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Groundwater Monitoring Program (Winter 2003)

Prepared for

The Clearwater Underground Water Conservation District

Prepared by

Turner Collie & Braden Inc.

Engineers • Planners • Project Managers

Groundwater Monitoring Program
(Winter 2003)

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1.0 Introduction

Turner Collie and Braden, Inc. (TCB) and LBG-Guyton and Associates (Guyton) conducted a survey of the groundwater resources of the Edwards Balcones Fault Zone (BFZ) aquifer and the Trinity aquifer in Bell County, which culminated in the Groundwater Resources Management Information report presented to the Clearwater Underground Water Conservation District (the District) in January 2002. One of the findings of the survey was that the groundwater resources of the Trinity aquifer are being reduced at a greater rate than they are being replenished. An example of the declining water resources of the Trinity aquifer is provided in *Figures 1* and *2*. These two figures are hydrographs for Trinity aquifer wells. *Figure 1* illustrates the declining depth to water for state well number 40-61-901 which is located on Farm-to-Market (FM) 93 south of the City of Temple and screened in the Hosston formation of the Trinity aquifer. *Figure 2* illustrates the declining depth to water for state well number 58-05-403, which is located near the intersection of Royal Street and Armstrong Road southeast of the community of Salado and screened in the Hensell formation of the Trinity aquifer. The rate of the water-level decline within these wells has averaged about 4.1 feet per year in state well number 40-61-901 and about 3.5 feet per year in state well number 58-05-403. Another finding of the survey is the identification of "bad water" areas of the Trinity aquifer within Bell County. These "bad water" areas are locations within the District where the concentration of total dissolved solids (TDS) in the groundwater is greater than 1000 milligrams per liter (mg/L) and unsuitable for long-term human consumption. With few exceptions the TDS concentration of the Trinity aquifer groundwater within Bell County is greater than 1000 mg/L.

The survey of the groundwater resources of the Edwards (BFZ) aquifer found that the resources have not been depleted at a rate greater than they have been replenished. An example of the consistent volume of groundwater within the aquifer may be seen in *Figure 3*. *Figure 3* illustrates the relatively

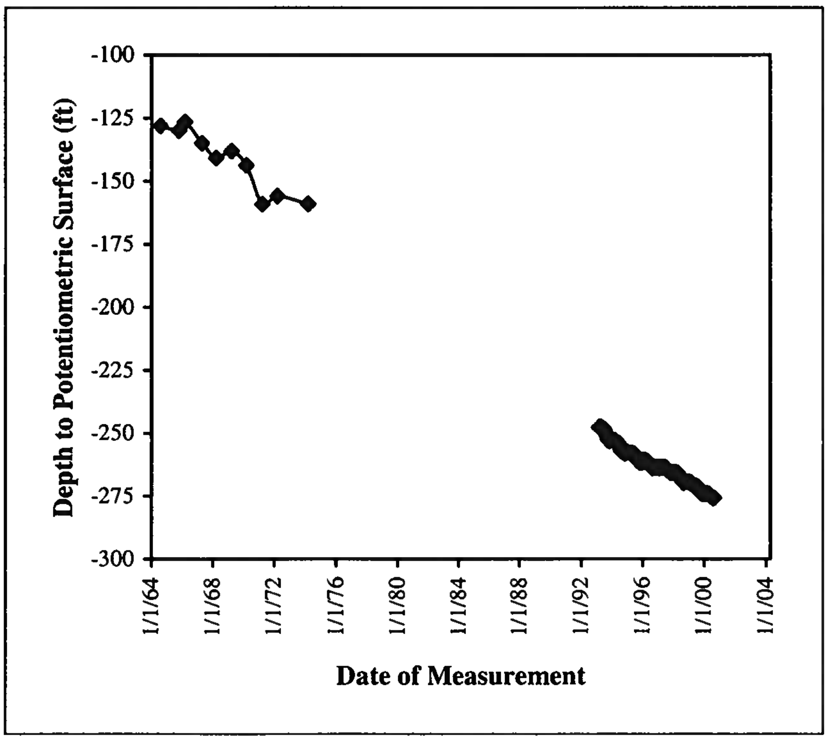


Figure 1. Hydrograph for Well #40-61-901 (Hosston Aquifer).

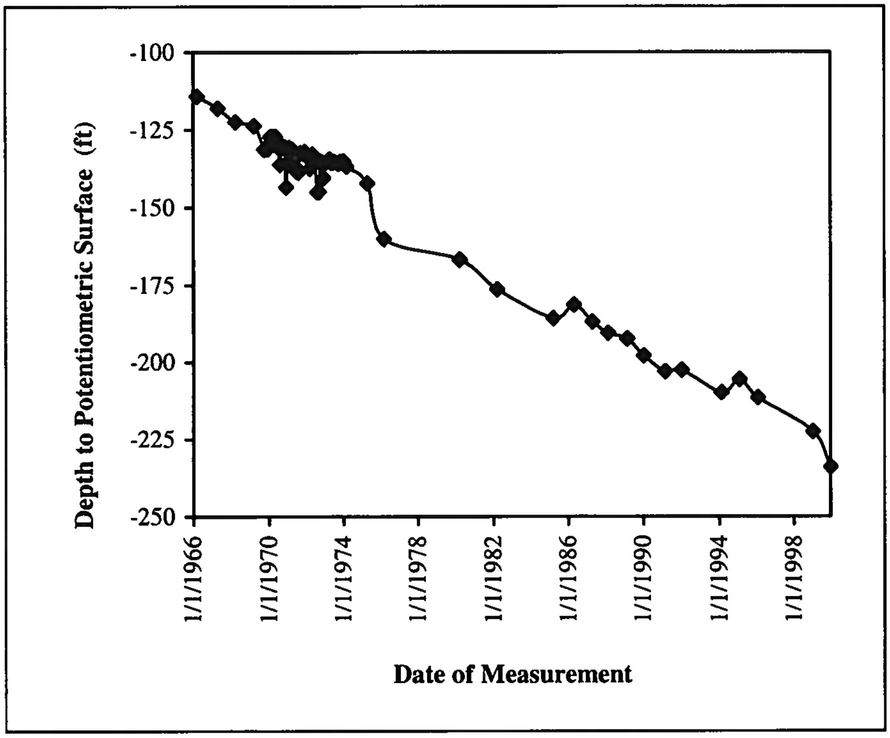


Figure 2. Hydrograph for Well #58-05-403 (Hensell Aquifer).

constant depth to water of state well number 58-04-602, which is located near the intersection of FM 2268 and Interstate Highway (IH) 35 south of the community of Salado. The depth to water for the measurement period has averaged 100 feet with only a few noticeable exceptions. This pattern of relatively constant water levels is characteristic of other Edwards (BFZ) aquifer wells in Bell County. Also, the fluctuations of the water levels about the mean indicate that the wells appear to respond quickly to rainfall and that the aquifer recharges rapidly. Additionally, the survey identified the location of a "bad-water" line that may be drawn along a path located a few miles east of the community of Salado south into Williamson County approximately midway between State Highway (SH) 95 and IH 35.

Finally, the survey report of the groundwater resources of Bell County contained several recommendations to the District to assist them with the attainment of their management goals. The first recommendation to the District was the development of a groundwater monitoring program to track the water-levels and the water quality of both the Edwards (BFZ) and Trinity aquifers. The groundwater monitoring program will provide the District with the ability to measure the volume of available groundwater in both the Edwards (BFZ) and Trinity aquifers and analyze historic and current trends in water quantity and quality. The monitoring program also provides the District with the background necessary to conduct future aquifer studies as their management goals and rules direct. This report briefly summarizes the development of the groundwater monitoring program, the analysis to be conducted as part of the program, the methodology for conducting the program, and the laboratory analytical data collected from the monitoring wells during the first round of sampling.

