H. PETRINI x62385

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Priority Groundwater Management Area Update on Area 16, Rolling Prairies Region of North Central Texas

By Robert G. Bradley and Harald Petrini

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Priority Groundwater Management Area Update on Area 16, Rolling Prairies Region of North Central Texas.

A Memorandum Report
By
Robert G. Bradley, Geologist
And
Harald Petrini, Geologist

This memorandum report is the Texas Water Development Board (TWDB)'s update to Report 337, *Evaluation of Water Resources in Parts of the Rolling Prairies Regions of North-Central Texas* by G.L. Duffin and B.E. Beynon, which was published in 1992. TWBD Report 337 was prepared in response to the 1985 passage of House Bill 2 by the 69th Texas Legislature. This bill called for the identification and study of areas that were experiencing or are anticipated to experience critical groundwater problems within the next 20 years.

The present study is in response to Senate Bill 1, passed in 1997 by the 75th Texas Legislature. This bill requires the identification of those areas of the State that are experiencing or that are expected to experience critical water problems within the immediately following 25-year period, including shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, and contamination of groundwater supplies.

The study area lies within the Brazos, Colorado, Red, and Trinity River Basins. It also encompasses all or parts of Archer, Armstrong, Baylor, Borden, Briscoe, Callahan, Childress, Clay, Collingsworth, Cottle, Crosby, Dickens, Donley, Eastland, Erath, Fisher, Floyd, Foard, Garza, Hall, Hardeman, Haskell, Jack, Jones, Kent, King, Knox, Montague, Motley, Nolan, Palo Pinto, Parker, Randall, Scurry, Shackelford, Stephens, Stonewall, Swisher, Taylor, Throckmorton, Wheeler, Wichita, Wilbarger, Wise, and Young Counties.

Groundwater conservation districts in the study area include the Collingsworth County Underground Water Conservation District, which was established in 1987, and the Salt Fork Underground Water Conservation District, which was established in 1989 and includes all of Kent County. Since Report 337 was completed, a groundwater conservation district was created in Garza County, and Wheeler County was furthermore annexed into Panhandle Groundwater Conservation District No. 3.

Hydrogeology Summary

Water–Level Fluctuations

To evaluate water level fluctuations and potential long-term water level trends since the completion of TWDB Report 337 (Duffin and Beynon, 1992), hydrographs for all wells originally included in the above report were expanded to incorporate water level measurements collected between 1992 and 1997. Figures 1, 2 and 3 illustrate water-level fluctuations in the Blaine, Dockum, and Seymour aquifers within the study area, respectively. The hydrographs generally reflect changes in water levels that correspond with changes in annual rainfall, public supply pumpage, or irrigation pumpage.

Water-level data available for the Blaine aquifer indicate significant seasonal fluctuations in water levels over time (Figure 1). While most of these variations are of enough magnitude to mask much of the effect of long-term trends, it does appear that the water levels are generally higher in the 1990s than they were in the 1950s and 1960s, particularly for well 22-14-504 located in King County, and to a lesser extent for wells 13-34-802 and 12-55-601 located in Hardeman and Cottle Counties, respectively. Water levels in Childress County well 12-23-603 have remained fairly stable over time, with little evidence of a long-term rise or decline.

The hydrographs for selected wells in the Dockum aquifer show a historical rise in water levels between the 1950s and approximately 1990 (Figure 2). Since 1990, water levels appear to have stabilized or generally decreased slightly in most of the selected wells, with few exceptions. However, additional information will be required to assess whether this apparent stabilization/decline represents a new long-term trend in this aquifer.

Water-level measurements from selected wells completed in the Seymour aquifer are shown in Figure 3. The hydrographs for wells located in the cities of Childress (12-30-916) and Vernon (13-46-504) show the greatest overall water-level elevation declines. Between 1951 and 1996, the City of Childress well (12-30-916) experienced a total water-level decline of approximately 55 feet. About 24 percent (13 feet) of this decline occurred between the years of 1992 and 1997. According to available information (TWDB, 1998a), this well is not used as a municipal water supply source for the City of Childress. The recorded historical water-level decline in this well may therefore reflect nearby pumpage for non-municipal uses. Between 1952 and 1987, the City of Vernon well (13-46-504) recorded a total water-level decrease of approximately 38 feet, with occasional minor seasonal water-level increases. Since 1987, however, the water level in this well appears to have been rising slightly, having recovered approximately 8 feet in the last 10 years. Water levels measured in wells located in Hardeman, Wichita, Baylor and Haskell Counties have generally increased slightly over time. However, this trend has been periodically disrupted by seasonal decreases in water levels. The hydrograph for well 30-18-510 in Jones County shows significant temporal variations in water levels, with a general declining trend continuing in the 1990s.

