clearing cost ($/acre)
DH = dike height

The total capital cost is determined by multiplying TA by UC.

Please note, 2001 Engineering News Record Construction Cost Index for 2001 was 6334. Adjusting to 2008 requires multiplying by 1.36 (2008 index of 8602 divided by 6334 equals 1.36).

4.3 R. W. Beck, Inc. 2004 Report – Chapter 5 Estimated Range of Costs

In 2003, TWDB commissioned a R. W. Beck, Inc. to provide a guidance manual for permitting desalination facilities. The report was presented to TWDB in November of 2004 and is referred to as Beck 2004. Included within that manual is guidance for estimating concept-level cost ranges for various facility configurations. A succinct table is included in the report which highlights cost ranges for brackish water facilities in particular (Table 7).

Beck 2004 manual states that costs were estimated on an installed basis using WTCost, a cost-estimating program developed by I. Moch & Associates, et al. Other references included previous reports prepared for TWDB (LBG-Guyton Associates, et al. and HDR, et al.). The range of costs for each raw water sourcing facility, and each treatment and brine disposal option, is minus ten percent and plus 25 percent.

Beck 2004 also qualifies their work by assuming generic site conditions are encountered and that a conventional design-bid-build procurement process will be employed. The report emphasizes that Site-specific conditions vary greatly and should be taken individually into account when developing the costs for a specific project.

February 2004 was used as the base date for costs, and Engineering News Record indices (Construction Cost, Building Cost, Skilled Labor, Materials, Steel Cost, Cement Cost and Labor Rate) were used to standardize the costs to the base date when possible *(the approximate factor to be applied in order to achieve approximate 2008 dollar values is 1.21)*. The exceptions to this procedure were the adjustments of the costs for brackish water wells and evaporation basins. In these two cases, a typical inflation rate of 2.5 percent per year was applied to the costs calculated as described.

Please note, Table 7 for brackish water facility concentrate disposal/re-use mechanisms shows that, when they can be employed, the options for co-disposal with wastewater, direct discharge to surface water and re-use via brine injection are much more cost-effective than evaporation basins or deep well injection.

Table 7: (Beck 2004)

Brackish Water Desalination Facility Feature Cost Ranges
(TDS 3,000 ppm)

Facility			Intake Configuration			Concentrate Disposal or Beneficial Re-use Mechanism		
Capacity (mgd)	Cost Range[1] ($1,000)		Description	Cost Range ($1,000)		Description	Cost Range ($1,000)	
	Low	High		Low	High		Low	High
3	4,091	5,625	Groundwater Wells	1,773	2,438	Co-disposal with wastewater	17	24
	6,364	8,750	Direct Intake from Surface Water Body	48	66	Deep Well Injection[2]	3,293	4,527
						Direct Discharge to Surface Water[3]	17	24
						Discharge to Surface Water after Blending with Power Plant Discharge	17	24
						Brine Lines [4]	17	24
						Evaporation Basins[5]	2,545	3,500
5	5,545	7,625	Groundwater Wells	2,491	3,425	Co-disposal with wastewater	24	33
	7,273	10,000	Direct Intake from Surface Water Body	62	85	Deep Well Injection[2]	3,293	4,527
						Direct Discharge to Surface Water[3]	24	33
						Discharge to Surface Water after Blending with Power Plant Discharge	24	33
						Brine Lines [4]	24	33
						Evaporation Basins[5]	5,091	7,000
10	9,000	12,375	Groundwater Wells	4,773	6,563	Co-disposal with wastewater	27	38
	11,364	15,625	Direct Intake from Surface Water Body	77	115	Deep Well Injection	3,823	5,257
						Direct Discharge to Surface Water[3]	27	38
						Discharge to Surface Water after Blending with Power Plant Discharge	27	38
						Brine Lines [4]	27	38
						Evaporation Basins[5]	---	---

(1) Includes pretreatment, RO membrane desalination, and post-treatment process costs, except costs for intake configuration; concentrate disposal mechanism; and land acquisition (with the exception of land for evaporation basins).
(2) Assumes a minimum well tubing diameter of six inches.
(3) Configurations using direct discharge to surface water are unlikely to meet regulatory requirements unless brackish water or seawater surface water bodies are available as receptors.
(4) Disposal via brine lines is prohibited by regulations. Brine lines are only feasible in circumstances where concentrate has a beneficial re-use.
(5) Evaporation basins are only feasible for small brackish water facilities, due to the amount of land required. Consequently, the cost of evaporation basins for 10 mgd brackish water facilities is not shown.

4.4 Current U.S. Water Costs and El Paso's Desalination Facility

"The annual survey conducted by the NUS Consulting Group found that the average price for water in the United States soared by 7.3 percent for the period ending July 1, 2008." (Reuters, September 24, 2008). As a reference, key outcomes of the 51 water system survey are as follows:

- The average cost of water of the surveyed communities was $2.81/Kgal
- Highest price paid in survey was in Boston, MA at $5.76/Kgal
- Lowest price paid in survey was in Savannah, GA at $1.09/Kgal

The article goes on to report that since 2003 average surveyed water prices in the U.S. have increased by nearly 30%. Additional, more than two-thirds of the surveyed cities had increased their water charges over the past year.

It can be noted that El Paso, Texas is currently ranked fourth most economical in the above referenced survey when combining water and sanitary sewer rates with a combined total cost of $3.56/Kgal. El Paso-Fort Bliss is home to the Kay Bailey Hutchison Desalination Plant, currently the largest inland desalination plant in the world, producing approximately 27.5 million gallons of fresh water daily through desalination (http://www.epwu.org/water/desal_info.html). The desalination facilities increase El Paso Water Utilities' fresh water production by approximately 25 percent. Deep-well injection was chosen in El Paso over conventional evaporation ponds as the preferred method of handling the concentrate disposal.

4.5 Case Study A: City of Clarksville City

In 2005 the City of Clarksville City received financial assistance from the Texas Water Development Board in the amount of $1,530,000 to finance improvements to the City's water system. The City of Clarksville City is located approximately five miles west of Longview, Texas on U.S. Highway 80, with an estimated population of approximately 930 and providing service to approximately 331 residential water connections and 12 commercial water connections (approximately 243 wastewater connections).

Clarksville City investigated surface water options from Lake O the Pines and Lake Gladewater. Groundwater with acceptable TDS levels (fresh water) was located near East Mountain, approximately seven miles away. However, the cost of transmission of the water to Clarksville City was greater then the cost to treat the higher TDS water that was available much closer to the City. They opted for two well sites that were within a half-mile of their treatment facility that contained brackish water.

Clarksville City, with assistance from Dunn Engineering Co., developed groundwater wells in the area near the Gregg-Upshur County boundary and constructed a reverse osmosis (RO) water treatment plant. The planned project included two groundwater wells each with a capacity of between 50 to 100 gallons per minute (gpm), two RO units, each with an approximated treated effluent (product water) capacity of 70 gpm for a total capacity of 140 gpm. However, Mr. Wendell Basham, Director of Utilities, reports that current output is between 160 to 165 gpm, on average. In addition, the project involved the construction of two 65,000 gallon ground storage tanks, high service pumps, and a supervisory control and data acquisition (SCADA) system. Mr. Michael Dunn, P.E., reported that the project received favorable bid prices as the project was advertised and opened shortly before the effects of Hurricanes Katrina and Rita began to elevate construction materials costs.

An additional important note, in early 2008 the City won best tasting water in Texas competition sponsored by the local chapter of the American Water Works Association and went on to compete nationally with 14 other entrants. Another important element to this system is that the RO concentrate is discharged directly to the sewer system (City of Gladewater).

Mr. Billy Silvertooth, City Manager for Clarksville City, provided the below costs (Table 8) that represent this project and production of 30 million gallons of water annually with a $3.49/Kgal cost.

Table 8: City of Clarksville City WTP Annual Costs

Description	Annual Costs	$/Kgal Costs
Loan Repayment, 30 yrs.	$104,736	$3.49
O&M items		
Labor	$12,045	
Electric	$17,790	
Anti-scalant	$6,334	
Caustic Soda	$2,704	
Chlorine	$1,823	
Pre-Filters	$988	
Subtotal		$1.40
Total Annual Cost	$146,420	$4.89

Ms. Leisa Richardson, City Secretary, provided City of Clarksville City water rates, effective August 1, 2008 (Table 9).

Table 9: City of Clarksville City Current Water Rates

For Customers inside the City		For Customers Outside the Corporate Limits of the City	
Gallons	Rate, $/1,000 gal	Gallons	Rate, $/1,000 gal
0	$15.00 (minimum)	0	$22.50 (minimum)
1 – 5,000	$4.00	1 – 49,999	$5.25
5,000 – 9,999	$4.25	50,000 – 79,999	$6.75
10,000 – 14,999	$4.30	80,000 and over	$7.75

15,000 – 19,999	$4.50		
20,000 – 24,999	$4.60		
25,000 – 49,999	$4.75		
50,000 – 79,999	$5.00		
80,000 and over	$5.50		
Plus an additional charge of $15.00 for all water taps with more than one connection		Plus an additional charge of $22.50 for all water taps with more than one connection	

In their circumstances, the City of Clarksville City found that desalting local brackish groundwater provided the most cost-effective water treatment scenario.

4.6 Case Study B: City of Tatum

The City of Tatum, Texas is located in Rusk County, approximately 20 miles southeast of Longview and in the Region I Water Planning Group. In 1999, in order to reduce the level of sodium and TDS in their water that were exceeding the Texas Commission on Environmental Quality (TCEQ) drinking water standards the City chose to retrofit its water system by adding a RO treatment facility. This project was partially funded by a grant from the Texas Department of Housing and Community Affairs to the City of Tatum.

The City of Tatum system consists of a 0.288 million gallons per day (MGD) water treatment plant consisting of three groundwater wells, two ground storage tanks, chlorination, four high service pumps and two elevated storage tanks. The existing groundwater qualities are shown below in Table 10:

Table 10: Water Quality Analysis of City of Tatum's Wells 1, 2, and 3

PARAMETER	CONCENTRATION			
	Well l	Well 2	Well 3	Composite
Chlorides (mg/L)	140	230	240	214
Sodium (mg/L)	322	413	431	399[1]
pH	8.7	8.65	8.7	
Silt Density Index (SDI)		0.22	0.2	0.21
Total Alkalinity (mg/L)	496	579	556	551
Total Dissolved Solids (mg/L)	911	1,206	1,126	1,107[2]

Note: 1: Exceeded TCEQ standard of 200 mg/L Sodium.
Note: 2: Exceeded TCEQ standard of 1,000 mg/L TDS.

The engineering consultants, Nish Vasavada, P.E and Walter T. Winn, Jr., P.E., recommended an RO unit at Plant #2, which would require the least modification as compared to the other sites (EDR was determined not to be as cost effective as RO treatment). A 200 gpm unit was recommended over a 100 gpm unit because the larger unit produced a better blended quality of water and would also satisfy 90% to 100% of Tatum's future water demand. Skid-mounted prefabricated RO units were specified in the contract.

A percentage of the well water is treated and achieves a reduced TDS level of 50 mg/L TDS. A portion of this same well water (25%) is bypassed and it is blended to achieve a final TDS of approximately 250 mg/L, significantly lower than the State standard of 1,000 mg/L.

The total cost of the recommended system including engineering, grant administration and construction was $570,000 (equivalent 2008 dollars is $786,600). The project included a skid-mounted RO system, 600 square feet RO building, variable speed drive pumps, sodium bisulfate feed system, a 50,000 gallon ground storage reservoir, 1,000 feet on 8-inch PVC piping, valves, flow meters and instrumentation. The concentrate waste is disposed of in the City of Tatum sanitary sewer system. The project was designed and completed in 11 months.

Annual Operating Cost

Approximate operating costs from March of 2001, three months after start-up, are as follows:

Table 11: City of Tatum Annual Operating Costs

DESCRIPTION	ANNUAL COST
Maintenance	$10,000
Replacement of Membrane Elements ($40,000 every four years)	$10,000
Power to Operate RO Unit	$20,000
Chemicals	$7,000
Maintenance, Supplies, Cleaning, Service	$10,000
Labor	No increase
Total Annual Operating Cost	$47,000
Amortized Capital Cost (7% Interest, 20 yr. Period)	$52,000
Total Annual Cost	$99,000
Cost per 1000 Gallons*	$0.94

* Based on 0.288 MGD, or 105 million gallons per year, and approximately 510 connections

In summary, the City of Tatum's option to retrofit an existing facility with an RO proved to be an acceptable and cost effective solution to improving its existing water quality at an additional $0.94 per 1,000 gallons, $1.28 in 2008 dollars. Mr. Michael Morton, Utilities Director for the City of Tatum, reports that the system is working well and customers are satisfied with the water quality.

4.7 Case Study C: Economic Implications of Conventional Water Treatment Versus Desalination: A Dual Case Study

"Economic Implications of Conventional Water Treatment Versus Desalination: A Dual Case Study" (Rogers et al., 2008) is a report authored by Texas A&M University's Department of Agricultural Economics and AgriLife Research and Extension Center, and the Texas Water Resources Institute (Rogers, Sturdivant, Rister, Lacewell and Harris), supported by Rio Grande Basin Initiative with funds provided by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture. It is a very pertinent study to this report as it compares a conventional water system to a desalination system with similar geographic location and construction periods relatively close in time.

The conventional surface-water system analyzed in this report is the McAllen Northwest facility near McAllen, Texas and the desalination facility analyzed is the Southmost Desalination facility near Brownsville, Texas. The authors sought to achieve an equitable comparison by combining Capital Budgeting – Net Present Value (NPV) with the calculation of annuity equivalent measures. They used two independent spreadsheet models, CITY H_2O ECONOMICS© and DESAL ECONOMICS©. Likely production efficiencies were applied to establish typical daily usage for the two plants, which resulted in the benchmarks of 6.435 MGD (7,208 ac-ft/yr.) for McAllen Northwest and 5.1 MGD (5,713 ac-ft/yr.) for Southmost.

Both facilities are new, not additions to existing facilities. However, it was necessary for the McAllen facility to acquire water rights for Rio Grande River water. Initial construction costs for both facilities were obtained and converted to 2006 dollars (Table 12 and Table 13). Capital replacement costs are depicted in Table 14, in 2006 dollars and compounded at slightly more than 2.0% for annual inflation.

Table 12. Initial Construction and Annual Continued Costs for the Ten Segments of the McAllen Northwest Facility, 2007 (Rogers et al. 2008). [a]

Facility Segment	Initial Construction/ Investment Costs	Continued Costs (annual)
1) Water Rights/Raw Water Intake/Reservoir	$25,142,292	$618,664
2) Pre-Disinfection	482,412	398,911
3) Coagulation/Flocculation	1,446,796	71,065
4) Sedimentation	875,574	35,838
5) Filtration/Backwash	2,677,879	36,221
6) Secondary/Disinfection	423,047	156,457
7) Sludge Disposal	747,699	107,193
8) Delivery to Municipal Line/Storage	4,683,612	212,345
9) Operations' Supporting Facilities	917,784	101,923
10) Overbuilds & Upgrades [b]	5,971,571	28,306
TOTAL	$43,368,666	$1,766,923

[a] Values are in 2006 dollars.

[b] Represents construction beyond the necessities and captures "elbow room" for future expansion.

Table 13. Initial Construction and Annual Continued Costs for the Seven Segments of the Southmost Desalination Facility, 2007 (Sturdivant et al. 2008). [a]

Facility Segment	Initial Construction/ Investment Costs	Continued Costs (annual)
1) Well Field	$7,768,525	$383,935
2) Intake Pipeline	1,979,682	4,283
3) Main Facility	9,554,574	994,494
4) Concentrate Discharge	57,363	3,871
5) Finished Water Line & Tank Storage	963,506	70,424
6) Delivery Pipeline	1,698,501	187,408
7) Overbuilds and Upgrades [b]	4,168,843	80,686
TOTAL	$26,190,993	$1,725,101

[a] Values are in 2006 dollars.

[b] Represents construction beyond the necessities and captures "elbow room" for future expansion.

Table 14. Capital Replacement Items, Occurrence, and Costs for the McAllen Northwest and Southmost Desalination Facilities, 2007 (Rogers et al. 2008 and Sturdivant et al. 2008).

Facility Capital Item	Frequency of Replacement	Cost per Item	No. of Items Replaced each Occurrence
McAllen Northwest (Conventional)			
SCADA Upgrades[a]	5 years	$75,000	1
Anthracite	2 years	15,000	1
High Speed Pump	18 years	45,000	3
Trucks	7 years	16,000	2
Chemical Feed Pumps	5 years	3,750	4
Turbidity Meters	6 years	2,500	6
Southmost (Desalination)			
Well / Pumps	3 years	10,000	20
Membranes	6 years	700,000	1

[a] SCADA is an acronym for 'Supervisory Control and Data Acquisition' "which is the hardware and software technology which collects data from sensors at remote locations and in real time sends the data to a centralized computer where facility management can control equipment/conditions at those locations" (Sturdivant et al. 2008).

The NPV for the two facilities over the 50-year life, in real 2006 dollars, totals $79,167,566 for the McAllen Northwest facility and $65,281,089 for Southmost Desalination facility (Table 15). The water production of this period for the two facilities equates to 143,164 ac-ft and 118,745 ac-ft, respectively (Table 15). This translates to a per unit life-cycle cost of $771.67/ac-ft/yr ($2.3682/Kgal/yr) for McAllen and $769.62/ac-ft/yr ($2.3619) for Southmost (Table 15). Table 16 presents percentage of total costs for the major cost categories. Table 17 is a breakout of specific O&M cost items.

Table 15: Aggregate Results for Costs of Production at the McAllen Northwest and Southmost Facilities, 2007.[a]

Results	Units	McAllen Northwest Nominal 2006 Value (Conventional)	McAllen Northwest Real Value[b] (Conventional)	Southmost Nominal Value 2006 (Desalination)	Southmost Real Value[b] (Desalination)
Initial Construction/ Investment Costs	2006 dollars	$43,368,658	$43,368,658	$26,190,993	$26,190,993
NPV of Total Cost Stream	2006 dollars	$207,706,012	$79,167,566	$195,914,480	$65,281,089
- annuity equivalent	$/year	N/A	$5,079,864	N/A	$4,201,075
Water Production	ac-ft (lifetime)	360,406	143,164	291,349	118,745
- annuity equivalent	ac-ft/year	N/A	6,583	N/A	5,460
Water Production	1,000-gal (lifetime)	117,438,750	46,650,165	94,936,500	38,693,220
- annuity equivalent	1,000-gal/year	N/A	2,145,074	N/A	1,779,196
Cost-of-Producing Water	$/ac-ft/year	N/A	$771.67	N/A	$769.62
Cost-of-Producing Water	$/1,000-gal/year	N/A	$2.3682	N/A	$2.3619

[a] The results of this table are considered the baseline analysis of the facilities in their current operating state, i.e., using current production efficiency level (78% for McAllen Northwest and 68% for Southmost), 2006 dollars, overbuilds and upgrades are included, and a zero net salvage value is recorded for all capital items and water rights.

[b] Determined using a 2.043% compound rate on costs, a 6.125% discount factor for dollars, a 4.000% discount factor for water, and a 0% risk factor (Rister et al. 2002).

Table 16: Costs of Producing Water by Cost Type for the McAllen Northwest and Southmost Facilities, 2007.

	McAllen Northwest (Conventional)					Southmost (Desalination)				
Cost Type	NPV of Cost Stream[b]	Annuity Equivalent in $/yr[b]	Annuity Equivalent in $/ac-ft/year[b]	Annuity Equivalent in $/1000-gal/year[b]	% of Total Cost	NPV of Cost Stream	Annuity Equivalent in $/yr[b]	Annuity Equivalent in $/ac-ft/year[b]	Equivalent in $/1000-gal/year[b]	% of Total Cost[b]
Initial Construction/ Investment	$43,368,658	$2,782,792	$422.72	$1.2973	54.8%	$26,190,993	$1,685,486	$308.77	$0.9476	40.1%
-Water Rights Purchase	*20,404,541*	*1,309,277*	*198.89*	*0.6104*	*25.8%*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Continued Costs	35,093,723	2,251,823	342.07	1.0498	44.3%	35,633,597	2,293,151	420.10	1.2892	54.6%
Capital Replacement	705,185	45,249	6.88	0.0211	0.9%	3,456,499	222,438	40.75	0.1251	5.3%
Total	$79,167,566	5,079,864	$771.67	$2.3682	100.0%	$65,281,089	$4,201,075	$769.62	$2.3619	100%

[a] The results of this table are considered the baseline analysis of the facilities in their current operating state, i.e., using current production efficiency level (78% for McAllen Northwest and 68% for Southmost), 2006 dollars, overbuilds and upgrades are included, and a zero net salvage value is recorded for all capital items and water rights.

[b] Determined using a 6.125% discount factor for dollars (Rister et al. 2002).

Table 17. Costs of Producing Water by Continued Cost Item for the McAllen Northwest and Southmost Facilities, 2007.[a]

Facility O&M Cost Item	NPV of Cost Stream[b]	Annuity Equivalent in $/yr[b]	Annuity Equivalent in $/ac-ft/year[b]	Annuity Equivalent in $/1,000 gal/year[b]	% of Total Cost
McAllen Northwest (Conventional)					
-Energy	$7,239,217	$464,511	$64.75	$0.1987	10.0%
-Chemicals	5,789,663	371,499	51.79	0.1589	8.0%
-Labor	7,124,847	457,173	63.73	0.1956	9.8%
-Raw Water Delivery	9,472,261	607,797	92.33	0.2833	12.0%
-All Other	3,270,998	209,887	29.26	0.0898	4.5%
Southmost (Desalination)					
-Energy	16,862,411	1,085,157	198.80	0.6101	25.8%
-Chemicals	5,090,723	327,607	60.02	0.1842	7.8%
-Labor	7,615,483	490,084	89.78	0.2755	11.7%
-All Other	4,368,142	281,106	51.50	0.1580	6.7%

[a] The results of this table are considered the baseline analysis of the facilities in their current operating state, i.e., using current production efficiency level (78% for McAllen Northwest and 68% for Southmost), 2006 dollars; overbuilds and upgrades are included; and a zero net salvage value is recorded for all capital items and water rights.

[b] Determined using a 6.125% discount factor for dollars (Rister et al. 2002).

However, Rogers and others 2008 goes on to recognize that there are shortcomings associated with some of the basic assumptions in the above calculations and comparison. These include the following:

1) assuring all financial calculations are determined in common time;
2) level annual production at 85% in accordance with the Rule of 85;
3) ignore overbuilds and upgrades intended to facilitate other functions and/or future expansions;
4) assume capital assets have a net salvage value of zero; and,
5) applying similar water quality standards

Incorporating the above-noted issues Rogers and others modified results net $649.67/ac-ft/yr ($1.9938/Kgal) for McAllen and $615.01/ac-ft/yr ($1.8874/Kgal) for Southmost (Table 15). Tables 16 presents the percentage of total costs for the "modified" major cost categories and Table 17 is a breakout of specific "modified" O&M cost items.

An important footnote to the modified calculation is that Section 49.507 of Senate Bill 3 passed by the Texas Legislature in 2007 states that municipalities are now only required to pay 68% of the market value for water rights converted from agriculture to municipal use after January 2008 (Texas Legislature Online 2007). If the cost of water rights were reduced to 68% of the original price ($2,300/ac-ft) the new price would be $1,564/ac-ft, resulting in a new modified operating state of $591.27/ac-ft/yr ($1.8145/Kgal).

Table 18. "Modified" Aggregate Results for Costs of Production at the McAllen Northwest and Southmost Facilities, 2007. [a]

Results	Units	McAllen Northwest Nominal 2006 Value (Conventional)	McAllen Northwest Real Value [b] (Conventional)	Southmost Nominal 2006 Value (Desalination)	Southmost Real Value [b] (Desalination)
Initial Construction/ Investment Costs	2006 dollars	$37,397,088	$37,397,088	$22,022,150	$22,022,150
NPV of Total Cost Stream	2006 dollars	$199,159,431	$72,633,777	$209,423,179	$65,208,300
- annuity equivalent	$/year	N/A	$4,660,618	N/A	$4,196,391
Water Production	ac-ft (lifetime)	392,750	156,012	364,187	148,431
- annuity equivalent	ac-ft/year	N/A	7,174	N/A	6,825
Water Production	1,000-gal (lifetime)	127,978,125	50,836,718	118,670,625	48,366,525
- annuity equivalent	1,000-gal/year	N/A	2,337,580		2,223,996
Cost-of-Producing Water	$/ac-ft/year	N/A	$649.67	N/A	$615.01
Cost-of-Producing Water	$/1,000-gal/year	N/A	$1.9938	N/A	$1.8874

[a] The results of this table are considered the adjusted analysis of the McAllen Northwest and Southmost facilities in their modified operating state, i.e., 85% efficiency production, 2006 dollars, overbuilds and upgrades are not included, and a zero net salvage value is recorded for all capital items and water rights.

[b] Determined using a 2.043% compound rate on costs, a 6.125% discount factor for dollars, a 4.000% discount factor for water, and a 0% risk factor (Rister et al. 2002).

Table 19. "Modified" Costs of Producing Water by Cost Type for the McAllen Northwest and Southmost Facilities, 2007. [a]

	McAllen Northwest (Conventional)					Southmost (Desalination)				
Cost Type	NPV of Cost Stream [b]	Annuity Equivalent in $/yr [b]	Annuity Equivalent in $/ac-ft/year [b]	Annuity Equivalent in $/1000-gal/year [b]	% of Total Cost	NPV of Cost Stream [b]	Annuity Equivalent in $/yr [b]	Annuity Equivalent in $/ac-ft/year [b]	Equivalent in $/1000-gal/year [b]	% of Total Cost
Initial Construction/ Investment	$37,397,088	$2,399,7621	$344.50	$1.0265	51.5%	$22,022,150	1,417,205	$207.70	$0.6374	33.8%
-Water Rights Purchase	*20,404,541*	*1,309,277*	*182.51*	*0.5601*	*28.1%*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Continued Costs	35,093,723	2,215,748	308.87	0.9479	47.5%	39,729,651	2,556,747	374.71	1.1499	60.9%
Capital Replacement	705,185	45,249	6.30	0.0194	0.9%	3,456,499	222,438	32.60	0.1000	5.3%
Total	$72,633,777	$4,660,618	$649.67	$1.9938	100.0%	$65,208,300	$4,196,391	$615.01	$1.8874	100%

[a] The results of this table are considered the adjusted analysis of the McAllen Northwest and Southmost facilities in their modified operating state i.e., 85% efficiency production, 2006 dollars, overbuilds and upgrades are not included, and a zero net salvage value is recorded for all capital items and water rights.

[b] Determined using a 6.125% discount factor for dollars (Rister et al. 2002).

Table 20. "Modified" Costs of Producing Water by Continued Cost Item for the McAllen Northwest and Southmost Facilities, 2007.[a]

O&M Cost Item	NPV of Cost Stream [b]	Annuity Equivalent in $/yr [b]	Annuity Equivalent in $/ac-ft/year [b]	Annuity Equivalent in $/1,000 gal/year [b]	% of Total Cost
McAllen Northwest (Conventional)					
-Energy	$7,239,217	$464,511	$64.75	$0.1987	10.0%
-Chemicals	5,789,663	371,499	51.79	0.1589	8.0%
-Labor	7,124,847	457,173	63.73	0.1956	9.8%
-Raw Water Delivery	9,472,261	607,797	84.72	0.2600	13.0%
-All Other	3,270,998	209,887	29.26	0.0898	4.5%
Southmost (Desalination)					
-Energy	21,078,014	1,356,447	198.80	0.6101	32.3%
-Chemicals	6,363,404	409,508	60.02	0.1842	9.8%
-Labor	7,615,483	490,084	71.83	0.2204	11.7%
-All Other	2,780,863	178,959	26.23	0.0805	4.3%

[a] The results of this table are considered the adjusted analysis of the McAllen Northwest and Southmost facilities in their modified operating state (i.e., 85% efficiency production, 2006 dollars, overbuilds and upgrades are not included, and a zero net salvage value is recorded for all capital items and water rights).

[b] Determined using a 6.125% discount factor for dollars (Rister et al. 2002).

5.0 CONCLUSIONS

The NETRWPA has an abundant source of brackish groundwater. Published studies have shown that total treatment costs of brackish groundwater now generally range from about $0.98/Kgal to $3.80/Kgal. However, an actual case study in East Texas has shown the cost to be $4.89/Kgal. Brackish groundwater is becoming more economical and technically feasible it generally is still more expensive than current methodologies because it requires additional treatment and disposal.

In some cases the use of brackish groundwater becomes the most cost-effective alternative. This was shown to be the case for the City of Clarksville City where the closest freshwater encountered was approximately seven miles away as well as in many areas where brackish groundwater is the only groundwater available, for example in many of the areas of the Gulf Coast and in some areas of West Texas. The City of Tatum had an existing condition where two of three wells were exceeding TCEQ maximum standards of TDS and sodium. Tatum retrofitted their existing water treatment facility with RO units and utilized blending for an additional cost of approximately one dollar per 1,000 gallons produced and are know producing TCEQ compliant water.

Disposal of concentrate can be a significant cost element of brackish groundwater treatment. This is especially true if there is not a sanitary sewer system in the vicinity that can accept the waste product. Scientific studies have shown that deep-well injection is a feasible and environmentally safe option. However, the permitting process remains time-consuming and therefore costly. Significant progress must be made in the permitting process of well injection in order for it to become economically feasible for small water user groups.

The prevalence of brackish groundwater does appear to diminish the likelihood that freshwater sources are readily encountered, which appears to be the case in the vicinity of the City of Clarksville City (Gregg Co.) and the City of Tatum (Rusk Co., Region I). It should also be noted that the City of Clarksville, in Red River County, and a private well on the border of Red River and Bowie counties are also encountering brackish groundwater. While City of Clarksville is not a WUG with an identified actual shortage, they remain very interested in providing a higher factor of safety in both quantity and quality for their customers by supplementing their wells with RO treatment. Based on verbal reports from the City's Director of Water and Wastewater, it is recommended that a brackish groundwater project for Clarksville be examined further.

In addition to small and medium sized water suppliers, El Paso-Fort Bliss' Kay Bailey Hutchison Desalination Plant is an excellent example of large scale use of inland groundwater desalination. At a capacity of 27.5 million gallons of fresh water daily it is currently the world's single largest producing inland desalination plant. The facility uses the reverse osmosis technology for desalination and handles waste concentrate disposal by deep-well injection.

Brackish groundwater in the aquifers described here is generally suitable for desalination and use for industrial and municipal use. The groundwater at each location would require specific assessment and treatment processes would need to be tailored for that groundwater and for the requirements of the water user group. One consideration in treating brackish groundwater is the disposal of the concentrate from the treatment. There are various approaches to disposal, such as discharge into surface water or injection, and this component of the treatment system should be assessed as part of the overall planning of the brackish groundwater development.

While currently more expensive, the above examples demonstrate that brackish groundwater should not be overlooked as a viable source for future water supplies. Brackish groundwater can supplement the North East Texas water supply and potentially safeguard remaining volumes of existing freshwater wells by augmenting their production. The State's hydrogeology is becoming more studied and familiar to government officials, planners, scientists and engineers. Conditions may warrant the use of brackish groundwater as feasible, but each case will require a site-specific hydrogeologic and engineering analyses and knowledge of current treatment technologies. The NETRWA would benefit from continued study of desalination technology, especially of the existing desalination facilities already in its region or nearby. Additional desalination facilities in the area will allow the NETRWPG region to become more familiar with the technology and process use and would be more likely to use it to supplement its growing water supply needs.

In ranking alternatives for water supply, the most cost effective option typically governs. While economy is often the primary factor, local control can be important. Capital costs and the inertia needed to implement a new project effect a decision to move to a new technology, especially when regionalization is becoming more prevalent. However, in unique circumstances, and as surface water becomes more costly and fresh groundwater diminishes, the treatment of brackish groundwater can become a very viable option.

