Texas Water Development Board

Report 335

# Ground-Water Quality Monitoring Results in the Winter Garden Area, 1990

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# ABSTRACT

The purpose of this study was to examine the quality of ground water from selected wells completed in the Queen City Sand, Carrizo Sand, and Wilcox Group in all or parts of Atascosa, Bexar, Dimmit, Frio, Karnes, La Salle, Medina, Wilson, and Zavala Counties. A total of 119 wells were sampled: 9 wells in the Queen City Sand; 103 wells in the Carrizo Sand; and 7 wells in the Wilcox Group. All analyses are presented in five sections: field measurements; dissolved inorganic constituents; nutrients; organic constituents; and radioactivity.

Levels of dissolved inorganic constituents in five wells in the Queen City Sand exceeded the established Maximum Contaminant Levels (MCLs): iron (5 wells); chloride (4 wells); dissolved solids (3 wells); manganese (3 wells); and sulfate (1 well). In the Carrizo Sand 50 wells had excessive dissolved inorganic constituents: iron (43 wells); manganese (20 wells); dissolved solids (12 wells); chloride (11 wells); sulfate (11 wells); and zinc (2 wells). In the Wilcox Group six wells had excessive dissolved inorganic constituents: dissolved solids (4 wells); iron (3 wells); manganese (3 wells); chloride (1 well); sulfate (1 well); and zinc (1 well).

No analysis of water from wells in any of the three aquifers exceeded the MCLs for nitrates or any other nutrient. None of the analyses of water from wells in the Queen City Sand and Wilcox Group had any detectable amounts of organic constituents, but 14 analyses of water from wells in the Carrizo Sand had organic constituents. Of these, 13 had amounts which were either below quantitation limits or were so small as to be negligible. An organic analysis from one well in Bexar County showed significant amounts of phenolic compounds, and the owner was advised to have additional testing.

The Queen City Sand and the Wilcox Group wells had no samples in excess of established MCLs for radioactivity. Analyses of water from 14 wells in the Carrizo Sand exceeded the established MCLs in gross alpha (10 wells) and combined Radium-226 and Radium-228 (13 wells).

A subjective attempt to compare historical water-quality analyses to current analyses from the same wells was done by comparing three parameters: chloride, sulfate, and dissolved solids. Analysis from one well in the Queen City Sand showed a slight deterioration in water quality. In the Carrizo Sand analyses of water from three wells showed improving water quality, and analyses of water from ten wells showed deterioration. Analysis of water from one well in the Wilcox Group showed deteriorating water quality, while analysis from a second Wilcox well showed improvement.

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# INTRODUCTION

## Purpose

The purpose of this report is to examine the quality of ground water from selected wells completed in the Queen City Sand, the Carrizo Sand, and the Wilcox Group in the Winter Garden area of southwest Texas. This study was done as part of the Texas Water Development Board Ground Water Quality Monitoring Program which has two primary purposes: 1) to establish as accurately as possible the dissolved constituents of the ground water occurring naturally in the aquifers of the State and 2) to monitor changes, if any, in the quality of ground water over a period of time. The southwestern portion of the area coincides with a joint ground-water evaluation study with the Texas Water Commission to investigate the effects of agricultural and oil-production practices on ground water. The northeastern portion coincides with a joint water-quality monitoring activity with the Evergreen Underground Water Conservation District.

## Location and Extent

The study area encompasses approximately 6,500 square miles in all or parts of Atascosa, Bexar, Dimmit, Frio, Karnes, La Salle, Medina, Wilson, and Zavala Counties (Figure 1). It extends from near Carrizo Springs in Zavala County to Stockdale in Wilson County. It also includes the towns of La Pryor, Crystal City, Pearsall, Cotulla, Jourdanton, Pleasanton, Falls City, Floresville, and numerous small unincorporated communities. Pearsall, which is near the center of the study area, is about 54 miles southwest of San Antonio.

## Topography and Drainage

The Winter Garden area is part of the Coastal Plains physiographic province and is characterized by a level to gently rolling plain which dips slightly southeastward toward the Gulf of Mexico. The soils are generally sandy or sandy loam types. Drainage in the area is into four major rivers: the Rio Grande, the Nueces, the Atascosa, and the Frio, either directly or through many of the smaller streams in their watersheds. Native vegetation includes live oak, mesquite, huisache, prickly pear cactus, and other hardy plants typical of the south Texas brush country.

## Climate

Long, hot summers and short, mild winters are the typical climate of the Winter Garden area. It is an arid region where the annual evaporation rate exceeds the annual precipitation rate. The mean July maximum temperature is approximately 98°F, and the mean January minimum is 42°F. The average annual rainfall varies from 21.50 inches in the southwest to 28.50 inches in the northeast. Most of the rainfall occurs during the months of May and September (Larkin and Bomar, 1983).

## Economy

The regional economy is based primarily on agriculture and mineral production. Principal agricultural products are livestock including dairy and beef cattle, hogs, sheep, and goats; grain crops including sorghum, wheat, and oats; peanuts; cotton; vegetables; melons; pecans; and strawberries. Frio County was the leading peanut producing county in Texas in 1987. Approximately 160,000 acres are irrigated across the Winter Garden area. Mineral production includes oil and gas, lignite, sand, clay, and gravel. Several small manufacturing companies operate plants in the region. A growing source of income for many landowners since the 1980s is the leasing of their land for hunting and wildlife management (Dallas Morning News, 1987).

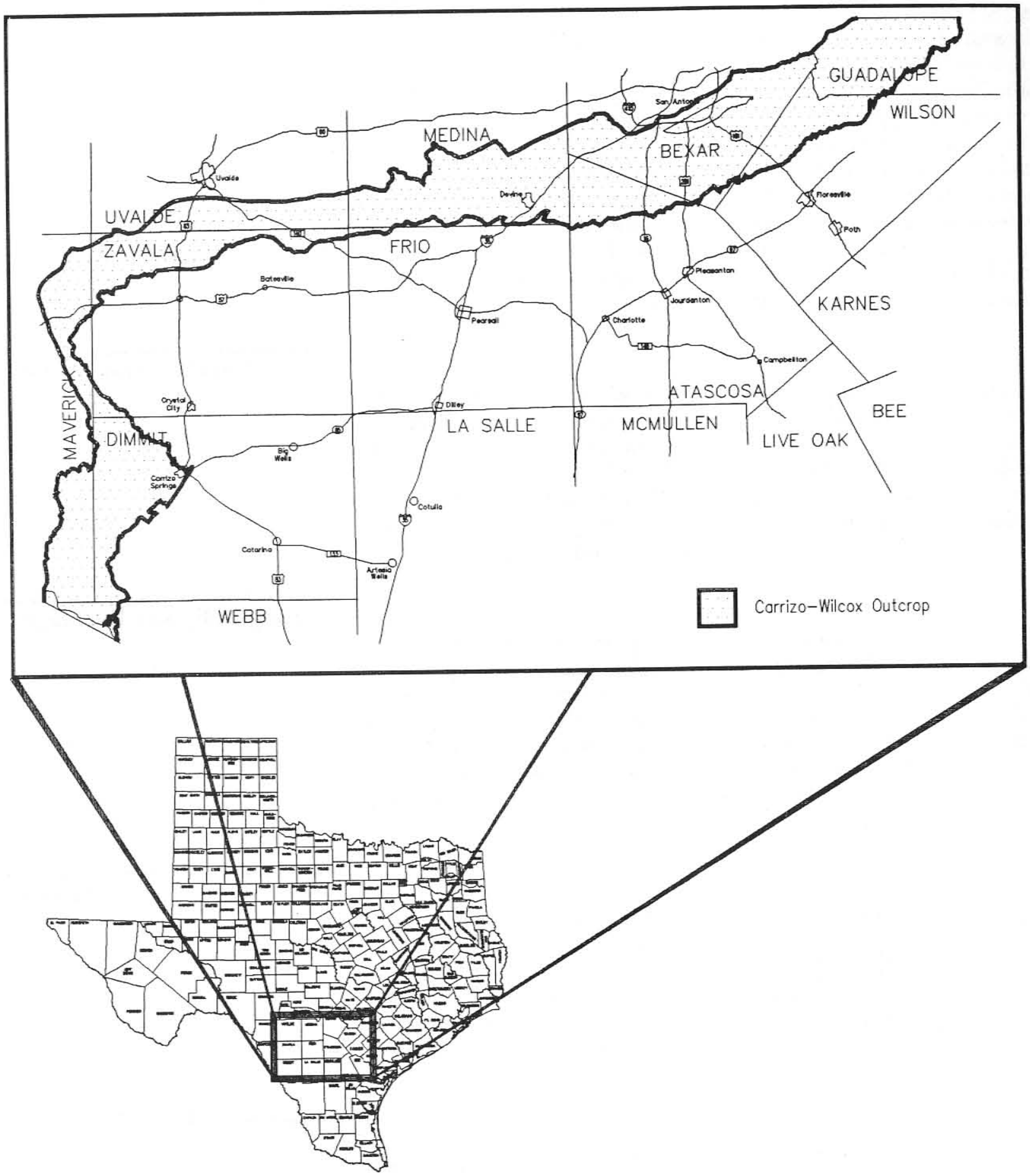


Figure 1

STUDY AREA

## Previous Investigations

Several governmental agencies, private companies, and consultants have worked in this area through the years and discussed their findings related to the geology and ground-water resources in numerous publications. Initial work began prior to 1940 and continues through the present.

Previous investigations by the Texas Water Development Board and predecessor agencies include Turner and others (1940); Outlaw and others (1952); Follett (1956); Mason (1960); and Harris (1965). A major comprehensive report on the geohydrology of the Eocene-age aquifers of this area is a two-volume publication, Report 210 (Klemt and others, 1976, and Marquardt and Rodriguez, 1977). Duffin and Elder (1979); Elder and others (1980); and Opfel and Elder (1977) also published reports based on research and material gathered for Report 210.

The Bureau of Economic Geology at The University of Texas has published several reports on the geology of the Winter Garden area: Hamlin (1988) studied the depositional and ground-water flow systems of the Carrizo; and Barnes described the geology in the Geologic Atlas in the Crystal City-Eagle Pass Sheet (1976), the San Antonio Sheet (1974a), and the Seguin Sheet (1974b).

## Acknowledgements

The Board appreciates the cooperation of the property owners within the study region for supplying information concerning their wells and allowing access to their property to sample for water quality. Appreciation is also extended to the Evergreen Underground Water Conservation District for obtaining permission to sample water wells within Atascosa, Bexar, Frio, Medina, and Wilson Counties.

# GEOHYDROLOGY

## Geologic Framework

The geologic formations which occur on the surface and in the subsurface of the study area are predominantly Eocene sands and shales. The important water-bearing units which were studied for this report are the Wilcox Group and the Carrizo and Queen City Sands of the Claiborne Group. The stratigraphic relationship, approximate thickness, brief descriptions, and water-bearing characteristics of the formations in the Winter Garden area are summarized in Table 1.

The deposition of these units was influenced by regional structural features known as the Rio Grande Embayment and the San Marcos Arch. At the end of the Mesozoic Era, deposition changed from carbonates and marine clastics to alternating transgressive and regressive sand and shale sequences. The shoreline of the Gulf of Mexico gradually moved southeastward as the sediments continued to accumulate. The subsequent coastal plain remains a relatively flat surface which dips gently basinward to the southeast.

The Wilcox Group is the oldest geologic unit, shifting from a regressive sequence of marine sands and muds in the lower Wilcox to massive deltaic sands in the middle Wilcox, and grading into an alluvial system in the Carrizo Sand (Hamlin, 1988). The Wilcox Group is undifferentiated in the outcrop and throughout the subsurface (above 4,000 feet) in this region. The sands of the downdip upper Wilcox (below 4,000 feet) are the equivalent of the updip Carrizo Sand. In the Winter Garden area the combined lower and middle Wilcox subgroups and the Carrizo Sand form the Carrizo-Wilcox aquifer. In this report the wells completed in the Wilcox Group are located on or immediately downdip from the Wilcox outcrop in Atascosa, Bexar, Dimmit, Medina, and Wilson Counties.

The Carrizo Sand overlies the middle Wilcox subgroup and is the major aquifer within the study area. It is an alluvial sequence with sand and clay lenses in the lower and upper units and a middle unit composed of stacked, massive channel sands (Klemt and others, 1976; Hamlin, 1988).

Above the Carrizo Sand are a series of interbedded sands and clays which represent lateral facies changes within the Rio Grande Embayment (Plummer, 1932; Barnes, 1976). A convenient geographic reference for these facies changes is the Frio River; west of the Frio are the continental deposits of the Bigford Formation and the El Pico Clay, and east of the Frio are the marine sediments of the Reklaw Formation, Queen City Sand, and Weches Formation. In this report all wells completed in the Queen City Sand are located in Wilson, Atascosa, and Frio Counties.

## Source and Occurrence

The primary source of ground water in the study area is the infiltration of precipitation either directly into the outcrop or indirectly as seepage from stream flow. Although most of the rainfall is lost to evaporation, a small amount percolates downward under the force of gravity to the zone of saturation, which is that portion in the rock where all of the voids contain water.

For a formation to be an aquifer, it must be porous, permeable, and yield water in usable quantities. Two important characteristics of all

# Table 1. - Geologic Units and Their Water–Bearing Characteristics

| System | Series | Group | Geologic Unit | | Approximate Thickness | | Character of Rock | | Water–Bearing Properties | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | West of Frio R. | East of Frio R. | West of Frio R. | East of Frio R. | West of Frio River | East of Frio River | West of Frio River | East of Frio River |
| Tertiary | Eocene | Claiborne | El Pico Clay | Weches Formation | 700 - 1,500 | 50 - 200 | Clay with interbedded sandstones, clay-stones, and lignite coal lenses. | Fossiliferous, glauconitic shale and sand. | Yields small quantities of slightly to moderately saline water. | Not known to yield water. |
| | | | | Queen City Sand | | 500 - 1,400 | | Marine, medium to fine sand with interbedded clay and shale. | | Yields small to moderate quantities of fresh to slightly saline water. |
| | | | Bigford Formation | Reklaw Formation | 200 - 900 | 200 - 400 | Sands with interbed-ded silts and shales. Plant remains are abundant. | Clay with interbedded glauconitic sand. | Yields small to moderate quantities of fresh to very saline water. | Yields small quantities of slightly to moderately saline water to wells in or near the outcrop. |
| | | | Carrizo Sand | | 150 - 1,200 | | Coarse to fine sand, massive, cross–bedded with a few partings of carbonaceous clay. | | Principal aquifer in the study area. Yields moderate to large quantities of fresh to slightly saline water. | |
| | | Wilcox | Indio Formation | Wilcox Group Undif. | 0 - 2,800 | | Interbedded sand, clay, and silt with discontin-ous beds of lignite. The shale and clay sometimes contain gypsum. | | Yields small to moderate quantities of fresh to slightly saline water. | |
| | | Midway | Kincaid Formation | Midway Grp. Undif. | 0-300 | | Shale, sandstone and limestone. | | Not known to yield water. | |

- Yields of wells, in gallons per minute (gal/min): small, less than 50 gal/min; moderate, 50–500 gal/min; large, more than 500 gal/min.
- Quality of water, in milligrams per liter (mg/l) dissolved solids: fresh, less than 1,000 mg/l; slightly saline, 1,000 - 3,000 mg/l; moderately saline, 3,000 - 10,000 mg/l; very saline, 10,000 - 35,000 mg/l.

References: Barnes (1974, 1976a, 1976b, 1977)
Guevara and Garcia (1972)
Hamlin (1988)
Hargis (1985)
Klemt and Others (1976)
Modified from McCoy (1991)

aquifer rocks are porosity, the amount of open space between the grains in the rock, and permeability, the ability of a porous material to transmit water. Fine-grained sediments such as clay and silts generally have high porosity, but little or no permeability, and consequently do not readily transmit water. Sand and gravel are usually both porous and permeable, the degree depending upon the size, shape, sorting, and amount of cementation between the grains.

Because of its lithologic characteristics, the Carrizo Sand is an excellent aquifer rock which can yield large quantities of water. The sand bodies are thick and extensive with coarse sand grains which permit high porosities and permeabilities. The Wilcox Group is not as prolific an aquifer as the Carrizo Sand because of the high clay content, and it yields smaller volumes of water. The Queen City Sand is similar to the Wilcox Group with its interbedded sands and clays limiting the yields of its wells.

## Recharge, Movement, and Discharge

Recharge is the process by which water is added to an aquifer. Precipitation on the outcrop of an aquifer is generally the most significant natural source of recharge; however, water may enter from surface streams and lakes on the outcrop and possibly through interformational leakage and return flow of irrigation water. The amount of recharge must balance the discharge over a long period of time or the water in the aquifer will eventually be depleted. Recharge is generally greater during the winter months when plant growth, pumpage, and evaporation rates are all low.

Because of a general lack of sustained regular rainfall in this area, most of the streams are intermittent. Therefore the recharge of these aquifers is primarily limited to the direct infiltration of rainfall.

Ground water moves in response to the hydraulic gradient from areas of recharge to areas of discharge. Under water table conditions, movement of ground water follows the drainage of the surface; under artesian conditions it moves in the direction of the regional dip of the aquifer. In areas of large and extensive withdrawals by wells, the natural gradient is altered and ground water moves from all directions to the areas of pumpage and lowered pressure.

Discharge is the process by which water is removed from the aquifer. This may be through natural processes, such as springs, streams, or lakes, or artificial processes, such as pumpage from wells. Excessive pumpage can have two undesirable consequences: (1) a change in the hydraulic gradient can cause natural springs to slow or stop flowing; and (2) as the hydraulic gradient is altered, interformational leakage between the aquifer and surrounding rocks containing more highly-mineralized water can cause deterioration of water quality.

# WATER QUALITY ANALYSIS

The chemical character of ground water mirrors the mineral composition of the rocks through which it has passed. As water moves through its environment, it dissolves some of the minerals from the surrounding rocks. Concentrations of the various dissolved mineral constituents depend upon the solubility of the minerals in the formation, the length of time the water is in contact with the rock, and the concentration of carbon dioxide present within the water. Dissolved mineral concentrations generally increase with depth and temperature. Neutralizing or removing undesirable constituents is usually difficult and can be expensive.

One of the most important tasks in water-quality sample collection is to sample water which is representative of the aquifer. To insure that the water is from the aquifer itself, the well must first be purged, which means removing a sufficient volume of ground water stored in the well casing. The temperature, specific conductance, and pH are monitored until stabilization of the readings occurs. At that point, the well may be sampled. The sample should be collected near the wellhead before the water has gone through pressure tanks, water softeners, or other treatment. Standby, new, or little-used wells may require a day or more of pumping before the water is of constant quality (Wood, 1976).

The most representative water samples usually can be obtained from municipal, industrial, or irrigation wells. Because of their constant pumping and high yield, these wells draw water from a larger area of the aquifer and usually insure a representative sample.

## Analytical Methods

Standardized procedures were used in collecting the ground-water samples for this investigation according to the Texas Water Development Board Field Manual for Ground Water Sampling (Nordstrom and Adidas, 1990). Upon arrival at the well site, the purging procedure was started. During purging, the temperature, specific conductance (using a VWR conductivity meter), and pH (using a Beckman pH meter) were monitored at five minute intervals until the readings stabilized. Constituents were collected and handled as follows, with the analytical methods and detection limits listed in Table 2 (except where noted):

**Dissolved anions:** Ground water was filtered through a 0.45 µm nonmetallic filter into a 1-liter polyethylene bottle. The sample was placed on ice and delivered to the Texas Department of Health (TDH) laboratory. Analyses were completed within 28 days. Samples were analyzed for sulfate, chloride, iodide, bromide, boron, fluoride, silica, and alkalinity contents.

**Dissolved cations/metals:** Ground water was filtered through a 0.45 µm nonmetallic filter into a 1-liter polyethylene bottle. The sample was preserved with $HNO_3$, placed on ice, and delivered to the TDH laboratory. Analyses were completed within 28 days. Samples were analyzed for aluminum, arsenic, barium, calcium, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury, molybdenum, potassium, selenium, silver, sodium, strontium, vanadium, and zinc.