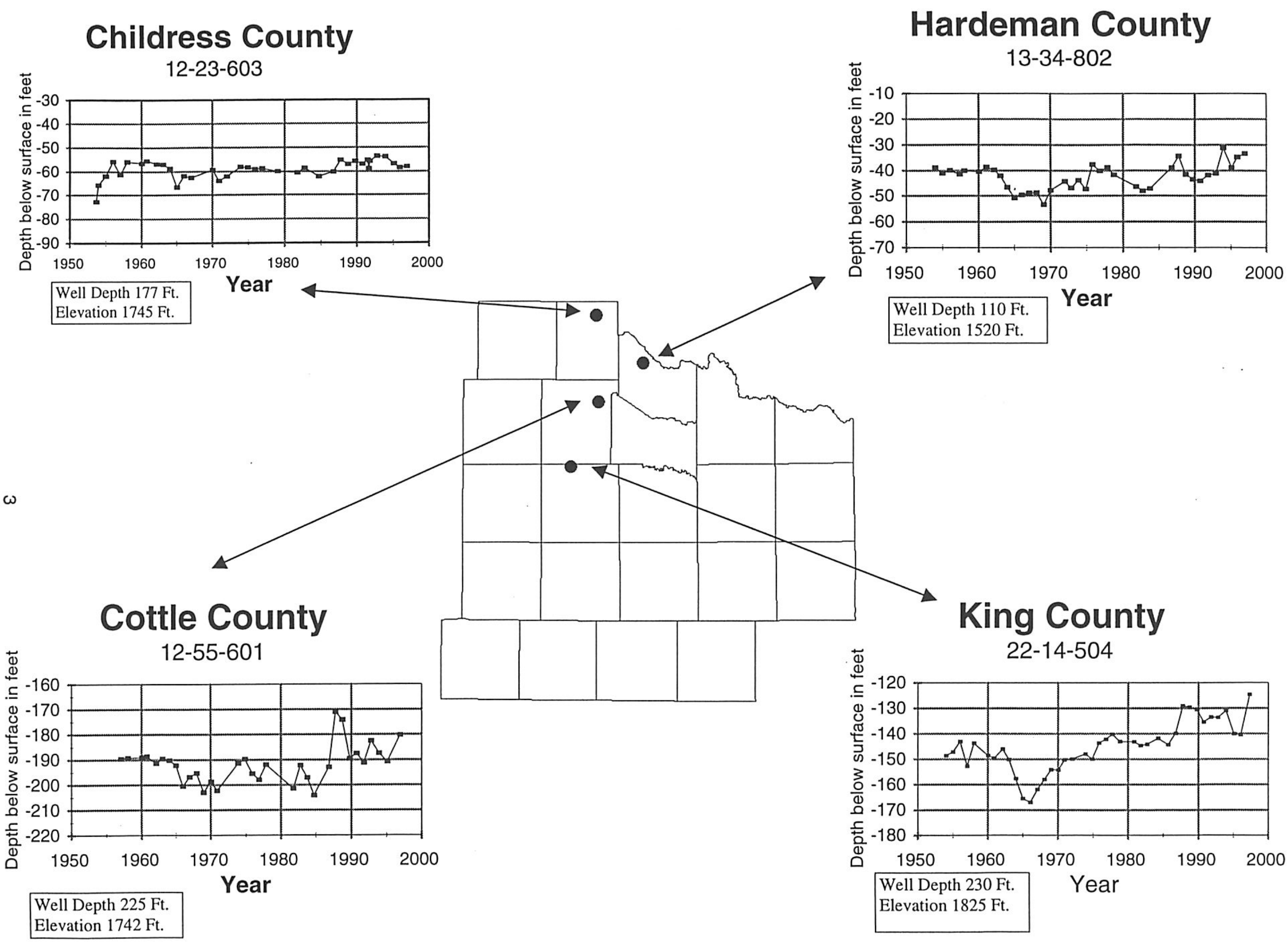

Figure 1. Hydrographs of selected wells in the Blaine aquifer.

