In cooperation with the City of Laredo

Quality of Ground Water in Webb County, Texas, 1997–98

Rapid development and population growth are occurring in Webb County in south Texas (fig. 1). Water managers need information on the ground-water resources of the area to address the increased demand for water caused by the development. To help meet this need, the U.S. Geological Survey (USGS), in cooperation with the City of Laredo, began a study in 1997 to assess the ground-water resources of the county. This report describes the quality of ground water determined from water samples collected during 1997–98.

Webb County receives an average of 20 inches (in.) of rainfall annually. Recharge to the aquifers occurs primarily by infiltration of precipitation on the aquifer outcrop (fig. 1). Regionally, depth to the aquifers increases in a southeasterly direction from the aquifer outcrop. The primary sources of ground water in Webb County are the Carrizo aquifer, Queen City-Bigford aquifer, Laredo aquifer, Yegua aquifer, Jackson aquifer, Gulf Coast aquifer, and alluvium deposits (table 1). The Indio, Bigford, and Goliad Formations and the alluvium deposits were not included in this study because suitable wells were not available to be sampled.

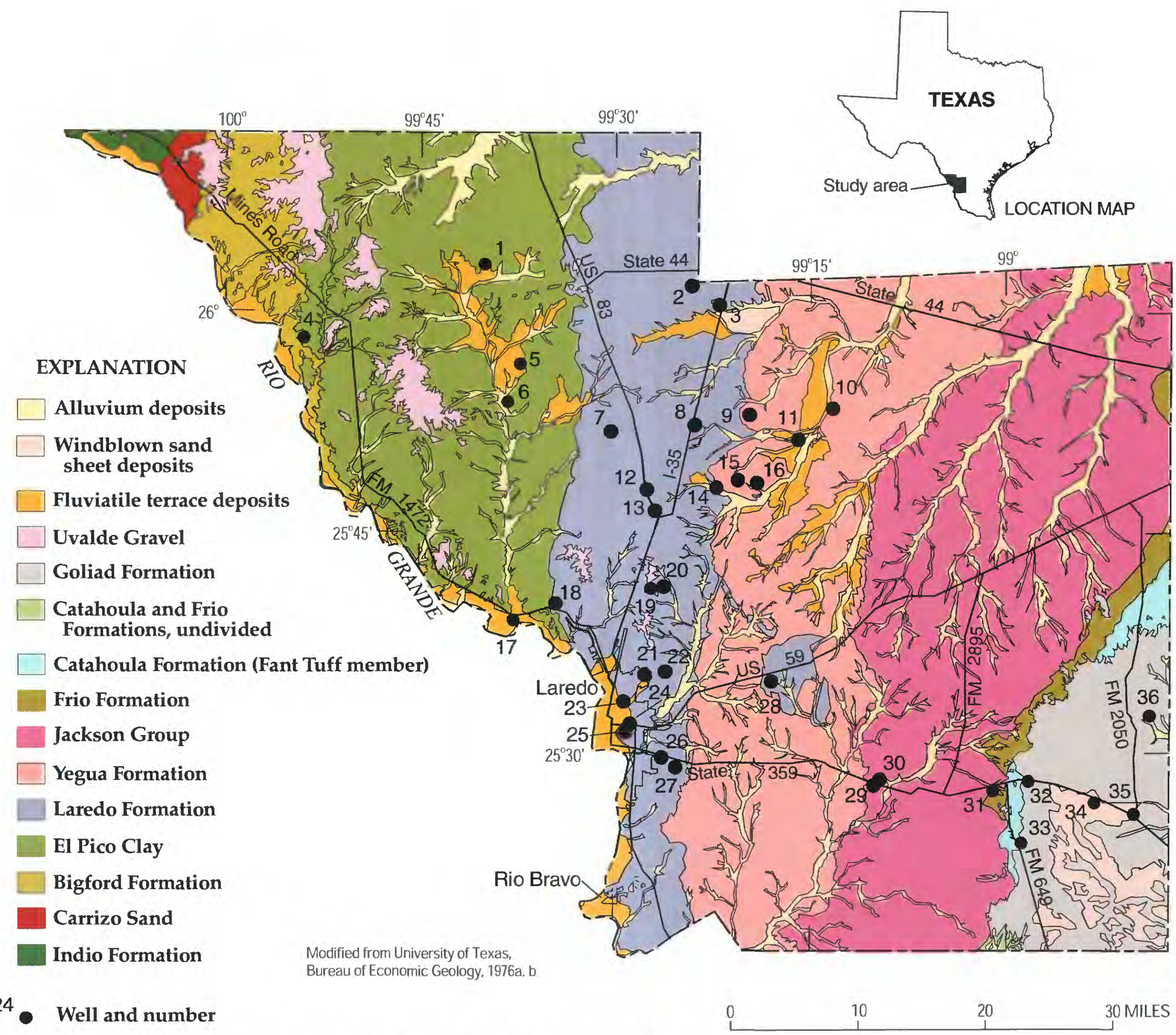

Figure 1. Surficial geology and location of sampled wells in Webb County, Texas.

Table 1. Summary of the lithologic and hydrologic properties of the geologic units in Webb County, Texas, 1997–98

[Lithologic and hydrologic properties modified from Lonsdale and Day, 1937; Winslow and Kister, 1956; Klemt and others, 1976; University of Texas, Bureau of Economic Geology, 1976a, b. Color-shading shows aquifer. ft, feet; AQ, aquifer; <, less than; gal/min, gallons per minute; CU, confining unit; >, greater than]

Hydrogeologic unit	Group, formation, or member		Hydrologic function	Maximum thickness (ft)	Lithology	Water quality and well yields
	Alluvium deposits[1]		AQ where saturated	50	Stream-deposited gravel, sand, and silt	Yields variable quantities of water along streams; some suitable for domestic use
	Windblown sand sheet deposits		Not saturated	Unknown	Sand	Not known to yield water; low to moderate water-holding capacity
	Fluviatile terrace deposits		Not saturated	Unknown	Gravel, sand, silt, and clay	Not known to yield water
	Uvalde Gravel		Not saturated	25	Gravel, conglomerate, sand, and caliche	Not known to yield water