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7.0 APPENDIX A – WATER USER GROUPS ANALYSES TABLES

Table I – Non-Residential Users

			Current Major Users					Wells			
County	Number of Systems	Plan to Add Major Customers	Name	Type	Annual Use (MG/yr.)	Source	Purchasing Capacity (MG/yr.)	Number	Capacity (GPM)	Depth (Ft.)	Aquifer
Camp County	1	No	Pilgrim Pride Corp	Manufacturing	126	NETMWD & Groundwater	149.3	7	130/80/75/100	450	Carrizo-Wilcox
			Pittsburg Hot Link Packers	Manufacturing					165/340/100	all	
Franklin County	1	No	Keller's Creamery	Industrial	37.8	Lake Cypress Springs	222.6				
			Presbyterian Hospital	Hospital	2.4						
			TDCJ	Prison	16.8						
Greg County	4	No	Snow Max	Industrial	1.3			6	110/125/80	600/600/600	Carrizo-Wilcox
									650(2)/60	1000/?	Carrizo-Wilcox
		No	Texas Eastman (Raw Water)	Manufacturing	1288.2	Lake Cherokee	3584				
			Texas Eastman (Treat. Water)	Manufacturing	248.2	Lake Fork	1174				
			Rexam	Manufacturing	68	Lake O'the Pines	0				
			Air Liquide	Manufacturing	37.2	Sabine River	1132				
			Marathon-LeToureau	Manufacturing	29.5						
			LeBus	Manufacturing	20.3						
			Compressed Gas Cyclinder	Manufacturing	13.2						
			Trinity Industries	Manufacturing	11.6						
		No	Gas solutions	Oil/Gas	19.5	City of Longview	380.65				
		No	City of Clarksville City	Wholesale	25.1	Lake Gladewater	NR				
			Warren City	Wholesale	11.5						
			Starrville-Friendship	Wholesale	0.001						
			Truman in Smith	Commercial	5.8						
			Housing Authority	Commercial	3.5						
			Texas Die Casting	Commercial	3.6						
			Gladewater Nursing Home	Commercial	2.4						
			CADDAX	Commercial	1.5						
			American health Care	Commercial	2.3						
Harrison County	1	No	Trinity Industries	Industrial	5	City of Longview	5	2	200/180	500/500	Carrizo-Wilcox
Hopkins County	1	No	Ocean Spray	Industrial	96.7	Cooper Lake	4745				
			Morningstar Speciality	Industrial	74	Lake Sulphur Springs	3193				
			Kohler Mix	Industrial	36.2						
			Dairy Farmers of America	Industrial	34.6						
			Hop. Co. Memorial Hosp.	Hospital	14.2						
			Flowserve	Industrial	11						
Hunt County	2	Yes	Boles Home	Wholesale	4.7	Lake Tawakoni	574				
		5000 Homes	Boles ISD	Wholesale	3.6	NTMWD	1792 AF/Yr				
			Combined Consumers WSC	Wholesale	1.9						
			Aqua Source	Wholesale	9.9						

Table I – Non-Residential Users (continued)

			Current Major Users					Wells			
County	Number of Systems	Plan to Add Major Customers	Name	Type	Annual Use (MG/yr.)	Source	Purchasing Capacity (MG/yr.)	Number	Capacity (GPM)	Depth (Ft.)	Aquifer
			City of Lone Oak	Wholesale	20						
			Lone Oak ISD	Wholesale	3.7						
			City of Quinlan	Wholesale	61.4						
			Sabine River Authority	Wholesale	0.4						
		Yes	L-3 Communications	Ind/MFG	53.9	Lake Ribitt	1.35				
		12-16 MGD	Rubbermaid Inc.	Ind/MFG	26.7	Lake Tawakoni	6.9				
			Fiberite Corp.	Ind/MFG	14.6						
			Other Manufacturing	Ind/MFG	31.8						
			Greenville Electrical	Ind/MFG	14.5						
Marion County	1	No	Blackburns Syrup	Manufacturing	2.4	NETMWD	NR				
			Nexfor Norbord	Manufacturing	10.2						
			Sonoco	Manufacturing	NR						
Morris County	3	No	(One Not Named)	Manufacturing	NR	NETMWD	As Needed				
		Yes	Reilly Ind	Manufacturing	6.1	NR	Nr				
		No	Mapa Manufactiring	Manufacturing	0.02	Groundwater		5	90/32/75	360/360/360	Carrizo-Wilcao
			Tamko Inc.	Manufacturing	3.8				112/105	400/402	Carrizo-Wilcao
			Top Hat Inc.	Manufacturing	0.37						
Red River County	1	No	David Rozell	Non-Residential	0.259	Lamar County ESC	54.5				
			12 Livestock Users	Livestock	5.269						
Titus County	1	No	Pilgrim's Pride	Industrial	1080	Lake Bob Sandlin	2750				
			Tri-Water Corp.	Water Supply	501	Cypress Springs Lake	510				
			City of Winfield	Water Supply	50	Lake Tankersley	3000 AF/Yr Backup				
Upshur County	1	No	The Pines	Recreational	3.8	Groundwater		17	55/50/70	760/375/562	Carrizo-Wilcox
			Pavement Tools MFRS Inc.	Manufacturing	1.4				58/66/73/	615/592/623	Carrizo-Wilcox
			Boersma Dairy	Livestock	0.6				100/155/100	650/621/770	Carrizo-Wilcox
			Xavera Dairy	Livestock	Backup				35/50/84	490/600/650	Carrizo-Wilcox
			Green Dairy	Livestock	1.3				42/85/52	570/600/1153	Carrizo-Wilcox
Van Zandt County	2	No	Deen Farms	Dairy	1.7	Lake Fork	730	2	100/100	475/490	Carrizo-Wilcox
			Chitty Nursery	Plant Farm	0.5						
			Flory Tree Farm	Plant Farm	1						
			Van Zandt Livestock Auction	Livestock	0.5						
		No	Wills Point ISD	School	1.1	Lake Tawakoni	365				
			9 Commercial	Commercial	1.1						
Wood County	6	No	Central Marble	Manufacturing	0.48	Groundwater		2	1306/60	400	NR

Table I – Non-Residential Users (continued)

			Current Major Users					Wells			
County	**Number of Systems**	**Plan to Add Major Customers**	**Name**	**Type**	**Annual Use (MG/yr.)**	**Source**	**Purchasing Capacity (MG/yr.)**	**Number**	**Capacity (GPM)**	**Depth (Ft.)**	**Aquifer**
		No	Salesman Club	Manufacturing	3	Groundwater		6	225/225/300	1216/1134/925	Carrizo-Wilcox
			Hawkins RV	Manufacturing	1				120/200/120	464/1050/1000	Carrizo-Wilcox
			Fish Haul RV	Manufacturing	0.05						
			Hall Dairy	Livestock	0.142						
		No	Billy Mack Chamness	Dairy	0.155	Groundwater		6	140/45/200	449/470/250	Carrizo-Wilcox
			Dennis Fraxier	RV Park	0.03				86/38/100	240/?/215	Carrizo-Wilcox
			Dorthy Yarbrough	Dairy	0.08						
		No	Wood Memorial Care Center	Commercial	4.3	Groundwater		3	400/600/750	290/270/260	Carrizo-Wilcox
			Harvest Care Center	Commercial	0.411						
			Mineola Packing	Commercial	2.5						
		No	Tonya McShan	Livestock	1.35	Groundwater		3	125/240/340	600/619/600	Carrizo-Wilcox
		No	Keller's Creamery	Industrial	37.8	Lake Cypress Springs	222.6				
			Presbyerian Hospital	Hospital	2.4						
			TDJC	Prison	16.8						
Total Usage					**4237.417**						
NR -No Response											
N/A -Not Applicable											

Table II – User Types by County

County	Number of WUG Reported	WUG with Non-Residential Users	Reported Non-Residential Users
Bowie County	10	0	0
Camp County	3	1	2
Cass County	6	0	0
Delta County	2	0	0
Franklin County	3	1	3
Greg County	12	4	19
Harrison County	16	1	1
Hopkins County	8	1	6
Hunt County	19	2	13
Lamar County	5	0	0
Marion County	4	1	3
Morris County	4	3	5
Raines County	5	0	0
Red River County	5	1	2
Smith County	5	0	0
Titus County	5	1	3
Upshur County	10	1	5
Van Zandt County	12	2	6
Wood County	14	6	15
Totals	**148**	**25**	**83**

Table III – Summary of User Types

User Types	Number of Users	Annual Usage (MG/Yr.)
Commercial	11	27.7
Institutional	6	53.7
Industrial	15	1555.9
Livestock/Dairy	10	11.1
Manufacturing	23	1871.0
Oil/Gas	1	19.5
Plant Farm	2	1.5
Recreational/R-V Park	2	3.8
Wholesale/Water Supply	13	693.2
Totals	**83**	**4237.4**

Table IV – County Trends of Users

		Connections											
		Residential		Non-Residential		Manufacturing		Livestock		Power Generation		Total	
System	**County**	*1999*	*2003*	*1999*	*2003*	*1999*	*2003*	*1999*	*2003*	*1999*	*2003*	*1999*	*2003*
COUNTY TOTALS	Bowie	9,483	10,238	532	555	2	2	0	0	0	0	10,017	10,795
CHANGE			755		23		0						778
% CHANGE			7.96%		4.32%		0		0		0		7.77%
COUNTY TOTALS	Camp	1,799	1,818	321	357	0	0	0	0	0	0	2,120	2,175
CHANGE			19		36								55
% CHANGE			1.06%		11.21%		0		0		0		2.59%
COUNTY TOTALS	Cass	2,798	2,915	209	218	5	5	0	0	0	0	3,012	3,138
CHANGE			117		9		0						126
% CHANGE			4.18%		4.31%		0		0		0		4.18%
COUNTY TOTALS	Delta	1,349	1,471	20	27	0	0	0	0	0	0	1,369	1,498
CHANGE			122		7		0						129
% CHANGE			9.04%		35.00%		0		0		0		9.42%
COUNTY TOTALS	Franklin	5,876	6,062	405	419	35	35	40	50	0	0	6,356	6,566
CHANGE			186		14		0		10				210
% CHANGE			3.17%		3.46%		0		25.00%		0		3.30%
COUNTY TOTALS	Greg	34,610	35,183	5,301	5,399	139	147	0	0	0	1	40,050	40,730
CHANGE			573		98		0		0		1		680
% CHANGE			1.66%		1.85%		0		0		0		1.70%
COUNTY TOTALS	Harrison	14,481	14,828	1,222	1,261	3	3	0	0	0	0	15,706	18,543
CHANGE			347		39		0		0		0		2,837
% CHANGE			2.40%		3.19%		0		0		0		18.06%
COUNTY TOTALS	Hopkins	9,606	10,241	882	882	23	24	52	39	0	0	10,563	11,186
CHANGE			635		0		1		-13		0		623
% CHANGE			6.61%		0		4.35%		-25.00%		0		5.90%
COUNTY TOTALS	Hunt	23,202	25,148	1,058	1,070	18	18	0	0	0	0	24,278	26,236
CHANGE			1,946		12		0		0		0		1,958
% CHANGE			8.39%		1.13%		0		0		0		8.06%
COUNTY TOTALS	Lamar	17,544	18,384	35	50	0	0	0	0	0	0	17,579	18,434
CHANGE			840		15		0		0		0		855
% CHANGE			4.79%		42.86%		0		0		0		4.86%
COUNTY TOTALS	Marion	2,408	2,583	1	2	2	3	0	0	0	0	2,411	2,588
CHANGE			175		1		1		0		0		177
% CHANGE			7.27%		100.00%		50.00%		0		0		7.34%

Table IV – County Trends of Users (continued)

		Connections											
		Residential		Non-Residential		Manufacturing		Livestock		Power Generation		Total	
System	**County**	*1999*	*2003*	*1999*	*2003*	*1999*	*2003*	*1999*	*2003*	*1999*	*2003*	*1999*	*2003*
COUNTY TOTALS	Morris	2,882	2,774	307	289	4	4	0	0	0	0	3,193	3,067
CHANGE			-108		-18		0		0		0		-126
% CHANGE			-3.75%		-5.86%		0		0		0		-3.95%
COUNTY TOTALS	Raines	3,411	3,994	62	75	1	1	0	0	0	0	3,474	4,070
CHANGE			583		13		0		0		0		596
% CHANGE			17.09%		20.97%		0		0		0		17.16%
COUNTY TOTALS	Red River	4,187	5,038	260	278	5	5	11	11	0	0	4,463	5,332
CHANGE			851		18		0		0		0		869
% CHANGE			20.3%		6.92%		0		0		0		19.47%
COUNTY TOTALS	Smith	3,759	4,625	162	188	14	15	4	4	0	0	3,939	4,832
CHANGE			866		26		1		0		0		893
% CHANGE			23.04%		16.05%		7.14%		0		0		22.67%
COUNTY TOTALS	Titus	5,247	5,447	37	47	0	0	0	0	0	0	5,284	5,494
CHANGE			200		10		0		0		0		210
% CHANGE			3.81%		27.03%		0		0		0		3.97%
COUNTY TOTALS	Upshur	8,162	8,393	99	115	3	3	3	3	0	0	8,267	8,514
CHANGE			231		16		0		0		0		247
% CHANGE			2.83%		16.16%		0		0		0		2.99%
COUNTY TOTALS	Van Zandt	10,424	13,434	206	219	179	190	4	4	0	0	10,813	13,847
CHANGE			3,010		13		11		0		0		3,034
% CHANGE			28.88%		6.31%		6.15%		0		0		28.06%
COUNTY TOTALS	Wood	16,875	18,141	1,019	1,078	19	19	1	1	0	0	17,914	19,239
CHANGE			1,266		59		0		0		0		1,325
% CHANGE			7.50%		5.79%		0		0		0		7.40%
REGION D TOTALS		**178,103**	**190,717**	**12,138**	**12,529**	**452**	**474**	**115**	**112**	**0**	**1**	**190,808**	**206,284**
CHANGE			**12,614**		**391**		**22**		**-3**		**1**		**15,476**
% CHANGE			**7.08%**		**3.22%**		**4.87%**		**-2.61%**		**0**		**8.11%**
NR - No Response N/A – Not Applicable													

Table V – Water Quality

				Water Treatment or Purchase									
		Total Connections					Wells						
System	County	1999	2003	Do You Treat Your Own Water	Recycle or Reuse	Source	Number	Capacity (GPM)	Depth (Ft.)	Aquifer	Have Wells Declined in Quantity or Quality	Volume MG/Yr. (Last Full Yr.)	Costs per 10,000 Gal
Redwater Water & Sewer Co.	Bowie	850	912	Yes	No	Texarkana Water Util.	2	35 &100	250 & 250	Carrizo-Wilcox	Yes (Quantity due to Dry Weather)	85	$ 33.00
City of Bogata	Red River	616	604	Yes	No	Groundwater	3	300/300/65	325/325/300	Nacatoch	Yes (Dry)	38.2	$ 37.00
City of Clarksville	Red River	1,711	1,624	Yes	No	Langford Lake	2	320/350	302/675	Blossom	Yes (Bacteria, High Sodium)	207	$ 36.00
Red River County WSC	Red River	1,844	1,994	Yes	No	Texarkana Utilities	4	170/150	550/550	Blossom	No	159	$ 43.50
						LCWSD		150/380	500/600	Blossom/Nacatoch	Yes (TDS Up to Max Well #1)		
City of Gilmer	Upshur	2,450	2,450	No	No	Groundwater	6	230/250/560	492/519/540	Carrizo-Wilcox	Wells 3 & 4 have Decreased	305.8	NR
Rosewood	Upshur	119	121	Yes	No	Groundwater	2	60/35	415/424	Carrizo-Wilcox	Fall in Static Level	9.5	$ 38.20
City of Canton	Van Zandt	1,785	1,860	Yes	No	Mill Creek Lake	1	280	520	Carrizo-Wilcox	Yes (Lower Pump 20 ft.since1988)	298	NR
New Hope WSC	Wood	704	735	Yes	No	Groundwater	3	125/240/340	600/619/600	Carrizo-Wilcox	Yes (40-50Ft. In 10 Yrs.)	89.9	$ 39.50
Yantis WSC	Wood	235	230	Yes	No	Groundwater	2	22/100	420/430	Carrizo-Wilcox	Yes (GPM Down 50%)	24.7	$ 42.00
NR - No Response													
N/A - Not Applicable													

Table VI – Reported Expansion in Capacity

County	No. of Systems	Surface Water Systems	Ground Water Systems	Planned Capacity Increase (MG/Yr.)	Year Planned	Last Full Year Volume (MG/Yr.)
Cass	1	1		660		148
Franklin	1	1		391	2009	297.7
Greg	2	1		263		172.4
			1	737.3		218.5
Harrison	5	1		18		66.2
			4	103.7		166.3
Hunt	5	2		839.5		213.6
			3	2,300		124.4
Lamar	1	1		6,124	2010	813.5
Smith	1		1	91		319.5
Upshur	5	4		930		505.3
			1	52		51.8
Van Zandt	2	1		182.5		202.2
			1	12		75
Wood	5		5	258		763.6
Totals	**28**	**12**	**16**	**12,962**		**4,138**

Table VII – Water Costs Above $50/10,000 Gallons

				Water Treatment or Purchase											
							Wells					Capacity Expansion Plans			
System	**County**	**2003 Connections**	**Plan to add Major Customers**	**Do you treat your own water**	**Source**	**Purchasing Capacity (MG/yr.)**	**Number**	**Capacity (GPM)**	**Depth (Ft.)**	**Aquifer**	**Have Wells Declined in Quantity or Quality**	**Source**	**Planned Capacity (MG/Yr.)**	**Volume MG/Yr. (Last Full Yr.)**	**Costs per 10,000 Gal**
$50+ Water Supply															
City of Reno	Lamar	1,127	No	No	Lamar County WSD	102.3								102.2	$ 50.07
Tryon Road SUD	Greg	1,715	No	No	Groundwater		9	400/50/0	835/300/250	Carrizo-Wilcox	No	Lake of the Pines	737.3	218.5	$ 51.00
City of Quitman	Wood	983	No	Yes	Lake Fork Reservoir	365								116	$ 51.46
City of Caddo Mills	Hunt	461	No	Yes	City of Greenville	As Required						Caddo Basin	Back-up only	40.9	$ 51.84
Central Bowie Co. WSC	Bowie	2,280	No	No	Texarkana Water Util.	172								172	$ 52.00
Mims WSC	Marion	480	No	No	NETMWD	25								20	$ 52.26
City of Edgewood	Van Zandt	595	No	Yes	City Lake									79.2	$ 57.31
City of Deport	Lamar	290	No	Yes	Lamar County WSD	NR								41.7	$ 57.50
MACBEE SUD	Van Zandt	2,043	No	Yes	Lake Fork	730	2	100/100	475/490	Carrizo-Wilcox	No			171.5	$ 57.99
South Tawakoni WSC	Van Zandt	1,372	No	Yes	Lake Tawakoni	365						Lake Tawakoni SRA	182.5	202.2	$ 58.79
Woodland Estates	Bowie	44	No	Yes	Groundwater		3	80/100/60	50/175/280	Wilcox	No			4	$ 59.99
NR - No Response															
N/A - Not Applicable															

Table VII – Water Costs Above $50/10,000 Gallons (continued)

				Water Treatment or Purchase											
							Wells					Capacity Expansion Plans			
System	**County**	**2003 Connections**	**Plan to add Major Customers**	**Do you treat your own water**	**Source**	**Purchasing Capacity (MG/yr.)**	**Number**	**Capacity (GPM)**	**Depth Ft.**	**Aquifer**	**Have Wells Declined in Quantity or Quality**	**Source**	**Planned Capacity (MG/Yr.)**	**Volume MG/Yr. (Last Full Yr.)**	**Costs per 10,000 Gal**
$60+ Water Supply															
410 WSC	Red River	815	No	No	Lamar County ESC	54.5								54.5	$ 61.29
City of Lone Oak	Hunt	283	No	No	Cash Water Supply	54.75								19.1	$ 61.94
Pritchett WSC	Upshur	2,329	No	No	Groundwater		17	55/50/70	760/375/562	Carrizo-Wilcox	No			181	$ 63.32
City of Hallsville	Harrison	1,074	No	No	City of Longview	86	4	27/106	204/243	Carrizo	No			108.4	$ 65.00
Combined Consumers WSC	Hunt	2,916	No	Yes	Lake Tawakoni-SRA	547.5						Surface Water-SRA	839.5	172.7	$ 65.48
NR - No Response															
N/A - Not Applicable															

Table VIII – Summary of All Survey Items

		Connections																Water Treatment or Purchase												
		Residential		Non-Residential		Manufacturing		Livestock		Power Generation		Total			Current Major Users							Wells					Capacity Expansion Plans			
System	County	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	Plan to Add Major Customers	Name	Type	Annual Use (MG/yr.)	Do You Treat Your Own Water	Recycle or Reuse	Source	Purchasing Capacity (MG/yr.)	Number	Capacity (GPM)	Depth (Ft.)	Aquifer	Have Wells Declined in Quantity or Quality	Source	Planned Capacity (MG/yr.)	Volume MG/yr. (Last Full Yr.)	Costs per 10,000 Gal
Central Bowie Co. WSC	Bowie	1727	2196	73	84	0	0	0	0	0	0	1800	2280	No				No	No	Texarkana Water Util.	172								172	$ 52.00
Cody M. H. Park	Bowie	20	30	0	0	0	0	0	0	0	0	20	30	No				Yes	No	Groundwater		2	20 & 20	44 & 44	NR	No			NR	NR
City of DeKalb	Bowie	785	773	95	101	0	0	0	0	0	0	880	874	No				No	No	Texarkana Water Util.	NR								73	$ 36.66
City of Hooks	Bowie	1214	1189	50	60	0	0	0	0	0	0	1264	1249	No				No	No	Texarkana Water Util.	151								147	NR
City of Maud	Bowie	538	527	54	45	2	2	0	0	0	0	594	574	No				No	No	Texarkana Water Util.	348.7								52.2	$ 23.60
City of New Boston	Bowie	2178	2230	245	245	0	0	0	0	0	0	2423	2475	No				No	No	Texarkana Water Util.	355								350	$ 35.09
Oak Grove WSC	Bowie	267	271	0	0	0	0	0	0	0	0	267	271	No				No	No	Texarkana Water Util.	24								18	$ 39.50
Redwater Water & Sewer Co.	Bowie	835	892	15	20	0	0	0	0	0	0	850	912	No				Yes	No	Texarkana Water Util.	54.6	2	35 &100	250 & 250	NR	Yes (Quantity due to Dry Weather)			85	$ 33.00
City of Wake Village	Bowie	1889	2086	0	0	0	0	0	0	0	0	1889	2086	No				No	No	Texarkana Water Util.	As Required								207	$ 27.74
Woodland Estates	Bowie	30	44	0	0	0	0	0	0	0	0	30	44	No				Yes	No	Groundwater		3	80/100/60	50/175/280	Wilcox	No			4	$ 59.99
Cherokee Point	Camp	47	63	0	0	0	0	0	0	0	0	47	63	No				Yes	No	Groundwater		1	125	362	Carrizo-Wilcox	No			3.8	$ 49.18
City of Pittsburg	Camp	1457	1555	321	357	0	0	0	0	0	0	1778	1912	No	Pilgrim Pride Corp	Manufacturing	126	Yes	No	NETMWD & Groundwater	149.3	7	130/80/75/100	450	Carrizo-Wilcox	No			362	$ 32.15
															Pittsburg Hot Link Packers	Manufacturing							165/340/100	all						
Alpha Utility of Camp Co.	Camp	295	200	0	0	0	0	0	0	0	0	295	200	No				Yes	No	NR		NR	NR						4.5	$ 30.25
City of Hughes Springs	Cass	1100	1141	20	26	3	3	0	0	0	0	1123	1170	No				No	No	Lake of the Pines	140						NETMWD	660	148	$ 29.50
McLeod ISD	Cass	0	0	1	1	0	0	0	0	0	0	1	1	No				No	No	East Cass WSC	1								NR	NR
City of Queen City	Cass	781	878	0	0	0	0	0	0	0	0	781	878	No				Yes	No			1	500	972	Queen City Sands	No			53.2	$ 32.36
Whispering Pines MHP	Cass	55	55	0	0	0	0	0	0	0	0	55	55	No				NR	No	Groundwater		2		445	Edwards	No			880.2	NR
Atlanta State Park/TPWLD	Cass	0	0	80	80	0	0	0	0	0	0	80	80	No				Yes	No	Groundwater		2	100/70	439/330	Carrizo-Wilcox	No			0.72	N/A
City of Linden	Cass	862	841	108	111	2	2	0	0	0	0	972	954	No				Yes	No	Groundwater		4	85/120	740/712	Wilcox	No			101	$ 36.00
																							130/140	834/786	Wilcox					
Charlston WSC	Delta	399	485	0	0	0	0	0	0	0	0	399	485	No				No	No	Cooper	44.3								44.3	$ 48.60
City of Cooper	Delta	950	986	20	27	0	0	0	0	0	0	970	1013	No				Yes	No		163.1								163.1	$ 39.30
Cypress Springs SUD	Franklin	3660	3843	0	0	0	0	40	50	0	0	3700	3893	No				Yes	NR	Lake Cypress Spgs. & Well	1140	1	125	500	Carrizo-Wilcox	No			359.5	$ 50.59
City of Mount Vernon	Franklin	856	866	181	196	19	19	0	0	0	0	1056	1081	No				Yes	NR	Lake Cypress Springs	158								158.8	$ 34.18
City of Winnsboro	Franklin	1360	1353	224	223	16	16	0	0	0	0	1600	1592	No	Keller's Creamery	Industrial	37.8	Yes	No	Lake Cypress Springs	222.6						Lake Cypress Springs	2009-391.0	297.7	$ 46.30
															Presbyterian Hospital	Hospital	2.4											2014-553.9		
															TDCJ	Prison	16.8											2020-1303.4		
E. J. Water Co.	Greg	131	131	0	0	0	0	0	0	0	0	131	131	No				Yes	No			2	NR	400/400	Carrizo	No			37.4	NC
Garden Acres Water	Greg	49	49	0	0	0	0	0	0	0	0	49	49	No				Yes	No			2	NR	365/360	Wilcox	No		Need Storage	4.46	$ 23.20
City of Kilgore	Greg	3773	4082	1081	777	46	49	0	0	0	0	4900	4908	No				Yes	No	Sabine River	1460	6	300/328/700	540/490/550	Carrizo-Wilcox	No			896.5	$ 30.70
																							280/290/290	480/465/480	Carrizo-Wilcox					
																							411/387	500/485	Carrizo-Wilcox					
Liberty City WSC	Greg	1482	1575	0	0	1	1	0	0	0	0	1483	1576	No	Snow Max	Industrial	1.3	Yes	No			6	110/125/80	600/600/600	Carrizo-Wilcox	No	Groundwater	263	172.4	$ 38.50
												0	0										650(2)/60	1000/?	Carrizo-Wilcox					
City of Longview Water Utilities	Greg	21133	21265	4093	4481	92	97	0	0	0	1	25318	25844	No	Texas Eastman (Raw Water)	Manufacturing	1288.2	Yes	Yes	Lake Cherokee	3584								6486.1	$ 23.81
															Texas Eastman (Treat. Water)	Manufacturing	248.2			Lake Fork	1174									
															Rexam	Manufacturing	68			Lake O'the Pines	0									
															Air Liquide	Manufacturing	37.2			Sabine River	1132									

Table VIII – Summary of All Survey Items (continued)

		Connections																Water Treatment or Purchase												
		Residential		Non-Residential		Manufacturing		Livestock		Power Generation		Total			Current Major Users							Wells					Capacity Expansion Plans			
System	County	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	Plan to Add Major Customers	Name	Type	Annual Use (MG/yr.)	Do You Treat Your Own Water	Recycle or Reuse	Source	Purchasing Capacity (MG/yr.)	Number	Capacity (GPM)	Depth (Ft.)	Aquifer	Have Wells Declined in Quantity or Quality	Source	Planned Capacity (MG/yr.)	Volume MG/yr. (Last Full Yr.)	Costs per 10,000 Gal
															Marathon-LeToureau	Manufacturing	29.5													
															LeBus	Manufacturing	20.3													
															Compressed Gas Cyclinder	Manufacturing	13.2													
															Trinity Industries	Manufacturing	11.6													
Sun Acres MHP	Greg	50	55	0	0	0	0	0	0	0	0	50	55	No				Yes		Groundwater		1	30	525	Carrizo-Wilcox	No			3.2	NR
Tryon Road SUD	Greg	1614	1695	5	20	0	0	0	0	0	0	1619	1715	No				No	No	Groundwater		9	400/50/0	835/300/250	Carrizo-Wilcox	No	Lake of the Pines	737.3	218.5	$ 51.00
																							0/20/18	250/252/220	Carrizo-Wilcox					
																							250/42/207	735/368/1000	Carrizo-Wilcox					
City of Warren City	Greg	121	123	2	3	0	0	0	0	0	0	123	126	No				No	No	City of Gladewater	NR								11.98	$ 37.50
West Greg SUD	Greg	1215	1287	0	0	0	0	0	0	0	0	1215	1287	No				Yes	No	Groundwater		7	145/140/140	NR	NR	No			11.3	$ 38.60
												0	0										160/115							
												0	0										95/115							
City of White Oak	Greg	2042	1967	107	102	0	0	0	0	0	0	2149	2069	No	Gas solutions	Oil/Gas	19.5	Yes	No	City of Longview	380.65								270.7	$ 27.70
City of Clarksville City	Greg	296	301	13	16	0	0	0	0	0	0	309	317	No				No	No	City of Gladewater	NR								28	$ 39.50
City of Gladewater	Greg	2704	2653	0	0	0	0	0	0	0	0	2704	2653	No	City of Clarksville City	Wholesale	25.1	Yes	No	Lake Gladewater	NR								261.7	$ 38.80
															Warren City	Wholesale	11.5													
															Starrville-Friendship	Wholesale	0.001													
															Truman in Smith	Commercial	5.8													
															Housing Authority	Commercial	3.5													
															Texas Die Casting	Commercial	3.6													
															Gladewater Nursing Home	Commercial	2.4													
															CADDAX	Commercial	1.5													
															American health Care	Commercial	2.3													
Caddo Lake State Park	Harrison	<100	<100	0	0	0	0	0	0	0	0	<100	<100	No				Yes	No	Groundwater		1	60	300	NR	No			2.9	N/A
Cypress Valley Water	Harrison	352	368	0	0	0	0	0	0	0	0	352	368	No				No	No	Groundwater		4	100/50	380/360	Wilcox	No			30.7	$ 30.15
																				City of Marsfhall	0.85		50/150	360/380						
Elysian Fields WSC	Harrison	276	308	3	3	0	0	0	0	0	0	279	311	No				NR	No	Groundwater		2	75/150	225/225	Wilcox	No			24.8	$ 28.00
Gum Springs WSC	Harrison	NR	NR										2451	No	Trinity Industries	Industrial	5	Yes	No	City of Longview	5	2	200/180	500/500	Carrizo-Wilcox	No			247.6	$ 37.39
City of Hallsville	Harrison	1043	1074	0	0	0	0	0	0	0	0	1043	1074	No				No	No	City of Longview	86	4	27/106	204/243	Carrizo	No			108.4	$ 65.00
												0	0										63/68	245/301	Carrizo					
Harleton WSC	Harrison	872	910	5	5	0	0	0	0	0	0	877	915	No						Groundwater		3	175/150/60	400/500/500	Carrizo-Wilcox	No	NETMWD	18	66.2	$ 37.00
North Harrison WSC	Harrison	337	399	5	5	0	0	0	0	0	0	342	404	No				Yes	No	Groundwater		3	130/115/100	400/450/650	Carrizo-Wilcox	No	Drill Another Well	NR	35	$ 13.00
Rolling Acres WSC	Harrison	35	35	0	0	0	0	0	0	0	0	35	35	No				Yes	No	Groundwater		1	370	360	Wilcox	No			NR	NR
Shadowood WSC	Harrison	75	75	0	0	0	0	0	0	0	0	75	75	No				Yes	No	Groundwater		2	70/30	425/425	Cypress	No			10.8	$ 27.27
Waskom Rural water Supply	Harrison	245	285	0	0	0	0	0	0	0	0	245	285	No				Yes	No	Groundwater		2	110/13	150/150	Cypress	No			26.2	$ 34.00
City of Waskom	Harrison	936	957	74	74	2	2	0	0	0	0	1012	1033	No				Yes	No	Groundwater		8	30/160/39	130/170/156	Wilcox	No			99	$ 30.00
												0	0										63/145/62	180/197/182	Wilcox					
												0	0										120/116	178/198	Wilcox					
West Harrison WSC	Harrison	374	392	2	2	1	1	0	0	0	0	377	395	No				Yes	No	Groundwater		3	60/25/200	350/350/500	Carrizo-Wilcox	No	Drill a Well	200GPM	38	$ 76.00
												0	0							Gum Springs WSC	60									
Blocker Crossroads	Harrison	350	383	3	6	0	0	0	0	0	0	353	389	No				Yes	No	Groundwater		2	42/14	270/284	Wilcox	No	Drill A Well	NR	28.4	$ 31.60
City of Marshall	Harrison	7999	8004	1110	1143	0	0	0	0	0	0	9109	9147	No				Yes	No				NR	NR	NR				1724	$ 32.38

Table VIII – Summary of All Survey Items (continued)

		Connections																Water Treatment or Purchase												
		Residential		Non-Residential		Manufacturing		Livestock		Power Generation		Total			Current Major Users							Wells					Capacity Expansion Plans			
System	County	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	Plan to Add Major Customers	Name	Type	Annual Use (MG/yr.)	Do You Treat Your Own Water	Recycle or Reuse	Source	Purchasing Capacity (MG/yr.)	Number	Capacity (GPM)	Depth (Ft.)	Aquifer	Have Wells Declined in Quantity or Quality	Source	Planned Capacity (MG/yr.)	Volume MG/yr. (Last Full Yr.)	Costs per 10,000 Gal
Gill WSC	Harrison	793	814	20	23	0	0	0	0	0	0	813	837	No				Yes	No	Groundwater		3	160/150	400/420	Wilcox	No	Drill A Well	NR	64.9	$ 27.00
												0	0							City of Marshall	Emergency Use Only		120	475	Carrizo					
Leigh WSC	Harrison	794	824	0	0	0	0	0	0	0	0	794	824	No				No	No	Groundwater		3	75/85/130	210/272/165	Wilcox	No			87.3	NR
																				City of Marshall	60									
Brashear WSC	Hopkins	267	290	37	43	0	0	7	9	0	0	311	342	No				No	No	City of Sulphur Springs	34								33.5	$ 47.24
Brinker WSC	Hopkins	686	747	0	0	0	0	0	0	0	0	686	747	No				Yes	No	City of Sulphur Springs	7	3	100/100/300	350/400/420	Wilcox	No			70.3	NR
City of Como	Hopkins	NR	280	0	0	0	0	0	0	0	0	NR	280	No				Yes	No			2	100/160	468/446	Carrizo	No			NR	$ 38.00
Cornersville WSC	Hopkins	318	343	0	0	0	0	0	0	0	0	318	343	No				Yes	No			3	100/100//250	350/350450	Wilcox	No			38	NR
MartinSprings WSC	Hopkins	988	1039	0	0	0	0	0	0	0	0	988	1039	No				Yes	No			6	185/300/100	400/400/350	Wilcox	No			132.1	NR
																							60/100/100	350/400/400						
North Hopkins WSC	Hopkins	1811	1964	31	29	1	2	45	30	0	0	1888	2025	No				No	No	City of Sulphur Springs	NR								179.4	$ 41.21
Pickton WSC	Hopkins	202	223	0	0	0	0	0	0	0	0	202	223	No				Yes	No			2	100/100	400/400	Wilcox	No			19.6	NR
City of Sulphur Springs	Hopkins	5334	5355	814	810	22	22	0	0	0	0	6170	6187	No	Ocean Spray	Industrial	96.7	Yes	No	Cooper Lake	4745								1262	$ 29.17
															Morningstar Speciality	Industrial	74			Lake Sulphur Springs	3193									
															Kohler Mix	Industrial	36.2													
															Dairy Farmers of America	Industrial	34.6													
															Hop. Co. Memorial Hosp.	Hospital	14.2													
															Flowserve	Industrial	11													
Ables Springs WSC	Hunt	946	1079	0	0	0	0	0	0	0	0	946	1079	No				No	No	Sabine River Authority	365								78.3	$ 64.75
																				City of Terrell	36									
Country Wood Estates	Hunt	79	95	0	0	0	0	0	0	0	0	79	95	No				Yes	No	Cash Water Supply	2.775	2	25/31	320/325	Nacatoch	No			6187	$ 49.18
Barrow Subdivision	Hunt	94	98	0	0	0	0	0	0	0	0	94	98	No				Yes	No			2	40/40	531/557	Nacatoch	No			7313	$ 49.18
Crazy Horse Ranchos	Hunt	134	157	0	0	0	0	0	0	0	0	134	157	No				Yes	No	Groundwater		3	39/44/25	120/120/175	Nacatoch	No	Groundwater	Drill a Well	11.2	$ 49.18
Quinlan South Subdivision	Hunt	37	39	0	0	0	0	0	0	0	0	37	39	No				Yes	No	Groundwater		2	22/40	272/320	Nacatoch	No			3.8	$ 49.18
Quinlan North Subdivision	Hunt	58	64	0	0	0	0	0	0	0	0	58	64	No				Yes	No	Groundwater		2	30/25	335/335	Nacatoch	No		Add Storage & Pressure	4.6	$ 49.18
Caddo Basin SUD	Hunt	2465	2832	0	0	0	0	0	0	0	0	2465	2832	No				No	No	City of Farmersville	50								261.3	$ 45.23
																				NTMWD	50									
City of Caddo Mills	Hunt	461	461	0	0	0	0	0	0	0	0	461	461	No				Yes	No	City of Greenville	As Required						Caddo Basin	Back-up only	40.9	$ 51.84
Campbell Water Supply	Hunt	NR	450	NR	18		0		0		0		468	**No**				Yes	No	Groundwater		4	120/90	360/360	Nacatoch	No	Groundwater	New Well	26	$ 47.75
																							60/60	260/340	Nacatoch	No				
Cash WSC	Hunt	4524	5077	0	0	0	0	0	0	0	0	4524	5077	Yes	Boles Home	Wholesale	4.7	Yes		Lake Tawakoni	574									
														5000 Homes	Boles ISD	Wholesale	3.6			NTMWD	1792 AF/Yr								541.7	$ 50.00
															Combined Consumers WSC	Wholesale	1.9													
															Aqua Source	Wholesale	9.9													
															City of Lone Oak	Wholesale	20													
															Lone Oak ISD	Wholesale	3.7													
															City of Quinlan	Wholesale	61.4													
															Sabine River Authority	Wholesale	0.4													
City of Celeste	Hunt	340	356	0	0	0	0	0	0	0	0	340	356	No				Yes	No	Groundwater		2	150/150	1920/1870	Woodbine	No			23.3	$ 34.90
Combined Consumers WSC	Hunt	2886	2916	0	0	0	0	0	0	0	0	2886	2916	No				Yes	Yes	Lake Tawakoni-SRA	547.5						Surface Water-SRA	839.5	172.7	$ 65.48
																			Filter Backwash											

Table VIII – Summary of All Survey Items (continued)