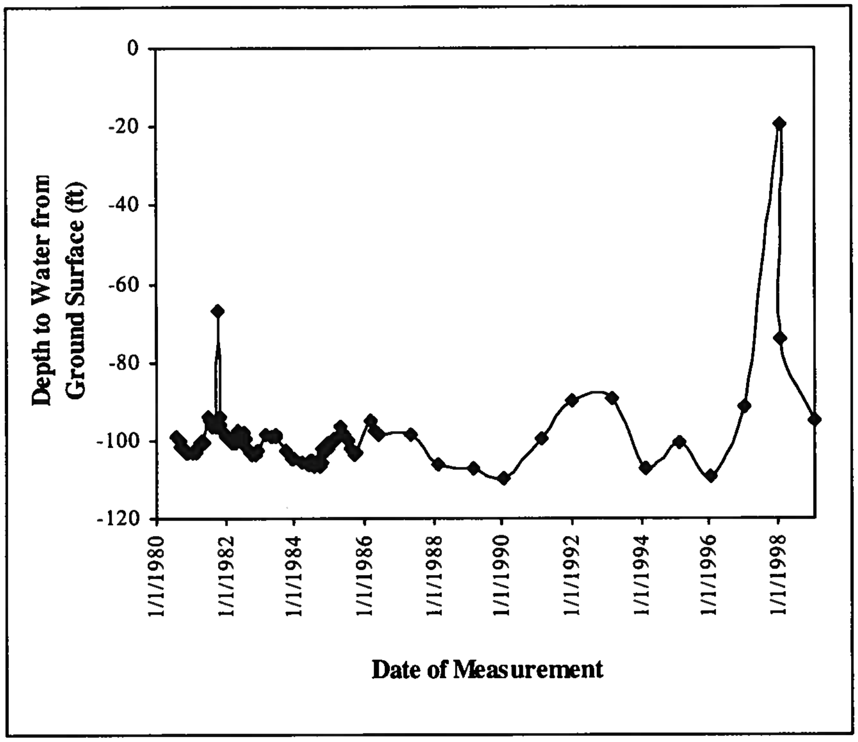


Figure 3. Hydrograph for Well #58-04-620 [Edwards (BFZ) Aquifer].

2.0 Water Level Measurements and Water Quality Components

Water levels were measured for eight wells in the District. The purpose of the water level measurements is to record the water levels of the Edwards (BFZ) and Trinity aquifers across the District and to assist the District with its management goals by providing a basis for the determination of available groundwater volume estimates, the implementation of a drought contingency plan, the development of future research projects, and the determination of adequate groundwater supplies for current and future water users. The location of the monitoring wells from which the groundwater levels were obtained are illustrated in *Figure 4*.

Water quality samples were obtained for four registered wells in the District. The parameters for the laboratory analysis of each of the water quality samples included the following:

1. Dissolved anions
2. Dissolved cations/metals
3. Nutrients
4. Alkalinity
5. Hardness
6. Total Dissolved Solids (TDS)
7. Total Suspended Solids (TSS).

The anions analyzed in each water quality sample included bromide (Br^-), chloride (Cl^-), fluoride (F^-), and sulfate ($SO4^{2-}$). Bromide concentrations were analyzed because of their potential to react with carbonaceous materials to form compounds such as 3-bromopropyne or bromomethane (or other trihalomethanes), which may cause damage to the central nervous system, kidneys, and lungs in humans after chronic exposures. Chloride concentrations were analyzed because of its potential to react with the

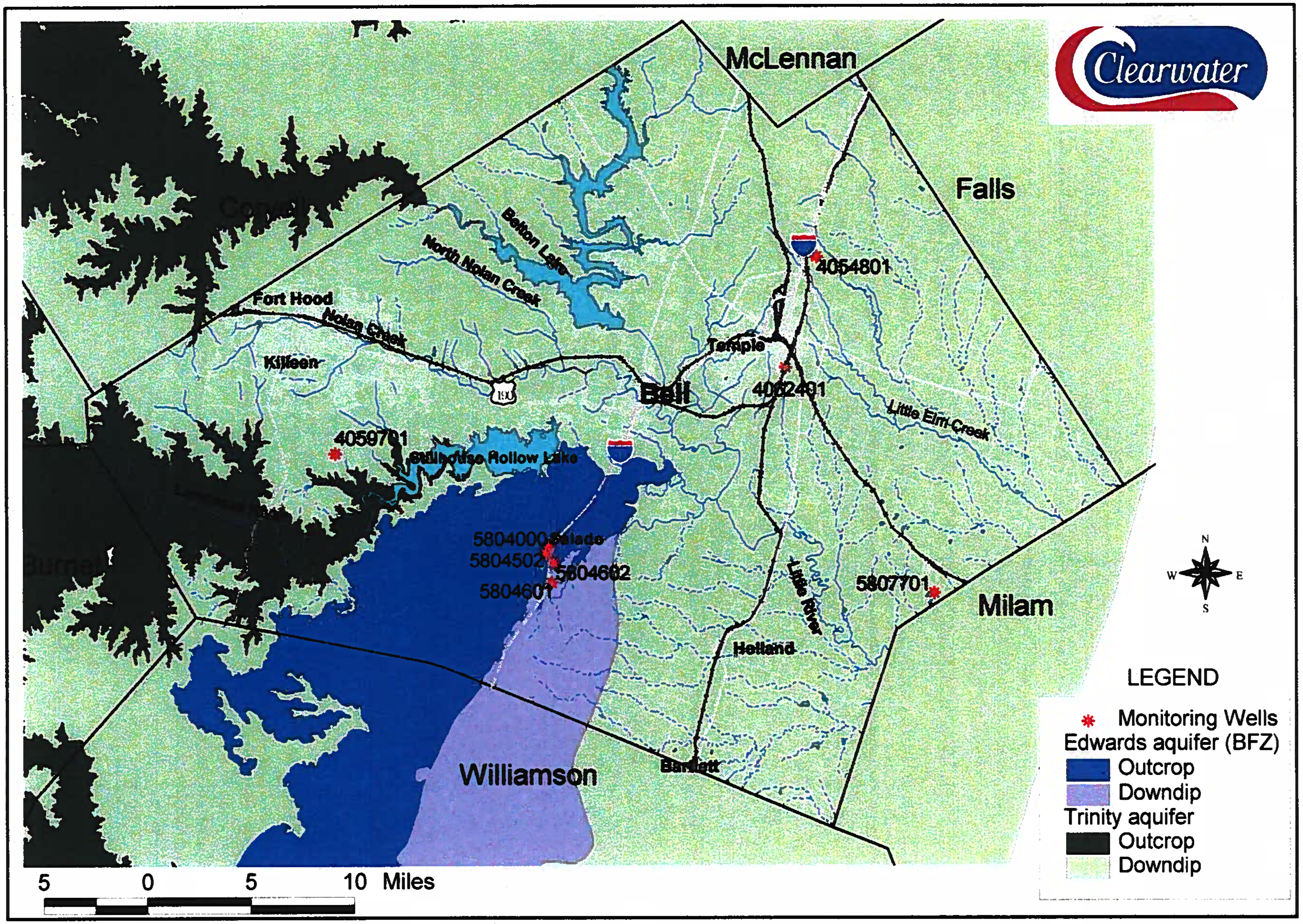


Figure 4. Monitoring Wells in Bell County (Winter 2003)

alkali and alkaline earth metals to form metal salts increasing the corrosiveness of water and giving drinking water a "salty" taste. Fluoride concentrations were analyzed because of their potential to readily form compounds and complex ions. In high concentrations, it is known to cause dental fluorosis in humans; however, low concentrations of about 1.0 mg/L are beneficial to human health. Sulfate concentrations were analyzed due to its ability to react with organic material under anaerobic conditions to form sulfide which may react with water to form hydrogen sulfide or sulfuric acid. These compounds are both toxic to plants, animals and humans, and corrosive to sewers and wastewater treatment facilities. *Table 1* lists most of the anions analyzed in the groundwater samples and discusses their potential sources, their significance as an indicator of water quality, and their acceptable ranges as a drinking water supply.

The cations/metals analyzed in each water quality sample included calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na). The analytes calcium and magnesium were analyzed since they impact the "hardness" of water. Hard waters are those waters that produce scale in hot-water pipes, heaters, and boilers. These hard waters are caused by divalent cations of which calcium and magnesium are the most prevalent in the aquifers in Central Texas. Calcium usually reacts with carbonate (CO_3^{2-}) or bicarbonate (HCO_3^-), while magnesium usually reacts with sulfate to produce scale. In the analysis performed on the groundwater samples, hardness was measured as the concentration of calcium carbonate. Potassium and sodium concentrations were analyzed due to their ability to react with chloride increasing the corrosivity of water and giving drinking water a "salty" taste.