Gulf Coast aquifer	Goliad Formation[1]		AQ	100	Reddish sand, conglomerate, and caliche, with some clay	Yields variable quantities of water at shallow depths in southeastern part of county. Quality variable, usually suitable for domestic use
Gulf Coast aquifer	Catahoula Formation	Fant Tuff member	AQ	600	Pyroclastic rocks: tuffaceous sandstone and conglomerate, silicified tuff, bentonitic clay; sandstone beds up to 20 ft in thickness	Outcrop area yields very little, highly mineralized water (<15 gal/min); in southeastern part of county, wells 150 to 400 ft deep yield considerable quantities of water (30 to 150 gal/min); fresh to slightly saline water suitable for multiple uses
Gulf Coast aquifer	Frio Formation		CU	200	Clay and sandy clay	Not known to yield water
Jackson aquifer	Jackson Group		AQ	1,500	Clay, sandy clay, sandstone, ashy sandstone, and volcanic ash; ashy beds contain plant fossils	Minor aquifer; yields variable quantities of slightly to highly saline water used mainly for stock
Yegua aquifer	Claiborne Group	Yegua Formation	AQ	670	Clay, sandy clay, thin beds of sandstone; secondary gypsum and some limestone concretions	Minor aquifer; yields small quantities (<15 gal/min) of slightly to moderately saline water suitable for stock
Laredo aquifer	Claiborne Group	Laredo Formation	AQ	700	Sandstone, glauconitic sandstone, glauconitic marl, and clay. Some limestone; fossiliferous	Major aquifer; sandstone of lower part constitutes important aquifer, yielding small to large quantities (5 to 170 gal/min) of fresh to moderately saline water. Flowing wells obtained in low areas of northeastern part of county. Suitable for most uses
Queen City-Bigford aquifer	Claiborne Group	El Pico Clay	CU	1,150	Clay, with interbedded sandstone; claystone and lignite coal lenses common	Yields small quantities of highly mineralized water
Queen City-Bigford aquifer	Claiborne Group	Bigford Formation[1]	AQ	650	Gypsiferous clay with thin-bedded to massive sandstone; lignite, coal	Minor aquifer; sandstone supplies small to moderate quantities of fresh to very saline water generally used for stock only
Carrizo aquifer	Claiborne Group	Carrizo Sand	AQ	600	Massive, crossbedded sandstone with minor quantities of clay or shale	Major aquifer; most prolific source of fresh ground water in county; generally yields moderate to large quantities (>150 gal/min) of fresh to slightly saline water suitable for all uses
Wilcox aquifer	Wilcox Group	Indio Formation[1]	AQ	850	Thin sandstone interbedded with carbonaceous clay, shale, and lignite	Yields small quantities of highly mineralized water suitable for stock

[1]Aquifer not included in this study.

