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DRAFT Planning Area Description

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Chapter 1: Planning Area Description

[31 TAC §357.30]

1.1 Background

Senate Bill 1 (SB1), which was passed into law in June 1997 and enacted by the 75th Texas Legislature, stemmed from increased awareness of Texas' vulnerability to drought and of the limitations of existing water supplies to meet the needs of the state's growing population. Senate Bill 2 (SB2), enacted in September 2001, expanded on the regional water planning process as created by SB1 and provided for further analysis and planning for water resources in the state. With rapidly growing populations, the need to adequately plan for existing and future water needs is vital to the economic health of the region and state.

The state water plan serves as a guide to state water policy and includes the Texas Water Development Board's (TWDB) legislative recommendations to facilitate voluntary water transfers. The state water plan addresses the needs of water user groups (WUGs) in Texas, including municipal, irrigation, manufacturing, livestock, mining, and steam-electric power. The state water plan also identifies river and stream segments of unique ecological value and sites of unique value for the construction of reservoirs that the TWDB recommends for protection.

1.1.1 Llano Estacado (Region O) Regional Water Planning Area

The TWDB divided the state into 16 planning regions designated by letters A through P (Figure 1.1). In the South Plains of Texas, the TWDB delineated 21 counties as Planning Region O, subsequently named the Llano Estacado Regional Water Planning Area (Llano Estacado Region) (Figure 1.2). The following counties are in the Llano Estacado Region (in alphabetical order)[1].

1. Bailey
2. Briscoe
3. Castro
4. Cochran
5. Crosby
6. Dawson
7. Deaf Smith
8. Dickens
9. Floyd
10. Gaines
11. Garza
12. Hale
13. Hockley
14. Lamb
15. Lubbock
16. Lynn
17. Motley
18. Parmer
19. Swisher
20. Terry
21. Yoakum

The 21-county Llano Estacado Region has an area of 20,294 square miles (12,988,160 acres), approximately 7.5 percent of the state's land area (Figure 1.2~~Figure 1.2~~), and is located in the upstream parts of four major river basins (Brazos, Canadian, Colorado, and Red). Of the total area, 8,732 square miles are located in the Brazos Basin, 94 square miles are located in the Canadian

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[1] Texas Water Development Board (TWDB). 2024. http://www.twdb.texas.gov/waterplanning/rwp/regions/o/index.asp

Basin, 4,787 square miles are located in the Colorado Basin, and 6,681 square miles are located in the Red Basin. The boundaries of the region are on the west by the Texas-New Mexico border, on the north by TWDB Planning Region A (Panhandle), on the south by TWDB Planning Region F, and on the east by TWDB Planning Regions B and G (Brazos). The region extends beyond the Caprock Escarpment and the eastern extent of the Ogallala Aquifer into the Rolling Plains. Although the region is located in the upstream parts of the Brazos, Canadian, Colorado, and Red River basins, limited amounts of surface water exist within the region.

The City of Lubbock is the largest city in the area, having a population of 266,878 within its city limits[2]. (Figure 1.3). Agribusiness is the major industry in the region, with the City of Lubbock serving as the hub for health care, and Texas Tech University, Lubbock Christian University, Wayland Baptist University, and South Plains College serving as education centers.

The translation of “Llano Estacado” from Spanish to English is “Staked Plain.” The Llano Estacado is one of the largest mesas or tablelands on the North American continent. The elevation rises from 3,000 feet in the southeast to over 5,000 feet in the northwest, sloping almost uniformly at approximately 10 feet per mile (Figure 1.4).

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[2] U.S. Census Bureau. 2024. QuickFacts: Lubbock City Texas. Population estimate July 1, 2023 https://www.census.gov/quickfacts/fact/table/lubbockcitytexas,US/PST045223