**Table 2.-Detection Limits and Analytical Methods for Inorganic Species.**

| **Dissolved Anions** | | | |
|---|---|---|---|
| | **Symbol** | **Detection Limit** | **Method** |
| Boron | B | 0.01 mg/l | Method 404A |
| Bromide | Br | 0.01 mg/l | Method 405 |
| Chloride | Cl | 1 mg/l | EPA Method 325.2 |
| Fluoride | F | 0.1 mg/l | EPA Method 325.2 |
| Iodide | I | 0.01 mg/l | Method 415A |
| Silica | $SiO_2$ | 1 mg/l | Method 425E |
| Sulfate | $SO_4$ | 2 mg/l | EPA Method 375.2 |

Unless otherwise specified, "Method" refers to Standard Methods for the Examination of Water and Wastewater (ACPHA, 1985).

| **Dissolved Cations/Metals** | | | |
|---|---|---|---|
| Aluminum | Al | 50 µg/l | ICP |
| Arsenic | As | 10 µg/l | GFAA |
| Barium | Ba | 10 µg/l | ICP |
| Cadmium | Cd | 10 µg/l | FAAS |
| Calcium | Ca | 1 mg/l | ICP |
| Chromium | Cr | 20 µg/l | ICP |
| Copper | Cu | 20 µg/l | ICP |
| Iron | Fe | 20 µg/l | ICP |
| Lead | Pb | 50 µg/l | FAAS |
| Magnesium | Mg | 1 mg/l | ICP |
| Manganese | Mn | 20 µg/l | ICP |
| Mercury | Hg | 0.2 µg/l | CVAAS |
| Molybdenum | Mo | 20 µg/l | ICP |
| Potassium | K | 1 mg/l | ICP |
| Selenium | Se | 2 µg/l | Fluorometric |
| Silver | Ag | 10 µg/l | FAAS |
| Sodium | Na | 1 mg/l | ICP |
| Strontium | Sr | 200 µg/l | ICP |
| Vanadium | V | 20 µg/l | ICP |
| Zinc | Zn | 20 µg/l | ICP |

ICP- Induction Coupled Plasma, EPA Method 200.7
GFAA- Graphite Furnace AA, EPA Method 206.2
FAAS- Flame AA, EPA Methods 213.1 (Cd), 239.1 (Pb), 272.1 (Ag)
CVAAS- Cold Vapor AA, EPA Method 245.1
Fluorometric, DAN Method, AOAC Method 25.157

| **Nutrients** | | | |
|---|---|---|---|
| Ammonia | $NH_3$ (N) | 0.02 mg/l | EPA Method 350.1 |
| Kjeldahl | N | 0.1 mg/l | EPA Method 351.2 |
| Nitrate | $NO_3$ (N) | 0.01 mg/l | EPA Method 353.2 |
| Nitrite | $NO_2$ (N) | 0.01 mg/l | EPA Method 353.2 |
| Orthophosphate | $PO_4$ (P) | 0.01 mg/l | EPA Method 365.1 |

| **Radioactivity** | | | |
|---|---|---|---|
| Gross Alpha | $\alpha$ | 2.0 pCi/l | EPA Method 900.0 |
| Gross Beta | $\beta$ | 4.0 pCi/l | EPA Method 900.0 |
| Radium-226 | $Ra^{226}$ | 0.2 pCi/l | EPA Method 903.1 |
| Radium-228 | $Ra^{228}$ | 1.0 pCi/l | EPA Method 904.0 |

**Nutrients:** Ground water was filtered through a 0.45 μm nonmetallic filter into a 500-ml opaque polyethylene bottle. The sample was preserved with $H_2SO_4$, placed on ice, and delivered to the TDH laboratory. Analyses were completed within 7 days. Samples were analyzed for ammonia, Kjeldahl, nitrate, nitrite, and orthophosphate.

**Organic Constituents:** Three samples for analysis of organic compounds were taken: one for Volatile Organic Compounds (VOCs); the second for pesticides (pesticide screen); and the third for other organic compounds, referred to as the Gas Chromatograph/ Mass Spectrometer (GC/MS) sample. The type of analysis for each well was based on the use of the land, presence of oil-production activities, and the type of industry in the locality. Unfiltered ground water without any chemical preservative was collected for all of these samples. For VOCs, two 40-ml glass bottles were filled to the brim and sealed with teflon-lined caps. These bottles were kept from light and placed on ice. For the pesticides and GC/MS samples, 1-quart glass bottles were filled to the brim, sealed with teflon-lined caps, and placed on ice. All samples were delivered to the TDH laboratory, and analyses were completed within 7 days. Pesticide samples were analyzed according the EPA Method 608 for Organic Pesticides and PCBs and Method 509B for Chlorinated Phenoxy Acid Herbicides (American Public Health Association, 1985). Table 3 shows the detection limit for each species.

Other organic chemicals were analyzed according to EPA Methods 624 and 625 for GC/MS. Samples are screened for the EPA priority pollutants and other contaminants. All of these chemicals have quantitation limits which vary from the acid extractables to the base neutrals and represent a high confidence level. Occasionally a chemical may be reported at less than the quantitation limit, meaning that the chemical is probably present but the exact level cannot be stated with the required high degree of confidence of a reporting level.

**Radioactivity:** Ground water was filtered through a 0.45 μm nonmetallic filter into a 1-gallon polyethylene bottle. The sample was preserved with $HNO_3$, placed on ice, and delivered to the TDH laboratory. Analyses were completed within 6 months. Initially gross alpha ($\alpha$) and gross beta ($\beta$) radiation were determined, followed by radium-226 ($Ra^{226}$) and radium-228 ($Ra^{228}$).

**Field Measurements:** In addition to the field measurements of temperature, specific conductance, and pH which established that the well was stabilized, measurements of the alkalinity (by titration) and Eh (using a pH meter with an Eh electrode) were taken. Two types of alkalinity were determined for each well: phenolphthalein alkalinity as $CaCO_3$ and total alkalinity as $CaCO_3$. Both were done according to the TWDB procedures for alkalinity determination (Nordstrom and Adidas, 1990).

## Analytical Results

The results of the analyses for each well are presented in Appendices II through V. The wells are grouped according to county and well number. The well locations are shown in Figure 2. In this report the results will be discussed by major chemical group: Field Measurements, Dissolved Inorganic Constituents, Nutrients, Organic Constituents, and Radioactivity. Within each major chemical group, the results are further broken down according to the aquifer.

**Field Measurements**: These measurements were taken in the field at the time of sampling. The range of each measurement is presented along with the average value.

**Table 3.-Detection Limits for Organic Pesticides.**

| Organic Compound | Detection Limit (μg/l) |
|---|---|
| Aldrin | 0.20 |
| α-BHC | 0.03 |
| β-BHC | 0.03 |
| δ-BHC | 0.03 |
| Banvel | 5.0 |
| Chlordane (cis) | 0.02 |
| Chlordane (trans) | 0.02 |
| Chloropyrifos | 0.6 |
| Dacthal | 0.05 |
| Dicamba | 1.0 |
| Dieldrin | 0.10 |
| Dursban | 0.60 |
| DDD | 0.30 |
| DDE | 0.20 |
| DDT | 0.30 |
| Endrin | 0.2 |
| Endosulfan I | 0.2 |
| Endosulfan II | 0.2 |
| Endosulfan Sulfate | 0.2 |
| Hexachlorobenzene | 0.02 |
| Heptachlor | 0.02 |
| Heptachlor Epoxide | 0.06 |
| Lindane | 0.03 |
| Malathion | 0.40 |
| Methoxychlor | 0.50 |
| Mirex | 0.50 |
| Methyl Parathion | 0.25 |
| Ethyl Parathion | 0.25 |
| PCBs (aroclors) | 1.0 |
| Pentachlorophenol | 2.0 |
| Picloram | 3.0 |
| Silvex | 5.0 |
| Toxaphene | 5.0 |
| Treflan | 0.06 |
| 2,4-D | 20.0 |
| 2,4,5-T | 5.0 |

**Dissolved Inorganic Constituents**: These are the results of the laboratory analyses for dissolved cations, anions, and selected metals. The range of concentrations for each species is presented along with the average concentration.

**Nutrients**: These are the results of the laboratory analyses for nutrients. The range of concentrations for each species is presented along with the average concentration.

**Organic Constituents**: These are the results of the laboratory analyses for VOCs, pesticides, and GC/MS. Only those wells which detected the presence of any organic chemicals are listed. This study was the first time that the TWDB had analyzed the ground water of this area for organic chemicals.

**Radioactivity**: These are the results of the laboratory analyses for radioactivity. The range of concentrations for each species is presented along with the average concentration. This study was the first time that the TWDB had analyzed the ground water of this area for radioactivity.

The ten wells completed in the Queen City aquifer are located in Atascosa, Frio, and Wilson Counties. Queen City ground water is used for domestic and livestock uses, public supply, and industrial cooling. The 102 wells completed in the Carrizo aquifer are located in Atascosa, Bexar, Dimmit, Frio, Karnes, La Salle, Medina, Wilson, and Zavala Counties. Carrizo ground water is used primarily for irrigation, and also for domestic and stock purposes, public supply, and industrial processes and cooling. The seven wells completed in the Wilcox aquifer are located in Atascosa, Bexar, Dimmit, Medina, and Wilson Counties. Wilcox ground water is used for domestic and stock purposes, public supply, and industrial cooling.

The Texas Department of Health has set the primary and secondary Maximum Concentration Levels (MCLs) for water which is used for human consumption. The standards for selected inorganic constituents can be found in Table 4.

**Table 4.-Drinking Water Standards for Selected Inorganic Constituents as Set by the Texas Department of Health**

| | | |
|---|---|---|
| **Primary Constituent Levels** | | |
| Arsenic | As | 0.05 mg/l |
| Barium | Ba | 1.0 mg/l |
| Cadmium | Cd | 0.010 mg/l |
| Chromium | Cr | 0.05 mg/l |
| Fluoride | F | 4.0 mg/l |
| Lead | Pb | 0.05 mg/l |
| Mercury | Hg | 0.002 mg/l |
| Nitrate (as N) | $NO_3$ (N) | 10.0 mg/l |
| Selenium | Se | 0.01 mg/l |
| Silver | Ag | 0.05 mg/l |
| Gross Alpha | $\alpha$ | 15 pCi/l |
| Gross Beta | $\beta$ | 50 pCi/l |
| Radium | $Ra^{226} + Ra^{228}$ | 5 pCi/l |
| **Secondary Constituent Levels** | | |
| Chloride | Cl | 300 mg/l |
| Copper | Cu | 1.0 mg/l |
| Fluoride | F | 2.0 mg/l (community) |
| Iron | Fe | 0.3 mg/l |
| Manganese | Mn | 0.05 mg/l |
| pH | | >7.0 |
| Sulfate | $SO_4$ | 300 mg/l |
| Dissolved Solids | TDS | 1,000 mg/l |
| Zinc | Zn | 5.0 mg/l |

# FIELD MEASUREMENTS

The summary of the field measurements from the Queen City aquifer, Carrizo aquifer, and the Wilcox aquifer is found in Table 5.

**Table 5.-Field Measurements of the Ground Water of the Queen City, Carrizo, and Wilcox Aquifers.**

| | Range | Average |
|---|---|---|
| **Queen City Aquifer** | | |
| Temperature | 25.3 - 37.5°C | 28.7°C |
| Specific Conductance | 505 - 2,750 μmho | 1,360 μmho |
| pH | 6 - 8.5 | 7.7 |
| Eh | -227.1 - -100.0 mV | -177.9 mV |
| Phenol Alkalinity | 0 - 16 mg/l | 3 mg/l |
| Total Alkalinity | 73 - 715 mg/l | 341 mg/l |
| **Carrizo Aquifer** | | |
| Temperature | 14.4 - 64.4°C | 31.1°C |
| Specific Conductance | 136 - 5,870 μmho | 1,082 μmho |
| pH | 5.3 - 8.5 | 7.1 |
| Eh | -92.5 - +281.1 mV | +105.3 mV |
| Phenol Alkalinity | 0 - 8 mg/l | 0 mg/l |
| Total Alkalinity | 7 - 987 mg/l | 272 mg/l |
| **Wilcox Aquifer** | | |
| Temperature | 24.5 - 26.9°C | 25.9°C |
| Specific Conductance | 750 - 3,700 μmho | 1,666 μmho |
| pH | 6.9 - 8.5 | 7.2 |
| Eh | -136.5 - +156.9 mV | -31.3 mV |
| Phenol Alkalinity | 0 - 8 mg/l | 1.1 mg/l |
| Total Alkalinity | 293 - 639 mg/l | 397 mg/l |

## Queen City Aquifer

The average temperature was 28.7°C. The pH was essentially neutral, ranging from 6.0 to 8.5 with an average of 7.7. The specific conductance ranged from 505 to 2750 μmhos, with an average of 1360 μmhos. The Eh ranged from -227.1 to -100.0 mV, with an average of -177.9 mV, indicating that this water is of a reducing nature. Phenolphthalein alkalinity (as $CaCO_3$) averaged 3 mg/l. Total alkalinity (as $CaCO_3$) averaged 341 mg/l.

## Carrizo Aquifer

The average temperature was 31.1°C. The pH was essentially neutral, ranging from 5.3 to 8.5 with an average of 7.1. The specific conductance ranged from 136 to 5870 μmhos with an average of 1082 μmhos. The Eh ranged from -92.5 to +281.1 mV, with an average of 105.3 mV, indicating that the ground water is oxidizing in nature. Phenolphthalein alkalinity (as $CaCO_3$) averaged zero. Total alkalinity (as $CaCO_3$) averaged 272 mg/l.

## Wilcox Aquifer

The average temperature was 25.9°C. The pH was essentially neutral, ranging from 6.9 to 8.5 with an average of 7.2. The specific conductance ranged from 750 to 3700 μmhos with an average of 1666 μmhos. The Eh ranged from -136.5 to +156.9 mV, with an average of -31.3 mV, indicating that the water is slightly reducing in nature. Phenolphthalein alkalinity (as $CaCO_3$) averaged 1.1 mg/l. Total alkalinity (as $CaCO_3$) averaged 397 mg/l.

# DISSOLVED INORGANIC CONSTITUENTS

Most of the water samples collected from area wells met drinking water standards for dissolved inorganic constituents. However, several wells in all three formations had some constituents in excess of the MCLs. These constituents were:

**Iron**: On exposure to air, iron in ground water oxidizes to form a reddish-brown precipitate. More than 300 µg/l iron in water can stain laundry and utensils. Larger quantities can cause an unpleasant taste and promote the growth of iron bacteria. Ground water which contains iron in excess of drinking water standards is not recommended for domestic use unless some kind of water treatment or filter system is used.

**Chloride**: Chloride is naturally dissolved from rocks and soils. It is present in sewage and is found in large amounts in oil-field brines, seawater, and industrial brines. In large amounts in combination with sodium, it gives a salty taste to drinking water. It can increase the corrosiveness of the water.

**Manganese**: Small amounts of manganese are found naturally in limestones and dolomites where it substitutes for calcium in the chemical structure and in clay minerals formed from the weathering of these carbonate rocks. In aqueous solution, divalent manganese commonly precipitates to form coatings of manganese oxide (desert varnish). Ground water which contains manganese in excess of drinking water standards is not recommended for domestic use unless some kind of water treatment or filter system is used.

**Dissolved Solids**: Dissolved solids are primarily mineral constituents dissolved from the rock. The TDH recommends that waters containing more than 1000 mg/l not be used if other less mineralized supplies are available. Ground water which contains dissolved solids in excess of drinking water standards is not recommended for domestic use unless some kind of water treatment or filter system is used.

**Sulfate**: Sulfate is naturally formed by the dissolution of sulfur from rocks and soils containing sulfur compounds such as gypsum and iron sulfide. In large amounts, sulfate in combination with other ions gives a bitter taste to drinking water.

**Zinc**: Zinc is a common element in the earth's crust, and it is an essential trace mineral for humans. Ground water from wells which exceed drinking water standards is not recommended for domestic use unless some kind of water treatment or filter system is used.

An analytical term used frequently is **hardness**, which is a calculation based on dissolved alkali earth metals. The property of hardness is associated primarily with reactions of water and soap; as the hardness increases, so does the soap-consuming ability of the water. Hard water forms scale in boilers, water heaters, and pipes. Hardness in excess of 180 mg/l is considered to be very hard. For general domestic use, the hardness of water is not particularly objectionable until it attains about 100 mg/l. Water softeners can be used to alleviate hard water and its associated problems.

A summary of the laboratory analyses of the dissolved inorganic constituents of the Queen City ground water is found in Table 6. The trilinear diagram in Figure 3 shows that the "typical" Queen City aquifer ground water from wells sampled in 1990 is a sodium-mixed cation - bicarbonate-mixed anion type. The lack of a dominant cation-anion mix is probably due to the small number of wells sampled, the varying depth of the aquifer, and the range of climatic conditions found across the region where these wells are completed.

**Table 6. Dissolved Inorganic Constituents in the Queen City Aquifer Ground Water.**

| Constituent | Concentration Range | Average Conc. |
|---|---|---|
| Aluminum | Below detection limit | — |
| Arsenic | Below detection limit | — |
| Barium | 33 - 162 μg/l | 60 μg/l |
| Boron | 240 - 1540 μg/l | 698 μg/l |
| Bromide | 0.11 - 1.10 mg/l | 0.66 mg/l |
| Cadmium | Below detection limit | — |
| Calcium | 2 - 170 mg/l | 56 mg/l |
| Chloride | 40 - 492 mg/l | 181 mg/l |
| Chromium | Below detection limit | — |
| Copper | Below detection limit | — |
| Dissolved Solids | 400 - 1563 mg/l | 858 mg/l |
| Fluoride | 0.2 - 0.9 mg/l | 0.5 mg/l |
| Hardness | 6 - 703 mg/l | 224 mg/l |
| Iodide | <0.1 - 1.77 mg/l | 0.44 mg/l |
| Iron | 34 - 2980 μg/l | 934 μg/l |
| Lead | Below detection limit | — |
| Magnesium | 0 - 68 mg/l | 20 mg/l |
| Manganese | <20 - 234 μg/l | 56 μg/l |
| Mercury | Below detection limit | — |
| Molybdenum | Below detection limit | — |
| Potassium | 3 - 19 mg/l | 10 mg/l |
| Selenium | Below detection limit | — |
| Silica | 15 - 92 mg/l | 29 mg/l |
| Silver | Below detection limit | — |
| Sodium | 33 - 400 mg/l | 233 mg/l |
| Strontium | <200 - 5350 μg/l | 1324 μg/l |
| Sulfate | 22 - 376 mg/l | 159 mg/l |
| Vanadium | Below detection limit | — |
| Zinc | <20 - 177 μg/l | 59 μg/l |

Average concentrations for calcium, magnesium, strontium, and barium were 56 mg/l, 20 mg/l, 1.324 mg/l, and .060 mg/l, respectively. Hardness of the Queen City ground water, which is calculated using these values, ranged from 6 to 703 mg/l with an average of 224 mg/l. Water softeners are recommended for most purposes when using this ground water.

Two other major cation species measured were sodium and potassium, which averaged 233 mg/l and 10 mg/l, respectively. There are no MCLs established for these elements. The following elements tested below detection limits: aluminum, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, silver, and vanadium.