		Connections																Water Treatment or Purchase												
		Residential		Non-Residential		Manufacturing		Livestock		Power Generation		Total			Current Major Users							Wells					Capacity Expansion Plans			
System	County	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	Plan to Add Major Customers	Name	Type	Annual Use (MG/yr.)	Do You Treat Your Own Water	Recycle or Reuse	Source	Purchasing Capacity (MG/yr.)	Number	Capacity (GPM)	Depth (Ft.)	Aquifer	Have Wells Declined in Quantity or Quality	Source	Planned Capacity (MG/yr.)	Volume MG/yr. (Last Full Yr.)	Costs per 10,000 Gal
City of Greenville	Hunt	7630	7783	1010	1002	18	18	0	0	0	0	8658	8803	Yes	L-3 Communications	Ind/MFG	53.9	Yes	No	Lake Ribitt	1.35								1571.5	$ 38.53
														12-16 MGD	Rubbermaid Inc.	Ind/MFG	26.7			Lake Tawakoni	6.9									
															Fiberite Corp.	Ind/MFG	14.6													
															Other Manufacturing	Ind/MFG	31.8													
															Greenville Electrical	Ind/MFG	14.5													
Hickory Creek SUD	Hunt	962	1063	4	4	0	0	0	0	0	0	966	1067	No					No	Groundwater		3	140	2318	Sabine	No	Yes	2300	87.2	$ 47.24
																							190	1963	Trinity	No	Drill Well			
																							360	1845	Sulphur	No				
Little Creek Acres	Hunt	26	26	0	0	0	0	0	0	0	0	26	26	No					No	Groudwater		1	20	209	Nacatoch	No				$ 43.43
City of Lone Oak	Hunt	262	237	44	46	0	0	0	0	0	0	306	283	No				No	No	Cash Water Supply	54.75								19.1	$ 61.94
North Hunt WSC	Hunt	1150	1224	0	0	0	0	0	0	0	0	1150	1224	No				Yes	No	City of commerce	NR	2	115/350	330/1960	Woodbine	No			91.2	$ 70.00
Shady Grove WSC	Hunt	375	418	0	0	0	0	0	0	0	0	375	418	No				No	No	City of Greenville	182								29	$ 60.50
Texas A&M Commerce	Hunt	773	773	0	0	0	0	0	0	0	0	773	773	No				No	No	City of Commerce	72	4	120/160	440/454	Nacatoch	No			83.1	N/A
																							140/120	445/483						
City of Deport	Lamar	290	290	0	0	0	0	0	0	0	0	290	290	No				Yes	No	Lamar County WSD	NR								41.7	$ 57.50
Lamar County WSD	Lamar	6068	6538	0	0	0	0	0	0	0	0	6068	6538	Yes				No	No	Pat Mayse Lake	1825						City of Paris	6124 after 2010	813.5	$ 49.00
City of Paris	Lamar	9905	10157	0	0	0	0	0	0	0	0	9905	10157	No				Yes		Pat Mayse Lake	5217.5								5225	$ 30.35
																				Lake Crook	7.6									
City of Reno	Lamar	994	1077	35	50	0	0	0	0	0	0	1029	1127	No				No	no	Lamar County WSD	102.3								102.2	$ 50.07
City of Roxton	Lamar	287	322	0	0	0	0	0	0	0	0	287	322	No				No	No	Lamar County WSD	22.6								24.5	$ 55.50
EMC WSC	Marion	645	743	0	0	0	0	0	0	0	0	645	743	No				Yes	No	Groundwater		4	150/150	250/250	Cypress	No			42	$ 48.00
																							150/80	650/370	Cypress					
City of Jefferson	Marion	1148	1200	0	0	2	3	0	0	0	0	1150	1203	No	Blackburns Syrup	Manufacturing	2.4	No	No	NETMWD	NR								126.4	$ 21.00
															Nexfor Norbord	Manufacturing	10.2													
															Sonoco	Manufacturing	NR													
Mims WSC	Marion	459	478	1	2	0	0	0	0	0	0	460	480	No				No	No	NETMWD	25								20	$ 52.26
Shady Shores	Marion	156	162	0	0	0	0	0	0	0	0	156	162	No				Yes	No	Groundwater		1	NR	954	NR				11.7	$ 38.00
City of Daingerfield	Morris	999	926	175	150	1	1	0	0	0	0	1175	1077	No	(One Not Named)	Manufacturing	NR	No	No	NETMWD	As Needed								138.1	$ 33.60
City of Lone Star	Morris	686	694	82	85	0	0	0	0	0	0	768	779	Yes	Reilly Ind	Manufacturing	6.1	No	No	NR	Nr								68.7	$ 66.00
City of Omaha	Morris	600	560	0	0	0	0	0	0	0	0	600	560	No				Yes	No			5	100/40/60	527/300/540	NR	No			36.6	$ 24.30
																							80/110	400/558						
City of Naples Water Works	Morris	597	594	50	54	3	3	0	0	0	0	650	651	No	Mapa Manufactiring	Manufacturing	0.02	Yes	No	Groundwater		5	90/32/75	360/360/360	Carrizo-Wilcao	No			64.2	$ 32.50
															Tamko Inc.	Manufacturing	3.8						112/105	400/402	Carrizo-Wilcao					
															Top Hat Inc.	Manufacturing	0.37													
Bright Star-Salem WSC	Raines	1559	1724	0	0	0	0	0	0	0	0	1559	1724	No					No										117.6	$ 44.00
Cedar Cove Landing	Raines		34									0	34					No	No	City of Emery									NR	NR
City of East Tawakoni	Raines	532	551	8	9	0	0	0	0	0	0	540	560	No						City of Emery	180								50.6	$ 43.90
City of Emory WTP	Raines	650	795	30	38	0	0	0	0	0	0	680	833	No				Yes	No	Lake Tawakoni	657								2425	$ 48.00
City of Point	Raines	670	890	24	28	1	1	0	0	0	0	695	919	Yes	Dal-Air Tool Inc.	Manufacturing	52.4	Yes	No	City of Emory	36.5								69.7	$ 47.80
410 WSC	Red River		803		1	0	0	11	11	0	0	11	815	No	David Rozell	Non-Residential	0.259	No	No	Lamar County ESC	54.5								54.5	$ 61.29
															12 Livestock Users	Livestock	5.269													
City of Bogata	Red River	616	604	0	0	0	0	0	0	0	0	616	604	No				Yes	No	Groundwater		3	300/300/65	325/325/300	Nacatoch	Yes (Dry)			38.2	$ 37.00

Table VIII – Summary of All Survey Items (continued)

		Connections																Water Treatment or Purchase												
		Residential		Non-Residential		Manufacturing		Livestock		Power Generation		Total			Current Major Users							Wells					Capacity Expansion Plans			
System	County	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	Plan to Add Major Customers	Name	Type	Annual Use (MG/yr.)	Do You Treat Your Own Water	Recycle or Reuse	Source	Purchasing Capacity (MG/yr.)	Number	Capacity (GPM)	Depth (Ft.)	Aquifer	Have Wells Declined in Quantity or Quality	Source	Planned Capacity (MG/yr.)	Volume MG/yr. (Last Full Yr.)	Costs per 10,000 Gal
City of Clarksville	Red River	1474	1370	232	249	5	5	0	0	0	0	1711	1624	No				Yes	No	Langford Lake	123	2	320/350	302/675	Blossom	Yes (Bacteria, High Sodium)			207	$ 36.00
City of Detroit	Red River	253	267	28	28	0	0	0	0	0	0	281	295	No				No	No	LCWSD	NR	1	110	2020	Trinity	No			22.2	$ 35.00
Red River County WSC	Red River	1844	1994	0	0	0	0	0	0	0	0	1844	1994	No				Yes	No	Texarkana Utilities	22	4	170/150	550/550	Blossom	No			159	$ 43.50
																				LCWSD	1		150/380	500/600	Blossom/ Nacatoch	Yes (TDS Up to Max Well #1)				
City of Lindale	Smith	1352	1700	135	160	0	0	0	0	0	0	1487	1860	No				Yes	No	Groundwater		4	550/450	990/880	Carrizo-Wilcax	No			239.1	NR
																							500/800	900/1100	Carrizo-Wilcax					
Garden Valley Golf Resort	Smith	NR	7	0	0	0	0	0	0	0		NR	7					NR	NR	NR									NR	NR
Lindale Rural WSC	Smith	1926	2346	18	19	14	15	4	4	0	0	1962	2384	No				Yes	no	Groundwater		5	280/265/220	1015/972/925	Carrizo	No	Drill a Well	91	319.5	$ 40.00
																							1000/280	1720/1018	Carrizo					
																				City of Lindale	0.76									
Starrville-FriendshipW SC	Smith	439	530	1	1	0	0	0	0	0	0	440	531	No				Yes	No	Groundwater		3	55/90/240	NR	NR	No			49.8	$ 35.00
																				City of Gladewater	NR									
Twin Oaks Ranch	Smith	42	42	8	8	0	0	0	0	0	0	50	50	No				No	No	Carrol WSC	1.02	1	80	900	Carrizo				7.3	N/A
Lake Bob Sandlin State Park	Titus	110	110	0	0	0	0	0	0	0	0	110	110	No				No	No	Tri-Water WSC	1.13								1.13	N/A
City of Mount Pleasant	Titus	4682	4900	0	0	0	0	0	0	0	0	4682	4900	No	Pilgrim's Pride	Industrial	1080	Yes	No	Lake Bob Sandlin	2750								4810	$ 27.81
															Tri-Water Corp.	Water Supply	501			Cypress Springs Lake	510									
															City of Winfield	Water Supply	50			Lake Tankersley	3000 AF/Yr Backup									
Northeast Texas Com. College	Titus	0	0	1	1	0	0	0	0	0	0	1	1	No				Yes	No	Tri-Water WSC	0.7	1	300	640	Carrizo-Wilcox	No			7	N/A
Talco Water Department	Titus	270	243	30	30	0	0	0	0	0	0	300	273	No				Yes	No			3	300/350/250	408/430/394	Nacatoch	No			43.3	$ 31.00
City of Winfield	Titus	185	194	6	16	0	0	0	0	0	0	191	210	No				No	No	City of Mount Pleasant	50								21.7	$ 3.17
Brookshire's CampJoy WSC	Upshur	95	97	0	0	0	0	0	0	0	0	95	97	No				Yes	No	Groundwater		2	48/48	260/268	NR	No			6.1	$ 32.00
Country Club Estates	Upshur	33	33	0	0	0	0	0	0	0	0	33	33	No				Yes	No	Groundwater		1	32	491	Wilcox	No			2.8	$ 38.20
Diana SUD	Upshur	1412	1472	31	48	0	0	0	0	0	0	1443	1520	No				Yrs	No	Groundwater		8	150/66/110	700/630/420	Carrizo-Wilcox	No	NETMUD	240	131.6	$ 43.11
																							158/160/156	1000/700/650	Carrizo-Wilcox					
																							165/300	496/610	Carrizo-Wilcox					
City of East Mountain	Upshur	540	545	5	6	0	0	0	0	0	0	545	551	No				Yes	No	Groundwater		4	325/150	600?	NR	No	New Well	52	51.8	$ 35.33
																				Glennwood Acres	0.56		110/100							
Friendship	Upshur	56	58	0	0	0	0	0	0	0	0	56	58	No				Yes	No	Groundwater		1	44	415	Carrizo				4.74	$ 38.20
City of Gilmer	Upshur	2450	2450	0	0	0	0	0		0		2450	2450	No				No	No	Groundwater		6	230/250/560	492/519/540	Carrizo-Wilcox	Wells 3 & 4 have Decreased	Lake Gilmer	540	305.8	NR
																							590/270/150	500/385/141	Carrizo-Wilcox					
Glenwood WSC	Upshur	781	849	0	0	1	1	0	0	0	0	782	850	No				Yes	No	Groundwater		6	75/75/140	529/480/824	Wilcox	No	NETMUD	50	67.9	$ 35.00
																							65/135/260	516/539/450	Carrizo-Wilcox					
City of Ore City	Upshur	494	463	47	42	0	0	0	0	0	0	541	505	No				Yes	No	Groundwater		3	135/135/150	400/480/790	Wilcox	No	NETMUD	NR	NR	$ 20.10
Pritchett WSC	Upshur	2182	2305	16	19	2	2	3	3	0	0	2203	2329	No	The Pines	Recreational	3.8	No	No	Groundwater		17	55/50/70	760/375/562	Carrizo-Wilcox	No			181	$ 63.32
															Pavement Tools MFRS Inc.	Manufacturing	1.4						58/66/73/	615/592/623	Carrizo-Wilcox					
															Boersma Dairy	Livestock	0.6						100/155/100	650/621/770	Carrizo-Wilcox					
															Xavera Dairy	Livestock	Backup						35/50/84	490/600/650	Carrizo-Wilcox					
															Green Dairy	Livestock	1.3						42/85/52	570/600/1153	Carrizo-Wilcox					
																							40/107	776/663	Carrizo					
Rosewood	Upshur	119	121	0	0	0	0	0	0	0	0	119	121	No				Yes	No	Groundwater		2	60/35	415/424	Carrizo	Fall in Static Level			9.5	$ 38.20

Table VIII – Summary of All Survey Items (continued)

		Connections																Water Treatment or Purchase												
		Residential		Non-Residential		Manufacturing		Livestock		Power Generation		Total			Current Major Users							Wells					Capacity Expansion Plans			
System	County	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	Plan to Add Major Customers	Name	Type	Annual Use (MG/yr.)	Do You Treat Your Own Water	Recycle or Reuse	Source	Purchasing Capacity (MG/yr.)	Number	Capacity (GPM)	Depth (Ft.)	Aquifer	Have Wells Declined in Quantity or Quality	Source	Planned Capacity (MG/yr.)	Volume MG/yr. (Last Full Yr.)	Costs per 10,000 Gal
Bethel-Ash WSC	Van Zandt	1251	1416	0	0	0	0	0	0	0	0	1251	1416	No				Yes	No	Groundwater		7	72/190/125	577/920/862	Wilcox	No			119.9	NR
																							150/200	770/540						
																							350/170	770/547						
Canton North II	Van Zandt		34									0	34	No				No	No	Groundwater		2	35/35	420/420	Wilcox	No			1.83	NR
City of Canton	Van Zandt	1785	1860	0	0	0	0	0	0	0	0	1785	1860	No				Yes	No	Mill Creek Lake	730	1	280	520	Carrizo-Wilcox	Yes (Lower Pump 20 ft.Since 1988)			298	NR
City of Edgewood	Van Zandt		595		0		0		0		0		595	No				Yes	No	City Lake									79.2	$ 57.31
																				Lake Fork										
Fruitvale WSC	Van Zandt	997	1059	0	0	0	0	0	0	0	0	997	1059	No				Yes	No	Groundwater		$ Groups	320/164	330/360	Wilcox	No			82.4	$ 24.37
																							394/60	500/280	Wilcox					
City of Grand Saline	Van Zandt	1172	1272	165	165	0	0	0	0	0	0	1337	1437	No				No	No	Groundwater		4	350/120	500/500	Carrizo-Wilcox	No			168.1	$ 24.75
																							300/250	500/500	Carrizo-Wilcox					
Martins Mill WSC	Van Zandt		66		1							0	67	No				Yes	No	Groundwater		2	35/28	470/530	Wilcox	No			NR	NR
MACBEE SUD	Van Zandt	1858	2017	14	17	3	7	2	2	0	0	1877	2043	No	Deen Farms	Dairy	1.7	Yes	No	Lake Fork	730	2	100/100	475/490	Carrizo-Wilcox	No			171.5	$ 57.99
															Chitty Nursery	Plant Farm	0.5													
															Flory Tree Farm	Plant Farm	1													
															Van Zandt Livestock Auction	Livestock	0.5													
R.P.M. WSC	Van Zandt	637	724	3	7	2	2	2	2	0	0	644	735	No				Yes	No	Groundwater		4	70/90	?/?	Wilcox	No	Groundwater	12	75	$ 47.00
																							150/130	454/470	Wilcox					
South Tawakoni WSC	Van Zandt	1252	1372	0	0	0	0	0	0	0	0	1252	1372	No				Yes	Yes	Lake Tawakoni	365						Lake Tawakoni SRA	182.5	202.2	$ 58.79
City of Van	Van Zandt		1390	0	0	0	0	0	0	0	0	0	1390	No				No	Yes	Groundwater		4	480/300	750-800	Wilcox	No			158.6	$ 30.75
																							250/425	750/1200	Wilcox					
City of Wills Point	Van Zandt	1472	1629	24	29	174	181	0	0	0	0	1670	1839	No	Wills Point ISD	School	1.1	Yes	No	Lake Tawakoni	365						Water Plant Expansion	To 3.0 MGD	205	$ 30.38
															9 Commercial	Commercial	1.1													
City of Alba	Wood	290	292	15	14	2	2	0	0	0	0	307	308	No	Central Marble	Manufacturing	0.48	Yes	No	Groundwater		2	1306/60	400	NR	No			NR	NR
Bright Star-Salem WSC	Wood	1559	1724	0	0	0	0	0	0	0	0	1559	1724	No				NR	Noi	NR									117.6	$ 44.00
Fouke WSC	Wood	1717	1881	17	17	0	0	0	0	0	0	1734	1898	No	Salesman Club	Manufacturing	3	Yes	No	Groundwater		6	225/225/300	1216/1134/925	Carrizo-Wilcox	No			178.8	$ 33.00
															Hawkins RV	Manufacturing	1						120/200/120	464/1050/1000	Carrizo-Wilcox					
															Fish Haul RV	Manufacturing	0.05													
															Hall Dairy	Livestock	0.142													
Golden WSC #1 & #2	Wood	1072	1135	19	25	1	1	0	0	0	0	1092	1161	No				Yes	No	Groundwater		6	100/150/150	450/600/600	Carrizo-Wilcox	No	New Well #7	100	104	NR
																							45/208/115	600/500/500	Carrizo-Wilcox					
Silverleaf Resorts, Inc.	Wood	1488	1703	0	0	0	0	0	0	0	0	1488	1703	No				Yes	No	Groundwater		7	105/345/100	1025/660/680	Carrizo-Wilcox	No	Plan to Expand	NR	135.3	$ 41.16
																							70/14	910/800	Carrizo-Wilcox					
																							170/140	610/725	Carrizo-Wilcox					
Jones WSC	Wood	1448	1570	0	0	0	0	0	0	0	0	1448	1570	No				Yes	No	Groundwater		6	90/250/110	450/550/450	Carrizo-Wilcox	No			122.4	$ 42.71
																							250/290/250	550/850/375	Carrizo-Wilcox					
Lake Fork WSC	Wood	894	1101	0	0	0	0	0	0	0	0	894	1101	No	Billy Mack Chamness	Dairy	0.155	Yes	No	Groundwater		6	140/45/200	449/470/250	Carrizo-Wilcox	No			55.6	$ 41.20
															Dennis Fraxier	RV Park	0.03						86/38/100	240/?/215	Carrizo-Wilcox					
															Dorthy Yarbrough	Dairy	0.08													
City of Mineola	Wood	2121	2123	527	578	0	0	0	0	0	0	2648	2701	No	Wood Memorial Care Center	Commercial	4.3	No	No	Groundwater		3	400/600/750	290/270/260	Carrizo	No	One New Well	45	252.3	NR
															Harvest Care Center	Commercial	0.411													

Table VIII – Summary of All Survey Items (continued)

		Connections																Water Treatment or Purchase												
		Residential		Non-Residential		Manufacturing		Livestock		Power Generation		Total			Current Major Users							Wells					Capacity Expansion Plans			
System	County	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	1999	2003	Plan to Add Major Customers	Name	Type	Annual Use (MG/yr.)	Do You Treat Your Own Water	Recycle or Reuse	Source	Purchasing Capacity (MG/yr.)	Number	Capacity (GPM)	Depth (Ft.)	Aquifer	Have Wells Declined in Quantity or Quality	Source	Planned Capacity (MG/yr.)	Volume MG/yr. (Last Full Yr.)	Costs per 10,000 Gal
															Mineola Packing	Commercial	2.5													
New Hope WSC	Wood	702	733	1	1	0	0	1	1	0	0	704	735	No	Tonya McShan	Livestock	1.35	Yes	No	Groundwater		3	125/240/340	600/619/600	Carrizo-Wilcox	Yes (40-50Ft. In 10 Yrs.)	New Well	100	89.9	$ 39.50
City of Quitman	Wood	772	786	193	197	0	0	0	0	0	0	965	983	No				Yes	No	Lake Fork Reservoir	365								116	$ 51.46
Ramey WSC	Wood	1054	1164	23	23	0		0	0	0	0	1077	1187	No				NR	No	Groundwater		9	60/90/120	340/330/480	Carrizo-Wilcox	No			81.8	$ 40.20
												0	0										240/110/130	460/350/330	Carrizo-Wilcox					
												0	0										300/35/35	680/480/330	Carrizo-Wilcox					
Sharon WSC	Wood	2163	2346	0	0	0	0	0	0	0	0	2163	2346	No				Yes	No	Groundwater		7	175/150/175	836/730/890	NR	No	New Well	13	181.9	NR
																				Winnsboro	72		160/100	900/885	NR					
																				(Will Not Renew)			250/210	500/570	NR					
City of Winnsboro	Wood	1360	1353	224	223	16	16	0	0	0	0	1600	1592	No	Keller's Creamery	Industrial	37.8	Yes	NR	Lake Cypress Springs	222.6								297.7	$ 46.30
															Presbyerian Hospital	Hospital	2.4													
															TDJC	Prison	16.8													
Yantis WSC	Wood	235	230	0	0	0	0	0	0	0	0	235	230	No				Yes	No	Groundwater		2	22/100	420/430	Carrizo-Wilcox	Yes (GPM Down 50%)			24.7	$ 42.00
TOTALS		178103	190717	12138	12529	452	474	115	112	0	1	190808	206284																	
																													52399.46	
			12614		391		22		-3		1		15476																	
			7.08%		3.22%		4.87%		-2.61%		0		8.11%																	
NR - No Response																														
N/A - Not Applicable																														

8.0 APPENDIX B – GUYTON ANALYSIS

LBG-GUYTON ASSOCIATES

PROFESSIONAL GROUNDWATER AND ENVIRONMENTAL ENGINEERING

1101 CAPITAL OF TEXAS HIGHWAY
SUITE B-220
AUSTIN, TX 78746
512-327-9640
FAX: 512-327-5573
www.lbg-guyton.com

May 8, 2009

James Ray Flemons, PE, FACEC
Senior Vice President
Bucher Willis & Ratliff Corporation
8140 Walnut Hill Lane
Dallas, Texas 75231

Dear Mr. Flemmons,

At the request of BWR, LBG-Guyton Associates has performed an evaluation of the brackish groundwater supply in the Region D area. The Texas Water Development Board (TWDB) data was searched and parsed for relevant information on brackish groundwater. Information in this database is populated from data obtained by well driller's reports, pumping test results, water quality analyses and other pertinent information obtain by the TWDB through reliable sources.

In general, brackish water that is greater than 1,000 mg/l in total dissolved solids (TDS) is found in the down-dip limits of the aquifers in the region. Most of the brackish water is either found in the Cretaceous aquifers in the northern part of Region D. Those aquifers with brackish water include: Nacatoch, Blossom, Woodbine and the Paluxy and Twin Mountain of the Trinity Aquifer (Figure 1). Brackish water can also be found in some of the deeper Wilcox portion of the Carrizo-Wilcox aquifer (Figure 1). Most wells found in the southeastern portion of the Region D area are completed into the Tertiary age, Carrizo and Queen City Sands that generally produce freshwater (<1,000 mg/l TDS).

Six geophysical logs were obtained from the Surface Casing Division of the Texas Commission of Environmental Quality representing the different aquifers with known brackish water. These logs are made from oil field test wells that span a number of the shallower aquifers. The state identification numbers for those wells are: 17-29-202, 17-21-807, 17-22-404, 16-33-601, 34-02-702, and 35-33-602 (Figure 1). Logs found in the northern portion of Region D show the Cretaceous aquifers and logs in the southern area show the Carrizo-Wilcox Aquifer. Based on review of geophysical logs in the area, brackish water is generally found in strata at depths less than 2,000 feet.

An evaluation of these logs indicate only a portion of each geologic unit is capable of producing significant water. The Cretaceous aquifers only have small footage intervals of sand or limestone that can actually produce water. The Wilcox aquifer generally has a variety of sandy layers that can produce water. Throughout the total thickness of the geologic unit, a variety of water quality can be interpreted from any particular sand interval on the geophysical log. Depending on the interval that is screened and open to produce water to the well will determine the overall average chemistry from a particular well. Generally, deeper sands have lower resistivities on the geophysical log, which correspond to higher TDS content of the water produced from those intervals.

Based on these logs and other wells completion information, wells completed in the Cretaceous aquifers (Nacatoch, Blossom, Woodbine and the Paluxy and Twin Mountain of the Trinity Aquifer) generally produce lower volumes often less than 50 gallons per minute (gpm) with one reported as high as 120 gpm completed into the Blossom Aquifer. Wells completed into the Wilcox generally have higher reported yields ranging up to about 600 gpm. However, a practical expectation for Wilcox brackish wells is about 100 to 300 gpm.

Brackish wells could be developed in the Woodbine and Trinity aquifers in Lamar and Red River Counties. Experience in Texas indicates that each brackish groundwater wellfield needs to be evaluated individually to identify specific water quality characteristics and well production capacity. It is possible to find brackish groundwater in most of the downdip sections of the Nacatoch aquifer, but especially in Hunt, Hopkins, and Bowie Counties. In the Carrizo and Wilcox aquifers, there are zones of brackish groundwater in many Region D counties where the aquifers exists. Generally, the brackish groundwater will be found in the deeper section of the aquifers, but there are exceptions to this general rule.

Brackish groundwater in the aquifers described here is generally suitable for desalination and use for industrial and municipal use. The groundwater at each location would require specific assessment and treatment processes would need to be tailored for that groundwater and for the requirements of the water user group. One consideration in treating brackish groundwater is the disposal of the concentrate from the treatment. There are various approaches to disposal, such as discharge into surface water or injection, and this component of the treatment system should be assessed as part of the overall planning of the brackish groundwater development.

Sincerely,
LBG-GUYTON ASSOCIATES

James Beach, PG

File No. 03 – 10598

Q5

UX3402701 702

COUNTY: RAINS No. EN 137
FIELD OR: WILDCAT
SURVEY: LAWHORN
WELL: GLASS #1
COMPANY: PARSON ANDREE
AUGUST 9, 1938

SCHLUMBERGER ELECTRICAL LOGS

Location of Well

300' FROM E/L
300' FROM S/L
1 MILE SOUTH
OF POINT, TEXAS

COMPANY: PARSON & ANDREE
WELL: GLASS #1
FIELD: WILDCAT
SURVEY: LAWHORN
COUNTY: RAINS
STATE: TEXAS FILING No.: EN 137
PROBLEM: STUDY OF FORMATIONS

Elevation: 530' DF

First Reading	: 3881 ft.	Started run	: 3:30	P	m.
Last Reading	: 110 ft.	Finished run	: 4:30	A	m.
Footage Measured	: 3771 ft.	Time well occupied by outfit	: 58		hrs.
Casing Shoe Depth: DRILLER	: 101 ft.	Time waiting at well	: 28		hrs.
Casing Shoe Depth: SCHLUMBERGER	: ... ft.	Total time incurred by run	: 13		hrs.
Bottom Depth: DRILLER	: 3900 ft.	Mileage incurred by run	: 120		Mi.
Total Depth Reached	: 3881 ft.				

MUD CHARACTERISTICS

Nature: NATURAL Viscosity: 28
Weight: 9.5 Resistivity: 8.7 @92 °F
Bottom Temperature: °F

Diameters of hole: from CSG. to 3690 : 9 7/8"; from 3690 to 3TD : 7 7/8"; from to

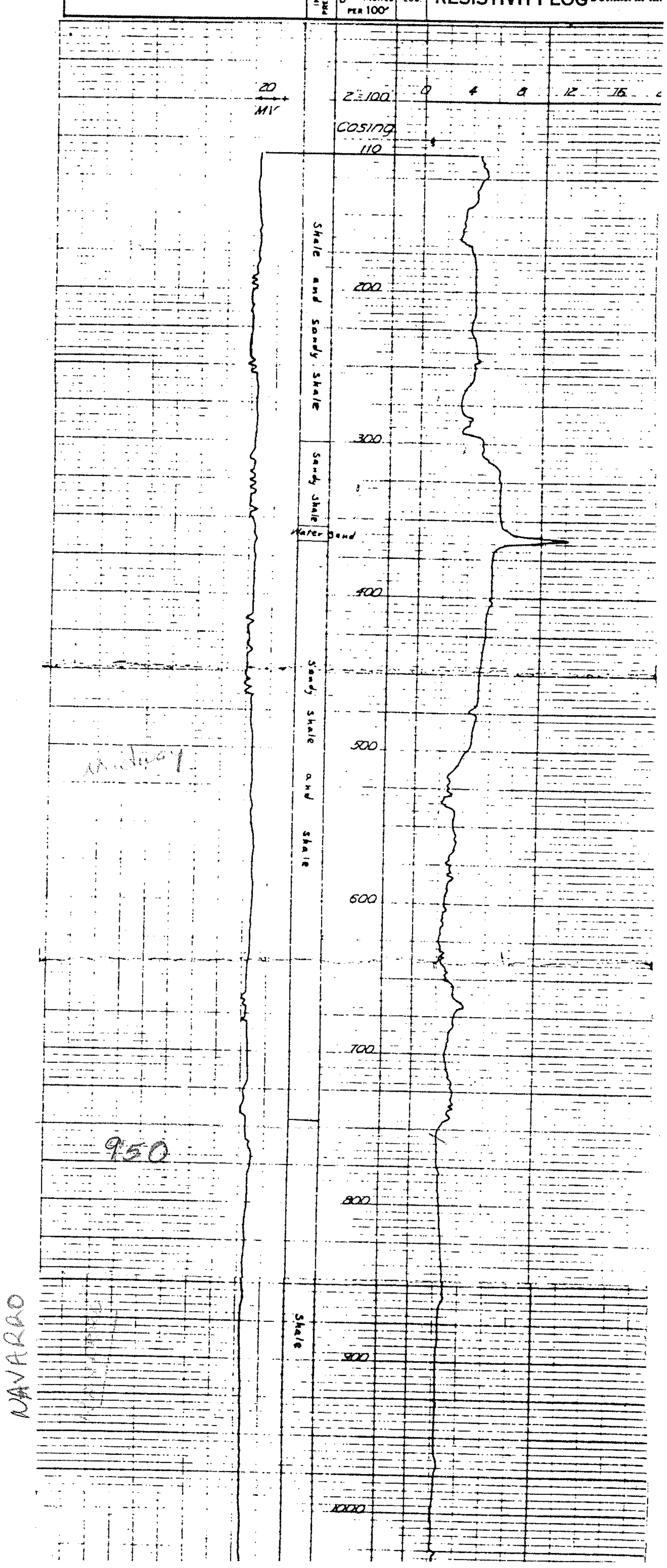
REMARKS

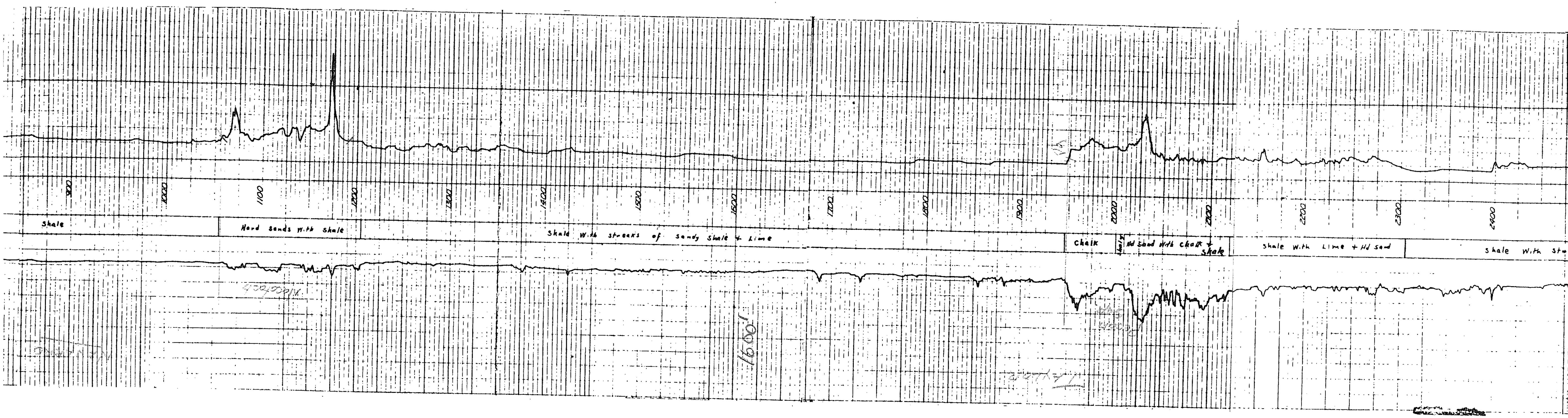
32.91604
95.85577
42-379-00013

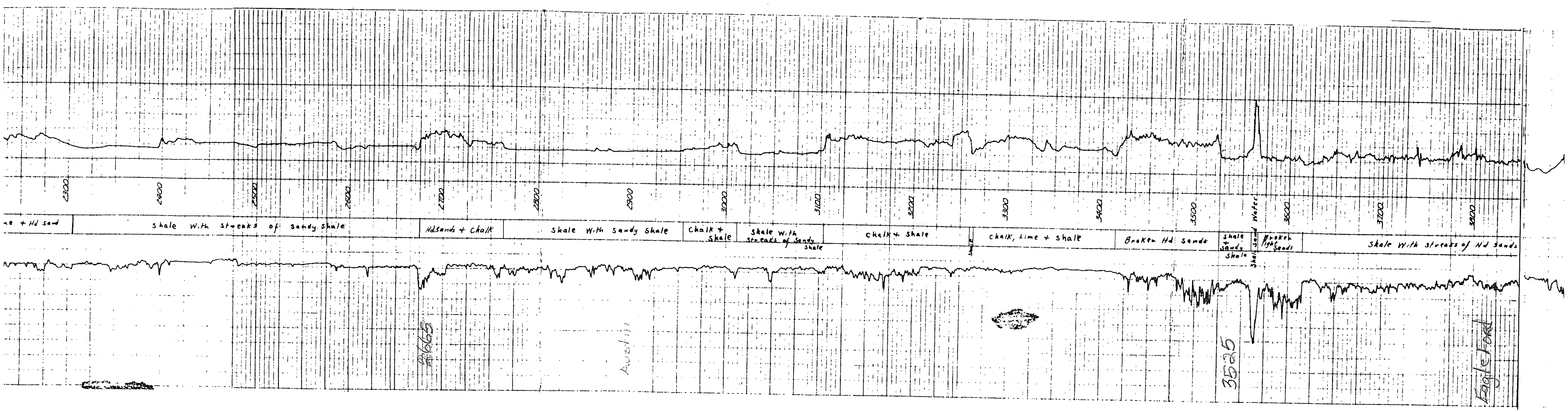
NOT MUCH USE IN ASSIGNING STATE NO. TO THIS WELL — D.E. WHITE
NO WILCOX

Date: AUGUST 9, 1938 Observers: R. T. GALE & W. J. LITTLE

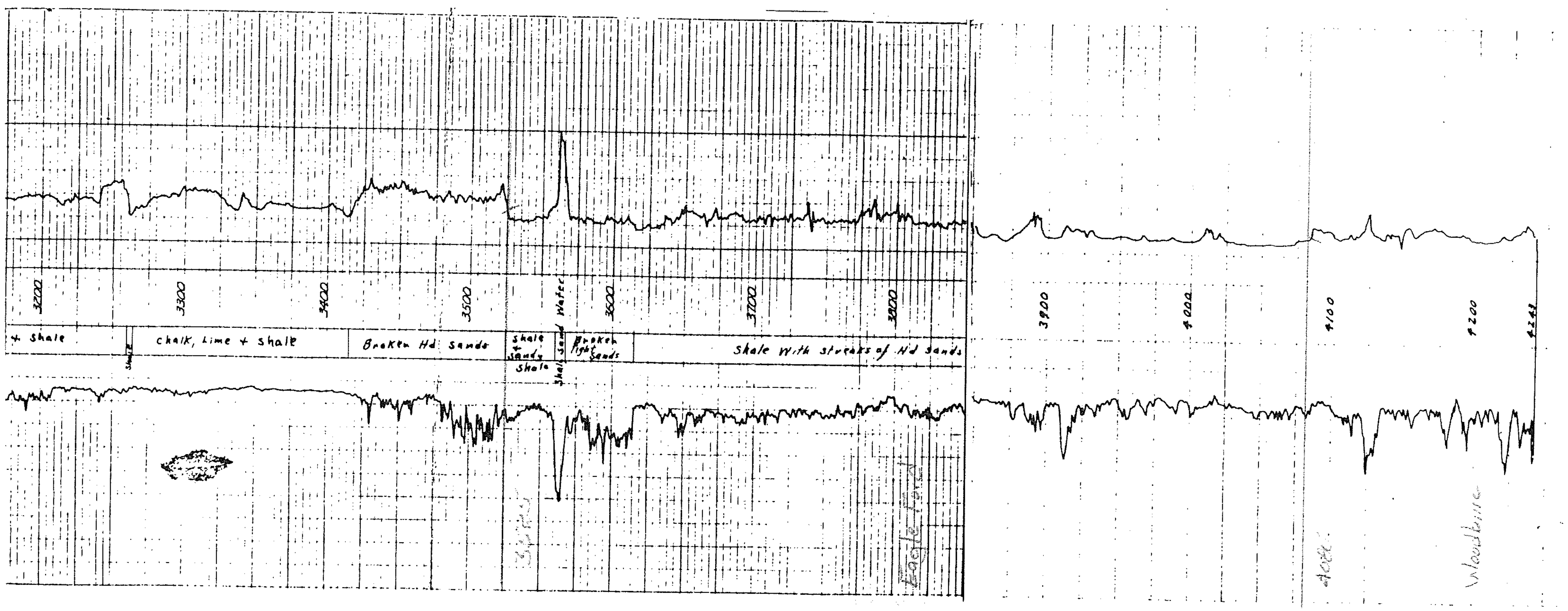
SELF-POTENTIAL LOG - millivolts	INTERPRETATION	DEPTHS 2 & 5 INCHES PER 100'	GEOL. LOG	RESISTIVITY LOG - ohms. m²/m.