The nutrients analyzed in each water quality sample were total organic nitrogen (total kjeldahl nitrogen), nitrogen-derived ions or compounds (i.e., nitrate (NO_3^-), nitrite (NO_2^-), ammonium (NH_4^+), and ammonia (NH_3)) and phosphate (PO_4^{3-}). Nitrate and nitrite concentrations were analyzed since they are an indicator of potential sources of pollution. They are also an indicator of the nutrient loading of water since nitrogen is required for the growth of biological organisms. Additionally, high concentrations of nitrates in drinking water have been linked to methemoglobinemia in infants, a condition whereby oxygen is not delivered to the tissues resulting in cellular hypoxia and potentially death. Ammonia was analyzed because it is an indicator of organic nitrogen since it may be formed from amino acids in plant and animal material. It is also an indicator of pollution and comparisons of the concentrations of ammonia and organic nitrogen to the concentration of nitrate can indicate the relative time of a polluting event under aerobic conditions. This may be seen by the changes in the concentration of nitrogen-derived compounds resulting from pollution in *Figure 5* (page 7). *Figure 5* illustrates the form of nitrogen-derived compounds resulting in polluted waters. Waters with high concentrations of organic nitrogen and ammonia relative to nitrate indicate that the pollution of the water occurred recently. However, waters with high concentrations of nitrate relative to the concentrations of organic nitrogen and ammonia indicate that the water was polluted a long time previously.

Alkalinity is a measure of the capacity to neutralize acid. Its primary components are carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), and hydroxide (OH^-). If the reported constituents of alkalinity are limited to the salts of calcium and magnesium, then the alkalinity values are equal to the hardness values. However, if the reported alkalinity values are greater than the hardness values, then other salts such as those of sodium and potassium are generally present. When the reported alkalinity values are less than the hardness values, the salts of calcium and magnesium are more likely to be sulfates rather than carbonates or hydroxides. Consequently, the reported alkalinity value may give an estimate of the non-acidic constituents in groundwater.

The specific conductance of each water quality sample was analyzed in the field to establish that the well is stabilized and that the groundwater in the well is representative of the aquifer at the time of sampling. Specific conductance is a measure of the ability of the water sample to carry an electrical current by dissolved cations and anions and reported in units of microohms per centimeter (μmhos/cm) or microsiemens per centimeter (μS/cm). Specific conductance readings that are strikingly dissimilar from one well to another may indicate that the groundwater in each well comes from a different source, that there is contamination from surface infiltration, or that there is leakage from a formation that contains water of disparate quality. At low to medium TDS concentrations, specific conductance and TDS are linearly related, and the specific conductance measurements taken in the field are indicative of the TDS

Table 1. Major water quality parameters and their significance to drinking water. (Source: Hill Country GCD).

GENERAL EXPLANATION OF WATER ANALYSIS REPORT

PARAMETER	SOURCE OF CAUSE	SIGNIFICANCE	LIMITS	TREATMENT
pH	pH is lowered by acids; acid-generating salts and free carbon dioxide; pH is raised by carbonates, bicarbonates, hydroxides, phosphates, silicates and borates.	pH is a measure of the acid qualities of water; a pH of 7.0 means a neutral solution; water with a pH below 7.0 is normally harmful in that it may dissolve iron from pumping facilities and mains and produce a "red water" problem.	(acceptable range = 6.5 to 8.5) 7.0+ = basic 7.0 - = acidic	Chemical Addition
Conductivity	Is an indicator of the dissolved mineral content of water; mostly calcium carbonate along with other dissolved salts.	Is a measure of the electrical Conductivity of water and varies with the amount of dissolved solids.	0 -0.5 mS/cm Good 0.5 - 1.5 mS/cm Normal >1.5 mS/cm High	
Total Hardness (CaC03 - calcium carbonate such as lime and chalk)	Caused by the presence of calcium and magnesium.	Hard water consumes soap before a lather will form and creates scale in boilers, water heaters, and pipes.	0 - 60 mg/L soft 61-120 mg/L moderate 121-180 mg/L hard >181 mg/L very hard	Water Softener
Calcium and Magnesium	Dissolved from soil and rock, especially from limestone, dolomite and gypsum. Calcium and Magnesium are found in large quantities in sea water.	Cause most of the hardness and scale-forming properties of water which for example, consume soap; water low in calcium and magnesium is desirable in the electroplating, tanning, dyeing and textile manufacturing industries as well as for boiler use.	No Standards Established	
Alkalinity	Indicates the presence of bicarbonates, carbonates and hydroxides (See pH.)	Information on alkalinity is useful in water treatment, softening and control of corrosion.	No Standards Established	
Carbonate (C03) and Bicarbonate (HC03)	Formed from carbonated rock, such as limestone and dolomite.	Produces alkalinity and forms scale in hot water facilities as a result of hardness in combination with calcium and magnesium; bicarbonates of sodium produces "burp water".	No Standards Established	
Sulfate	Dissolved from rock and soil containing gypsum, iron sulfides and other sulfur compounds; commonly present in industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers; in large amounts sulfate can give a bitter taste to water and /or have a laxative effect.	300 mg/L *MC Limit	Reverse Osmosis
Chloride	Dissolved from rock and soil; found in large amounts in oil field brine, sea water and industrial brine.	When combined with sodium, gives salty taste to drinking water and may increase the corrosiveness of water.	300 mg/L *MC Limit	Reverse Osmosis
Nitrate	Produced by decaying organic matter, sewage, fertilizers and nitrates in the soil.	High concentrations may suggest pollution; water of high nitrate content may cause methemoglobinemia (blue babies) and should not be used in infant feeding; some animals such as ruminants (cudchewers) can be poisoned by nitrate if the concentration is high; NO3 encourages growth of algae and other organisms which may produce undesirable tastes and odor.	10 mg/L as N *MC Limit 45 mg/L as NO3	Reverse Osmosis
Fluoride	Dissolved in small quantities from rock and soil. Fluoride may in some cases actually be added to drinking water supplies.	May cause molting of the teeth in children depending on the quantity and temperature average per year. In proper amounts may reduce cavities	0.-0.6 mg/L Good 0.6-2.0 mg/L Optimum 2.0-4.0 mg/L Mottling of teeth >4.0 mg/L Possible health risk	Reverse Osmosis
Iron	Dissolved from rock and soil; may also come from iron pipes, pumps and other equipment if low pH water is present.	On exposure to air, iron in ground water oxidizes to reddish-brown (red water) which may stain laundry and utensils; large quantities can cause unpleasant taste and encourage the growth of iron bacteria.	0.3 mg/L	Iron Filtration
Total Dissolved Solids	Dissolved mineral content from various rock formations	Considered a general indicator of the quality of water.	>1000 mg/L	Reverse Osmosis

*MC Limit - Maximum Contaminant Limit for Public Drinking Water concentration in the sample. The TDS concentration of each sample was also analyzed in the laboratory under controlled conditions since measurements of specific conductance are temperature dependent and can vary from sample to sample. The TDS concentrations analyzed in the laboratory were measured in units of mg/L.

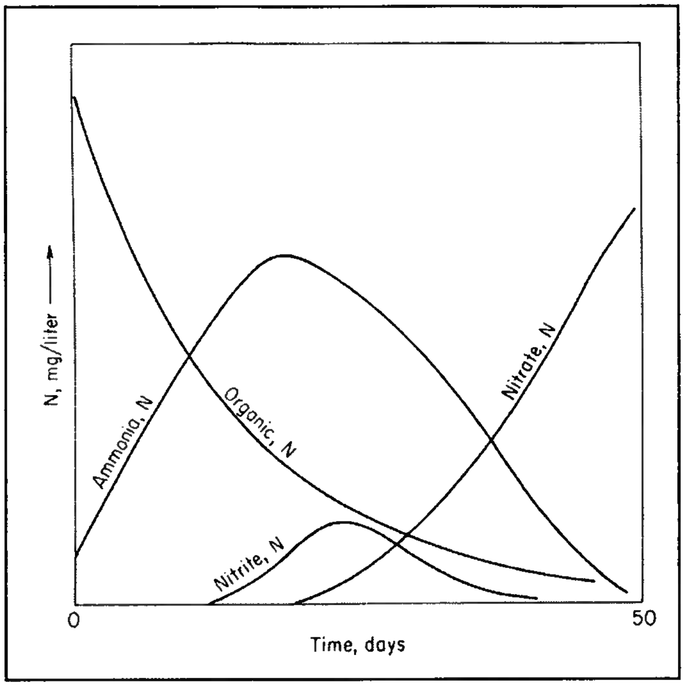


Figure 5. Changes in the form of nitrogen present in polluted waters.
(Reproduced from Sawyer, C.N., McCarty, P.L., and Parking, G.F. 1994. *Chemistry for Environmental Engineers.* New York: McGraw-Hill.)