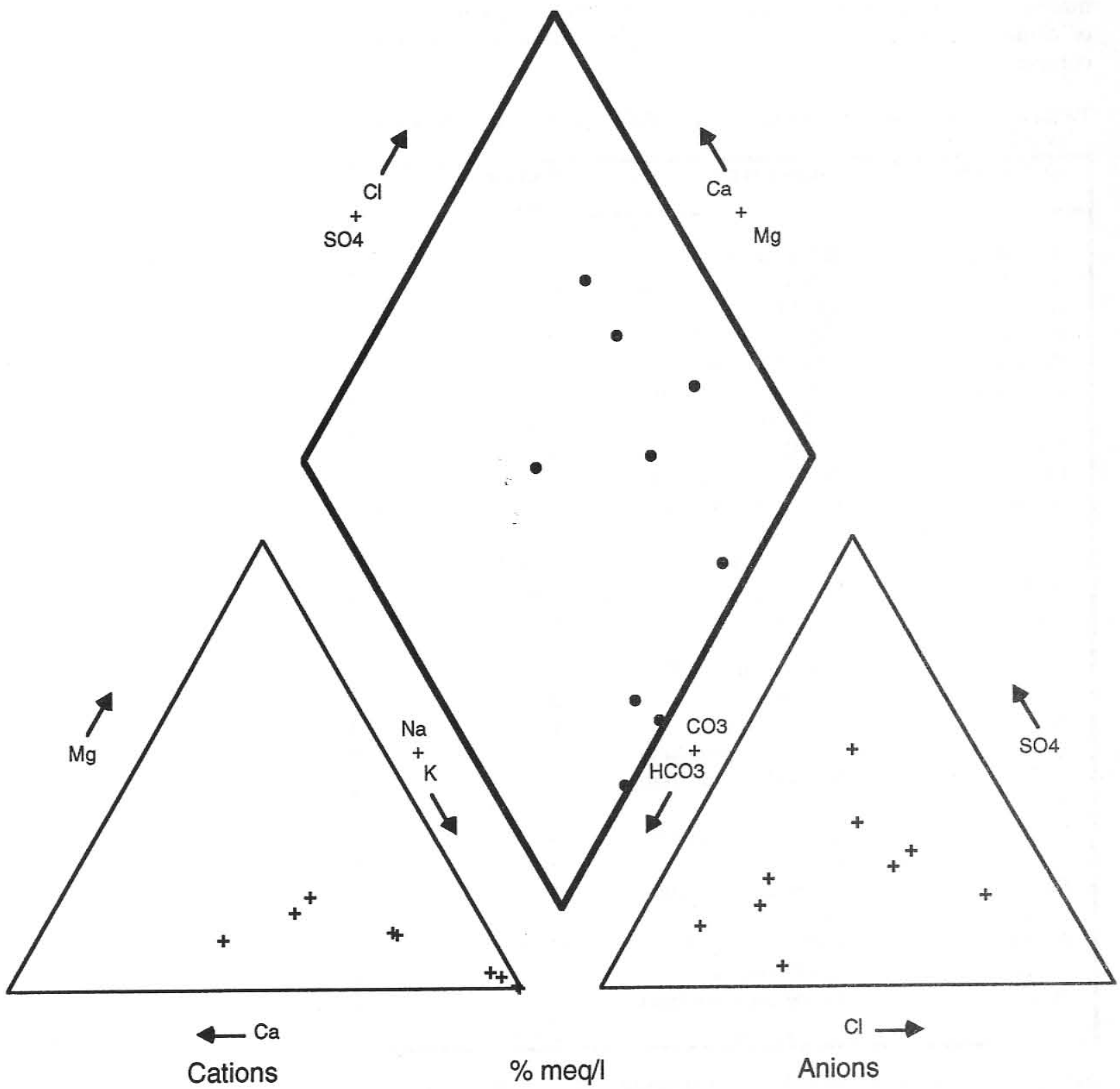


**Figure 3. Trilinear Diagram of the Queen City Aquifer Water**

Two elements were present in Queen City ground water but below the allowed MCLs or secondary levels in all wells. These elements and their average concentrations included: fluoride, 0.5 mg/l; and zinc, 0.059 mg/l.

Four other dissolved species were measured: boron, bromide, iodide, and silica. The average measurements of these were 0.2 mg/l, 0.238 mg/l, 0.44 mg/l, and 18 mg/l, respectively. There are no established MCLs for these species.

Five wells had constituents which exceeded drinking water standards:

**68-59-922 (Atascosa)**
Sulfate was 376 mg/l
Chloride was 417 mg/l
Dissolved Solids was 1563 mg/l
Iron was 2980 μg/l
Manganese was 70 μg/l

**77-16-408 (Frio)**
Chloride was 336 mg/l
Iron was 325 μg/l

**78-02-709 (Frio)**
Chloride was 492 mg/l
Dissolved Solids was 1290 mg/l
Iron was 744 μg/l
Manganese was 84 μg/l

**68-55-502 (Wilson)**
Chloride was 336 mg/l
Dissolved Solids was 1312 mg/l
Iron was 1120 μg/l
Manganese was 234 μg/l

**68-62-507 (Wilson)**
Iron was 2190 μg/l

The constituents exceeded were iron (5 wells); chloride (4 wells); dissolved solids (3 wells); manganese (3 wells); and sulfate (1 well). All are thought to be produced from natural processes, which are discussed in more detail in the following section on the Carrizo aquifer. Water treatment systems or filters are recommended if water from these wells is used for domestic purposes.

## Carrizo Aquifer

A summary of the laboratory analyses of the dissolved inorganic constituents of ground water of the Carrizo aquifer is found in Table 7. A trilinear diagram of Carrizo aquifer wells is shown in Figure 4. The "typical" Carrizo ground water from wells sampled in 1990 is a sodium-mixed cation-calcium - bicarbonate-mixed anion-chloride type.

Hamlin (1988) found that Carrizo ground water has initial composition variability in the outcrop, but becomes dominated by sodium and bicarbonate as depth and distance along flow paths increase. Exceptions to this trend can be found in two areas: 1) the southwestern counties where clay content is the greatest and chloride and sulfate ground waters develop as a result; and 2) a strike-aligned belt across Atascosa, Frio, and Zavala Counties where dissolution of caliche (calcium carbonate) allows the development of calcium-bicarbonate ground waters.

**Table 7.- Dissolved Inorganic Constituents in the Carrizo Aquifer Ground Water.**

| Constituent | Concentration Range | Average Conc. |
|---|---|---|
| Aluminum | Below detection limit | — |
| Arsenic | <10 - 10 µg/l | — |
| Barium | <20 - 386 µg/l | 100 µg/l |
| Boron | 60 - 6510 µg/l | 670 µg/l |
| Bromide | <0.1 - 32 mg/l | 0.94 mg/l |
| Cadmium | Below detection limit | — |
| Calcium | 2 - 370 mg/l | 59 mg/l |
| Chloride | 5 - 1637 mg/l | 157 mg/l |
| Chromium | Below detection limit | — |
| Copper | Below detection limit | — |
| Dissolved Solids | 91 - 4103 mg/l | 714 mg/l |
| Fluoride | 0.1 - 3.3 mg/l | 0.9 mg/l |
| Hardness | 6 - 1161 mg/l | 202 mg/l |
| Iodide | <0.1 - 0.82 mg/l | — |
| Iron | <20 - 6860 µg/l | 668 µg/l |
| Lead | Below detection limit | — |
| Magnesium | 1 - 85 mg/l | 13 mg/l |
| Manganese | <20 - 552 µg/l | 36 µg/l |
| Mercury | <0.2 - 0.2 µg/l | — |
| Molybdenum | Below detection limit | — |
| Potassium | 2 - 26 mg/l | 7 mg/l |
| Selenium | <2 - 10 µg/l | — |
| Silica | 13 - 60 mg/l | 22 mg/l |
| Silver | Below detection limit | — |
| Sodium | 13 - 1390 mg/l | 175 mg/l |
| Strontium | <200 - 6600 µg/l | 793 µg/l |
| Sulfate | 10 - 1352 mg/l | 138 mg/l |
| Vanadium | <20 - 22 µg/l | — |
| Zinc | <20 - 4030 µg/l | 85 µg/l |

Average concentrations for calcium, magnesium, strontium, and barium were 59 mg/l, 13 mg/l, 0.793 mg/l, and 0.100 mg/l, respectively. Hardness of the Carrizo ground water, which is calculated using these values, ranged from 6 to 1161 mg/l with an average of 202 mg/l. Water softeners are recommended for most purposes when using this ground water.

Two other major cation species measured were sodium and potassium, which averaged 175 mg/l and 7 mg/l, respectively. There are no MCLs established for these elements.

The following elements tested below detection limits: aluminum, cadmium, chromium, copper, lead, molybdenum, and silver. Three elements measured below detection limits in all but one well each: arsenic (well #69-58-707 had 10 µg/l); mercury (well #69-62-902 had 0.2 µg/l); and vanadium (well #76-48-802 had 22 µg/l). These measurements are below the established MCLs, except for vanadium which has no MCL.

Fluoride had an average concentration of 0.9 mg/l, which is below the MCl for that element. Twelve wells had detectable amounts of selenium, ranging up to 10 µg/l, but none exceeded the established MCL.

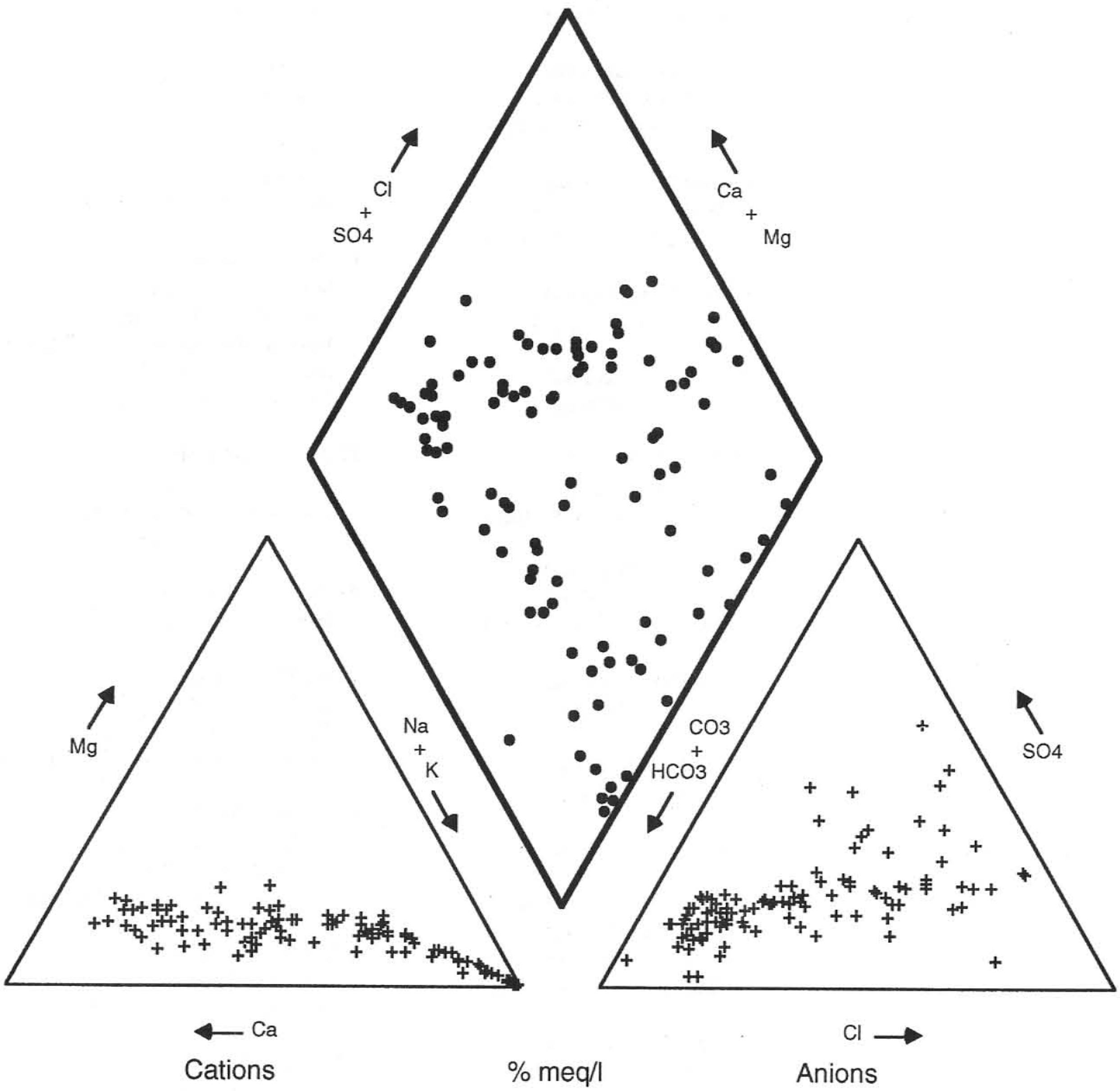


**Figure 4. Trilinear Diagram of the Carrizo Aquifer Water**

Average results for four other dissolved species were: boron (0.670 mg/l); bromide (0.94 mg/l); iodide (below detection limits); and silica (22 mg/l). There are no established MCLs for these species.

Fifty wells had constituents which exceeded drinking water standards:

**68-51-701 (Atascosa)**
Iron was 1070 µg/l

**68-52-709 (Atascosa)**
Iron was 2920 µg/l
Manganese was 54 µg/l

**68-59-614 (Atascosa)**
Iron was 4030 µg/l
Manganese was 98 µg/l

**68-60-527 (Atascosa)**
Iron was 1310 µg/l

**68-61-207 (Atascosa)**
Iron was 0986 µg/l

**68-61-905 (Atascosa)**
Iron was 392 µg/l
Manganese was 60 µg/l

**78-03-601 (Atascosa)**
Iron was 2810 µg/l
Manganese was 85 µg/l

**78-04-104 (Atascosa)**
Iron was 418 µg/l

**78-11-217 (Atascosa)**
Iron was 572 µg/l

**78-12-502 (Atascosa)**
Sulfate was 1352 mg/l
Chloride was 563 mg/l
Dissolved Solids were 3074 mg/l
Iron was 1420 µg/l
Manganese was 192 µg/l

**78-20-801 (Atascosa)**
Iron was 1090 µg/l

**68-46-801 (Bexar)**
Sulfate was 359 mg/l
Dissolved Solids were 1054 mg/l
Iron was 671 µg/l

**68-53-809 (Bexar)**
Iron was 654 µg/l

**77-18-710 (Dimmit)**
Iron was 334 µg/l

**77-18-904 (Dimmit)**
Iron was 697 µg/l

**77-25-205 (Dimmit)**
Iron was 797 µg/l
Manganese was 188 µg/l

**77-28-503 (Dimmit)**
Sulfate was 321 mg/l
Chloride was 659 mg/l
Dissolved Solids were 1790 mg/l
Iron was 1090 µg/l
Manganese was 70 µg/l

**77-33-309 (Dimmit)**
Iron was 1150 µg/l
Manganese was 552 µg/l
Zinc was 4.030 mg/l

**77-33-611 (Dimmit)**
Iron was 1620 µg/l

**77-35-802 (Dimmit)**
Sulfate was 789 mg/l
Chloride was 1057 mg/l
Dissolved Solids were 3180 mg/l

**77-37-501 (Dimmit)**
Sulfate was 431 mg/l
Chloride was 822 mg/l
Dissolved Solids were 2937 mg/l

**77-41-201 (Dimmit)**
Iron was 1200 µg/l
Manganese was 69 µg/l

**77-42-801 (Dimmit)**
Iron was 865 µg/l

**68-57-619 (Frio)**
Iron was 6860 µg/l
Manganese was 88 µg/l

**68-58-506 (Frio)**
Iron was 493 µg/l

**69-62-902 (Frio)**
Iron was 691 µg/l

**77-06-301 (Frio)**
Iron was 471 µg/l

**77-08-201 (Frio)**
Iron was 4270 µg/l
Manganese was 107 µg/l

**77-16-408 (Frio)**
Iron was 325 µg/l

**77-16-603 (Frio)**
Iron was 386 µg/l

**77-23-305 (Frio)**
Iron was 429 µg/l

**77-23-808 (Frio)**
Iron was 943 µg/l

**78-01-501 (Frio)**
Iron was 58 µg/l

**78-02-701 (Frio)**
Iron was 728 µg/l
Manganese was 51 µg/l

**78-09-503 (Frio)**
Iron was 312 µg/l

**78-18-501 (Frio)**
Chloride was 1276 mg/l
Dissolved Solids were 2894 mg/l
Iron was 796 µg/l

**77-47-802 (La Salle)**
Sulfate was 1343 mg/l
Chloride was 944 mg/l
Dissolved Solids were 3925 mg/l

**68-49-606 (Medina)**
Sulfate was 468 mg/l
Chloride was 1015 mg/l
Dissolved Solids were 2658 mg/l

**68-58-101 (Medina)**
Iron was 3040 µg/l
Zinc was 1.410 mg/l

**69-56-903 (Medina)**
Iron was 1510 µg/l
Manganese was 204 µg/l

**67-41-801 (Wilson)**
Iron was 3770 µg/l
Manganese was 124 µg/l

**67-49-201 (Wilson)**
Manganese was 73 µg/l

**68-48-601 (Wilson)**
Iron was 859 µg/l

**68-62-205 (Wilson)**
Iron was 6060 µg/l
Manganese was 79 µg/l
Dissolved Solids were 3387 mg/l
Manganese was 285 µg/l

**77-01-404 (Zavala)**
Iron was 1020 µg/l
Manganese was 57 µg/l

**77-03-403 (Zavala)**
Sulfate was 395 mg/l
Chloride was 409 mg/l
Dissolved Solids were 1420 mg/l
Iron was 1040 µg/l

**77-11-701 (Zavala)**
Iron was 634 µg/l
Manganese was 60 µg/l

**77-20-101 (Zavala)**
Sulfate was 341 mg/l
Chloride was 570 mg/l
Dissolved Solids were 1685 mg/l

The constituents exceeded were iron (43 wells); manganese (20 wells); dissolved solids (12 wells); chloride (11 wells); sulfate (11 wells); and zinc (2 wells). All are thought to be produced from natural processes, and water treatment systems or filters are recommended if this water is to be used for domestic purposes.

Iron is abundant within the Carrizo Sand, giving the sandstone its red color in the outcrop. The probable source of the iron was the transport of weathered material from the west and northwest. Figure 5 shows Carrizo wells and the iron concentrations of each.

Manganese is also found in trace amounts in the Carrizo aquifer. The probable source of the manganese was the transport of weathered material from the west and northwest. Manganese can substitute in clay minerals for other more common clay-forming elements. Figure 6 shows Carrizo wells and the manganese concentrations of each.

The dissolved solids content of ground water usually increases with depth and/or length of time that the ground water is in contact with soluble minerals. In localized areas within the Carrizo, deteriorating water quality is being caused by excessive pumpage and poorly cemented well casing.

As the hydraulic gradient is artificially changed by excessive pumpage, more saline water from the overlying Bigford and Queen City aquifers leaks into the Carrizo. McCoy (1991) identified two areas where the Carrizo aquifer is being de-watered: (1) the Carrizo Springs-Crystal City portions of Dimmit and Zavala Counties, and (2) northeastern Zavala County. This second area extends into Frio and Medina Counties. Ground water from the Bigford and Queen City aquifers is also leaking into the Carrizo via casing leaks in poorly constructed wells.

The excessive chloride content observed in some Carrizo wells is probably also caused by interformational leakage from the Bigford and the Queen City aquifers. Most wells which have excessive chloride content also have excessive dissolved solids.

Excessive sulfate content observed in some Carrizo wells is probably caused by the dissolution of naturally occurring sulfur minerals such as pyrite (iron sulfate) and gypsum. Weathered anhydrite and gypsum to the north and west probably provided the source for the original sulfate.

In addition to leaking casing and poorly cemented wells allowing poorer quality water into the Carrizo aquifer, another potential source of pollution is contamination from oil production activities. This pollution may be caused by (1.) leaching of salt beneath abandoned salt-water disposal pits; (2.) illegal dumping of produced salt water onto the surrounding land or into surface streams; (3.) leaky well casing, either in producing wells or salt-water injection wells; and (4.) improperly plugged or abandoned wells, core holes, or shot holes. Based upon computer calculations and ionic ratio analyses, no evidence of pollution from oil producing activites was found.

Zinc is found in trace amounts in the Carrizo. The probable source of the zinc was the transport of weathered material from the west and north.

## Wilcox Aquifer

A summary of the laboratory analyses of the dissolved inorganic constituents of Wilcox aquifer ground water is found in Table 8. The trilinear diagram in Figure 7 shows the "typical" Wilcox ground water from the wells sampled in 1990 is a sodium-mixed cation - bicarbonate-mixed anion type. The lack of a dominant cation-anion mix is probably the result of the small number of wells sampled, the varying depth of the aquifer, and the range of climatic conditions found across the region where these wells are completed.

**Table 8.-Dissolved Inorganic Constituents in the Wilcox Aquifer Ground Water.**

| Constituent | Concentration Range | Average Conc. |
|---|---|---|
| Aluminum | Below detection limit | — |
| Arsenic | Below detection limit | — |
| Barium | <20 - 166 µg/l | 66 µg/l |
| Boron | 480 - 1100 µg/l | 717 µg/l |
| Bromide | 0.1 - 1.46 mg/l | 0.38 mg/l |
| Cadmium | Below detection limit | — |
| Calcium | 9 - 117 mg/l | 68 mg/l |
| Chloride | 135 - 239 mg/l | 191 mg/l |
| Chromium | Below detection limit | — |
| Copper | Below detection limit | — |
| Dissolved Solids | 449 - 1275 mg/l | 1144 mg/l |
| Fluoride | 0.3 - 0.6 mg/l | 0.4 mg/l |
| Hardness | 35 - 420 mg/l | 287 mg/l |
| Iodide | <0.1 - 0.2 mg/l | — |
| Iron | 105 - 2570 µg/l | 778 µg/l |
| Lead | Below detection limit | — |
| Magnesium | 3 - 61 mg/l | 28 mg/l |
| Manganese | <20 - 150 µg/l | 46 µg/l |
| Mercury | Below detection limit | — |
| Molybdenum | Below detection limit | — |
| Potassium | 6 - 18 mg/l | 10 mg/l |
| Selenium | Below detection limit | — |
| Silica | 9 - 25 mg/l | 19 mg/l |
| Silver | Below detection limit | — |
| Sodium | 49 - 797 mg/l | 306 mg/l |
| Strontium | 310 - 4080 µg/l | 1707 µg/l |
| Sulfate | 62 - 399 mg/l | 224 mg/l |
| Vanadium | Below detection limit | — |
| Zinc | <20 - 2650 µg/l | 391 µg/l |

Average concentrations for calcium, magnesium, strontium, and barium were 68 mg/l, 28 mg/l, 1.707 mg/l, and .066 mg/l, respectively. Hardness of the Wilcox ground water, which is calculated using these values, ranged from 35 to 420 mg/l with an average of 287 mg/l. Water softeners are recommended for most purposes when using this ground water.