900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
Shale
Hard sands with shale
Shale with streaks of sandy shale + Lime
Chalk
Hd sand with chalk + shale
Shale with Lime + Hd sand
Shale with streal
1600'



2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
ne + Hd Sand
Shale With streaks of Sandy Shale
Hd Sands + Chalk
Shale With Sandy Shale
Chalk + Shale
Shale With streaks of Sandy Shale
Chalk + Shale
Chalk, Lime + Shale
Broken Hd Sands
Shale + Sandy Shale
Shale sand Water
Broken tight Sands
Shale With streaks of Hd sands
2665
Austin
3525
Eagle Ford


3200
3300
3400
3500
Water
3600
3700
3800
3900
4000
4100
4200
4241
+ Shale
Shale
Chalk, Lime + Shale
Broken Hd Sands
Shale + Sandy Shale
Shale Sand
Broken light Sands
Shale With streaks of Hd sands
Eagle Ford
4088
Woodbine

SCHLUMBERGER WELL SURVEYING CORPORATION

COUNTY: GREGG
FIELD OR LOCATION: EAST TEXAS
WELL: WM. BAXTER #17
COMPANY: THE TEXAS CO.

Location of Well: 2200 FEL, 1300 FSL

Elevation: D.F. 385, G.L. 380

COMPANY: THE TEXAS CO.
35-33-602
WELL: WM. BAXTER NO. 17
RUN NO.: 1 (NO)
FIELD: EAST TEXAS
LOCATION: MARY SCOTT SURVEY
COUNTY: GREGG
STATE: TEXAS
FILING No.: EN-143

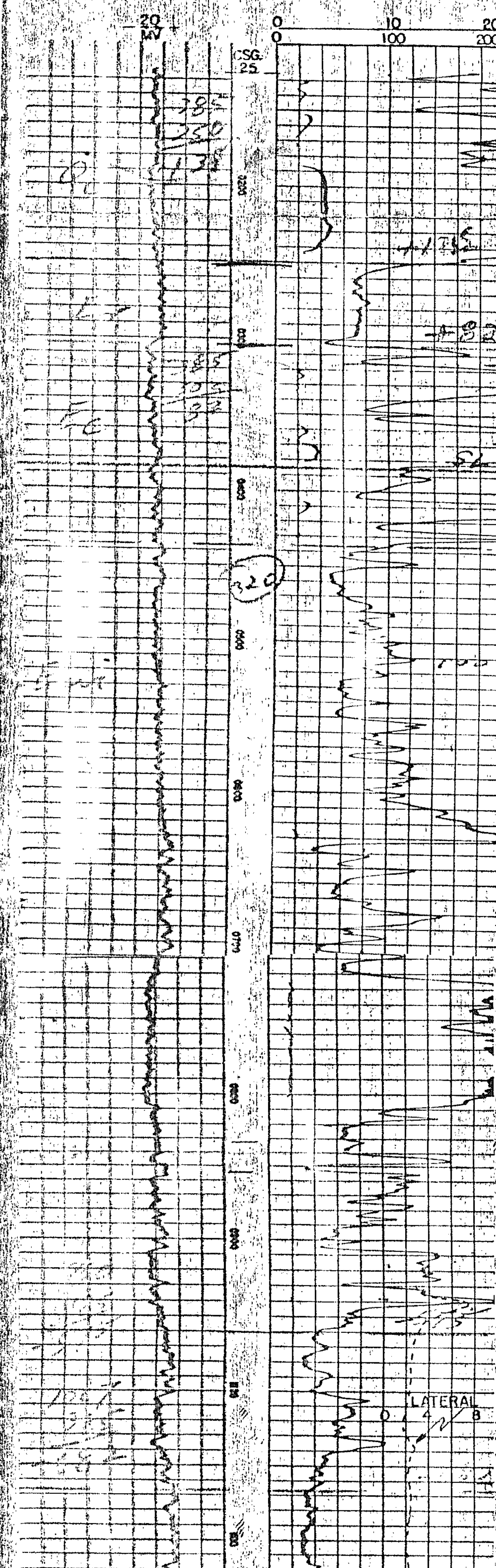
5 mi NNW Kilgore

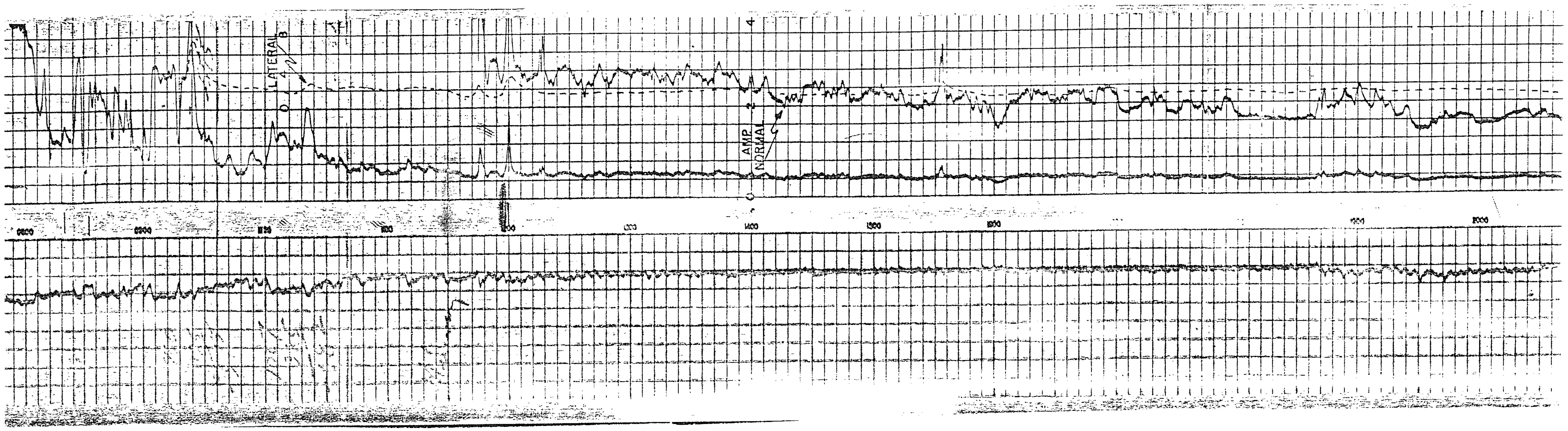
Q-147

REMARKS

SELF-POTENTIAL millivolts | DEPTHS | RESISTIVITY ohms. m²/m.

KH-35-33-602




LATERAL
AMP
NORMAL
1400
1500
1600
2000

03-1996

SCHLUMBERGER

WELL SURVEYING CORPORATION

COUNTY: GREGG
FIELD OR LOCATION: EAST TEXAS
WELL: WM. BAXTER #17
COMPANY: THE TEXAS CO.

Location of Well
2200' FEL
1300' FSL

C-8

Elevation: KB. 386±
DF. 385±
or GL. 380

COMPANY: THE TEXAS CO.
35-33-602
WELL: WM. BAXTER NO. 17
RUN NO.: 1 (NO)
FIELD: EAST TEXAS
LOCATION: WM. HART SCOTT SURVEY
COUNTY: GREGG A-187
STATE: TEXAS
FILING No. EN-143

3 mi NNW Kilgore

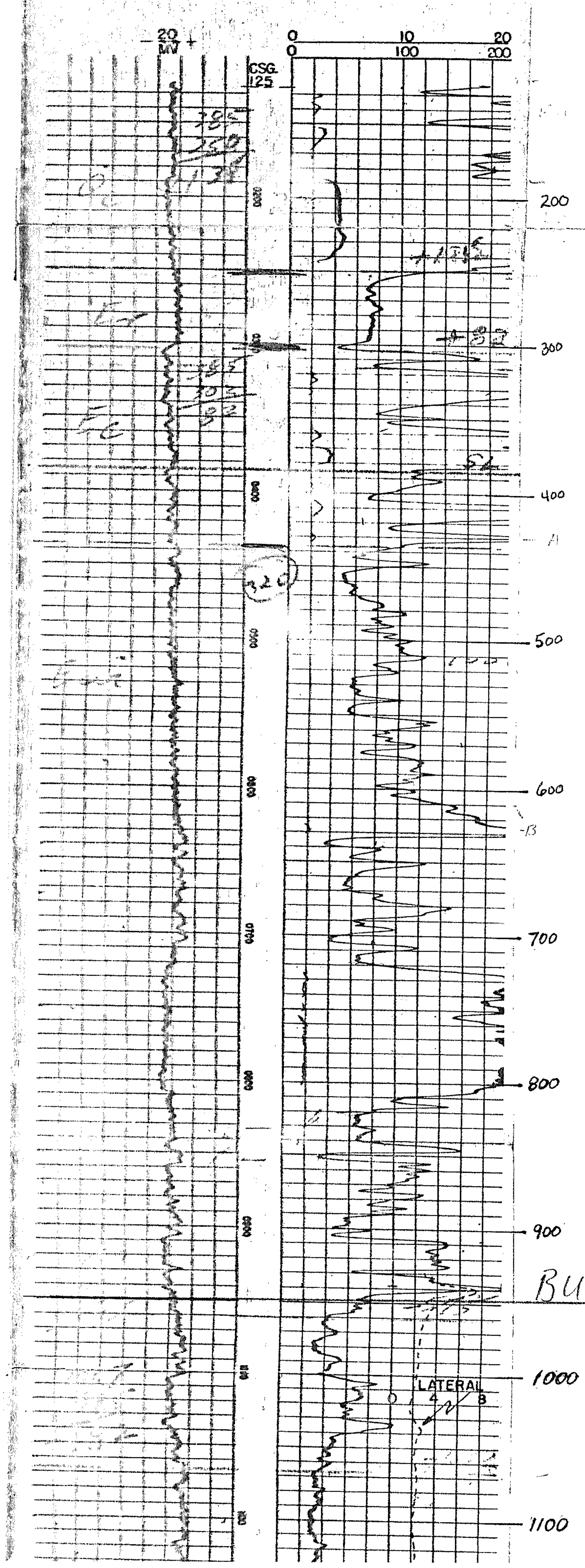
Q-147

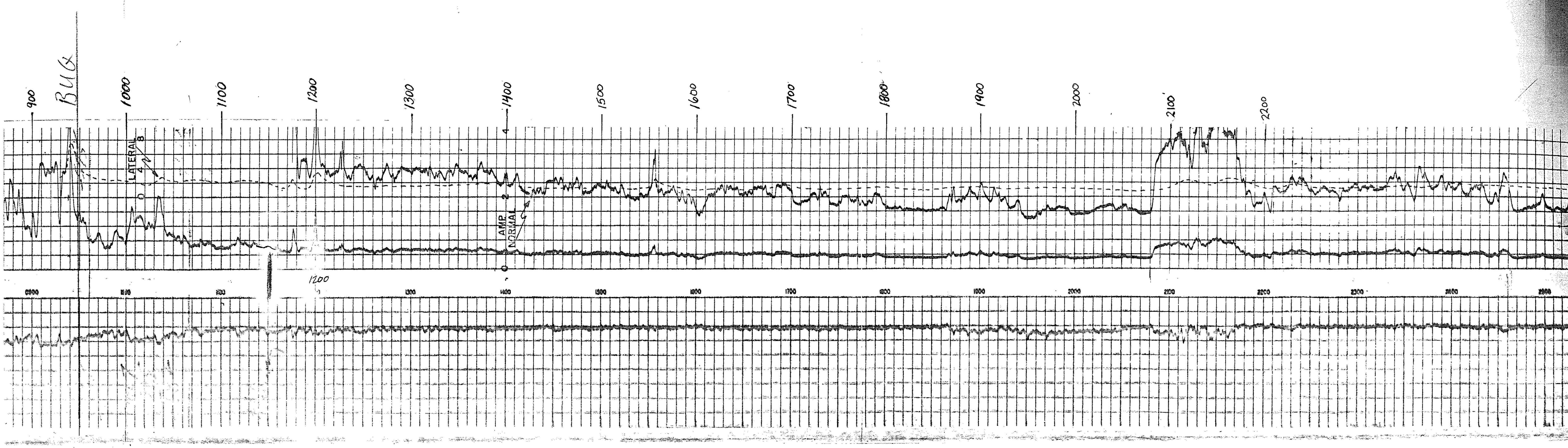
REMARKS
Api-183

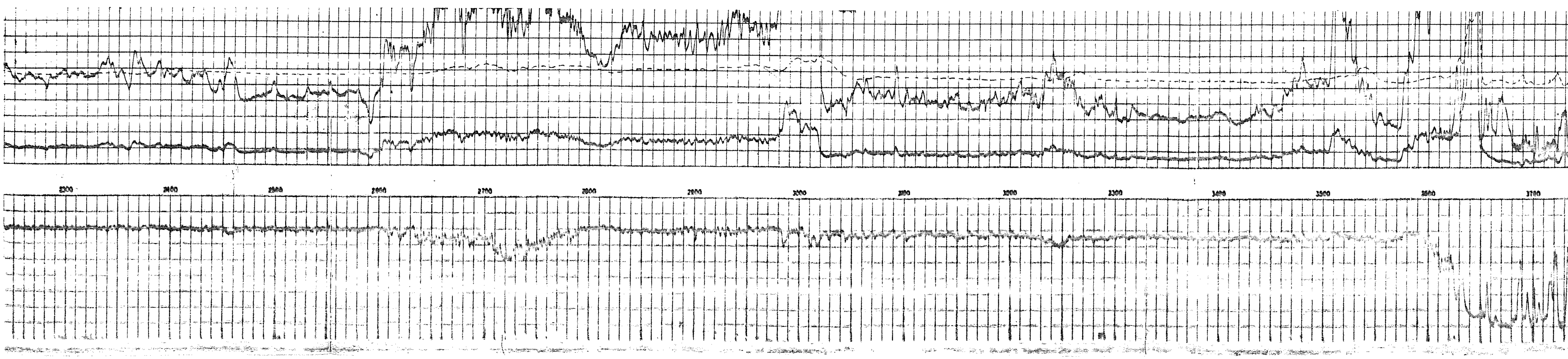
SELF-POTENTIAL millivolts | DEPTHS | RESISTIVITY ohms. m²/m.

KH-35-33-602

on East Tx Maps




BUG
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
LATERAL
AMP
NORMAL



SCHL. T.D. 3739
DRLR. T.D. 3740

K-44

SCHLUMBERGER WELL SURVEYING CORPORATION
HOUSTON, TEXAS

Induction-Electrical Log

COUNTY RED RIVER
FIELD or LOCATION WILDCAT
WELL ALBERT SIMMONS #1
COMPANY W. M. COATS & R. E. MOORE

COMPANY W. M. COATS & R. E. MOORE
WELL ALBERT SIMMONS #1
FIELD WILDCAT
LOCATION LEE TAYLOR SUR.
COUNTY RED RIVER
STATE TEXAS

Other Surveys: GST

Location of Well: 1067' F S/L & 330' F E/L of 254.45 a. tr. 9 mi. S/Annona

Elevation: D.F.: 326.5
K.B.:
or G.L.:

FILING No.

RUN No.	ONE				
Date	5-11-50				
First Reading	3098				
Last Reading	100				
Feet Measured	2998				
Csg. Schlum.	--				
Csg. Driller	63				
Depth Reached	3104				
Bottom Driller	3104				
Depth Datum	K. B. OR 7.5' ABOVE G. L.				
Mud Nat.	NAT.				
Dens. | Visc.	10 | 40				
Mud Resist.	5.6 @ 88 °F	@ °F	@ °F	@ °F	@ °F
" Res. BHT	4.2 @ 119 °F	@ °F	@ °F	@ °F	@ °F
Rmf	-- @ °F	@ °F	@ °F	@ °F	@ °F
Rmc	-- @ °F	@ °F	@ °F	@ °F	@ °F
" pH	-- @ °F	@ °F	@ °F	@ °F	@ °F
" Wtr. Loss	-- CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.
Bit Size	7 7/8"				
Spcgs.—AM	16"				
MN	27'2"				
IND.	40"				
Opr. Rig Time	2 HOURS				
Truck No.	1558-TYLER				
Recorded By	MILLIGAN				
Witness	MR. COATS, MR. MAXWELL				

FOLD HERE

REMARKS C.D. NOT USED ; S.O.
MUD PIT SAMPLE

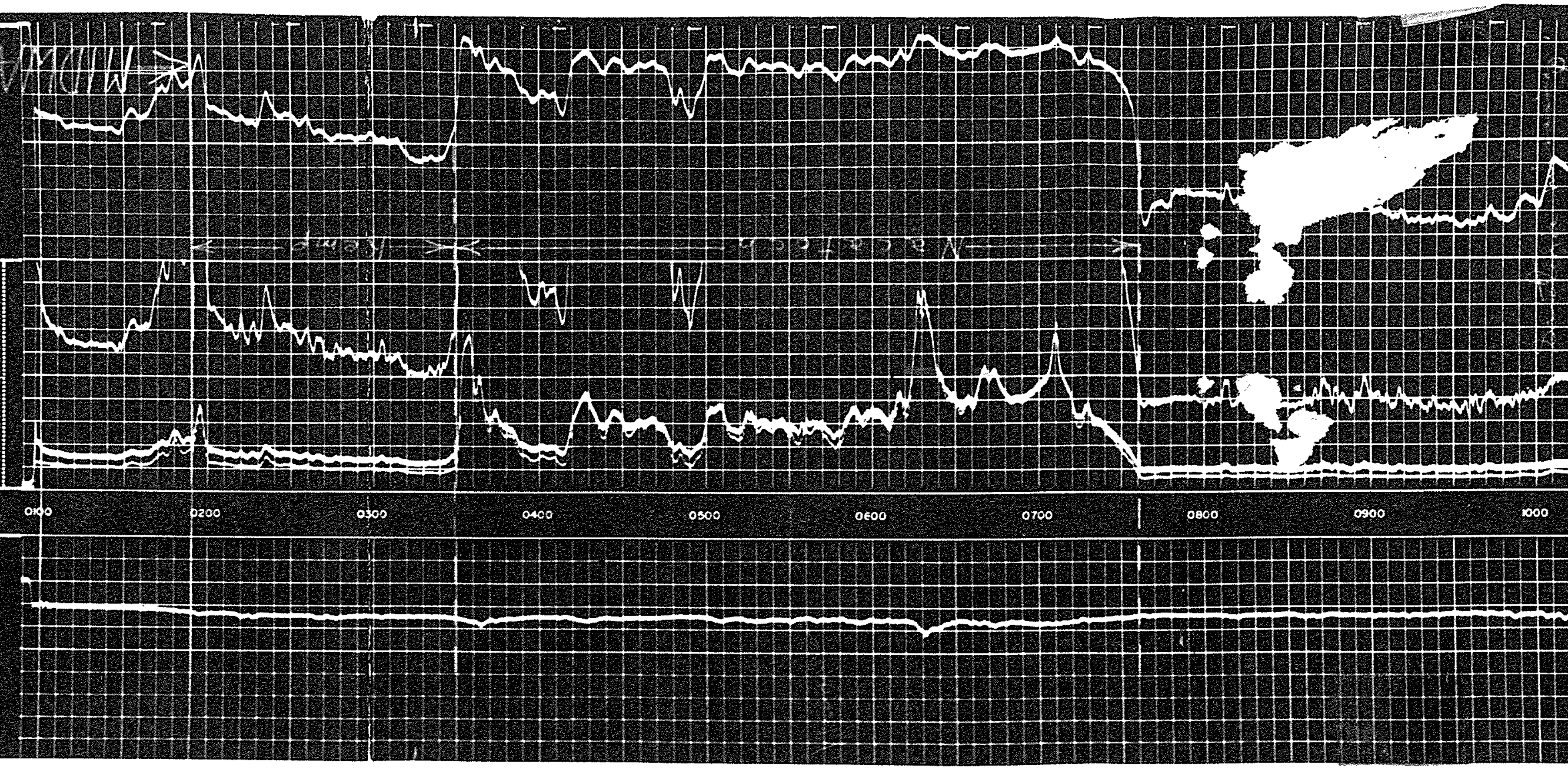
Cartridge No. IRC-C-60
Panel No. IRP-B-22
Sonde No. IRS-C-187

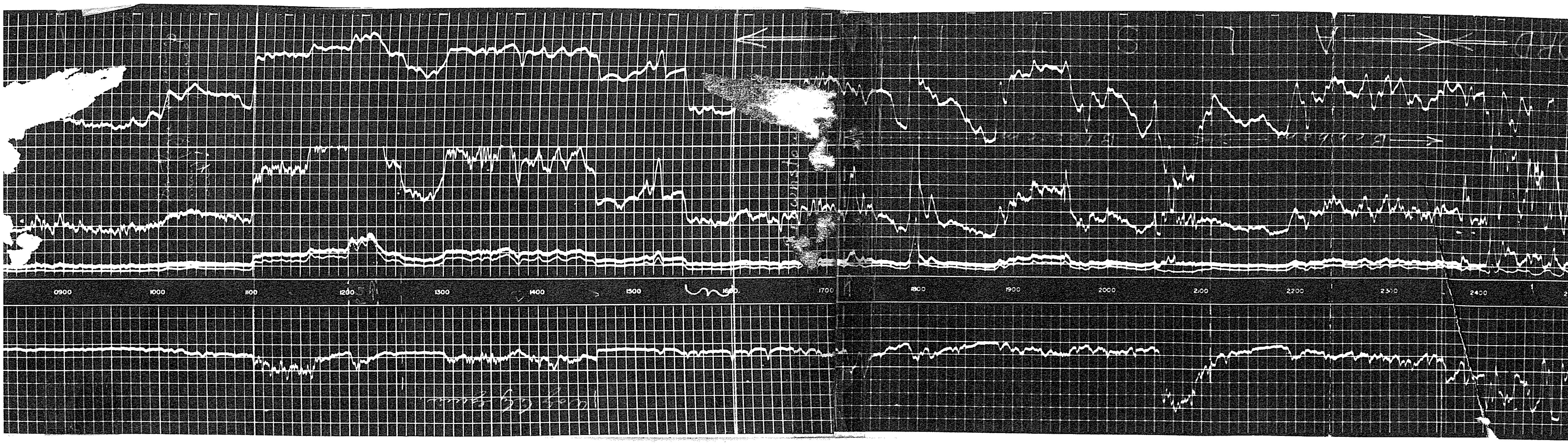
CONDUCTIVITY millimhos/m = 1000 / ohms. m²/m
INDUCTION 2000 1000 0
3000 2000

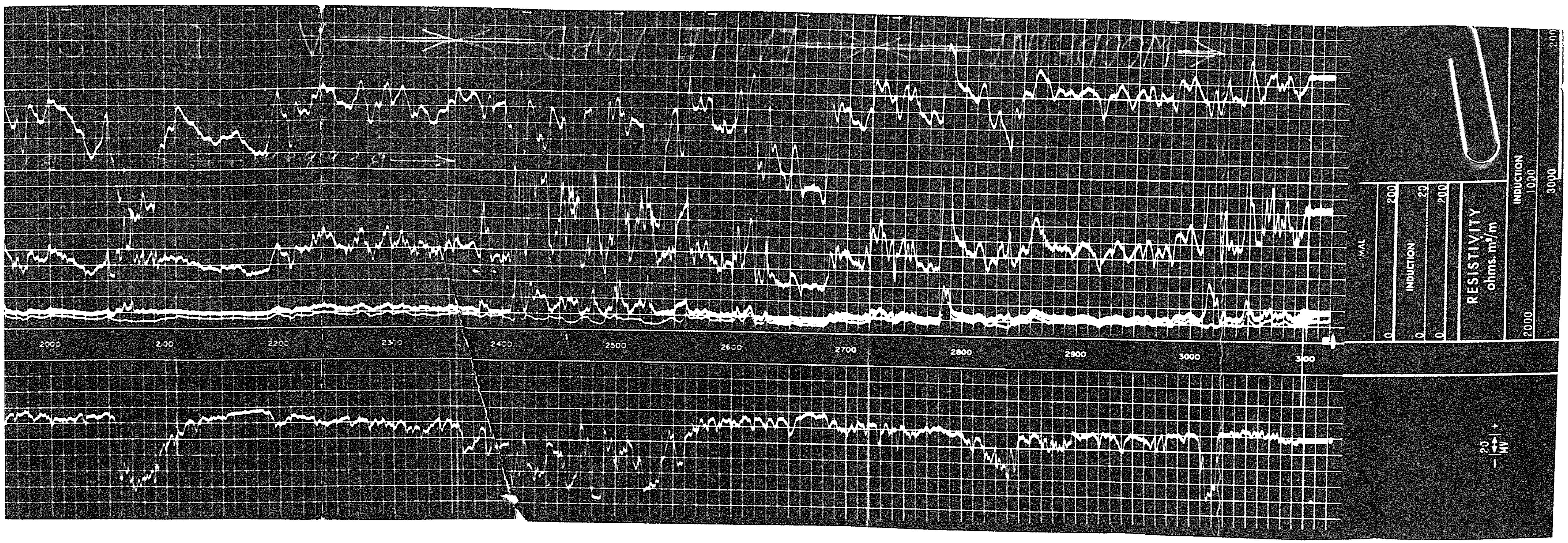
RESISTIVITY -ohms. m²/m
16" NORMAL 0 20
0 200
INDUCTION 0 20
0 200

SPONTANEOUS-POTENTIAL millivolts
— |20| + MV

DEPTHS




0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500



2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
RESISTIVITY
ohms. m²/m
INDUCTION
INDUCTION
0
200
0
20
0
200
2000
1000
3000
200
20
MV

Q-9

SCHLUMBERGER WELL SURVEYING CORPORATION

HOUSTON, TEXAS

Electrical Log

COUNTY	LAMAR
FIELD or LOCATION	WILDCAT
WELL	HOLLIS TIDWELL #1
COMPANY	JOHN D. STEPHENS

COMPANY JOHN B. STEPHENS

WELL HOLLIS TIDWELL #1

FIELD WILDCAT

LOCATION MEP & PRR CO. SUR.

COUNTY LAMAR

STATE TEXAS

Other Surveys: NONE

Location of Well: 330' FS&EL's of Sur. 100 ac. tr. 3 mi. N/ Blossom

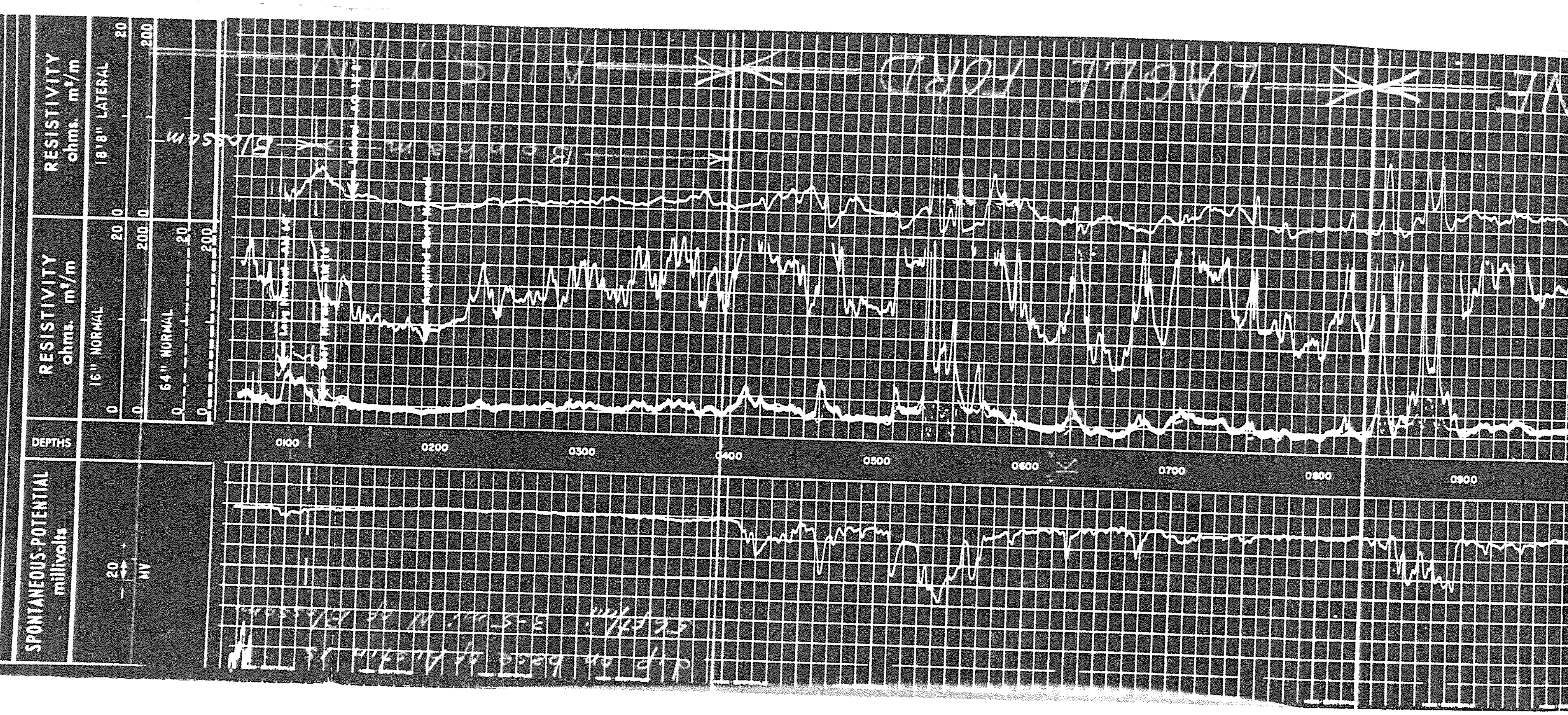
Elevation: D.F. 534, K.B. ___, or G.L. 537

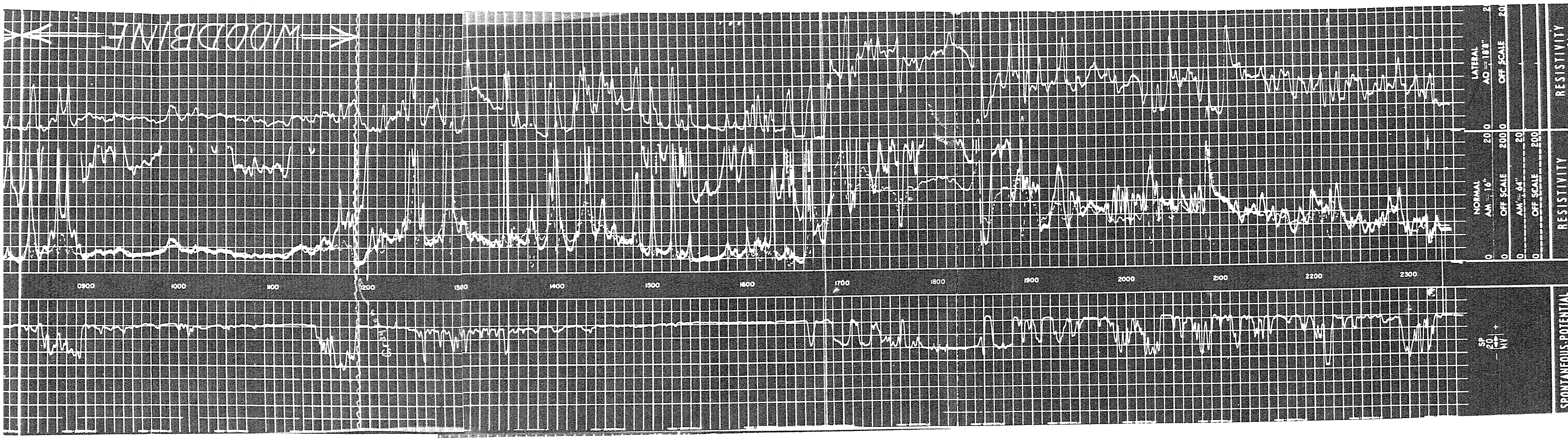
FILING No.

