Ground-Water Supply Systems: Hydrogeology and the Delivery of a Water Supply

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Presentation Outline

Introduction

Ground-Water Supplies

Aquifer Productivity
- Area Hydrogeology
- Local Hydrogeology
- Areal Monitoring & Subsidence

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- Areal Reconnaissance

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- Materials Selection
- Well Efficiency

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- Pumping Levels
- Cost of Production

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- Water Safety: Impact of Potential Contaminants
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Local Planning vs, Regional Planning

Gulf Coast Aquifer

The Gulf Coast aquifer forms a wide belt along the Gulf of Mexico from Florida to Mexico. In Texas, the aquifer provides water to all or parts of 54 counties and extends from the Rio Grande northeastward to the Louisiana-Texas border. Municipal and irrigation uses account for 90 percent of the total pumpage from the aquifer. The Greater Houston metropolitan area is the largest municipal user, where well yields average about 1,600 gal/min.

The aquifer consists of complex interbedded clays, silts, sands, and gravels of Cenozoic age, which are hydrologically connected to form a large, leaky artesian aquifer system. This system comprises four major components consisting of the following generally recognized water-producing formations. The deepest is the Catahoula, which contains ground water near the outcrop in relatively restricted sand layers. Above the Catahoula is the Jasper aquifer, primarily contained within the Oakville Sandstone. The Burkeville confining layer separates the Jasper from the overlying Evangeline aquifer, which is contained within the Fleming and Goliad sands. The Chicot aquifer, or upper component of the Gulf Coast aquifer system, consists of the Lissie, Willis, Bentley, Montgomery, and Beaumont formations, and overlying alluvial deposits. Not all formations are present throughout the system, and nomenclature often differs from one end of the system to the other. Maximum total sand thickness ranges from 700 feet in the south to 1,300 feet in the northern extent.

Water quality is generally good in the shallower portion of the aquifer. Ground water containing less than 500 mg/l dissolved solids is usually encountered to a maximum depth of 3,200 feet in the aquifer from the San Antonio River Basin northeastward to Louisiana. From the San Antonio River Basin southwestward to Mexico, quality deterioration is evident in the form of increased chloride concentration and saltwater encroachment along the coast. Little of this ground water is suitable for prolonged irrigation due to either high salinity or alkalinity, or both. In several areas at or near the coast, including Galveston Island and the central and southern parts of Orange County, heavy municipal or industrial pumpage had previously caused an updip migration, or saltwater intrusion, of poor-quality water into the aquifer. Recent reductions in pumpage here have resulted in a stabilization and, in some cases, even improvement of ground-water quality.

Years of heavy pumpage for municipal and manufacturing use in portions of the aquifer have resulted in areas of significant water-level decline. Declines of 200 feet to 300 feet have been measured in some areas of eastern and southeastern Harris and northern Galveston counties. Other areas of significant water-level declines include the Kingsville area in Kleberg County and portions of Jefferson, Orange, and Wharton counties. Some of these declines have resulted in compaction of dewatered clays and significant land surface subsidence. Subsidence is generally less than 0.5 foot over most of the Texas coast, but has been as much as nine feet in Harris and surrounding counties. As a result, structural damage and flooding have occurred in many low-lying areas along Galveston Bay in Baytown, Texas City, and Houston. Conversion to surface-water use in many of the problem areas has reversed the decline trend.

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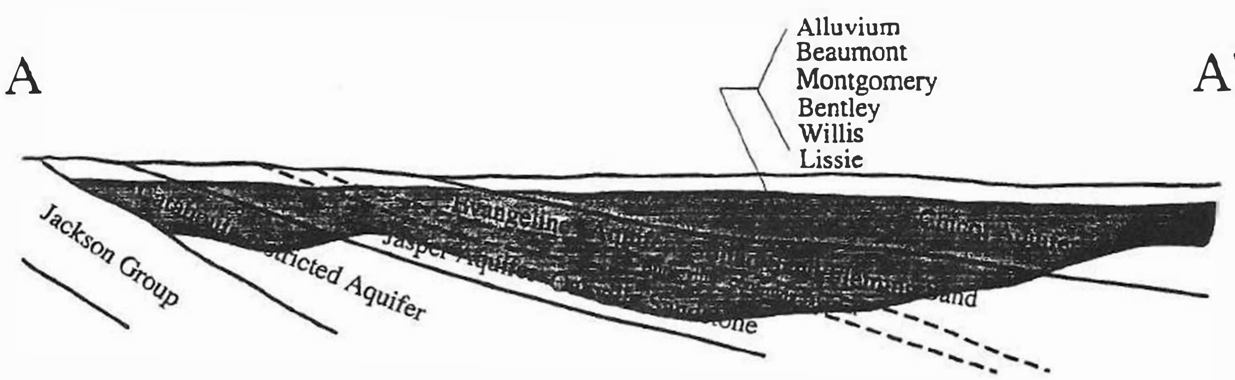
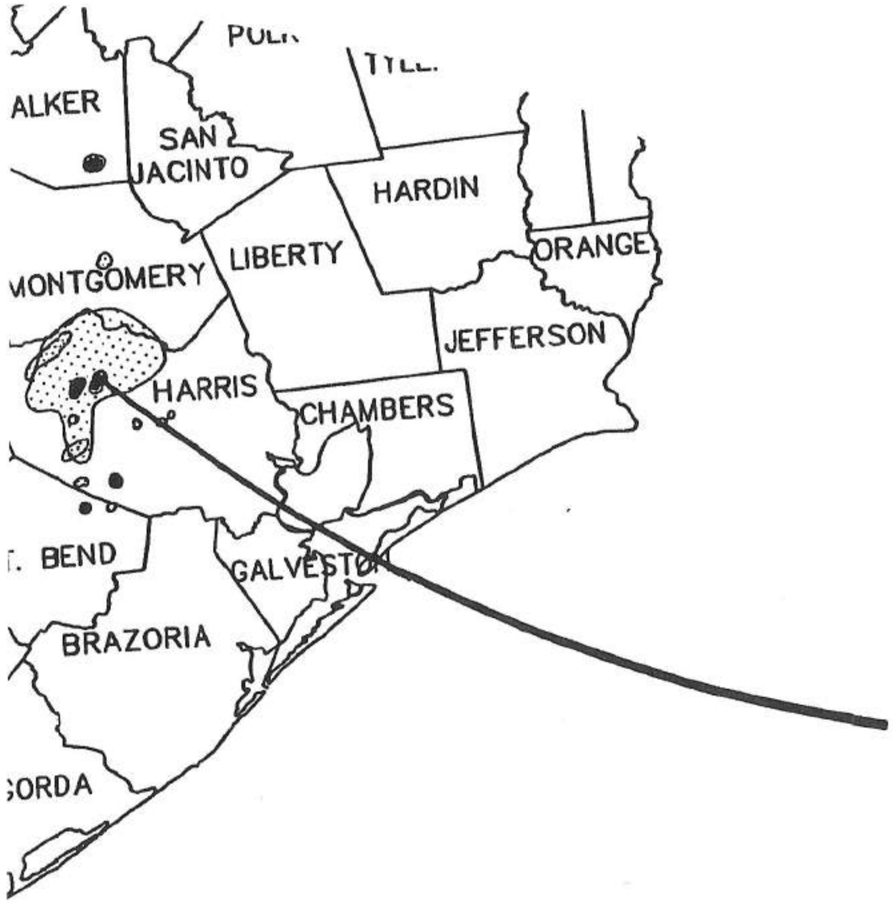
Gulf Coast

