Hydrogeologic trends in the Dell City area, Hudspeth County, Texas

Sharp, John M., Jr., James R. Mayer, and Eldon McCutcheon, 1993, pp. 327-330

in:

Carlsbad Region (New Mexico and West Texas), Love, D. W.; Hawley, J. W.; Kues, B. S.; Austin, G. S.; Lucas, S. G.; [eds.], New Mexico Geological Society 44th Annual Fall Field Conference Guidebook, 357 p.

This page is intentionally left blank to maintain order of facing pages.

HYDROGEOLOGIC TRENDS IN THE DELL CITY AREA, HUDSPETH COUNTY, TEXAS

JOHN M. SHARP, JR[1], JAMES R. MAYER[1] and ELDON MCCUTCHEON[2]
[1]Department of Geological Sciences, The University of Texas at Austin, Austin, Texas 78712; [2]Dell City, Texas 79837

Abstract—The Dell City irrigation district lies on the western edge of the Salt Basin in Texas and New Mexico. Extensive irrigation began in the 1950s and the area has been a prolific producer of cotton, alfalfa, melons, onions and garlic. Ground water for irrigation is pumped from underlying Permian carbonates (Bone Spring and Victorio Peak formations). Comparison of data from May 1992 with those of the late 1940s and 1960 shows an average 30-foot drop in the potentiometric surface, but hydraulic gradients in the aquifer are very small. The water table is nearly horizontal and pumping discharge is high, which indicates very high transmissivities, and there is a subtle east-west trough just south of Dell City. There are indications of local recharge within the irrigation area. The distributions of total dissolved solids (TDS) show an unexpected rise in the center of the irrigation district. TDS concentrations decrease radially, until they rise sharply again near the salt flats. This indicates that there has been little salt-water intrusion. The higher TDS near Dell City may be caused by irrigation return flow and a greater proportion of evaporite minerals in shallow sediments within a paleotopographic low. We suggest that the flow system is strongly fault-controlled. This has minimized salt-water intrusion by juxtaposition of hydrostratigraphic units and may control effective recharge areas.

INTRODUCTION

The farming community of Dell City, Hudspeth County, Texas, relies on water from underlying Permian limestones to support irrigation. Crops include alfalfa, cotton, feed grains, peppers, melons, sesame, onions and garlic. The agricultural district is in the northeastern portion of the Diablo Plateau and abuts the western margin of the Salt Basin. There is little relief on the west side of the basin, which merges almost imperceptibly with the Diablo Plateau. The plateau surface rises gently upwards to the west to the Sacramento and Cornudas mountains, and southwest to the escarpment of the Diablo Plateau near the Rio Grande (Kreitler and Sharp, 1990).

Potentiometric surface maps (Sharp, 1989; Kreitler et al., 1990; Barrett et al., written comm. 1992; Davis and Leggat, 1965; Bjorklund, 1957; Scalapino, 1950) indicate that the regional flow is northeast across the Diablo Plateau, east from the Cornudas Mountains, and perhaps southeast from the Sacramento Mountains (Fig. 1). In the Dell City area, however, the water table is nearly horizontal and flat, indicating extremely high transmissivity, very low natural discharge rates, or both.

Natural recharge is apparently from surface water infiltration through fractures underlying arroyos and stream beds. Discharge is by pumping and subsequent evapotranspiration and by flow into the salt flats, where waters evaporate close to or at the land surface. Kreitler et al. (1990) also speculated about the possibility of interbasin discharge into the Pecos River flow systems (Lafave and Sharp, 1987; Sharp, 1989). Direct areal recharge from precipitation is minimal; rainfall at Dell City averages about 9 in./yr (22.9 cm/yr) and potential evapotranspiration rates are almost an order of magnitude greater (Scalapino, 1950). Depths to water range from nearly zero in Salt Basin playas to more than 800 ft in the Diablo Plateau.

The prolific aquifer is in Leonardian rocks of the Permian shelf—the Bone Spring and Victorio Peak Limestones. Some wells may also produce from the underlying Wolfcampian Hueco Limestone. The ground-water flow is highly fracture-dominated. Fractures, together with extensive solution features, account at least partially for the low regional gradient of the potentiometric surface. In some portions of the Dell City area, the Bone Spring Limestone and some Tertiary volcanic rocks crop out. As much as 150 ft of alluvium, from which are derived the fertile Dell City soils, mantles the bedrock.