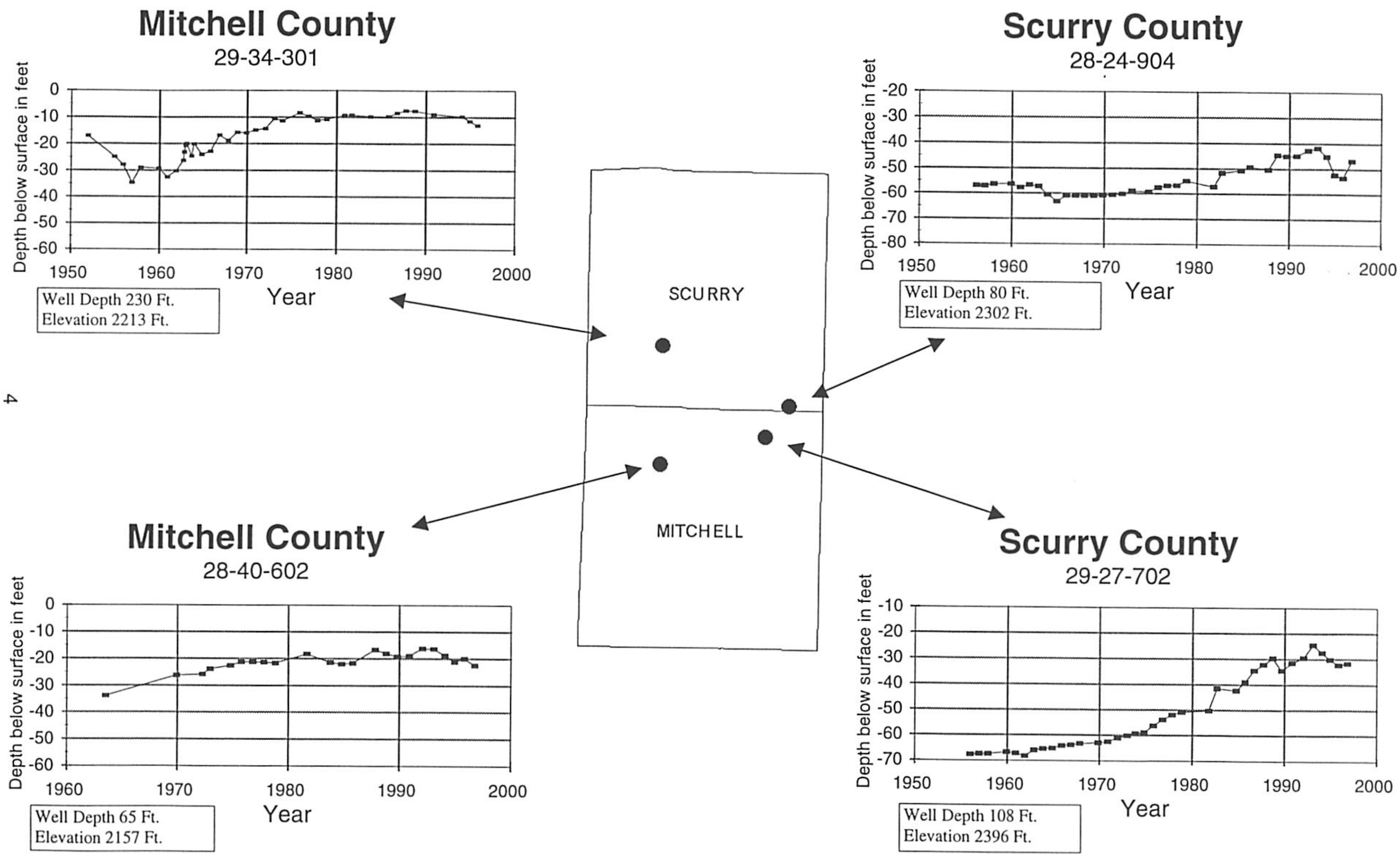

Figure 2. Hydrographs of selected wells in the Dockum aquifer.