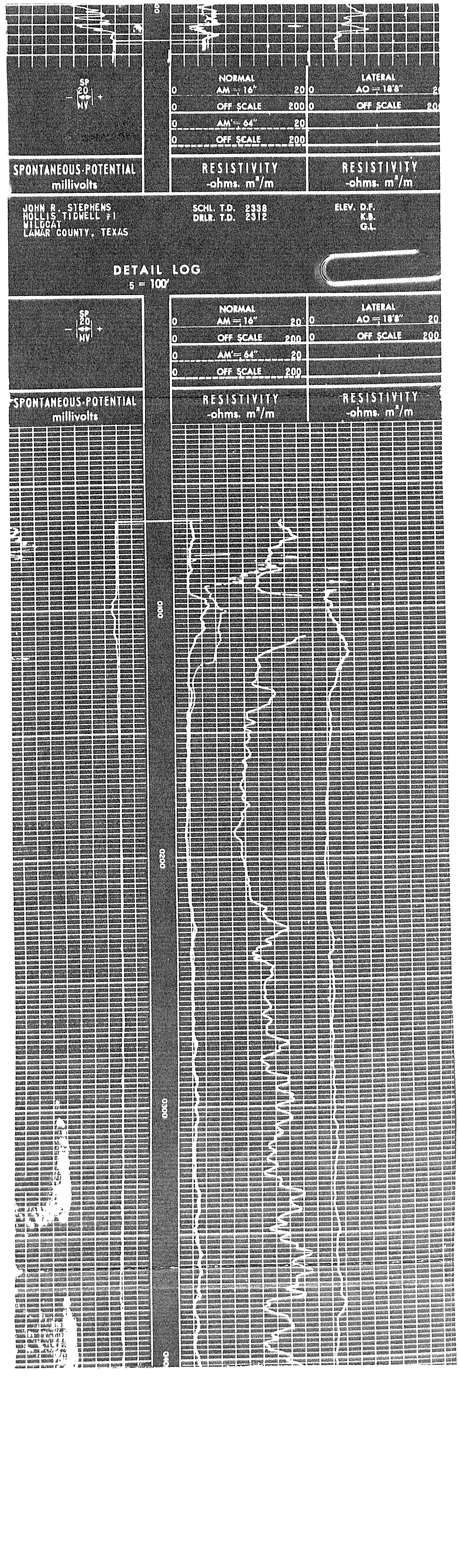
RUN No.	ONE				
Date	4-11-60				
First Reading	2338				
Last Reading	65				
Feet Measured	2273				
Csg. Schlum.	--				
Csg. Driller	--				
Depth Reached	2338				
Bottom Driller	2312				
Depth Datum	K. B. OR 9' ABOVE GROUND LEVEL				
Mud Nat.	NAT				
Dens. Visc.	9.0 38				
Mud Resist.	12.0 @ 16 °F	@ °F	@ °F	@ °F	@ °F
" Res. BHT	9.0 @ 100 °F	@ °F	@ °F	@ °F	@ °F
Rmf	-- @ °F	@ °F	@ °F	@ °F	@ °F
Rmc	-- @ °F	@ °F	@ °F	@ °F	@ °F
" pH	-- @ °F	@ °F	@ °F	@ °F	@ °F
" Wtr. Loss	-- CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.
Bit Size	6 1/4"				
Spcgs.—AM	16"				
A	64"				
AO	18'8"				
Opr. Rig Time	HOUR				
Truck No.	1586-TYLER				
Recorded By	GOODWIN				
Witness	MR. WILLIAMS, MR. MAXWELL				

FOLD HERE

REMARKS




WOODBINE
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
LATERAL
AO = 18'8"
OFF SCALE
RESISTIVITY
-ohms. m²/m
NORMAL
AM = 16"
OFF SCALE
AM' = 64"
OFF SCALE
RESISTIVITY
-ohms. m²/m
SP
20
MV
SPONTANEOUS-POTENTIAL


SP
20
MV
SPONTANEOUS-POTENTIAL
millivolts
NORMAL
0 AM = 16" 20
0 OFF SCALE 200
0 AM' = 64" 20
0 OFF SCALE 200
RESISTIVITY
-ohms. m²/m
LATERAL
0 AO = 18'8" 20
0 OFF SCALE 200
RESISTIVITY
-ohms. m²/m
JOHN R. STEPHENS
HOLLIS TIDWELL #1
WILDCAT
LAMAR COUNTY, TEXAS
SCHL. T.D. 2338
DRLR. T.D. 2312
ELEV. D.F.
K.B.
G.L.
DETAIL LOG
5 = 100'
SP
20
MV
SPONTANEOUS-POTENTIAL
millivolts
NORMAL
0 AM = 16" 20
0 OFF SCALE 200
0 AM' = 64" 20
0 OFF SCALE 200
RESISTIVITY
-ohms. m²/m
LATERAL
0 AO = 18'8" 20
0 OFF SCALE 200
RESISTIVITY
-ohms. m²/m
0100
0200
0300

Q-12

SCHLUMBERGER WELL SURVEYING CORPORATION

Electrical Log

COUNTY LAMAR
FIELD or LOCATION WILDCAT
WELL JOHNSON NO. 1
COMPANY DILWORTH S. HAGER

COMPANY DILWORTH S. HAGER

WELL JOHNSON NO. 1

FIELD WILDCAT

LOCATION R. G. MILLER SURVEY

COUNTY LAMAR

STATE TEXAS

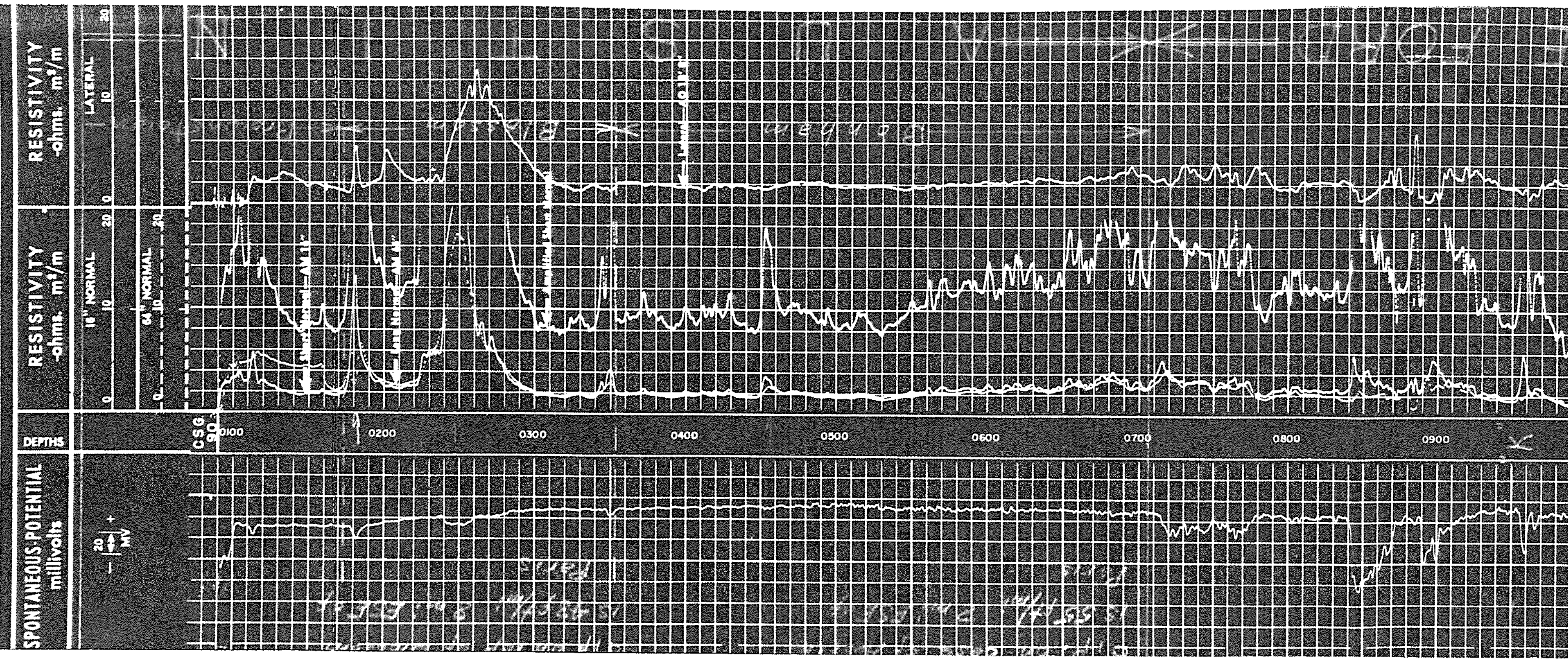
Location of Well
520' FR S'LY S-L & 330' FR S'LY S-L OF SURVEY ON 57 AC. TR. 8 MILES E OF PARIS.

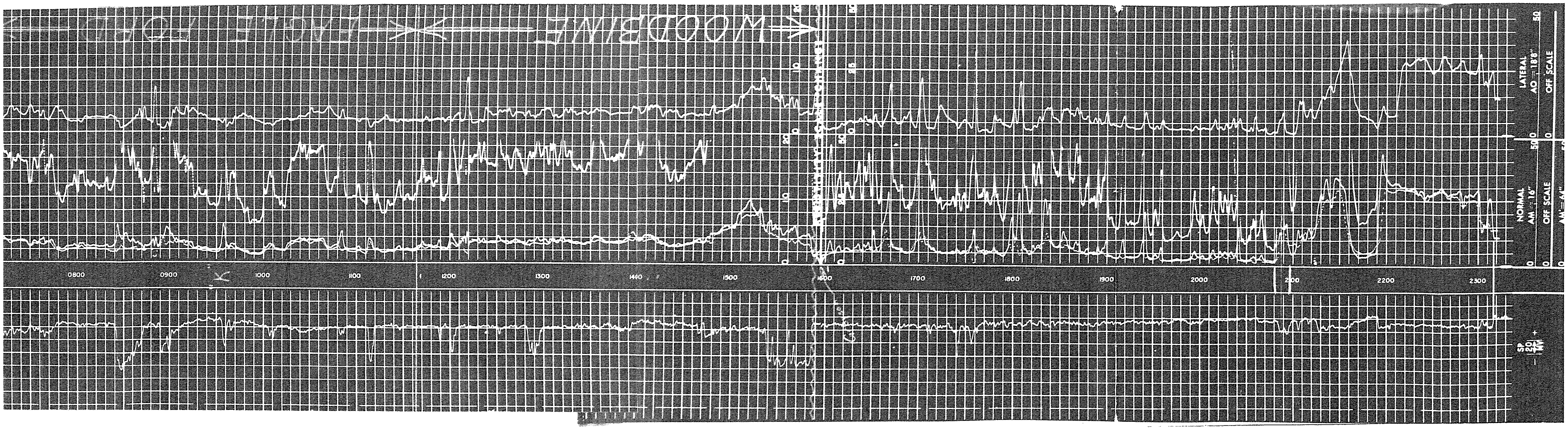
Elevation: D.F.: 531
K.B.: 532
or G.L.: 523

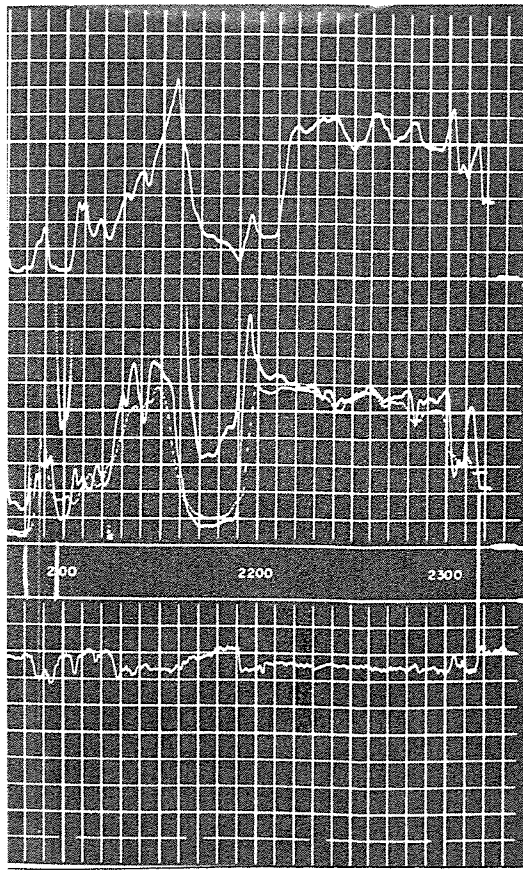
FILING No.

RUN No.	1				
Date	10-21-56				
First Reading	2317				
Last Reading	90				
Feet Measured	2227				
Csg. Schlum.	90				
Csg. Driller	102				
Depth Reached	2317				
Bottom Driller	2314				
Depth Datum	K. B. OR 8.0' ABOVE GND. LEVEL				
Mud Nat.	GEL. CAU. TAN. DRIS.				
" Density	10.2				
" Viscosity	54				
" Resist.	3.6 @ 72 °F	@ °F	@ °F	@ °F	@ °F
" Res. BHT	2.3 @ 114 °F	@ °F	@ °F	@ °F	@ °F
" pH	* @ °F	@ °F	@ °F	@ °F	@ °F
" Wtr. Loss	* CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.
Max. Temp. °F	- - -				
Bit Size	7 7-8"				
Spcgs.—AM	16"				
AM	64"				
AO	18' 8"				
Opr. Rig Time	1 HR.				
Truck No.	1558-TYLER				
Recorded By	FINK				

REMARKS
* NOT AVAILABLE
MUD PIT SAMPLE
RES. SCALE CHANGE AT 1974 FR 20 OHMS TO 50 OHMS




EAGLE FORD
WOODBINE
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2200
2300
LATERAL
NORMAL
OFF SCALE
SP



LATERAL AO = 18'8" 0 50
OFF SCALE
RESISTIVITY -ohms. m²/m

NORMAL AM = 16" 0 50
AM' = 64" 0 50
OFF SCALE
RESISTIVITY -ohms. m²/m

SP — |20| + MV
SPONTANEOUS-POTENTIAL millivolts

ELEV. D.F. 531
K.B. 532
G.L. 523

SCHL. T.D. 2317
DRLR. T.D. 2314

NO MICRO LOG RUN

CORE DESCRIPTION & DST NOT AVAILABLE

SCHLUMBERGER WELL SURVEYING CORPORATION

HOUSTON, TEXAS

DETAIL LOG

COUNTY LAMAR
FIELD or LOCATION WILDCAT
WELL JOHNSON NO. 1
COMPANY DILWORTH S. HAGER

COMPANY DILWORTH S. HAGER

WELL JOHNSON NO. 1

FIELD WILDCAT

LOCATION R. G. MILLER SURVEY

COUNTY LAMAR

STATE TEXAS

Location of Well
520' FR S'LY 3-L. &
330' FR S'LY S-L. OF SURVEY ON 57 AC. TR.
8 MILES E OF PARIS.

Elevation: D.F.: 531
K.B.: 532
or G.L.: 523

FILING No.

RUN No.					
Date					
First Reading					
Last Reading					
Feet Measured					
Csg. Schlum.					
Csg. Driller					
Depth Reached					
Bottom Driller					
Depth Datum					
Mud Nat.					
" Density					
" Viscosity					
" Resist.	@ °F	@ °F	@ °F	@ °F	@ °F
" Res. BHT	@ °F	@ °F	@ °F	@ °F	@ °F
" pH	@ °F	@ °F	@ °F	@ °F	@ °F
" Wtr. Loss	CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.
Max. Temp. °F					
Bit Size					
Spcgs.—AM					
A					
AO					
Opr. Rig Time					
Truck No.					
Recorded By					
Witness By					

FOLD HERE

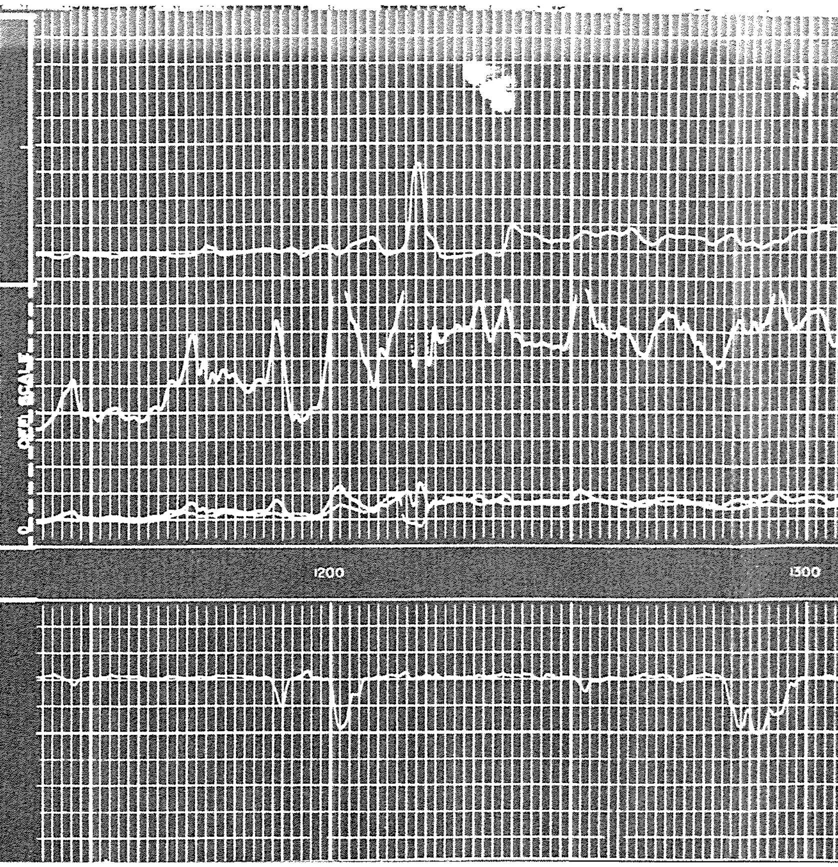
REMARKS

RESISTIVITY -ohms. m²/m
LATERAL AO = 18'8" 0 20
OFF SCALE

RESISTIVITY -ohms. m²/m
NORMAL AM = 16" 0 20
OFF SCALE
AM' = 64" 0 20
OFF SCALE

DEPTHS

SPONTANEOUS-POTENTIAL millivolts
SP — |20| + MV



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East Texas Photocopy Co.
P. O. Drawer 59
Tyler, Texas
File No. 03-5584

L-7

Q-13

SCHLUMBERGER WELL SURVEYING CORPORATION

HOUSTON, TEXAS

Electrical Log

COUNTY	LAMAR
FIELD or LOCATION	WILDCAT
WELL	ROSA COURSEY #1
COMPANY	CRU PET. COMPANY

COMPANY CRU PET. COMPANY

WELL ROSA COURSEY #1

FIELD WILDCAT

LOCATION DRUMMOND SURVEY

COUNTY LAMAR

STATE TEXAS

Location of Well

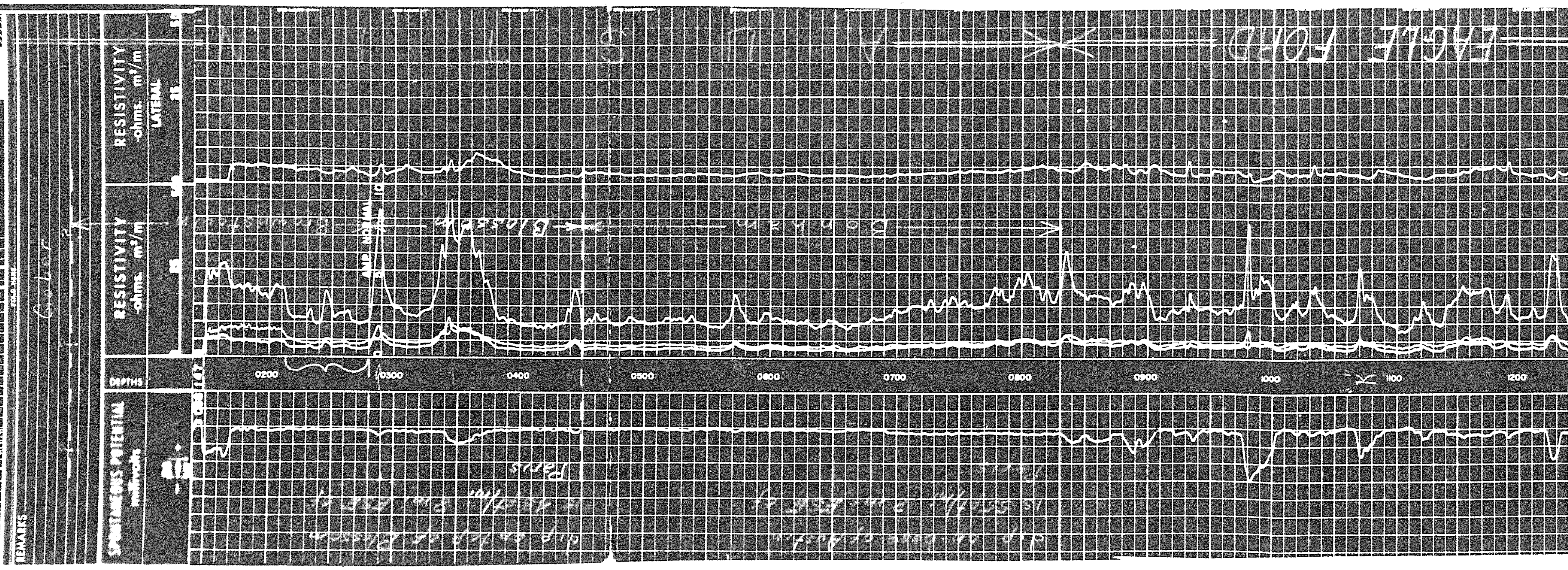
330' fr E/L &
990' fr S/L of
SURV.

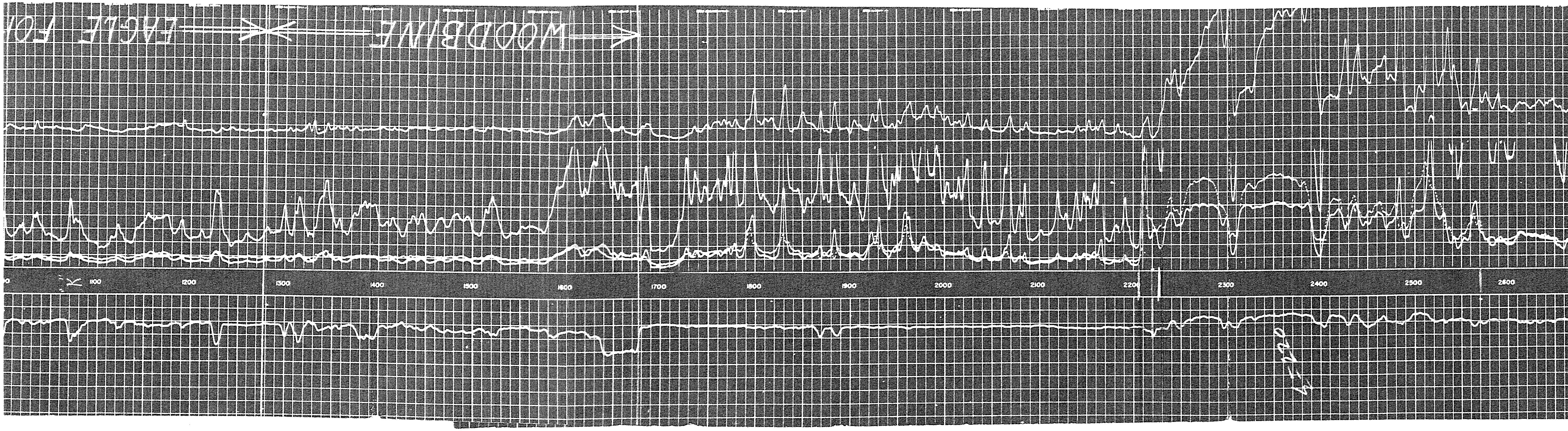
Elevation: D.F.: 568
K.B.:
or G.L.:

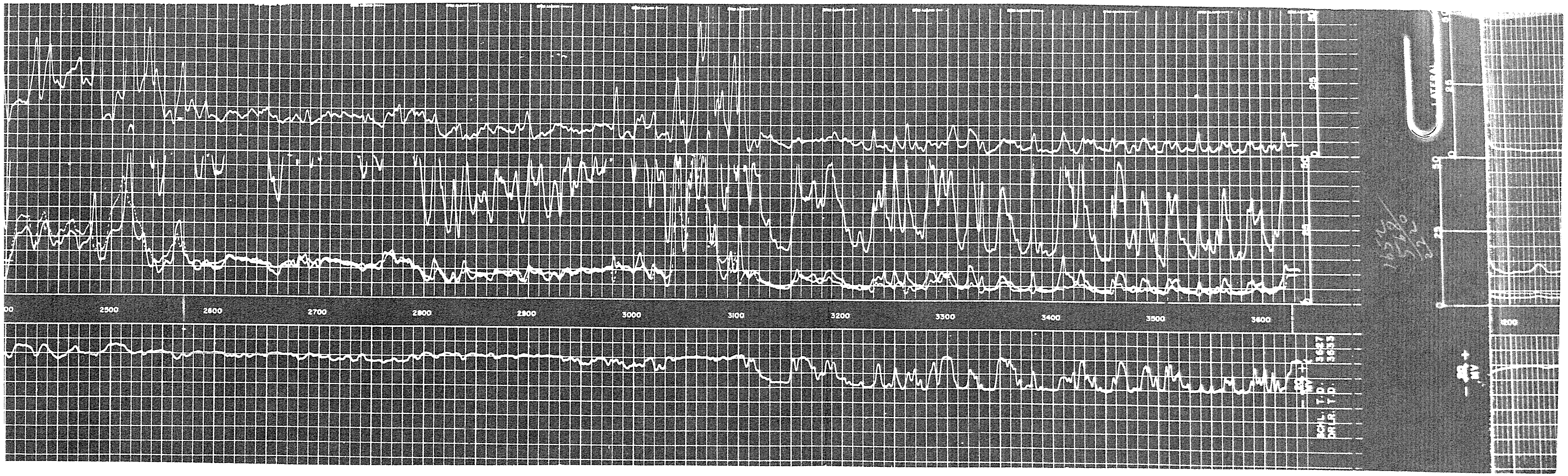
FILING No.

RUN No.	1				
Date	4-6/7-52				
First Reading	3627				
Last Reading	147				
Feet Measured	3480				
Csg. Schlum.	147				
Csg. Driller	163				
Depth Reached	3627				
Bottom Driller	3633				
Depth Datum	1' ABOVE ROT.				
Mud Nat.	AQU. CAU. TANN. DRIS.				
" Density	10.2				
" Viscosity	42				
" Resist.	3.1 @ 64°F	@ °F	@ °F	@ °F	@ °F
" Res. BHT	1.68 @ 118°F	@ °F	@ °F	@ °F	@ °F
" pH	@ °F	@ °F	@ °F	@ °F	@ °F
" Wtr. Loss	CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.
Max. Temp. °F	118				
Bit Size	8 3/4"				
Spcgs.—AM	16"				
A	64"				
AO	18'8"				
Opr. Rig Time	2 HRS				
Truck No.	823-TYLER				
Recorded By	MARAMAN				
Witness By	THOMPSON				

REMARKS




1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600



2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600

9.0 APPENDIX C –TWDB COMMENTS AND RESPONSES

<u>TWDB Comments on Draft Final Region-Specific Study Reports</u>:

Region-Specific Study Number 2: Brackish Groundwater

1. *The report is a summary of existing information collected from a few sources. Unfortunately, the most important questions (i.e., tasks listed in the Contract Scope of Work) that the study set out to answer were never answered. Please see the following comments on the scope of work tasks not completed.*

2. Task A1: The contract scope of work states that water system surveys from the previous planning cycle would be reviewed. Please conduct the review as stated in the contract scope of work and document the effort in the final report.

   Response: Water system surveys from the previous planning period have been reviewed and the effort documented in the report. Summary of the analysis is provided in Section 3.3 of report and Section 7, Appendix A contains the compilation of the water system survey analysis.

3. Task A2: The contract scope of work states that potential use for industrial needs would be focused upon. Please evaluate the use of brackish groundwater to meet industrial demands as stated in the contract scope of work and document the effort in the final report.

   Response: Industrial, commercial and generally non-residential needs were focused on in the review of the water system surveys from the previous planning period. An additional telephone survey was conducted of major non-residential users and is documented in Section 3.3.1.

4. Task B: The contract scope of work states that a detailed analysis of lack of alternatives would be performed. Please conduct the alternatives analysis as stated in the contract scope of work and document the effort in the final report.

   Response: The detailed analysis of lack of alternatives is inherent in many items of the report, such as the desalination process, current costs and brine disposal options, WUG proximity to oil and gas reserves and known brackish groundwater (new Section 3.7 and existing Table 4), and review of the water surveys (updated effort). After review of the water surveys, WUGs with lack of alternatives have been identified in the report – City of Clarksville (Section 3.3.2), City of Clarksville City (Section 4.5) and City of Tatum (Section 4.6). A new summary on the lack of alternatives is also included in Section 5, Conclusion.

5. Task B1: The contract scope of work states that geophysical logs and well driller reports would be used to locate potential brackish groundwater fields. Please locate and utilize this information as stated in the contract scope of work and document the effort in the final report. Additionally, please identify the aquifer name, depth zones, and well fields that will be used for supply of brackish groundwater to the Region.

Response: Geophysical logs and well driller reports have been used to locate potential brackish groundwater fields. These are summarized in new Section 3.4 and actual logs and well driller reports are included in Appendix B and Appendix E. Information obtained from geophysical logs, well driller reports and other studies are located on existing Figures 4 – 15, new Figure 16, existing Figure 22 and additionally summarized in existing Table 4. Aquifer name, depth zones, and well fields that could be used for supply of brackish groundwater to the Region is provided in new Figure 16 and new Section 3.4.

6. Task B2: The contract scope of work states that production capacity of wells in brackish groundwater zones and the number of wells required to meet demands would be determined. Please include this analysis in the final report.

   Response: Production capacity of wells in brackish groundwater zones is estimated in new Section 3.4. As an example, the number of wells required for a community of 1,440 connections is presented in Section 3.3.2. The number of wells required will depend on the production quantity and quality characteristics specific to the WUG.

7. Task D1: The contract scope of work states that potential brackish groundwater projects would be identified for incorporation into the Regional Plan. Please include this analysis in the final report.

   Response: The water user groups identified in Sections 3.3.2 and 3.3. (as stated at the end of Section 3.3.3) are identified as potential brackish groundwater projects for consideration into the Regional Plan.

8. Task D2: The contract scope of work states that water supply alternatives would be ranked. Please include this analysis in the final report.

   Response: A statement on ranking alternatives is included in Section 5, Conclusion.

9. Task D3: The contract scope of work states that specific brackish water projects would be recommended if appropriate. Please include this analysis in the final report.

   Response: Recommendation of specific brackish groundwater projects is included in Section 3.3.2 and Section 5, Conclusion.

10. Page 1, paragraph 4: Please change ph to pH.

    Response: Corrected.

11. Page 4, section 2.0, paragraph 1, lines 7-8. The original information is from TWDB's Water for Texas 2007. Please consider using the original source and referencing it accordingly.

    Response: Original source used and referenced.

12. Page 4, section 2.0, paragraph 2, last line. The reference "TWDB" is incomplete. Please complete the reference.

    Response: Completed.

13. Page 8, section 2.2, paragraph 3, line 3. The "Merriam-Webster" reference in not included in the References section on pages 66 and 67. Please include the reference.

    Response: Reference included.

14. Page 10, section 2.4, paragraph 1, lines 4-5. The "Arroyo and Kalaswad" reference is not listed in the References section on pages 66 and 67. Please include the reference.

    Response: Reference corrected.

15. Page 16, Table 2. The reference "BWR and others" used in the table header is not listed in the References section on pages 66 and 67. Please include the reference.

    Response: Reference included.

16. Page 47, section 4.2.6, paragraph 1, last line. The "USBOR 2001" reference is not listed in the References section on pages 66 and 67. Please include the reference.

    Response: Reference included.

17. Page 47, section 4.2.7, paragraph 1, lines 2 and 8. The "USBOR 2001" reference is not listed in the References section on pages 66 and 67. Please include. References have not been cited consistently in the report. For example, Guyton 2003 and LBG Guyton Associates 2003 are used interchangeably as are NRS 2008 and NRS and Consultants 2008. Please cite references consistently in the report.

    Response: Referenced cited consistently.

18. The term "mildly saline" (for example, pages 5 and 18) is incorrect. The correct term is "slightly saline". Please correct wherever used incorrectly in the report.

    Response: The term "mildly saline" has been corrected to "slightly saline."

10.0 APPENDIX D – TCEQ PROPOSED GENERAL PERMIT

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

NOTICE OF PROPOSED UNDERGROUND INJECTION CONTROL GENERAL PERMIT AUTHORIZING THE USE OF A CLASS I INJECTION WELL TO INJECT NONHAZARDOUS BRINE FROM A DESALINATION OPERATION OR NONHAZARDOUS DRINKING WATER TREATMENT RESIDUALS

The Texas Commission on Environmental Quality (TCEQ or commission) proposes to issue a general permit (Proposed General Permit Number WDWG010000) authorizing the use of a Class I injection well to inject nonhazardous brine from a desalination operation or nonhazardous drinking water treatment residuals. The proposed general permit applies to the entire state of Texas. This general permit is authorized by Texas Water Code, §27.023.

PROPOSED GENERAL PERMIT. The executive director has prepared a draft general permit that provides requirements and conditions for the authorization of Class I injection wells to inject nonhazardous brine from a desalination operation or nonhazardous drinking water treatment residuals. The executive director proposes to require regulated facilities to submit a Notice of Intent to obtain authorization for injection.

The executive director has reviewed this action for consistency with the goals and policies of the Texas Coastal Management Program (CMP) according to Coastal Coordination Council (CCC) regulations, and has determined that the action is consistent with applicable CMP goals and policies.

A copy of the proposed general permit and fact sheet are available for viewing and copying at the TCEQ Office of the Chief Clerk located at the TCEQ's Austin office, at 12100 Park 35 Circle, Building F. These documents are also available at the TCEQ's 16 regional offices and at *http://www.tceq.state.tx.us/permitting/waste_permits/advgroups/uic_gp.html* on the TCEQ Web site.

PUBLIC COMMENT/PUBLIC MEETING. You may submit public comments about this general permit. In addition, the TCEQ will hold a public meeting on this general permit pursuant to 30 TAC §331.202. A public meeting is not a contested case hearing. The purpose of a public meeting is to provide the opportunity to submit comments or to ask questions about the general permit. The public meeting will be held as follows: **June 2, 2009, at 1:30 p.m. at the TCEQ Austin Office, 12100 Park 35 Circle, Building E, Room 254S.**

Written public comments must be submitted to the Office of the Chief Clerk, MC 105, Texas Commission on Environmental Quality, P.O. Box 13087, Austin, Texas 78711-3087 or electronically at http://www5.tceq.state.tx.us/ecmnts/index.cfm within 30 days from the date this notice is published in the *Texas Register* or at the end of the public meeting, whichever is later.

APPROVAL PROCESS. After the comment period, the executive director will consider all the public comments and prepare a written response. The response will be filed with the TCEQ Office of the Chief Clerk at least ten days before the scheduled commission meeting when the commission will consider approval of the general permit. This commission meeting will be open to the public. The commission will consider all public comments in making its decision and will either adopt the executive director's response or prepare its own response. The commission will issue its written response on the general permit at the same time the commission issues or denies the general permit. A copy of any issued general permit and response to comments will be made available to the public for inspection at the agency's Austin and regional offices. A notice of the commissioners' action on the proposed general permit and a copy of its response to comments will be mailed to each person who made a comment. Also, a notice of the commission's action on the proposed general permit and the text of its response to comments will be published in the *Texas Register.*

MAILING LIST. In addition to submitting public comments, you may request to be placed on a mailing list to receive future public notices mailed by the Office of the Chief Clerk. You may request to be added to: (1) the mailing list for this specific general permit; (2) the mailing list for a specific county; and/or (3) the mailing list for a specific applicant name and permit number. Clearly specify which list(s) to which you wish to be added and send your request to TCEQ Office of the Chief Clerk at the address listed previously. Unless you otherwise specify, you will be included only on the mailing list for this specific general permit.

AGENCY CONTACTS AND INFORMATION. If you need more information about this general permit or the permitting process, please call the TCEQ Office of Public Assistance, at 1-800-687-4040. General information about the TCEQ can be found at our Web site at *http://www.tceq.state.tx.us/.* Further information may also be obtained by calling Kathryn Flegal at (512) 239-6890.

Si desea información en Español, puede llamar al 1-800-687-4040.