Table 2. Aquifer and depth of sampled wells in Webb County, Texas, 1997–98

[--, depth unknown]

Well no. (fig. 1)	Aquifer	Depth of well (feet)	Well no. (fig. 1)	Aquifer	Depth of well (feet)
1	Carrizo	2,031	19	Carrizo	3,320
2	Laredo	520	20	Laredo[1]	--
3	Laredo	600	21	Laredo	800
4	Carrizo	1,500	22	Laredo	710
5	Carrizo	1,991	23	Laredo	300
6	Carrizo	1,900	24	Laredo	235
7	Laredo	301	25	Laredo	440
8	Laredo	502	26	Laredo	370
9	Laredo	468	27	Laredo	290
10	Laredo	1,200	28	Laredo	500
11	Laredo	1,200	29	Laredo[1]	--
12	Laredo	520	30	Laredo	1,230
13	Laredo	550	31	Yegua	2,717
14	Laredo[1]	--	32	Jackson	340
15	Laredo[1]	--	33	Gulf Coast (Catahoula)	198
16	Laredo	500	34	Gulf Coast (Catahoula)	360
17	Carrizo	1,918	35	Gulf Coast (Catahoula)	340
18	Laredo	240	36	Gulf Coast (Catahoula)	440

[1]Although the well depth is unknown, water-quality data from sample and water level in well indicate the aquifer probably is the Laredo.

Water-Quality Data

Water samples from 36 wells were collected during 1997–98 and analyzed for major ions, dissolved solids, trace elements, and organic compounds. Wells sampled included 6 in the Carrizo aquifer, 24 in the Laredo aquifer, 1 in the Yegua aquifer, 1 in the Jackson aquifer, and 4 in the Gulf Coast aquifer (table 2). Boxplots of selected constituents were constructed to show the relative concentration and the variability in concentration within and between the aquifers (fig. 2).

Major Ions

The water sample from well 31 in the Yegua aquifer had the largest sodium concentration (1,700 milligrams per liter [mg/L]) (fig. 2). Sodium concentrations in water samples from the Gulf Coast aquifer ranged from 197 mg/L in well 33 to 379 mg/L in well 34. The sodium concentration in the water sample from well 32 (Jackson aquifer) was 465 mg/L. Water samples from the Laredo aquifer had the greatest variability in sodium concentrations compared to the other aquifers, ranging from 130 mg/L in well 30 to 1,300 mg/L in well 28. Sodium concentrations in water from the Carrizo aquifer were moderate, ranging from 319 mg/L in well 4 to 870 mg/L in well 17 (fig. 2).

The U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) for sulfate is 500 mg/L and the secondary maximum contaminant level (SMCL) is 250 mg/L (U.S. Environmental Protection Agency, 1996). The MCL is defined as the maximum permissible level of a contaminant in water that is delivered to any user of a public water system. The SMCL is an unenforceable guideline regarding taste, odor, color, and certain other non-aesthetic effects of drinking water. Sulfate concentrations were less than 500 mg/L in all water samples from wells in the Gulf Coast, Jackson, Yegua, and Carrizo aquifers, ranging from 0.5 mg/L in well 19 (Carrizo aquifer) to 378 mg/L in well 31 (Yegua aquifer) (fig. 2). Similar to sodium concentrations, sulfate concentrations in water samples from the Laredo aquifer had the greatest variability compared to the other aquifers, with the median about 500 mg/L (fig. 2). Sulfate concentrations in water samples from the Laredo aquifer ranged from 192 mg/L in well 2 to 1,700 mg/L in well 28; concentrations in 13 samples exceeded the MCL, and concentrations in 23 samples exceeded the SMCL. The sulfate concentration in the sample from the Yegua aquifer exceeded the SMCL.