The TSS concentration was analyzed for each water sample because it may be an indicator of high concentrations of nutrients, pesticides, and/or metals since it originates from a variety of sources including silt, industrial waste, and decaying plant and animal matter. High concentrations of TSS may also scour or obstruct pipes and other industrial machinery.

3.0 Methodology

The methods for measuring the static water levels in each well and obtaining water quality samples were based on the methods developed by the Texas Water Development Board (TWDB) for their well monitoring program. Detailed explanations of the methodology utilized by the TWDB may be found in *UM-52: Explanation of the Texas Water Development Board Ground-Water Level Monitoring Program and Water-Level Measuring Manual* by Janie Hopkins and *UM-51: A Field Manual for Ground Water Sampling* by Philip Nordstrom and Robert Ozment.

Groundwater levels were measured from the top of the surface casing for each well using a steel tape. In order to obtain the correct water level measurement, the distance from the top of the surface casing to the ground surface was subtracted from the water level indicated by the steel tape. Care was taken when lowering the steel tape into the casing to ensure that the tape did not become snagged yielding an unreliable measurement. At each well, every effort was made to duplicate the water level measurements. Included with the attached data for each of the appropriate wells are comments describing the reliability of the water level measurements. The reliability of a water level measurement may be complicated due to wet or leaky casings that cause spotting of the steel tape, wells that are caved and prohibit the tape from reaching the water level or hang-up the tape, or wells that are pumping or have been recently pumped. For each of the current monitoring wells, measuring water levels using a steel tape is the preferable to using an e-line since the access opening for most of the wells is smaller in diameter than the probe of the e-line.

Originally, ten monitoring wells were recommended for water level measurements. These monitoring wells were selected based on their history of water level measurements, their location within the district, and their source of groundwater. *Table 2* lists the original ten wells that were recommended for monitoring. However, due to a number of circumstances, the water levels in several of the wells listed in *Table 2* could not be measured. For example, state well number 4053902 appears to have been destroyed several days prior to attempting to obtain a water level measurement. Additionally, the well casing in state well number 4061105 appears to have caved in preventing any measurement of the water level in that well. Similarly, the casing at state well number 5803901 appears to have an obstruction that prevented the steel tape from reaching the water level or caused the steel tape to hang. Consequently, additional monitoring wells were selected to substitute for the original monitoring wells in which water levels measurements could not be obtained. The list of the final monitoring wells may be found in *Section 4.0.*

Table 2. List of wells originally proposed and actually sampled for the District monitoring program

SW#	Latitude	Longitude	Owner	Aquifer Name	Well Depth	Well Use	Proposed (P) or Sampled (S) Monitor Well
4053902	31.1492	-97.4136	Temple Municipal Airport	Trinity	1355	Unused	P
4054801	31.1524	-97.3151	Little Elm Valley WSC	Trinity	2045	Public supply	S
4059701	31.0231	-97.7117	Wineford Cosper	Trinity	640	Unused	P/S
4061105	31.1161	-97.4750	U.S. Corps of Engrs.	Trinity	1080	Public supply	P
4062401	31.0753	-97.3434	Veterans Admin. Hospital	Trinity	2323	Public supply	S
4062801	31.0242	-97.3061	Bell County WCID No.5	Trinity	2366	Public supply	P
5804502	30.9489	-97.5422	Salado I.S.D.	Edwards (BFZ)	90	Public supply	P/S
5804601	30.9281	-97.5383	Paul Pirtle	Trinity	2300	Stock	P/S
5804602	30.9414	-97.5361	Salado WSC	Edwards (BFZ)	105	Public Supply	P/S
5805902	30.8803	-97.4108	City of Holland Well #2	Trinity	2420	Public Supply	P
5803901	30.8997	-97.6333	Solana Ranch	Trinity	857	Domestic	P
5807701	30.9143	-97.2273	City of Rogers	Trinity	3178	Unused	S
Unregistered	30.9501	-97.5408	Salado I.S.D. (5804000)	Edwards (BFZ)	Unknown	Public supply	S

The water quality samples for each of the wells were obtained after purging the groundwater from the well casing prior to sampling. The TWDB recommends purging approximately three times the volume of the water in the well casing measured from the water level in the casing to the bottom of the screening interval. As noted above, the purpose of the well purging is to ensure that the water in the sample is representative of the water in the aquifer. The water quality sample may be collected when the pH, specific conductance, and temperature of the purged groundwater stabilizes or when three times the volume of the groundwater in the well casing has been purged. However, in the latter case, the pumping rate or discharge of the well must be accurately determined.

The water quality samples were analyzed by the Lower Colorado River Authority's (LCRA) Environmental Laboratory in Austin, Texas. While the TWDB manual recommends buffering the water quality samples with either sulfuric or nitric acid (depending upon the analysis to be conducted), the LCRA provided all the bottles with the appropriate buffering solutions for the required analyses.

4.0 Water Level Measurements

4.1 State Well Number 40-59-701

The water level was measured and a water quality sample was obtained from state well number 40-59-701 on February 3, 2003. This well obtains its groundwater from the Hosston and Glen Rose formations and is normally used for irrigation and livestock. The well had not been operated for months prior to measuring the water level and obtaining the water quality sample. *Figure 6* shows the well site. *Table 3* illustrates the historic water level measurements at this well and includes the water level measurement obtained in February 2003.

Table 3. Water level measurement data for state well #40-59-701.

Well Name: Cosper Well
Aquifer ID: Glen Rose/Hosston
Latitude: 31°1.369'
Longitude: 97°42.692'

State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
4059701	P	-217.5	9	15	1967	1	1	
4059701	P	-215.03	3	22	1968	1	1	
4059701	P	-220.3	3	3	1969	1	1	
4059701	P	-224.4	3	9	1970	1	1	
4059701	P	-230.5	3	17	1971	1	1	
4059701	P	-251.73	3	9	1972	1	1	
4059701	P	-253.1	3	19	1973	1	1	
4059701	P	-266.31	3	11	1974	1	1	
4059701	P	-253.29	4	25	1975	1	1	
4059701	N		3	15	1976	1	1	63
4059701	N		3	10	1977	1	1	47
4059701	N	-263.54	3	15	1978	1	1	20
4059701	N		3	27	1979	1	1	47
4059701	P	-294.5	3	14	1980	1	1	
4059701	N		5	11	1983	1	1	44
4059701	N		3	8	1984	1	1	44
4059701	P	-281.7	3	11	1985	1	1	
4059701	P	-289.88	4	23	1986	1	1	
4059701	P	-292.66	4	21	1987	1	1	
4059701	N		2	18	1988	1	1	47
4059701	P	-305.9	2	27	1989	1	1	
4059701	P	-312.1	1	9	1990	1	1	
4059701	P	-285.5	2	26	1991	1	1	
4059701	N		1	10	1992	1	1	47
4059701	P	-299.5	2	24	1993	1	1	
4059701	P	-298.1	2	8	1994	1	1	
4059701	N		1	27	1995	1	1	47
4059701	P	-287.5	1	18	1996	1	1	20
4059701	N		1	9	1997	1	1	81
4059701		-285.4	2	3	2003	2	1	20