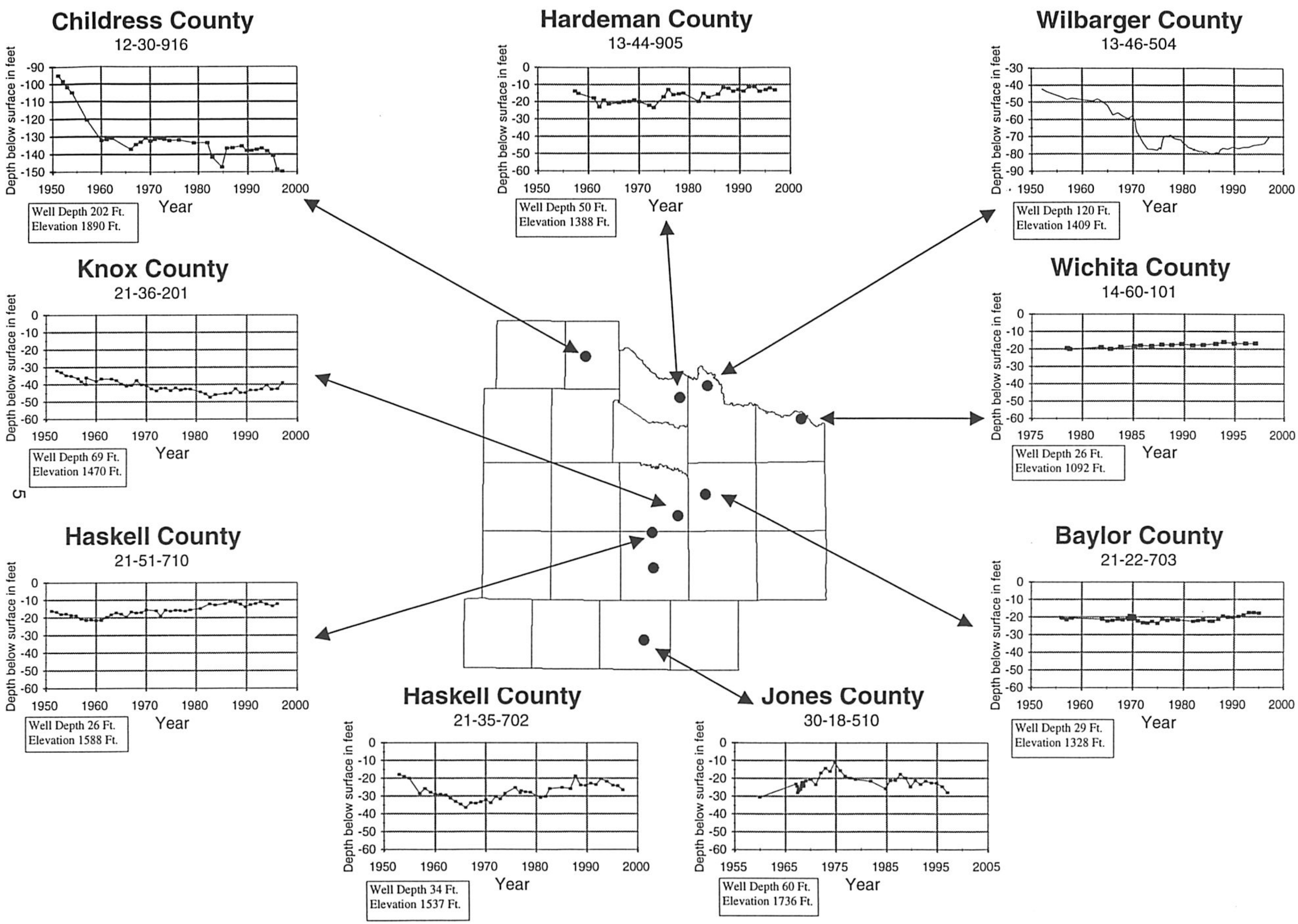

Figure 3. Hydrographs of selected wells in the Seymour aquifer.

Finally, well 21-36-201 in Knox County experienced a long-term water-level decline from the 1950s to about 1982. Since 1983, the trend appears to have reversed, with water levels having recovered approximately 8 feet over the last 14 years.

Water Quality

The water quality of the three aquifers was evaluated to determine if any significant deterioration of had occurred since TWBD Report 337 (Duffin and Beynon, 1992) was issued. Water-quality data were obtained from the TWDB Groundwater Database (TWDB, 1998a). To allow for comparisons between historical and current water quality, two sets of data were compiled from the database. Total dissolved-solids (TDS), chloride, sulfate and nitrate samples collected prior to 1988 were selected to evaluate historical water quality in the area. Of these parameters, TDS is considered to be the primary limiting factor for groundwater use (Duffin and Beynon, 1992). Analytical results for the same parameters collected between 1988 and 1998 were selected for a comparative assessment of recent water quality. 1988 was selected as the cutoff date between the data sets because samples collected prior to 1988 were collected using less stringent and not necessarily consistent sampling and analysis protocols, and are therefore considered to be less reliable than more recent samples. From 1988 onward, samples were collected by the Groundwater Monitoring Unit of the TWDB in accordance with standardized procedures outlined in *A Field Manual for Ground-Water Sampling* (Nordstrom and Beynon, 1991). Tables 1 and 2 summarize historical (pre-1988) and current (1988 - 1998) TDS, sulfate, chloride and nitrate concentrations for the Blaine aquifer. Analogous summaries are presented in Tables 3 and 4 for the Dockum aquifer, and in Tables 5 and 6 for the Seymour aquifer.

Historical (pre-1988) TDS concentrations for the Blaine aquifer range from 171 to 9,170 mg/l (Table 1) and average 3,107 mg/l. TDS concentrations for Blaine aquifer samples collected between 1988 and 1998 range from 491 to 7,106 mg/l (Table 1) and average 3,030 mg/l. Samples from all counties in the study area for both the pre-1988 and 1988 to 1998 periods are characterized by average TDS concentrations exceeding 1,000 mg/l.

The average TDS levels for Blaine aquifer wells located in Childress, Collingsworth, Cottle and King Counties have increased in the 1988 to 1998 period as compared with the pre-1988 period. Insufficient information is available to conduct a similar comparison of average TDS concentrations for the other counties listed in Table 1. It is important to note that the above comparison is qualitative in nature because the wells sampled prior to 1988 do not necessarily coincide with the wells sampled in the 1988 to 1998 period, thus introducing geographic variability into the data pool. Furthermore, sampling protocols followed during the two periods differ from each other and could therefore also influence the magnitude of the reported TDS levels. Therefore, while the average TDS concentration increases are noteworthy, care should be exercised in concluding that they reflect a deterioration of groundwater quality.

Table 1. TDS Concentrations for the Blaine aquifer

	TDS (mg/l)							
	Samples collected before 1988				Samples collected from 1988 to 1998			
County	No. of Samples	Average	Minimum	Maximum	No. of Samples	Average	Minimum	Maximum
Childress	95	3,627	838	7,311	5	4,306	3,440	5,611
Collingsworth	132	2,730	261	6,289	10	2,848	1,114	6,078
Cottle	3	1,821	451	4,103	11	2,284	491	3,699
Fisher	5	3,605	171	8,763	*	*	*	*
Foard	*	*	*	*	2	3,436	2,799	4,072
Hardeman	1	2,760	2,760	2,760	6	3,153	2,525	3,763
King	16	2,654	323	9,170	7	3,407	896	7,106
Stonewall	3	3,048	2,921	3,203	*	*	*	*
Wheeler	*	*	*	*	1	2,574	2,574	2,574

* No groundwater quality sample available
Source: TWDB, 1998a

Table 2. Chloride, Sulfate, and Nitrate Concentrations for the Blaine aquifer.

	Samples collected before 1988				Samples collected from 1988 to 1998			
	No. of samples	Average	Minimum	Maximum	No. of samples	Average	Minimum	Maximum
Chloride (mg/l)	255	279	3.9	3840	42	372	12	2248.1
Sulfate (mg/l)	254	1750	10	3723	42	1603	119	2529
Nitrate (mg/l)	148	24	0	165	42	20	<0.04	85.8

Source: TWDB, 1998a

The county with the highest average TDS concentration in both pre- and post-1988 periods is Childress County, which coincides with the location of several brine emission areas (Duffin and Beynon, 1992).