Issue Date: April 14, 2009

11.0 APPENDIX E – WELL DRILLERS LOGS FROM HAYES ENGINEERING, INC.

ANA-LAB CORP. THE COMPLETE SERVICE LAB

Corporate 2600 Dudley Road -- Kilgore, TX 75662
903/984-0551 FAX 903/984-5914

CMID

07/06/2006

Sample	Description	Taken		Project	Received	Mail
836926	City of East Mountain	06/22/2006	0940	319734	06/22/2006	/ /

Parameter	Results	Units	EQL	Analyzed	By
Nitrite	ND	mg/L	0.250	06/22/2006	GDG
Nitrate	ND	mg/L	0.250	06/22/2006	GDG
Chloride	450	mg/L	30.0	06/24/2006	GDG
Fluoride	ND	mg/L	0.500	06/22/2006	GDG
Sulfate	29.4	mg/L	1.50	06/22/2006	GDG
Laboratory Dissolved Oxygen	9.5	mg/L	1	06/23/2006	CBC
Sulfide as Hydrogen Sulfide	ND	mg/L	0.021	06/26/2006	RED
Sulfide	ND	mg/L	0.02	06/26/2006	RED
Acidity	ND	uEq/L	100	06/29/2006	RED
Alkalinity (as CaCO3)	200	mg/L	10	06/26/2006	RED
Carbon Dioxide	177	mg/L	0.5	06/26/2006	TWV
Free Carbon Dioxide	2.49	mg/L	0.5	06/26/2006	TWV
Carbonate (as CaCO3)	2.93	mg/L	0.5	06/26/2006	TWV
Lab Spec. Conductance at 25 C	2100	umhos/cm		06/26/2006	RED
Color	ND	PtCo Units	5.0	06/22/2006	TLK
Bicarbonate (as CaCO3)	197	mg/L	0.5	06/26/2006	TWV
Hydroxide	ND	mg/L	0.5	06/26/2006	TWV
Total Dissolved Solids	950	mg/L	50	06/27/2006	LLW
Turbidity	1.97	NTU	1	06/23/2006	RED
Laboratory pH	8.2 @ 12C	SU		06/23/2006	RED
Silver	ND	mg/L	0.001	06/23/2006	HVM
Aluminum	ND	mg/L	0.010	06/23/2006	HVM
Arsenic	ND	mg/L	0.002	06/23/2006	HVM
Barium	0.235	mg/L	0.001	06/23/2006	HVM
Beryllium	ND	mg/L	0.001	06/23/2006	HVM
Calcium	11.5	mg/L	0.200	06/23/2006	ALH
Cadmium	ND	mg/L	0.001	06/23/2006	HVM
Chromium	ND	mg/L	0.001	06/23/2006	HVM
Copper	ND	mg/L	0.001	06/23/2006	HVM
Iron	ND	mg/L	0.040	06/23/2006	ALH
Mercury	ND	mg/L	0.000	06/23/2006	WOB
Potassium	11.0	mg/L	0.500	06/23/2006	ALH
Magnesium	4.53	mg/L	0.100	06/23/2006	ALH
Manganese	0.0306	mg/L	0.001	06/23/2006	HVM
Sodium	360	mg/L	5.00	06/23/2006	ALH
Nickel	ND	mg/L	0.001	06/23/2006	HVM
Lead	ND	mg/L	0.001	06/23/2006	HVM
Selenium	ND	mg/L	0.002	06/23/2006	HVM
Zinc	0.00906	mg/L	0.005	06/23/2006	HVM
Total Hardness Ca/Mg Eq. CaCO3	47.4	mg/L	0.200	06/23/2006	ALH

East Mountain Water Well #4 - Summary of Test Well Analyses

No.	Constituent	Well 4 results	unit	TX MCL	TX SCL	Reference	Well 2 4/18/1997	Well 3 12/29/2001	Well 2 4/10/2000	Well 3 6/10/2003	Well 2 5/20/2005	Well 3 5/20/2005	Well 2+4 Weighted	Well 3+4 Weighted
1	Color	ND	PtCo Units		15	SCL (30 TAC 290.105(b))		5						
2	pH	8			> 7.0	SCL (30 TAC 290.105(b))	8	8.4		8.4			8.0	8.2
3	Alkalinity CaCO3	240	ppm				202			200			222	124
4	Total Hardness	49.3	ppm				7.8	14.5		12.7			29.27	32.50
5	Iron	0.0682	ppm		0.3	SCL (30 TAC 290.105(b))	0.17	0.025		0.059			0.117	0.047
6	Manganese	0.033	ppm		0.05	SCL (30 TAC 290.105(b))	0.01	0.0149		0.0118			0.022	0.024
7	Turbidity SiO2	ND	NTU				0.9	ND						
8	Acidity CaCO3		uEq/L				0	ND						
9	Chlorides	452	ppm		300	SCL (30 TAC 290.105(b))	69.1	161	161	156	239	135	349	312
10	Sodium	382	ppm			Not regulated by State	144.3	225	211	208			299	306
11	Potassium		ppm				2	2.78					0.97	1.34
12	Fluoride	ND	ppm	4		MCL for inorganic (30 TAC 290.104(b))	0.4	0.184		0.884				
					2	SCL (30 TAC 290.105(b))								
13	Arsenic	ND	ppm	0.05		MCL for inorganic (30 TAC 290.104(b))	<0.005	ND						
14	Cadmium	ND	ppm	0.005		MCL for inorganic (30 TAC 290.104(b))	<0.005	ND						
15	Chromium	ND	ppm	0.1		MCL for inorganic (30 TAC 290.104(b))	<0.005	ND						
16	Copper	ND	ppm		1	SCL (30 TAC 290.105(b))	<0.01	ND						
17	Aluminum	ND	ppm		0.05 to 0.2	SCL (30 TAC 290.105(b))		0.0284						
18	Beryllium	ND	ppm	0.004		MCL for inorganic (30 TAC 290.104(b))		ND						
19	Lead	ND	ppm					ND		ND				
20	Zinc	0.0084	ppm		5	SCL (30 TAC 290.105(b))	0.02	0.039					0.014	0.023
21	Dissolved Oxygen		ppm				3.8						1.83	0.00
22	CO2	215	ppm										111	111
23	H2S		ppm		0.05	SCL (30 TAC 290.105(b))								
24	Barium	0.236	ppm	2		MCL for inorganic (30 TAC 290.104(b))	0.04	0.061					0.141	0.152
25	Mercury	ND	ppm	0.002		MCL for inorganic (30 TAC 290.104(b))		ND						
26	Nitrate	ND	ppm	10		MCL for inorganic (30 TAC 290.104(b))	<0.5	ND		ND				
27	Selenium	0.0022	ppm	0.05		MCL for inorganic (30 TAC 290.104(b))	<0.05	ND						
28	Silver	ND	ppm		0.1	SCL (30 TAC 290.105(b))	<0.005	ND						
29	Calcium	13.9	ppm				1.6	3.89		3.56			7.96	9.07
30	Magnesium	3.55	ppm				0.9	1.15		0.81			2.27	2.39
31	Temperature		deg C											
32	Conductivity	2200	ohms				600						1428	1138
33	Nitrite	ND	ppm	1		MCL for inorganic (30 TAC 290.104(b))	ND							
34	Sulfate	ND	ppm		300	SCL (30 TAC 290.105(b))	13	12.8		13.1				
35	Total Dissolved Solids	1240	ppm		1000	SCL (30 TAC 290.105(b))	430	556		582			849	922
36	Nickel	ND	ppm				ND	ND						
	* =													
	ND=Not Detected													
	Well #2 capacity	140	gpm											
	Well #3 capacity	115	gpm											
	Well #4 proposed	150	gpm											

ANA-LAB CORP. THE COMPLETE SERVICE LAB

Corporate

2600 Dudley Road -- Kilgore, TX 75662
903/984-0551 FAX 903/984-5914

CMID

02/02/2009

Sample	Description	Taken	Project	Received	Mail
065785	TCEQ Deep Well Construction West Harrison Water Supply Com	01/19/2009 17:40	428110	01/20/2009	/ /

Parameter	Results	Units	EQL	Analyzed	By
Nitrite	ND	mg/L	0.250	01/20/2009	GDG
Nitrate	ND	mg/L	0.250	01/20/2009	GDG
Chloride	845	mg/L	15.0	01/20/2009	GDG
Fluoride	ND	mg/L	0.500	01/20/2009	GDG
Nitrate-Nitrogen Total	ND	mg/L	0.050	01/20/2009	GDG
Sulfate	ND	mg/L	1.50	01/20/2009	GDG
Silver	ND	mg/L	0.001	01/21/2009	WOB
Aluminum	0.0626	mg/L	0.010	01/21/2009	WOB
Arsenic	ND	mg/L	0.002	01/21/2009	WOB
Barium	0.136	mg/L	0.001	01/21/2009	WOB
Beryllium	ND	mg/L	0.001	01/21/2009	WOB
Dissolved Calcium	5.84	mg/L	0.250	01/21/2009	LAS
Calcium	5.64	mg/L	0.250	01/21/2009	LAS
Cadmium	ND	mg/L	0.001	01/21/2009	WOB
Chromium	ND	mg/L	0.001	01/21/2009	WOB
Copper	0.00604	mg/L	0.001	01/21/2009	WOB
Dissolved Iron	ND	mg/L	0.040	01/21/2009	LAS
Iron	0.115	mg/L	0.040	01/21/2009	LAS
Mercury	ND	mg/L	0.000	01/21/2009	LAS
Dissolved Potassium	5.72	mg/L	0.100	01/21/2009	LAS
Potassium	6.15	mg/L	0.100	01/21/2009	LAS
Dissolved Magnesium	1.29	mg/L	0.100	01/21/2009	LAS
Magnesium	1.35	mg/L	0.100	01/21/2009	LAS
Dissolved Manganese	0.0206	mg/L	0.010	01/21/2009	LAS
Manganese	0.0213	mg/L	0.001	01/21/2009	WOB
Dissolved Sodium	540	mg/L	12.5	01/21/2009	LAS
Sodium	574	mg/L	12.5	01/22/2009	LAS
Nickel	ND	mg/L	0.001	01/21/2009	WOB
Lead	ND	mg/L	0.001	01/21/2009	WOB
Selenium	ND	mg/L	0.002	01/21/2009	WOB
Silicon Recoverable	6.04	mg/L	0.020	01/21/2009	HVM
Thallium	ND	mg/L	0.001	01/21/2009	WOB
Zinc	0.0135	mg/L	0.005	01/21/2009	WOB
Acidity	38.7	uEq/L	50	01/21/2009	ALX
Alkalinity as CaCO3	298	mg/L	1	01/21/2009	ALX
Cation-Anion Balance	24.0 / 28.9	meq/meq		02/02/2009	NGT
Cyanide	ND	mg/L	0.005	01/21/2009	RSV
Carbon Dioxide	259	mg/L	0.5	01/26/2009	BRJ
Free Carbon Dioxide	1.44	mg/L	0.5	01/26/2009	BRJ
Carbonate (as CaCO3)	10.7	mg/L	0.5	01/26/2009	BRJ
Lab Spec. Conductance at 25 C	3120	umhos/cm		01/27/2009	JWK
Color	5	PtCo Units	5.0	01/21/2009	JDD
Dissolved Oxygen, in Lab	10.8	mg/L	1	01/26/2009	CBC
Sulfide as Hydrogen Sulfide	ND	mg/L	0.021	01/23/2009	ALX
Bicarbonate (as CaCO3)	287	mg/L	0.5	01/26/2009	BRJ

ANA-LAB CORP. THE COMPLETE SERVICE LAB

Corporate

2600 Dudley Road -- Kilgore, TX 75662

903/984-0551 FAX 903/984-5914

CMID

02/02/2009

Sample Description Taken Project Received Mail

Silicon Dioxide (SiO2)	12.9	mg/L	0.042	01/21/2009	HVM
Hydroxide	ND	mg/L	0.5	01/26/2009	BRJ
Sulfide	ND	mg/L	0.02	01/23/2009	ALX
Total Dissolved Solids	1280	mg/L	50	01/19/2009	LMB
Total Hardness Ca/Mg Eq. CaCO3	19.6	mg/L	0.250	01/21/2009	LAS
Turbidity	2.52	NTU	1	01/20/2009	JWK
Laboratory pH	8.6 @ 6C	SU		01/26/2009	RED

West Harrison Water Well #4 - Summary of Test Well Analyses

No.	Constituent	Well 4 results	unit	TX MCL	TX SCL	Reference	Well 1 7/13/1994	Well 2 8/31/1994	Well 3 11/11/1994	Well 1,2,3 Weighted	Well 1,2,3,4 Weighted
1	Color	5	PtCo Units		15	SCL (30 TAC 290.105(b))					
2	pH	8.6			> 7.0	SCL (30 TAC 290.105(b))	8.3	8.7	8.6	8.6	8.6
3	Alkalinity CaCO3	298	ppm				150	180	216	203.3	225.7
4	Total Hardness	19.6	ppm				4.5	11.6	4.3	4.8	8.3
5	Iron	0.115	ppm		0.3	SCL (30 TAC 290.105(b))	0.06	0.08	0.11	0.1	0.1
6	Manganese	0.0213	ppm		0.05	SCL (30 TAC 290.105(b))					
7	Turbidity SiO2	2.52	NTU								
8	Acidity CaCO3	38.7	uEq/L								
9	Chlorides	845	ppm		300	SCL (30 TAC 290.105(b))	14	12.5	18.2	17.2	213.3
10	Sodium	574	ppm			Not regulated by State	105.6	98.6	118.7	115.3	224.0
11	Potassium	6.15	ppm								5.04
12	Fluoride	ND	ppm	4		MCL for inorganic (30 TAC 290.104(b))	0.1	0.2	0.5	0.4	
					2	SCL (30 TAC 290.105(b))					
13	Arsenic	ND	ppm	0.05		MCL for inorganic (30 TAC 290.104(b))					
14	Cadmium	ND	ppm	0.005		MCL for inorganic (30 TAC 290.104(b))					
15	Chromium	ND	ppm	0.1		MCL for inorganic (30 TAC 290.104(b))					
16	Copper	0.00604	ppm		1	SCL (30 TAC 290.105(b))					
17	Aluminum	0.0626	ppm		0.05 to 0.2	SCL (30 TAC 290.105(b))					
18	Beryllium	ND	ppm	0.004		MCL for inorganic (30 TAC 290.104(b))					
19	Lead	ND	ppm								
20	Zinc	0.0135	ppm		5	SCL (30 TAC 290.105(b))					
21	Dissolved Oxygen	10.8	ppm								
22	CO2	259	ppm								
23	H2S	ND	ppm		0.05	SCL (30 TAC 290.105(b))					
24	Barium	0.136	ppm	2		MCL for inorganic (30 TAC 290.104(b))					
25	Mercury	ND	ppm	0.002		MCL for inorganic (30 TAC 290.104(b))					
26	Nitrate	ND	ppm	10		MCL for inorganic (30 TAC 290.104(b))					
27	Selenium	ND	ppm	0.05		MCL for inorganic (30 TAC 290.104(b))					
28	Silver	ND	ppm		0.1	SCL (30 TAC 290.105(b))					
29	Calcium	5.64	ppm				1.6	4	1.6	1.8	2.7
30	Magnesium	1.35	ppm				0.1	0.4	0.07	0.1	0.4
31	Temperature		deg C								
32	Conductivity		ohms								
33	Nitrite	ND	ppm	1		MCL for inorganic (30 TAC 290.104(b))					
34	Sulfate	32.7	ppm		300	SCL (30 TAC 290.105(b))	62	27.2	19.4	26.5	28.0
35	Total Dissolved Solids	1280	ppm		1000	SCL (30 TAC 290.105(b))	361.5	330.4	407.2	394.9	604.6
36	Nickel	ND	ppm								
	* =										
	ND=Not Detected										
	Well #1 capacity	50	gpm								
	Well #2 capacity	22	gpm								
	Well #3 capacity	250	gpm								
	Well #4 proposed	100	gpm								

West Harrison Well #4 - Summary of Test Well Analyses							
No.		Constituent	Well 4 results	unit	TX MCL	TX SCL	Reference
1		Color	5	PtCo Units		15	SCL (30 TAC 290.105(b))
2		pH	8.6			> 7.0	SCL (30 TAC 290.105(b))
3		Alkalinity CaCO3	298	ppm			
4		Total Hardness	19.6	ppm			
5		Iron	0.115	ppm		0.3	SCL (30 TAC 290.105(b))
6		Manganese	0.0213	ppm		0.05	SCL (30 TAC 290.105(b))
7		Turbidity SiO2	2.52	NTU			
8		Acidity CaCO3	38.7	uEq/L			
9		Chlorides	845	ppm		300	SCL (30 TAC 290.105(b))
10		Sodium	574	ppm			Not regulated by State
11		Potassium	6.15	ppm			
12		Fluoride	ND	ppm	4		MCL for inorganic (30 TAC 290.104(b))
						2	SCL (30 TAC 290.105(b))
13		Arsenic	ND	ppm	0.05		MCL for inorganic (30 TAC 290.104(b))
14		Cadmium	ND	ppm	0.005		MCL for inorganic (30 TAC 290.104(b))
15		Chromium	ND	ppm	0.1		MCL for inorganic (30 TAC 290.104(b))
16		Copper	0.00604	ppm		1	SCL (30 TAC 290.105(b))
17		Aluminum	0.0626	ppm		0.05 to 0.2	SCL (30 TAC 290.105(b))
18		Beryllium	ND	ppm	0.004		MCL for inorganic (30 TAC 290.104(b))
19		Lead	ND	ppm			
20		Zinc	0.0135	ppm		5	SCL (30 TAC 290.105(b))
21		Dissolved Oxygen	10.8	ppm			
22		CO2	259	ppm			
23		H2S	ND	ppm		0.05	SCL (30 TAC 290.105(b))
24		Barium	0.136	ppm	2		MCL for inorganic (30 TAC 290.104(b))
25		Mercury	ND	ppm	0.002		MCL for inorganic (30 TAC 290.104(b))
26		Nitrate	ND	ppm	10		MCL for inorganic (30 TAC 290.104(b))
27		Selenium	ND	ppm	0.05		MCL for inorganic (30 TAC 290.104(b))
28		Silver	ND	ppm		0.1	SCL (30 TAC 290.105(b))
29		Calcium	5.64	ppm			
30		Magnesium	1.35	ppm			
31		Temperature		deg C			
32		Conductivity		ohms			
33		Nitrite	ND	ppm	1		MCL for inorganic (30 TAC 290.104(b))
34		Sulfate	32.7	ppm		300	SCL (30 TAC 290.105(b))
35		Total Dissolved Solids	1280	ppm		1000	SCL (30 TAC 290.105(b))
36		Nickel	ND	ppm			
		* =					
		ND=Not Detected					

23
46
230

POPE *Testing* LABORATORIES, Inc.

CONSULTING ANALYTICAL CHEMISTS
AND TESTING ENGINEERS

FEEDS, DAIRY PRODS.
MISCL. ANALYSES
SEED PRODUCTS
G HOUSE PRODUCTS

P. O. BOX 903
DALLAS, TEXAS 75221
AC 214 742-8491
FAX 214 748-5817

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

March 7, 1995

Rec'd: 3-6-95

ntinental Drilling Company
5 Montgomery Street
reveport, LA 71107

port of Tests on: Water

entification Marks: Harleton W/S Test Well #4

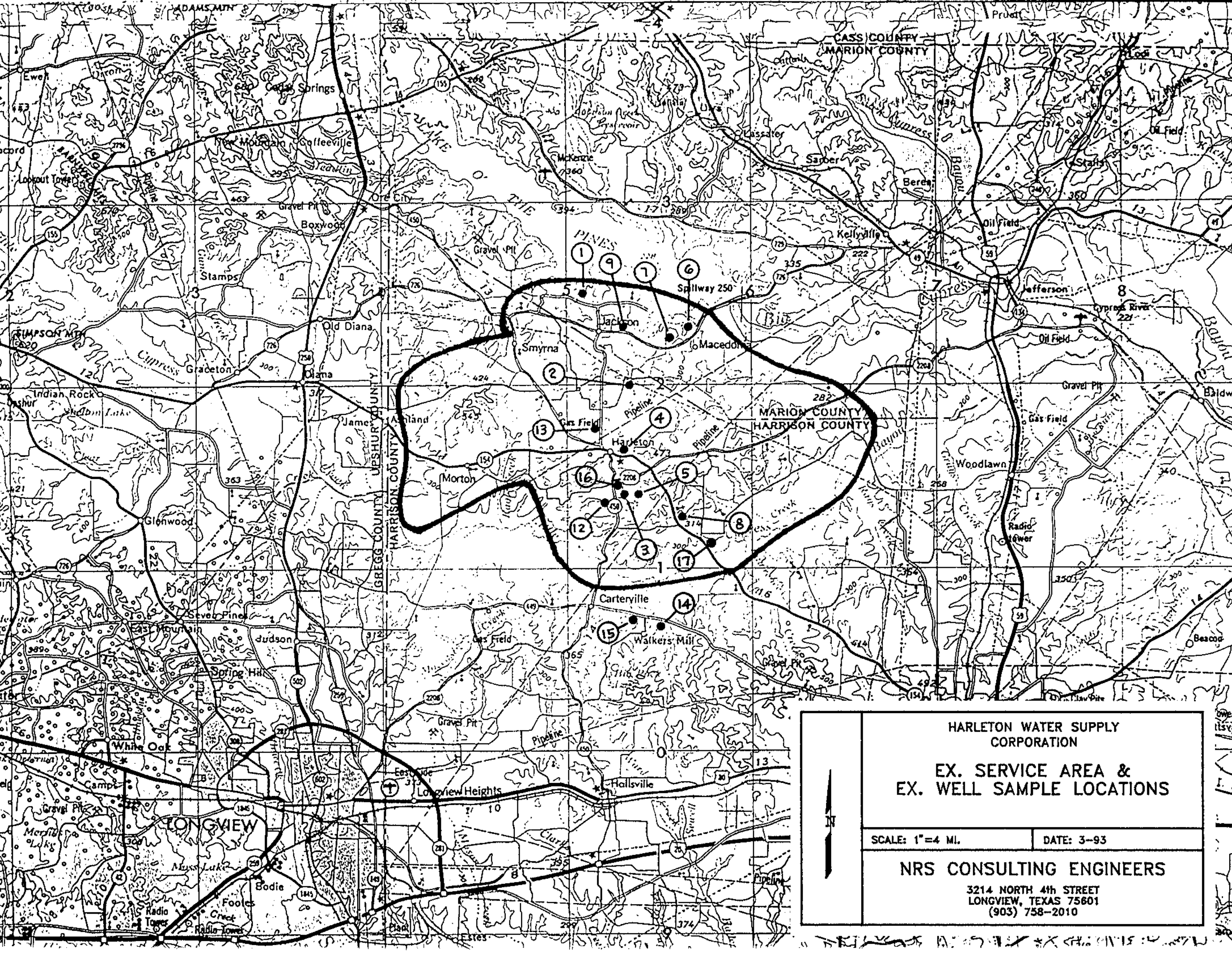
	mg/L
Calcium	3.2
Magnesium	0.9
Iron	0.10
Manganese	0.0
Sodium	329.0
Carbonate	21.6
Bicarbonate	400.2
Sulfate	3.9
Chloride	254.4
Fluoride	0.7
Nitrate	0.0
Phenolphthalein Alkalinity as CaCO3	18.0
Total Alkalinity as CaCO3	364.0
Total Hardness as CaCO3	11.6
Dissolved Residue (TS) Calculated	1014.0
Specific Conductance Micromhos/cm	1400
pH	8.5
Total Iron	0.25

****

Respectfully submitted,
POPE TESTING LABORATORIES, INC.

Leon Hunter

Lab No. 76694


HARLETON WATER SUPPLY CORPORATION
EX. SERVICE AREA &
EX. WELL SAMPLE LOCATIONS
SCALE: 1"=4 MI.
DATE: 3-93
NRS CONSULTING ENGINEERS
3214 NORTH 4th STREET
LONGVIEW, TEXAS 75601
(903) 758-2010
N
CASS COUNTY
MARION COUNTY
HARRISON COUNTY
GREGG COUNTY
UPSHUR COUNTY
Harleton
Jackson
Smyrna
Macedonia
Morton
Ashland
Carterville
Walkers Mill
Spillway 250
Jefferson
Kellyville
Woodlawn
Baldwin
Hallsville
Longview Heights
LONGVIEW
Ore City
Diana
Old Diana
Gladewater
Glenwood
Judson
Spring Hill
White Oak
Seven Pines
East Mountain
Coffeeville
New Mountain
Cedar Springs
Boxwood
Stamps
Graceton
Indian Rock
McKenzie
Lassater
Sarber
Berea
Bodie
Fooles
Gas Field
Gravel Pit
Pipeline
Oil Field
Radio Tower
Cypress River
Ewell
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HARLETON WATER SUPPLY CORPORATION

PREVIOUS WELL TEST

	DESCRIPTION	RESULT
1)	Gene Wrights House - Crystal Cove	See Summary
2)	Lake Deerwood	See Summary
3)	Louis Boyd #1	See Summary
4)	B. C. Newman #1	See Summary
5)	Louis Boyd #2	See Summary
6)	U.S. Corps - Brushy Creek Park	See Summary
7)	U.S. Corps - Shady Grove Park	See Summary
8)	C. C. Williams - 840'	Dry
9)	M. Watts - 820'	Dry
10)	B. B. Orr	Excess Salt
11)	G. H. Whitehead	Not Available
12)	Pine Ridge Subdivision	Not Available
13)	B. Humphries Survey	Dry
14)	Gum Springs Water Supply	See Summary

PROJECT: HARLETON WSC - WELL TEST SUMMARY

DESC.	WRT	DEER	BOYD1	WELL3	BOYD2	BCP	SGP	GUM S	
GPM			185	150	60	2-18	2-18	2-250	
SITE #	1	2	3	4	5	6	7	14	LIMITS
CALC	2.3	2.4	3.2	4	2.4	1	2	1	
MAGN	0.3	1.3	1.3	1.9	1	<1	1	<1	
IRON	0.04	0.16	0.1	0.2	0.4	<.02	0.05	0.03	0.3
MANG	0	0	0	0.01	0	<.02	<.02	0.02	0.05
SODI	260.3	330.5	324.4	449.5	286.8	282	404	237	
CARB	14.4	0	12	14.4	28.8	7	0	3	
BICAR	429.7	374.4	444.1	327	511.5	517	399	508	
SULP	16	4	8	5	0	3	2	29	250
CHLOR	127.7	297	231.5	495	117.9	128	403	41	250
FLOUR	0.5	0.4	0.6	0.6	0.7	0.7	0.4	1	.6-1
NITRA	3	1	0	0	0	0.42	0.65	0.41	45
P-ALK	12	0	10	12	24	6	0	3	
T-ALK	376.2	306.9	384	292	467.3	436	327	422	
T-HAR	7	11.5	13.5	18	10	5	8	4	
DR-TS	854.2	1011.	1025.2	1297.6	949.5	680	1013	566	500
SCM	1000	1200	1200	1800	1100	1260	2000	1088	
pH	8.4	7.9	8.5	8.4	8.6	8.5	8	8.4	6.5-8.5

Sample Site #1

Send original copy by certified mail to the Texas Water Development Board P. O. Box 12386 Austin, Texas 78711	State of Texas WATER WELL REPORT	For TWDB use only Well No. Located on map Received: Form GW 8 Form GW 9

1) OWNER:
Person having well drilled Crystal Cover, Gene Wright (Name) Address [illegible] (Street or RFD) (City) (St

Landowner same (Name) Address same (Street or RFD) (City) (St

2) LOCATION OF WELL:
County Marion Labor League Abstract No.

NW¼ NE¼ SW¼ SE¼ of Section Block No. Survey
(Circle as many as are known)

miles in 12.7 east (NE, SW, etc.) direction from Ore City (Town).

NORT

Over

Sketch map of well location with distances from adjacent section or survey lines, and to landmarks, roads, and creeks.

3) TYPE OF WORK (Check):
New Well ☒ Deepening ☐
Reconditioning ☐ Plugging ☐

4) PROPOSED USE (Check):
Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

5) TYPE OF WELL (Check):
Rotary ☒ Driven ☐ Dug
Cable ☐ Jetted ☐ Bored

6) WELL LOG:
Diameter of hole 6 3/4" - 3 7/8" in. Depth drilled 755 ft. Depth of completed well 755 ft. Date drilled 8-4-
All measurements made from 0 ft. above ground level.

From (ft.)	To (ft.)	Description and color of formation material	From (ft.)	To (ft.)	Description and color of formation material
0	25	red, yellow & white sandy clay & sa.	124	200	green & brown sa. & sh.
25	65	brown lignitic sh. w/sa. st. & lignite	200	253	gray sticky sh. w/brown sh lignite st. w/blue sh. st.
65	100	gray sh. w/brown sh. mixed w/ sa. st. & lignite	253	261	fine gray sa.
100	110	green & brown sand & sandy sh	261	300	brown & gray sh. w/lignite sa. st.
110	124	brown & gray sh.	300	315	gray sh. w/sandy sh. st.

(Use reverse side if necessary)

7) COMPLETION (Check):
Straight wall ☐ Gravel packed ☒ Other ☐
Under reamed ☐ Open hole ☐

8) WATER LEVEL:
Static level 41 ft. below land surface Date 8-4-7
Artesian pressure lbs. per square inch Date

9) CASING:
Type: old ☐ New ☒ Steel ☒ Plastic ☐ Other ☐
Cemented from ft. to ft.

Diameter (inches)	Setting From (ft.)	Setting To (ft.)	Gage

10) SCREEN:
Type wire wrapped stainless steel
Perforated ☐ Slotted ☐

Diameter (inches)	Setting From (ft.)	Setting To (ft.)	Slot size
2 1/2	666	746	.008
		80 ft	

11) WELL TESTS:
Was a pump test made? ☐ Yes ☐ No If yes by whom?

Yield: gpm with ft. drawdown after hrs
Bailer test 100 gpm with 65 ft. drawdown after 4 hrs
Artesian flow gpm Date
Temperature of water
Was a chemical analysis made? ☐ Yes ☐ No
Did any strata contain undesirable water? ☐ Yes ☐ No
Type of water? depth of strata

12) PUMP DATA:
Manufacturer's Name Fairbanks & Morse
Type submersible H.P. 2
Designed pumping rate gpm ☐ gph
Type power unit
Depth to bowls, cylinder, jet, etc., 252 below land surface.

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief.

NAME Gastonn W. DeBerry (Type or Print) Water Well Drillers Registration No. 321

Address P. O. Box 1524 (Street or RFD) Ore City (City) Texas (State)

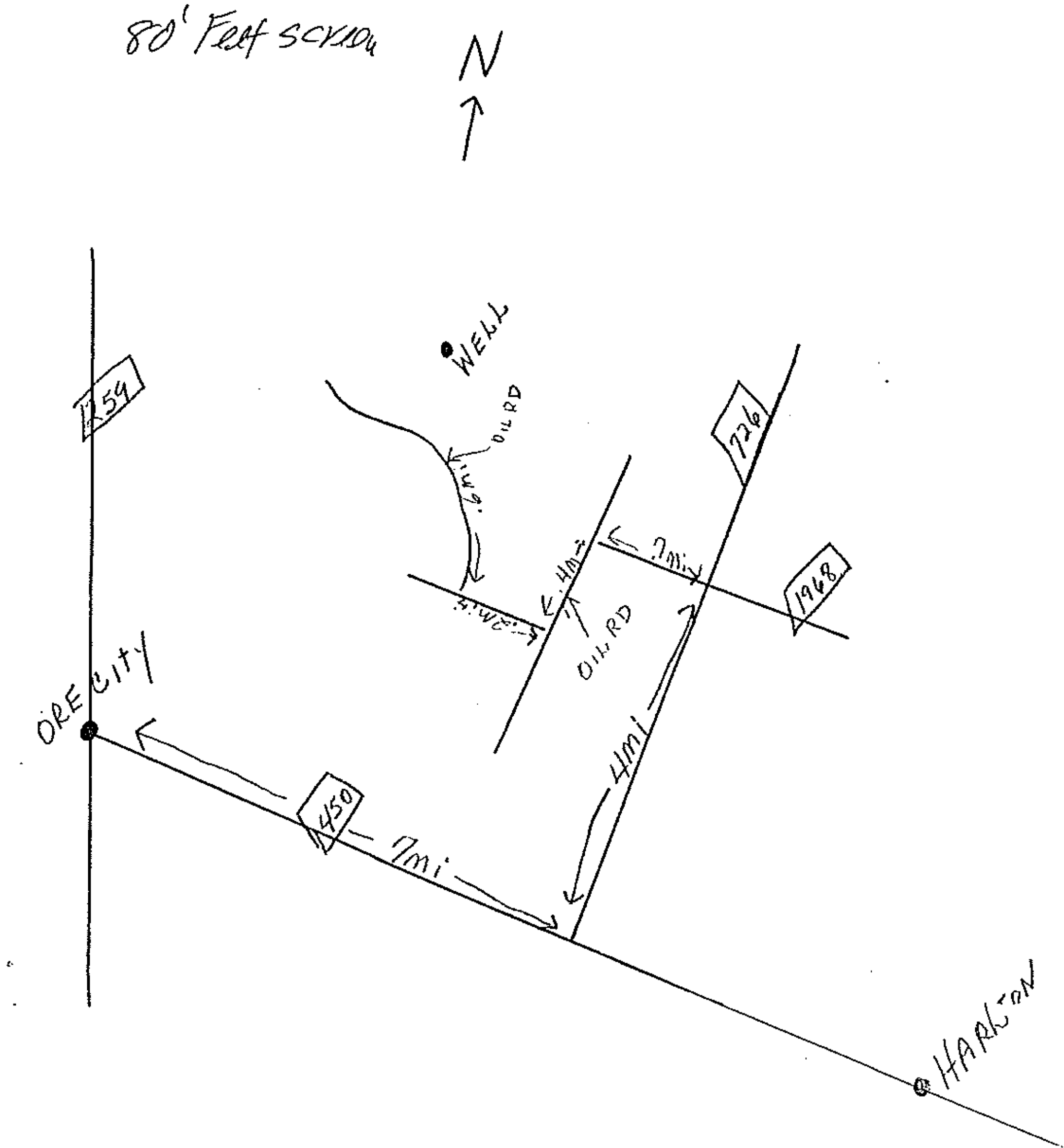
(Signed) (Water Well Driller) DeBerry Drilling Co. (Company Name)

Please attach electric log, chemical analysis, and other pertinent information, if available.

Sample Site #1

315	-	324	gray sa.
324	-	380	gray sticky sh. w/brown lignitic sh.st. w/sandy sh. st.
380	-	420	gray sa. & sh. w/thin rk layers
420	-	500	gray sh. w/lignite st. & lignitic sh.
500	-	514	gray sandy sh.
514	-	525	fine gray sa.
525	-	553	gray sticky sh.
553	-	561	gray sa.
561	-	577	gray ~~sand~~ sh.
577	-	582	gray sandy sh.
582	-	605	gray sa. fine
605	-	641	gray shale & sandy sh. w/sa. st.
641	-	755	gray sa.

Set screen 114' solid sand
in this section
80' Feet screen



Sample Site #1,

POPE *Testing* LABORATORIES, Inc.

CONSULTING ANALYTICAL CHEMISTS
AND TESTING ENGINEERS

FOODS. FEEDS. DAIRY PRODS.
WATER. MISCL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS

P. O. BOX 903
DALLAS, TEXAS 75221
742-7471

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
NATL. SOYBEAN PROCESSOR'S ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

Date Rec'd 6-4-87

To: Harleton Water Supply Corporation
Harleton, Texas

Report of Tests on Water

Received From: You

Identification Marks: Gene Wright's House Crystal Cone Sample #3

Values reported are for minerals in solution

	Well #1	*Parts Per Million*
Calcium	3.0	2.3
Magnesium	1	0.3
Iron	.16	0.04
Manganese	.02	0.0
Sodium	330	260.3
Carbonate	17	14.4
Bicarbonate	436	459.7
Sulphate	4	16.0
Chloride	244	127.7
Fluoride	.5	0.5
Nitrate	.01	3.0
Phenolphthalein Alkalinity as $CaCO_3$	14	12.0
Total Alkalinity as $CaCO_3$	385	376.2
Total Hardness as $CaCO_3$	10	7.0
Dissolved Residue (TS) Calculated	816	854.2
Specific Conductance Micromhos/cm	1584	1000
pH	8.8	8.4

RECOMMENDED LIMITS FOR DRINKING WATER (P. P. M.)

Iron	0.3	Fluoride	0.6 — 1.0
Manganese	0.05	Nitrate	45
Sulphate	250	Total Solids	500
Chloride	250		

POPE TESTING LABORATORIES, Inc.

By Leon Hunter

Lab. No. 42154

F-158—1M

Sample site #2

②

POPE *Testing* LABORATORIES, Inc.

CONSULTING ANALYTICAL CHEMISTS
AND TESTING ENGINEERS

FOODS, FEEDS, DAIRY PRODS.
WATER, A.SOL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS
FERTILIZERS

P. O. BOX 903
DALLAS, TEXAS 75221
(214) 742-8491

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

Date Rec'd 1-26-88

To: Harleton Water Supply Corp.
Harleton, TX

Report of Tests on Water

Received From: You

Identification Marks: L. Deerwood #1

Values reported are for minerals in solution

	Parts Per Million
Calcium	2.4
Magnesium	1.3
Iron	0.16
Manganese	0.0
Sodium	330.5
Carbonate	0.0
Bicarbonate	374.4
Sulphate	4.0
Chloride	297.0
Fluoride	0.4
Nitrate	1.0
Phenolphthalein Alkalinity as $CaCO_3$	0.0
Total Alkalinity as $CaCO_3$	306.9
Total Hardness as $CaCO_3$	11.5
Dissolved Residue (TS) Calculated	1011.2
Specific Conductance Micromhos/cm	1200
pH	7.9

RECOMMENDED LIMITS FOR DRINKING WATER (P. P. M.)