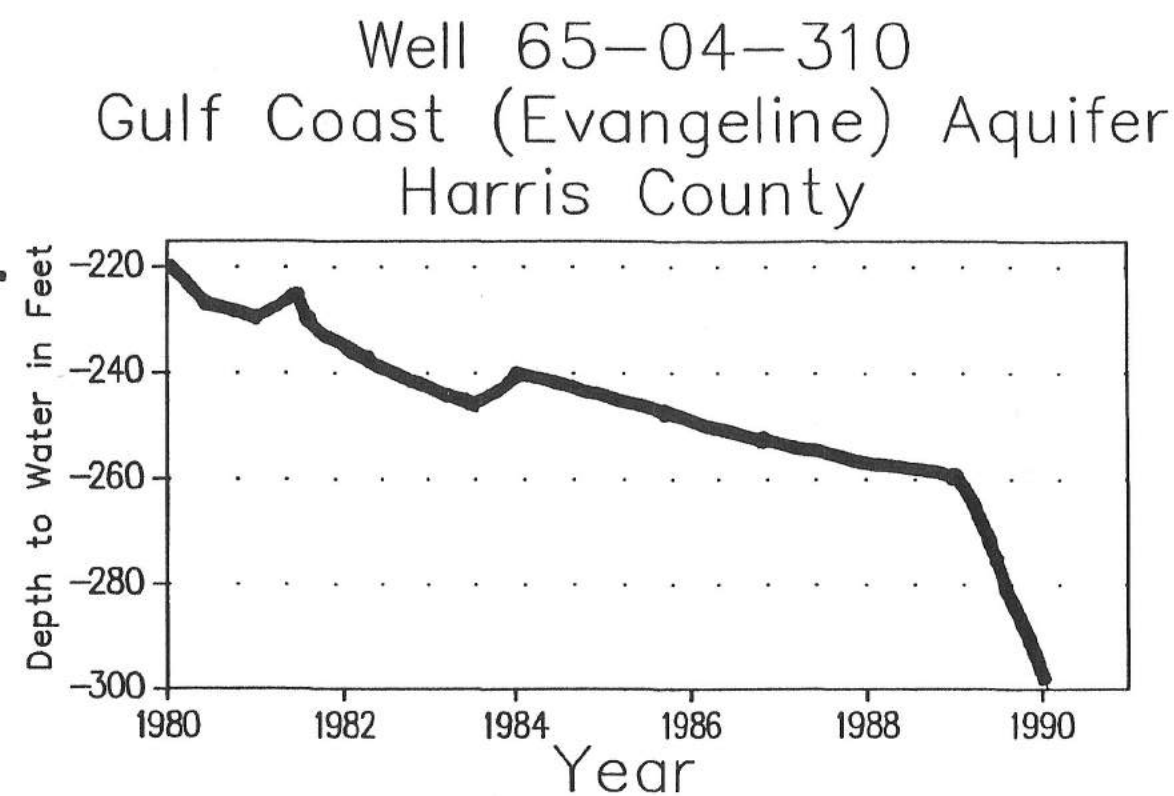


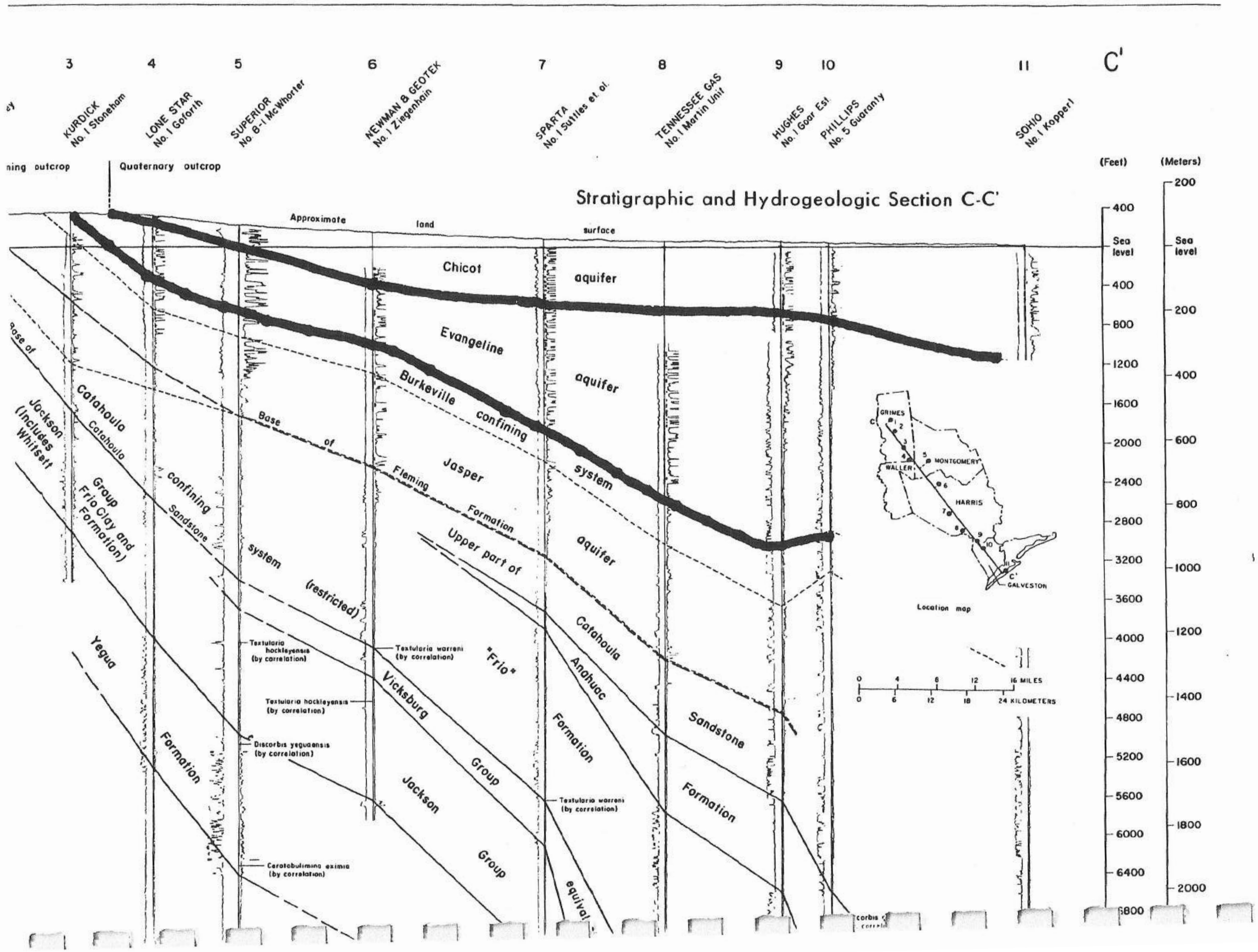
Modified from Baker, 1979

Areas Experiencing Significant Ground-Water Level Decline: 1980 – 1990

(after Payne, 1991,TWDB)



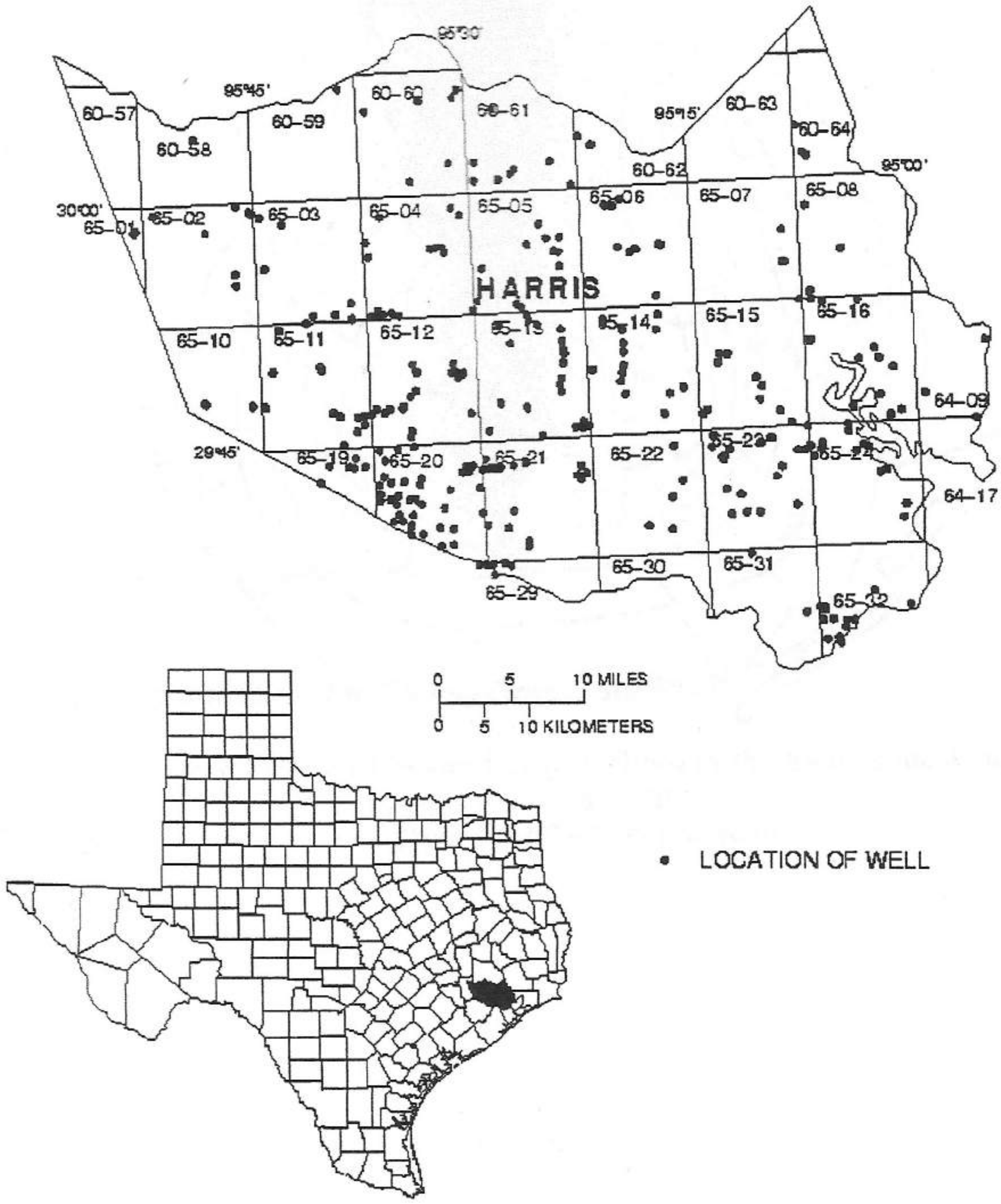




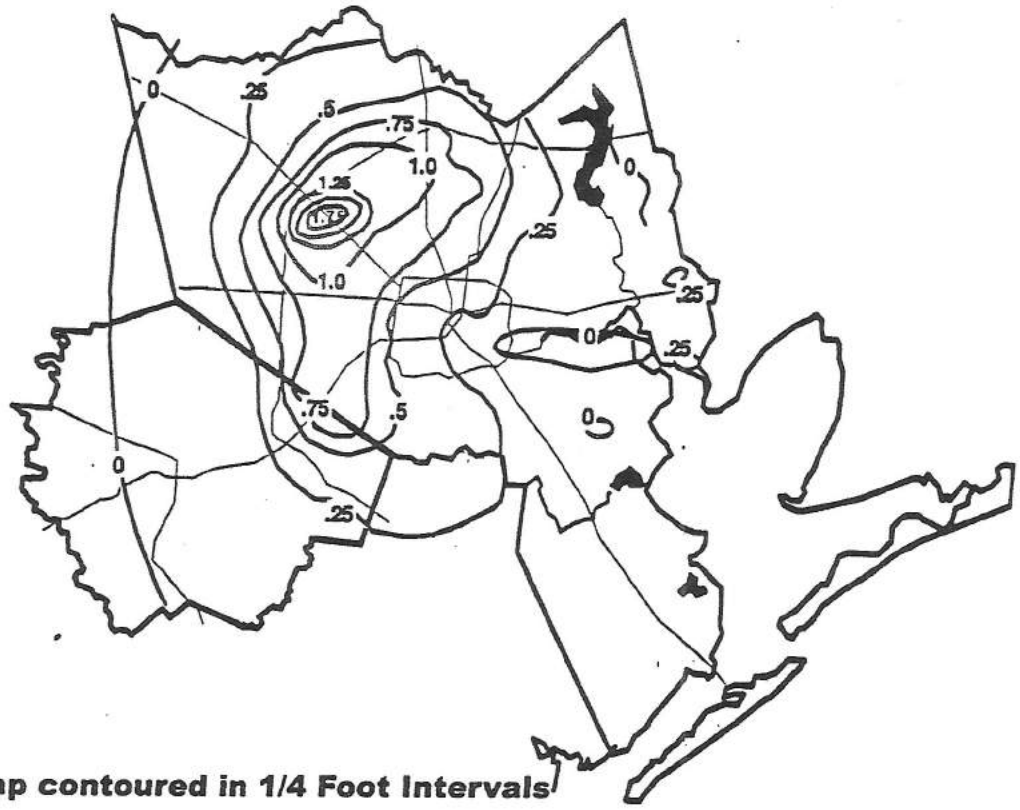
Stratigraphic and Hydrogeologic Section C-C'
C'
3 KURDICK No. 1 Stoneham
4 LONE STAR No. 1 Goforth
5 SUPERIOR No. B-1 McWhorter
6 NEWMAN & GEOTEK No. 1 Ziegenhain
7 SPARTA No. 1 Suttles et al.
8 TENNESSEE GAS No. 1 Martin Unit
9 HUGHES No. 1 Goar Est.
10 PHILLIPS No. 5 Guaranty
11 SOHIO No. 1 Kopperl
ning outcrop
Quaternary outcrop
Approximate land surface
Chicot aquifer
Evangeline aquifer
Burkeville confining system
Jasper aquifer
Base of Fleming Formation
Upper part of Catahoula Sandstone Formation
Catahoula confining system (restricted)
Catahoula Sandstone
Catahoula Group
Frio Clay and Formation)
Jackson (Includes Whitsett
Base of
Yegua Formation
Vicksburg Group
Jackson Group
"Frio"
Anahuac Formation
equival
Textularia hockleyensis (by correlation)
Textularia warreni (by correlation)
Textularia hockleyensis (by correlation)
Discorbis yeguaensis (by correlation)
Textularia warreni (by correlation)
Ceratobulimina eximia (by correlation)
(Feet)
(Meters)
400
Sea level
400
800
1200
1600
2000
2400
2800
3200
3600
4000
4400
4800
5200
5600
6000
6400
6800
200
Sea level
200
400
600
800
1000
1200
1400
1600
1800
2000
GRIMES
MONTGOMERY
WALLER
HARRIS
GALVESTON
C
C'
Location map
0 4 8 12 16 MILES
0 6 12 18 24 KILOMETERS