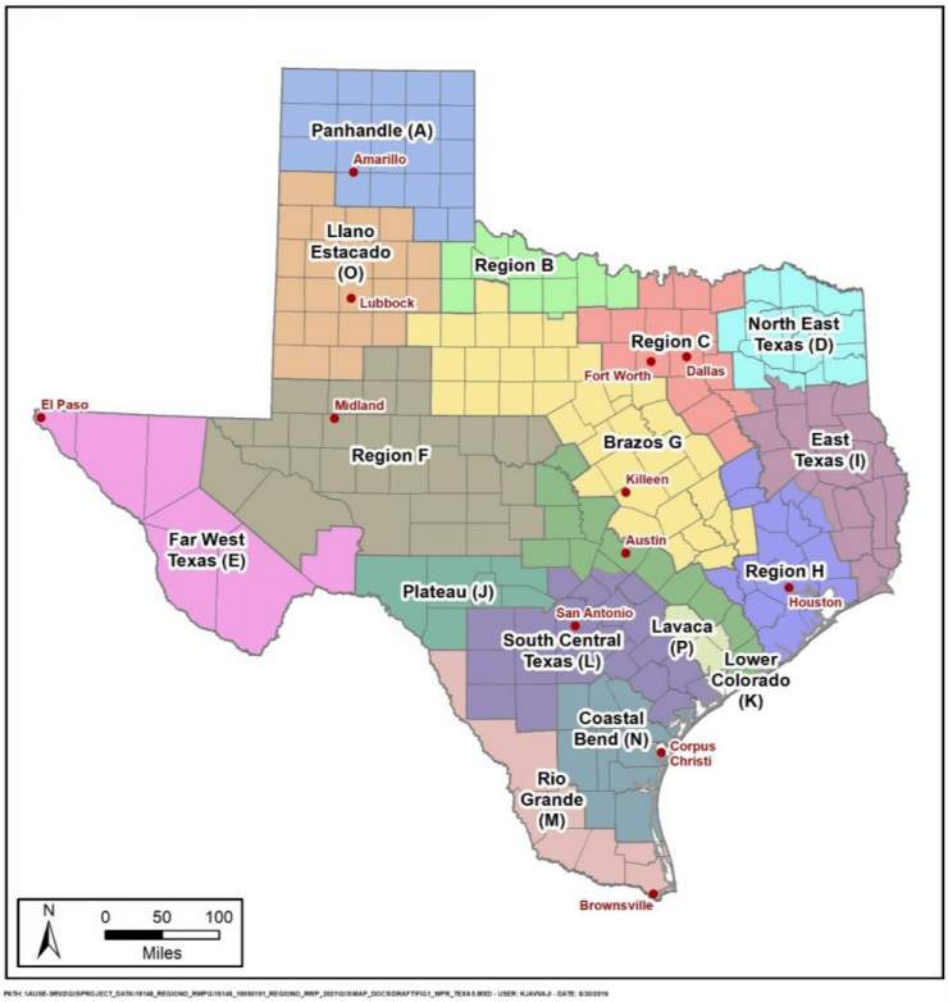

Figure 1.1. Water Planning Regions of Texas

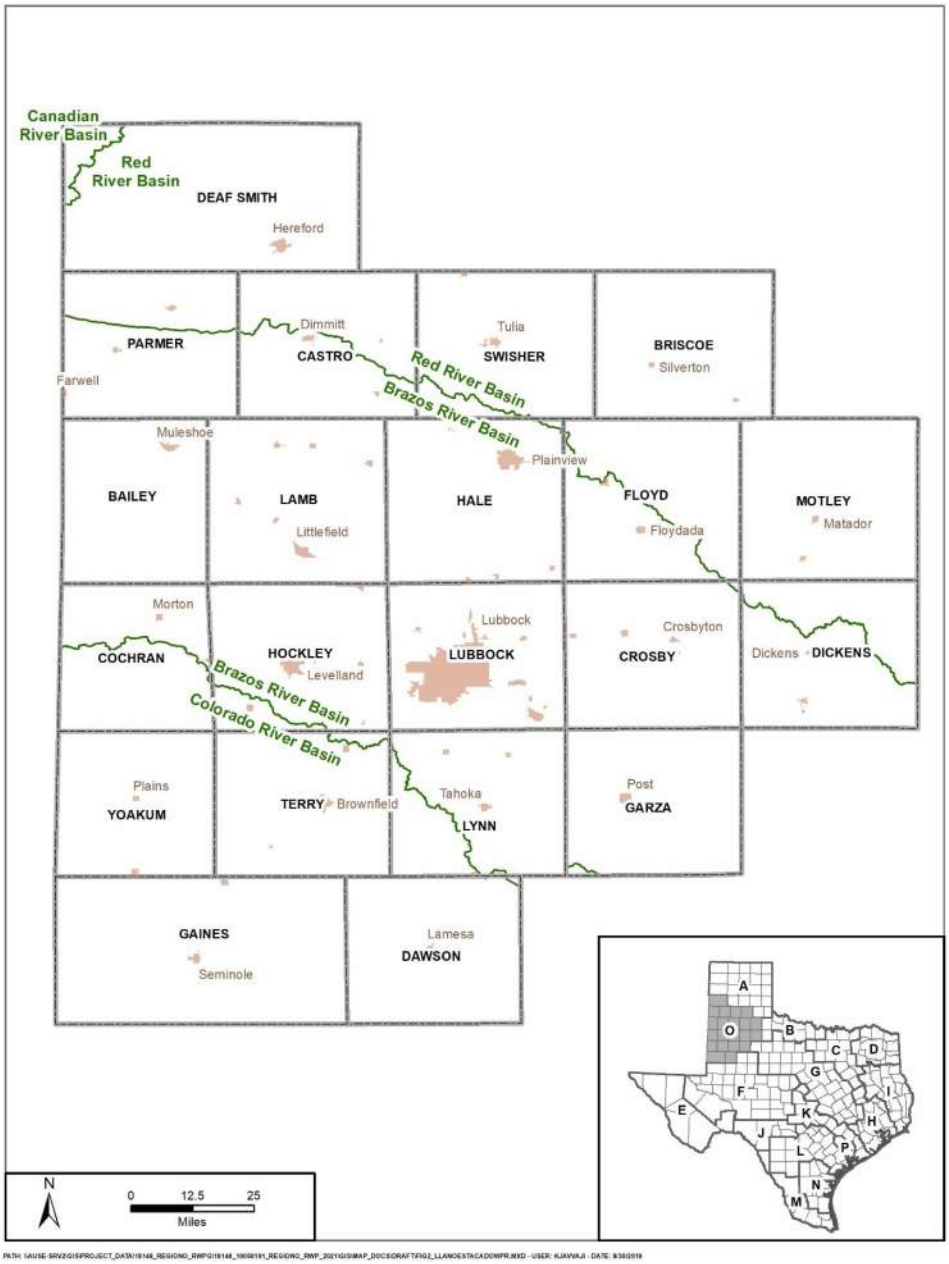

Figure 1.2. Llano Estacado Region

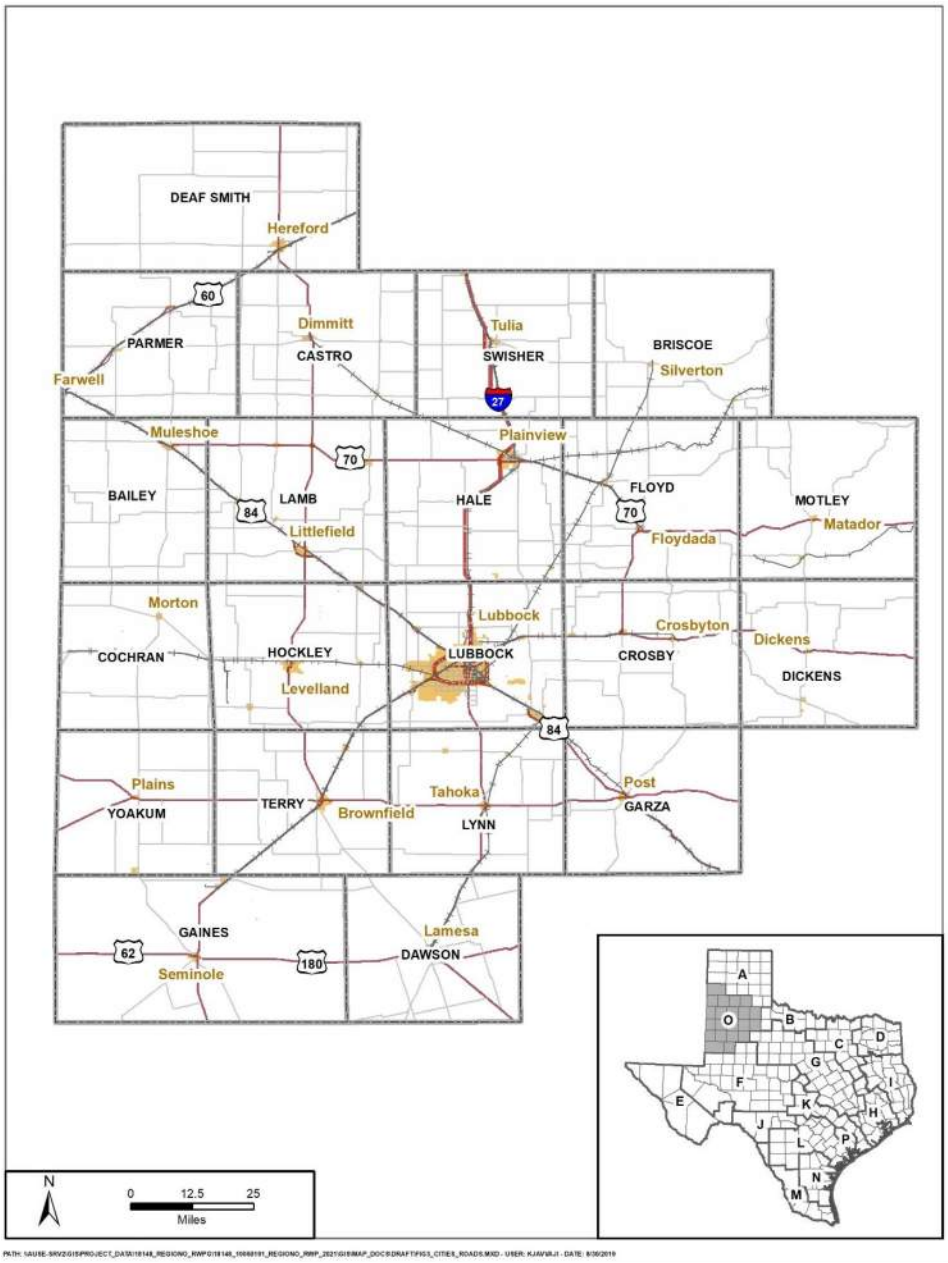

Figure 1.3. Cities of the Llano Estacado Region

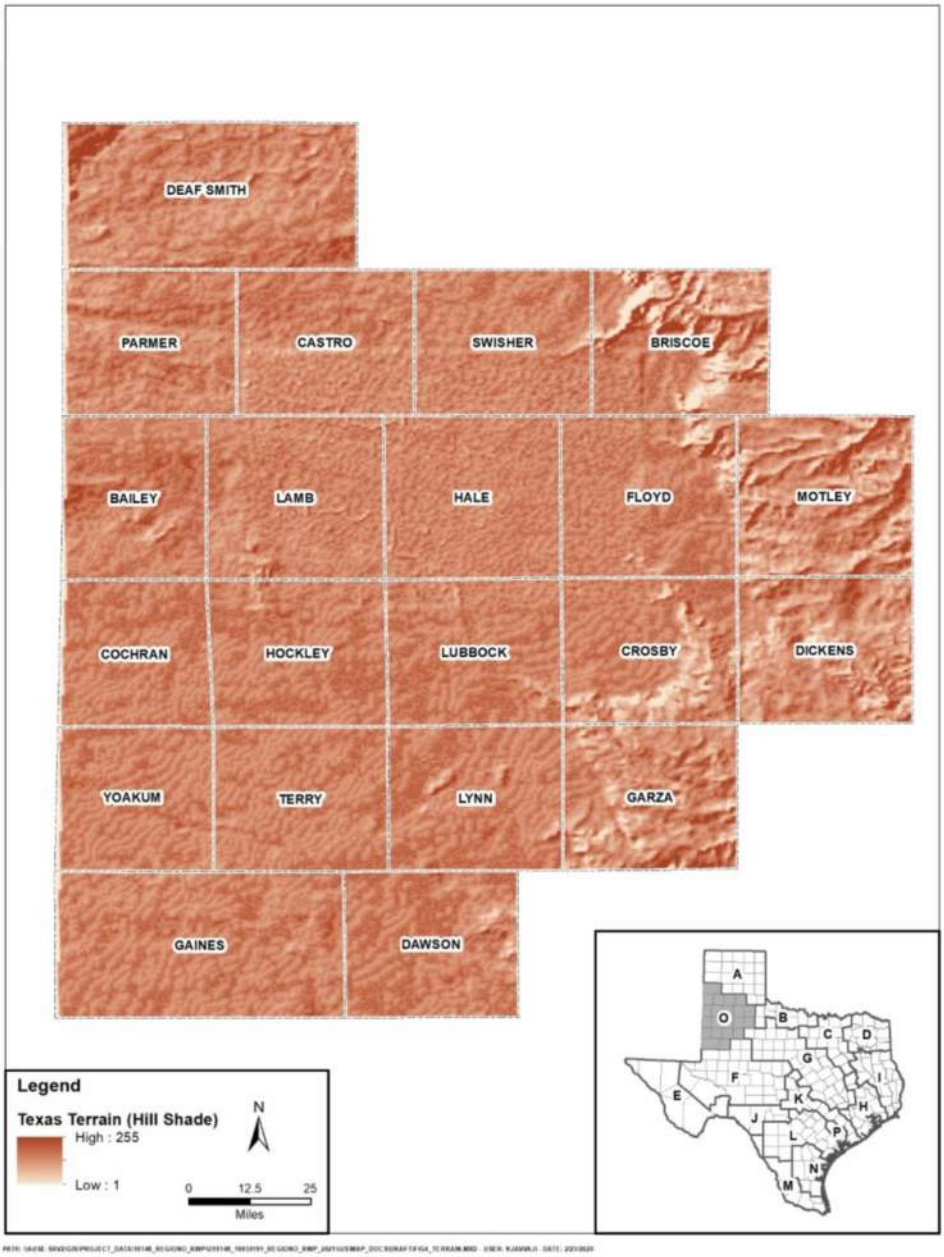

Figure 1.4. Topography Shaded Relief Map of the Llano Estacado Region

Llano Estacado Regional Water Planning Group

The TWDB appointed the Llano Estacado Regional Water Planning Group (LERWPG) to represent 12 stakeholder interests, as specified in 31 Texas Administrative Code (TAC) §357.11(d), and to act as the steering and decision-making body of the Llano Estacado Region planning effort. A list of LERWPG voting members is presented in Table 1-1 and non-voting member in Table 1-2, which include TWDB appointees and members appointed from nominations by local citizens[3]. Non-voting members include the TWDB project manager, representatives from Texas Parks and Wildlife Department (TPWD), Texas Department of Agriculture (TDA), Texas Commission on Environmental Quality (TCEQ), the Texas State Soil and Water Conservation Board, a designated liaison from adjacent regional water planning group (Brazos, Region G), and the regional water planning group's technical consultant. The LERWPG by-laws specify the terms of office of LERWPG members and methods of replacement.