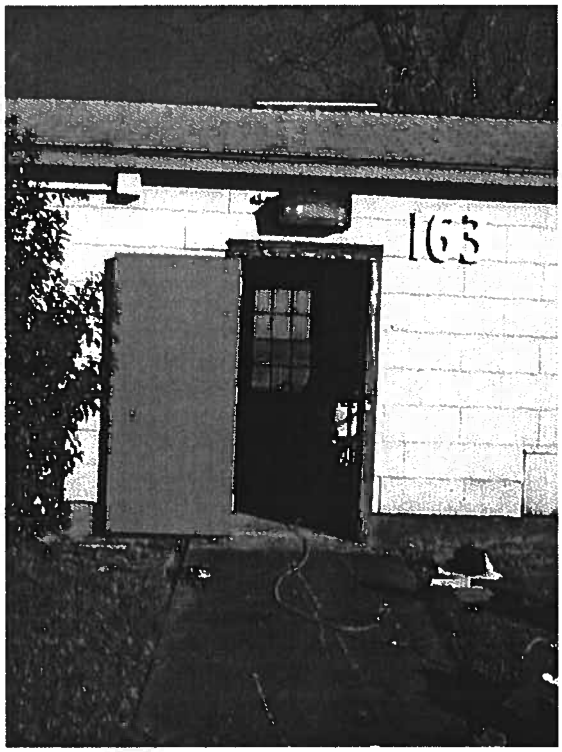
Comments
- 20 Questionable measurement, inconsistent or spotty tape mark due to wet or leaky casing, or open hole conditions
- 44 No measurement - tape or e-line hangs
- 47 No measurement - casing leaky or wet
- 63 No measurement - access to well bore temporarily blocked
- 81 Well deleted from current water level observation program

Method of Measurement
- 1 Steel Tape
- 7 Unknown

Agency
- 1 TWDB or predecessor agencies
- 2 Clearwater Underground Water Conservation District

4.2 State Well Number 40-62-401

The water level was measured and a water quality sample was obtained from state well number 40-62-401 on March 6, 2003. This well obtains its groundwater from the Hosston formations and is normally used for irrigation. The well had not been operated prior to measuring the water level and obtaining the water quality sample. *Figures 7 and 8* show the well site. *Table 3* illustrates the historic water level measurements at this well and includes the water level measurement obtained in March 2003.



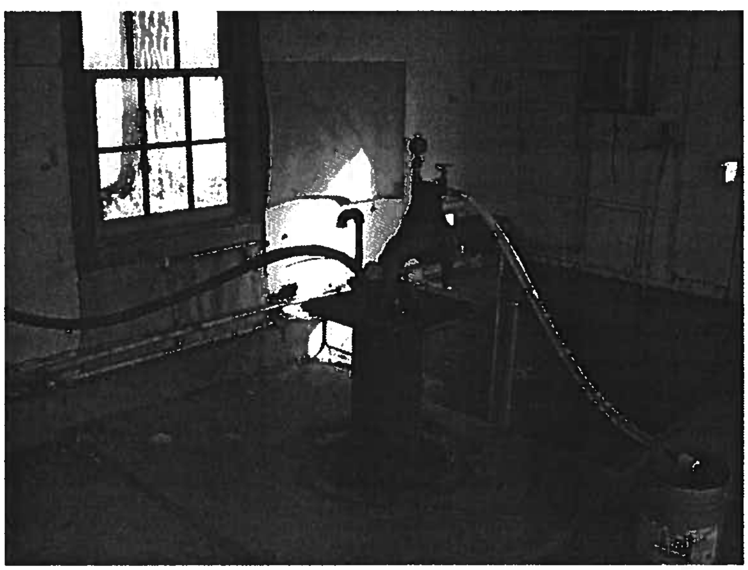


Figure 7 and 8. Typical views of the pump house and the surface casing for state well #40-62-401.

Table 4. Water level measurement data for state well #40-62-401.

Well Name: Veterans Administration Hospital
Aquifer ID: Hosston
Latitude: 31°4.515'
Longitude: 97°20.604'

State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
4062401	P	-73	5	30	1944	1		
4062401	P	-72	6	24	1944	1		
4062401	P	-348.3	3	6	2003	2	1	

Method of Measurement
1 Steel Tape
7 Unknow

Agency
1 TWDB or predecessor agencies
2 Clearwater Underground Water Conservation District

4.3 State Well Number 58-04-502

The water level was measured in state well number 58-04-502 on January 31, 2003. This well obtains its groundwater from the Edwards aquifer and is normally used for irrigation of the softball fields at the school. The well had not been operated prior to measuring the water level. *Figures 9 and 10* show the well site. *Table 5* illustrates the historic water level measurements at this well and includes the water level measurement obtained in January 2003.

Figure 9 and 10. Typical views of the pump house and top of casing for state well #58-04-502.

Table 5. Water level measurement data for state well #58-04-502.

Well Name: Salado ISD
Aquifer ID: Edwards
Latitude: 30°56.952'
Longitude: 97°32.523'

State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
5804502	P	-40	7	23	1967	1	1	
5804502	P	-48.75	9	13	1978	1	1	
5804502	P	-48.81	10	3	1978	1	1	
5804502	P	-49.49	11	1	1978	1	1	
5804502	P	-48.52	12	4	1978	1	1	
5804502	P	-48.43	1	8	1979	1	1	
5804502	P	-47.12	2	12	1979	1	1	
5804502	P	-47.53	2	27	1979	1	1	
5804502	P	-45.79	4	4	1979	1	1	
5804502	P	-46.38	5	8	1979	1	1	
5804502	P	-45.62	6	7	1979	1	1	
5804502	P	-46.52	7	9	1979	1	1	
5804502	P	-47.25	8	2	1979	1	1	
5804502	P	-47.78	9	5	1979	1	1	
5804502	P	-48.06	10	1	1979	1	1	
5804502	P	-48.23	11	1	1979	1	1	
5804502	P	-51.16	12	3	1979	1	1	
5804502	P	-48.07	1	2	1980	1	1	
5804502	P	-48.17	2	6	1980	1	1	
5804502	P	-48.14	3	3	1980	1	1	
5804502	P	-48.18	3	31	1980	1	1	
5804502	P	-48.26	5	6	1980	1	1	
5804502	P	-48.77	6	10	1980	1	1	
5804502	P	-49.21	6	30	1980	1	1	
5804502	P	-50.63	8	18	1980	1	1	
5804502	P	-53.14	9	2	1980	1	1	
5804502	P	-49.95	10	14	1980	1	1	
5804502	P	-49.6	11	7	1980	1	1	
5804502	P	-48.84	12	2	1980	1	1	
5804502	P	-50.72	1	7	1981	1	1	
5804502	P	-48.92	1	20	1981	1	1	
5804502	P	-48.1	3	10	1981	1	1	
5804502	P	-48.74	4	7	1981	1	1	
5804502	P	-49.44	5	7	1981	1	1	
5804502	P	-49.18	6	4	1981	1	1	
5804502	P	-46.3	7	7	1981	1	1	
5804502	P	-48.07	8	4	1981	1	1	
5804502	P	-48.52	9	8	1981	1	1	
5804502	P	-48.05	10	14	1981	1	1	
5804502	P	-47.49	11	5	1981	1	1	
5804502	P	-47.85	12	3	1981	1	1	
5804502	P	-47.85	1	27	1982	1	1	
5804502	P	-49.42	3	4	1982	1	1	
5804502	P	-49.82	4	6	1982	1	1	
5804502	P	-49.22	5	5	1982	1	1	
5804502	P	-49.64	6	8	1982	1	1	
5804502	P	-48.95	7	7	1982	1	1	
5804502	P	-50.7	7	30	1982	1	1	

Table 5 cont'd. Water level measurement data for state well #58-04-502.