Sulfate, chloride and nitrate concentration ranges and averages for Blaine aquifer samples collected prior to 1988, and between 1988 and 1998, are summarized in Table 2. Qualitatively, it appears that average concentrations of these analytes in the groundwater have not changed significantly over time. However, as with the TDS results, the impacts of differing sampling protocols and geographic sampling locations on the analytical results cannot be assessed quantitatively.

The secondary drinking water maximum contaminant limit (MCL) for chloride and sulfate is 300 mg/l (Texas Administrative Code, 1997, §290). The MCL for nitrate is 44.3 mg/l (Texas Administrative Code, 1997, §290). MCLs were exceeded in 24 percent of the chloride samples, 96 percent of the sulfate samples, and 11 percent of the nitrate samples collected prior to 1988. For the more recent (1988 – 1998) data set, MCL exceedance rates were as follows: 31 percent for chloride, 95 percent for sulfate, and 5 percent for nitrate. Given the high variability that exists between data sets, the exceedance rates are considered to be remarkably consistent over time for all three analytes, but particularly for sulfate.

The highest average sulfate and nitrate concentrations in both pre-1988 and 1988 – 1998 samples were associated with samples from Childress County. For chloride, the highest average concentrations were associated with samples from King County prior to 1988, and with samples from Childress County in the 1988 – 1998 period (TWDB, 1998a).

Pre-1988 TDS concentrations for the Dockum aquifer range from 185 to 50,784 mg/l and average 2,759 mg/l. TDS concentrations for the Dockum aquifer collected between 1988 and 1998 range from 280 to 46,672 mg/l and average 3,110 mg/l (Table 3). Average TDS concentrations have increased in samples from the Dockum aquifer in the following seven counties during the 1988 – 1998 period, as compared with pre-1988 averages: Briscoe, Dickens, Fisher, Garza, Kent, Motley, and Nolan. Samples from the remaining four counties, including Armstrong, Crosby, Floyd and Scurry, report a decrease in average TDS levels. Again, apparent differences in average TDS concentrations over time may be at least partially attributable to sampling at differing geographic locations with differing sampling protocols prior to and after 1988. The highest average TDS concentrations were reported for Garza County for both time periods (Table 3).

Sulfate, chloride and nitrate concentration ranges and averages for Dockum aquifer pre- and post-1988 samples are summarized in Table 4. As with the Blaine aquifer, average concentrations of these analytes in the groundwater do not appear to have changed appreciably over time. However, this is a qualitative statement, since the impacts of differing sampling protocols and geographic sampling locations cannot be assessed quantitatively.

Table 3. TDS Concentrations for the Dockum aquifer

County	TDS (mg/l) Samples collected before 1988 No. of Samples	Average	Minimum	Maximum	Samples collected from 1988 to 1998 No. of Samples	Average	Minimum	Maximum
Armstrong	6	399	343	551	5	378	280	543
Briscoe	3	507	369	602	6	517	360	719
Crosby	3	890	464	1,528	2	427	351	503
Dickens	14	664	306	1,300	10	860	303	2,302
Fisher	5	624	383	795	5	1,226	393	2,038
Floyd	8	399	283	715	7	344	312	374
Garza	11	26,380	1,115	50,784	8	28,726	471	46,672
Kent	2	1,404	1,381	1,426	4	1,415	885	2,043
Motley	24	447	207	1,142	9	458	304	770
Nolan	59	579	185	2,550	16	780	324	1,951
Scurry	110	1,628	286	17,496	32	853	368	2,007

Source: TWDB, 1998a

Table 4. Chloride, Sulfate, and Nitrate Concentrations for the Dockum aquifer.

	Samples collected before 1988 No. of samples	Average	Minimum	Maximum	Samples collected from 1988 to 1998 No. of samples	Average	Minimum	Maximum
Chloride (mg/l)	293	1198	6	52392	113	1352.8	13	25786
Sulfate (mg/l)	293	361	0	6950	113	392.38	9	2845
Nitrate (mg/l)	274	14	0	220	113	22.022	<0.04	196.07

Source: TWDB, 1998a

Twenty one percent of chloride samples, 24 percent of sulfate samples, and 11 percent of nitrate samples exceeded their respective MCLs for the pre-1988 data set. For the 1988 – 1998 period, MCL exceedance rates for the same analytes are once again fairly consistent, and equal 25 percent, 23 percent, and 17 percent, respectively.

The highest average chloride, sulfate and nitrate concentrations were associated with samples from Garza and/or Hockey Counties prior to 1988. Since 1988, the highest average chloride and sulfate levels have been reported for Garza County, while the highest average nitrate levels are associated with Fisher and Nolan Counties.