Water quality is highly variable, ranging from less than 1500 mg/1 total dissolved solids on the periphery of the irrigation area to halite saturation (over 300,000 mg/L) in the Salt Basin playas. Water quality has deteriorated in the 55+ years of irrigation, but some unexpected trends, including a lack of intrusion of brines from the east and a zone of poorer quality water southeast of Dell City, suggest natural hydrogeological controls.

We have compared data on water tables and salinities from 1948-49 (Scalapino, 1950), 1960 (Davis and Leggat, 1965) and 1992 (Barrett et al., written comm. 1992, and SCS data files) to evaluate both temporal and regional trends of the hydrogeologic system at Dell City.

HYDROGEOLOGIC MAPS

Figs. 2, 3 and 4 represent, respectively, water table maps for 1948 (interpreted from Scalapino, 1950), 1960 and 1992. All maps show the

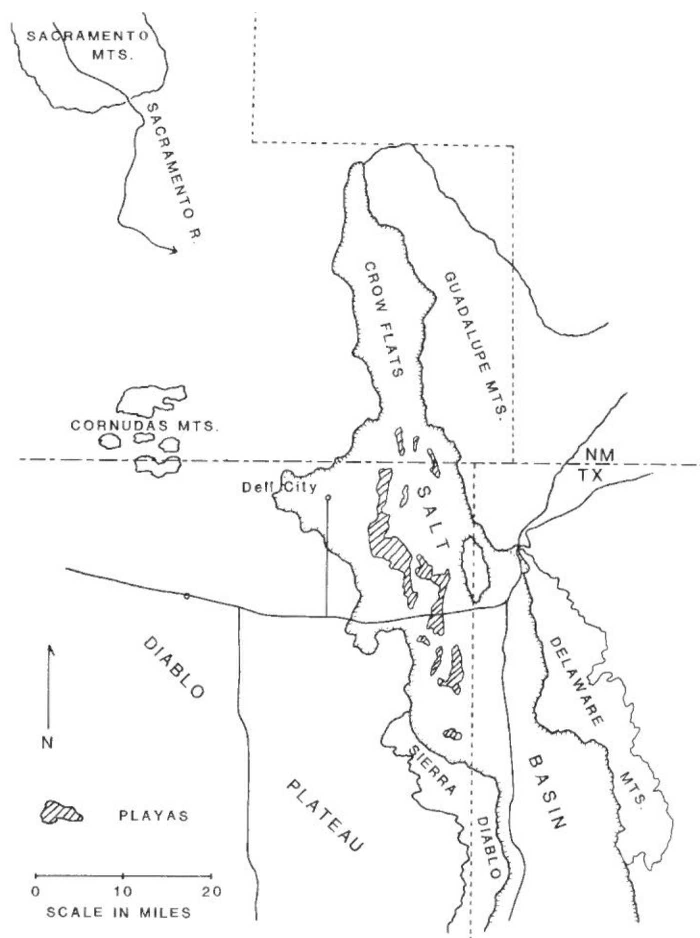

FIGURE 1. Location map showing key geologic features of the Dell City area.

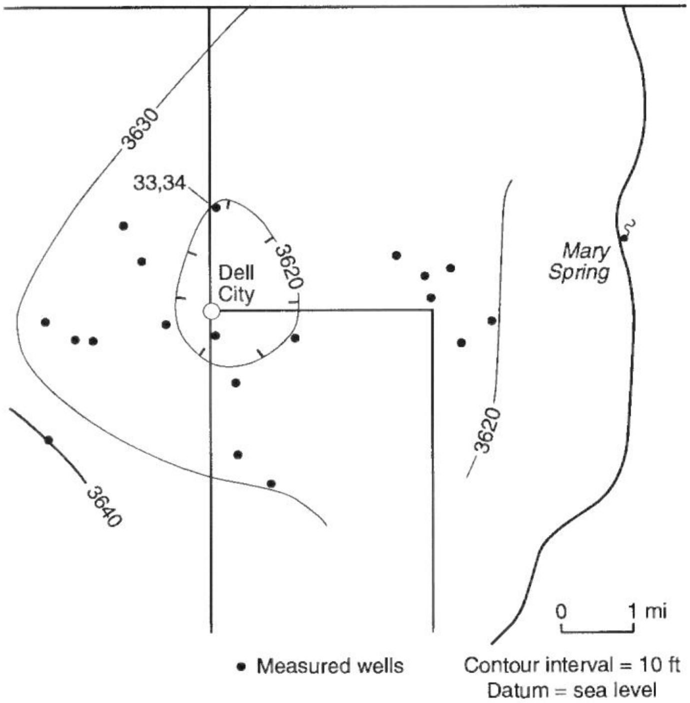

FIGURE 2. Generalized water-table map for the Dell City area in 1948 (data from Scalapino, 1950). Bold line on the east is the approximate western limit of the salt flats. Top line is the Texas–New Mexico border. Also shown are roads FM 1437 (north-south through Dell City), FM 1576 and FM 2249 (east out of Dell City).