Table 1-1. Current Llano Estacado Regional Water Planning Group Voting Membership[4]

Member	Term	Interest Category
Melanie Barnes, Ph. D.	2025	Public
Jason Coleman, PE	2024	Water Districts
Lincoln Devault	2022	Agricultural
Carrie Dodson	2022	Groundwater Management Areas (#6)
Dr. Chris Grotegut, DVM	2021	Agricultural
Joey Hardin	2022	Industries
Ronnie Hopper	2022	Groundwater Management Areas (#2)
Shane Jones	2021	Water Utilities
Mark Kirkpatrick	2022	Agricultural
Don McElroy	2022	Small Businesses
Alan Monroe	2025	Municipalities (small) less than 10,000
Charlie Morris	2022	Counties
Ken Rainwater, Ph. D.	2022	Public
Jeff Sammon	2022	River Authorities
Drew Satterwhite, PE	2022	Water Utilities
Neil Weems	2021	Municipalities (medium) 10-30,000
Wood Franklin, PE	2025	Municipalities (large) 30,000 or more
Jim Steiert	2022	Environmental
Ben Weinheimer, Sr., PE	2022	Agricultural
Bret Yeary, PE	2025	Electric Generating Utilities

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Table 1-2. Current Llano Estacado Regional Water Planning Group Non-Voting Membership[4]

Non-Voting Member	Term	Representing
John Maurer	n/a	Texas Water Development Board (TWDB) Project Manager
Heather Johnson	n/a	Texas Parks and Wildlife Department
Jason Lindeman	n/a	Texas Commission on Environmental Quality
	n/a	Texas Department of Agriculture
Rusty Ray	n/a	Texas State Soil and Water Conservation Board
	n/a	Region G Liaison to Region O

Commented [PM2]: To be updated before IPP submittal

[3] LERWPG. 2024. Llano Estacado Regional Water Planning Group SPAG http://www.llanoplan.org/

1.1.2 Planning Guidelines

The TWDB planning guidelines require each regional water plan to address the following minimum reporting requirements[4]. The sections of the planning area description follow a twelve-point outline.

1. Describe the social and economic aspects of a region such as information on current population, economic activity, and economic sectors heavily dependent on water resources.
2. Describe the current water use and major water demand centers.
3. Describe current groundwater, surface water, and reuse supplies including major springs that are important for water supply or protection of natural resources.
4. Characterize the major water providers (MWPs).
5. Describe agricultural and natural resources.
6. Describe identified water quality problems.
7. Describe identified threats to agricultural and natural resources due to water quantity problems or water quality problems related to water supply.
8. Summarize existing local and regional water plans.
9. Describe the identified historic droughts of record within the water planning region.
10. Describe current preparations for drought within the regional water planning area (RWPA).
11. Characterize information provided by the TWDB from water loss audits performed by Retail Public Utilities pursuant to 31 Texas Administrative Code (TAC) §358.6 (relating to water loss audits).
12. Identify each threat to agricultural and natural resources and discuss how that threat will be addressed or affected by the water management strategies evaluated in the plan.

1.2 Climate of the Llano Estacado Region

Climate is an important consideration in water supply planning because climate summarizes weather, or short-term atmospheric conditions, and provides the probability of drought and the availability of water for various uses. Two key indicators commonly measured are air temperature and precipitation, which provide a long-term record of conditions. Temperatures in the Llano Estacado Region range from an average low of 24 degrees Fahrenheit (˚F) in January to an average high of 93˚F in July. Average annual precipitation ranges from 16 to 22 inches across the region. Detailed climate information is presented in Chapter 7, *Drought Response Information, Activities, and Recommendations*.

[4] TWDB. 2024. Regional Water .Planning In Texas. https://www.twdb.texas.gov/waterplanning/rwp/planningdocu/2026/projectdocs/RWP_RulePamphlet.pdf?d=53149.30000001192

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1.3 Social and Economic Aspects of the Llano Estacado Region

Social and economic conditions drive the need for water. Water is at the core of sustainable development and is critical for socio-economic development, energy and food production, and healthy ecosystems. Increasing population and economic growth put greater demands on a limited water supply. Understanding these pressures is critical for water management.

1.3.1 Population

The regional population of 516,202 represents approximately 1.7 percent of the state total population of approximately 30.5 million persons in 2023[5,6]. Eleven major cities with a population greater than 5,000 persons are located in the region, with these population centers relatively equality distributed within the 21 counties of the planning area. Lubbock County is the only county that contains more than one population center of 5,000 or more (cities of Lubbock, Wolfforth and Slaton). Twelve counties in the region (Briscoe, Castro, Cochran, Crosby, Dickens, Floyd, Garza, Lynn, Motley, Parmer, Swisher, and Yoakum) have no cities with more than 5,000 persons.

Historical and Recent Trends in Population

The area's population has grown from 11,418 in 1900 to 489,926 in 2010[7] and to 516,202 in 2023[8] (Table 1-3~~Table 1-3~~). From 1900 to 1920, the region experienced steady population growth as the large ranches that were predominant in the area, such as the XIT Ranch, and the railroads began to sell to farmers. Farmers converted ranchland to row crops and small grains and the economy of the region broadened to an economy of broad-based agribusiness, including the use of agricultural inputs from the non-farm manufacturing, trades, and service sectors, including marketing and processing agricultural commodities.

[5] U.S. Census Bureau (USCB). 2024. Quick Facts Texas. Population estimate July 1, 2023. https://www.census.gov/quickfacts/TX

[6] U.S. Census Bureau, Population Division. 2024. Annual Estimates of the Resident Population for Counties in Texas: April 1, 2020 to July 1, 2023 (CO-EST2023-POP-48). https://www.census.gov/data/datasets/time-series/demo/popest/2020s-counties-total.html

[7] USCB. 2023. County Population by Characteristics: 2010-2019. https://www.census.gov/data/tables/time-series/demo/popest/2010s-counties-detail.html#par_textimage

[8] U.S. Census Bureau, Population Division. 2024. Annual Estimates of the Resident Population for Counties in Texas: April 1, 2020 to July 1, 2023 (CO-EST2023-POP-48). https://www.census.gov/data/datasets/time-series/demo/popest/2020s-counties-total.html

Table 1-3. Population Growth (1900 to 2023) Llano Estacado Region[9,10,11,12]

Year	Population
1900	11,418
1910	47,015
1920	80,722
1930	206,015
1940	229,280
1950	309,329
1960	402,533
1970	408,579
1980	449,533
1990	438,490
2000	453,997
2010	489,926
2020	509,782
2023	516,202

As settlers moved to the area between 1920 and 1930, the population increased 155 percent. During the late 1920s, the number of farms peaked at 25,595; however, due to farm consolidation, the number has declined slightly almost every year since[13]. In 2007, there were 12,287 farms in the region. By 2017, there were 9,821 farms in the region[14,15]. The 2022 Census of Agriculture reports that there were 11,185 farming operations at the time of reporting: either indicating an uptick in agricultural activities over the region, or a change in census methodology[16].

Eleven cities in the region have a population greater than 5,000 (Table 1-4~~Table 1-4~~). These larger urban areas constituted 70.0 percent of the region's 2023 population of 516,202, with most of this

[9] U.S. Census Bureau, Population Division. 2024. Annual Estimates of the Resident Population for Counties in Texas: April 1, 2020 to July 1, 2023 (CO-EST2023-POP-48). https://www.census.gov/data/datasets/time-series/demo/popest/2020s-counties-total.html

[10] USCB. 1996. Population of States and Counties of the United States: 1790-1990. March 1996. https://www2.census.gov/library/publications/decennial/1990/population-of-states-and-counties-us-1790-1990/population-of-states-and-counties-of-the-united-states-1790-1990.pdf

[11] Texas Health and Human Services. 2021. Texas Population, 2000. https://healthdata.dshs.texas.gov/dashboard/surveys-and-profiles/health-facts-profiles/population-profiles

[12] USCB. 2019. Quick Facts Texas. Population estimate July 1, 2019. https://www.census.gov/quickfacts/TX

[13] Inter-University Consortium for Political and Social Research (ICPSR). 2018. Study 00003: Historical Demographic, Economic and Social Data: U.S., 1790-1970.

[14] U.S. Department of Agriculture (USDA). 2017. Census of Agriculture, Volume 1 Geographic Area Series. Table 1. County Summary Highlights: 2017. https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Texas/st48_2_0001_0001.pdf

[15] USDA. 2017. Census of Agriculture. 2017 State and County Profiles – Texas. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Texas/

[16] U.S. Department of Agriculture (USDA). 2022. Census of Agriculture, Volume 1 Geographic Area Series. Table 1. County Summary Highlights: 2022. https://www.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_2_County_Level/Texas/st48_2_001_001.pdf

urban population located in the City of Lubbock, which had a 2010 population of 229,573 persons[17] and a 2023 population of 266,878[18].