Pre-1988 TDS concentrations for the Seymour aquifer range from 164 to 21,087 mg/l (Table 4) and average 1,005 mg/l. TDS concentrations between 1988 and 1998 for the Seymour aquifer range from 215 to 7,955 mg/l and average 1,290 mg/l. Average TDS concentrations increased in samples from the Seymour aquifer in the great majority of the counties listed in Table 3 during the 1988 – 1998 period, as compared with the pre-1988 results. Exceptions to this increase are Childress and Motley Counties, for which average TDS levels decreased, and Cottle and Wheeler Counties, for which a comparison could not be performed. As before, differences in sampling protocols and sampling locations could account for the recorded average differences in TDS values. The highest average TDS levels for the 1988 – 1998 period were found in samples from Fisher County. The second highest TDS average for this period is associated with Jones County, which had the highest average for the pre-1988 period (TWDB, 1998a).

Sulfate, chloride and nitrate concentration ranges and averages for Seymour aquifer samples collected prior to 1988, and between 1988 and 1998, are summarized in Table 6. Qualitatively, it appears that average concentrations of these analytes in the groundwater have not changed significantly over time. However, it is not possible to conduct a quantitative comparison due to the differences in sampling protocols and geographic sampling locations between the data sets.

MCLs were exceeded in 31 percent of the chloride samples, 13 percent of the sulfate samples, and 67 percent of the nitrate samples collected prior to 1988. These exceedance rates compare with 28 percent for chloride, 25 percent for sulfate, and 69 percent for nitrates in the 1988 – 1998 data set. The predominance of nitrate MCL exceedances is highly consistent for both periods of interest.

Average chloride concentrations are highest in samples from Stonewall and Jones Counties for both the pre-1988 and 1988-1998 (TWDB, 1998a). TWDB Report 337 (Duffin and Beynon, 1992) discusses the presence of elevated nitrate concentrations in Haskell and Knox Counties. This observation is generally supported by an evaluation of 1988 – 1998 data, which indicate that the highest average nitrate levels are present in Jones, Baylor, Haskell and Knox Counties (TWDB, 1998a).

Table 5. TDS Concentrations for the Seymour aquifer

County	TDS (mg/l) Samples collected before 1988 No. of Samples	Average	Minimum	Maximum	Samples collected from 1988 to 1998 No. of Samples	Average	Minimum	Maximum
Baylor	73	846	315	6,193	6	912	650	1,355
Childress	11	1,390	296	4,883	3	675	389	1,073
Clay	18	320	164	759	3	473	441	504
Collingsworth	12	419	373	550	12	936	324	2,527
Cottle	*	*	*	*	2	703	650	755
Fisher	2	1,621	1,100	2,142	2	4,673	4,668	4,677
Foard	21	1,027	362	7,153	4	1,028	594	1,944
Hall	5	855	706	1,012	3	881	561	1,424
Hardeman	10	402	312	522	7	510	337	796
Haskell	974	905	164	4,074	22	1,167	509	2,740
Jones	8	1,931	1,197	3,389	7	2,230	681	7,955
Kent	12	779	355	1,247	2	940	303	1,577
Knox	1163	1,167	312	21,087	77	1,637	215	5,932
Motley	31	795	729	860	1	789	789	789
Stonewall	79	1,261	431	4,753	9	1,533	807	3,011
Taylor	1	435	435	435	3	1,026	460	1,341
Wheeler	*	*	*	*	2	588	565	611
Wichita	23	524	360	1,044	8	543	442	809
Wilbarger	39	559	277	1,138	15	564	250	1,300

* No groundwater quality sample available
Source: TWDB, 1998a

Table 6. Chloride, sulfate, and nitrate concentrations for the Seymour aquifer.

	No. of samples	Average	Minimum	Maximum	No. of samples	Average	Minimum	Maximum
Chloride (mg/l)	2422	497	4	22000	188	313	3	2965
Sulfate (mg/l)	1670	177	5	3072	188	284	14	3024
Nitrate (mg/l)	1633	67	0.4	934.7	188	74	0.2	1483.71

Source: TWDB, 1998a

Water Demands

Population

Population estimates by the TWDB are divided into two categories: major city and county-other. Cities that are county seats or have a population of at least 1,000 people are classified as major cities. All other cities and the rural county population is classified as county-other. The major city populations exclude those cities that lie outside the study area but are located within a county partially covered by the study area. County-other populations were used for an entire county if it covered more than 10 percent of the study area. For this study, the major cities within the study area show a total estimated population increase of approximately 48,500 people, or 11 percent, between 1997 and 2030 (TSDC, 1997; TWDB, 1998b). The county-other population projections show a increase in population of about 16,200 people, or 7 percent, between 1997 and 2030.

Water Use

In 1995, approximately 212,312 acre-feet of surface water and 166,887 acre-feet of groundwater (from the three main aquifers) were used to meet the water supply needs of the study area (TWDB, 1998c; TWDB, 1998d). The Seymour aquifer supplied approximately 76 percent of the total groundwater for all uses. The Blaine and Dockum aquifers supplied 10 and 4 percent, respectively, with the remainder being produced from a variety of minor aquifers.

Estimated amounts of pumpage for 1980, 1985, 1990, and 1995 (TWDB, 1998d) are listed in Table 7. Estimated groundwater pumpage declined for the entire area by approximately 87,400 acre-feet per year (34 percent) between 1980 and 1995, and by approximately 20,500 acre-feet per year (11 percent) between 1990 and 1995. The primary declines in pumpage have been associated with municipal, irrigation, and livestock uses.