USGS
science for a changing world

GROUND-WATER WELLS HARRIS COUNTY

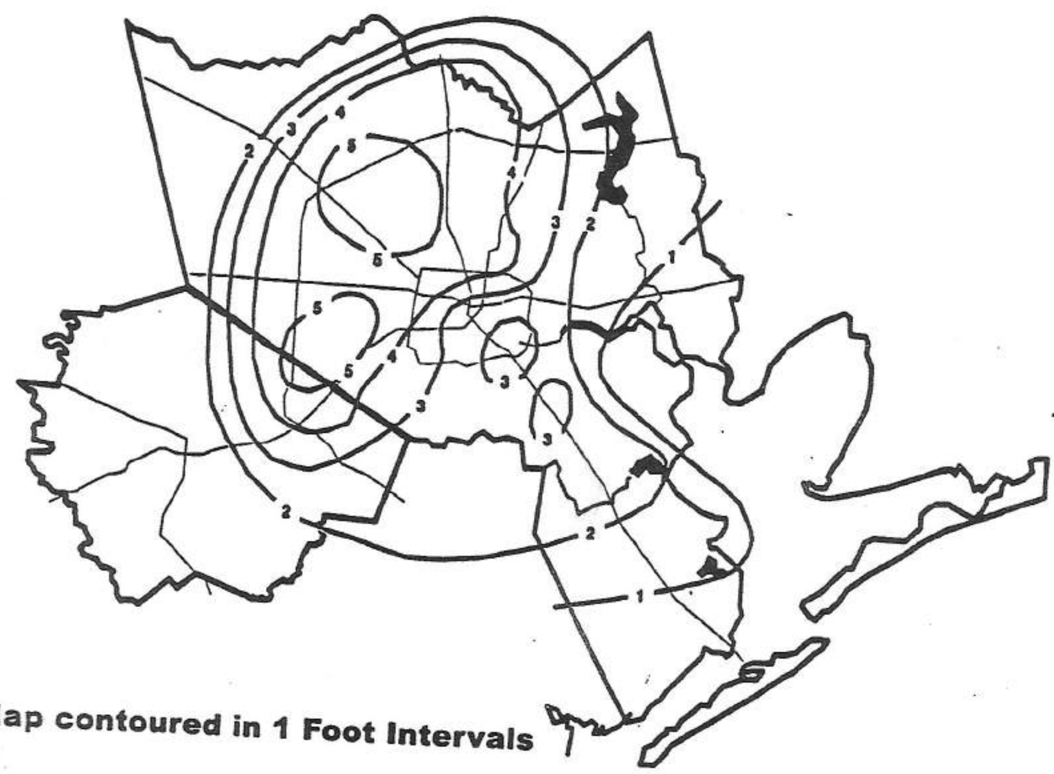


LOCAL WELL	SITE ID	Page



Map contoured in 1/4 Foot Intervals

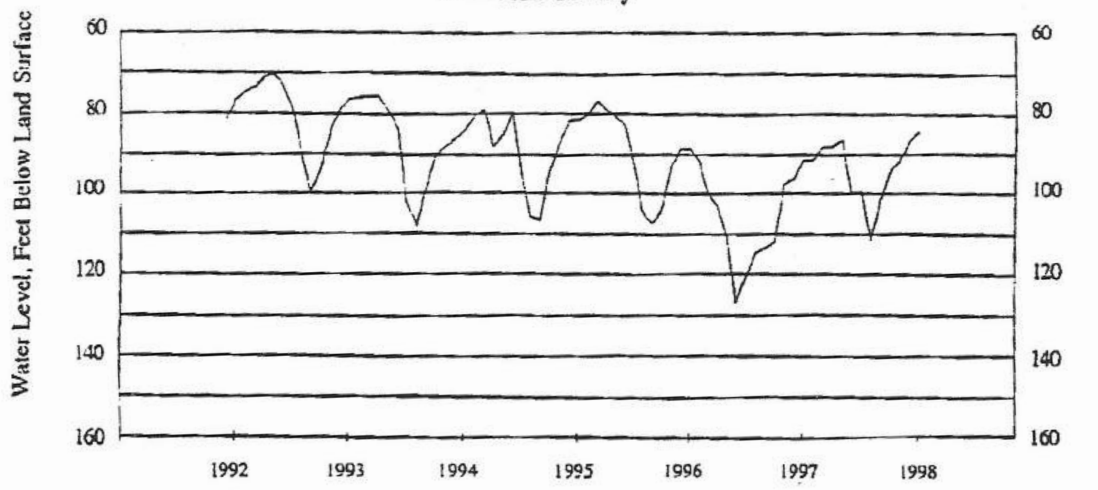
Figure 5. **Subsidence - 1987 - 1995**
Data Source: National Geodetic Survey
Contour Interpretations: HGCSD



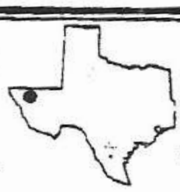
Map contoured in 1 Foot Intervals

Figure 6. **Predicted Subsidence - 1995-2030**
Data Source: Fugro-McClelland CSD 96

Well No. 68-60-912
Near Carrizo-Wilcox,
Atascosa County



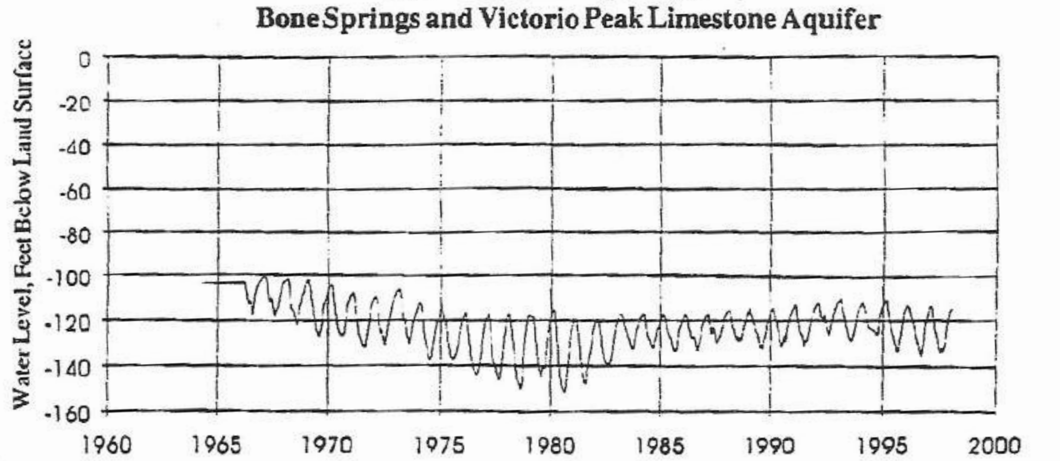
The February water-level measurement in this Carrizo aquifer well, elevation 446 feet above sea level, was 84.28 feet below land surface. This was 2.37 feet above last month's measurement, 7.32 feet above last year's measurement, and 3.03 feet below the initial measurement recorded in 1992.



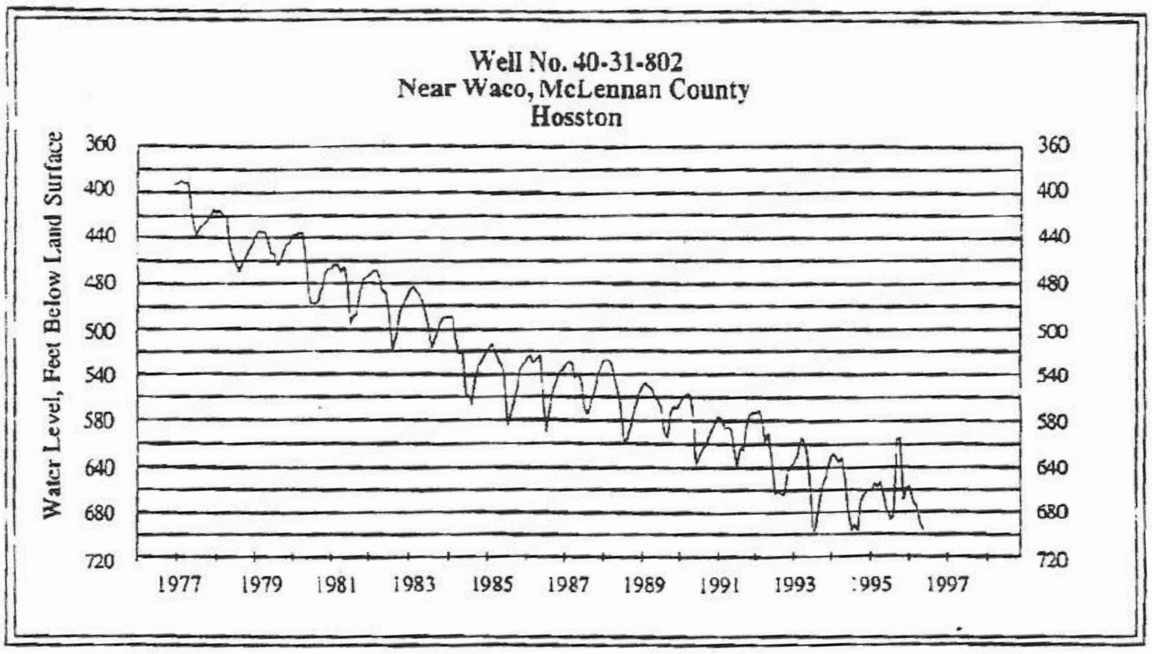
Hydrograph of the Month

Each month this space features a hydrograph (marked • on the map) depicting different aquifers and different conditions in Texas.