State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
5804502	P	-50.53	9	7	1982	1	1	
5804502	P	-47.27	12	7	1982	1	1	
5804502	P	-48.44	3	10	1983	1	1	
5804502	P	-48.72	6	9	1983	1	1	
5804502	P	-50.66	9	27	1983	1	1	
5804502	P	-49.34	12	14	1983	1	1	
5804502	P	-49.54	3	12	1984	1	1	
5804502	P	-51.7	5	15	1984	1	1	
5804502	P	-50.62	6	1	1984	1	1	
5804502	P	-50.78	6	15	1984	1	1	
5804502	P	-51.1	7	2	1984	1	1	
5804502	P	-52.12	7	16	1984	1	1	
5804502	P	-50.95	7	30	1984	1	1	
5804502	P	-51.84	8	13	1984	1	1	
5804502	P	-52.55	8	28	1984	1	1	
5804502	P	-52.38	9	13	1984	1	1	
5804502	P	-52.32	9	26	1984	1	1	
5804502	P	-51.37	10	10	1984	1	1	
5804502	P	-49.85	11	15	1984	1	1	
5804502	P	-49.12	12	18	1984	1	1	
5804502	P	-48.9	1	8	1985	1	1	
5804502	P	-48.38	2	12	1985	1	1	
5804502	P	-48.45	3	13	1985	1	1	
5804502	P	-48.43	4	16	1985	1	1	
5804502	P	-48.99	5	8	1985	1	1	
5804502	P	-49.65	6	10	1985	1	1	
5804502	P	-50.54	7	18	1985	1	1	
5804502	P	-50.68	8	6	1985	1	1	
5804502	P	-50.22	9	10	1985	1	1	
5804502	P	-50.5	10	15	1985	1	1	
5804502		-48.7	1	31	2003	2	1	

Method of Measurement
1 Steel Tape
7 Unknown

Agency
1 TWDB or predecessor agencies
2 Clearwater Underground Water Conservation District

4.4 State Well Number 58-04-602

The water level was measured in state well number 58-04-602 on January 31, 2003. This well obtains its groundwater from the Edwards aquifer and is normally used as a municipal water supply. The well had been operated prior to measuring the water level. *Figure 11* shows the well site. *Table 6* illustrates the historic water level measurements at this well and includes the water level measurement obtained in January 2003.

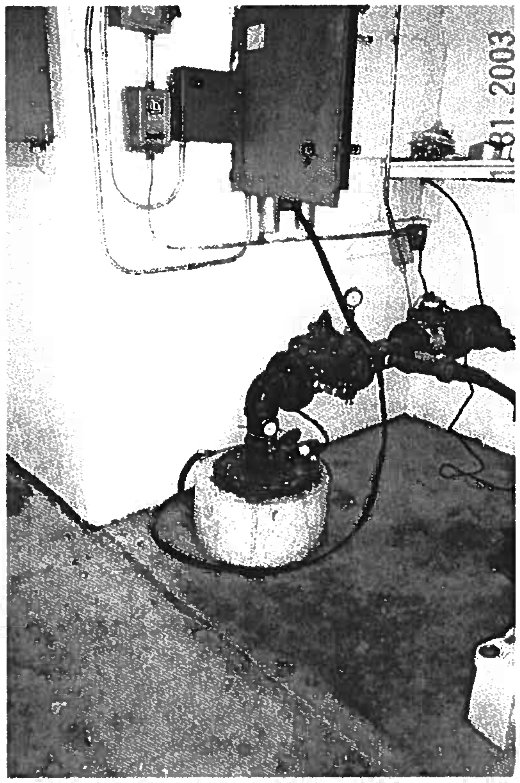


Figure 11. Typical view of state well #58-04-602.

Table 6. Water level measurement data for state well #58-04-602.

Well Name: Salado Water Supply Corporation
Aquifer ID: Edwards
Latitude: 30°56.504'
Longitude: 97°32.166'

State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
5804602	P	-35	2	19	1968	1	7	
5804602	P	-27	5	1	1977	1	7	
5804602	P	-29.27	1	21	1981	1		
5804602		-63.2	1	31	2003	2	1	4

Comments
4 Well pumped recently

Method of Measurement
1 Steel Tape
7 Unknown

Agency
1 TWDB or predecessor agencies
2 Clearwater Underground Water Conservation District

4.5 State Well Number 58-04-601

The water level was measured in state well number 58-04-601 on February 3, 2003. This well obtains its groundwater from the Travis Peak formation but is not currently being used. *Figure 12* shows the well site. *Table 7* illustrates the historic water level measurements at this well and includes the water level measurement obtained in February 2003.

Figure 12. Typical view of state well #58-04-601.

Table 7. Water level measurement data for state well #58-04-601.

Well Name: Pirtle
Aquifer ID: Travis Peak
Latitude: 30°55.653'
Longitude: 97°32.223'

State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
5804601	P	-54	3	31	1961	1	7	
5804601	P	-57.07	3	14	1966	1	1	
5804601	P	-59.8	8	30	1966	1	1	
5804601	P	-59.1	9	28	1966	1	1	
5804601	P	-60.9	11	3	1966	1	1	
5804601	P	-60.72	11	23	1966	1	1	
5804601	P	-60.96	12	28	1966	1	1	
5804601	P	-62.03	4	17	1967	1	1	

Table 7 cont'd. Water level measurements for state well #58-04-601.

State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
5804601	P	-61.7	5	5	1967	1	1	
5804601	P	-62.3	6	9	1967	1	1	
5804601	P	-65.45	6	29	1967	1	1	
5804601	P	-62.81	8	14	1967	1	1	
5804601	P	-62.79	10	4	1967	1	1	
5804601	P	-62.68	11	9	1967	1	1	
5804601	P	-61.6	12	8	1967	1	1	
5804601	P	-62.12	1	12	1968	1	1	
5804601	P	-58.83	2	8	1968	1	1	
5804601	P	-59.63	3	17	1969	1	1	
5804601	P	-58.9	3	23	1970	1	1	
5804601	P	-62.5	3	12	1971	1	1	
5804601	P	-61.63	3	9	1972	1	1	
5804601	P	-57.72	3	19	1973	1	1	
5804601	P	-58.52	3	11	1974	1	1	
5804601	P	-57.26	4	25	1975	1	1	
5804601	P	-61.6	3	15	1976	1	1	
5804601	N		3	10	1977	1	1	61
5804601	P	-62.06	3	15	1978	1	1	
5804601	P	-58.1	3	27	1979	1	1	
5804601	P	-60.47	3	17	1980	1	1	
5804601	P	-60.3	4	10	1981	1	1	
5804601	P	-61.23	3	15	1982	1	1	
5804601	P	-62.86	3	8	1984	1	1	
5804601	P	-59.05	3	11	1985	1	1	
5804601	P	-58.6	4	23	1986	1	1	
5804601	P	-59.25	4	21	1987	1	1	
5804601	N		2	19	1988	1	1	61
5804601	P	-67.1	2	27	1989	1	1	
5804601	P	-72.5	1	9	1990	1	1	
5804601	P	-76.6	2	8	1991	1	1	
5804601	P	-60.4	1	10	1992	1	1	
5804601	P	-60.5	2	24	1993	1	1	
5804601	P	-67.2	2	8	1994	1	1	
5804601	N		2	13	1995	1	1	61
5804601	N		1	18	1996	1	1	61
5804601	N		1	9	1997	1	1	81
5804601		-61.2	2	3	2003	2	1	

Comments

61 No measurement - well site temporarily unavailable
81 Well deleted from current water level observation program

Method of Measurement

1 Steel Tape
7 Unknown

Agency

1 TWDB or predecessor agencies
2 Clearwater Underground Water Conservation District

4.6 State Well Number 40-54-801

The water level was measured in state well number 40-54-801 on March 10, 2003. This well obtains its groundwater from the Hosston formation and is currently used as a municipal water supply. Measuring the water levels at this well is difficult due to obstructions in the well about 430 feet below the top of casing. Duplication of the water level measurements at this site was not possible due to these obstructions and the intermittent pumping of the well. Two water level measurements were obtained, one at 436.5 feet below the land surface and one at 428.4 feet below the land surface. The latter water level measurement is reported because there is greater confidence in that measurement. *Figure 13* shows the well site. *Table 8* illustrates the historic water level measurements at this well and includes the water level measurement obtained in March 2003.

Figure 13. Typical view of state well #40-54-801.

Table 8. Water level measurement data for state well #40-54-801.