Chloride does not have an established MCL but does have an SMCL of 250 mg/L (U.S. Environmental Protection Agency, 1996). The largest concentration of chloride, 1,772 mg/L, was measured in the water sample from well 31 (Yegua aquifer) (fig. 2). Most chloride concentrations measured in the water samples exceeded the SMCL. Chloride concentrations in the Gulf Coast aquifer were generally smaller and less variable than in the other aquifers, ranging from 210 mg/L in well 35 to 335 mg/L in well 34, with the concentration in one sample exceeding the SMCL. The chloride concentration in the sample from well 32 (Jackson aquifer) was 792 mg/L. In the Laredo aquifer, chloride concentrations in the water samples ranged from 98 mg/L in well 3 to 1,000 mg/L in well 14 and exceeded the SMCL in water samples from 18 of the 24 wells. Chloride concentrations in water samples from the Carrizo aquifer ranged from 122 mg/L in well 19 to 630 mg/L in well 17. The median chloride concentration in

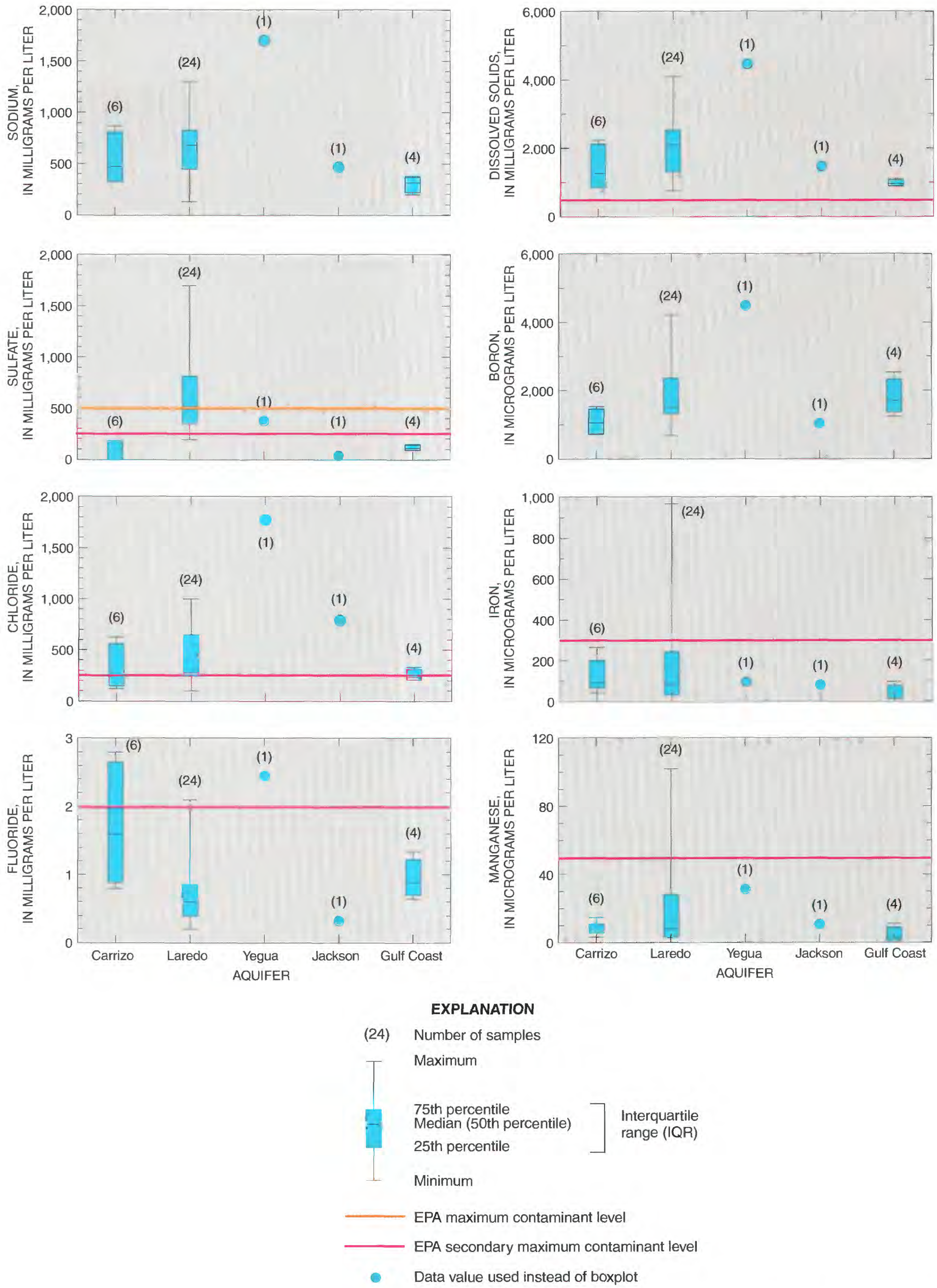

Figure 2. Concentrations of selected major ions, dissolved solids, and trace elements in aquifers in Webb County, Texas, 1997–98.

the Carrizo aquifer was about 250 mg/L, with concentrations in three of the six samples exceeding the SMCL.