Table 1-4. Major Cities and U.S. Census Population (1990 to 2023) Llano Estacado Region[19] [20] [21] [22]

City	County	1990		2000		2010		2023	
		Pop.	% of Region	Pop.	% of Region	Pop.	% of Region	Pop.	% of Region
Brownfield	Terry	9,560	2.2	9,488	2.1	9,657	2.0	8,652	1.7
Hereford	Deaf Smith	14,745	3.4	14,597	3.2	15,370	3.1	14,752	2.9
Lamesa	Dawson	10,809	2.5	9,952	2.2	9,422	1.9	8,266	1.6
Levelland	Hockley	13,986	3.2	12,866	2.8	13,542	2.8	12,530	2.4
Littlefield	Lamb	6,489	1.5	6,507	1.4	6,732	1.4	5,768	1.1
Lubbock	Lubbock	186,206	42.5	199,564	44.0	229,573	46.9	266,878	51.7
Muleshoe	Bailey	4,571	1.0	4,530	1.0	5,158	1.1	4,970	1.0
Plainview	Hale	21,700	4.9	22,336	4.9	22,194	4.5	19,420	3.8
Seminole	Gaines	6,342	1.4	5,910	1.3	6,430	1.3	7,231	1.4
Slaton	Lubbock	6,078	1.4	6,109	1.3	6,121	1.2	5,684	1.1
Wolfforth	Lubbock	1,941	0.4	2,554	0.5	3,670	0.7	7,258	1.4
	Total	287,126	65.4	299,530	65.9	327,869	67.9	361,409	70.0

Demographic and Socioeconomic Characteristics

In terms of population density, Motley County is the least populated, with 1,020 residents or 1.0 persons per square mile (Table 1-5~~Table 1-5~~). Lubbock County had the highest population density in the region, with 320,940 residents or 358.2 persons per square mile . The regional average population density is 25.5 persons per square mile[23].

[17] USCB. 2012. 2010 U.S. Census of Population and Housing, U.S. Department of Commerce, Washington, D.C. https://www.census.gov/quickfacts/fact/table/

[18] U.S. Census Bureau. 2024. QuickFacts: Lubbock City Texas. Population estimate July 1, 2023 https://www.census.gov/quickfacts/fact/table/lubbockcitytexas,US/PST045223

[19] U.S. Census Bureau, Population Division. 2024. Annual Estimates of the Resident Population for Counties in Texas: April 1, 2020 to July 1, 2023 (CO-EST2023-POP-48). https://www.census.gov/data/datasets/time-series/demo/popest/2020s-counties-total.html

[20] Texas State Library and Archives Commission. 1990. 1990 Census: Population of Texas Cities, Arranged in Alphabetical Order. https://www.tsl.texas.gov/ref/abouttx/popcity1.html

[21] Texas State Library and Archives Commission. 2000. 2000 Census: Population of Texas Cities, Arranged in Alphabetical Order. https://www.tsl.texas.gov/ref/abouttx/popcity12000.html

[22] Texas State Library and Archives Commission. 2010. 2010 Census: Population of Texas Cities, Arranged in Alphabetical Order. https://www.tsl.texas.gov/ref/abouttx/popcity12010.html

[23] U.S. Census Bureau, Population Division. 2024. Annual Estimates of the Resident Population for Counties in Texas: April 1, 2020 to July 1, 2023 (CO-EST2023-POP-48). https://www.census.gov/data/datasets/time-series/demo/popest/2020s-counties-total.html

Table 1-5. County U.S. Census Population and Area for Llano Estacado Region[24,25]

County	Area (sq. mi.)	Population (2010)	Density (2010) (persons/sq. mi.)	Population (2023)	Density (2023) (persons/sq. mi.)
Bailey	827	7,165	8.7	6,672	8.1
Briscoe	900	1,637	1.8	1,445	1.6
Castro	894	8,062	9	7,227	8.1
Cochran	775	3,127	4	2,509	3.2
Crosby	900	6,059	6.7	4,917	5.5
Dawson	900	13,833	15.4	12,004	13.3
Deaf Smith	1,497	19,372	12.9	18,347	12.3
Dickens	902	2,444	2.7	1,711	1.9
Floyd	992	6,446	6.5	5,090	5.1
Gaines	1,502	17,526	11.7	22,523	15.0
Garza	893	6,461	7.2	4,517	5.1
Hale	1,005	36,273	36.1	31,761	31.6
Hockley	908	22,935	25.2	21,460	23.6
Lamb	1,016	13,977	13.8	12,711	12.5
Lubbock	896	278,831	311.3	320,940	358.2
Lynn	982	5,915	6.6	5,761	5.9
Motley	990	1,210	1.2	1,020	1.0
Parmer	881	10,269	11.7	9,617	10.9
Swisher	890	7,854	8.8	6,955	7.8
Terry	889	12,651	14.2	11,547	13.0
Yoakum	800	7,879	9.9	7,468	9.3
Total	20,239	489,926	24.2	516,202	25.5

In 2010, the age distribution across the region was relatively uniform from county to county[26] (Table 1-6~~Table 1-6~~). The two age groups that included the highest percentages of the population in 2010 across all counties were 60 years and above (18 percent) and 5 to 14 years (17 percent). In 2020, the two largest age groups were 5 to 17 years of age and 45 to 64 years of age, making up 18.6 and 22.0 percent of the population respectively.

With respect to the level of education, of those residents in the Llano Estacado Region who are 25 years of age or older, 82 percent have at least a high school diploma (State of Texas average is 85 percent), while 25 percent have a college degree (State of Texas average is 32 percent) (Table 1-7~~Table 1-7~~)[27]. The region's unemployment rate was 3.6 percent in 2022[28]. The region's median household income was $58,848 in 2022.

[24] U.S. Census Bureau, Population Division. 2024. Annual Estimates of the Resident Population for Counties in Texas: April 1, 2020 to July 1, 2023 (CO-EST2023-POP-48). https://www.census.gov/data/datasets/time-series/demo/popest/2020s-counties-total.html

[25] USCB. 2023. County Population by Characteristics: 2010-2019. https://www.census.gov/data/tables/time-series/demo/popest/2010s-counties-detail.html#par_textimage

[26] USCB. 2012. 2010 U.S. Census of Population and Housing, U.S. Department of Commerce, Washington, D.C.

[27] USCB. 2022. U.S. Census Educational Attainment 2018-2022 American Community Survey 5-Year Estimates. U.S. Department of Commerce, Washington, D.C.

[28] Texas Association of Counties. 2024. Texas County Profiles: 2022. https://txcip.org/tac/census/CountyProfiles.php

Table 1-6. Age Distribution of the U.S. Census Population in 2020 for Llano Estacado Region[29]

County	Population (2020)	Age Distribution (values are percent population)								
		0-4	5-17	18-24	25-34	35-44	45-64	65-84	85-99	100+
Bailey	6,904	7.6	22.3	8.8	13.4	12.3	21.1	12.5	1.9	0.0
Briscoe	1,435	5.3	17.1	5.1	8.6	11.2	25.0	23.8	3.8	0.0
Castro	7,371	6.8	21.7	8.5	11.8	11.7	22.2	14.9	2.6	0.0
Cochran	2,547	7.3	21.4	8.1	11.0	11.9	23.0	15.2	2.1	0.0
Crosby	5,133	5.3	20.4	7.1	10.1	10.9	25.7	17.9	2.3	0.1
Dawson	12,456	6.3	17.8	8.3	14.1	13.0	23.5	14.8	2.0	0.0
Deaf Smith	18,583	7.9	22.4	9.9	12.5	11.9	21.5	12.2	1.7	0.0
Dickens	1,770	5.1	17.6	5.5	7.5	11.5	27.5	22.8	2.5	0.1
Floyd	5,402	6.2	21.1	6.7	10.1	11.1	24.3	17.8	2.7	0.0
Gaines	21,598	9.6	25.0	10.7	13.8	11.8	19.8	8.2	1.1	0.0
Garza	5,816	4.2	13.5	7.2	15.3	17.5	27.7	13.4	1.2	0.1
Hale	32,522	6.1	19.6	10.0	12.9	12.0	24.1	13.4	1.8	0.0
Hockley	21,537	6.3	19.7	9.4	11.9	12.1	24.2	14.5	1.9	0.0
Lamb	13,045	6.2	20.9	7.9	11.1	11.3	24.6	15.5	2.5	0.0
Lubbock	310,639	6.2	17.3	14.8	14.4	12.3	21.2	12.2	1.6	0.0
Lynn	5,596	6.7	21.7	6.1	11.8	12.9	24.9	14.2	1.7	0.0
Motley	1,063	5.3	15.6	5.4	10.1	9.7	23.8	27.2	2.8	0.2
Parmer	9,869	7.5	21.3	9.9	12.6	10.7	23.5	12.7	1.8	0.0
Swisher	6,971	5.8	18.7	8.3	12.8	12.6	23.4	16.4	2.1	0.1
Terry	11,831	7.1	20.4	8.5	13.1	12.5	23.0	13.6	1.7	0.0
Yoakum	7,694	7.3	21.5	8.9	12.3	11.9	23.7	12.4	1.9	0.1
Total	509,782	6.5	18.6	12.5	13.7	12.2	22.0	12.8	1.7	0.0

Table 1-7. Summary of Selected Socioeconomic Indicators (2018-2022) for Llano Estacado Region[30] [31] [32]

County	High School Graduates (% of Population) (2018-2022)	College Graduates (% of Population) (2018-2022)	Civilian Labor Force (2018-2022)	Unemployment Rate (2022)	Median Household Income (2018-2022)
Bailey	73%	15%	58%	4.3%	$69,830
Briscoe	85%	16%	48%	3.6%	$35,446
Castro	75%	20%	67%	3.2%	$59,886
Cochran	69%	9%	60%	4.8%	$41,597
Crosby	78%	14%	62%	4.2%	$50,268
Dawson	70%	14%	49%	4.4%	$45,268
Deaf Smith	72%	12%	64%	3.0%	$51,942
Dickens	86%	20%	49%	4.8%	$46,638
Floyd	71%	16%	58%	4.2%	$49,321
Gaines	60%	10%	61%	3.0%	$73,299
Garza	70%	13%	37%	4.2%	$56,215

[29] USCB. 2024. County Population by Characteristics: 2020-2023. https://www.census.gov/data/tables/time-series/demo/popest/2020s-counties-detail.html

[30] USCB. 2022. U.S. Census Educational Attainment 2018-2022 American Community Survey 5-Year Estimates. U.S. Department of Commerce, Washington, D.C.