Two other major cation species measured were sodium and potassium, which averaged 306 mg/l and 10 mg/l, respectively. There are no MCLs established for these elements.

The following elements tested below detection limits: aluminum, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, silver, and vanadium. Two elements were present in Wilcox ground water but below the allowed MCLs or secondary levels in all wells: fluoride (0.6 mg/l average); and zinc (0.391 mg/l average).

Average results for four other dissolved species were: boron (0.660 mg/l); bromide (0.38 mg/l); iodide (below detection limits); and silica (19 mg/l). There are no established MCLs for these species.

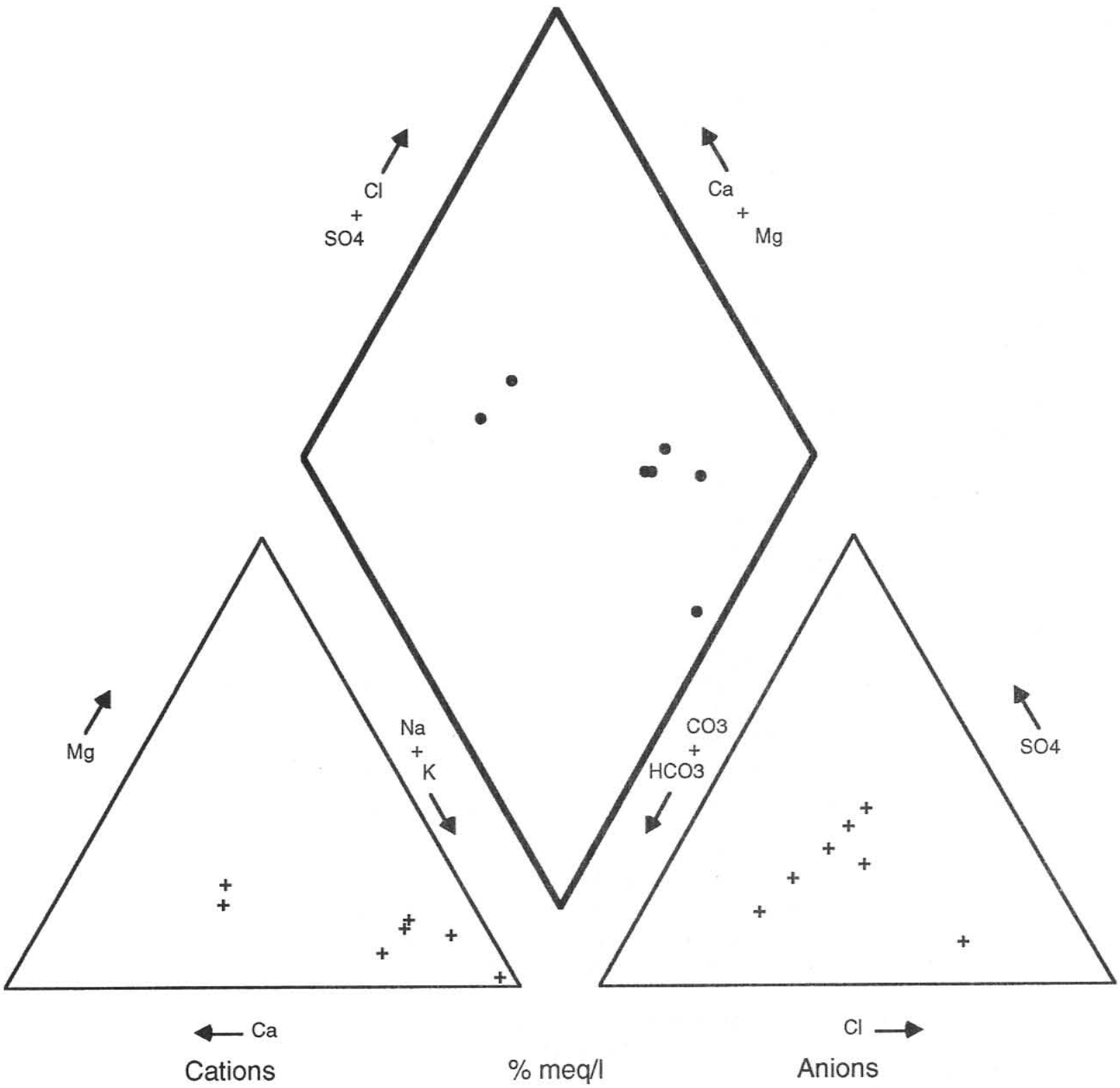


**Figure 7. Trilinear Diagram of the Wilcox Aquifer Water**

Six wells had constituents which exceeded drinking water standards:

**68-50-603 (Atascosa)**
Iron was 1830 μg/l
Manganese was 150 μg/l

**68-52-405 (Bexar)**
Iron was 472 μg/l
Manganese was 80 μg/l

**76-48-401 (Dimmit)**
Dissolved Solids were 1268 mg/l
Manganese was 66 μg/l
Zinc was 2.650 mg/l

**69-54-601 (Medina)**
Chloride was 1008 mg/l
Dissolved Solids were 2476 mg/l
Iron was 2570 μg/l

**68-47-303 (Wilson)**
Sulfate was 399 mg/l
Dissolved Solids were 1275 mg/l

**68-48-102 (Wilson)**
Dissolved Solids were 1051 mg/l

The constituents exceeded were dissolved solids (4 wells); iron (3 wells); manganese (3 wells); chloride (1 well); sulfate (1 well); and zinc (1 well). All are thought to be produced from natural processes, which are discussed in more detail in the preceding section on the Carrizo aquifer. Water treatment systems or filters are recommended if water from these wells is used for domestic purposes.

## NUTRIENTS

Five nutrients were analyzed in each well: nitrate, nitrite, Kjeldahl, ammonia, and orthophosphate. Of these, only nitrate has a drinking water standard.

Because of the heavy agricultural usage of the land in the study area, nitrate may be among the potential pollutants found in the region. Nitrate ($NO_3$) is a derivative of nitric acid and is one of the most important nutrient species. It is an end product of the aerobic stabilization of nitrogen, particularly organic nitrogen. Nitrate is used extensively as a fertilizer, as a food preservative, and as an oxidizing agent in the chemical industry. Nitrates are particularly detectable in soil and, therefore, ground water (De Zuane, 1990). Higher concentrations of nitrate in ground water should be expected where fertilizers are used, in decayed animal and vegetable matter, in leachates from sludge and refuse disposal, and in industrial discharges. The nitrate concentration of natural waters should always be higher than the nitrite concentration.

Nitrite ($NO_2^{2-}$) is a derivative of nitrous acid. It is formed by the action of bacteria upon ammonia and organic nitrogen. Nitrite is not found as abundantly as nitrate in the environment because it is oxidized to form nitrate. Nitrite is used in industry as a food preservative (sodium and potassium salts), particularly in meat and cheese. When nitrite is detected in potable water in considerable amounts, it is an indication of sewage/bacterial contamination and inadequate disinfection. (De Zuane, 1990). Large concentrations of nitrite in water may result in the potential formation of carcinogenic nitrosamines in the bloodstream. There is no MCL for nitrite.

No infant under the age of six months should drink ground water or any formula prepared from ground water which contains more than 10 mg/l nitrate (as N) because it is known to cause methemoglobinemia, a sometimes fatal illness related to the impairment of the oxygen-carrying ability of the blood. Partial reduction of nitrates to nitrites takes place in human saliva and in the gastrointestinal tract of infants. Nitrite oxidizes the hemoglobin in the blood to methemoglobin, which is not an oxygen carrier. This may lead to anoxia and result in death (De Zuane, 1990).

The Kjeldahl value includes the amount of total organic nitrogen plus ammonia (as N) in the water. To find the amount of organic nitrogen, the ammonia concentration is subtracted from the Kjeldahl value. There are no MCLs for ammonia or Kjeldahl. The presence of nitrate, nitrite, and ammonia in water are indicators of pollution.

Phosphate ($PO_4^{3-}$) in nature is found in phosphate rock and in the mineral apatite. It is an important source of the insoluble element phosphorous. Phosphate is also the inorganic component of bones and teeth. Water supplies may contain phosphate derived from natural contact with minerals or through pollution from the application of fertilizers, sewage, and industrial waste. The measurements reported in this study are only for the phosphorous content of orthophosphate, the type of phosphate used in fertilizers. There is no MCL for phosphorous.

A summary of the laboratory analyses for nutrients of the ground water of the Queen City, Carrizo, and Wilcox aquifers is found in Table 9.

**Table 9. Dissolved Nutrients of the Ground Water of the Queen City, Carrizo, and Wilcox Aquifers.**

| Queen City Aquifer | | |
|---|---|---|
| | **Range** | **Average** |
| Nitrate (N) | 0.04 - 0.10 mg/l | 0.07 mg/l |
| Ammonia (N) | 0.05 - 0.67 mg/l | 0.23 mg/l |
| Kjeldahl (N) | 0.3 - 1.2 mg/l | 0.6 mg/l |
| Nitrite (N) | <0.01 mg/l | <0.01 mg/l |
| Orthophosphate (P) | <0.01 - 0.15 mg/l | 0.08 mg/l |
| **Carrizo Aquifer** | | |
| | **Range** | **Average** |
| Nitrate (N) | <0.01 - 5.21 mg/l | 0.36 mg/l |
| Ammonia (N) | <0.02 - 1.11 mg/l | 0.17 mg/l |
| Kjeldahl (N) | <0.1 - 1.5 mg/l | 0.3 mg/l |
| Nitrite (N) | <0.01 - 0.01 mg/l | <0.01 mg/l |
| Orthophosphate (P) | <0.01 - 0.09 mg/l | <0.01 mg/l |
| **Wilcox Aquifer** | | |
| | **Range** | **Average** |
| Nitrate (N) | <0.01 - 1.86 mg/l | 0.27 mg/l |
| Ammonia (N) | 0.03 - 1.88 mg/l | 0.59 mg/l |
| Kjeldahl (N) | 0.2 - 2.0 mg/l | 0.9 mg/l |
| Nitrite (N) | <0.01 mg/l | <0.01 mg/l |
| Orthophosphate (P) | <0.01 - 0.11 mg/l | 0.03 mg/l |

## Queen City Aquifer

The average concentration of nitrate (as N) in the Queen City aquifer was 0.07 mg/l. None of the analyses from the eight wells completed in the Queen City aquifer indicated concentrations that exceeded the MCL for nitrate.

The Kjeldahl value includes the amount of total organic nitrogen plus ammonia (as N) in the water. The average Kjeldahl value for the Queen City aquifer wells was 0.6 mg/l. Ammonia averaged 0.08 mg/l in these wells, indicating that most of the nitrogen is organic in nature.

Nitrite measurements were below detection limits in all Queen City wells. The average concentration of phosphorous (as orthophosphate) was 0.08 mg/l.

## Carrizo Aquifer

The average concentration of nitrate (as N) in the Carrizo aquifer was 0.36 mg/l. None of the analyses from wells completed in the Carrizo aquifer indictade concentrations that exceeded the MCL for nitrate.

The Kjeldahl value includes the amount of total organic nitrogen plus ammonia (as N) in the water. The average Kjeldahl value for the Carrizo aquifer wells was 0.3 mg/l. Ammonia averaged 0.17 mg/l in these wells, indicating that approximately half of the nitrogen is organic in nature.

Nitrite measurements averaged below detection limits. The average concentration of phosphorous (as orthophosphate) was also below detection limits.

## Wilcox Aquifer

The average concentration of nitrate (as N) in the Wilcox aquifer was 0.27 mg/l. None of the analyses from wells completed in the Wilcox aquifer indicated concentrations that exceeded the MCL for nitrate.

The Kjeldahl value includes the amount of total organic nitrogen plus ammonia (as N) in the water. The average Kjeldahl value for the Wilcox aquifer wells was 0.9 mg/l. Ammonia averaged 0.59 mg/l in these wells, indicating that less than half of the nitrogen is organic in nature.

Nitrite measurements averaged below detection limits. The average concentration of phosphorous (as orthophosphate) was 0.03 mg/l.

# ORGANIC CONSTITUENTS

There are millions of synthetic organic chemicals in use throughout the world. Some are known by their "official name" as designated by the International Union of Pure and Applied Chemistry (IUPAC) and others by their commercial name. In the United States alone, over 700 synthetic organic chemicals have been identified in drinking water. Many organic chemicals have no drinking water standards.

Because of the great number of potential chemical pollutants, three separate analyses for organic compounds were used: one for Volatile Organic Compounds (VOCs); the second for pesticides (pesticide screen); and the third for other organic compounds, referred to as the Gas Chromatograph/ Mass Spectrometer (GC/MS) sample. Of primary importance were the priority pollutants designated by the United States Environmental Protection Agency (USEPA). All three analyses screened for these pollutants and also identified any others which may have been present. The type of analysis for each well was based on the use of the land (agricultural, pasture, etc.), presence of oil-production activities, and the type of industry in the locality.

In reporting organic chemicals, the term "quantitation limit" is used in addition to detection limit. The quantitation limit is the real reporting limit and is about 10 times as great as the detection limit of the instrument. This quantitation limit gives a very high confidence interval for the reported value (Boyer, pers. comm.). Occasionally there may be organic chemicals present in the sample but not at quantitation levels. These chemicals are listed; but since they do not have the high confidence interval of the reporting level, the well should be sampled a second time to confirm the presence of the contaminant. Even if the contaminant is confirmed, in most cases the amounts are so small as to be negligible.

## Queen City Aquifer

There were no detectable organic chemicals present in the ground water from the Queen City aquifer.

## Carrizo Aquifer

None of the analyses from the wells completed in the Carrizo aquifer had any measurable amounts of pesticides or VOCs. From the GC/MS analysis, 14 wells had detectable amounts of 15 organic chemicals:

**68-53-809 (Bexar)**

Bis-phenol-A was 230 µg/l
Ethylhexanol was 92 µg/l
Phenol was 36 µg/l
Bis (2-ethylhexyl) phthalate was 7 µg/l
* Ethylmethyl phenol was 2 µg/l
* (Methylethyl) phenol was 5 µg/l
* (Hydroxyphenyl)methylethyl phenol was 5 µg/l
* Phenylethanone was 5 µg/l
** Cyclohexanone was 4 µg/l
* Pentylcyclopropane was 4 µg/l

**77-18-904 (Dimmit)**
** Cyclohexanone was 6 µg/l

**77-19-810 (Dimmit)**
** Cyclohexanone was 6 µg/l
* Butylbenzyl phthalate was 4 µg/l

**77-26-610 (Dimmit)**
* Trimethylcyclopentane was 5 µg/l

**77-28-503 (Dimmit)**
Propene was 6 µg/l

**77-33-309 (Dimmit)**
* Butylbenzyl phthalate was 1 µg/l

**77-33-611 (Dimmit)**
** Cyclohexanone was 5 µg/l
* Butylbenzyl phthalate was 3 µg/l

**77-34-204 (Dimmit)**
* Fluoranthene was 1 µg/l
* Butylbenzyl phthalate was 1 µg/l

**77-35-802 (Dimmit)**
Cyclohexanone was 9 µg/l

**77-37-202 (Dimmit)**
* Bis (2-ethylhexyl) phthalate was 1 µg/l

**77-30-502 (La Salle)**
* Bis (2-ethylhexyl) phthalate was 4 µg/l

**77-31-103 (La Salle)**
Bis (2-ethylhexyl) phthalate was 14 µg/l
* Bis-phenol was 7 µg/l

**77-38-201 (La Salle)**
* Bis (2-ethylhexyl) phthalate was 4 µg/l

**77-47-802 (La Salle)**
* Bis (2-ethylhexyl) phthalate was 4 µg/l
** Cyclohexanone was 3 µg/l

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* Reported at less than quantitation limit.
** Common laboratory contaminant.

Of particular importance is well 68-53-809 in Bexar County. TDH chemists re-checked the raw data and concluded that these chemicals were indeed in the sample and that their presence was not due to equipment malfunction. They suggested a possible original contamination by a phenolic compound such as bis-phenol-A and that many of the other phenolic compounds present were degradation products. Many of those secondary phenolic compounds are reported at less than quantitation limits. A follow-up visit was made by a TWDB geologist to the site to investigate the wellsite and confer with the owner's representative. A second sampling will be necessary to confirm that these chemicals are present in the water before any other action can be taken to locate their source.

Phenol is a highly soluble compound which has one or more hydroxyl groups attached to an aromatic ring (Concise Encyclopedia of Chemical Terminology, 1983). Its chemical formula is $C_6H_5 \bullet OH$, and it is a derivative of benzene (De Zuane, 1990). Phenol is commonly called carbolic acid, hydroxybenzene, phenic acid, or phenylic acid (Verschueren, 1983). It is used in the manufacture of explosives, fertilizers, paints, paint removers, synthetic resins, and many other products. There is no drinking water standard for phenol, but it should not exceed 300 µg/l (Sitting, 1981). The United States Public Health Service (USPHS) and the World Health Organization (WHO) have suggested that the phenol content not exceed 1 µg/l, but this is based upon concerns for the taste of chlorinated drinking water and not the toxicological effects of phenol.

Other phenolic compounds are used extensively in medicinals, dyes, resins, and other commercial products. Bis-phenol-A is sometimes used as a fungicide. There are no MCLs for these compounds.

Also present in well 68-53-809 was ethylhexanol. It is used as a plasticizer for PVC resins, a defoaming agent, a wetting agent, and in the manufacture of paint lacquers, baking finishes, textile finishing compounds, inks, paper, lubricants, dry cleaning, and photography (Verschueren, 1983).

In the other nine wells, six organic compounds were present: Bis (2-ethylhexyl) phthalate is used as a plasticizer for resins. It commonly appears in laboratory results if the water has come into contact with plastic, either in the well tubing or through a hose (Boyer, pers. comm.). There is no drinking water standard for this compound. It was present in four wells below the quantitation limit of 5 µg/l, meaning that it was in the water in such small quantities as to be essentially negligible. Two wells had measurements in excess of 5 µg/l; further samplings and inspections of the wells may be necessary to determine the source of this chemical.

Four other chemicals were present but below the quantitation limits: butylbenzyl phthalate, fluoranthene, bisphenol, and cyclohexane. None of these compounds has drinking water standards, and these concentrations are essentially negligible.

## Wilcox Aquifer

There were no detectable organic chemicals present in the ground water from the Wilcox aquifer.

## RADIOACTIVITY

Gross alpha (α) radiation consists of the emissions of positively charged helium nuclei from the nucleus of atoms having high atomic weight. When the α particle is emitted from the atom, the atomic weight decreases by 4 atomic units. This radioactive decay is measured as gross α and in the units of picoCuries per liter (pCi/l). Alpha-emitting isotopes in natural waters are primarily isotopes of radium and radon which are members of the uranium and thorium disintegration series (Hem, 1985).

A major contributing factor to the gross α radiation is the combined radiation of $Ra^{226}$ and $Ra^{228}$. Both of these isotopes are α-emitters. $Ra^{226}$ is a disintegration product of uranium ($U^{238}$), whereas $Ra^{228}$ is a disintegration product of thorium ($Th^{232}$). $Ra^{226}$ decays to $Rn^{222}$ (radon gas), which is also an α-emitter.

Gross beta (β) radiation consists of the emission of high energy electrons and positrons from the nucleus of atoms having high atomic weight. During the production of a β particle, the neutron of the atom is converted to a proton and an electron is emitted as a β particle. When a β particle is emitted from an atom, the atomic number of the atom increases one unit. Natural β-emitting isotopes are those in the uranium and thorium disintegration series, but there are other natural sources as well.