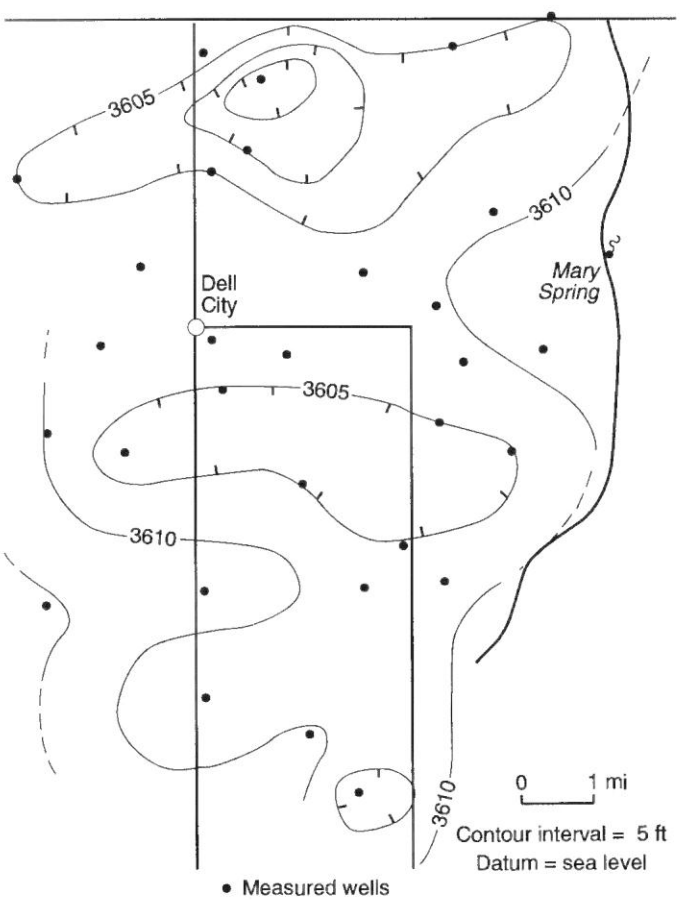

FIGURE 3. Generalized water-table map for the Dell City area in 1960 (redrawn from Davis and Leggat, 1965).

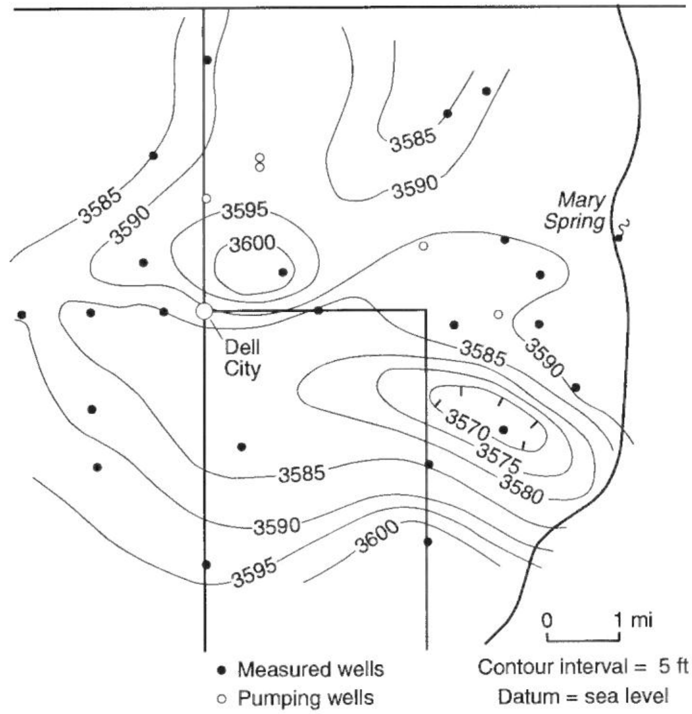

FIGURE 4. Generalized water-table map for the Dell City area on June 1, 1992 (redrawn from Barrett et al., 1992).