[31] U.S. Census Bureau. QuickFacts: https://www.census.gov/quickfacts/fact/table/

[32] Texas Association of Counties. 2024. Texas County Profiles: 2022. https://txcip.org/tac/census/CountyProfiles.php

County	High School Graduates (% of Population) (2018-2022)	College Graduates (% of Population) (2018-2022)	Civilian Labor Force (2018-2022)	Unemployment Rate (2022)	Median Household Income (2018-2022)
Hale	75%	15%	59%	5.0%	$50,721
Hockley	80%	17%	62%	3.7%	$53,283
Lamb	77%	13%	58%	4.0%	$54,519
Lubbock	88%	33%	65%	3.4%	$61,911
Lynn	81%	25%	61%	3.6%	$52,996
Motley	86%	20%	59%	4.1%	$66,528
Parmer	71%	19%	65%	2.4%	$65,575
Swisher	78%	19%	52%	4.1%	$40,290
Terry	76%	11%	59%	4.2%	$42,694
Yoakum	69%	10%	64%	4.1%	$80,317
Region Totals	82%	25%	63%	3.6%	$58,848
State Totals	85%	32%	65%	3.9%	$73,035

1.3.2 Economics

The economy of the region is intertwined with the water resources. Understanding the multiple connections and feedback mechanisms between water resources and the economy is crucial for sustainable water management. This section describes the economic aspects of the region, such as economic activity and economic sections heavily dependent on water resources.

The region's economic base is agriculture, with significant contributions from manufacturing, oil and gas, and trades and services, such as wholesale and retail trade, finance, insurance, legal, advertising, medical, personal, research, entertainment, repair services, and higher education. Agricultural processing, oilfield equipment, and electronics form the core of the region's manufacturing base. Beef cattle and cotton are the predominant agricultural enterprises, although vegetables and oilseed crops are significant contributors to the region's economy.

Crop Production

Due to the semi-arid climate, limited water, and a relatively short growing season, the region can only grow certain crops. The major crops grown are cotton, grain sorghum, wheat, corn, soybeans, peanuts, and hay (Table 1-8~~Table 1-8~~) [33]. Reported production of these major crops is shown for each county of the region for 2022 (most recent census of agriculture).

All commodity farm sales in the Llano Estacado Region had a combined market value of over $8.3 billion in 2022. The major crops accounted for a combined market value of over $1.1 billion. Cotton, a somewhat drought-tolerant plant, was the leading crop of the region, with a market value of over $1.2 billion. The major crops from the Llano Estacado Region provided both a significant portion of the production (e.g., 78 percent of peanuts and 36 percent of cotton) and market value (17 percent) for the state.

[33] USDA. 2024. National Agricultural Statistics Service 2022 Census of Agriculture https://www.nass.usda.gov/Publications/AgCensus/2022/index.php#full_report

Table 1-8. Crop Production in 2022 for Llano Estacado Region[34]

County	Selected Crops Harvested						
	Cotton (bales)	Wheat (bushels)	Corn (bushels)	Grain Sorghum (bushels)	Peanuts (lbs.)	Soybeans (bushels)	Hay and Haylage (tons)
Bailey	27,894	273,870	418,527	444,442	1,273,900	7,035	116,217
Briscoe	16,114	199,233	-	71,934	-	-	603
Castro	36,059	690,901	1,774,078	913,257	-	-	134,923
Cochran	58,426	317,021	578,165	919,030	21,547,871	-	-
Crosby	100,669	212,841	203,103	168,553	-	-	-
Dawson	61,535	172,511	-	315,924	15,857,199	-	87
Deaf Smith	14,542	1,442,109	2,335,942	1,984,377	-	-	69,945
Dickens	6,105	7,633	-	-	-	-	5,100
Floyd	107,914	409,975	570,051	469,882	-	-	1,261
Gaines	115,018	744,310	1,624,846	582,399	127,958,561	-	95,133
Garza	14,793	11,081	-	20,583	-	-	63
Hale	129,516	677,176	1,751,504	717,299	-	-	81,679
Hockley	103,516	165,220	787,905	983,873	-	-	6,648
Lamb	71,477	293,993	1,028,352	759,166	-	-	57,334
Lubbock	66,751	120,955	398,217	166,487	1,910,000	-	789
Lynn	86,673	41,267	219,764	144,110	-	-	-
Motley	23,546	-	-	-	-	-	1,292
Parmer	39,773	796,267	517,295	673,632	-	-	245,195
Swisher	46,473	932,787	853,132	653,156	-	-	9,750
Terry	32,546	442,013	80,425	287,788	27,057,384	-	50,293
Yoakum	44,786	181,340	330,295	406,108	35,508,500	-	-
Region Total	1,204,126	8,132,503	13,471,601	10,682,000	231,113,415	7,035	876,312
State Total	3,390,501	50,999,411	163,247,152	55,171,394	297,433,439	1,273,916	7,974,739
Region % State	35.5%	15.9%	8.3%	19.4%	77.7%	0.6%	11.0%

Irrigated Crops

In the semi-arid Llano Estacado Region, farmers supplement precipitation with irrigation from groundwater to increase crop yields, with the level of irrigation being determined by the quantities of precipitation received during the growing season and the quantities of irrigation water available to individual producers. During wetter years, farmers need to pump less irrigation water from the aquifer than during drought years, and during periods of severe drought, such as 1998, only irrigated crops produced “harvestable” yields. The 2017 Census of Agriculture[35] indicates that irrigated lands

[34] USDA. 2024. National Agricultural Statistics Service 2022 Census of Agriculture https://www.nass.usda.gov/Publications/AgCensus/2022/index.php#full_report

[35] USDA. 2017. National Agricultural Statistics Service 2017 Census of Agriculture https://www.nass.usda.gov/Publications/AgCensus/2017/index.php#full_report

were approximately 2.012 million acres (26 percent) of the cropland in the region. The 2022 Census of Agriculture[36] reports much less land in the region being irrigated with 1.4 million acres.

Table 1-9 Irrigated land by acre in 2022 and 2017 for the USDA Census of Agriculture[37] [38]

County	Year	
	2022	2017
Bailey	39,702	54,222
Briscoe	10,881	22,057
Castro	121,782	121,837
Cochran	66,668	113,184
Crosby	48,858	86,465
Dawson	35,436	54,834
Deaf Smith	115,252	122,396
Dickens	5,168	8,876
Floyd	61,317	120,101
Gaines	140,156	197,021
Garza	3,700	8,877
Hale	125,825	189,342
Hockley	66,248	106,373
Lamb	109,314	173,865
Lubbock	62,819	166,725
Lynn	48,877	83,101
Motley	3,602	4,405
Parmer	144,077	110,098
Swisher	42,612	71,462
Terry	102,527	104,419
Yoakum	45,813	92,765
Region	1,400,634	2,012,425
Texas	3,765,438	4,363,345

When farmers began extensive irrigation in the 1940s, and for more than two decades thereafter, they gave little thought to irrigation water efficiency. However, now, the Llano Estacado Region is a leader in adoption and use of highly-efficient water use technology, and as new technology becomes available, farmers adopt it as rapidly as economics allow. In fact, the region has developed better and better water conservation methods and equipment, and in some cases, individual farmers have built prototypes of equipment that specialized manufactures have produced and sold.

In the Llano Estacado Region, drought planning is a way of life as opposed to being a contingency plan. Farmers are always aware of how precious water is, and they work hard to make efficient use of precipitation, while saving the groundwater supply for use when precipitation is not adequate to grow crops.

[36] USDA. 2024. National Agricultural Statistics Service 2022 Census of Agriculture https://www.nass.usda.gov/Publications/AgCensus/2022/index.php#full_report

[37] USDA. 2017. National Agricultural Statistics Service 2017 Census of Agriculture https://www.nass.usda.gov/Publications/AgCensus/2017/index.php#full_report

[38] USDA. 2024. National Agricultural Statistics Service 2022 Census of Agriculture https://www.nass.usda.gov/Publications/AgCensus/2022/index.php#full_report

Dryland Crops

Dryland, also known as rain-fed[39], farming produces crops without irrigation using only the precipitation provided by nature. Approximately 75 percent of the average annual precipitation occurs during the growing season, which is from May through September. Maximum conservation of this precipitation is the key to producing acceptable crop yields. Farmers accomplish this by holding the rainfall, which often falls in high-intensity, short-duration precipitation events, in place until it has time to soak into the soil. Methods that are effective at holding rainfall on the soil include bench leveling, parallel terraces, contour farming, furrow dikes, deep chiseling, and crop residue management. Minimum tillage using chemicals to control weeds instead of plowing also conserves moisture, since plowing provides an opportunity for moisture to evaporate when turned to the surface.

Crops produced by the dryland farming method include cotton, wheat, rye, and grain sorghum.

Livestock Production

Total livestock water use in 2017 accounted for 1 to 2 percent of the water demand in the Llano Estacado Region over the planning period from 2020 to 2070. Major types of livestock produced include feedlot cattle, range cattle, dairy cattle, swine, and sheep. The largest classification of livestock is cattle and calves, which includes feedlot livestock, followed by beef cows, sheep, and lambs. The most recent information available regarding fed cattle in the Llano Estacado Region originated from Ben Weinheimer, LERWPG member and Texas Cattle Feeders Association representative[40]. U.S. Department of Agriculture (USDA) information indicates that the one-time feedlot capacity in 2017 was 1.53 million head in 2017 (Table 1-10~~Table 1-10~~).