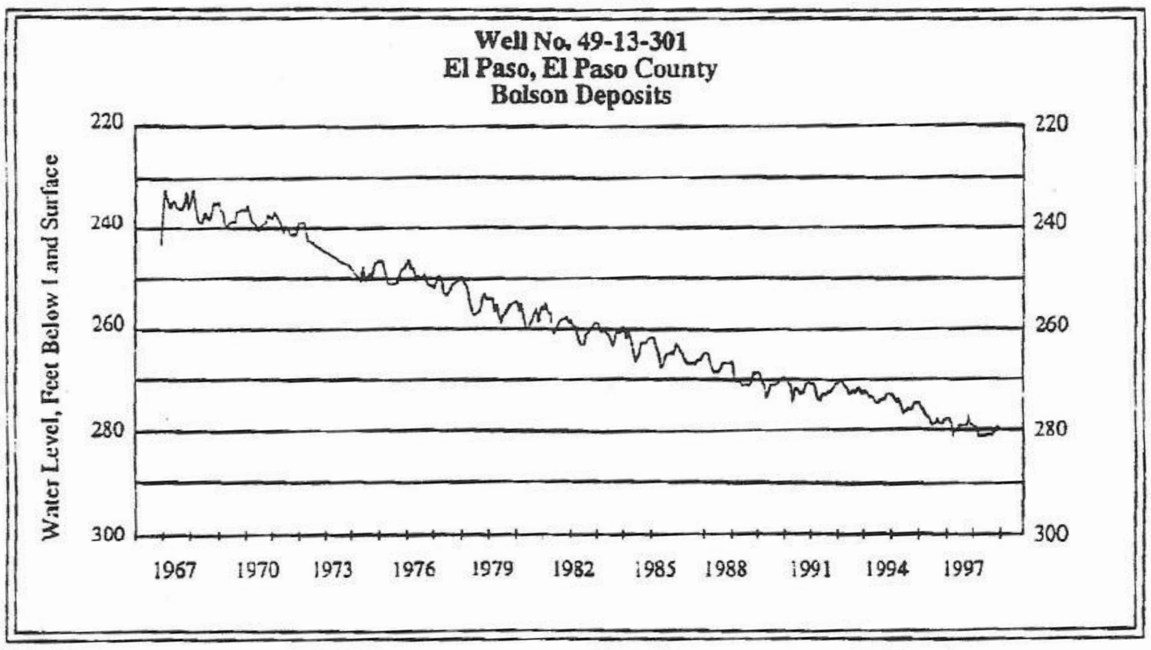
Well No. 48-07-516
In Dell City, Hudspeth County
Bone Springs and Victorio Peak Limestone Aquifer



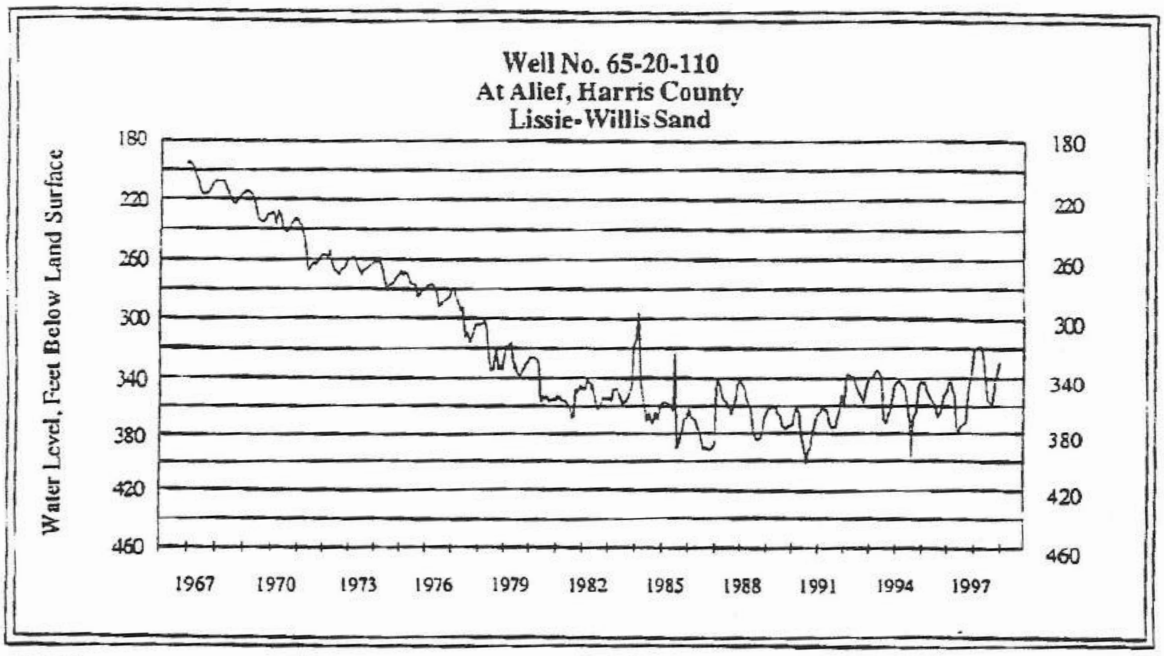
The February water-level measurement for this Bone Springs and Victorio Peak aquifer well, elevation 3702 feet above sea level, was 113.77 feet below land surface. This was 1.42 feet above last month's measurement, 0.41 of a foot below last year's measurement, and 9.85 feet below the initial measurement recorded in 1964.



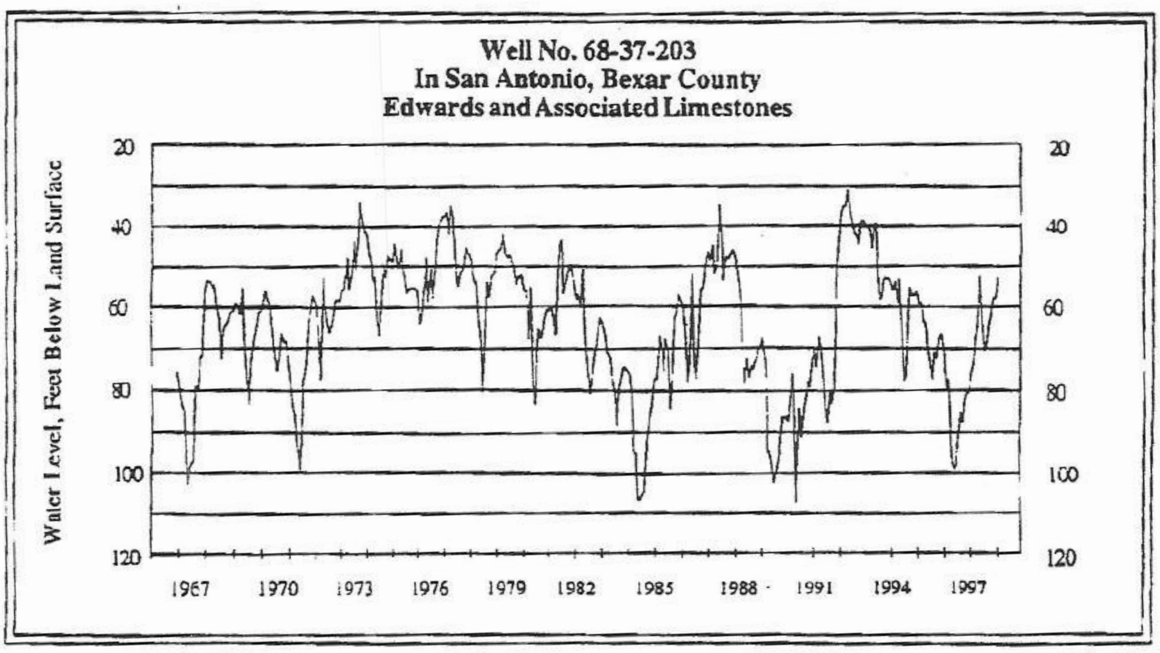
Current water-level measurements are unavailable from this Hosston Formation well due to cave-in problems. The well is scheduled to be repaired in 1998.



The February water-level measurement in this Bolson Deposits aquifer well, elevation 3882 feet above sea level, was 279.48 feet below land surface. This was 0.52 of a foot above last month's measurement, 0.94 of a foot below last year's measurement, and 47.58 feet below the initial measurement recorded in 1964.

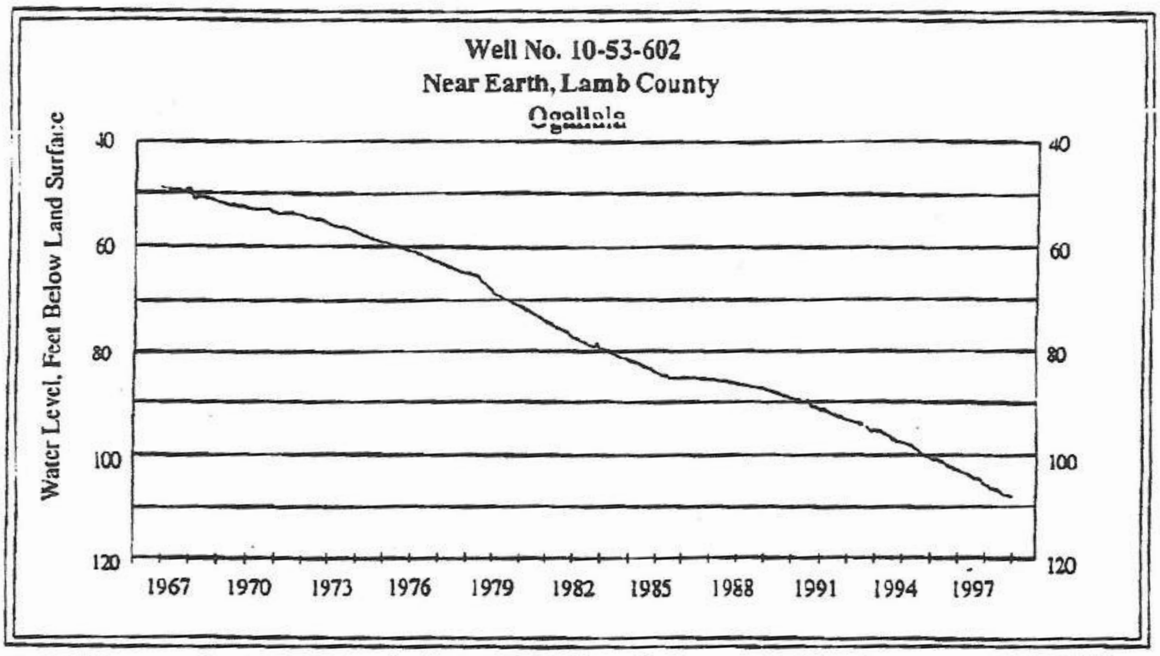


The February water-level measurement in this Lissie Willis Sand aquifer well, elevation 83 feet above sea level, is no longer available, and will be replaced with an equivalent well next month.