A summary of the laboratory analyses for radioactivity in the ground water of the Queen City, Carrizo, and Wilcox aquifers is found in Table 10.

**Table 10.- Radioactivity of the Ground Water of the Queen City, Carrizo, and Wilcox Aquifers.**

| | Range | Average |
|---|---|---|
| **Queen City Aquifer** | | |
| Gross alpha (α) | <2.0 - 8.4 pCi/l | <2.0 pCi/l |
| Gross beta (β) | <4.0 - 15 pCi/l | 6.8 pCi/l |
| $Ra^{226}$ | <0.2 - 1.7 pCi/l | 0.8 pCi/l |
| $Ra^{228}$ | 1.3 - 3.1 pCi/l | 1.6 pCi/l |
| **Carrizo Aquifer** | | |
| Gross alpha (α) | <2.0 - 37 pCi/l | 4.5 pCi/l |
| Gross beta (β) | <4.0 - 25 pCi/l | 7.1 pCi/l |
| $Ra^{226}$ | <0.2 - 9.5 pCi/l | 2.2 pCi/l |
| $Ra^{228}$ | <1.0 - 3.4 pCi/l | 1.3 pCi/l |
| **Wilcox Aquifer** | | |
| Gross alpha (α) | <2.0 - 8.4 pCi/l | <2.0 pCi/l |
| Gross beta (β) | <4.0 - 15 pCi/l | 6.8 pCi/l |
| $Ra^{226}$ | 0.6 - 1.3 pCi/l | 1.0 pCi/l |
| $Ra^{228}$ | <1.0 - 1.6 pCi/l | <1.0 pCi/l |

## Queen City Aquifer

The average gross α radiation of the Queen City aquifer ground water was below detection limits. The average β radiation was 6.8 pCi/l, far below the MCL of 50 pCi/l. The average $Ra^{226}$ and $Ra^{228}$ measurements were 0.8 pCi/l and 3.1 pCi/l, respectively, for a combined measurement of 3.9 pCi/l. This is below the MCL of 5 pCi/l.

## Carrizo Aquifer

The average gross α radiation of the Carrizo aquifer ground water was 4.5 pCi/l, far below the MCL of 15 pCi/l. The average β radiation was 7.1 pCi/l, far below the MCL of 50 pCi/l. The average $Ra^{226}$ and $Ra^{228}$ measurements were 2.2 pCi/l and 1.3 pCi/l, respectively, for a combined measurement of 3.5 pCi/l. This is below the MCL of 5 pCi/l.

Fourteen wells measured radiation which exceeded drinking water standards:

**68-51-701 (Atascosa)**
α was 22 pCi/l
Combined $Ra^{226}$ and $Ra^{228}$ was 6.8 pCi/l

**68-58-304 (Atascosa)**
α was 37 pCi/l
Combined $Ra^{226}$ and $Ra^{228}$ was 11.0 pCi/l

**78-03-601 (Atascosa)**
Combined $Ra^{226}$ and $Ra^{228}$ was 5.2 mg/l

**77-25-205 (Dimmit)**
α was 40 pCi/l
Combined $Ra^{226}$ and $Ra^{228}$ was 19.3 pCi/l

**77-33-611 (Dimmit)**
α was 23 pCi/l
Combined $Ra^{226}$ and $Ra^{228}$ was 8.8 pCi/l

**68-57-619 (Frio)**
Combined $Ra^{226}$ and $Ra^{228}$ was 8.2 pCi/l

**69-62-902 (Frio)**
α was 23 pCi/l
Combined $Ra^{226}$ and $Ra^{228}$ was 9.8 pCi/l

**77-07-904 (Frio)**
α was 34 pCi/l
Combined $Ra^{226}$ and $Ra^{228}$ was 7.0 pCi/l

**68-49-917 (Medina)**
α was 16 pCi/l

**68-57-209 (Medina)**
Combined $Ra^{226}$ and $Ra^{228}$ was 6.5 pCi/l

**68-58-101 (Medina)**
α was 21 pCi/l
Combined $Ra^{226}$ and $Ra^{228}$ was 7.5 pCi/l

**69-64-202 (Medina)**
Combined $Ra^{226}$ and $Ra^{228}$ was 6.4 pCi/l

**69-58-707 (Zavala)**
$\alpha$ was 19 pCi/l
Combined $Ra^{226}$ and $Ra^{228}$ was 6.4 pCi/l

**77-02-403 (Zavala)**
$\alpha$ was 22 pCi/l
Combined $Ra^{226}$ and $Ra^{228}$ was 7.9 pCi/l

Of these wells, 10 have $\alpha$ levels above the MCL, 1 had $\beta$ level above the MCL, and 13 have combined $Ra^{226}$ and $Ra^{228}$ levels in excess of the MCL. It is thought that the source of the radium and $\alpha$ radiation in the Carrizo aquifer is due to the presence of naturally occurring radioactive elements, such as uranium and its daughter products, which are associated with volcanic ash deposits.

## Wilcox Aquifer

The average gross $\alpha$ radiation of the Wilcox aquifer ground water was below detection limits. The average $\beta$ radiation was 5.1 pCi/l, far below the MCL of 50 pCi/l. The average $Ra^{226}$ and $Ra^{228}$ measurements were 1.0 pCi/l and <1.0 pCi/l, respectively, for a combined measurement of a minimum of 1.0 pCi/l. This is far below the MCL of 5 pCi/l.

## COMPARISON TO PREVIOUS WORK

Water quality analyses have been run periodically on ground water in the Winter Garden area since 1930. However, it is difficult to compare previous tests with those of today. There are two reasons for this apparent dilemma: (1) until recently there were no quality assurance and quality control procedures in either the collection of field samples or laboratory analyses, and (2) the laboratory instruments lacked the analytical precision of modern equipment. However, comparisons should at least be attempted, although some results may have a subjective bias.

The samples collected for this study were analyzed for field measurements; cations, anions, and selected metals; nutrients; organic constituents, which included pesticides, VOCs, and GC/MS; and radioactivity. This is the first study to analyze this ground water for selected metals, organic constituents and radioactivity; therefore, no comparison to previous work can be made for these constituents.

Historical sampling only measured major cations and anions, nitrate, and field parameters including pH, specific conductance, and temperature. Of these, only three constituents can be compared with any confidence: sulfate, chloride, and dissolved solids. The sulfate and chloride concentrations of ground water are relatively stable and not subject to decomposition if a water sample is detained or misplaced on the way to the laboratory. While the individual cations and anions may be difficult to analyze accurately, the dissolved solids are a good indication of the overall composition of the sample.

In reviewing the historical summaries of water quality presented, some measurements may appear to be incorrect, either too high or too low as compared to values from other years. All such apparently "incorrect" measurements were found to be correct as reported from the laboratories. These deviations serve as reminders of the lack of quality assurance and quality control in the past.

### Queen City Aquifer

Four of the wells completed in the Queen City aquifer have previous water quality analyses. These wells are located in Atascosa, Frio, and Wilson Counties. Table 11 shows the results for sulfate, chloride, and dissolved solids for these wells.

The water quality of three of these wells is fresh to slightly saline, with all three constituents in three wells meeting drinking water standards. Only well 78-02-709 had concentrations of both chloride and dissolved solids in excess of standards. Wells 78-05-409, 78-20-801, and 78-02-709 show little change in water quality throughout their histories. Well 67-49-202 shows slight deterioration in water quality since 1952, although the ground water meets drinking water standards.

**Table 11.-Historical Water Quality Analyses of the Queen City Aquifer Wells**

| Well | County | Aquifer | Date | Sulfate* | Chloride* | TDS* |
|---|---|---|---|---|---|---|
| 78-05-409 | Atascosa | QNCT | 03/04/62 | 0 | 102 | 469 |
| | | | 11/03/66 | 4 | 99 | 476 |
| | | | 11/09/67 | 7 | 102 | 484 |
| | | | 04/22/69 | 5 | 103 | 486 |
| | | | 02/12/86 | 6 | 100 | 492 |
| | | | 07/09/86 | 5 | 101 | 490 |
| | | | 08/07/90 | 22 | 118 | 583 |
| 78-20-801 | Atascosa | QNCT | 03/23/59 | 106 | 79 | 947 |
| | | | 11/26/62 | 104 | 80 | 953 |
| | | | 06/23/77 | 101 | 75 | 933 |
| | | | 02/06/86 | 104 | 78 | 958 |
| | | | 08/09/90 | 108 | 75 | 976 |
| 78-02-709 | Frio | QNCT | 08/27/70 | 241 | 598 | 1447 |
| | | | 06/08/77 | 192 | 491 | 1234 |
| | | | 02/13/86 | 250 | 604 | 1449 |
| | | | 08/08/90 | 206 | 492 | 1290 |
| 67-49-202 | Wilson | QNCT | 04/01/52 | 166 | 85 | 599 |
| | | | 11/13/52 | 181 | 91 | 633 |
| | | | 06/16/54 | 172 | 82 | 524 |
| | | | 11/02/65 | 201 | 111 | 649 |
| | | | 12/13/66 | 187 | 121 | 642 |
| | | | 02/18/68 | 206 | 117 | 667 |
| | | | 12/31/68 | 194 | 115 | 641 |
| | | | 02/18/69 | 211 | 114 | 688 |
| | | | 11/23/70 | 187 | 116 | 643 |
| | | | 11/17/71 | 197 | 115 | 651 |
| | | | 06/11/77 | 201 | 114 | 680 |
| | | | 08/07/90 | 207 | 135 | 732 |

* Units in mg/l

## Carrizo Aquifer

Seventy-five wells completed in the Carrizo aquifer have been sampled previous to this study and are located in Atascosa (19 wells), Bexar (1 well), Dimmit (18 wells), Frio (16 wells), La Salle (4 wells), Medina (2 wells), Wilson (5 wells), and Zavala (10 wells) Counties. Table 12 shows the results of the analyses for sulfate, chloride, and dissolved solids. Generally, the ground water of the Carrizo aquifer in this region is fresh.

The changes in water quality are shown in Figure 8 and are summarized below:

Atascosa County- Well 78-12-502 showed significant deterioration in water quality from 1976 to 1990. Sulfate, chloride, and dissolved solids concentrations exceeded drinking water standards in 1990.

Dimmit County- Three wells, 77-28-503, 77-35-802, and 77-37-501 showed deteriorating water quality; and all had sulfate, chloride, and dissolved solids concentrations in excess of drinking water standards in 1990. Two wells showed improving water quality: well 77-35-601 had extremely high levels of sulfate, chloride, and dissolved solids in 1977, followed by three measurements of fresh water quality; and well 77-44-101 showed a slight improvement in the chloride and dissolved solids concentrations throughout its history.

Frio County- Two wells, 68-57-619 and 78-18-501, showed deteriorating water quality throughout their histories. Well 68-57-619 showed a significant increase in sulfate, chloride, and dissolved solids concentrations in 1990, although the levels were still within drinking water standards. Well 78-18-501 had concentrations of chloride and dissolved solids well in excess of drinking water standards in 1986 and 1990. Well 69-63-604 showed improving water quality over the last 21 years.

La Salle County- Well 77-47-802 showed a significant deterioration in water quality in 1990. This ground water had previously tested as slightly saline, exceeding the MCLs for sulfate, chloride, and dissolved solids.

Medina County- Well 69-64-202 showed a slight increase in chloride and dissolved solids concentrations in 1990, although the levels were not in excess of drinking water standards.

Wilson County- None of the five wells which had previous sampling histories showed any significant change in water quality.

Zavala County- Three wells, 69-58-801, 76-08-503, and 77-20-101, showed deteriorating water quality. Well 69-58-707 had increased chloride and dissolved solids concentrations in 1990, although both were within drinking water standards. Wells 76-08-503 and 77-20-101 showed increased sulfate, chloride, and dissolved solids concentrations in 1990. All three measurements were in excess of drinking water standards in both wells.

## Wilcox Aquifer

All seven wells completed in the Wilcox aquifer have previous water quality analyses. The wells are located in Atascosa, Bexar, Dimmit, Medina, and Wilson Counties. Table 13 shows the results for sulfate, chloride, and dissolved solids for these wells. The water from these wells completed in the Wilcox aquifer is of somewhat lesser quality than that of the Carrizo or Queen City aquifers. Four of these wells have ground water which does not meet drinking water standards.

**Table 12.-Historical Water Quality Analyses of the Carrizo Aquifer Wells.**

| Well | County | Aquifer | Date | Sulfate* | Chloride* | TDS* |
|---|---|---|---|---|---|---|
| 68-51-701 | Atascosa | CRRZ | 04/01/70 | 22 | 41 | 164 |
| | | | 06/09/77 | 23 | 114 | 292 |
| | | | 02/07/86 | 20 | 38 | 151 |
| | | | 06/26/90 | 19 | 48 | 171 |
| 68-52-709 | Atascosa | CRRZ | 03/09/70 | 32 | 67 | 303 |
| | | | 04/13/70 | 36 | 64 | 303 |
| | | | 06/25/90 | 36 | 70 | 267 |
| 68-59-614 | Atascosa | CRRZ | 09/16/69 | 32 | 50 | 173 |
| | | | 07/28/77 | 37 | 54 | 205 |
| | | | 07/08/86 | 38 | 57 | 191 |
| | | | 06/25/90 | 36 | 57 | 203 |
| 68-61-207 | Atascosa | CRRZ | 07/30/69 | 24 | 37 | 143 |
| | | | 09/07/77 | 22 | 33 | 138 |
| | | | 07/07/86 | 42 | 74 | 233 |
| | | | 06/19/90 | 21 | 34 | 133 |
| 68-61-905 | Atascosa | CRRZ | 07/07/86 | 34 | 32 | 217 |
| | | | 06/19/90 | 34 | 32 | 225 |
| 78-03-601 | Atascosa | CRRZ | 02/11/86 | 28 | 31 | 324 |
| | | | 06/20/90 | 35 | 32 | 337 |
| 78-04-104 | Atascosa | CRRZ | 07/31/69 | 35 | 39 | 242 |
| | | | 07/08/86 | 42 | 33 | 312 |
| | | | 06/20/90 | 35 | 35 | 226 |
| 78-04-803 | Atascosa | CRRZ | 08/05/64 | 28 | 28 | 323 |
| | | | 10/08/65 | 26 | 31 | 292 |
| | | | 03/03/67 | 28 | 33 | 305 |
| | | | 06/26/72 | 26 | 30 | 301 |
| | | | 07/14/72 | 25 | 30 | 301 |
| | | | 02/11/86 | 30 | 29 | 319 |
| | | | 07/08/86 | 31 | 31 | 320 |
| | | | 06/20/90 | 31 | 31 | 350 |
| 78-05-116 | Atascosa | CRRZ | 06/05/44 | 22 | 55 | — |
| | | | 02/12/86 | 46 | 54 | 355 |
| | | | 06/18/90 | 61 | 83 | 459 |
| 78-05-501 | Atascosa | CRRZ | 05/09/44 | 24 | 30 | — |
| | | | 02/11/86 | 15 | 42 | 424 |
| | | | 06/18/90 | 11 | 62 | 545 |
| 78-06-504 | Atascosa | CRRZ | 06/19/69 | 34 | 36 | 413 |
| | | | 11/28/72 | 13 | 39 | 393 |
| | | | 11/07/78 | 5 | 37 | 401 |
| | | | 06/28/90 | 19 | 46 | 428 |

**Table 12.-Historical Water Quality Analyses of the Carrizo Aquifer Wells. (continued)**

| Well | County | Aquifer | Date | Sulfate* | Chloride* | TDS* |
|---|---|---|---|---|---|---|
| 78-06-903 | Atascosa | CRRZ | 08/19/64 | 46 | 23 | 425 |
| | | | 10/17/69 | 70 | 46 | 550 |
| | | | 02/07/86 | 52 | 31 | 454 |
| | | | 06/19/90 | 66 | 37 | 486 |
| 78-11-217 | Atascosa | CRRZ | 02/18/60 | 43 | 32 | 351 |
| | | | 03/17/61 | 42 | 25 | 364 |
| | | | 08/13/62 | 47 | 16 | 452 |
| | | | 08/05/64 | 44 | 30 | 349 |
| | | | 12/17/64 | 44 | 30 | 464 |
| | | | 01/31/66 | 41 | 30 | 461 |
| | | | 02/01/67 | 45 | 32 | 467 |
| | | | 02/16/68 | 44 | 32 | 473 |
| | | | 05/26/69 | 38 | 31 | 460 |
| | | | 10/28/69 | 42 | 29 | 352 |
| | | | 04/15/70 | 49 | 27 | 332 |
| | | | 07/25/73 | 48 | 31 | 356 |
| | | | 07/22/74 | 41 | 31 | 347 |
| | | | 11/12/74 | 46 | 34 | 477 |
| | | | 06/19/75 | 40 | 31 | 341 |
| | | | 07/21/76 | 41 | 31 | 343 |
| | | | 06/10/77 | 42 | 30 | 350 |
| | | | 02/05/85 | 3 | 29 | 258 |
| | | | 07/08/86 | 43 | 29 | 326 |
| | | | 06/21/90 | 45 | 30 | 359 |
| 78-12-502 | Atascosa | CRRZ | 05/26/76 | 41 | 35 | 348 |
| | | | 06/02/90 | 1352 | 563 | 3074 |
| 78-14-302 | Atascosa | CRRZ | 11/14/69 | 47 | 28 | 429 |
| | | | 07/25/73 | 65 | 32 | 476 |
| | | | 07/23/74 | 53 | 32 | 475 |
| | | | 06/20/75 | 53 | 33 | 470 |
| | | | 07/21/76 | 48 | 33 | 481 |
| | | | 06/14/77 | 58 | 32 | 485 |
| | | | 07/07/86 | 60 | 31 | 473 |
| | | | 06/27/90 | 44 | 31 | 466 |
| 78-15-805 | Atascosa | CRRZ | 03/03/69 | 23 | 62 | 540 |
| | | | 11/13/69 | 65 | 60 | 602 |
| | | | 05/12/71 | 38 | 62 | 564 |
| | | | 05/10/72 | 42 | 64 | 583 |
| | | | 06/14/73 | 43 | 64 | 591 |
| | | | 06/15/74 | 50 | 64 | 600 |
| | | | 07/07/75 | 42 | 62 | 589 |
| | | | 08/02/76 | 23 | 64 | 589 |
| | | | 09/16/76 | 37 | 64 | 604 |
| | | | 02/16/86 | 68 | 62 | 621 |
| | | | 06/19/90 | 35 | 74 | 619 |
| 78-20-801 | Atascosa | CRRZ | 03/23/59 | 106 | 79 | 947 |
| | | | 11/26/62 | 104 | 80 | 953 |
| | | | 06/23/77 | 101 | 75 | 933 |
| | | | 02/06/86 | 104 | 78 | 958 |
| | | | 08/09/90 | 108 | 75 | 976 |

**Table 12.-Historical Water Quality Analyses of the Carrizo Aquifer Wells. (continued)**

| Well | County | Aquifer | Date | Sulfate* | Chloride* | TDS* |
|---|---|---|---|---|---|---|
| 78-21-106 | Atascosa | CRRZ | 08/12/69 | 48 | 19 | 350 |
| | | | 07/23/74 | 47 | 18 | 342 |
| | | | 06/23/75 | 46 | 18 | 335 |
| | | | 07/22/76 | 44 | 18 | 332 |
| | | | 06/13/77 | 45 | 17 | 336 |
| | | | 02/06/86 | 43 | 16 | 343 |
| | | | 06/21/90 | 51 | 18 | 352 |
| 78-22-202 | Atascosa | CRRZ | 11/07/69 | 51 | 43 | 650 |
| | | | 09/18/75 | 49 | 47 | 696 |
| | | | 02/06/86 | 54 | 45 | 599 |
| | | | 06/27/90 | 61 | 44 | 683 |
| 68-53-809 | Bexar | CRRZ | 08/22/77 | 13 | 38 | 128 |
| | | | 06/26/90 | 27 | 54 | 172 |
| 77-18-710 | Dimmit | CRRZ | 03/16/69 | 49 | 65 | 425 |
| | | | 09/18/90 | 44 | 50 | 382 |
| 77-18-904 | Dimmit | CRRZ | 06/26/69 | 60 | 36 | 405 |
| | | | 07/08/77 | 59 | 52 | 445 |
| | | | 09/27/90 | 60 | 41 | 391 |
| 77-19-810 | Dimmit | CRRZ | 06/26/69 | 69 | 37 | 425 |
| | | | 07/08/77 | 75 | 58 | 466 |
| | | | 09/26/90 | 74 | 37 | 422 |
| 77-25-205 | Dimmit | CRRZ | 07/07/77 | 188 | 112 | 593 |
| | | | 09/20/90 | 176 | 129 | 630 |
| 77-26-424 | Dimmit | CRRZ | 04/03/69 | 39 | 33 | 365 |
| | | | 09/25/90 | 43 | 39 | 370 |
| 77-26-610 | Dimmit | CRRZ | 02/12/86 | 39 | 39 | 364 |
| | | | 09/18/90 | 46 | 39 | 377 |
| 77-27-305 | Dimmit | CRRZ | 04/11/69 | 55 | 46 | 422 |
| | | | 09/26/90 | 64 | 55 | 471 |
| 77-28-503 | Dimmit | CRRZ | 07/13/64 | 55 | 32 | 389 |
| | | | 04/11/69 | 54 | 34 | 412 |
| | | | 07/11/85 | 60 | 40 | 417 |
| | | | 02/10/86 | 183 | 318 | 1042 |
| | | | 07/14/86 | 138 | 212 | 802 |
| | | | 09/17/90 | 321 | 659 | 1790 |
| 77-33-309 | Dimmit | CRRZ | 03/26/69 | 51 | 95 | 384 |
| | | | 09/26/90 | 46 | 107 | 372 |
| 77-33-611 | Dimmit | CRRZ | 03/26/69 | 87 | 142 | 535 |
| | | | 07/11/85 | 84 | 121 | 484 |
| | | | 07/16/86 | 87 | 120 | 491 |
| | | | 09/26/90 | 81 | 118 | 460 |