Texas/New Mexico border on the north, the intersection of FM 1437 and 2249 in Dell City and the junction where FM 2249 turns south near Round Mountain and becomes FM 1576. Also shown are the locations of Mary Spring and the approximate boundary of the Salt Basin playa deposits.

A cone of depression already existed in the immediate vicinity of Dell City in 1948 (Fig. 2). By 1960 (Fig. 3), water levels had dropped 10 to 30 ft with a cone of depression developed both north and south of the town. By 1992, water levels had declined between 30 and 45 ft. A cone of depression exists south-southeast of Dell City (Fig. 4) and a recharge mound is located just northeast of Dell City.

We caution that all three water-table maps incorporate some uncertainties because wellhead elevations were estimated from the U.S. Geological Survey 1:24,000 Dell City topographic map. Some wells were located on top of small mounds and fields that have been extensively reworked and graded. The total relief of the water table is 30 ft or less and the water table is nearly horizontal over large areas. Nevertheless, a number of general conclusions can be drawn.

First, the carbonate aquifers must have a very high transmissivity, because the water-table relief is small and the discharge is high. Secondly, we can infer regional ground-water flow to the northeast (from the Diablo Plateau), east (from the Cornudas Mountains) and southeast (from the Sacramento Mountains) to the salt flats and Dell City. Before the water table was lowered by irrigation pumping, there was discharge from springs, such as Mary Spring and Crow Spring and probably more diffuse regional flow into the Salt Basin. Since pumping began, water levels have continued to decline, although the bulk of the decline occurred prior to the mid-1970s (J. Ashworth, personal comm. 1993). Recharge from surface impoundments and irrigation return flow, as well as pumping, creates ephemeral variations in the water-table configuration.

SALINITY MAPS

Figs. 5 and 6 show the distribution of total dissolved solids from wells in the Dell City area for 1960 and 1992, respectively. Scalapino's (1950, table 5) data for 1948-49 are not presented here as a map, but they can be summarized simply. Salinities (TDS) were generally less than 1800 mg/L, except near the salt flats. In the two wells with greater

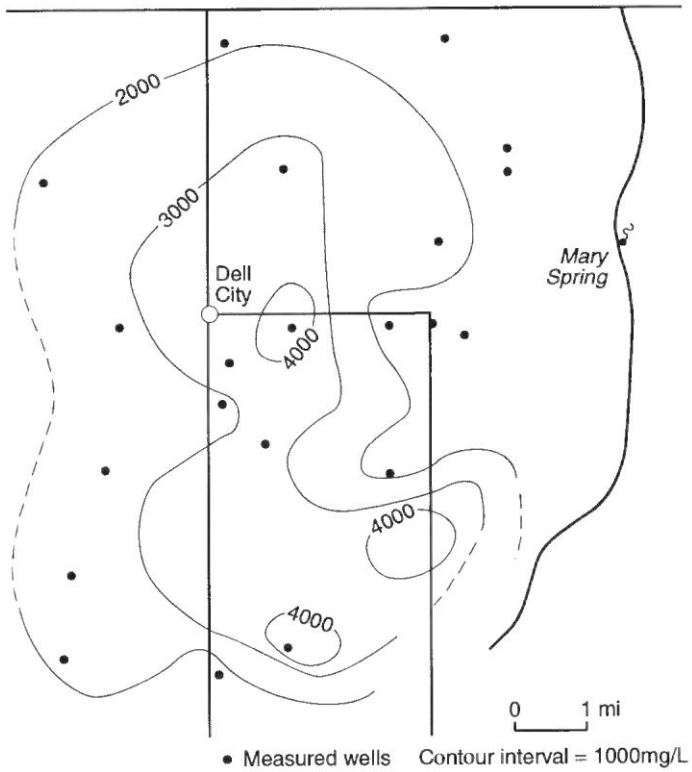

FIGURE 5. Generalized isocons, TDS (mg/L), for the Dell City area in 1960 (redrawn from Davis and Leggat, 1965).