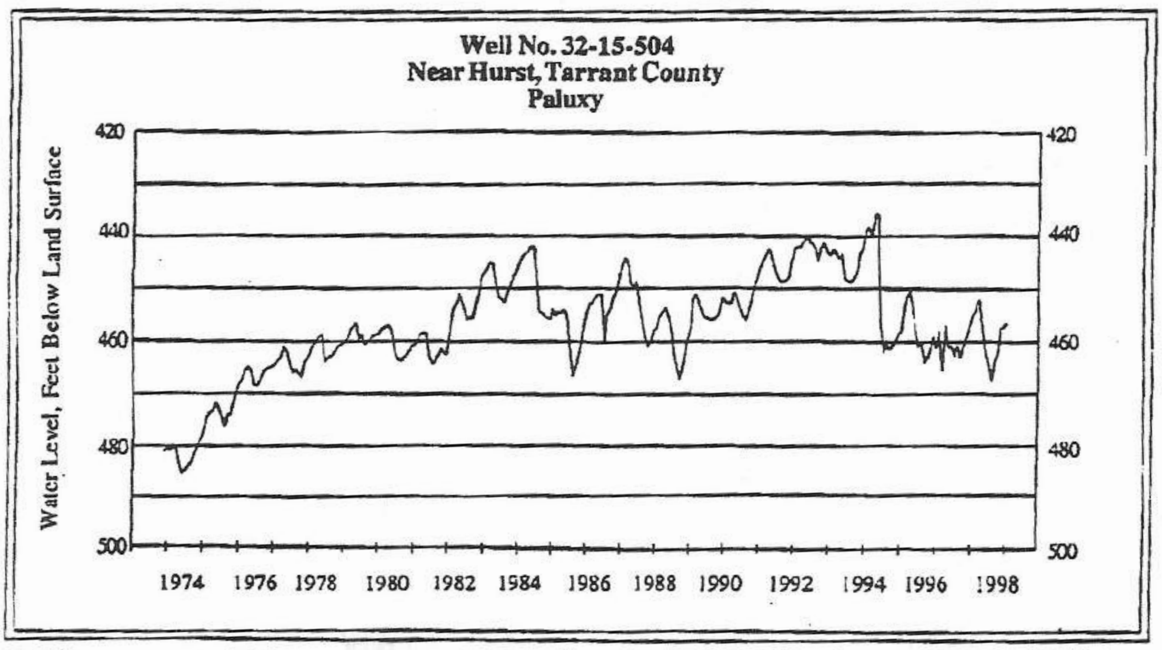


The February water-level measurement in this Edwards aquifer well, elevation 731 feet above sea level, was 53.30 feet below land surface. This was 4.90 feet above last month's measurement, 23.00 feet above last year's measurement, and 6.32 feet above the initial measurement recorded in 1962.

GROUND WATER LEVELS IN OBSERVATION WELLS



The February water-level measurement in this Ogallala aquifer well, elevation 3667 feet above sea level, was 108.11 feet below land surface. This was 0.10 of a foot below last month's measurement, 2.42 feet below last year's measurement, and 79.96 feet below the initial measurement recorded in 1950.



The February water-level measurement in this Paluxy aquifer well, elevation 535 feet above sea level, was 456.54 feet below land surface. This measurement was 0.82 of a foot above last month's measurement, 0.51 of a foot below last year's measurement, and 63.15 feet below the initial measurement recorded in 1953.

Texas Water Development Board

WATER Conditions

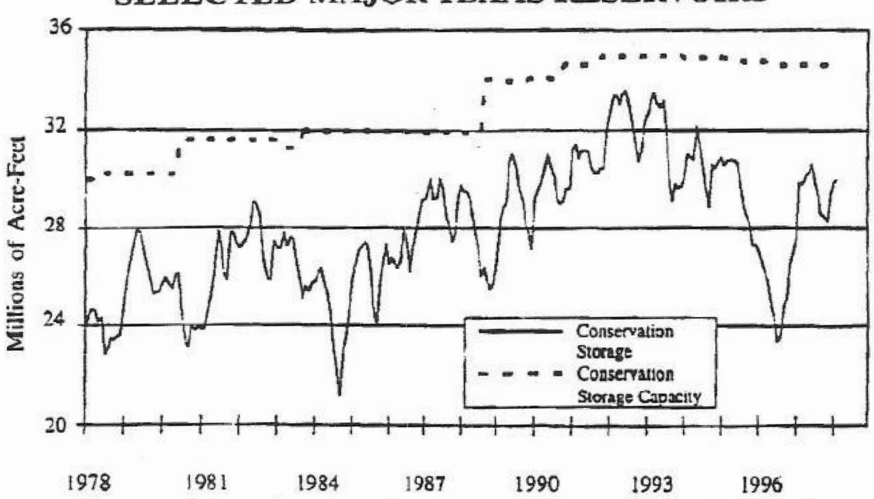
RESERVOIR STORAGE

March 1998

Near the end of February, the 77 reservoirs monitored for this report held 29,994,040 acre-feet in conservation storage. This was 87 percent of the conservation storage capacity of the State's major reservoirs. Compared to last month, storage has increased 81,780 acre-feet. Compared to this month last year, storage has increased 117,470 acre-feet.

Of the monitored reservoirs, 41 held 100 percent or more of their conservation storage capacities near the end of February. Lakes Sulphur Springs, Tawakoni, Eagle Mountain, Ray Hubbard, Richland-Chambers, Graham, Granbury, Pat Cleburne, Limestone, Cypress Springs, Bob Sandlin, Toledo Bend, Palestine, Tyler, Cedar Creek, Livingston, Coleto Creek, Houston, and Texana were full and spilling. An additional amount of water (acre-feet) was contained in the flood storage pool in each of the reservoirs as follows: Pat Mayse, 10,100; Cooper, 19,690; Benbrook, 12,300; Joe Pool, 11,280; Ray Roberts, 18,070; Lewisville, 67,480; Grapevine, 9,840; Lavon, 47,080; Navarro, 4,170; Bardwell, 140; Whitney, 10,630; Waco, 40,480; Proctor, 90; Belton, 32,280; Stillhouse, 21,230; Georgetown, 5,200; Granger, 4,680; Wright Patman, 276,180; Lake O' the Pines, 15,350; Sam Rayburn, 578,520; Somerville, 35,000, and Travis, 2,010.

CONSERVATION STORAGE DATA FOR SELECTED MAJOR TEXAS RESERVOIRS



Current data are based on elevation near end of month at 77 reservoirs that represent 98 percent of total conservation storage capacity in Texas reservoirs having a capacity of 5,000 acre-feet or more.

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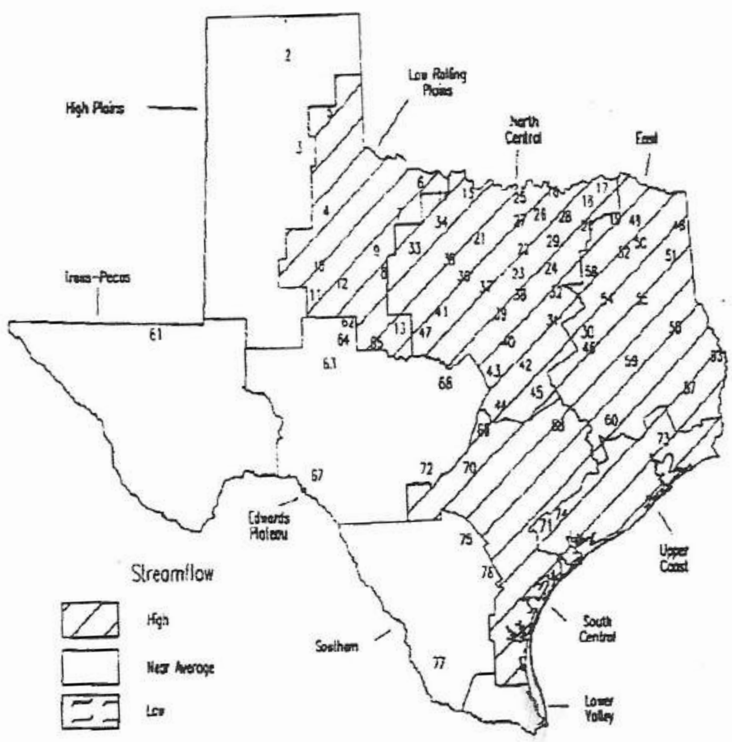
STREAMFLOW

Streamflow conditions across Texas ranged from near-normal to above-normal during the month of February. North-central Texas received extensive rainfall for February and the Wichita Falls area also recorded above normal rainfall during the month. Elsewhere across the State rainfall and runoff were normal for the month of February. The following is a summary of the measured flows at various index stations across the State.

The index station for the East Texas climatic division is located on the Neches River near Rockland. Streamflow for February was above-normal, averaging 5,754 cubic feet per second (cfs). The monthly average flow rate, when compared to the 1961-90 reference period, was 181 percent of the reference period median and 1055 cfs above the near-normal level for this location. For North-central Texas, the index station is located on the North Bosque River near Clifton. Streamflow past the gage was above-normal, averaging 440 cfs, or 942 percent of the monthly reference period median. This was 245 cfs above the station's near-normal flow level. Elsewhere across the State, the index station for the Edwards Plateau is located on the North Concho River near Carlsbad. Streamflow past the gage was near-normal, averaging 2.91 cfs, or 112 percent of the monthly reference period median. This was 1.42 cfs below the station's above-normal flow level. The index station for South-central Texas is located on the Guadalupe River near Spring Branch. Streamflow past the gage was above-normal, averaging 500 cfs, or 226 percent of the monthly reference period median. This was 12 cfs above the station's near-normal flow level.

STREAMFLOW CONDITIONS FOR FEBRUARY COMPARED WITH PAST RECORD



Reservoirs Shown on Map

1. Palo Duro Reservoir
2. Lake Meredith
3. MacKenzie Reservoir
4. White River Lake
5. Greenbelt Reservoir
6. Lake Kemp
7. Miller's Creek Reservoir
8. Fort Phantom Hill Reservoir
9. Lake Stamford
10. Lake J. B. Thomas
11. Lake Colorado City
12. Champion Creek Reservoir
13. Hords Creek Lake
14. Lake Kickapoo
16. Lake Arrowhead
15. Lake Texoma
17. Pat Mayse Lake
18. Cooper Lake
19. Lake Sulphur Springs
20. Lake Tawakoni
21. Bridgeport Reservoir
22. Eagle Mountain Reservoir
23. Benbrook Lake
24. Joe Pool Lake
25. Ray Roberts Lake
26. Lewisville Lake
27. Grapevine Lake
28. Lavon Lake
29. Lake Ray Hubbard
30. Richland-Chambers Creek Lake
31. Navarro Mills Lake
32. Bardwell Lake
33. Hubbard Creek Reservoir
34. Lake Graham
35. Possum Kingdom Lake
36. Lake Palo Pinto
37. Lake Granbury
38. Lake Pat Cleburne
39. Whitney Lake
40. Waco Lake
41. Proctor Lake
42. Belton Lake
43. Stillhouse Hollow Lake
44. Lake Georgetown
45. Granger Lake
46. Lake Limestone
47. Lake Brownwood
48. Wright Patman Lake
49. Lake Cypress Springs
50. Lake Bob Sandlin
51. Lake O' the Pines
52. Lake Fork Reservoir
53. Toledo Bend Reservoir
54. Lake Palestine
55. Lake Tyler
56. Sam Rayburn Reservoir
57. B. A. Steinhagen Lake
58. Cedar Creek Reservoir
59. Lake Livingston
60. Lake Conroe
61. Red Bluff Reservoir
62. E. V. Spence Reservoir
63. Twin Buttes Reservoir
64. O. C. Fisher Lake
65. O. H. Ivie Reservoir
66. Lake Buchanan
67. Int'l. Amistad Reservoir
68. Somerville Lake
69. Lake Travis
70. Canyon Lake
71. Coleto Creek Reservoir
72. Medina Lake
73. Lake Houston
74. Lake Texana
75. Choke Canyon Reservoir
76. Lake Corpus Christi
77. Int'l. Falcon Reservoir

Texas Surface Water Quality—
What Is It, and How Is It Measured?