The MCL for fluoride is 4.0 mg/L, and the SMCL is 2.0 mg/L (U.S. Environmental Protection Agency, 1996). Fluoride concentrations in all 36 sampled wells were less than the MCL; concentrations exceeded the SMCL in water samples from 6 wells in the Carrizo, Laredo, and Yegua aquifers (fig. 2). Water samples from the Carrizo aquifer had the greatest variability in concentration within an aquifer and also a larger median fluoride concentration than samples from the Laredo and Gulf Coast aquifers.

Dissolved Solids

Freshwater is defined as having a dissolved solids concentration of less than 1,000 mg/L, and saline water is defined as having a dissolved solids concentration of 1,000 mg/L or greater (Winslow and Kister, 1956). Slightly saline water has a dissolved solids concentration ranging from 1,000 to 3,000 mg/L, moderately saline water ranging from 3,000 to 10,000 mg/L, and very saline water ranging from 10,000 to 35,000 mg/L (Winslow and Kister, 1956). The EPA SMCL for dissolved solids is 500 mg/L (U.S. Environmental Protection Agency, 1996), and 5,000 mg/L is recommended as the upper limit for livestock by some investigators (Hem, 1989).

The dissolved solids concentrations in all of the water samples collected in Webb County exceeded 500 mg/L but were less than 5,000 mg/L (fig. 2). Water from the Gulf Coast aquifer is fresh to slightly saline, and water from the Jackson aquifer is slightly saline. Dissolved solids concentrations in the Gulf Coast aquifer decrease to the southeast. The largest dissolved solids concentration, 4,470 mg/L, was measured in the water sample from well 31 completed in the Yegua aquifer (fig. 2). Water samples from the Laredo aquifer had the greatest variability in dissolved solids concentrations, with a boxplot pattern similar to that of sodium, sulfate, and chloride for the Laredo aquifer. Dissolved solids in the Laredo aquifer ranged from fresh to moderately saline. Dissolved solids concentrations in the Carrizo aquifer increase to the southeast, ranging from fresh to slightly saline.

Trace Elements

Water samples were analyzed for the following trace elements: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, uranium, vanadium, and zinc. All of the trace elements, except for antimony, beryllium, cadmium, cobalt, and nickel, were detected in one or more of the water samples. Results of the analyses indicate that arsenic, boron, iron, manganese, mercury, and uranium have elevated concentrations in some of the aquifers in Webb County.

Arsenic was detected in water samples from wells 32, 33, and 35 (Jackson and Gulf Coast aquifers). The EPA MCL for arsenic is 50 micrograms per liter (μg/L) (U.S. Environmental Protection Agency, 1996). Arsenic concentrations in water samples from wells 32 and 33 were 29.9 and 7.5 μg/L, respectively. However, in the water sample from well 35 the arsenic concentration was 77 μg/L, exceeding the MCL.

The EPA has not established an MCL for boron. The largest concentration of boron was 4,490 μg/L in water from well 31 (Yegua aquifer) (fig. 2). Generally, the smallest concentrations of boron were in water samples from wells in the Carrizo aquifer, ranging from 710 μg/L in well 1 to 1,530 μg/L in well 17. The range in boron concentrations in the Laredo aquifer was greater than in the Carrizo aquifer, from 670 μg/L in well 2 to 4,200 μg/L in well 18. Boron concentrations in water samples from the Gulf Coast aquifer were larger than in the Carrizo aquifer but similar to concentrations in the Laredo aquifer. Boron concentrations in water samples from the Gulf Coast aquifer ranged from 1,230 μg/L in well 33 to 2,540 μg/L in well 34 (fig. 2). In the Jackson aquifer, the boron concentration in the sample from well 32 was 1,030 μg/L.

The largest concentrations of iron generally were in water samples collected from the Laredo aquifer; concentrations in 5 of the 24 wells exceeded the SMCL of 300 μg/L (U.S. Environmental Protection Agency, 1996). Iron concentrations in those wells (2, 8, 12, 18, and 28) ranged from 302 to 960 μg/L (fig. 2). Iron concentrations in water samples from wells in the Gulf Coast, Jackson, Yegua, and Carrizo aquifers were less than in the Laredo aquifer, with none exceeding the SMCL.