Well Name: Little Elm Valley Water Supply Corporation
Aquifer ID: Hosston
Latitude: 31°09.147'
Longitude: 97°18.905'

State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
4054801	P	-273	2	27	1969	1	7	
4054801		-428.4	3	10	2003	2	1	4

Comments
4 Well pumped recently

Method of Measurement
1 Steel Tape
7 Unknown

Agency
1 TWDB or predecessor agencies
2 Clearwater Underground Water Conservation District

4.7 State Well Number 58-07-701

The water level was measured and a water quality sample obtained from state well number 58-07-701 on February 3, 2003. This well obtains its groundwater from the Travis Peak formation but is not currently being used. *Figure 14* shows the well site. *Table 9* illustrates the historic water level measurements at this well and includes the water level measurement obtained in February 2003.

Figure 14. Typical view of state well #58-07-701.

Table 9. Water level measurement data for state well #58-07-701.

Well Name: City of Rogers
Aquifer ID: Hosston
Latitude: 30°54.86'
Longitude: 97°13.635'

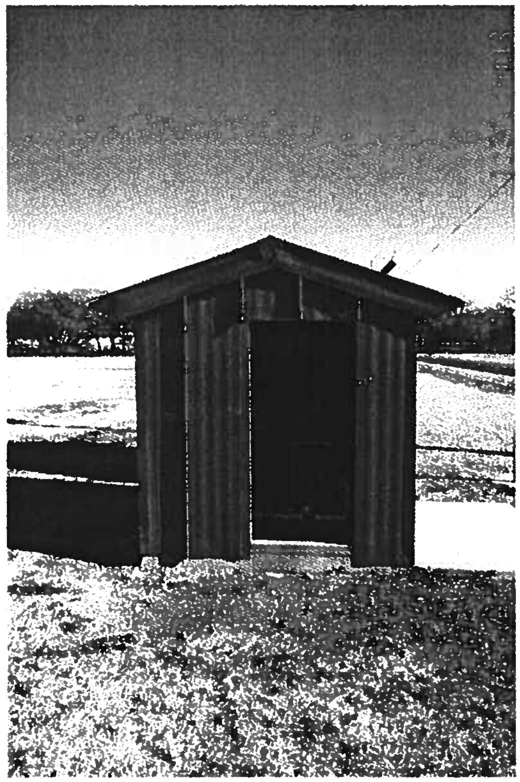
State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
5807701	N		10	14	1965	1		
5807701		1.3	2	3	2003	2		

Method of Measurement
1 Steel Tape
7 Unknown

Agency
1 TWDB or predecessor agencies
2 Clearwater Underground Water Conservation District

4.8 Salado ISD (unregistered well)

The water level was measured and a water quality sample was obtained from this unregistered well on January 31, 2003. This well obtains its groundwater from the Edwards aquifer and is normally used for irrigation at the school. The well had not been operated prior to measuring the water level and obtaining the water quality sample. *Figures 15 and 16* show the well site. *Table 10* illustrates the water level measurement obtained in January 2003. This well is referred to as 58-04-000 in *Figure 4*.



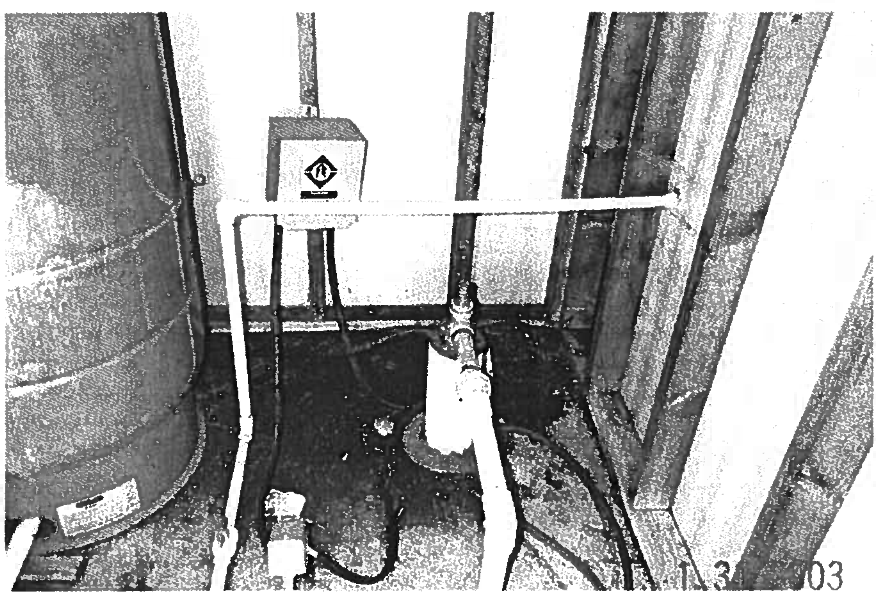


Figure 15 and 16. Typical views of the pump house and top of casing for the Salado ISD unregistered well.

Table 10. Water level measurement data for the unregistered Salado ISD water well.

Well Name: Salado ISD (unregistered)
Aquifer ID: Edwards
Latitude: 30°57.008'
Longitude: 97°32.449'

State Well Number	Published/ Not Published	Depth from Land Surface	Month	Day	Year	Agency	Method of Measurement	Comments
N/A		-39.8	1	31	2003	2	1	

Method of Measurement
1 Steel Tape
7 Unknown

Agency
1 TWDB or predecessor agencies
2 Clearwater Underground Water Conservation District

5.0 Water Quality Data

5.1 State Well Number 40-59-701 *Cosper*

State Well Number	Month	Day	Year	Temperature (°C)	Balanced/ Unbalanced Analysis*	Silica (SiO_2) (mg/L)	Calcium (Ca) (mg/L)	Magnesium (Mg) (mg/L)	Sodium (Na) (mg/L)	Potassium (K) (mg/L)	Carbonate (CO_3) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Sulfate (SO_4) (mg/L)	Chloride (Cl) (mg/L)	Fluoride (F) (mg/L)	Ammonia (NH_3) as N (mg/L)	Nitrate (NO_3) (mg/L)	Total Kjeldahl Nitrogen (mg/L)	pH	Dissolved Solids (mg/L)	Phenol Alkalinity (mg/L)	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)	Specific Conductance (µohms/cm)
4059701	9	18	1968		B	12	66	60	640		0	444.21	1020	296	5.3		6.5		7.7	2324	0	364	411	4290
4059071	2	3	2003	21.3	U	12.3	50.9	58.9	610	8.53	ND	370	1080	291	4.58	0.057	2.16	0.62	7.88	2380	ND	370	370	3180

5.2 State Well Number 40-62-401 *VA Center*

State Well Number	Month	Day	Year	Temperature (°C)	Balanced/ Unbalanced Analysis*	Silica (SiO_2) (mg/L)	Calcium (Ca) (mg/L)	Magnesium (Mg) (mg/L)	Sodium (Na) (mg/L)	Potassium (K) (mg/L)	Carbonate (CO_3) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Sulfate (SO_4) (mg/L)	Chloride (Cl) (mg/L)	Fluoride (F) (mg/L)	Ammonia (NH_3) as N (mg/L)	Nitrate (NO_3) (mg/L)	Total Kjeldahl Nitrogen (mg/L)	pH	Dissolved Solids (mg/L)	Phenol Alkalinity (mg/L)	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)	Specific Conductance (µohms/cm)
4062401	1	3	1944		U						20	378	250	224							16.67	343.09		
4062401	1	3	1944		U						11	418.2	250	242							9.17	361.03		
4062401	1	3	1944		U						20	416	250	246							16.67	374.23		
4062401	1	3	1944		B	14	12	4.5	440		13	424	269	248	2		1.8		8	1212	10.83	369.1	48	
4062401	1	8	1944		B	8.5	24	4.4	394		22	365	284	216			0.2			1132	18.33	335.76	78	1880
4062401	2	15	1944	37	U						27	385	260	249							22.5	360.48		
4062401	2	16	1944	37	U						28	376	258	250							23.33	354.77		
4062401	2	17	1944	37	B	16	8.8	2.6	438		18	400	259	249	2		0		7.8	1190	15	357.78	32	
4062401	2	17	1944	37	U						23	382	259	248							19.17	351.37		
4062401	2	17	1944		B	18	12	3	437		0	433.22	269	254	1.8	<	0.4		8	1208	0	355	42	
4062401	7	24	1944		U						0	300.08	220	212							0	245.9		
4062401	7	26	1944		U						0	442.13	260	252							0	362.3		
4062401	3	6	2003	31.4	B	18.7	5.96	2.33	390	2.84	8	338	200	200	1.81	0.605	ND	1.53	8.59	1140	4	345	24.5	1755