Texas' precious water resources are the lifeblood of the state's environmental and economic future. In order to ensure that water is safe and available for people to use, the State of Texas has established standards that protect the ways that the water bodies in the state will be used, and defined measurements that w ill assure the water quality is good enough to maintain those uses. The standards are developed with a significant margin of safety, such that conditions at or just less than the standards indicate a potential for use impairment, before actual impairment is likely to occur.

Using those standards and measurements, the Texas Natural Resource Conservation Commission (TNRCC), in collaboration with other federal, regional, and local agencies, carries out a regular program of monitoring and assessment to determine which water bodies are meeting the standards set for their use, and which are not. The agency also monitors for water bodies that may violate standards in the near future. The results of this monitoring and assessment effort are published in *The State of Texas Water Quality Inventory*, or Clean Water Act (CWA) Section 305(b) Report.

The 305(b) Report and other available data and information on water quality are then used to produce *The State of Texas List of Impaired Water Bodies*, or CWA Section 303(d) List. This List identifies:

- water bodies which do not meet the standards set for their use, or are expected not to meet their use in the near future;
- which pollutants are responsible for the failure of a water body to meet standards; and
- water bodies that are targeted for clean-up activities within the next two state fiscal years.

All water bodies listed on the Section 303(d) List must eventually be cleaned up, if possible.

Texas Surface Water Quality Standards

The Texas Surface Water Quality Standards are rules designed to:

- establish numerical and narrative goals for water quality throughout the state; and
- provide a basis on which TNRCC regulatory programs can establish reasonable methods to implement and attain the state's goals for water quality.

All standards are protective; that is, they signal a situation where there is some possibility that water quality may be inadequate to meet its designated uses. There are instances, for example, in which a water body fails to meet the standard for aquatic life use, yet no fish kills are observed. In this instance, however, what may be observed is a decline in the variety or number of aquatic species, and an increased probability of fish kills.

Four general categories for water use are defined in the Texas Surface Water Quality Standards: aquatic life use, contact recreation, public water supply, and fish consumption.

Aquatic Life Use

The standards associated with this use are designed to protect aquatic species. Those standards establish optimal conditions for the support of aquatic life and define indicators used to measure whether these conditions are met. Some pollutants or conditions that may violate this standard include low levels of dissolved oxygen, or toxics such as metals or pesticides dissolved in water.

Contact Recreation

The standard associated with this use measures the level of certain bacteria in water to estimate the relative risk of swimming or other water sports involving direct contact with the water and the bacteria and viruses in it. It is possible to swim in water that does not meet this standard without becoming ill; however, the probability of becoming ill is higher than it would be if bacteria levels were lower.

Public Water Supply

The standards associated with this use indicate whether a water body is suitable for use as a source for a public water supply system using only conventional surface water treatment. This use, because of its importance to human health, is further defined in the Drinking Water Standards (30 Texas Administrative Code, Sections 290.101 - 290.120, based on the federal Drinking Water Regulations under the Safe Drinking Water Act). Indicators used to m easure the safety or usability for drinking water include the presence or absence of substances such as metals or pesticides. The concentration of dissolved solids is also measured since treatment to remove them from drinking water is expensive.

Fish Consumption (fresh water and salt water)

The standards associated with this use are designed to protect the public from consuming fish or shellfish that may be contaminated by pollutants in the water. The standards identify levels at which certain toxic substances dissolved in water pose a significant risk that these toxics may accumulate in the tissue of aquatic species. Because toxic substances in water may exceed these levels while no accumulation in fish tissue is observable, the state conducts tests on fish and shellfish tissue to determine if there is a risk to the public from consuming fish caught in state waters. The standards also specify bacterial levels in marine waters to assure that oysters or other shellfish subject to commercial harvest and marketing are safe for public sale and consumption.

Indicators of water quality that are not tied to specific uses—such as dissolved solids, nutrients, and toxics in sediment—are also described in the standards. A complete copy of the *Texas Surface Water Quality Standards* is available from the TNRCC.

Indicators of Water Quality

Several different parameters are measured to determine whether a water body meets the standards for its use. Some of the most common are listed here, with an explanation of why they are important to the health of a water body.

Metals

At levels higher than the standards set for them, metals such as cadmium, mercury, and lead pose a threat to drinking water supplies and human health. Eating fish contaminated with metals can cause these toxic substances to accumulate in human tissue, posing a significant health threat. Metals also pose a threat to livestock and aquatic life. Potentially dangerous levels of metals and other toxic substances are identified through chemical analysis of water, sediment, and fish tissue.

Organics

Toxic substances from pesticides and industrial chemicals, called organics, pose the same concerns as metals. Polychlorinated biphenyls (PCBs), for example, are industrial chemicals that are toxic and probably carcinogenic. Although banned in the United States in 1977, PCBs remain in the environment, and they accumulate in fish and human tissues when consumed.

Fecal coliform bacteria

These bacteria are measured to determine the relative risk of swimming (contact recreation). Fecal coliform bacteria originate from the wastes of warm-blooded animals. The presence of fecal co liform indicates that pathogens from these wastes may be reaching a body of water from inadequately treated sewage, improperly managed animal waste from livestock, pets in urban areas, aquatic birds and mammals, or failing septic systems.

Dissolved oxygen

The concentration of dissolved oxygen is a single, easy-to-measure characteristic of water that correlates with the occurrence and diversity of aquatic life in a water body. A water body that can support diverse, abundant aquatic life is a good indication of high water quality. A related problem is an excess of nutrients in water. Large quantities of nutrients in water can cause excessive growth of vegetation. This excessive vegetation, in turn, can cause low dissolved oxygen.

Dissolved solids

High levels of dissolved solids such as chloride and sulfate can cause water to be unusable, or simply too costly to treat for drinking water uses. Changes in dissolved solids concentrations also affect the quality of habitat for aquatic life.

Fish Consumption Advisories and Closures

The Texas Department of Health (TDH) conducts chemical testing of fish tissue to determine whether there is a risk to human health from consuming fish or shellfish caught in Texas creeks, rivers, and lakes. Fish seldom contain levels of contaminants high enough to cause an imminent threat to human health, even to someone who eats fish regularly. Risk increases for those persons who regularly consume larger fish and predatory fish from the same area of contaminated water over a long period of time. To reduce health risks in areas of contamination, people should eat smaller fish from a variety of water bodies. When a fish consumption advisory is issued, a person may legally take fish or shellfish from the water body under advisory, but it is not recommended. When a fish consumption closure is issued for a water body, the taking of fish or shellfish is legally prohibited.

Fish Consumption Advisories

Fish advisories may warn against the consumption of particular fish or shellfish species from the affected water body, or may recommend the amount of fish that may be consumed over certain periods of time by specific segments of the population. For example, an advisory may read:

> "Consumption Advice:
> The advisory includes all species of fish and recommends limiting consumption to the following:
> 1) Adults should consume no more than one meal, not to exceed 8 ounces of fish per serving, each week.
> 2) Children seven years of age and older should consume no more than one meal, not to exceed 4 ounces of fish per serving, each week.
> 3) Children 6 and under, pregnant women, or women who may soon become pregnant should not consume fish from this reservoir.
> 4) Persons consuming fish from this reservoir should not consume mineral dietary supplements with selenium exceeding 50 micrograms per day."

Fish Consumption Closures

Fish consumption closures identify a specific water body, or portion of a water body, where the taking of fish is prohibited because the human health risk from fish consumption is very high. The closure notice will also identify the contaminant of concern, such as mercury, and w ill list any (or all) species of fish or shellfish which people are prohibited from taking from the area of closure.

Watershed Action Plans

The state of Texas must develop action plans to remediate or protect water bodies listed on the Section 303(d) List of Impaired Water Bodies. The state uses watersheds as the management regions for implementing water quality control measures. A watershed action plan includes a quantitative assessment of water quality problems and contributing pollutant sources, as well as an implementation plan that identifies responsible parties and specifies actions needed to restore and protect a water body. Total maximum daily loads (TMDLs) are the scientific basis for these plans, and provide the foundation necessary to identify appropriate management objectives and strategies. A TMDL is an estimate of the maximum amount of pollution a body of water can receive and still meet water quality standards set for its use.

The TNRCC will coordinate the technical assessment of impairments in priority watersheds, the development of TMDLs, and the subsequent implementation of necessary management strategies using a collaborative approach that will involve local stakeholders in every step of the process.

To receive a copy of the 1998 Section 303(d) List of Impaired Water Bodies in Texas:

Louanne Jones, Water Quality Division, TNRCC
Call: (512) 239-2310
E-mail: lojones@tnrcc.state.tx.us
Write: Texas Natural Resource Conservation Commission
MC150
P.O. Box 13087
Austin, Texas 78711-3087

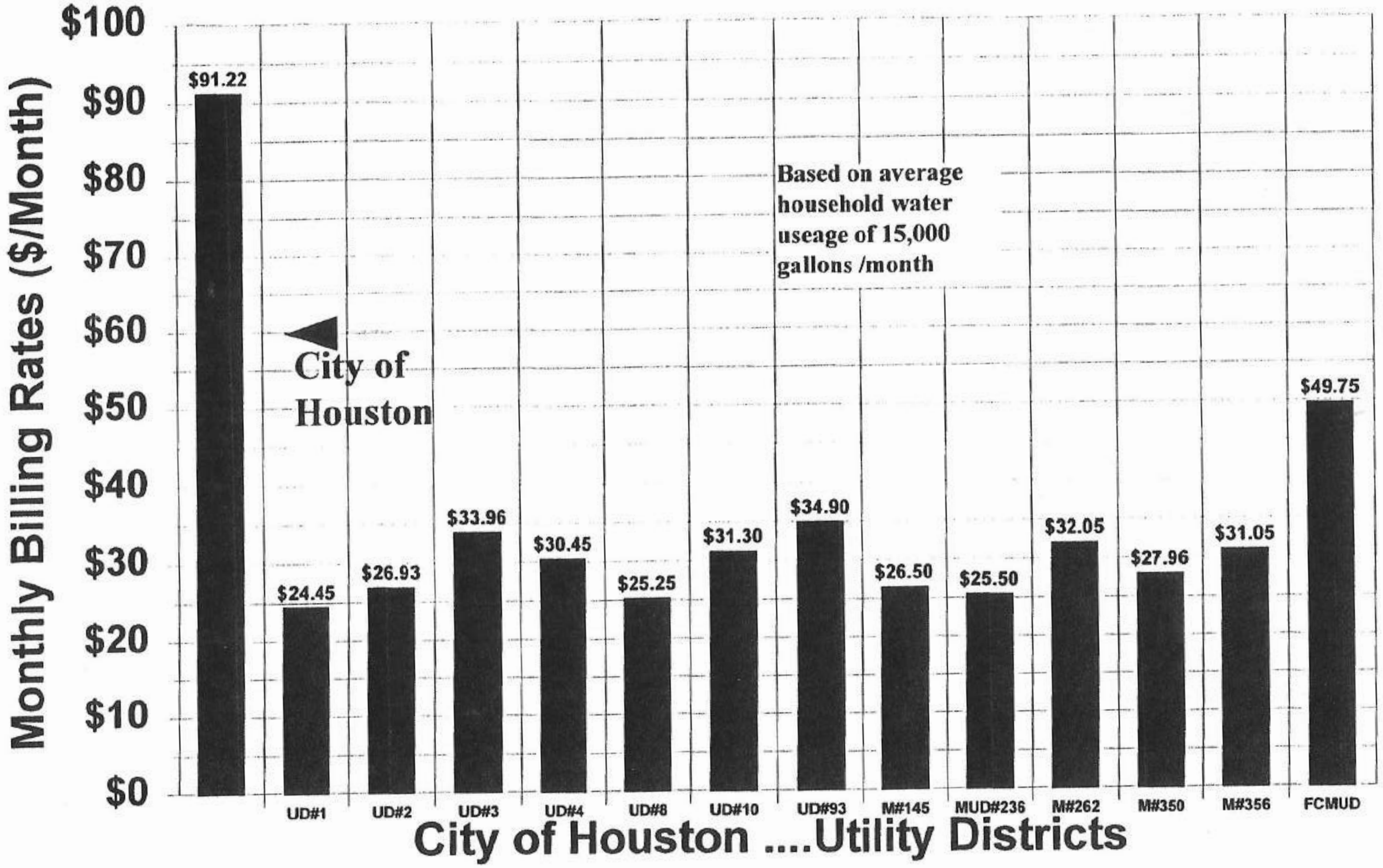
To comment on the 1998 Section 303(d) List of Impaired Water Bodies in Texas:

Patrick Roques, Water Quality Division, TNRCC
Call: (512) 239-4604
E-mail: proques@tnrcc.state.tx.us
Write: Texas Natural Resource Conservation Commission, at the address shown above

To get involved with water quality in your area, contact the regional management agency for your river basin, or the TNRCC central office:

Water Quality Division
Call: (512) 239-4411
Write: Texas Natural Resource Conservation Commission, at the address shown above

Comparison of Water & Wastewater Costs
Utility Districts vs. City of Houston



Note: See Seminar Handout for Cost Details

COMPARE Ground WATER & SEWER COSTS

Utility District vers. City of Houston

The average household uses about 15,000 gallons of water per month.

How does your current monthly Ground water and sewer bill compare to that under the City of Houston billing rates.

Usage (gal/mo)	Houston ($$/mo)	UD1 ($$/mo)	UD2 ($$/mo)	UD3 ($$/mo)	UD4 ($$/mo)
1,000	**$8.50**	$19.13	$23.03	$26.76	$25.50
2,000	**$8.50**	$19.51	$23.03	$26.76	$25.50
3,000	**$8.50**	$19.89	$23.03	$26.76	$25.50
4,000	**$24.62**	$20.27	$23.03	$26.76	$25.50
5,000	**$29.88**	$20.65	$23.03	$26.76	$25.50
6,000	**$36.53**	$21.03	$23.03	$27.43	$25.50
7,000	**$41.96**	$21.41	$23.03	$28.10	$26.05
8,000	**$47.39**	$21.79	$23.03	$28.77	$26.60
9,000	**$52.82**	$22.17	$23.03	$29.44	$27.15
10,000	**$58.25**	$22.55	$23.03	$30.11	$27.70
11,000	**$63.68**	$22.93	$23.81	$30.88	$28.25
12,000	**$69.11**	$23.31	$24.59	$31.65	$28.80
13,000	**$76.48**	$23.69	$25.37	$32.42	$29.35
14,000	**$83.85**	$24.07	$26.15	$33.19	$29.90
15,000	**$91.22**	**$24.45**	**$26.93**	**$33.96**	**$30.45**
16,000	**$98.59**	$24.83	$27.71	$34.73	$31.10
17,000	**$105.96**	$25.21	$28.49	$35.50	$31.75
18,000	**$113.33**	$25.59	$29.27	$36.27	$32.40
19,000	**$120.70**	$25.97	$30.05	$37.04	$33.05
20,000	**$128.07**	$26.35	$30.83	$37.81	$33.70
21,000	**$135.44**	$26.73	$31.61	$38.68	$34.35
22,000	**$142.81**	$27.11	$32.39	$39.55	$35.00
23,000	**$150.18**	$27.49	$33.17	$40.42	$35.65
24,000	**$157.55**	$27.87	$33.95	$41.29	$36.30
25,000	**$164.92**	$28.25	$34.73	$42.16	$36.95
26,000	**$172.29**	$29.01	$35.51	$43.03	$37.70
27,000	**$179.66**	$29.77	$36.29	$43.90	$38.45
28,000	**$187.03**	$30.53	$37.07	$44.77	$39.20
29,000	**$194.40**	$31.29	$37.85	$45.64	$39.95
30,000	**$201.77**	$32.05	$38.63	$46.51	$40.70
31,000	**$209.14**	$32.81	$39.41	$47.38	$41.45
32,000	**$216.51**	$33.57	$40.19	$48.25	$42.20
33,000	**$223.88**	$34.33	$41.22	$49.12	$42.95
34,000	**$231.25**	$35.09	$42.25	$49.99	$43.70
35,000	**$238.62**	$35.85	$43.28	$50.86	$44.45
36,000	**$245.99**	$36.61	$44.31	$51.73	$45.30
37,000	**$253.36**	$37.37	$45.34	$52.60	$46.15
38,000	**$260.72**	$38.13	$46.37	$53.47	$47.00
39,000	**$268.10**	$38.89	$47.40	$54.34	$47.85
40,000	**$275.47**	$39.65	$48.43	$55.21	$48.70
41,000	**$282.84**	$40.41	$49.46	$56.08	$49.55
42,000	**$290.21**	$41.17	$50.49	$56.95	$50.40
43,000	**$297.58**	$41.93	$51.52	$57.82	$51.25
44,000	**$304.95**	$42.69	$52.55	$58.69	$52.10
45,000	**$312.20**	$43.45	$53.58	$59.56	$52.95
46,000	**$319.69**	$44.21	$54.61	$60.43	$53.80
47,000	**$327.06**	$44.97	$55.64	$61.30	$54.65
48,000	**$334.43**	$45.73	$56.67	$62.17	$55.50

COMPARE WATER & SEWER COSTS

Utility District vers. City of Houston

The average household uses about 15,000 gallons of water per month.

How does your current monthly water and sewer bill compare to that under the City of Houston billing rates.

Usage (gal/mo)	Houston ($$/mo)	UD8 ($$/mo)	UD10 ($$/mo)	UD93 ($$/mo)	MUD145 ($$/mo)
1,000	**$8.50**	$18.10	$22.64	$27.75	$20.00
2,000	**$8.50**	$18.10	$22.64	$27.75	$20.00
3,000	**$8.50**	$18.65	$23.21	$28.30	$20.50
4,000	**$24.62**	$19.20	$23.78	$28.85	$21.00
5,000	**$29.88**	$19.75	$24.35	$29.40	$21.50
6,000	**$36.53**	$20.30	$24.92	$29.95	$22.00
7,000	**$41.96**	$20.85	$25.49	$30.50	$22.50
8,000	**$47.39**	$21.40	$26.06	$31.05	$23.00
9,000	**$52.82**	$21.95	$26.63	$31.60	$23.50
10,000	**$58.25**	$22.50	$27.20	$32.15	$24.00
11,000	**$63.68**	$23.05	$28.02	$32.70	$24.50
12,000	**$69.11**	$23.60	$28.84	$33.25	$25.00
13,000	**$76.48**	$24.15	$29.66	$33.80	$25.50
14,000	**$83.85**	$24.70	$30.48	$34.35	$26.00
15,000	**$91.22**	**$25.25**	**$31.30**	**$34.90**	**$26.50**
16,000	**$98.59**	$25.80	$32.12	$35.45	$27.00
17,000	**$105.96**	$26.35	$32.94	$36.00	$27.50
18,000	**$113.33**	$26.90	$33.76	$36.55	$28.00
19,000	**$120.70**	$27.45	$34.58	$37.10	$28.50
20,000	**$128.07**	$28.00	$35.40	$37.65	$29.00
21,000	**$135.44**	$28.55	$36.47	$38.45	$29.50
22,000	**$142.81**	$29.10	$37.54	$39.25	$30.00
23,000	**$150.18**	$29.90	$38.61	$40.05	$30.50
24,000	**$157.55**	$30.70	$39.68	$40.85	$31.00
25,000	**$164.92**	$31.50	$40.75	$41.65	$31.50
26,000	**$172.29**	$32.30	$41.82	$42.45	$32.25
27,000	**$179.66**	$33.10	$42.89	$43.25	$33.00
28,000	**$187.03**	$33.90	$43.96	$44.05	$33.75
29,000	**$194.40**	$34.70	$45.03	$44.85	$34.50
30,000	**$201.77**	$35.50	$46.10	$45.65	$35.25
31,000	**$209.14**	$36.30	$47.17	$46.70	$36.00
32,000	**$216.51**	$37.10	$48.24	$47.75	$36.75
33,000	**$223.88**	$38.15	$49.31	$48.80	$37.50
34,000	**$231.25**	$39.20	$50.38	$49.85	$38.25
35,000	**$238.62**	$40.25	$51.45	$50.90	$39.00
36,000	**$245.99**	$41.30	$52.52	$51.95	$39.75
37,000	**$253.36**	$42.35	$53.59	$53.00	$40.50
38,000	**$260.72**	$43.40	$54.66	$54.05	$41.25
39,000	**$268.10**	$44.45	$55.73	$55.10	$42.00
40,000	**$275.47**	$45.50	$56.80	$56.15	$42.75
41,000	**$282.84**	$46.55	$57.87	$57.20	$43.50
42,000	**$290.21**	$47.60	$58.94	$58.25	$44.25
43,000	**$297.58**	$48.65	$60.01	$59.30	$45.00
44,000	**$304.95**	$49.70	$61.08	$60.35	$45.75
45,000	**$312.20**	$50.75	$62.15	$61.40	$46.50
46,000	**$319.69**	$51.80	$63.22	$62.45	$47.25
47,000	**$327.06**	$52.85	$64.29	$63.50	$48.00
48,000	**$334.43**	$53.90	$65.36	$64.55	$48.75

COMPARE WATER & SEWER COSTS

Utility District vers. City of Houston

The average household uses about 15,000 gallons of water per month.

How does your current monthly water and sewer bill compare to that under the City of Houston billing rates.