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Table 1-10. Livestock Numbers in 2022 for Llano Estacado Region

County	2022 Livestock and Poultry						
	Feedlot Capacity (number)	Cattle & Calves (number)	Beef Cows (numbers)	Milk Cows (number)	Swine (Hogs & Pigs) (number)	Sheep & Lambs (number)	Poultry Layers (number)
Bailey	46,750	128,705	5,722	26,730	247	654	226
Briscoe	-	45,616	11,536	-	24	-	(D)
Castro	227,800	582,951	13,927	68,107	1167	2,970	155
Cochran	2,550	2,743	1,596	-	(D)	-	34
Crosby	-	9,286	6,125	-	36	(D)	452
Dawson	-	3,358	2,295	-	490	224	260
Deaf Smith	583,100	700,069	30,595	52,135	(D)	(D)	438
Dickens	-	22,739	13,110	-	44	245	421
Floyd	52,700	53,490	5,770	-	(D)	1,317	432
Gaines	4,250	7,672	(D)	(D)	126	1,560	714
Garza		8,286	5,953	-	(D)	12	378
Hale	68,000	121,898	6,311	27,601	521	1,248	294
Hockley	1,700	7,559	4,177	-	96	434	600

Commented [SJ3]: Will need to reach out for feedlot capacities

[39] D. Molden, ... D. Peden, in Treatise on Water Science, 2011. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/rainfed-agriculture

[40] Weinheimer, B. 2017. Personal communication, Texas Cattle Feeders Association, September 25, 2017.

County	2022 Livestock and Poultry						
	Feedlot Capacity (number)	Cattle & Calves (number)	Beef Cows (numbers)	Milk Cows (number)	Swine (Hogs & Pigs) (number)	Sheep & Lambs (number)	Poultry Layers (number)
Lamb	106,250	156,623	8,383	25,190	79	377	790
Lubbock	42,500	38,032	(D)	(D)	2,005	1,856	(D)
Lynn	-	8,592	5,862	-	96	814	126
Motley	-	14,678	9,824	-	(D)	94	82
Parmer	224,825	362,742	8,633	56,420	7	31	(D)
Swisher	173,400	196,293	13,356	-	30	(D)	345
Terry	-	13,296	(D)	(D)	122	212	316
Yoakum	-	10,656	3,043	-	56	312	165
Total	1,533,825	2,495,284	156,218	256,183	5,146	12,360	6,228

(D) data withheld

Commented [SJ3]: Will need to reach out for feedlot capacities

Beef Cows

Beef cows, which include any cow kept primarily for calf production, make up 6 percent of the total livestock in the Llano Estacado Region. In 2022, there were approximately 156,000 beef cows in the region (beef cows versus cattle and calves in Table 1-10~~Table 1-10~~), which is just under 4 percent of the state's total beef cow population of 4,360,026. The leading counties in beef cow numbers are Deaf Smith, Castro, Swisher, and Dickens.

Feedlot Livestock

During the last 25 to 30 years, the South Plains of Texas observed the development and growth of the confined cattle feeding industry to finish weights before slaughter. In the early years of development, individual ranchers built and operated feedlots to add value to their own cattle. During the 1960s, feedlot operators expanded the size and numbers of feedlots, and began feeding cattle for others (custom feeding). This procedure opened a new market for ranchers across the region and the state; they could now have their own cattle custom-fed in a custom cattle feedlot. Farmers saw immediate grain marketing benefits from the establishment of feedlots in the Llano Estacado Region.

Fed cattle marketing in Texas increased from 477,000 head in 1960 to 2.7 million in 1969, a 467 percent growth rate as new capital flowed into the industry. During the 1970s, fed cattle marketing grew to 4.9 million head. The more modest 82 percent growth rate reflected the "market crash" of 1973 to 1974 that led to fewer new feedlots and slowed expansion of existing feedlots. During the 1980s, fed cattle marketing peaked at 5.3 million head in 1986, reflecting an 8.2 percent growth for the decade, with expansion during the 1980s being predominantly from expansion of existing feedlots. During the 1990s, the Texas feedlot industry matured with a 12 percent growth rate and marketing of 6.06 million head in 1998—resulting primarily from expansion of existing feedlots. Of the 142 feedlots in Texas in 1998, almost 50 percent were located in the Llano Estacado Region. In 1998, the cattle feedlots in the Llano Estacado Region marketed over 3.39 million head of fed cattle from 69 feedlots located in the 21 counties in the region. In 2017, fed cattle inventory included 1.53 million head.[41]

[41] Weinheimer, B. 2017. Personal communication, Texas Cattle Feeders Association, September 25, 2017.

Dairies

In the Llano Estacado Region, the dairy industry included a total of 70 dairies. Table 1-11 shows estimates of milk cow numbers for the Llano Estacado Region based on information from Harry DeWit, LERWPG member and CEO of Blue Sky Farms, based on December 2019 Texas Milk Market Administration information and dry cow estimates.[42]

Table 1-11. Dairy and Milk Cow Production in the Llano Estacado Region

County	Dairies	milk/month (lbs)	lbs/cow/day	Milk Cows	Dry Cows	Total Dairy Cows
Bailey	10	607,408,168				
Castro	15	1,625,008,771				
Deaf Smith	14	1,215,795,419				
Hale	6	629,746,193				
Lamb	13	1,057,884,031				
Lubbock	<3	0				
Parmer	16	1,540,110,744				
Total	70	6,675,953,326				

lbs - pounds

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Other Livestock

Ranchers in the Llano Estacado Region also produce swine, sheep, and poultry, although in relatively low numbers. Production has been cyclical with some periods of declines in the numbers.

Oil and Gas

In the Llano Estacado Region, most of the oil and gas production activity is concentrated in the southern counties. Gaines and Yoakum counties are the leading oil and gas-producers in the region[43] (Table 1-12~~Table 1-12~~). In 2023, oil production in the Llano Estacado Region was 71.7 million barrels or 4 percent Texas' total production. The 2023 natural gas production (casing head gas plus gas well gas) was 85,525,152 thousand cubic feet (mcf) or approximately 1 percent of Texas' total production. The wellhead value of oil and gas production of the region in 2023 is estimated at approximately $6 billion.

Table 1-12. Oil and Gas Production in 2023 for Llano Estacado Region[44]

County	Oil (bbl)	Condensate (bbl)	Casing head Gas (mcf)	Gas Well Gas (mcf)
Bailey	0	0	0	0
Briscoe	0	0	0	0
Castro	0	0	0	0
Cochran	2,245,703	98	1,401,224	29,333
Crosby	581,236	0	0	0
Dawson	6,943,452	0	5,021,976	0
Deaf Smith	0	0	0	0

[42] DeWit, H. 2020. Personal communication, Blue Sky Farms, January 20, 2020.

[43] The Railroad Commission of Texas. 2023. General Production Query. http://webapps2.rrc.texas.gov/EWA/productionQueryAction.do

[44] The Railroad Commission of Texas. 2023. General Production Query. http://webapps2.rrc.texas.gov/EWA/productionQueryAction.do

County	Oil (bbl)	Condensate (bbl)	Casing head Gas (mcf)	Gas Well Gas (mcf)
Dickens	319,165	0	17,712	0
Floyd	0	0	0	0
Gaines	18,567,950	3,026	16,462,918	962,957
Garza	1,656,594	0	817,771	0
Hale	852,860	0	1,178,927	0
Hockley	9,669,100	1,186	6,225,247	7,849
Lamb	172,110	0	177,276	0
Lubbock	859,022	0	60,519	0
Lynn	128,664	0	32,317	0
Motley	18,225	0	1,387	0
Parmer	0	0	0	0
Swisher	0	0	0	0
Terry	2,203,528	0	298,662	0
Yoakum	27,447,086	0	52,801,096	27,981
Region Total 2017	**75,633,987**	**11,669**	**65,745,520**	**4,739,817**
Region Total 2023	**71,664,695**	**4,310**	**84,497,032**	**1,028,120**
Region Change 2017/2023	**-5%**	**-63%**	**29%**	**-78%**
Texas Total 2017	**1,083,758,987**	**176,265,505**	**2,637,886,440**	**4,811,630,451**
Texas Total 2023	**1,645,224,799**	**4,817,284,259**	**7,400,296,142**	**318,193,139**
Texas Change 2017/2023	**52%**	**2633%**	**181%**	**-93%**

bbl = barrel; mcf = thousand cubic feet

Manufacturing

The leading types of manufacturing plants in the region are food and kindred products, agricultural and industrial machinery and equipment, printing and publishing, and fabricated metal products, and ethanol plants. Information from 2022 for manufacturing (North American Industry Classification System [NAICS] codes 31-33) , the region's 379 manufacturing establishments contributed and provided 12,568 jobs with an annual payroll of $686.68 million (Table 1-13~~Table 1-13~~).