5.3 State Well Number 58-07-701 *Rogers*

State Well Number	Month	Day	Year	Temperature (°C)	Balanced/ Unbalanced Analysis*	Silica (SiO_2) (mg/L)	Calcium (Ca) (mg/L)	Magnesium (Mg) (mg/L)	Sodium (Na) (mg/L)	Potassium (K) (mg/L)	Carbonate (CO_3) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Sulfate (SO_4) (mg/L)	Chloride (Cl) (mg/L)	Fluoride (F) (mg/L)	Ammonia (NH_3) as N (mg/L)	Nitrate (NO_3) (mg/L)	Total Kjeldahl Nitrogen (mg/L)	pH	Dissolved Solids (mg/L)	Phenol Alkalinity (mg/L)	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)	Specific Conductance (µmhos/cm)
5807701	11	18	1940		B	24	10	3	399		36	427.12	288	117	2.4		<0.4		8.6	1089	30	410	37	
5807701	11	19	1940		B	24	10	3	399		36	427.12	288	117	2.4		<0.4		8.6	1089	30	410	37	
5807701	4	0	1943		B	20	9.1	2.9	381	6	18	475	277	110	2.8		0		8.4	1060	15	419.23	34	
5807701	6	2	1949		B	33	20	2	386		6	500.34	291	117	2.8		<0.4		8.5	1104	5	420	58	
5807701	1	18	1954		B	60	10	4	395		0	500.34	307	121	2.4		<0.4		8.3	1145	0	410	41	
5807701	5	4	1960		B		23	9	420		0	488.14	450	156	1.2		<0.4		8	1299	0	400	94	2340
5807701	11	3	1961		B		24	10	460		0	475.93	398	150	2.8		<0.4		8.2	1279	0	390	101	2600
5807701	11	3	1971	49	B	23	29	11	457	4	0	480.82	467	152	2.8		<0.4		8	1382	0	394	117	2457
5807701	2	7	1972		B		65	27	680		0	424.68	1018	267	2.8		<0.4		8	2269	0	348	273	4140
5807701	4	26	1972		B		48	20	590	7	0	439.32	800	228	2.8		2		8	1913	0	360	202	3420
5807701	4	26	1972		B		29	10	466	5	2.4	484.48	499	160	2.8		<0.4		8.4	1412	2	401	113	2512
5807701	12	6	1973		B		31	9	466		0	484.48	470	163	3.9		<0.4		8	1381	0	397	114	2560
5807701	12	2	1974		B		75	23	650	9	0	452.75	950	264	3.7		1		8.3	2198	0	371	281	4018
5807701	3	29	1977		B		94	26	690	12	0	435.66	1090	287	2.7		5.62		7.9	2421	0	357	341	4370
5807701	7	25	1980		B	22	144	34	946		0	394.17	1602	353	2.7		<0.1		8.3	3297	0	323	499	6048
5807701	2	3	2003	**	U	22.4	375	128	1830	27.6	ND	190	4660	1040	2.61	4.11	ND	8.27	7.61	8090	ND	190	1470	9890

5.4 Salado ISD (unregistered)

State Well Number	Month	Day	Year	Temperature (°C)	Balanced/ Unbalanced Analysis*	Silica (SiO_2) (mg/L)	Calcium (Ca) (mg/L)	Magnesium (Mg) (mg/L)	Sodium (Na) (mg/L)	Potassium (K) (mg/L)	Carbonate (CO_3) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Sulfate (SO_4) (mg/L)	Chloride (Cl) (mg/L)	Fluoride (F) (mg/L)	Ammonia (NH_3) as N (mg/L)	Nitrate (NO_3) (mg/L)	Total Kjeldahl Nitrogen (mg/L)	pH	Dissolved Solids (mg/L)	Phenol Alkalinity (mg/L)	Total Alkalinity (mg/L)	Hardness as $CaCO_3$ (mg/L)	Specific Conductance (µohms/cm)
N/A	1	31	2003	20.4	U	16.6	81.8	31.3	12.6	1.27	ND	320	11.5	19.1	1.28	ND	4.44	0.17	7.64	392	ND	320	333	693

*The balanced/unbalanced notation indicates the relative error that arises in the calculations resulting from dilution of the groundwater samples as required to meet the calibration standards of the laboratory. This error occurs when the sample is diluted because the dilution affects the solution matrix.

**The temperature was not measured at state well number 58-07-701 because it was a flowing, artesian well, and the water flowing from it was unquestionably representative of the water in the aquifer rather than the water in the casing.

6.0 Conclusions and Recommendations

The first round of water level measurements associated with the District's groundwater monitoring program appears to affirm the conclusions of the Groundwater Resources Management Information report presented to the District in January 2002; that is, there does not appear to be any depletion of the groundwater resources of the Edwards (BFZ) Aquifer, while the groundwater resources of the Trinity Aquifer appear to be declining at a constant rate in some areas of the county. For example, the water level of state well number 58-04-502, which is screened in the Edwards (BFZ) Aquifer, was measured at 48.7 feet below the land surface, which agrees closely with the average depth of 49.1 feet below the land surface for the other water level measurements taken from the well from 1967 to 1985. However, this should be supported by continued water level measurements of this well as well as the two other Edwards (BFZ) Aquifer wells in the District's new monitoring program and data collected from the Texas Water Development Board's groundwater monitoring program. On the other hand, water levels appear to be declining in the Trinity Aquifer in the northern part of the Bell County. For example, water levels in state well numbers 40-54-801 and 40-62-401 show water level declines of 155 feet and 275.3 feet, respectively, from their first water level measurement to their most recent water level measurement (although it should be noted that the well identified as 40-54-801 had been pumped recently prior to obtaining the water level measurement). The location of these wells is near the City of Temple in the north part of Bell County. However, state well numbers 40-59-701 and 58-07-701 do not appear to illustrate any declining trend in water levels over their respective period of records. The former well is located just west of Stillhouse Hollow Lake, and the latter is located near the City of Rogers along the border of Bell County and Milam County. Both are located in the central part of the county in a band extending east to west. Evaluation of the groundwater resources of the Trinity Aquifer in the southern portion of Bell County are currently inconclusive. Water level data obtained from state well number 58-04-601 show no trend to support declining groundwater resources of the Trinity Aquifer in this area. However, the water levels in state well number 58-03-901, one of the original monitoring wells, clearly show that the resources are declining. Unfortunately, problems encountered with the well casing prevented a current water level measurement from being obtained during this round of monitoring. Consequently, more study in this area needs to be conducted.

The reason for the incongruent groundwater level trends in the Trinity Aquifer may be due to faulting. The faulting of the geologic formations has created isolated sections of the Trinity Aquifer that are disparate from other sections. An example of the faulting may be seen in Figures 20-22 (pages 20-22) of Groundwater Resources Management Information. Consequently, the whole extent of the Trinity Aquifer within Bell County may not experience a consistent reduction in available groundwater. The availability of groundwater may be localized in particular areas of the County and subject to recharge potential and groundwater use. This is an area of the study that the District may want to consider in the future.

The results of the water quality sampling showed no significant deviations or trends for any of the parameters for any of the monitoring wells with the exception of state well number 58-07-701. The water quality sample at this location showed marked increases in specific conductance, dissolved solids concentration, and sulfate and chloride concentrations along with decreases in the alkalinity and the pH of the groundwater. The marked differences could indicate that there is leakage from one formation to another and that the current source of the water at this well may be from a different formation than the historical source. Another possibility, however, is pollution from a source such as a nearby oil or gas well. The District may want to continue evaluating the water quality of the groundwater at this site and surrounding areas to determine which of these possibilities is indeed the case.

Finally, the District needs to consider adding wells to their monitoring program. These wells should be Trinity Aquifer wells located in the southern portion of the county since this area of the county is expected to undergo significant development in the next decade. This development will bring additional demands on the groundwater resources of the Trinity Aquifer. Since the quantity of available groundwater in this area is currently unknown, further study needs to be conducted in this area of the county so that the District can make a regular assessment of the water supply and groundwater storage conditions as described in its management plan.