than 6000 mg/L TDS, nitrate values were over 200 mg/L. This is a clear indication of anthropogenic pollution (animal waste or fertilizer are possible sources, perhaps coupled with improperly cased wells). For instance, in Scalapino's well 33, 1.5 mi north of the Dell City intersection, the salinity was 6850 mg/L TDS and NO, concentrations were 256 mg/L. It is adjacent to well 34 (Scalapino's identification,

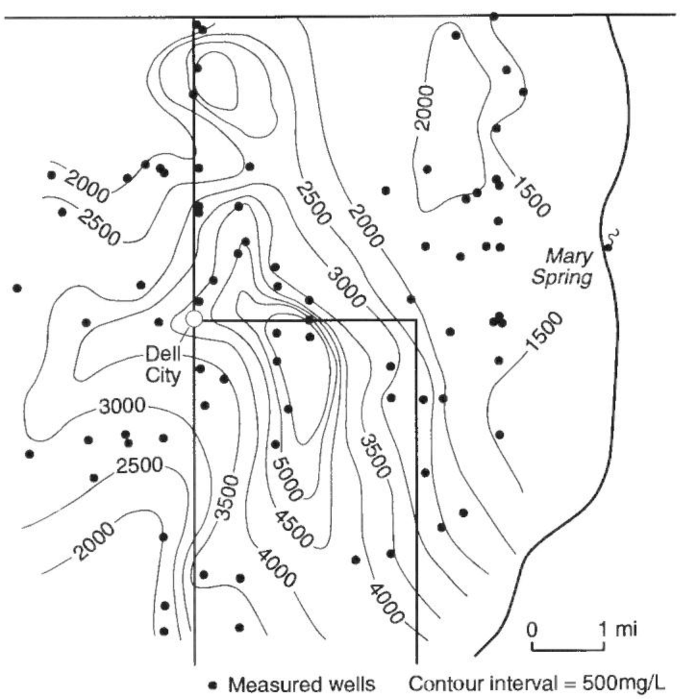

FIGURE 6. Generalized isocons, TDS (mg/L), for the Dell City area in 1992 (based on SCS data, redrawn from Barrett et al., 1992).

see Fig. 2), which had TDS of 1120 mg/L and NO, concentration of 2.8 mg/L. The only other trend inferrable from the pre-1950 data is that ground waters north of Dell City tended to be the least saline.

By 1960, however, salinities had increased to 3000 mg/L in much of the irrigation district with three areas of _.-4000 mg/L TDS (Fig. 4). By 1992 (Fig. 5) salinities, based upon specific conductance data collected by McCutcheon, had continued to increase with a prominent south-southeast-trending zone of greater than 5000 mg/L east of Dell City. On the fringes of the irrigation district, however, salinities remain less than 2000 mg/L and in some wells water quality has actually improved. No salt water intrusion from the salt flats has occurred, even though the hydraulic gradients have been reversed.

A southward-plunging anticline is expressed in outcrops of the Permian Bone Spring Limestone near Dell City (Fig. 7). The zone of greatest salinity is just west of this structurally and topographically high feature. It is possible that the paleotopographic trough west of this fold may have had evaporite minerals deposited in paleoplayas. The zone of highest salinity may then reflect irrigation return-flow leaching of these soluble salts, together with salts accumulated in the soil by crop transpiration. Data from the Texas Water Development Board (1991) demonstrate that, although the acreage irrigated decreased between 1958 and 1989, the amount of water used per acre increased. Approximately five times as much irrigation water is used than is needed for the crops in order to flush these salts from the soil zone. Near Dell City, some local salinization may have been caused by disposal of brines from a municipal desalination plant.

CONCLUSIONS

In the period following 1948, water levels in the Dell City irrigation district dropped between 30 and at least 45 ft. During this same period, water quality also declined. The concentration of total dissolved solids increased by between 500 and 2000 mg/L over much of the area to reach a maximum just east of Dell City of more than 5000 mg/L. Because of the increase in TDS, cropland requires additional irrigation water to flush accumulated salts from the soil; consequently, the amount