The municipal water needs of the communities within the study area are primarily supplied from surface water sources, with some communities supplementing their water with groundwater supplies. Total amounts of groundwater and surface water used for municipal supply in 1995 (TWDB, 1998e) are shown in Table 8. Total municipal groundwater use decreased by approximately 5,000 acre-feet per year between 1980 and 1995 (Table 7). Major city groundwater use declined approximately 450 acre-feet per year (6 percent) between 1988 and 1995. Major city surface-water use has increased approximately 2,400 acre-feet per year (4 percent) between 1988 and 1995. 1988 major city water use data employed for this comparison were obtained from TWBD Report 337 (Duffin and Beynon, 1992). Total irrigation pumpage declined by approximately 86,000 acre-feet per year (37 percent) between 1980 and 1995 (Table 7). Livestock water usage declined more than 1,000 acre-feet per year between 1980 and 1995 (Table 7).

Table 7. Estimated Groundwater Pumpage, 1980-1995 (TWDB, 1998d)

	Acre-feet per year			
	1980	1985	1990	1995
Municipal	18,002	15,153	13,474	13,072
Manufacturing	79	331	138	185
Power	0	0	0	0
Mining	2,609	8,882	7,715	7,106
Irrigation	229,410	141,813	163,402	143,386
Livestock	4,178	2,410	2,637	3,138
Total	254,278	168,586	187,366	166,887

Table 8. 1995 Major City Water Use (TWDB, 1998e)

City	Groundwater acre-feet	Surface Water acre-feet	Total acre-feet
Abilene	412	20,163	20,575
Albany	0	661	661
Anson	0	400	400
Archer City	0	336	336
Aspermont	171	84	255
Baird	0	309	309
Benjamin	36	9	45
Breckenridge	0	969	969
Bridgeport	0	565	565
Burkburnett	869	656	1525
Childress	0	1414	1414
Chillicothe	87	91	178
Cisco	0	496	496
Crowell	0	157	157
Dickens	84	0	84
Eastland	0	790	790
Electra	140	344	484
Graham	0	1546	1546
Guthrie	69	0	69
Hamlin	320	173	493
Haskell	0	540	540
Henrietta	0	440	440
Iowa Park	0	940	940
Jacksboro	0	476	476
Jayton	131	0	131
Knox City	0	230	230

Table 8. 1995 Major City Water Use (continued)

City	Groundwater acre-feet	Surface Water acre-feet	Total acre-feet
Matador	202	0	202
Memphis	385	79	464
Merkel	8	403	411
Mineral Wells	0	2835	2835
Munday	0	303	303
Olney	0	598	598
Paducah	266	0	266
Palo Pinto	0	76	76
Post	0	470	470
Quanah	0	605	605
Ranger	0	405	405
Roby	8	82	90
Roscoe	230	0	230
Rotan	0	232	232
Rule	62	31	93
Seymour	722	0	722
Shamrock	57	0	57
Snyder	0	2393	2393
Spur	0	281	281
Stamford	0	719	719
Sweetwater	198	2003	2201
Throckmorton	0	196	196
Tye	3	152	155
Vernon	2052	0	2052
Wellington	436	0	436
Wichita Falls	0	17,268	17,268
Total	6948	61,394	68,342

Projected Water Demands and Supply Sources, Years 2000 to 2030

Table 9 shows the projected water demands and supply sources for the study area by major city, county other, and other uses (TWDB, 1997). The allocation of available or new water supplies to future water uses presented in Table 9 was analyzed at the individual city and county level. First, water use and supply management measures that have less impact and are typically cost-effective were identified for future needs. Then, water use and supply management measures that are more costly, environmentally sensitive, or controversial were considered if needed.

Generally, the process involved incorporating water conservation savings into all significant water uses to allow for more efficient use of existing water resources, thus delaying the need for new supply development. If necessary, the allocation method then considered the expanded use of existing developed supplies, followed by the expanded use of local undeveloped supplies (such as the building of infrastructure needed to access other existing local surface water or groundwater supplies, or wastewater reuse). Alternative opportunities for additional water supplies were also identified, including reallocation of reservoir storage or type of use, water marketing, and other measures.

Finally, access to additional water supplies through long-distance conveyance systems, interbasin transfers, or new reservoir development was evaluated if needed to meet projected water demands. However, the entities in need were expected to achieve an advanced level of water conservation before new reservoir development and interbasin transfers would be considered.

Under projected conditions, the total annual water requirement for the study area is expected to decrease by approximately 2.7 percent from the year 2000 to the year 2030. In 2030, the projected water demand is estimated to be 344,074 acre-feet per year (Table 9).

Major city groundwater use is projected to increase 759 acre-feet per year (or 11 percent) from 1995 to 2000 (TWDB, 1998b), subsequently declining from the year 2000 onward. By the year 2030, major city groundwater use is projected to be similar to the present rate (Table 8). Surface water use for major cities is projected to increase by 26,725 acre-feet (or 43.5 percent) between 1995 and 2030.

County-other and other uses within the study area are also projected to decline between the year 2000 and 2030.