Usage (gal/mo)	Houston ($$/mo)	MUD236 ($$/mo)	MUD262 ($$/mo)	MUD350 ($$/mo)	MUD356 ($$/mo)
1,000	**$8.50**	$19.00	$23.00	$19.30	$22.00
2,000	**$8.50**	$19.00	$23.00	$19.30	$22.00
3,000	**$8.50**	$19.50	$23.60	$19.87	$22.60
4,000	**$24.62**	$20.00	$24.20	$20.44	$23.20
5,000	**$29.88**	$20.50	$24.80	$21.01	$23.80
6,000	**$36.53**	$21.00	$25.40	$21.58	$24.40
7,000	**$41.96**	$21.50	$26.00	$22.15	$25.00
8,000	**$47.39**	$22.00	$26.60	$22.72	$25.60
9,000	**$52.82**	$22.50	$27.20	$23.29	$26.20
10,000	**$58.25**	$23.00	$27.80	$23.86	$26.80
11,000	**$63.68**	$23.50	$28.65	$24.68	$27.65
12,000	**$69.11**	$24.00	$29.50	$25.50	$28.50
13,000	**$76.48**	$24.50	$30.35	$26.32	$29.35
14,000	**$83.85**	$25.00	$31.20	$27.14	$30.20
15,000	**$91.22**	**$25.50**	**$32.05**	**$27.96**	**$31.05**
16,000	**$98.59**	$26.00	$32.90	$28.78	$31.90
17,000	**$105.96**	$26.50	$33.75	$29.60	$32.75
18,000	**$113.33**	$27.00	$34.60	$30.42	$33.60
19,000	**$120.70**	$27.50	$35.45	$31.24	$34.45
20,000	**$128.07**	$28.00	$36.30	$32.06	$35.30
21,000	**$135.44**	$28.50	$37.40	$33.13	$36.40
22,000	**$142.81**	$29.00	$38.50	$34.20	$37.50
23,000	**$150.18**	$29.75	$39.60	$35.27	$38.60
24,000	**$157.55**	$30.50	$40.70	$36.34	$39.70
25,000	**$164.92**	$31.25	$41.80	$37.41	$40.80
26,000	**$172.29**	$32.00	$42.90	$38.48	$41.90
27,000	**$179.66**	$32.75	$44.00	$39.55	$43.00
28,000	**$187.03**	$33.50	$45.10	$40.62	$44.10
29,000	**$194.40**	$34.25	$46.20	$41.69	$45.20
30,000	**$201.77**	$35.00	$47.30	$42.76	$46.30
31,000	**$209.14**	$35.75	$48.40	$43.83	$47.40
32,000	**$216.51**	$36.50	$49.50	$44.90	$48.50
33,000	**$223.88**	$37.50	$50.60	$45.97	$49.60
34,000	**$231.25**	$38.50	$51.70	$47.04	$50.70
35,000	**$238.62**	$39.50	$52.80	$48.11	$51.80
36,000	**$245.99**	$40.50	$53.90	$49.18	$52.90
37,000	**$253.36**	$41.50	$55.00	$50.25	$54.00
38,000	**$260.72**	$42.50	$56.10	$51.32	$55.10
39,000	**$268.10**	$43.50	$57.20	$52.39	$56.20
40,000	**$275.47**	$44.50	$58.30	$53.46	$57.30
41,000	**$282.84**	$45.50	$59.40	$54.53	$58.40
42,000	**$290.21**	$46.50	$60.50	$55.60	$59.50
43,000	**$297.58**	$47.50	$61.60	$56.67	$60.60
44,000	**$304.95**	$48.50	$62.70	$57.74	$61.70
45,000	**$312.20**	$49.50	$63.80	$58.81	$62.80
46,000	**$319.69**	$50.50	$64.90	$59.88	$63.90
47,000	**$327.06**	$51.50	$66.00	$60.95	$65.00
48,000	**$334.43**	$52.50	$67.10	$62.02	$66.10

REGIONAL WATER PLANNING AREAS
And
SPECIAL WATER RESOURCES

Adopted Rules For:

REGIONAL WATER PLANNING GRANTS

REGIONAL WATER PLANNING GUIDELINES

STATE WATER PLANNING GUIDELINES

And

INITIAL COORDINATING BODY REPRESENTATIVES

Effective

March 11, 1998

RE-SCHEDULED:

An Educational Seminar

on

New Ground-Water Supply Issues

This seminar was originally scheduled for March 31, 1998 but because it conflicted with an important local seminar on Senate Bill No.1, we have re-scheduled and expanded our seminar for presentation on:

Thursday
April 16, 1998

Holiday Inn - North
I – 45 North, Near FM 1960
8:00 – 12:00 Noon

Environmental
Litigation
Associates

Another Training Program
Sponsored by:

Environmental Litigation Associates

Houston, Texas

Seminar Objectives:

- To meet and deal with problems before they:

    a) cost your operations too much money

    and/or

    b) turn into costly litigation.

- To review EPA's Contaminants Candidate List (CCL) and its impact on future regulatory activity.

- To look at your water-supply system in terms of:

    a) local hydrogeology

    b) water well system

    c) water quality, in terms of:

        i) water chemistry
        ii) water microbiology
        iii) potential contaminants
        iv) toxicology

- To consider the impact of The Safe Drinking Water Act on MUD operations.

- To hear what the Harris County Health Department is doing to protect our water supply,

- To hear what the Texas Natural Resources Conservation Commission (TNRCC) does to protect our water supply,

- To consider what the CCL means to MUDs, large and small.

Seminar Program:

8:00 am **<u>Introductions:</u>** Michael D. Campbell, P.G., P.H.
Principal,
Environmental Litigation Associates

8:05 am **<u>Presentation:</u>** Jose A. Berlanga, J. D.
Partner,
Gardere Wynne Sewell & Riggs

EPA's Contaminants Candidate List (CCL) and its Future Implications.

- 1996 Amendments to Safe Drinking Water Act
- Public Information and Developing Requirements
- Increased Regulations & Costs

8:30 am **<u>Presentation:</u>** Michael D. Campbell, P.G., P.H.
Principal Hydrogeologist
Environmental Litigation Associates

Ground-Water Supply Systems: Hydrogeology and the Delivery of a Water Supply.

- Aquifer Productivity
- Well-Site Selection
- Well Design and Installation
- Well Operation and Maintenance
- Contaminant Transport

8:55 am **<u>Presentation:</u>** William S. Hitchcock, Ph.D.
Principal Chemist
Environmental Litigation Associates

Hydrochemistry and the Contaminants Candidate List.

- Classes of Compounds on the CCL
- Realistic Objectives for Chemical Analyses
- Potential Problems with Chemical Sampling & Analyses

9:20 am **<u>Presentation:</u>** Richard E. Woodward, M. A.
Principal Microbiologist
Environmental Litigation Associates

Microbiology and the Potential Impact on Water Quality.

- Water Taste, Odor, and Appearance
- Pathogens
- Productions Limitations

9:45 am <u>**Presentation:**</u> **F. Ben Thomas, DABT, Ph.D.**
Principal Toxicologist
Environmental Litigation Associates

The Toxicological Significance of Chemicals in Water Supplies (or What is Clean Water?)

- Human Health and the Environment
- Toxicity and Human Health

10:10 am ***Coffee Break***

10:25 am <u>**Presentation:**</u> **Marilyn Christian, B.S.**
Section Chief, Environmental Engineering, Harris County Health Department

What the Harris County Health Department does to Protect our Water Supply and the Impact of Recent Regulations.

10:40 am <u>**Presentation:**</u> **Sally C. Gutierrez, M.A., R.S.**
Director, Water Quality Division, Texas Natural Resource Conservation Commission (TNRCC)

What the TNRCC does to Protect our Water Supply and the Impact of Recent Regulations.

10:55 am <u>**Presentation:**</u> **Jose A. Berlanga, J. D.**
Partner,
Gardere Wynne Sewell & Riggs

Potential Litigation Areas in Providing and Operating a Water-Supply System: Case Histories in Water Quality Issues.

- Today's Unregulated Contaminants
- Tomorrow's Contaminants of Concern

11:30 am Panel Discussion and Questions

12:00 Noon Summary Remarks and Close of Seminar

Location and Cost of Seminar:

Holiday Inn - North
April 16, 1998
I – 45 North, Near FM 1960
8:00 – 12:00 Noon

Cost: $ 25.00 (Paid at Door)
Cash or Checks (Payable to Environmental Litigation Associates)

Please let us know you are planning to attend.
RSVP by Phone: (281) 440-7665, or
RSVP by Fax: (281) 583-9730, or
RSVP by Email: ela1@ela-iet.com

Please provide your name and number in your party so that we can accommodate those in attendance with appropriate space.

Note:

1) The charge is to cover the costs of the seminar site, handbook, and coffee.

2) Four (4) Continuing Educational Credits (CECs) have been approved by the TNRCC.

Something About the Seminar Sponsor:

Environmental Litigation Associates

ELA consists of a group of seven senior environmental professional scientists and engineers who provide litigation support and expert witness services to the legal community in the Texas and the U.S.

ELA sponsors training in the environmental field to reduce unnecessary litigation through the Institute of Environmental Technology and other forums. For additional information about ELA, see the group's web site: http://www.ela-iet.com/elsassoc.htm

Something About the Seminar Speakers:

Michael D. Campbell, P.G., P.H. is the Principal Hydrogeologist for Environmental Litigation Associates, Principal Hydrogeologist in the environmental consulting firm of Campbell and Associates, and Principal Lecturer for the Institute of Environmental Technology, since 1992. Additional information is available through the ELA web site: http://www.ela-iet.com/el01001.htm

José A. Berlanga, Esq. is a partner in the law firm of Gardere Wynne Sewell & Riggs, L.L.P. and maintains a litigation practice with an emphasis in toxic tort litigation. He has previously served as an Assistant United States Attorney and as *in house* counsel for the Shell Oil Company in Houston, Texas. Mr. Berlanga has a background in civil litigation and has participated in a variety of cases. Additional information is available through the firm's web site at: http://www.gardere.com/

William S. Hitchcock. Ph.D. is a Principal in Environmental Litigation Associates, and a Principal of Hitchcock and Associates, an environmental consulting firm located in Houston, TX. Dr. Hitchcock is also a Primary Lecturer for the Institute of Environmental Technology. Additional information is available through the ELA web site at http://www.ela-iet.com/el05001.htm

Richard E. Woodward, M. A. is a Principal Microbiologist in Environmental Litigation Associates, President of Sierra Environmental Services, Inc., a firm that specializes in evaluating microbiological problems in water supplies and in bioremediation of industrial hazardous wastes. Additional information is available through the ELA / IET web site: http://www.ela-iet.com/el04001.htm

F. Ben Thomas, DABT, Ph.D. is Principal Toxicologist in Environmental litigation Associates, Executive Vice President in Compliance Solutions, Inc., and a regular guest lecture for the Institute of Environmental Technology. He conducts risk assessment, regulatory negotiation, litigation support, strategic planning, program development, and program management. Additional information is available through the ELA / IET web site: http://www.ela-iet.com/el06001.htm

Marilyn Christian, P.E., is Section Chief, Environmental Engineering, Harris County Health Department. Over the past 13 years she has served Sanitarian in the Environmental Engineering Department and for the City of Houston Health and Human Services. Additional information is available through their web site located at: http://www.hd.co.harris.tx.us/env/env.htm

Sally C. Gutierrez, M.S., R.S. is Director of the Water Quality Division of the Texas Natural Resource Conservation Commission (TNRCC) in Austin, Texas. Over the past 5 years she has served the TNTCC in a number of functions, such Director of the Water Utilities Division, Acting Deputy Director for the Office of Water Resource Management, Leader of the Drinking Water Monitoring Operations Team, and other positions within the TNRCC. Additional information is available through the TNRCC web site: http://www.tnrcc.state.tx.us/water/wu/index.html