Manganese concentrations were small in water samples from wells completed in the Gulf Coast, Jackson, and Carrizo aquifers and slightly larger in water samples from well 31 (Yegua aquifer) (fig. 2). Water samples from wells in the Laredo aquifer had the largest concentrations of manganese and showed the greatest variability in concentration. Three water samples from the Laredo aquifer had manganese concentrations that exceeded the SMCL of 50 μg/L (U.S. Environmental Protection Agency, 1996). Manganese concentrations in water samples from wells 12, 13, and 28 ranged from 53 to 101.7 μg/L.

Mercury was detected in water samples from wells 20 and 29 (Laredo aquifer) and from well 35 (Gulf Coast aquifer). Mercury concentrations ranged from 0.15 μg/L in well 35 to 0.6 μg/L in well 20, less than the EPA MCL of 2.0 μg/L (U.S. Environmental Protection Agency, 1996).

Uranium deposits are common in the Gulf Coast aquifer, which is commercially mined for uranium. The MCL for uranium is 20 μg/L (U.S. Environmental Protection Agency, 1996). Two wells in the Gulf Coast aquifer had detectable uranium concentrations. The uranium concentration was 2.75 μg/L in the water sample from well 33 and 29.95 μg/L in the sample from well 35, exceeding the MCL.

Organic Compounds

Water samples from wells in Webb County were analyzed for 140 organic compounds, including volatile organic compounds, semivolatile organic compounds, base-neutral acid extracts, and pesticides. Twelve of the sampled wells had detectable concentrations of at least one of the compounds.

Bis(2-ethylhexyl)phthalate was detected in seven wells (1, 5, 12, 17, 18, 23, and 31) and ranged from 5.05 μg/L in well 12 to 49.2 μg/L in well 5. Methyl chloride was detected in water samples from three wells (20, 32, and 33), ranging from 0.475 μg/L in well 20 to 0.508 μg/L in well 32. Phenol was detected in water samples from three wells (11, 17, and 23), ranging from 8.65 μg/L in well 17 to 20.8 μg/L in well 11. Toluene was detected in two water samples with concentrations of 0.350 μg/L in well 17 and 2.60 μg/L in well 25. Prometon, the only pesticide detected, had a concentration of 0.414 μg/L in the water sample from well 20.

Sources of Potable Water

The Gulf Coast, Laredo, and Carrizo aquifers provide the best quality of water in sufficient yields needed for public supply and other uses. All of the aquifers had dissolved solids concentrations exceeding the EPA SMCL of 500 mg/L, a result of large concentrations of sodium, sulfate, and chloride. The Gulf Coast aquifer in southeastern Webb County yields fresh to slightly saline water with dissolved solids concentrations that are less than 1,100 mg/L and that meet most of the EPA recommended MCLs and SMCLs. The Gulf Coast aquifer, however, had larger concentrations of some trace elements, including arsenic, boron, and uranium. In well 35, uranium and arsenic concentrations exceeded the MCL.

In central Webb County (fig. 1), wells in the Laredo aquifer yield mainly fresh to slightly saline water. The dissolved solids concentrations in water samples from wells 2 and 3 in northern Webb County were less than 850 mg/L, and farther to the south, the dissolved solids concentrations in samples from wells 7, 8, 11, 14, 15, and 16 ranged from 1,000 to 1,500 mg/L. The salinity of water in the Laredo aquifer increases to the east and to the south towards Laredo. Concentrations in water samples from the Laredo aquifer exceeded the EPA MCL for sulfate (13 of 24) and exceeded the SMCL for chloride (18 of 24), fluoride (2 of 24), manganese (3 of 24), and iron (5 of 24).

The freshest water in the Carrizo aquifer is in northwestern Webb County. Wells 1 and 4 had dissolved solids less than 1,000 mg/L. Farther to the south and southeast, the salinity of water in the Carrizo aquifer increases, and water from wells 5, 6, 17, and 19 are slightly saline. Similar to water from the Laredo aquifer, water from the Carrizo aquifer generally had smaller concentrations of ions and trace elements, except for fluoride, than the other aquifers in the county. Fluoride concentrations in the Carrizo aquifer increase as the salinity increases to the southeast, in some wells exceeding the EPA SMCL of 2.0 mg/L.

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