Table 1-13. Manufacturing Activity in 2022 for Llano Estacado Region[45]

County	Total Number of Establishments	Total Number of Employees	Annual Payroll (million-dollars)
Bailey	10	200	6.41
Briscoe	0	0	0.00
Castro	8	42	2.68
Cochran	0	0	0.00
Crosby	0	0	0.00
Dawson	9	92	4.33
Deaf Smith	18	2,615	163.77
Dickens	0	0	0.00
Floyd	8	46	1.91
Gaines	18	239	16.86
Garza	0	0	0.00
Hale	16	661	32.71
Hockley	14	210	11.36

[45] USCB. 2024. 2022 Economic Census, Washington D.C. https://www.census.gov/data/datasets/2022/econ/cbp/2022-cbp.html

County	Total Number of Establishments	Total Number of Employees	Annual Payroll (million-dollars)
Lamb	11	288	13.37
Lubbock	228	5,502	276.30
Lynn	5	87	3.80
Motley	0	0	0.00
Parmer	9	2333	139.60
Swisher	8	65	4.77
Terry	9	105	3.77
Yoakum	8	83	5.04
Total	379	12,568	686.68

Wholesale Trade

The wholesale trade classification (NAICS code 42) includes durable goods such as motor vehicles, furniture and home furnishings, lumber and construction materials, electrical goods, and non-durable goods, such as farm products, chemicals and allied products, and petroleum and petroleum products, with the leading type of wholesale trade within the Llano Estacado Region being non-durable goods. The region's 733 wholesale trade establishments provide over 9,147 jobs with an annual payroll of over $625.55 million in 2022 (Table 1-14~~Table 1-14~~).

Table 1-14. Wholesale Trade 2022 Llano Estacado Region[46]

County	Total Number of Establishments	Total Number of Employees	Annual Payroll (million-dollars)
Bailey	18	229	11.19
Briscoe	0	0	0.00
Castro	11	114	7.79
Cochran	3	40	2.76
Crosby	9	92	8.16
Dawson	16	85	5.26
Deaf Smith	26	384	26.13
Dickens	0	0	0.00
Floyd	12	88	4.52
Gaines	43	417	32.28
Garza	6	25	1.67
Hale	47	532	32.28
Hockley	26	175	10.41
Lamb	19	141	8.36
Lubbock	422	6,237	432.22
Lynn	9	33	1.71
Motley	0	0	0.00
Parmer	20	172	19.10
Swisher	11	67	2.53
Terry	21	237	13.26
Yoakum	14	79	5.94
Total	733	9,147	625.55

[46] USCB. 2024. Annual Report for Wholesale Trade: 2022. https://www.census.gov/data/datasets/2022/econ/cbp/2022-cbp.htm

County	Total Number of Establishments	Total Number of Employees	Annual Payroll (million-dollars)

Retail Trade

The retail trade classification (NAICS codes 44-45) includes building materials and garden supplies, general merchandise stores, food stores, automotive dealers and service stations, apparel and accessory stores, furniture and home furnishing stores, household appliance stores, restaurants, and retail stores. The leading areas of retail trade within the Llano Estacado Region are restaurants, food stores, automotive dealers and service stations, and general merchandise stores. In 2022, the region's reported 1,656 retail trade establishments contributed and provided over 27,2728 jobs with an annual payroll of over $895.90 million (Table 1-15~~Table 1-15~~).

Table 1-15. Retail Trade in 2022 for Llano Estacado Region[47]

County	Total Number of Establishments	Total Number of Employees	Annual Payroll (million-dollars)
Bailey	23	273	6.214
Briscoe	9	61	1.53
Castro	23	139	3.40
Cochran	5	40	0.84
Crosby	18	160	3.94
Dawson	40	520	25.43
Deaf Smith	53	892	29.64
Dickens	10	48	1.29
Floyd	15	110	2.37
Gaines	64	671	22.65
Garza	19	185	4.67
Hale	94	1279	34.58
Hockley	66	1097	24.97
Lamb	34	359	9.73
Lubbock	1060	20,272	692.20
Lynn	12	81	2.23
Motley	4	37	0.63
Parmer	25	200	4.20
Swisher	14	133	4.00
Terry	39	424	13.63
Yoakum	29	297	7.78
Total	1656	27,278	895.90

Services

The services group of businesses (NAICS codes 54, 56, 61, 72, and 81) includes accounting services, amusement services, business services, computer services, educational services, engineering services, funeral services, health services, legal services, management services,

[47] USCB. 2024. Annual Retail Trade Survey: 2022. https://www.census.gov/data/datasets/2022/econ/cbp/2022-cbp.html

personal services, research services, and social services. The services group also includes auto repair, automobile parking, barber shops, beauty shops, commercial sports, credit reporting, hotels and motels, motion pictures, personnel supply services, photographic studios, shoe repair and services to buildings. Additionally, membership organizations and services provided by local, state, and federal agencies are part of the services group of businesses. The leading types of services within the Llano Estacado Region are health services, business services, social services, and membership organizations. The 2022 Economic Census reported 3,919 services establishments in the Llano Estacado Region, with a value of $1,467 million in payroll (Table 1-16~~Table 1-16~~).

Table 1-16. Services 2022 Llano Estacado Region[48]

County	Total Number of Establishments	Total Number of Employees	Annual Payroll (million-dollars)
Bailey	46	332	7.03
Briscoe	7	27	0.44
Castro	52	399	9.83
Cochran	10	25	0.42
Crosby	16	47	1.02
Dawson	87	550	13.46
Deaf Smith	106	903	31.76
Dickens	11	30	0.81
Floyd	37	157	3.78
Gaines	154	1404	49.53
Garza	35	366	16.02
Hale	206	2295	61.75
Hockley	131	1108	27.62
Lamb	69	492	14.43
Lubbock	2700	38,004	1180.97
Lynn	20	109	5.15
Motley	7	10	0.12
Parmer	68	474	14.51
Swisher	39	215	4.77
Terry	67	456	12.09
Yoakum	51	291	11.73
Total	3919	47,694	1467.22

Finance, Insurance, and Real Estate

The finance, insurance, and real estate classification (NAICS codes 52 and 53) includes banks, savings and loans, non-depository institutions, security and commodity brokers, insurance carriers, insurance agents, brokers and services, real estate holdings and other investment offices. In 2022, the region's 1,508 finance, insurance, and real estate establishments provided 9,366 jobs with an annual payroll of over $615.70 million (Table 1-17~~Table 1-17~~).

[48] USCB. 2022. Economic Data. https://www.census.gov/data/datasets/2022/econ/cbp/2022-cbp.html

Table 1-17. Finance, Insurance, and Real Estate 2022 Llano Estacado Region[49]

County	Total Number of Establishments	Total Number of Employees	Annual Payroll (million-dollars)
Bailey	11	40	2.392
Briscoe	4	36	2.38
Castro	15	44	2.42
Cochran	5	10	0.86
Crosby	7	23	0.81
Dawson	29	108	7.26
Deaf Smith	45	222	12.34
Dickens	0	0	0.00
Floyd	12	57	2.86
Gaines	33	320	21.92
Garza	10	32	1.62
Hale	87	291	16.45
Hockley	59	248	16.94
Lamb	31	124	5.83
Lubbock	1077	7,451	498.73
Lynn	10	36	3.07
Motley	0	0	0.00
Parmer	21	99	6.90
Swisher	10	35	2.92
Terry	24	106	5.75
Yoakum	18	84	4.26
Total	1508	9,366	615.70

Recreation

Most of the region's revenue derived from recreation comes from Lubbock County and is almost certainly due to Texas Tech University and other education institutions in the area. In rural areas of the Llano Estacado Region, spending on hunting and fishing comprise the majority of recreation-based revenue. Based on 2020 data from the U.S. Census Bureau[50], annual payroll in the economic area of recreation was over $53 million. This figure includes the $51 million generated in Lubbock County.

While hunting and fishing will probably remain a substantial part of the outdoor recreation picture, the activity of ecotourism has been growing rapidly in the region since 1980. The definition of ecotourism is discretionary travel to natural areas that conserve the environmental, social, and cultural values, while generating an economic benefit to the local community. Ecotourists engage in activities, including bird watching, wildlife viewing, hiking, rock climbing, backpacking, camping, and outdoor photography. Forecasts are for this activity to increase within the Llano Estacado Region in the future, especially where water is available to attract wildlife. In addition, landowners can increase opportunities to attract hunters and ecotourists at fairly low cost and little effort.

[49] USCB. 2022. Economic Data. https://www.census.gov/data/datasets/2022/econ/cbp/2022-cbp.html

[50] USCB. 2022. Economic Data. https://www.census.gov/data/datasets/2022/econ/cbp/2022-cbp.html

1.4 Current Water Use and Major Water Demand Centers

Residents of the Llano Estacado Region use water to grow crops and livestock, manufacture goods, and to meet energy needs. There are six major types of water use classifications in the Llano Estacado Region: (1) agriculture irrigation; (2) agriculture livestock; (3) industrial manufacturing; (4) industrial mining; (5) industrial power generation; and (6) municipal.

1.4.1 Agriculture Irrigation Water Use

In the Llano Estacado Region, some agricultural producers pump water from aquifers to supplement precipitation for crop production. This choice means that irrigating producers pump more water during periods of drought than during years when precipitation is higher.

In 2017, the High Plains Underground Water Conservation District No. 1 (HPWD), which covers the majority of the Llano Estacado Region, reported 2,172,911 irrigated acres within the district. This total included 1,741,133 acres were irrigated with center pivot systems and 431,778 acres irrigated with subsurface drip irrigation[51]. In 2023, the HPWD reported 2,250,058 irrigated acres within the district. This total included 1,791,640 acres irrigated with center pivots and 458,418 acres irrigated with subsurface drip irrigation[52]. Total projected irrigation demand in the Llano Estacado Region in 2020 is 3,182,630 acre-feet per year (ac-ft/yr) and in 2070 is 2,215,638 ac-ft/yr.

1.4.2 Agriculture Livestock Water Use

Cattle feeding and dairy operations constitute approximately 1 percent in 2020 to 2.5 percent of the total demand in the Llano Estacado Region. Water classified as livestock water use is used for consumption by cattle, sanitation, and dust control. Total livestock demand in the Llano Estacado Region in 2020 is 41,589 ac-ft/yr and in 2070 is 60,304 ac-ft/yr.