**Table 12.-Historical Water Quality Analyses of the Carrizo Aquifer Wells. (continued)**

| Well | County | Aquifer | Date | Sulfate* | Chloride* | TDS* |
|---|---|---|---|---|---|---|
| 77-34-204 | Dimmit | CRRZ | 12/07/38 | 172 | 190 | — |
| | | | 03/22/57 | — | 136 | — |
| | | | 02/06/69 | 155 | 166 | 750 |
| | | | 08/02/77 | 116 | 167 | 671 |
| | | | 07/10/85 | 167 | 237 | 869 |
| | | | 07/16/86 | 185 | 224 | 886 |
| | | | 09/19/90 | 113 | 190 | 696 |
| 77-35-403 | Dimmit | CRRZ | 04/04/69 | 182 | 245 | 879 |
| | | | 08/03/77 | 172 | 174 | 749 |
| | | | 07/10/85 | 167 | 149 | 698 |
| | | | 07/16/86 | 176 | 154 | 713 |
| | | | 09/24/90 | 187 | 188 | 766 |
| 77-35-601 | Dimmit | CRRZ | 08/04/77 | 587 | 1109 | 3085 |
| | | | 07/10/85 | 76 | 79 | 487 |
| | | | 07/16/86 | 78 | 79 | 494 |
| | | | 09/24/90 | 84 | 87 | 512 |
| 77-35-802 | Dimmit | CRRZ | 02/25/65 | 363 | 850 | 2136 |
| | | | 07/23/65 | 178 | 165 | 738 |
| | | | 07/09/85 | 265 | 402 | 1252 |
| | | | 07/16/86 | 257 | 373 | 1197 |
| | | | 09/27/90 | 789 | 1057 | 3180 |
| 77-37-102 | Dimmit | CRRZ | 04/10/69 | 73 | 59 | 459 |
| | | | 07/06/77 | 74 | 60 | 463 |
| | | | 07/11/85 | 74 | 59 | 456 |
| | | | 07/15/86 | 70 | 61 | 459 |
| | | | 09/20/90 | 70 | 61 | 453 |
| 77-37-501 | Dimmit | CRRZ | 07/15/86 | 277 | 482 | 2169 |
| | | | 09/20/90 | 431 | 822 | 2937 |
| 77-42-801 | Dimmit | CRRZ | 03/19/30 | 243 | 71 | 724 |
| | | | 03/26/57 | — | 73 | — |
| | | | 07/24/75 | 232 | 72 | 680 |
| | | | 07/20/76 | 228 | 72 | 677 |
| | | | 08/03/77 | 230 | 71 | 679 |
| | | | 07/09/85 | 235 | 71 | 687 |
| | | | 07/15/86 | 233 | 72 | 685 |
| | | | 09/20/90 | 232 | 72 | 692 |
| 77-44-101 | Dimmit | CRRZ | 05/26/71 | 112 | 185 | 786 |
| | | | 08/03/77 | 120 | 118 | 609 |
| | | | 07/09/85 | 119 | 118 | 594 |
| | | | 07/15/86 | 120 | 116 | 595 |
| | | | 09/26/90 | 117 | 125 | 612 |
| 77-01-404 | Zavala | CRRZ | 07/10/73 | 42 | 91 | 443 |
| | | | 07/17/85 | 70 | 97 | 499 |
| | | | 07/23/86 | 73 | 100 | 508 |
| | | | 08/08/90 | 87 | 93 | 522 |

Table 12.-Historical Water Quality Analyses of the Carrizo Aquifer Wells. (continued)

| Well | County | Aquifer | Date | Sulfate* | Chloride* | TDS* |
|---|---|---|---|---|---|---|
| 77-02-403 | Zavala | CRRZ | 11/30/60 | 23 | 17 | 334 |
| | | | 09/05/62 | 27 | 14 | 317 |
| | | | 03/27/68 | 23 | 17 | 302 |
| | | | 06/29/72 | 22 | 14 | 423 |
| | | | 07/19/72 | 23 | 15 | 303 |
| | | | 03/23/74 | 25 | 18 | 435 |
| | | | 03/04/75 | 25 | 16 | 435 |
| | | | 06/30/77 | 25 | 16 | 307 |
| | | | 07/15/85 | 24 | 13 | 298 |
| | | | 07/23/86 | 30 | 29 | 332 |
| | | | 08/07/90 | 44 | 61 | 391 |
| 77-04-601 | Zavala | CRRZ | 02/06/86 | 41 | 24 | 345 |
| | | | 07/22/86 | 40 | 25 | 355 |
| | | | 08/07/90 | 39 | 25 | 353 |
| 77-11-701 | Zavala | CRRZ | 12/27/48 | 83 | 36 | 439 |
| | | | 06/07/68 | 75 | 34 | 452 |
| | | | 07/10/73 | 66 | 36 | 444 |
| | | | 07/10/74 | 75 | 35 | 450 |
| | | | 07/29/76 | 37 | 33 | 343 |
| | | | 06/30/77 | 76 | 35 | 464 |
| | | | 07/16/85 | 63 | 34 | 360 |
| | | | 09/20/90 | 75 | 34 | 451 |
| 77-18-510 | Zavala | CRRZ | 08/23/38 | 64 | 42 | 419 |
| | | | 09/15/39 | 63 | 43 | 424 |
| | | | 02/02/41 | 65 | 39 | 430 |
| | | | 12/09/42 | 65 | 41 | 421 |
| | | | 01/08/45 | 64 | 43 | 416 |
| | | | 10/19/46 | 78 | 53 | 449 |
| | | | 07/11/47 | 72 | 11 | 377 |
| | | | 03/07/53 | 16 | 227 | 562 |
| | | | 04/24/54 | 85 | 156 | 612 |
| | | | 08/26/55 | 66 | 144 | 567 |
| | | | 09/08/56 | 62 | 42 | 459 |
| | | | 08/23/62 | 63 | 82 | 370 |
| | | | 09/03/63 | 55 | 57 | 390 |
| | | | 11/20/64 | 52 | 44 | 369 |
| | | | 08/25/65 | 52 | 44 | 366 |
| | | | 09/08/65 | 62 | 42 | 392 |
| | | | 10/15/66 | 52 | 47 | 373 |
| | | | 01/16/68 | 51 | 41 | 356 |
| | | | 01/13/69 | 52 | 44 | 365 |
| | | | 07/15/85 | 50 | 34 | 358 |
| | | | 07/18/86 | 52 | 36 | 366 |
| | | | 08/09/90 | 54 | 36 | 386 |

**Table 12.-Historical Water Quality Analyses of the Carrizo Aquifer Wells. (continued)**

| Well | County | Aquifer | Date | Sulfate* | Chloride* | TDS* |
|---|---|---|---|---|---|---|
| 77-18-512 | Zavala | CRRZ | 11/17/48 | 36 | 29 | 312 |
| | | | 05/13/49 | 46 | 44 | 380 |
| | | | 08/08/52 | 77 | 57 | 460 |
| | | | 03/07/53 | 47 | 46 | 387 |
| | | | 04/24/54 | 53 | 43 | 254 |
| | | | 08/26/55 | 47 | 36 | 360 |
| | | | 09/08/56 | 38 | 28 | 353 |
| | | | 10/21/57 | 61 | 33 | 360 |
| | | | 07/20/59 | 46 | 26 | 328 |
| | | | 10/10/60 | 41 | 28 | 316 |
| | | | 07/21/61 | 46 | 31 | 325 |
| | | | 08/23/62 | 44 | 30 | 319 |
| | | | 09/06/63 | 77 | 181 | 627 |
| | | | 11/20/64 | 40 | 33 | 324 |
| | | | 08/25/65 | 38 | 30 | 317 |
| | | | 10/15/66 | 59 | 40 | 376 |
| | | | 01/16/68 | 48 | 81 | 426 |
| | | | 01/13/69 | 39 | 26 | 309 |
| | | | 08/09/90 | 40 | 25 | 336 |
| 77-20-101 | Zavala | CRRZ | 02/24/65 | 28 | 26 | 354 |
| | | | 07/10/74 | 52 | 24 | 370 |
| | | | 07/08/75 | 44 | 24 | 364 |
| | | | 07/26/76 | 44 | 26 | 364 |
| | | | 06/30/77 | 51 | 24 | 372 |
| | | | 02/07/86 | 342 | 572 | 1870 |
| | | | 08/08/90 | 341 | 570 | 1885 |

* Units in mg/l

**Table 13.- Historical Water Quality Analyses for Wilcox Aquifer Wells.**

| Well | County | Aquifer | Date | Sulfate* | Chloride* | TDS* |
|---|---|---|---|---|---|---|
| 68-50-603 | Atascosa | WLCX | 11/20/69 | 189 | 138 | 817 |
| | | | 09/02/77 | 108 | 92 | 608 |
| | | | 02/07/86 | 157 | 127 | 733 |
| | | | 06/26/90 | 138 | 108 | 694 |
| 68-52-405 | Bexar | WLCX | 02/10/70 | 49 | 62 | 422 |
| | | | 08/15/73 | 46 | 56 | 377 |
| | | | 07/26/77 | 43 | 46 | 381 |
| | | | 09/09/83 | 41 | 49 | 352 |
| | | | 06/26/90 | 62 | 64 | 449 |
| 76-48-401 | Dimmit | WLCX | 07/21/60 | 1180 | 2750 | 6365 |
| | | | 07/07/77 | 60 | 1570 | 3986 |
| | | | 09/25/90 | 284 | 293 | 1268 |
| 69-54-601 | Medina | WLCX | 12/08/69 | 256 | 958 | 2424 |
| | | | 07/13/77 | 241 | 1000 | 2471 |
| | | | 02/20/86 | 6 | 1056 | 2346 |
| | | | 06/19/90 | 198 | 1008 | 2476 |
| 68-47-303 | Wilson | WLCX | 06/27/68 | 287 | 160 | 957 |
| | | | 02/19/69 | 403 | 282 | 1340 |
| | | | 04/19/76 | 327 | 210 | 1090 |
| | | | 06/21/90 | 399 | 239 | 1275 |
| 68-48-102 | Wilson | WLCX | 01/27/65 | 287 | 192 | 1036 |
| | | | 06/18/68 | 268 | 197 | 1012 |
| | | | 02/19/69 | 294 | 192 | 1040 |
| | | | 04/22/71 | 300 | 199 | 1038 |
| | | | 05/14/73 | 302 | 205 | 1050 |
| | | | 05/22/74 | 222 | 182 | 908 |
| | | | 04/19/76 | 208 | 95 | 841 |
| | | | 07/26/77 | 300 | 190 | 1052 |
| | | | 06/20/90 | 298 | 192 | 1051 |
| 68-54-501 | Wilson | WLCX | 04/02/69 | 100 | 153 | 682 |
| | | | 07/28/77 | 218 | 131 | 817 |
| | | | 02/13/86 | 171 | 136 | 746 |
| | | | 06/19/90 | 190 | 135 | 799 |

* Units in mg/l

Well 68-47-303 showed deteriorating water quality with increased sulfate, chloride, and dissolved solids concentrations in 1990; and the sulfate and dissolved solids levels were in excess of drinking water standards. Well 76-48-401 showed improving water quality; however, it still had dissolved solids in excess of drinking water standards.

## CONCLUSIONS

The quality of the ground water from the Queen City aquifer in the Winter Garden area of southwest Texas was good based on the nine wells sampled. There were no dissolved nutrients or radioactive elements which exceeded drinking water standards. There were no detectable levels of any organic chemicals. Four wells had naturally-occurring inorganic constituents which exceeded drinking water standards: iron, chloride, dissolved solids, manganese, and sulfate.

The quality of the ground water of the Carrizo aquifer in the Winter Garden area was good based on the 103 wells sampled, although some individual wells had localized water quality problems. There were no dissolved nutrients which exceeded drinking water standards. Fifty wells had naturally-occurring dissolved inorganic constituents which exceeded drinking water standards: iron, manganese, dissolved solids, chloride, sulfate, and zinc. Fourteen wells had detectable amounts of 15 organic chemicals, but six wells had amounts of these chemicals below quantitation levels. All 14 of these wells should be resampled to verify the presence of these chemicals. Fourteen wells contained naturally-occurring dissolved radioactive constituents which exceeded drinking water standards: alpha particles and combined $Ra^{226}$ and $Ra^{228}$.

The quality of the ground water of the Wilcox aquifer in the Winter Garden area was good based on seven wells sampled. There were no dissolved nutrients or dissolved radioactive constituents which exceeded drinking water standards. There were no detectable levels of any organic chemicals. Six wells had naturally-occurring dissolved inorganic constituents which exceeded drinking water standards: dissolved solids, iron, manganese, chloride, sulfate, and zinc.

Changes in water quality are based on measurements of sulfate, chloride, and dissolved solids. One well in the Queen City aquifer showed some deterioration in water quality since 1952. Ten wells in the Carrizo aquifer showed deterioration in water quality, and three wells showed improvement in water quality. One well in the Wilcox aquifer showed deterioration in water quality, and one well showed improvement.

The water quality is generally unchanged in the study area. A few localized changes have occurred as a result of leakage of ground water from the overlying Bigford and Queen City aquifers into the Carrizo. This leakage is caused primarily by excessive pumpage of the Carrizo in the Carrizo Springs-Crystal City area and from northeastern Zavala County into Frio and Atascosa Counties. Poorly cemented well casing also contributes to this leakage.

Water quality in the Winter Garden area will probably remain good. The most significant problem to be overcome is to curb the rate at which the Carrizo aquifer is being depleted before further deterioration occurs.

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# Appendix I
# Records of Wells

**Aquifer Codes**

124 CRRZ - Carrizo Aquifer
124 QNCT - Queen City Aquifer
124 WLCX - Wilcox Aquifer

**Lift**

N - None
P - Piston Pump
S - Submersible Pump
T - Turbine

**Power**

E - Electric Motor
G - Gasoline
N - Natural Gas
W - Windmill

**Use**

H - Domestic
I - Irrigation
N - Industrial
P - Public Supply
S - Stock
U - Unused

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Atascosa

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68-50-603 | O. M. Naegelin | Adcock Pipe & Supply | 1965 | 249 | C | 8 | 0 | 151 | 124WLCX | 655 | -89.64 | 11-19-1969 | S E | H I S | Observation well. Cemented to 50 |
| | | | | | S | 8 | 151 | 249 | | | -82.70 | 01-29-1991 | 10.00 | | feet. Reported yield 120 gpm. |
| 68-51-701 | Diamond A Cattle Co. | | | 150 | | | | | 124CRRZ | 610 | -58.93 | 04-01-1970 | S E | H S | Temp. 74 degrees F. Observation |
| | | | | | | | | | | | -56.05 | 01-25-1991 | | | well. |
| 68-52-709 | J.D.Harrison | Olaf L. Boone | 1949 | 315 | | | | | 124CRRZ | 660 | -154.56 | 04-20-1965 | T E | N | Slotted from 155 to 315 ft. Gravel |
| | | | | | | | | | | | -155.22 | 04-13-1970 | 30.00 | | packed. Temp. 76 degrees F. |
| 68-58-304 | George Thompson | Strickers Water | 1969 | 450 | | | | | 124CRRZ | 675 | -165.04 | 06-02-1972 | T G | I | Slotted from 250 to 450 ft. |
| | | Well Service | | | | | | | | | | - - | 150.00 | | |
| 68-59-512 | Henry Fortinberry | Stewart Well Service | 1989 | 300 | | | | | 124CRRZ | 547 | | - - | S E | H S | |
| | | | | | | | | | | | | - - | | | |
| 68-59-614 | Kenneth Hoffman | Olaf L. Boone | 1962 | 455 | C | 10 | 0 | 240 | 124CRRZ | 480 | -60.00 | 0 -0 -1964 | T E | H S | Irrigated 80 acres in 1964. Temp. |
| | | | | | C | 7 | 240 | 400 | | | | - - | 30.00 | | 80 degrees F. |
| | | | | | S | 7 | 400 | 455 | | | | | | | |
| 68-59-922 | Robert W. Barrows | James W. Cude | 1978 | 102 | C | 5 | 0 | 62 | 124QNCT | 430 | -21.00 | 07-03-1978 | S E | S H | |
| | | | | | S | 5 | 62 | 102 | | | -56.56 | 07-20-1990 | | | |
| 68-60-527 | City of Poteet | | 1985 | 925 | | | | | 124CRRZ | | | - - | T E | P | |
| | | | | | | | | | | | | - - | | | |
| 68-61-207 | Tony Divin | Olaf L. Boone | 1964 | 805 | | | | | 124CRRZ | 510 | -116.00 | 03-0 -1964 | T E | I | Slotted from 568 to 805 ft. Report- |
| | | | | | | | | | | | | - - | 60.00 | | ed yield 1155 gpm. Irrigates 300 ac |
| | | | | | | | | | | | | | | | Development test, 1984, Stewart & |
| | | | | | | | | | | | | | | | Stevenson Srvs Inc: 920 gpm at 136 |
| | | | | | | | | | | | | | | | ft pumping level, 1535 gpm at 142 |
| | | | | | | | | | | | | | | | ft, and 1990 gpm at 150 ft. |
| 68-61-905 | Ned Royal | Olaf L. Boone | 1965 | 1413 | C | 10 | 0 | 515 | 124CRRZ | 482 | -92.28 | 04-26-1965 | T G | I | Observation well. |
| | | | | | C | 7 | 515 | 1200 | | | -127.90 | 01-16-1991 | 75.00 | | |
| | | | | | S | 7 | 1200 | 1413 | | | | | | | |
| 78-03-601 | Edgar Muellar | Lawrence and Joe | 1953 | 1647 | C | 8 | 0 | 212 | 124CRRZ | 565 | -96.00 | 04-19-1956 | N | H | Obseravtion well. Reported yield |
| | | Swierc | | | C | 6 | 212 | 1470 | | | -191.77 | 01-28-1991 | | | 400 gpm with 34 ft drawdown in 1953 |