Iron	0.3	Fluoride	0.6 — 1.0
Manganese	0.05	Nitrate	45
Sulphate	250	Total Solids	500
Chloride	250		

POPE TESTING LABORATORIES, Inc.

By [signature]

Lab. No. 52149

F-158-1W

Sample Site #3 #1
Ex. Well No. 1

Send original copy by certified mail to the Texas Department of Water Resources P. O. Box 13087 Austin, Texas 78711

State of Texas
WATER WELL REPORT

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

Texas Water Well Drillers Board P. O. Box 13087 Austin, Texas 78711

1) OWNER Horleton Water Supply (Name) Address P.O. Box 372 (Street or RFD) Harelton (City) Texas (State) 75671 (Zip)

2) LOCATION OF WELL: County Harrison 1.8 miles in se (N.E., S.W., etc.) direction from Harleton (Town)

Driller must complete the legal description to the right with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ Legal description:
Section No. ______ Block No. ______ Township ______
Abstract No. 116 Survey Name J. M. Brown
Distance and direction from two intersecting section or survey lines ______

☒ See attached map.

3) TYPE OF WORK (Check): ☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check): ☐ Domestic ☐ Industrial ☒ Public Supply ☐ Irrigation ☐ Test Well ☐ Other

5) DRILLING METHOD (Check): ☒ Mud Rotary ☐ Air Hammer ☐ Driven ☐ Bored ☐ Air Rotary ☐ Cable Tool ☐ Jetted ☐ Other

6) WELL LOG:

8-3-87
Date drilled 8-19-87

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
12 1/4	Surface 0	362
7 7/8	362	485

7) BOREHOLE COMPLETION:
☐ Open Hole ☐ Straight Wall ☐ Underreamed
☒ Gravel Packed ☐ Other
If Gravel Packed give interval ... from 345 ft. to 485 ft.

From (ft.)	To (ft.)	Description and color of formation material
0	9	tan & yellow sand
9	17	yellow & white clay
17	80	brown & gray sh. w/sanddy sh. & sa. st.
80	141	brown sh. w/ sandy st.
141	180	gray sh.
180	245	brown & gray sh. w/few sa. st.
245	275	green sa. & sh. w/fossell
275	330	brown & gray sh. w/sa. & sandy sh. st.
330	365	gray sandy sh.& sa.
365	376	gray sand (shaley)
376	475	gray sa.
475	485	brown sh. & lignite little sandy

(Use reverse side if necessary)

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	To	Gage Casing Screen
8 5/8	n	steel pipe casing	+4	362	
4	n	blank-steel pipe	341	383	
4	n	S.S.Sandscreen	383	425	
4	n	steel pipe blank	425	429	
4	n	s. s. sandscreen	429	4	
4	n	steel pipe blank			

CEMENTING DATA
Cemented from 0 ft. to 362 ft.
Method used pressure cement
Cemented by Gib-Son Cement Co. (Company or Individual)

9) WATER LEVEL:
Static level 75 ft. below land surface Date 8-19-87
Artesian flow ______ gpm. Date ______

10) PACKERS: Type Depth

11) TYPE PUMP:
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other
Depth to pump bowls, cylinder, jet, etc., ______ ft.

12) WELL TESTS:
☐ Type Test: ☐ Pump ☐ Bailer ☒ Jetted ☐ Estimated
Yield: 300 gpm with 175 ft. drawdown after 1 hrs.

13) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable water? ☐ Yes ☒ No
If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ______ Depth of strata ______
Was a chemical analysis made? ☒ Yes ☐ No

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief.

COMPANY NAME DeBerry Butane Gas Co. (Type or Print) Water Well Driller's License No. 321

ADDRESS P.O. Box 10 (Street or RFD) Ore City (City) Texas (State) 75683 (Zip)

(Signed) Gaston W. DeBerry (Licensed Water Well Driller) (Signed) ______ (Registered Driller Trainee)

Please attach electric log, chemical analysis, and other pertinent information, if available.

For TDWR use only
Well No. ______
Located on map ______

DWR-0392 (Rev. 5-27-82)

DEPARTMENT OF WATER RESOURCES COPY

Sample site #3
Ex. well No. 1

POPE Testing LABORATORIES, Inc.

CONSULTING ANALYTICAL CHEMISTS
AND TESTING ENGINEERS

FOODS, FEEDS, DAIRY PRODS.
WATER; MISCL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS

P. O. BOX 903
DALLAS, TEXAS 75221

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
NATL. SOYBEAN PROCESSOR'S ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

Date Rec'd 8-6-87

To: DeBerry Drilling Company
Ore City, Texas

Report of Tests on Water

Received From: You

Identification Marks: Harleton Water Supply Box 372 Harleton, Texas Test Well #5

Values reported are for minerals in solution

	Parts Per Million
Calcium	3.2
Magnesium	1.3
Iron	0.10
Manganese	0.0
Sodium	324.4
Carbonate	12.0
Bicarbonate	444.1
Sulphate	8.0
Chloride	231.5
Fluoride	0.6
Nitrate	0.0
Phenolphthalein Alkalinity as $CaCO_3$	10.0
Total Alkalinity as $CaCO_3$	384.0
Total Hardness as $CaCO_3$	13.5
Dissolved Residue (TS) Calculated	1025.2
Specific Conductance Micromhos/cm	1200
pH	8.5

RECOMMENDED LIMITS FOR DRINKING WATER (P. P. M.)

Iron	0.3	Fluoride	0.6 — 1.0
Manganese	0.05	Nitrate	45
Sulphate	250	Total Solids	500
Chloride	250		

POPE TESTING LABORATORIES, Inc.

By Leon Hunter

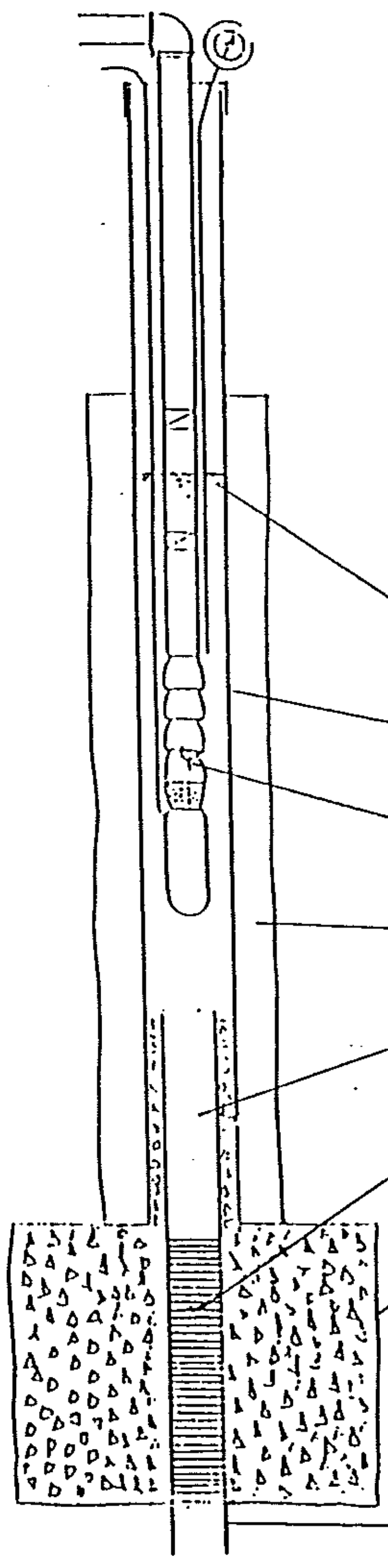
Lab. No. 45018

F-158—1M

Powell Drilling Co.

Rt. 4, Box 363
Jefferson, Texas 75657
(214) 665-3615

Sample Site #4
Ex Well #3



MATERIAL REPORT

Bit size 12 1/4 inch

Depth 560 Feet

Static level 115 Feet

Casing 8 5/8 in. (32 Lb.) 497 Ft.

Submersible pump 20 H.P. 150 G.P.M.

Cement 194 sack of Type I Portland

Liner 123 FT. of 4 1/2 in.

Stainless steel wire wrap screen 40 Ft of 4 1/2 in.

Underream 63 Ft. of 16 in.

Pilot hole

Powell Drilling Co.

Sample Site #4
Ex. Well #3

Rt. 4, Box 363
Jefferson, Texas 75657
(214) 665-3615

WELL LOG

CLEARWATER 1-800 492-9101

0 – 2	Soil
2 – 9	Clay Red
9 – 43	Sand yellow
4? – 46	Shale blue
46 – 70	Sand Gray
70 – 89	Sandy Shale
89 – 126	Sand gray
2 – 158	Shale Blue
58 – 202	Sand gray
0: 260	Shale blue
60 – 350	Shale & Sandy Shale
5 – 498	Shale blue
498 – 560	Sand Gray

PUMP DATA

Bowl Assembly: 12 Stage, Size 6" Type Sub Discharge Column Setting 252 Feet, Discharge Size 3" Design 150 GPM. At 400' THD

MOTOR DATA: HP: 20 Make Franklin Speed 3450 Voltage 460 Type Sub

Remarks: Set SP 27-12 (20HP) 3PH 150 GPM Grundfos Submersible Pump

Powell Drilling Co.

Sample Site #1
Ex Well #3

Rt. 4, Box 363
Jefferson, Texas 75657
(214) 665-3615

CASING AND CEMENTING DATA

Cementing Date 2- 4- 88

Size of Drill Bit 12 ¼

Size of Casing 8 5/8

Sacks of Cement Used 194 Sacks of Type I Portland

Calculated Annular Height Of Cement Slurry Behind Pipe 497 Ft.

Sample Site # 4
Ex Well # 3

POPE Testing LABORATORIES, Inc.

CONSULTING ANALYTICAL CHEMISTS
AND TESTING ENGINEERS

FOODS, FEEDS, DAIRY PRODS.
WATER, MISCL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS
FERTILIZERS

P. O. BOX 903
DALLAS, TEXAS 75221
(214) 742-8491

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

Date Rec'd 1-20-88

To: Powell Drilling
Jefferson, TX

Report of Tests on Water

Received From: You

Identification Marks: Harleton WSC

Values reported are for minerals in solution

	Parts Per Million
Calcium	4.0
Magnesium	1.9
Iron	0.20
Manganese	0.01
Sodium	449.5
Carbonate	14.4
Bicarbonate	327.0
Sulphate	5.0
Chloride	495.0
Fluoride	0.6
Nitrate	0.0
Phenolphthalein Alkalinity as $CaCO_3$	12.0
Total Alkalinity as $CaCO_3$	292.0
Total Hardness as $CaCO_3$	18.0
Dissolved Residue (TS) Calculated	1297.6
Specific Conductance Micromhos/cm	1,800
pH	8.4

RECOMMENDED LIMITS FOR DRINKING WATER (P. P. M.)

Iron	0.3	Fluoride	0.6 — 1.0
Manganese	0.05	Nitrate	45
Sulphate	250	Total Solids	500
Chloride	250		

POPE TESTING LABORATORIES, Inc.

By Leon Hunter

Lab. No. 51881

F-158—1M

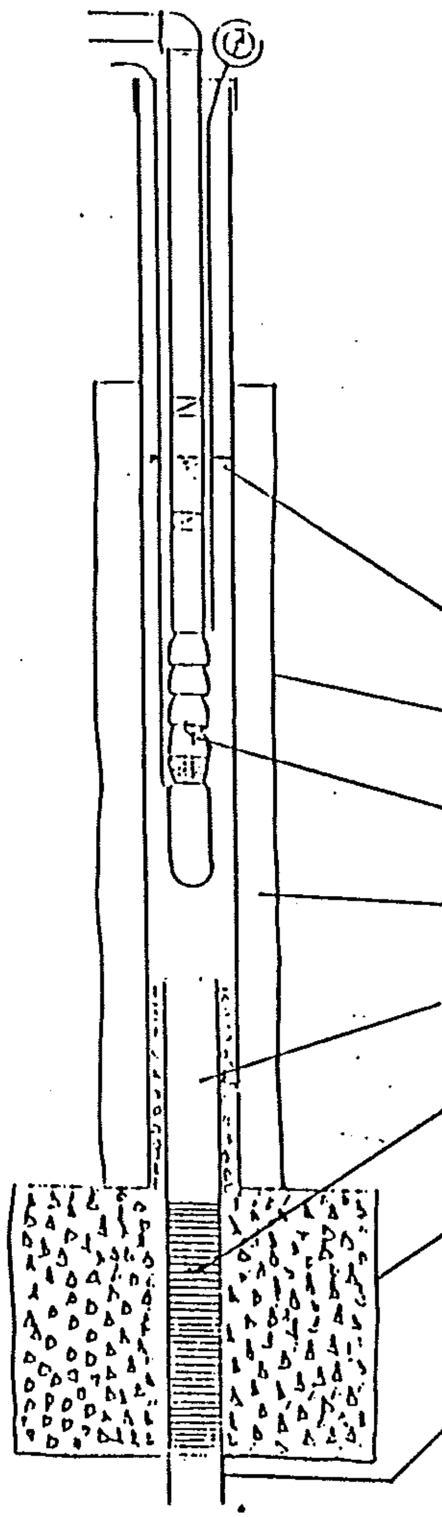
Powell Drilling Co.

Rt. 4, Box 363
Jefferson, Texas 75657
(214) 665-3615

well #2

(5)

Sample Site #5
Ex. Well No. 2



MATERIAL REPORT

Bit size 12 1/4 inch

Depth 420 Ft.

Static level 50 Ft.

Casing 8 5/8 inch

Submersible pump 15 HP 60 GPM

Cement 151 Sacks Type I Portland

Liner 105 Ft. of 4 1/2 inch

Stainless steel wire wrap
screen 30 Ft. 4 1/2 inch .018 slot

Underream 30 Ft. of 16 inch

Pilot hole ______

Sample Site #5
Ex. well No. 2

Powell Drilling Co.

Rt. 4, Box 363
Jefferson, Texas 75657
(214) 665-3615

WELL LOG

0 - 2	Soil
2 - 10	Clay yellow
10 - 48	Sand yellow
48 - 91	Sand & Sandy Shale
91 - 114	Shale Blue
114 - 164	Sand Grey
164 - 250	Shale Blue
250 - 307	Silty Sand Grey
307 - 390	Shale Blue
390 - 420	Sand Grey

PUMP DATA

Bowl Assembly: 16 Stage, Size 6" Type Sub Discharge Column Setting 273 Feet, Discharge Size 3 in Design 60 GPM. At 560 THD

MOTOR DATA: HP: 15 Make Franklin Speed 3450 Voltage 460 Type sub

Remarks: Set SP 16-16 (15 HP) 3 Ph 60 GPM Grundfos Submersible Pump

Sample Site #5
Ex. ... No. 2

Powell Drilling Co.

Rt. 4, Box 363
Jefferson, Texas 75657
(214) 665-3615

CASING AND CEMENTING DATA

Cementing Date 12-7-87

ize of Drill Bit 12 1/4

Size of Casing 8 5/8

acks of Cement Used 151 Sacks of Type I Portland

Calculated Annular Height Of Cement Slurry Behind Pipe 388 Ft.

Sample site #5
Ex Well No. 2

Powell Drilling Co.

Rt. 4, Box 363
Jefferson, Texas 75657
(214) 665-3615

PUMP TEST

Test Conducted By: Powell Drilling Co

Well Owner: Harleton W.S.C.

Well No: # 2 Pump Setting: 268 Static Water Level: 50 Ft

Date and Time [illegible]-15-87	Pumping Rate GPM	Altitude Gage Reading			
10:30	260	50	P.M. 7:00	60	262
10:35	200	200	8:00	60	262
10:40	74	225	9:00	60	262
10:45	60	262	10:00	60	262
[illegible]:00	60	262	11:00	60	262
AM 12:00	60	262	AM 12:00	60	262
1:00	60	262	1:00	60	262
2:00	60	262	2:00	60	262
3:00	60	262	3:00	60	262
4:00	60	262	4:00	60	262
5:00	60	262	5:00	60	262
6:00	60	262	6:00	60	262
7:00	60	262	7:00	60	262
8:00	60	262	8:00	60	262
9:00	60	262	9:00	60	262
10:00	60	262	10:00 STOP	60	262
11:00	60	262	10:15		151
PM 12:00	60	262	10:30		87
1:00	60	262	10:45		63
2:00	60	262	11:00		50
[illegible]:00	60	262			
[illegible]:00	60	262			
5:00	60	262			
6:00	60	262			

Sample Site #5
Ex. Well No. 2

POPE *Testing* LABORATORIES, Inc.

CONSULTING ANALYTICAL CHEMISTS
AND TESTING ENGINEERS

ODS, FEEDS, DAIRY PRODS.
ATER, MISCL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS

P. O. BOX 903
DALLAS, TEXAS 75221

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
NATL. SOYBEAN PROCESSOR'S ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

Date Rec'd 10-21-87

To: Powell Drilling
Jefferson, TX

Report of Tests on Water

Received From: You

Identification Marks: ~~None~~ HARLETON W.S.C.

Values reported are for minerals in solution

	Parts Per Million
Calcium	2.4
Magnesium	1.0
Iron	0.40
Manganese	0.0
Sodium	286.8
Carbonate	28.8
Bicarbonate	511.5
Sulphate	0.0
Chloride	117.9
Fluoride	0.7
Nitrate	0.0
Phenolphthalein Alkalinity as $CaCO_3$	24.0
Total Alkalinity as $CaCO_3$	467.3
Total Hardness as $CaCO_3$	10.0
Dissolved Residue (TS) Calculated	949.5
Specific Conductance Micromhos/cm	1100
pH	8.6

RECOMMENDED LIMITS FOR DRINKING WATER (P. P. M.)

Iron	0.3	Fluoride	0.6 — 1.0
Manganese	0.05	Nitrate	45
Sulphate	250	Total Solids	500
Chloride	250		

POPE TESTING LABORATORIES, Inc.

By Leon Hunter

Lab. No. 48083

F-158-1M

Sample Site #5
Ex. Well No. 2

WATER ANALYSIS REPORT
TEXAS DEPARTMENT OF HEALTH
DIVISION OF WATER HYGIENE
1100 WEST 49 TH STREET
AUSTIN, TEXAS 78756

HARLETON WATER SUPPLY CORP.
J.F.FONTAINE &ASSOC.,INC.
P.O.BOX 980
PALESTINE TX 75801

WATER SUPPLY #:
LABORATORY NO: EP802962
SAMPLE TYPE:

COLLECTOR REMARKS:
SOURCE: WELL 2
DATE COLLECTED 2/16/88 DATE RECEIVED 2/22/88 DATE REPORTED 3/ 1/88

CONSTITUENT NAME		RESULT	UNITS	+/-
Calcium		4	mg/l	
Chloride		101	mg/l	
Fluoride		0.8	mg/l	
Magnesium	<	1	mg/l	
Nitrate (as N)	<	0.01	mg/l	
Sodium		278	mg/l	
Sulfate		4	mg/l	
Total Hardness/CaCO3		11	mg/l	
pH		8.8		
Dil.Conduct(umhos/cm)		1260		
Tot. Alka. as CaCO3		482	mg/l	
Bicarbonate		544	mg/l	
Carbonate		22	mg/l	
Dissolved solids		679	mg/l	
P. Alkalinity /CaCO3		18	mg/l	
Iron		0.07	mg/l	
Manganese	<	0.02	mg/l	

(2)

Non-community Water Supply Chemical Analysis Report
Texas Department of Health - Division of Water Hygiene
1100 West 49 th Street Austin, Texas 78756

(6)

Sample Site #6

Send Report To:
U.S. Army - Corps of Engineers
P.O. Drawer W
Jefferson, Texas 75657

NAME OF WATER SUPPLY:
Brushy Creek Park
Water Supply I.D. # 1580034 (1-7)
County Marion

SAMPLE TYPE	IF FROM WELL	IF SURFACE SUPPLY
☒ Distribution	Depth 600 ft.	Name of Source
☐ Plant Discharge	Age ____ yrs.	
☐ Raw Supply	Well No. 1&2	
☐ Other	REMARKS:	

J. W. Starkey

Date Collected 03 / 15 / 85 (31-36)

Laboratory [redacted] (10-13) (17-20) Date Received 21 DEC (10-13) Date Reported APR 10 '85 (17-20)

(10-13) SAMPLE NO.: EP5-5062 (17-20)

1016	Calcium	mg/l	1
1031	Magnesium	mg/l	<1
1052	Sodium	mg/l	282
1929	Carbonate 254	mg/l	7
1928	Bicarbonate	mg/l	517
1055	Sulfate	mg/l	3
1017	Chloride	mg/l	128
1025	Fluoride	mg/l	.7
1040	Nitrate (asN)	mg/l	.42
1930	Dissolved solids		680
1931	Phenolphthalein Alkalinity as CaCO3	mg/l	6
1927	Total Alkalinity as CaCO3	mg/l	436
1915	Total Hardness as CaCO3	mg/l	5
1925	pH		8.5
1926	Diluted Conductance Micromhos/cm.		1260

SAMPLE NO. EP5-5062

(10-13) (17-20)

1028	IRON	<0.02	mg/l
1032	MANGANESE	<0.02	mg/l

1927 Total Alkalinity as CaCO ____ . mg/l

1915 Total Hardness as CaCO ____ . mg/l

1925 pH __.__

1926 Diluted Conductance Micromhos/cm. ____ .

FORM NO. H-71

⑤ ⑦

Non-community Water Supply Chemical Analysis Report
Texas Department of Health - Division of Water Hygiene
1100 West 49 th Street Austin, Texas 78756

Sample Site #7

Send Report To:
U.S. Army - Corps of Engineers
P.O. Drawer W
Jefferson, Texas 75657

NAME OF WATER SUPPLY: Shady Grove Park
Water Supply I.D. # 1580004 (1-7)
County Marion

SAMPLE TYPE

- ☒ Distribution
- ☐ Plant Discharge
- ☐ Raw Supply
- ☐ Other

IF FROM WELL

Depth 600 ft.
Age ____ yrs.
Well No. 1 & 2

IF SURFACE SUPPLY

Name of Source ____

REMARKS: ____

J.W. Starkey
(Signature)

Date Collected 03 / 15 / 85 (31-36)

Laboratory No. [redacted] (10-13) (17-20)   Date Received MAR 21 1985 (10-13)   Date Reported APR 10 '85 (17-20)

1016 Calcium ____. mg/1

(10-13) SAMPLE NO.:EP5-5059(17-20)

016	Calcium	mg/l	2
1031	Magnesium	mg/l	1
1052	Sodium	mg/l	404
1929	Carbonate 196	mg/l	0
1928	Bicarbonate	mg/l	399
1055	Sulfate	mg/l	2
017	Chloride	mg/l	403
1025	Fluoride	mg/l	.4
1040	Nitrate (asN)	mg/l	.65
1930	Dissolved solids		1013
1931	Phenolphthalein Alkalinity as CaCO3	mg/l	0
1927	Total Alkalinity as CaCO3	mg/l	327
1915	Total Hardness as CaCO3	mg/l	8
1925	pH		8.0
1926	Diluted Conductance Micromhos/cm.		2000

SAMPLE NO. EP5-5059
(10-13) (17-20)

1028	IRON	.05	mg/l
1032	MANGANESE	<0.02	mg/l

1927 Total Alkalinity as CaCO ____. mg/1

1915 Total Hardness as CaCO ____. mg/1

1925 pH __.__

1926 Diluted Conductance Micromhos/cm

PHONE 214-968-2222

DEBERRY DRILLING COMPANY
WATER WELL CONTRACTORS
P. O. BOX 1524
ORE CITY, TEXAS 75683

(8)

Sample Site #8

July 23, 1987

J. C. Williams

Harleton Water Supply Corp.
P.O. Box 372
Harleton, Texas 75671

Statement on test well #24

840 ft........drill 3 7/8" test hole w/test well
logging and hand sampling.
Price per ft. top to bottom....$3.50 ft.. .....$ 2,940.00

Note: Hand sampling no good productive water bearing sand.
Test well plugged.
Included is a copy of log.

Gaston W. DeBerry
Gaston W. DeBerry
Texas Water Well License 321

Test well located on B. Williams place.

PHONE 214-968-2222

DeBERRY DRILLING COMPANY
WATER WELL CONTRACTORS
P. O. BOX 1524
ORE CITY, TEXAS 75683

(9)

Sample Site #9

M Watts

July 20, 1987

Harleton Water Supply Corp.
P.O. Box 372
Harleton, Texas 75671

Statment on test well #13

820 ft......drill 3 7/8" test hole w/test well
logging and hand sampling.
Price per ft. top to botton...$3.50 ft........$ 2,870.00

Note: Hand sampling no good productive water bearing sand.
Test well plugged.
Included is a copy of log.

Gaston W. DeBerry
Gaston W. DeBerry
Texas Water Well License 321

Test well located on Milton Watts land.

Survey: Albright

NE 214-968-2222

DeBERRY DRILLING COMPANY

WATER WELL CONTRACTORS
P. O. BOX 1524
ORE CITY, TEXAS 75683

(10)

Sample Site #10

Orr Massengale

July 22, 1987

Harleton Water Supply, Inc.
P.O. Box 372
Harleton, Texas 75671

Statment on testing B. T. Orr supply well in Marion county.
J.U.Fields - Survey.

Mininum rig charge with two compressor, all equipment, and crew to test water well with compressed air for salt content in water. Test showed excess amount of salt. It could not be used in water system...........$ 1,295.00

Gaston W. DeBerry

Gaston W. DeBerry
Texas Water Well License 321

Sample Site #11 (10)

Send original copy by certified mail to the Texas Department of Water Resources P. O. Box 13087 Austin, Texas 78711

State of Texas
WATER WELL REPORT

For TDWR use only
Well No.
Located on map
Received:

1) OWNER G. H. Whitehead (Name) Address Route 5, Box 164 A (Street or RFD) Harleton, (City) Texas (State) (Zip)

2) LOCATION OF WELL:
County ______, ______ miles in ______ (N.E., S.W., etc.) direction from ______ (Town)

Driller must complete the legal description to the right with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ Legal description:
Section No. ______ Block No. ______ Township ______
Abstract No. ______ Survey Name ______
Distance and direction from two intersecting section or survey lines ______

☒ See attached map.

3) TYPE OF WORK (Check):
☒ New Well ☐ Deepening
☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check):
☒ Domestic ☐ Industrial ☐ Public Supply
☐ Irrigation ☐ Test Well ☐ Other ______

5) DRILLING METHOD (Check):
☒ Mud Rotary ☐ Air Hammer ☐ Driven ☐ Bored
☐ Air Rotary ☐ Cable Tool ☐ Jetted ☐ Other ______

6) WELL LOG:
Date drilled 18Dec79

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
6¾	Surface	390
4	390	520

7) BOREHOLE COMPLETION:
☐ Open Hole ☐ Straight Wall ☐ Underreamed
☐ Gravel Packed ☐ Other 370 520
If Gravel Packed give interval . . . from ______ ft. to ______ ft.

From (ft.)	To (ft.)	Description and color of formation material
0	12	Shale
12	20	Clay W. sand streaks
20	77	Clay (white)
77	164	Sand(wh/bl darker on bot.
164	168	Lignite
168	194	Shale (dark)
194	223	Sand (dark)
223	260	Shale (light on end)
260	280	Shale (chocolate)
280	304	Shale (light)
304	392	Sand (3 layer rocks)
392	395	Lignite
395	410	Shale (rock at 410)
410	435	Sand (rock at 442)
435	447	Shale (soft)
447	460	Sand
460	467	Lignite
467	475	Sand
475	479	Lignite
479	485	Shale
485	497	Sand
497	500	Shale
500	520	Sand (rock at 520)

(Use reverse side if necessary)

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mgf., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casing Screen
4	new	Plastic	0	390	Sch 40
1½	"	" lap pipe	370	410	200#
"	"	" .016 slotted	410	460	Sch 40
"	"	" Blank	460	465	200#
"	"	" .016 slotted	465	475	Sch 40
"	"	" Blank	475	485	200#
"	"	" .016 slotted	485	517	Sch 40

CEMENTING DATA
Cemented from 0 ft. to 390 ft.
Method used Haliburton
Cemented by Self (Company or Individual)

9) WATER LEVEL:
Static level 120 ft. below land surface Date 18 Dec '79
Artesian flow ______ gpm. Date ______

10) PACKERS: Type Depth

11) TYPE PUMP:
☐ Turbin ☐ Jet ☒ Submersible ☐ Cylinder
☐ Other ______
Depth to pump bowls, cylinder, jet, etc., 250 ft.

12) WELL TESTS:
☐ Type Test: ☐ Pump ☐ Bailer ☒ Jetted ☒ Estimated
Yield: 20 gpm with 192 ft. drawdown after 1 hrs.

13) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable water? ☐ Yes ☒ No
If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ______ Depth of strata ______
Was a chemical analysis made? ☐ Yes ☐ No
2 gpg hard 9PH 0ppm iron trace of sulpfur

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief.

NAME Melvin W. Fuller (Type or Print) Water Well Drillers Registration No. 1845

ADDRESS 802 East Rusk (Street or RFD) Marshall (City) Texas (State) 75670 (Zip)

(Signed) ______ (Water Well Driller) FULLER WATER WELL DRILLING (Company Name)

Please attach electric log, chemical analysis, and other pertinent information, if available.

*Additional instructions on reverse side.

TDWR-0392

...original copy by ...ied mail to the ...s Department of Water Resources ...Box 13087 ...in, Texas 78711

State of Texas
WATER WELL REPORT

Pine Ridge Addition — Sample Site #12 — elev off 350

For TDWR use only ____
Well No. ____
Located on map ____
Received: ____

1) OWNER: Tommy Moseley (Name) off 450 — Address: Route #5, Box 33AA, Harleton 75651 (Street or RFD) (City) (State) (Zip)

2) LOCATION OF WELL: County Harrison, 1 1/2 miles in South (N.E., S.W., etc.) direction from Harleton (Town) on Hwy. #450

Driller must complete the legal description to the right with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ Legal description: Section No. ____ Block No. ____ Township ____ Abstract No. ____ Survey Name ____ Distance and direction from two intersecting section or survey lines ____

☒ See attached map.

3) TYPE OF WORK (Check): ☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check): ☒ Domestic ☐ Industrial ☐ Public Supply ☐ Irrigation ☐ Test Well ☐ Other ____

5) DRILLING METHOD (Check): ☒ Mud Rotary ☐ Air Hammer ☐ Driven ☐ Bored ☐ Air Rotary ☐ Cable Tool ☐ Jetted ☐ Other ____

6) WELL LOG: Date drilled 09-15-78

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
6 3/4	Surface	310
4	310	460

From (ft.)	To (ft.)	Description and color of formation material
0	110	Sand w. clay streaks
110	130	Dark Sand
130	160	Sahle (dark)
160	205	Sand (dark) ~~Shale (dark brown)~~
205	215	Shale (dark brown)
215	217	Lignite
217	265	Shale (darkw. rock)
265	270	Sand (dark)
270	310	Shale
310	334	Sand (Black)
334	348	~~Sand~~ Shale (Dark brown)
348	353	Sand (Dark)
353	360	Shale (Dark)
360	364	Lignite
364	372	Shale (light gray)
372	415	Sand (light gray)
415	418	Shale (gray)
418	460	Sand (light gray)

(Use reverse side if necessary)

7) BOREHOLE COMPLETION: ☐ Open Hole ☐ Straight Wall ☐ Underreamed ☒ Gravel Packed ☐ Other ____
If Gravel Packed give interval ... from 270 ft. to 460 ft.

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mgf., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casing Screen
4	New	Plastic	0	170	160#
4	New	Plastic	170	310	Sch 40
1 1/4	New	Plastic	270	380	200#
1 1/4	New	Plastic .035 slot.	380	460	Sch 40

CEMENTING DATA
Cemented from 310 ft. to Surface ft.
Method used Haliburton Seal
Cemented by Self (Company or Individual)

9) WATER LEVEL: Static level 153 ft. below land surface Date 09-13-78
Artesian flow ____ gpm. Date ____

10) PACKERS: Type ____ Depth ____

11) TYPE PUMP: ☐ Turbin ☐ Jet ☒ Submersible ☐ Cylinder ☐ Other ____
Depth to pump bowls, cylinder, jet, etc., 240 ft.

12) WELL TESTS: ☐ Type Test: ☐ Pump ☐ Bailer ☒ Jetted ☒ Estimated
Yield: 20 gpm with 77 ft. drawdown after 1 hrs.

13) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable water? ☐ Yes ☒ No
If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ____ Depth of strata ____
Was a chemical analysis made? ☒ Yes ☐ No
Iron 0ppm Hardness 2gpg PH 9.5

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief.

NAME Melvin Wayne Fuller (Type or Print) — Water Well Drillers Registration No. 1845

ADDRESS 802 East Rusk (Street or RFD) Marshall (City) Texas (State) 75670 (Zip)

(Signed) ____ (Water Well Driller) — FULLER WATER WELLS (Company Name)

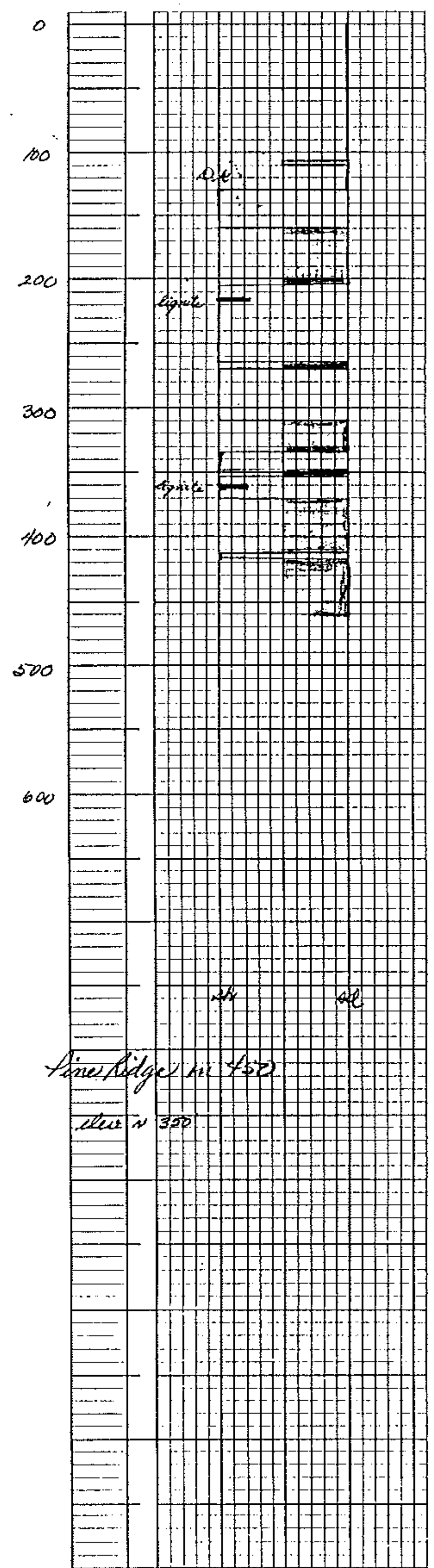
Please attach electric log, chemical analysis, and other pertinent information, if available.

*Additional instructions on reverse side.