Availability of Water

Current Availability of Groundwater

The 1997 Consensus Water Plan (TWBD, 1997) estimates of available fresh to slightly saline groundwater from delineated aquifers within the study area totals approximately 420,300 acre-feet. Estimated totals for available groundwater are 262,800 acre-feet in the Seymour aquifer, 142,600 acre-feet in the Blaine aquifer, and 14,900 acre-feet in the Dockum. aquifer. The total estimated effective recharge to all aquifers is 366,900 acre-feet per year (Duffin and Beynon, 1992). Approximately 166,900 acre-feet of groundwater were pumped from all aquifers in 1995, which amounts to 55 percent of the estimated effective recharge. Therefore, except in areas of heavy pumping and excessively dry conditions, sufficient quantity of groundwater should be available for this area through 2030.

Current Availability of Surface Water

Currently, twenty-five major surface reservoirs supply water within the area. Combined supplies of available water from these reservoirs total over 0.62 million acre-feet per year within the study area. The MacKenzie Reservoir in the Red River Basin, Bridgeport, and Amon Carter Reservoirs in the Trinity River Basin, and Alan Henry Reservoir in the Brazos River Basin have portions of their supplies allocated to users outside the study area. Oak Creek and J.B. Thomas Reservoirs located in the Colorado River Basin outside the study area, allocate part of their water supplies to users within the study area. (TWDB, 1997). The City of Abilene owns 16 percent of Ivie Reservoir, and will have to build a pipeline to this reservoir by 2025 to meet the city's projected needs (Texas Water Development Board, 1997, p.3-41).

Table 9. Projected water demands and supply sources, 2000 to 2030 (TWDB, 1997).

			Acre-feet per year			
			2000	2010	2020	2030
Municipal Use						
	Major Cities					
		Ground	7,707	7,432	7,115	6,945
		Surface	78,625	78,833	79,462	81,174
		Sub Total	86,332	86,265	86,577	88,119
	County Other					
		Ground	8,292	8,102	7,662	7,230
		Surface	11,103	10,624	9,689	8,946
		Sub Total	19,395	18,726	17,351	16,176
	Total		105,727	104,991	103,928	104,295
Other Uses						
		Ground	147,738	152,333	153,233	134,898
		Surface	100,303	100,745	104,132	104,881
		Sub Total	248,041	253,078	257,365	239,779
Study Area						
		Ground	163,737	167,867	168,010	149,073
		Surface	190,031	190,202	193,283	195,001
		Sub Total	353,768	358,069	361,293	344,074

GW AREA 16, 38 counties with certain cities excluded

1997 Water Plan allocation results with the Ogallala and Trinity aquifers excluded

Additionally, several smaller reservoirs with capacities less than 5,000 acre-feet exist in the study area and supply local needs. Surface water supplies are adequate to meet current and projected needs through 2030. The cities of Post and Cisco have a projected surface water shortage for 2000 (TWDB, 1997). However, both cities have groundwater alternatives to meet future needs.

Conclusions

Most of the aquifers in the study area have experienced either a rise or an apparent stabilization in water levels in the 1990s. However, significant exceptions to this trend can be noted throughout the area in each of the aquifers. One such exception is associated with most of the wells selected for monitoring in the Dockum aquifer, which appear to have experienced a slight general decline in water levels in the period between 1992 and 1997. The most dramatic continued decrease in water levels in the 1990s is associated with Seymour aquifer well 12-30-916, located near the city of Childress. According to available information this well is not used as a municipal water supply source for the City of Childress (TWDB, 1998a). The recorded historical water-level decline in this well may thus reflect nearby pumpage for non-municipal uses. Well 13-46-504, also completed in the Seymour aquifer in the vicinity of the city of Vernon, has recorded a steady recovery in the water level for the past 14, years following a 30-year period marked by steady water-level declines.

With respect to water quality, high levels of TDS (> 1000 mg/l) characterize the majority of the groundwater samples collected from all three aquifers. Qualitatively, it appears that the average TDS levels in samples from the Dockum and Seymour aquifers have increased somewhat in the period of 1988 to 1998, as compared with pre-1988 available results. However, caution should be exercised when drawing conclusions about water quality deterioration because the data sets for the time periods compared also differ in terms of sampling protocols and geographic sampling locations.

The highest TDS concentrations reported in the study area are associated with the Dockum aquifer in Garza County, where a groundwater conservation district has already been established (TNRCC, 1997, p.11).

A comparison of sulfate, chloride and nitrate levels in the groundwater with their respective MCLs (for both the pre-1988 and 1988-1998 data sets) indicates that the MCL exceedance frequencies for most analytes in a given aquifer are remarkably consistent over time, even in spite of the large variability assumed to exist between the two data sets. Furthermore, high MCL exceedance rates for sulfate in the Blaine aquifer (95 to 96 percent), and for nitrates in the Seymour aquifer (67 to 69 percent), are also consistent with findings previously stated in TWDB Report 337 (Duffin and Beynon, 1992), which discusses high mineralization in the Blaine aquifer and broad areas of elevated water levels in the Seymour aquifer.

Based on the hydrogeologic, water quality, and projected water use information presented in this report, it appears that water quality issues in general may tend to limit the future use of this resource in the study area more than water availability issues. Groundwater use is projected to decline, while surface-water use is projected to increase through the year 2030. These projections, together with the estimates of current groundwater and surface water availability discussed previously, support the conclusion that adequate quantities of groundwater and surface water should exist to meet the current and projected needs through the year 2030.

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