RECORDS OF WELLS, SPRINGS, AND TEST HOLES

COUNTY - Atascosa

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAMETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASUREMENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 78-03-601 (Continued) | | | | | S | 6 | 1470 | 1647 | | | | | | | |
| 78-04-104 | L.E. Molak | Lawrence and Joe Swierc | 1963 | 1038 | C<br>S | 8<br>8 | 0<br>840 | 840<br>1038 | 124CRRZ | 490 | -40.00 | 0 -0 -1964<br>- - | T E<br>30.00 | I | Reported yield 615 gpm. Drawdown 50 feet pumping 900 gpm in 1964. |
| 78-04-803 | City of Jourdanton | McKinley Drlg | 1957 | 1960 | | | | | 124CRRZ | 480 | -55.00<br>-74.85 | 04-0 -1957<br>04-28-1965 | T E<br>75.00 | P | Slotted from 1825 to 1960 ft. Reported yield of 725 gpm. Development test: drawdown of 65 ft while pumping 2032 gpm on Apr. 24,1957. |
| 78-05-116 | Alfredo Sotello | Tom Draper | 1932 | 1200 | | | | | 124CRRZ | 373 | 40.00<br>-36.07 | 06-05-1944<br>01-08-1991 | S E<br>0.50 | S S | Well 76 in Water-Supply Paper 1079-C. Reported flow of 65 gpm in 1965. Observation well. |
| 78-05-409 | City of Pleasanton | Olaf L. Boone | 1957 | 800 | | | | | 124QNCT | 380 | -79.00<br>-69.92 | 07-09-1963<br>01-29-1991 | T E<br>20.00 | P | Drawdown of 30 feet pumping 290 gpm July 9,1963. Slotted from 640 to 800 ft. Observation well. |
| 78-05-501 | E.G. Miles | Ormand and Boone | 1941 | 1943 | | | | | 124CRRZ | 405 | 38.00<br>-75.60 | 05-09-1944<br>01-08-1991 | S E<br>0.75 | H S | Perforated from 1840 to 1943 ft. Reported flow of 217 gpm in 1944. Temp. 98 degrees F. Observation well. |
| 78-06-504 | Erwin Kretzschmar | McKinley Drlg | 1966 | 2302 | | | | | 124CRRZ | 340 | 25.00 | 05-0 -1966<br>- - | N T<br>25.00 | S I | Slotted from 2125 to 2302 ft. Cemented from 2075 ft to surface. Reported flow of 200 gpm and yield of 400 gpm. Temp. 110 degrees F. |
| 78-06-903 | Jim Woodley | Quintant Petroleum | 1962 | 3500 | | | | | 124CRRZ | 336 | | - -<br>- - | N | I | Oil test; converted to water well. Slotted from 2900 to 3500 ft. Top of Carrizo Sand at 2580 ft. |
| 78-11-217 | City of Charlotte | Boone and Thierry | 1957 | 1869 | C<br>C<br>S | 10<br>8<br>8 | 0<br>510<br>1703 | 510<br>1703<br>1869 | 124CRRZ | 530 | -107.00<br>-133.00 | 04-0 -1957<br>04-29-1965 | T E<br>50.00 | P | Reported yield of 475 gpm. Cemented from 1700 ft to surface. Drawdown of 93 ft while pumping 1200 gpm on Jan.2, 1957. |
| 78-12-502 | Franklin Steinli | Lawrence & Joe Swierc | 1971 | 2610 | | | | | 124CRRZ | 431 | -87.86 | 05-27-1976<br>- - | S E<br>60.00 | I H S | Slotted from 2304 to 2610 ft. Cemented from 486 ft to surface. |
| 78-12-601 | Ladik Vyvlecka | Lawrence & Joe Swierc | 1971 | 1456 | | | | | 124QNCT | 410 | -40.00 | 07-0 -1971<br>- - | T G<br>60.00 | I | Slotted from 1286 to 1456 ft. Reported yield 300 gpm. |

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Atascosa

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 78-14-302 | Gala Ranch | | 1969 | 3400 | | | | | 124CRRZ | 291 | | - - | N | H S I | Slotted from 3100 to 3400 ft. |
| | | | | | | | | | | | | - - | | | Cemented from 3100 ft to surface. |
| | | | | | | | | | | | | | | | Reported flow of 550 gpm. Temp. |
| | | | | | | | | | | | | | | | 100 degrees F. |
| 78-15-805 | Fashing Peggy Water | Layne Texas | 1968 | 4359 | | | | | 124CRRZ | 469 | -60.00 | 11-13-1969 | S E | P | Plug set from 4357 to 4359 ft. |
| | Supply Corp. | | | | | | | | | | -102.90 | 01-21-1991 | | | Slotted from 4293 to 4320 ft. Cem- |
| | | | | | | | | | | | | | | | ented from 4200 ft to surface. Temp |
| | | | | | | | | | | | | | | | 140 degrees F. Observation well. |
| | | | | | | | | | | | | | | | Drawdown of 10 ft while pumping 115 |
| | | | | | | | | | | | | | | | gpm for 30 hours on June 26, 1968. |
| 78-20-801 | Sam Countiss | Lawrence & Joe | 1948 | 2300 | | | | | 124QNCT | 315 | | - - | N | H S | Well located in McMullen Co in TWC |
| | Rancho Seco | Swierc | | | | | | | | | | - - | | | Bulletin 6520 and TWDB Report 210. |
| | | | | | | | | | | | | | | | Reported flow 20 gpm in 1962. |
| 78-21-106 | Alonzo M. Peeler | J. Hiller | 1964 | 2975 | C | 10 | 0 | 400 | 124CRRZ | 305 | 59.40 | 06-23-1965 | N T | I H S | Observation well. Temp 119 degrees |
| | | | | | C | 7 | 400 | 2800 | | | -31.69 | 01-21-1991 | 40.00 | | F. Reported flow of 50 gpm in 1969. |
| | | | | | S | 7 | 2800 | 2975 | | | | | | | Reported yield of 842 gpm. |
| 78-22-202 | City of Corpus Christi | Layne Texas Co. | 1951 | 4132 | C | 18 | 0 | 360 | 124CRRZ | 242 | 189.10 | 02-0 -1951 | N | P | Log Q-32. Flow 400 gpm and pumped |
| | | | | | C | 10 | 361 | 3425 | | | 90.32 | 03-18-1988 | | | at 1400 gpm. |
| | | | | | C | 8 | 3425 | 3643 | | | | | | | |
| | | | | | S | 8 | 3643 | 3784 | | | | | | | |
| | | | | | C | 8 | 3784 | 3884 | | | | | | | |
| | | | | | S | 8 | 3884 | 3915 | | | | | | | |
| | | | | | C | 8 | 3915 | 3930 | | | | | | | |
| | | | | | S | 8 | 3930 | 3950 | | | | | | | |
| | | | | | C | 8 | 3950 | 4020 | | | | | | | |
| | | | | | S | 8 | 4020 | 4120 | | | | | | | |
| | | | | | C | 8 | 4128 | 4130 | | | | | | | |

Jan 13, 1992

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Bexar

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68-46-801 | City of Elendorf | J-B Drilling | 1985 | 520 | | | | | 124CRRZ | 510 | | - -<br>- - | S E<br>20 | | |
| 68-52-405 | Twin Valley Terrace Suburban Water Devel. | Adcock Pipe and Supply | 1966 | 408 | | | | | 124WLCX | 560 | | - -<br>- - | S E<br>1.50 | P | Perforated from 318 to 408 ft. Gravel packed. Development test: Drawdown of 182 ft. while pumping 200 gpm for 4 1/2 hours on February 12, 1966. Temp. 72 degrees F. |
| 68-53-809 | Jack Brown | Moys Water Well Drilling | 1969 | 446 | | | | | 124CRRZ | 555 | -150.00 | 12-0 -1969<br>- - | S E<br>1.00 | H S | Cemented from 382 ft. to surface. Pump set at 168 ft. |

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Dimmit

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAMETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASUREMENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 76-48-401 | H. A. Fitzsimons | R.B. Owens | | 246 | | | | | 124WLCX | 700 | -97.90<br>-109.53 | 07-21-1960<br>02-15-1991 | P W | H S | Perforated. Gravel packed. |
| 76-48-802 | H. A. Fitzsimons<br>San Pedro Ranch | | | | | | | | 124CRRZ | 688 | | - -<br>- - | S E | H S I | |
| 77-18-710 | Allen Plumbing and Supply | Cribbs and Davidson | 1927 | 992 | | | | | 124CRRZ | 570 | | - -<br>- - | T E<br>75.00 | H I | WEll N7-47 in Texas Board of Water Engineers Bulletin 6003. Reported yield of 332 gpm. Developement test drawdown of 22 ft while pumping 190 gpm on Dec. 15,1954. Temp. 94 degrees F. |
| 77-18-904 | Doug Potts | C.F. Burch | 1964 | 1273 | C<br>S | 12<br>10 | 0<br>950 | 950<br>1273 | 124CRRZ | 570 | -344.05<br>-321.12 | 03-18-1966<br>02-10-1981 | T N<br>100.00 | I | Reported yield 903 gpm. Temp. 94 degrees F. Observation well. |
| 77-19-810 | Bruce Weaver | McKinley Drl co | 1954 | 1333 | C | 12 | 0 | 1333 | 124CRRZ | 550 | -336.20<br>-307.00 | 04-04-1957<br>01-13-1978 | T<br>150.00 | U | Formerly well was HZ-77-27-302 in Vol II of Texas Water Development board Reporte 210. Observation well. |
| 77-25-205 | Patti Coleman | R.B. Owens | 1959 | 325 | | | | | 124CRRZ | 653 | -195.00<br>-246.55 | 01-0 -1962<br>01-15-1969 | T E<br>40.00 | I S | Open hole from 45 to 325 ft. |
| 77-26-424 | A.J. Votaw | | 1917 | 315 | | | | | 124CRRZ | 601 | | - -<br>- - | S E<br>15.00 | H I | Well N7-103 in Texas Board of Water Engineers Bulletin 6003. Reported yield of 175 gpm. Temp. 82 degrees F. |
| 77-26-610 | City of Carrizo Sprngs | McKinley Drilling | 1985 | 841 | | | | | 124CRRZ | 532 | | - -<br>- - | T E | P | WEll is across road from recorder. |
| 77-27-305 | Linda Castellaw | | 1912 | 1236 | | | | | 124CRRZ | 520 | -26.10 | 01-31-1928<br>- - | S E<br>25.00 | H S | Well N9-3 in TExas Board of Water Engineers Bulletin 6003. Perforated from 900 to 1200 ft. PUmp set at 500 ft. Reported yield of 150 gpm. Temp. 96 degrees F. |
| 77-27-702 | Dale Hasten | --Seward | 1928 | 866 | C<br>C | 10<br>8 | 0<br>260 | 260<br>630 | 124CRRZ | 555 | -182.80<br>-183.75 | 12-15-1960<br>01-21-1964 | P W | S | WEll N8-72 in Texas Board of Water Engineers Bulletin 6003. Open hole |

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Dimmit

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77-27-702 (Continued) | | | | | O | | 630 | 866 | | | | | | | from 630 to 860 ft. Unused domestic and livestock well. Historical obseration well. |
| 77-28-503 | City of Big Wells | McKinley Drlg | 1984 | 1500 | | | | | 124CRRZ | 535 | -277.49<br>-277.84 | 03-18-1966<br>02-14-1991 | S E | P | Slotted from 1320 to 1500 ft. Cemented from 1260 ft to surface. Reported yield of 175 gpm. Temp.87 degrees F. Observation well. |
| 77-33-309 | CDR. H. J. Cartwright | Charles Lindeborn | 1928 | 335 | | | | | 124CRRZ | 665 | | - -<br>- - | S E<br>2.00 | H S | Well S1-7 in Texas Board of Water Engineers Bulletin 6003. Temp.80 degrees F. |
| 77-33-611 | Jim Bob Nance | O.F. Webb | 1944 | 360 | | | | | 124CRRZ | 690 | -90.00<br>-126.45 | 0 -0 -1944<br>02-15-1991 | T G<br>50.00 | I H S | Well S1-43 in Texas Board of Water Engineers Bulletin 6003. Open hole from 40 to 360 ft. Temp. 80 degrees F. Observation well. |
| 77-34-204 | Charles Wilson | Elmo Owens | 1930 | 670 | | | | | 124CRRZ | 600 | -205.82<br>-227.03 | 08-16-1950<br>02-11-1981 | T E<br>30.00 | H S I | WEll S2-18 in Texas Board of Water Engineers Bulletin 6003. Open hole form 518 to 670 ft. Temp. 83 degree Observation well. |
| 77-34-608 | City of Asherton | McKinley Drilling Co. | 1990 | 740 | C<br>C<br>S<br>C<br>S<br>C | 14<br>10<br>10<br>10<br>10<br>10 | 0<br>460<br>480<br>541<br>570<br>661 | 480<br>480<br>541<br>570<br>661<br>673 | 124CRRZ | 553 | | - -<br>- - | T E<br>125 | P | |
| 77-35-403 | Wesley E. Tollett | O.F. Webb | 1943 | 706 | | | | | 124CRRZ | 535 | | - -<br>- - | S E<br>3.00 | H S | Perforated from 348 to 680 ft. Temp 83 degrees F. |
| 77-35-601 | Dorothy Johnson | | 1927 | 1050 | | | | | 124CRRZ | 550 | -208.46<br>-235.36 | 02-11-1970<br>02-08-1989 | T E<br>60.00 | H S I | WEll S3-6 in Texas Board of Water Engineers Bulletin 6003. Observat-ion well. |
| 77-35-802 | Steve Kennedy | J.W. Hickerson | 1960 | 1300 | | | | | 124CRRZ | 590 | -298.90<br>-279.40 | 02-10-1965<br>02-10-1987 | T E<br>125.00 | H S I | Perforated from 1000 to 1300 ft. Reported yield of 900 gpm. Temp. 91 degrees F. Observation well. |
| 77-37-102 | Lawrence W. Henrichson | Stan Ross Drilling | 1955 | 1768 | | | | | 124CRRZ | 460 | | - -<br>- - | T G<br>125.00 | H S I | Open hole from 1068 to 1768 ft. Pump set at 300 ft. Reported yield |

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Dimmit

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77-37-102 (Continued) | | | | | | | | | | | | | | | of 553 gpm. Temp. 102 degrees F. |
| 77-37-202 | Royce Beall<br>Flying "W" Ranch | Titan Perforators,<br>Inc. | 1980 | 1830 | C<br>S | | 0<br>1810 | 1810<br>1830 | 124CRRZ | 520 | | - -<br>- - | S E | H S | |
| 77-37-501 | Orval Daniel | McKinley Drilling | 1951 | 2065 | | | | | 124CRRZ | 485 | -172.80<br>-230.20 | 05-21-1957<br>02-14-1991 | T G<br>200.00 | I | Well T1-12 in Texas Board of Water Engineers Bulletin 6003. Slotted from 1850 to 2060 ft. Observation well. |
| 77-41-201 | Leroy Jones | | 1910 | | | | | | 124CRRZ | 747 | | - -<br>- - | S E<br>3 | H S | Owner reworked well in 1965 and cemented up to 500 ft. |
| 77-42-801 | Dolph Briscoe | | 1928 | 1374 | | | | | 124CRRZ | 613 | -72.45<br>-171.95 | 12-10-1929<br>02-19-1991 | S E | H S | Well S5-5 in Texas Board of Water Engineers Bulletin 6003. Open hole from 1083 to 1374 ft. Observation well. |
| 77-44-101 | Eddie Vivian | | | 1200 | | | | | 124CRRZ | 480 | -165.83<br>-181.77 | 07-11-1957<br>02-19-1991 | S E | H S | Well S3-23 in Texas Board of Water Engineers Bulletin 6003. Reported yield of 350 gpm. Observation well. |

Jan 13, 1992

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Frio

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68-57-619 | Aldridge Nursery | Lawrence and Joe Swierc | 1968 | 416 | | | | | 124CRRZ | 732 | | - -<br>- - | T E<br>60.00 | I | Slotted from 196 to 412 ft. Temp. 80 degrees F. Reported yield of 488 gpm. Drawdown 33 feet pumping 1700 gpm for 8 hrs 12-68. |
| 68-58-506 | J. E. Ingram | E. H. Cannon Dril-ling | 1963 | 636 | | | | | 124CRRZ | 611 | -116.00<br>-192.20 | 03-0 -1963<br>02-01-1991 | T G<br>125.00 | I | Slotted from 430 to 550 ft. Open hole from 550 to 636 ft. Top of Carrizo Sand 350 ft. Reported yield of 642 gpm. Temp. 82 degrees F. Cased to 550 ft. Observation well. Development test on March 19, 1963 by Peerless Equipment Co. 1049 gpm at 147 ft pumping level and 1650 gpm at 158 feet. |
| 69-61-901 | O. W. Machen | E. H. Cannon Drlg | 1946 | 260 | | | | | 124CRRZ | 700 | -85.18<br>-99.36 | 07-12-1951<br>04-14-1955 | T G<br>125.00 | I | Slotted from 154 to 260 ft. Top of Carrizo Sand 154 ft. Pump set at 220 ft. Reported yield of 1500 gpm. Historical observation well. |
| 69-62-902 | P.R. Rutherford<br>T.J. Goad, well 4 | E.H. Cannon Drlg | 1957 | 717 | | | | | 124CRRZ | 610 | -102.00<br>-165.95 | 02-0 -1957<br>04-10-1991 | T E<br>75.00 | I | Slotted from 402 to 550 ft. Open hole from 550 to 715 feet. Observa-tion well. Top of Carrizo Sand 391 feet. Drawdown 46 feet pumping 1702 gpm and 38 feet at 1108 gpm in Feb. 1957. |
| 69-63-604 | Bufrod Allen | Alfred Mann Water Wells | 1956 | 233 | | | | | 124CRRZ | 630 | -83.00<br>-148.35 | 04-0 -1956<br>10-01-1969 | T G<br>125.00 | I S I | Open hole form 221 to 233 ft. Top of Carrizo Sand 217 ft. Pump set at 170 ft. Temp. 84 degrees F. Cased to 221 ft. |
| 69-64-607 | Moore Water Supply Corp | H. and S. Water Well Srv | 1967 | 460 | | | | | 124CRRZ | 670 | -178.00 | 06-17-1967<br>- - | S E<br>15.00 | P | Slotted from 300 to 450 ft. Cement-ed from 170 ft to surface. Temp. 84 degrees F. Reported yield of 100 gpm. Development test: drawdown of 12 ft while pumping 208 gpm for 7 hours on June 17, 1967. |

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Frio

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77-06-301 | Mrs. Carrie E. Thompson | McKinley Drlg Co. | 1942 | 816 | | | | | 124CRRZ | 605 | -65.00<br>-196.40 | 0 -0 -1942<br>04-08-1991 | S E | H S | Top of Carrizo Sand 716 ft. Observation well. |
| 77-07-904 | Halff and Oppenheimer Leona Farms | McKinley Drilling | 1964 | 1725 | C<br>C<br>S | 12<br>10<br>10 | 0<br>840<br>1470 | 840<br>1470<br>1720 | 124CRRZ | 558 | -187.00 | 12-04-1964<br>- - | T E<br>150.00 | I | Top of Carrizo Sand at 1330 feet. Cemented from 1400 ft to surface. Drawdown of 50 ft while pumping 1900 gpm and 24 feet at 1001 gpm on December 4, 1964. |
| 77-08-201 | A.C. Hardcastle | | 1958 | 906 | | | | | 124CRRZ | 700 | -207.82<br>-315.90 | 12-01-1960<br>03-18-1991 | S E | H S | Perforated from 860 to 900 feet. Cased to 900 ft. Observation well. |
| 77-08-716 | City of Pearsall | E. H. Cannon Drilling | 1963 | 1572 | | | | | 124CRRZ | 618 | -253.00<br>-321.50 | 11-0 -1963<br>04-03-1991 | T N<br>200.00 | P | Slotted from 1320 to 1570 feet. Cemented from 1250 feet to surface. Top of Carrizo Sand 1270 feet. Reported yield of 950 gpm. Observation well. Cased to 1572 ft. 400 ft of 8-in column pipe. Development test by Peerless Equip. Co.,Nov. 1963: 1037 gpm at 270 ft pumping level, 1664 gpm at 292 ft. |
| 77-08-813 | Iven H. Neal | E.H. Cannon Drlg | 1970 | 160 | | | | | 124QNCT | 633 | | - -<br>- - | S E<br>0.75 | H S | Slotted from 140 to 154 ft. Cemented from 120 ft to surface. Reported yield 8 gpm. |
| 77-14-903 | J.H. King | E.H. Cannon Drlg | 1955 | 1672 | | | | | 124CRRZ | 520 | -135.00 | 07-0 -1955<br>- - | T N<br>225.00 | I | Slotted from 1516 to 1662 ft. Top of Carrizo Sand 1345 ft. Reported yield of 970 gpm. Development test drawdown of 40 ft while pumping 1303 gpm in July 1955. Temp 100 degrees F. Casing: 12-in to 413 ft 10 in from 413 to 1672 ft. Test, July 1955: 1037 gpm at 163 ft pumping level, 1303 gpm at 175 ft. |
| 77-16-408 | Murray McKinley | Murray McKinley | 1972 | 905 | C<br>S<br>C<br>S<br>O | 7<br>7<br>4<br>4<br> | 0<br>406<br>360<br>785<br>875 | 406<br>436<br>785<br>875<br>905 | 124QNCT | 585 | | - -<br>- - | S E<br>2.0 | H | |