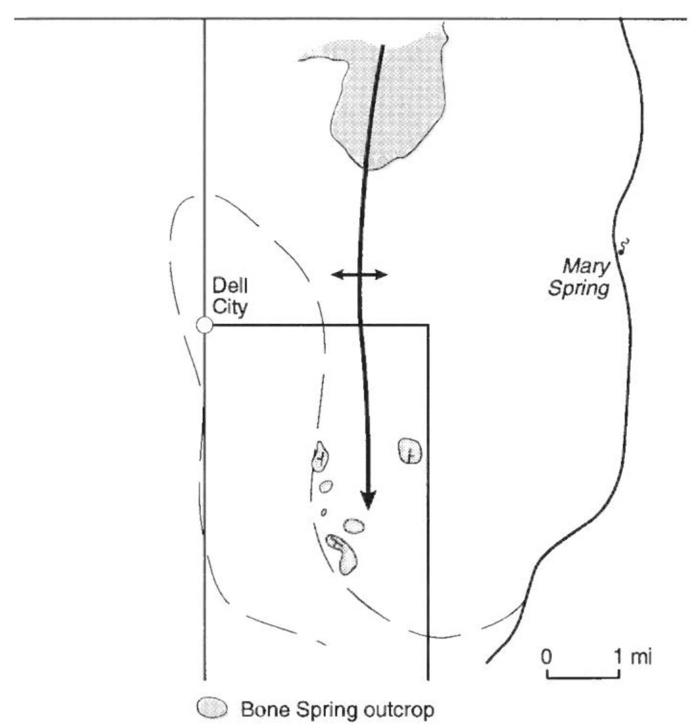

FIGURE 7. Outcrops of Bone Spring Limestone in the Dell City area. Area west of the outcrops coincides with the highest salinities. We speculate that a higher concentration of soluble salts may have been deposited as a relict arm of the salt flats.

of water applied per acre has increased steadily since 1958. Considering the arid climate and high potential evaporation of the region, these trends are likely to continue. However, water chemistry trends suggest that salt water intrusion from the salt flats to the east is not a significant threat. The low hydraulic gradient makes it difficult to determine regional flow direction and, hence, the ultimate source of recharge to the Dell City area. Future work should include a broader, integrated, regional study to determine regional flow paths and isotope work to determine how much water is recent recharge and how much is ancient water, possibly recharged during the Pleistocene.

ACKNOWLEDGMENTS

We thank the well owners of the Dell City area for permission to test their well waters and measure water levels and John Ashworth of the Texas Water Development Board and Pat Dickerson of The University of Texas at Austin for reviewing this manuscript. We also wish to acknowledge the reconnaissance work of Mike Barrett, Mark Gleason, Byron Jorns, Min-Der Lin, Jim Simmons and Tom Warren in May and June of 1992 in the Groundwater Field Methods class at The University of Texas at Austin. Manuscript preparation costs were supported by the Owen-Coates Fund of the Geology Foundation, The University of Texas at Austin. Jeff Horowitz prepared the final illustrations.

REFERENCES

Bjorklund, L. J., 1957, Reconnaissance of ground-water conditions in the Crow Flats area, Otero County, New Mexico: New Mexico State Engineer Technical Report 8, 26 p.

Davis, M. E. and Leggat, E. F., 1965, Reconnaissance investigation of the ground-water resources of the upper Rio Grande Basin, Texas: Texas Water Commission, Bulletin 6502, 99 p.

Kreitler, C. W., Mullican, W. F. III and Nativ, R., 1990, Hydrogeology of the Diablo Plateau, Trans-Pecos Texas; *in* Kreitler, C. W. and Sharp, J. M. Jr., eds., Hydrogeology of Trans-Pecos Texas: University of Texas Bureau of Economic Geology, Guidebook 25, p. 49-58.

Kreitler, C. W. and Sharp, J. M. Jr., 1990, Hydrogeology of Trans-Pecos Texas: University of Texas Bureau of Economic Geology, Guidebook 25, 120 p.

LaFave, J. 1. and Sharp, J. M. Jr., 1987, Origins of ground water discharging at the springs of Balmorhea: West Texas Geological Society Bulletin, v. 26, p. 5-14.

Scalapino, R. A., 1950, Development of ground water for irrigation in the Dell City area, Hudspeth County, Texas: Texas Board of Water Engineers, Bulletin 5004, 38 p.

Sharp, J. M. Jr., 1989, Regional ground-water systems in northern Trans-Pecos Texas; *in* Muehlberger, W. R. and Dickerson, P. W., eds., Structural geology and stratigraphy of Trans-Pecos Texas: 28th International Geological Congress, Guidebook T-317, p. 123-130.

Texas Water Development Board, 1991, Surveys of irrigation in Texas-1958, 1964, 1969, 1974, 1984 and 1989: Texas Water Development Board, Report 329, 125 p.