TDWR-0392

Pump 3/4 HP Red Jacket

sample site #12



Sample Site #14 (179)

NO. 1202

LAYNE TEXAS COMPANY
HOUSTON -:- DALLAS

MATERIAL SETTING

REPORT NO. 7634
S. O. 2701-66
PAGE 1 OF 1
FILE NO. 3116
DATE 10/4/67

CUSTOMER LOCATION

Gum Springs Water Supply Corporation

LOCATION WELL Gum Springs

SURVEY FIELD

COUNTY Harrison STATE Texas

OTHER LAND MARKS 3 Mi. E. of intersection of F.M. Road No. 450

WELL DATA At site of T.H.6

NAME WELL WELL NO. 1

ELEVATION DATUM

TYPE WELL Gravel-wall

SURFACE CASING CEMENTED 385' NO. SACKS 121+8%Gel

SIZE, HOLE UNDERREAMED 20" DEPTH 465'

GRAVEL TYPE 112,113, NO. CU. YDS. 18

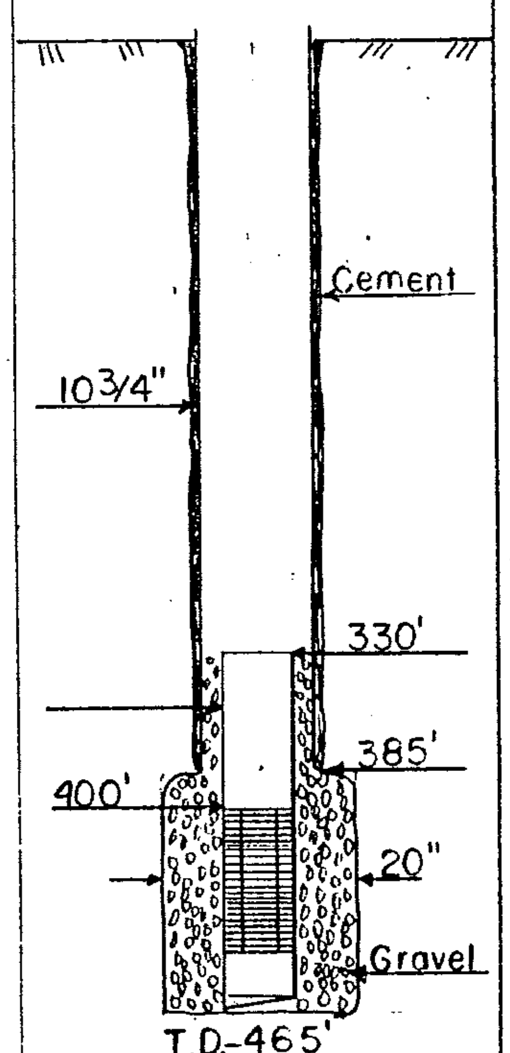
TYPE SCREEN 165 S.S. W.W. GAGE .030"

DRILLER C. Butler RIG NO. 15

OTHER J.O. Rowe

DEPTH	LENGTH	SIZE, KIND, WEIGHT MATERIAL
+2'		10-3/4" O.D. surface casing 2' above ground
0		Surface
330'		Top of 6-5/8" O.D. liner
385'	387'	10-3/4" O.D. surface casing
400'	70'	6-5/8" O.D. blank liner
450'	50'	6-5/8" O.D. S.S. W.W. screen .030" ga.
463'	13'	6-5/8" O.D. blank pipe
465'	2'	6-5/8" O.D. set nipple & back pressure valve
Total	depth 465	ft.

SKETCH



Sample Site #15 (15)

LANFORD DRILLING COMPANY, INC.

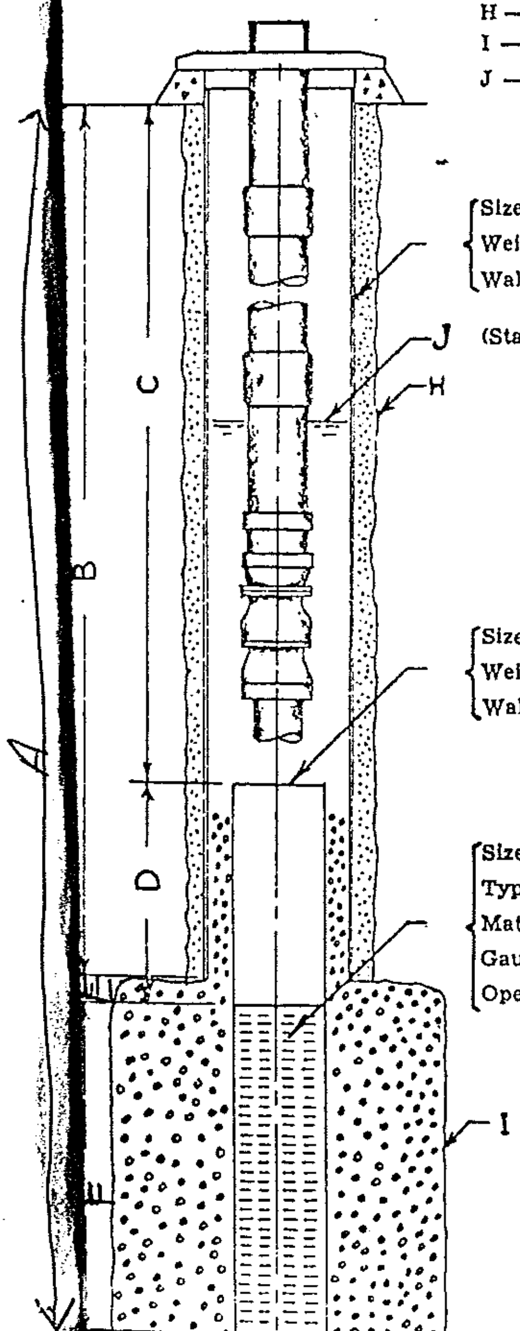
O. Box 98 — Shreveport, Louisiana 71161 — Tel. 869-2519

WELL LOG and MATERIAL REPORT

STOMER Gum Springs Water Supply Corporation — WELL NO. 2

CATION Hwy. #449 - 2 miles East of Carterville — COMPLETED Nov. 1982

DRESS P. O. Box 173, Marshall, TX 75670 — CONTRACT NO.



DIMENSIONS:

A — 527 ft.
B — 437 ft.
C — 373 ft.
D — 64 ft.
E — 0
F — 80 ft.
G — 10 ft.
H — 15" Diam.
I — 20" Diam.
J — 153 ft.

Size 10-3/4" O.D.
Weight 40.48#
Wall .365

(Static Level)

Size 6-5/8" O.D
Weight 18.97#
Wall .280

Size 6-5/8" O.D
Type Bar Lug
Material S.S.
Gauge .020
Opening .020

PUMP DATA:

Bowl Assembly 8 Stage, Size 6" Type Sub.

Discharge Column — Setting 252 Feet

Size — 3" Pipe - Tubing - Shaft

Head-Type -- Size Discharge 3"

Suction, Length 6" Size 6"

Design Conditions: — 200 USGPM 305 TDH

MOTOR DATA:

HP ~~20~~ 30 Make Franklin Speed 3450

Voltage 460 ~~Frame~~ 3 Phase Type Sub.

~~Serial No.~~

REMARKS: Set Grundfos (SP-45-8) Pump End.

FORMATION LOG:

0 -	3	Sand
3 -	11	Clay
11 -	60	Sand
60 -	90	Clay
90 -	120	Sand
120 -	220	Shale
220 -	280	Sand
280 -	290	Shale
290 -	330	Sand
330 -	437	Shale
437 -	518	Sand
518 -	705	Shale
705 -	TD	

New Motor/Pump

Sample Site #14 & #15 combined

WATER ANALYSIS REPORT
TEXAS DEPARTMENT OF HEALTH
DIVISION OF WATER HYGIENE
1100 WEST 49 TH STREET
AUSTIN, TEXAS 78756

GUM SPRINGS WATER SUPPLY CORP
C/O JIMMY STEELE - PRESIDENT
P O BOX 750
HALLSVILLE TX 75650

WATER SUPPLY #: 1020026
LABORATORY NO: EP101818
SAMPLE TYPE: DISTRIBUTION

COLLECTOR REMARKS:
SOURCE:
DATE COLLECTED 11/ 1/90 DATE RECEIVED 11/12/90 DATE REPORTED 1/10/91

CONSTITUENT NAME		RESULT	UNITS	+/-
CALCIUM		2	MG/L	
CHLORIDE		83	MG/L	
FLUORIDE		0.7	MG/L	
MAGNESIUM	<	1	MG/L	
NITRATE (AS N)		0.40	MG/L	
SODIUM		216	MG/L	
SULFATE		23	MG/L	
TOTAL HARDNESS/CACO3		5	MG/L	
PH		8.3		
DIL.CONDUCT(UMHOS/CM)		980		
TOT. ALKA. AS CACO3		335	MG/L	
BICARBONATE		409	MG/L	
CARBONATE		0	MG/L	
DISSOLVED SOLIDS		531	MG/L	
P. ALKALINITY /CACO3		0	MG/L	
ARSENIC	<	0.010	MG/L	
BARIUM		0.020	MG/L	
CADMIUM	<	0.005	MG/L	
CHROMIUM	<	0.02	MG/L	
COPPER	<	0.02	MG/L	
IRON		0.03	MG/L	
LEAD	<	0.0200	MG/L	
MANGANESE	<	0.02	MG/L	
MERCURY	<	0.0002	MG/L	
SELENIUM	<	0.002	MG/L	
SILVER	<	0.010	MG/L	
ZINC	<	0.02	MG/L	

Vera Williams Sample Site #16

…original copy by
…ertified mail to the
Texas Department of Water Resources
P. O. Box 13087
Austin, Texas 78711

State of Texas
WATER WELL REPORT

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

Texas Water Well Drillers Board
P. O. Box 13087
Austin, Texas 78711

1) OWNER Ben Newman / Vera Williams Farm (Name) Address Rt. 1, Box 52 (Street or RFD) Harleton (City) Texas (State) 75651 (Zip)

2) LOCATION OF WELL: County Harrison, 1 1/2 miles in south (N.E., S.W., etc.) direction from Harleton (Town)

Driller must complete the legal description to the right with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ Legal description:
Section No. ____ Block No. ____ Township ____
Abstract No. A-717 Survey Name T. M. Thomas
Distance and direction from two intersecting section or survey lines ____

☐ See attached map.

3) TYPE OF WORK (Check): ☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check): ☐ Domestic ☐ Industrial ☐ Public Supply ☐ Irrigation ☐ Test Well ☐ Other supply

5) DRILLING METHOD (Check): ☒ Mud Rotary ☐ Air Hammer ☐ Driven ☐ Bored ☐ Air Rotary ☐ Cable Tool ☐ Jetted ☐ Other ____

6) WELL LOG:

Date drilled 9-9-85 / 9-12-95

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
	Surface	
7 7/8	0	450

7) BOREHOLE COMPLETION:
☐ Open Hole ☐ Straight Wall ☐ Underreamed
☒ Gravel Packed ☐ Other ____
If Gravel Packed give interval . . . from 0 ft. to 450 ft.

From (ft.)	To (ft.)	Description and color of formation material
0	15	red yellow & white sandy cl.
15	20	light brown sh.
20	50	gray
50	105	green & brown sh. & sa.
105	120	brown & gray sh.w/lignite st.
120	157	brown sa.
157	165	brown sh.
165	185	gray sh. & brown w/ st. of green sandy sh.
185	260	brown & green sh. w/sandy sh. & sa. st.
260	280	green sa.
280	295	brown sh.
295	305	fine gray sa.
3051	335	gray & brown sh.
335	350	fine gray sa.& sandy sh.
350	355	gray sh. w/sandy st.
355	450	gray sand

(Use reverse side if necessary)

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mgf., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casing Screen

CEMENTING DATA

Cemented from ____ ft. to ____ ft.
Method used ____
Cemented by ____ (Company or Individual)

9) WATER LEVEL:
Static level 40 ft. below land surface Date 9-12-85
Artesian flow ____ gpm. Date ____

10) PACKERS: Type Depth

11) TYPE PUMP:
☐ Turbine ☒ Jet ☐ Submersible ☐ Cylinder
☐ Other ____
Depth to pump bowls, cylinder, jet, etc., ____ ft.

12) WELL TESTS:
☐ Type Test: ☐ Pump ☐ Bailer ☒ Jetted ☐ Estimated
Yield: 60 gpm with 190 ft. drawdown after 1 hrs.

13) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable water? ☐ Yes ☒ No
If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ____ Depth of strata ____
Was a chemical analysis made? ☐ Yes ☒ No

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief.

COMPANY NAME DeBerry Drilling Co. (Type or Print) Water Well Driller's License No. 321

ADDRESS P.O. Box 10 (Street or RFD) Ore City, (City) Texas (State) 75683 (Zip)

(Signed) Gaston W. DeBerry (Licensed Water Well Driller) (Signed) ____ (Registered Driller Trainee)

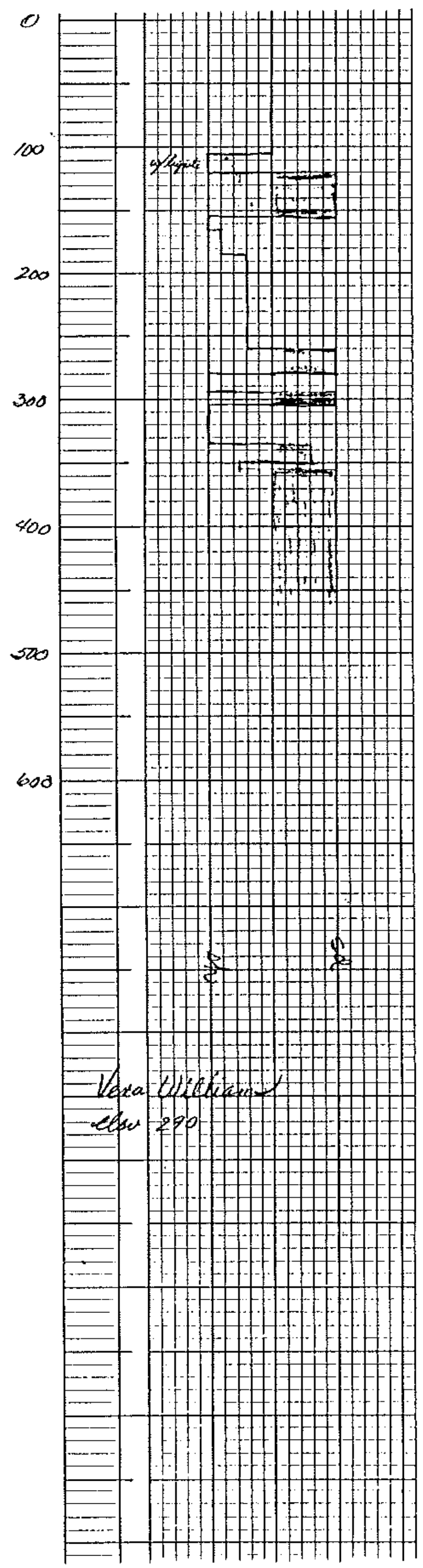
For TDWR use only
Well No. ____
Located on map ____

Please attach electric log, chemical analysis, and other pertinent information, if available.

TDWR 0392 (Rev. 5-27-82)

DEPARTMENT OF WATER RESOURCES COPY

Sample Site #16



Sample Site #17
154 to Little Cypress

Send original copy by certified mail to the Texas Department of Water Resources
P. O. Box 13087
Austin, Texas 78711

State of Texas
WATER WELL REPORT

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

Texas Water Well Drillers Board
P. O. Box 13087
Austin, Texas 78711

1) OWNER Newman Corporation (Name) Address P. O.Box 376 (Street or RFD) Harleton (City) Texas (State) 75651 (Zip)

2) LOCATION OF WELL:
County Harrison 5 miles in east (N.E., S.W., etc.) direction from Harleton (Town)

Driller must complete the legal description to the right with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ Legal description:
Section No. ______ Block No. ______ Township ______
Abstract No. A395 Survey Name William Love
Distance and direction from two intersecting section or survey lines ______

☒ See attached map.

3) TYPE OF WORK (Check):
☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) PROPOSED USE (Check):
☐ Domestic ☐ Industrial ☐ Public Supply ☒ Irrigation ☐ Test Well ☐ Other

5) DRILLING METHOD (Check):
☒ Mud Rotary ☐ Air Hammer ☐ Driven ☐ Bored ☐ Air Rotary ☐ Cable Tool ☐ Jetted ☐ Other

6) WELL LOG:

Date drilled 10-10-83 / 10-21-83

DIAMETER OF HOLE Dia. (in.)	From (ft.)	To (ft.)
	Surface	
7 7/8	0	441

7) BOREHOLE COMPLETION:
☐ Open Hole ☒ Straight Wall ☐ Underreamed
☒ Gravel Packed ☐ Other
If Gravel Packed give interval . . . from 0 ft. to 441 ft.

From (ft.)	To (ft.)	Description and color of formation material
0	8	surface sand
8	17	brown, red, & white shale
17	25	white & yellow sand
25	70	brown & gray shale
70	90	dark brown shale, ss. & sandy sh.
90	110	brown sh. w/sandy sh.
110	260	gray & brown sh. w/lignite st. rock st. 155'
260	265	lignite
265	300	gray & brown sh.
300	340	fine gray ss. w/some sh.
340	361	gray sh., little sandy
361	441	fine gray sand

(Use reverse side if necessary)

8) CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mgf., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casing Screen
4	n	steel pipe casing	+6	441	
4	n	sloted pipe	328	420	

CEMENTING DATA
Cemented from ______ ft. to ______ ft.
Method used ______
Cemented by ______ (Company or Individual)

9) WATER LEVEL:
Static level ______ ft. below land surface Date ______
Artesian flow 4 gpm. Date 10-21-83

10) PACKERS: Type Depth

11) TYPE PUMP:
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ______
Depth to pump bowls, cylinder, jet, etc., ______ ft.

12) WELL TESTS:
☐ Type Test: ☐ Pump ☐ Bailer ☒ Jetted ☐ Estimated
Yield: 100 gpm with 435 ft. drawdown after 1 hrs.

13) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable water? ☐ Yes ☐ No
If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ______ Depth of strata ______
Was a chemical analysis made? ☐ Yes ☐ No

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief.

COMPANY NAME DeBerry Drilling Company (Type or Print) Water Well Driller's License No. 321

ADDRESS P. O.Box 1524 (Street or RFD) Ore City (City) Texas (State) (Zip)

(Signed) Gaston W. DeBerry (Licensed Water Well Driller) (Signed) ______ (Registered Driller Trainee)

Please attach electric log, chemical analysis, and other pertinent information, if available.

For TDWR use only
Well No. ______
Located on map ______

TWR 0392 (Rev. 5-27-82)

WELL OWNER'S COPY

ONE 214-968-2222

DEBERRY DRILLING COMPANY
WATER WELL CONTRACTORS
P. O. BOX 1524
ORE CITY, TEXAS 75683

Ben Newman ~~Corp.~~
Bear Bottom Ranch

Log on test hole
10-10-83
10-21-83

0 - 8	Surface sand
8 - 17	brown, red & white shale
17 - 25	white & yellow sand
25 - 70	brown & gray shale (rock 35')
70 - 90	dark brown shale & greenish sand & sandy shale
90 - 110	brown shale w/sandy shale
110 - 260	gray & brown shale w/lignite st. (rock st. 155')
260 - 265	lignite
265 - 300	gray & brown shale (little sandy st.)
300 - 340	fine gray sand w/sone shale
340 - 361	gray shale (little sandy) (rock 361')
361- 441	fine gray sandy (drill shaley) (rock 406')
441 - 467	gray shale w/few sandy shale st. (rock 460')
467 - 480	gray & brown shaley sandy (very fine)
480 - 500	gray sand & shale (½ & ½)
500 - 525	gray sahle w/fine sand & lignite st.
525 - 642	gray sand
642 - 698	gray shale w/few sandy shale st. (rock 681'- 696'-698')

APPENDIX B

ı pH to cause

ted and developed to
et surface casing down
B zone to minimize
connections from the
length of the surface
H water along the
lso to retard corro-
water; (3) set screens
pumping levels to

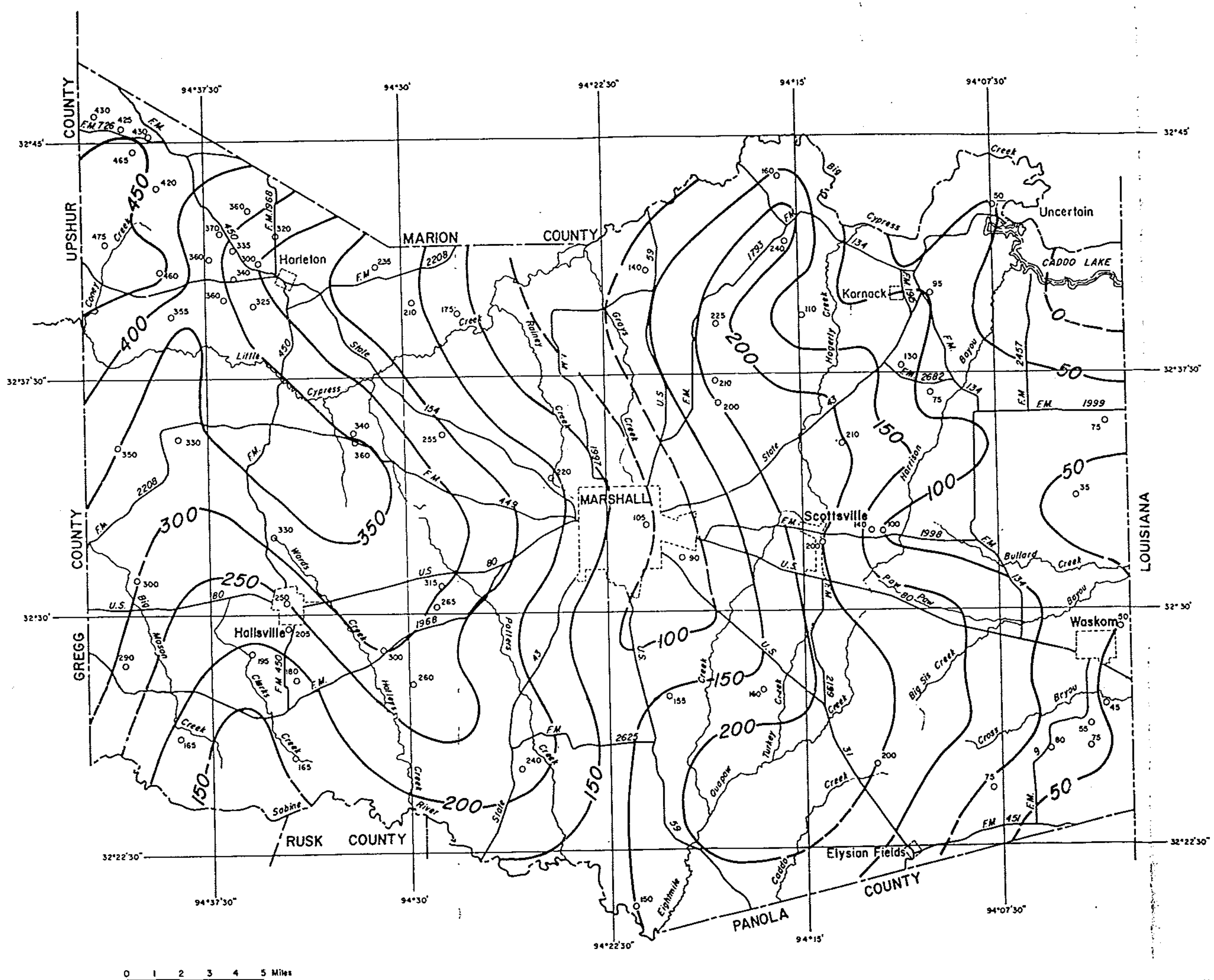
els are allowed to
xidation of the re-
oxidation of the
ase of iron to solu-
d iron will be pre-
water conduits of
near or drop to the
in dissolved iron
water conduits can
ted iron oxide.
levels above the
oval of the accumu-
lire further correc-

VELOPMENT

t from the Cypress
logic, chemical-
importance are the
rate of recharge to
re the low pH water
ater in zone B, and
us depths. Chloride
the cost of the
ties of water.

cient of transmis-
rated sand thickness
hat approximately
rrison County; how-
able for development.
of the aquifer can
fic yield of 15
uld be about

per mile), the
cre-feet, or 13.4 mgd.
echarge, which might
aquifer, and an



Base compiled from topographic maps of the U.S. Geological Survey and county maps of the Texas State Highway Department

Figure 10
Approximate Thickness of Sand Containing Fresh to Slightly Saline Water in the Cypress Aquifer
U.S. Geological Survey in cooperation with the Texas Water Development Board and the Harrison County Commissioners Court

EXPLANATION

○75
Well used for control
Number indicates thickness of sands in the Cypress aquifer that contain fresh to slightly saline water, in feet

——100—— — —
Isopach
Line showing approximate thickness of sand containing fresh to slightly saline water. Dashed where data are less accurate. Contour interval 50 feet

u ary to Cypress
n Gregg County
, and on the basis
t e Sabine River),
echarge is about
y). This figure
s been consumed
echarge can be
approximate
s, the quantity
per mile) is

s aquifer from areas
a few hundred feet
al infiltration and
. After reaching
ly has a large hori-
head). The move-
The flow is greatest
sand, and least in
as cemented sand

raulic gradient of the
y a contour map
flect the altitude
the aquifer, but rather
the water level at
shown on the map.
generally is toward the
moves outwardly from
me water moves east-
thence the water
ne River.

aturally and artifi-
d seeps, evaporation
s whose roots reach
jected recharge) was
r year, or 35.7 mgd.
n, but the quantity
nd the great density
is from flowing or
1964.

ell, a hydraulic gradi-
ished toward the well.
e water table or
e discharging level
ore start of flow) is

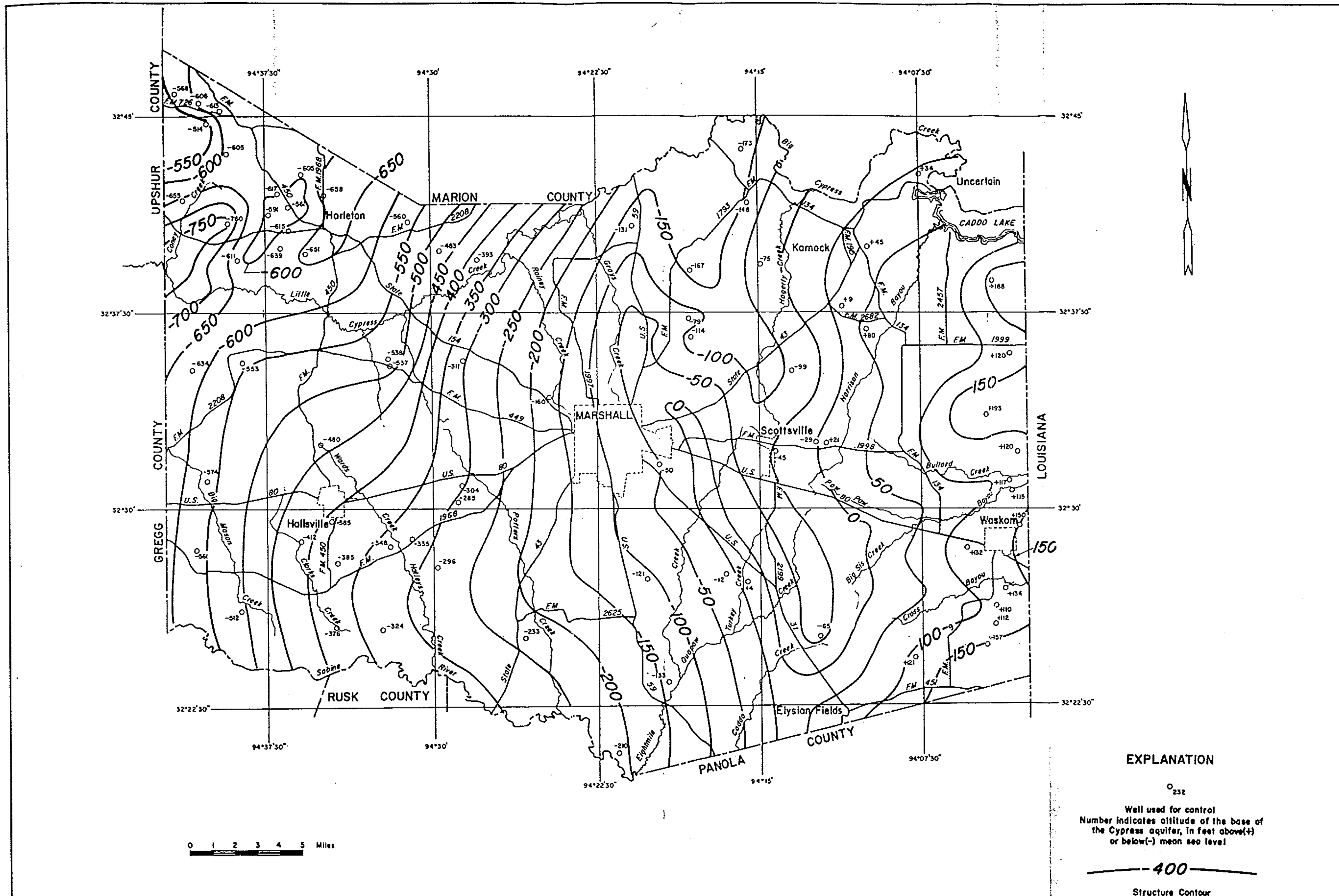


Figure 3

Approximate Altitude of the Base of the Cypress Aquifer

U.S. Geological Survey in cooperation with the Texas Water Development Board and the Harrison County Commissioners Court

12.0 APPENDIX F - SURVEY OF NON-RESIDENTIAL USER INTEREST IN BRACKISH GROUNDWATER

North East Texas Regional Water Planning Group
Brackish Groundwater Study
Telephone Survey of Non-Residential Users Interest in Using Brackish Groundwater
April 9, 2009
Jeff Hogan, P.E.

Entity **Air Liquide 903-553-1821 water utilities**

System **City of Longview**

County **Gregg**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

3. Do you currently use groundwater to satisfy any aspect of your operations?

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

   37.2 Treated water for boiler feed H_2O, 2,000 # boiler, feed water, cooling tower water, solid levels real close. Not interested due to boiler feed quality specs and cooling tower water….”We have to watch our solids closely.”

North East Texas Regional Water Planning Group
Brackish Groundwater Study
Telephone Survey of Non-Residential Users Interest in Using Brackish Groundwater
April 8, 2009
Jeff Hogan, P.E.

Entity **Eastman – Kevin McGuire (903-237-6742)** **called; left message on 4/8/09**
called; left message on 4/9/09

System **City of Longview W.U.**

County **Gregg**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

3. Do you currently use groundwater to satisfy any aspect of your operations?

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

North East Texas Regional Water Planning Group
Brackish Groundwater Study
Telephone Survey of Non-Residential Users Interest in Using Brackish Groundwater
May 8, 2009
Jeff Hogan, P.E.

Entity **Eastman – Steve long 903-237-5311**

System **City of Longview (Lake Cherokee, Sabine River, Lake Fork)**

County **Harrison**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

   no

3. Do you currently use groundwater to satisfy any aspect of your operations?

   yes

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

   no

5. What factors would effect your decision - cost, location, water quality, other?

   all

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

   Sanitary sewer

8. Other

   Generally, not interested in using treated or non-treated brackish groundwater

   Processes and equipment are too sensitive to TDS. Treated BGW is not as cost

   Effective.

North East Texas Regional Water Planning Group
Brackish Groundwater Study
Telephone Survey of Non-Residential Users Interest in Using Brackish Groundwater
April ____ 2009
Jeff Hogan, P.E.

Entity **Keller's Creamery (903-342-3713) Rick Grigsby, Quality Control**

System **City of Winnsboro**

County **Wood**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

3. Do you currently use groundwater to satisfy any aspect of your operations?

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

   Called, left message on ~ 4/9/09

North East Texas Regional Water Planning Group
Brackish Groundwater Study
Telephone Survey of Non-Residential Users Interest in Using Brackish Groundwater
April 9, 2009
Jeff Hogan, P.E.

Entity **L3 Communications (903-455-3450) Left message on Facilities Voice Mail**

System **City of Greenville**

County **Hunt**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

3. Do you currently use groundwater to satisfy any aspect of your operations?

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

North East Texas Regional Water Planning Group
Brackish Groundwater Study
Telephone Survey of Non-Residential Users Interest in Using Brackish Groundwater
April 9, 2009
Jeff Hogan, P.E.

Entity **MorningStar Specialty Foods (903-885-0881) Randall W left message**

System **City of Sulphur Springs**

County **Hopkins**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

3. Do you currently use groundwater to satisfy any aspect of your operations?

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

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April 9, 2009
Jeff Hogan, P.E.

Entity **Ocean Spray - 903-885-8676 - Craig Miller left message**

System **City of Sulphur Springs**

County **Hopkins**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

   No.

3. Do you currently use groundwater to satisfy any aspect of your operations?

   No.

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

   96.7 MG/YR Water goes into product. Not a possibility….too picky about their water quality.

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April 30, 2009
Jeff Hogan, P.E.

Entity **Pilgrim's Pride - Vernon Rowe (903-856-5133 office; 903-767-0945 cell)**
Called on 4/30/09 and 5/7/09; left messages
System **City of Pittsburg; City of Mt. Pleasant; Bi-County Water – chicken farms**

County **Camp + five**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

   no

3. Do you currently use groundwater to satisfy any aspect of your operations?

   yes

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

   No interest

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

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April 8, 2009
Jeff Hogan, P.E.

Entity **Rexam (903-297-5400) Philip Burgess, Finance Mgr. called 4/8/09**
made contact 4/9/09

System **City of Longview Water Utility**

County **Gregg**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

   No.

3. Do you currently use groundwater to satisfy any aspect of your operations?

   No.

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

   No.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

   Cooling; washing; R.O.I. too low to bother with it; ww going out. Mr. Burgess, Finance Mgr., state entertaining different water would not make a significant difference in their bottom line; therefore, he did not think Rexam would be interested.

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Jeff Hogan, P.E.

Entity **Rubbermaid (903-455-0011) Bill-TRAFFIC; Joe Castillo-overall mgr.**

System **City of Greenville (dialed 7 then, Facilities Support, left message)**

County **Hunt**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

   No.

3. Do you currently use groundwater to satisfy any aspect of your operations?

   No.

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

   No.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

   Patrick McGrath (903-455-0210) – Water quality is significant factor due to our Injection mold process.

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May 7, 2009
Jeff Hogan, P.E.

Entity **Max Shumake (maxshumake@aol.com**

System **Individual family**

County **well is in Bowie Co. at county line with Bowie**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

3. Do you currently use groundwater to satisfy any aspect of your operations?

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter hat are dissolved in water.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

   Family well, 1955, drilling rig seismic 800' cased-up, drink, watered stock, used it for everything. High sodium, collect on side 3 of jars and bucket 73° (hot). Artesian wells most are similar; diary years and years. Test water?

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March 25, 2009
Jeff Hogan, P.E.

Entity **Steam Electric (AEP-SWEPCO)**

System **N/A**

County **Harrison**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

   No

3. Do you currently use groundwater to satisfy any aspect of your operations?

   No, not really.

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

   No.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

   Greg Carter, P.E. (903-746-4585) Corrode and scale…would not go up the towers very well. Not applicable to Steam-Electric.

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April 7, 2009
Jeff Hogan, P.E.

Entity **The Pines (903-845-5834)** **Message left for Bill Tuttle, Prop. Mgr.**

System **Pritchett WSC**

County **Upshur**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

3. Do you currently use groundwater to satisfy any aspect of your operations?

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

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April 23, 2009
Jeff Hogan, P.E.

Entity **Titus Co. Fresh Water Supply**

System **N/A**

County **Titus**

1. How much water do you use annually in your operation?

2. Do you currently use non-treated water to satisfy any aspect operations?

   No.

3. Do you currently use groundwater to satisfy any aspect of your operations?

   No.

4. Would you be willing to use groundwater that has higher total dissolved solids (TDS)? TDS are comprised of inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates, and some small amounts of organic matter that are dissolved in water.

   No.

5. What factors would effect your decision - cost, location, water quality, other?

6. What amount would you likely be able to use?

7. What method of disposal do you have access to, or, be interested in using?

8. Other

   Tommy Spurill (903-572-1844) said there is no need for Titus Co. to look to BGW as it is very hit and miss to find groundwater and they have a very large lake.