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Frio

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77-16-603 | J.H. Woodward | E.H. Cannon Drlg | 1963 | 1785 | C | 13 | 0 | 600 | 124CRRZ | 640 | -250.00 | 02-0 -1963 | T N | I | Observation well. Top of Carrizo Sand at 1,585 feet. Development test by Peerless Equip. Co., Feb. 1963: 1049 gpm at 287 ft pumping level, 1321 gpm at 299 ft. |
| | | | | | C | 10 | 600 | 1585 | | | -346.85 | 03-13-1991 | 150.00 | | |
| | | | | | S | 10 | 1585 | 1785 | | | | | | | |
| 77-22-502 | Milton Urban | E.H. Cannon Drlg | 1955 | 2150 | C | 12 | 0 | 600 | 124CRRZ | 610 | -261.06 | 02-10-1964 | T G | I | Observation well. Reported yield of 1100 gpm. Top of Carrizo Sand at 1850 ft. |
| | | | | | C | 10 | 600 | 1850 | | | -395.00 | 03-18-1991 | 125.00 | | |
| | | | | | S | 10 | 1850 | 1950 | | | | | | | |
| | | | | | C | 10 | 1850 | 1950 | | | | | | | |
| | | | | | S | 10 | 2050 | 2150 | | | | | | | |
| 77-23-305 | Willie Carter | McKinley Drlg | 1972 | 1852 | | | | | 124CRRZ | 481 | | - - | T G | I | Slotted from 1802 to 1852 ft. Temp. 101 degrees F. Development test: drawdown of 117 ft pumping 1497 gpm for 24 hours on Jan.31,1972. |
| | | | | | | | | | | | | - - | 240.00 | | |
| 77-23-808 | City of Dilley | Murray McKinley | 1988 | 2150 | C | 14 | 0 | 723 | 124CRRZ | 561 | -329.98 | 02-14-1989 | T E | P | |
| | | | | | C | 10 | 723 | 1830 | | | | - - | 100.00 | | |
| | | | | | C | 8 | 1767 | 1829 | | | | | | | |
| | | | | | S | 8 | 1829 | 1920 | | | | | | | |
| | | | | | C | 8 | 1920 | 1984 | | | | | | | |
| | | | | | S | 8 | 1984 | 2145 | | | | | | | |
| | | | | | C | 8 | 2145 | 2150 | | | | | | | |
| 77-24-202 | Bennett Brothers | E.H. Cannon Drlg | 1963 | 2030 | C | 13 | 0 | 512 | 124CRRZ | 458 | -111.00 | 01-0 -1963 | T N | I | Reported yield 1,050 gpm. Top of Carrizo Sand at 1760 ft. Drawdown of 51 feet pumping 1623 gpm in Jan. 1963. Observation well. |
| | Benton Roberts | | | | C | 10 | 512 | 1760 | | | -224.50 | 04-11-1991 | 225.00 | | |
| | | | | | S | 10 | 1760 | 2030 | | | | | | | |
| 78-01-501 | M.R. McDonald | Pegg Brothers | 1956 | 1199 | | | | | 124CRRZ | 525 | -75.00 | 11-15-1956 | T E | I | Slotted from 832 to 1199 feet. Cemented from 850 feet to surface. Cased to 850 ft. Reported yield of 1200 gpm. Development test: drawdown of 62 ft pumping 2050 gpm and 38 ft at 1027 gpm on Nov.15, 1956. Observation well. |
| | | | | | | | | | | | -167.70 | 04-03-1991 | 100.00 | | |
| 78-02-701 | Otto Mann, Sr. | E.H. Cannon Drlg | 1954 | 1588 | C | 10 | 0 | 300 | 124CRRZ | 553 | -60.00 | 04-0 -1965 | | H S | Drawdown 85 ft pumping 700 gpm in 1954. Top of Carrizo Sand 1175 ft. |
| | | | | | C | 7 | 300 | 1200 | | | -206.50 | 02-05-1991 | | | |

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Frio

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 78-02-701 | (Continued) | | | | 0 | | 1200 | 1588 | | | | | | | Casing: 10-in to 300 ft, 7-in from 300 to 1200 ft. |
| 78-02-709 | Otto Mann, Jr | Olaf L. Boone | | 555 | | | | | 124QNCT | 565 | -201.89<br>-186.86 | 08-27-1970<br>02-05-1991 | S E<br>1.00 | H | Perforated. Temp 84 degrees F. Observation well. |
| 78-09-503 | Oppenheimer and Lang | | 1952 | 1700 | | | | | 124CRRZ | 520 | -80.00 | 12-0 -1954<br>- - | T E<br>100.00 | I | Oil test drilled to 5004 ft. Plug-ged back to 1700 ft. and converted to water well. Top of Carrizo Sand at 1,510 ft. Reported yield of 565 gpm. Temp. 98 degrees F. |
| 78-18-501 | Joe Hindes | | 1917 | 2114 | | | | | 124CRRZ | 401 | 80.00<br>-18.80 | 0 -0 -1929<br>04-08-1991 | S E | S | WEll 114 in Water Supply Paper 676. Temp. 99 degrees F. Observation well. Formerly an irrigation well. Reported flow 600 gpm in 1929. Estimated flow 300 gpm, Apr.11,1944 Measured flow 7 gpm, June 13,1962. |

Jan 13, 1992

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Karnes

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | CASING AND SCREEN DATA: DIAM-ETER (IN.) | CASING AND SCREEN DATA: TOP DEPTH (FT.) | CASING AND SCREEN DATA: BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | WATER LEVEL: DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68-64-902 | El-Oso W.S.C. | Layne-Western | 1990 | 3165 | C | 14 | 0 | 600 | 124CRRZ | 358 | -28.00 | 05-00-1980 | T E | P | City well #1. North of Falls City. |
| | | | | | C | 10 | 600 | 2930 | | | | - - | 60 | | |
| | | | | | C | 6 | 2730 | 3165 | | | | | | | |
| | | | | | S | 6 | 2936 | 3160 | | | | | | | |

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - La Salle

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77-30-502 | Joe Mathews | E.H. Cannon Drilling | 1965 | 2030 | | | | | 124CRRZ | 610 | -322.00<br>-328.40 | 12-0 -1965<br>02-09-1987 | T G | I | Perforated from 1730 to 2030 ft. Reported yield of 1100 gpm. Development test: drawdown of 38 ft while pumpinng 1525 gpm in Dec. 1965. Temp. 108 degrees F. Obsrvation well. |
| 77-31-103 | Calvin Vernon | E.H. Cannon Drlg | 1967 | 2400 | | | | | 124CRRZ | 510 | | - -<br>- - | T G<br>275.00 | H S I | Slotted from 2020 to 2400 ft. Cemented from 2000 ft to surface. Pump set at 450 ft. Reported yield of 1100 gpm. Development test: drawdown of 159 ft while pumping 1852 gpm for 32 hours in Mar. 1967. |
| 77-38-201 | C.M. Dismukes | Humble Oil and Ref | 1942 | 2200 | | | | | 124CRRZ | 475 | -108.20<br>-241.37 | 02-18-1959<br>02-13-1991 | T E<br>60.00 | I | Oil test drilled to 9000 ft, plug-ged back to 2200 ft, and converted to water well. Gun perforated from 1800 to 2200 ft. Pump set at 320 ft. Reported yield of 1000 gpm. Temp. 105 degrees F. Observation well. |
| 77-39-407 | City of Cotulla | McKinley Drilling | 1982 | 2337 | | | | | 124CRRZ | 431 | -196.19<br>-196.60 | 02-21-1986<br>02-12-1991 | T E | P | |
| 77-47-802 | Sam Evans Estate | Shields and Narrilles | 1947 | 3290 | | | | | 124CRRZ | 398 | 20.00<br>-39.87 | 04-26-1959<br>02-13-1991 | P W | S | Oil test drilled to 5505 ft, plug-ged back to 3290 ft, and converted to water well. Slotted from 3060 to 3290 ft. Reported flow of 10 gpm in 1959. Temp. 108 degrees F. Observation well. |

Jan 13, 1992

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Medina

| WELL | OWNER | DRILLER | DATE COM- PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM- ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE- MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68-49-605 | A. L. Campsey | Campsey Drilling | 1989 | 75 | C | 5 | 0 | 75 | 124CRRZ | 695 | | - -<br>- - | S E<br>.50 | H | |
| 68-49-606 | Edgar Christopher | Campsey Drilling | 1988 | 70 | C<br>S | 5<br>5 | 0<br>50 | 50<br>70 | 124CRRZ | 700 | | - -<br>- - | S E | H | |
| 68-49-917 | City of Devine | Roy Stricker Drilling | 1987 | 320 | | | | | 124CRRZ | 690 | | - -<br>- - | S E | P | |
| 68-57-209 | Morales Feed Lot | E.h. Cannon Drlg | 1965 | 360 | | | | | 124CRRZ | 690 | | - -<br>- - | T E<br>100.00 | I I | Slotted from 160 to 360 ft. Gravel packed. Reported yield of 800 gpm. Temp. 79 degrees F. |
| 68-58-101 | J.W. Wingate | | | 237 | | | | | 124CRRZ | 650 | -110.92<br>-147.90 | 05-12-1960<br>01-25-1991 | P W | H S | Well deepened from 116 to 141 ft in 1964. Perforated. Observation well. Well J-7-21 in U.S. Geol. Survey Water-Supply Paper 678. |
| 69-54-601 | Herman Fohn | | | 150 | | | | | 124WLCX | 760 | -65.35 | 12-08-1969<br>- - | P W | S | Temp. 74 degrees F. |
| 69-56-903 | Frank Silvey | John W. Moy | 1989 | 375 | | | | | 124CRRZ | 750 | | - -<br>- - | T D<br>140 | I | |
| 69-64-202 | Chirstine Weaver | Alfred Mann Water Wells | 1951 | 210 | | | | | 124CRRZ | 660 | -94.50 | 02-19-1952<br>- - | T G<br>65.00 | I | Well I-9-28 in Texas Board of Water Engineers Bulletin 5601. Perforated from 90 to 210 ft. Pump set at 197 ft. Reported yield of 460 gpm with drawdown of 34 ft on Feb.19,1952. Temp. 77 degrees F. Casing: 21 ft, perforated from 90 to 210 ft. Drawdown 34.3 ft while pumping 460 gpm Feb.19,1952. |

Jan 13, 1992

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Wilson

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 67-41-801 | J. P. Lorenz | H. & J. Drilling Co. | 1964 | 1086 | | | | | 124CRRZ | 547 | -146.65<br>-143.99 | 03-12-1969<br>12-11-1990 | | H S | Oil test converted to water well. Slotted from 1,026 to 1,086 ft. Observation well. |
| 67-49-201 | City of Stockdale | Layne Texas Co. | 1963 | 916 | | | | | 124CRRZ | 470 | -75.00<br>-99.00 | 04-29-1963<br>12-12-1989 | T E<br>50.00 | P | Slotted from 716 to 776 ft. and 811 to 901 ft. Cemented from 0-705 ft. Drawdown of 32 ft. while pumping 1,040 gpm for 24 hours on April 25 Observation well. Temp. 83 degrees F. |
| 67-49-202 | City of Stockdale | A. R. Theirry | 1952 | 460 | | | | | 124QNCT | 472 | -76.34<br>-77.61 | 02-18-1969<br>12-12-1990 | S E<br>35.00 | P | Well C-25 in TBWE Bulletin 5710. Observation well. Temp 79 degrees F drilled to 600 ft. and plugged back to 460 ft. Perforated from 330 ft. to surface. Reported yield 350 gpm. |
| 68-47-303 | City of Lavernia | Pursley Water Wells | 1968 | 525 | | | | | 124WLCX | 495 | | - -<br>- - | S E | P | |
| 68-47-601 | Lawrence Powell | | | 440 | | | | | 124CRRZ | 652 | -202.55<br>-203.80 | 01-23-1964<br>12-13-1989 | P E<br>0.25 | H S | Observation well. |
| 68-48-102 | City of La Vernia | Moys Water Well Drilling | 1962 | 514 | | | | | 124WLCX | 495 | | - -<br>- - | S E<br>15.00 | P | Slotted from 454 to 514 ft. Cemented from 454 ft. to surface. Reported yield of 250 gpm. Temp. 80 degrees F. |
| 68-48-601 | David Baker | Moys Water Well Drilling | 1962 | 202 | | | | | 124CRRZ | 490 | -84.04<br>-197.23 | 01-27-1964<br>12-12-1990 | S E<br>1.00 | H S | Slotted from 52 to 202 ft. Gravel packed. Top of Carrizo Sand 163 ft. Observation well. |
| 68-54-501 | W. R. Deuvall | Hardin & Guenther | 1948 | 720 | | | | | 124WLCX | 432 | | - -<br>- - | T G<br>25.00 | I | Well A-51 in Texas Board of Water Engineers Bulletin 5710. Oil test converted to water well. Slotted from 680 to 720 ft. Reported flow of 75 gpm. Reported yield of 500 gpm. Temp. 70 degrees F. |

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Wilson

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68-55-502 | M. J. Oats | Ace Pump Co. | 1965 | 200 | | | | | 124QNCT | 453 | | - -<br>- - | T N<br>35.00 | I | Slotted from 150 to 200 ft. Reported yield 150 gpm. |
| 68-55-903 | City of Floresville | Layne Texas Co. | 1962 | 1260 | | | | | 124CRRZ | 390 | -12.40<br>-26.09 | 05-02-1969<br>02-18-1982 | T E<br>75.00 | P | Slotted from 965 to 1,260 feet. Cemented from 955 feet to surface. Observation well. Reported yield of 1200 gpm. Drawdown 45 feet while pumping 2180 gpm for 24 hours on Jan.5, 1962. Temp 91 degrees F. |
| 68-56-409 | S&S Water Supply Corp | Thomas Moy | 1988 | 1091 | C<br>S | 13<br>6 | 0<br>941 | 941<br>1091 | 124CRRZ | 560 | -176.00 | 02-00-1988<br>- - | S E | P | |
| 68-62-205 | John Henry Kelly | Watkins Brothers Drilling Co. | 1964 | 972 | | | | | 124CRRZ | 532 | -135.35<br>-161.43 | 03-13-1969<br>12-12-1990 | T G<br>75.00 | I | Slotted from 830 to 972 feet. Cemented from 830 feet to surface. Observation well. Reported yield of 586 gpm. Temp. 86 degrees F. Drawdown of 70 ft. while pumping 1,753 gpm for 30 hrs. on 7-31-64. |
| 68-62-507 | Vaughn Yeager | Thomas Moy | 1977 | 482 | C<br>S | 5<br>5 | 0<br>402 | 402<br>482 | 124QNCT | 500 | -84.00 | 04-00-1977<br>- - | S E | H | |
| 68-62-902 | Boening Brothers | Wise Drilling Co. | 1953 | 1600 | | | | | 124CRRZ | 437 | -30.80<br>-97.13 | 05-26-1955<br>12-11-1989 | T G<br>95.00 | I | Well F-65 in TBWE Bulletin 5710. Observation well. Slotted from 1460 to 1600 feet. Reported yield 1200 gpm. Temp. 99 degrees F. |
| 68-63-803 | Three Oaks Water Supply Corp. | McKinley Drilling Co. | 1971 | 2215 | | | | | 124CRRZ | 431 | -151.00<br>-95.54 | 06-0 -1971<br>05-22-1972 | S E | P | Slotted from 2,084 to 2,184 feet. Cemented from 2,056 ft. to surface. Drawdown 64 feet pumping 200 gpm for 24 hours when drilled. |
| 68-64-401 | City of Poth | | 1951 | 2012 | | | | | 124CRRZ | 400 | 10.00<br>-40.30 | 06-09-1954<br>12-12-1990 | | P | |

TEXAS WATER DEVELOPMENT BOARD
GROUND WATER DATA SYSTEM

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Zavala

| WELL | OWNER | DRILLER | DATE COM-PLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAM-ETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASURE-MENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 69-58-707 | Dennis Blair | J.E. and E.L. Kite | 1948 | 244 | C<br>S | 12<br>12 | 0<br>138 | 138<br>200 | 124CRRZ | 790 | -146.00<br>-155.96 | 04-08-1958<br>02-20-1991 | S E | I H | Well H7-28 in Texas Board of Water Engineers Bulletin 5203. Perforated from 138 ot 200 ft. Obsevation well . |
| 69-58-801 | Walker Brothers | E.L. Kite Sr | 1943 | 100 | C | 6 | 0 | 100 | 124CRRZ | 750 | -61.90<br>-61.53 | 12-27-1946<br>02-20-1991 | S E | H S | Well H8-68 in Texas Board of Water Engineers Bulletin 5203. Observat- Well deepened in 1963 from 84ft.to 100ft.<br>ion well. |
| 76-08-503 | Chaparrosa Ranch | | | 150 | | | | | 124CRRZ | 740 | -75.85<br>-92.85 | 03-15-1966<br>03-11-1988 | P W | S | Temp 74 degrees F. Observation well . |
| 76-24-901 | Pete Simpson | | 1926 | 140 | C<br>C<br>O | 6<br>6<br>6 | 0<br>0<br>20 | 20<br>20<br>100 | 124CRRZ | 665 | -76.00<br>-104.62 | 02-04-1930<br>02-20-1991 | P W | S | Well M9-5 in Texas Board of Water Engineers Bulletin 5203. Open hole from 20 to 100 ft. Observation well. |
| 77-01-404 | Chaparrosa Ranch<br>B.K.Johnson owner | | 1966 | 189 | C<br>S | 8<br>8 | 0<br>154 | 154<br>185 | 124CRRZ | 731 | -102.11<br>-114.27 | 03-11-1970<br>02-20-1991 | S E<br>1.00 | S | Perforated from 154 to 185 ft. Cemented from 150 ft to surface. Observation well. |
| 77-02-403 | Zavala County WCID | Verdell Brothers Drlg | 1959 | 567 | | | | | 124CRRZ | 750 | -350.00<br>-349.15 | 09-30-1964<br>02-10-1981 | T E<br>75.00 | P | Perforated from 425 to 575 ft. Pump set at 400 ft. Temp. 81 degrees F. Observation well. |
| 77-03-403 | Dr. Alvaro Lebrija | | 1983 | 580 | | | | | 124CRRZ | 752 | | - -<br>- - | S E | H S | |
| 77-04-441 | Batesville W S C | Wilson Drilling Co. | 1987 | 898 | C<br>C<br>S | 20<br>13<br>13 | 0<br>0<br>700 | 60<br>700<br>898 | 124CRRZ | 708 | | - -<br>- - | T E | P | Well drilled to replace 7704431. |
| 77-04-601 | Felton Fitch | J.W.Hickerson | 1962 | 1018 | | | | | 124CRRZ | 680 | -304.38<br>-297.19 | 12-23-1965<br>01-04-1978 | T E<br>125.00 | I | Sloted form 885 to 1018 ft. Pump set at 360 ft. Observation well. |
| 77-11-701 | Del Monte Corp | Wiegand Brothers | 1946 | 1163 | | | | | 124CRRZ | 632 | -165.70<br>-421.35 | 02-14-1948<br>02-10-1965 | T N<br>225.00 | I | Well N5-92 in Texas Board of Water Engineers Bulletin 5203. Slotted. |

RECORDS OF WELLS, SPRINGS, AND TEST HOLES
COUNTY - Zavala

| WELL | OWNER | DRILLER | DATE COMPLETED | DEPTH OF WELL (FT.) | CASING AND SCREEN DATA: CASING OR SCREEN | DIAMETER (IN.) | TOP DEPTH (FT.) | BOT DEPTH (FT.) | WATER BEARING UNIT | ALTITUDE OF LAND SURFACE (FT.) | WATER LEVEL: MEASUREMENT FROM LSD (FT.) | DATE | METHOD OF LIFT AND POWER | USE OF WATER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 77-11-701 (Continued) | | | | | | | | | | | | | | | Cemented from 930 ft to surface. Pump set at 700 ft. Reproted yield of 798 gpm. TEmp. 94 degrees F. Histroical observation well. |
| 77-18-510 | City of Crystal City | Floyd Trimm | 1927 | 1050 | | | | | 124CRRZ | 556 | | - -<br>- - | T E<br>200.00 | P | Well N5-48 in Texas Board of Water Engineers Bulletin 5203. Reported yield of 1089 gpm. |
| 77-18-512 | City of Crystal City | | 1948 | 1035 | | | | | 124CRRZ | 570 | | - -<br>- - | T E<br>200.00 | P | |
| 77-20-101 | Mrs. Norman W. Gates | Dixon Drlg | 1962 | 4698 | | | | | 124CRRZ | 640 | -370.70<br>-314.84 | 12-10-1964<br>02-21-1991 | S E | S | Observation well. |