1.4.3 Industrial Manufacturing Water Use

Water is used in a variety of ways for manufacturing purposes, including process uses (water used in the manufacture of products), cooling of portions of the manufacturing process, wash-down water for cleaning, water for employee drinking purposes, sanitary uses in restrooms, and landscape irrigation. The amount of water used for each purpose is usually particular to the type of industry. In the Llano Estacado Region, the major manufacturing uses of water are for food processing, industrial machinery and equipment, and fabricated metal products.

In response to the high costs to treat and dispose of wastewater, rising energy costs, and environmental considerations, industries use water more efficiently now than they did in the past. Some specific areas where savings are taking place are process modification or substitution, cooling water recycling and reuse, and steam and hot water conservation. Methods used in manufacturing to conserve cooling water may include use of saline water or treated wastewater, air cooling, and using

[51] HPWD. 2017. Annual Report. https://static1.squarespace.com/static/53286fe5e4b0bbf6a4535d75/t/5a56223053450a0fe1c03fd7/1515594293311/2017+Annual+Report.pdf

[52] HPWD. 2023. Annual Report. https://www.hpwd.org/files/8cada94b1/2023+Annual+Report.pdf

recirculating cooling systems. Methods used to conserve water used for steam and hot water manufacturing processes include energy conservation and waste heat recovery.

1.4.4 Industrial Mining Water Use

Different types of mining or extractive industries use water in different ways. The primary water use in the mining industry in the Llano Estacado Region is for enhanced recoveryof petroleum, such as with water injection and hydraulic fracturing. Sand and gravel mining operations also use water in their operations. Methods used to conserve freshwater may include the use of brackish or saline water or treated wastewater or the capture and recirculation of used water.

1.4.5 Industrial Power Generation Water Use

In the Llano Estacado Region, steam-electric power is generated in Hale, Lamb, Lubbock, and Yoakum counties. A steam-electric plant works by heating water in a boiler to generate steam. The steam turns the turbine-generator, which produces electricity, after which the steam goes to a condenser to cool back into water. Most of the water used in steam-electric power generation is to cool the steam back into water. The condensed water returns to the steam generator to become steam again that the cooling water discharges as wastewater or recycles through cooling ponds or towers. Within a steam-electric plant, make-up water replaces the water lost as steam, blowdown (purging) of boilers, washing of stacks, and power plant and employee sanitation.

Steam-electric power generation closely resembles manufacturing uses of water where steam is required; therefore, conservation practices in the two industries closely resemble each other. Water used for cooling purposes constitutes most water use in a steam-electric plant and is perhaps where the greatest water saving can be achieved. Methods used to conserve freshwater may include use of saline water or treated wastewater, air-cooling, and using recirculating cooling systems.

1.4.6 Municipal Water Use

Municipal water use, as defined by the TWDB, includes water used for residential and commercial purposes. Residential water use includes water for drinking, cooking, bathing, flushing toilets, general cleaning and sanitation, swimming pools, car washing, gardening, and lawn watering. Outside household use ranges from near zero in humid areas to 60 percent of total domestic use in arid areas.[53]

The TWDB municipal water use definition also includes water used by commercial facilities such as hotels, restaurants, laundries, car washes, office buildings, educational institutions, prisons, government and military facilities, retail establishments, public swimming pools, fire protection, and irrigation of public parks and open spaces. In the Llano Estacado Region, per capita municipal water use in 2011 was approximately 176 gallons per day (gpd), and the 2020 estimate is 165 gpd.

Although most counties in the Llano Estacado Region have small towns and communities, several major municipal demand centers exist within the region. The City of Lubbock is the largest demand center in the region for municipal and manufacturing water use. The major water demand centers for water used in oil and gas extraction are in counties located in the southern portion of the region, while large cattle feedlots, most of which are located in the northern half of the region, are the major

[53] U.S. Environmental Protection Agency (EPA). 2024. How We Use Water. https://www.epa.gov/watersense/how-we-use-water

demand centers for livestock water. Unlike water demand for municipal, manufacturing, electric power generation, and mining purposes, water demand for irrigation is throughout the region.

1.5 Current Water Supplies

Water sources used to supply water use demands within the Llano Estacado Region include groundwater, surface water, springs, and reuse. Groundwater is the primary water source in the Llano Estacado Region. Protecting water sources is critical for long-term management and use of the resource.

1.5.1 Groundwater

Groundwater is the primary source of water in the Llano Estacado Region. The principal aquifer in the Llano Estacado Region is the High Plains Aquifer[54], which consists of the Ogallala Aquifer, Dockum Aquifer, Edwards-Trinity (High Plains) Aquifer, and Rita Blanca Aquifer. The Llano Estacado Region overlies the southern part of the Ogallala Aquifer, small areas of the Seymour Aquifer and Blaine Aquifer, and two minor aquifers (Dockum and ETHP) (Figure 1.5~~Figure 1.5~~ and Figure 1.6).

The Ogallala Aquifer, the most productive source of groundwater supply for the Llano Estacado Region, consists of the saturated section of the Ogallala Formation, as well as those underlying and overlying geologic units that are in hydraulic continuity. The Ogallala Formation consists chiefly of sediments deposited by headwater streams in the mountainous areas to the west and northwest. The Ogallala Formation was deposited on the eroded surfaces of underlying Triassic and Cretaceous aged sediments. In general, the Ogallala Formation is thicker in the northern part of the area, with the thickness ranging from 400 to 500 feet in central Parmer County, west central Castro County, and southwestern Floyd County to an edge where the formation pinches out against outcrops of older rocks.

The original layer of sediments that formed the Ogallala Formation extended from the Rocky Mountains eastward through north central Texas. The Ogallala Formation has subsequently eroded such that the segment in southeastern New Mexico and the Southern High Plains of Texas is isolated from underground connection with other water-bearing beds, except through underlying older sediments, which may contain highly mineralized water unlike the fresh water in the Ogallala Aquifer. In Texas and New Mexico, the source of the recharge to the Ogallala Aquifer is precipitation falling on the unconsolidated lacustrine, fluvial, and eolian deposits sediments, which overlie the Ogallala Formation. Thus, these Quaternary-aged materials serve as important conduits for recharge to the Ogallala Aquifer. The amount of recharge depends on many factors, including the amount, distribution, and intensity of precipitation and the type of soil and vegetative cover. Research has estimated that recharge to the Ogallala Aquifer in Groundwater Management Area (GMA) 2 can vary from ¼ inch to 2 ¼ inches per year[55].

[54] McGuire, V.L., M.R. Johnson, R.L., Schieffer, J.S. Stanton, S.K. Sebree, and I.M. Verstraeten. 2003. Water in storage and approaches to ground-water management, High Plains Aquifer, 2000: U.S. Geological Survey Circular 1243, U.S. Department of the Interior, Reston, Virginia, 51p.

[55] Texas Groundwater Management Area 2. https://gma2.hpwd.org/

Generally, the water in the Ogallala Aquifer occurs under water-table conditions, although locally it may be under slight artesian pressure. The water in the Ogallala Aquifer occupies the pore spaces or voids in the unconsolidated sediments. The thickness of the zone of saturation in the Ogallala Aquifer varies throughout the Llano Estacado Region, ranging from less than 1 foot to more than 300 feet. Transmissivities range from less than 500 gallons per day per foot (gpd/ft) to greater than 200,000 gpd/ft. Transmissivities tend to be greater than 5,000 gpd/ft, and average over 30,000 gpd/ft.[56] In general, the movement of water in the Ogallala Aquifer is from the northwest to the southeast. The water-table slopes roughly parallel to the slopes of both the bedrock and land surface. Estimates of the rate of water movement in the formation are approximately 150 feet per year.[57]

The water in the Ogallala Aquifer in the Llano Estacado Region is generally of good chemical quality, except that it is "hard," due to high levels of calcium and magnesium. Most of the water is suitable for irrigation and meets the U.S. Public Health Service recommendations for public supplies, although the water from some wells has excessive fluoride content.

The long-term trend throughout much of the region has been a steady decline in the water table, due primarily to large quantities of water withdrawn for irrigation. The topography of the land surface, the proximity to areas of recharge or natural discharge, the proximity of pumping wells, and the configuration of the bedrock surface affect the depth to water below land surface. The depth to water in the aquifer within the region ranges from less than 50 feet to more than 300 feet.

The TWDB has identified and characterized nine major and 21 minor aquifers in the state based on the quantity of water supplied by each[58]. The Blaine Aquifer is located in the upper northwest corner of Motley County but does not provide a significant source of water for the Llano Estacado Region and therefore is not discussed in any further detail.

The stratigraphy of the region's aquifers and the formations that comprise them is depicted in Table 1-18~~Table 1-17~~. Throughout the area, recent aged fluvial deposits occur along major stream valleys. The Quaternary-aged Blackwater Draw Formation overlies the Ogallala Formation. The Ogallala Aquifer is composed of Tertiary-age sediments and is the most consistently productive aquifer in the area. Wells have been flow-tested to 800 gallons per minute (gpm) in Lubbock County, as recently as 2011[59]. However, thin saturated thicknesses limit productivity in some areas.

Table 1-18~~17~~. Stratigraphy of the Llano Estacado Region

System	Formation	Aquifer
Quaternary	Ogallala	Ogallala
Tertiary		
Cretaceous	Duck Creek	Edwards-Trinity High Plains
	Kiamichi	
	Edwards	

[56] Brackish Groundwater Manual for Texas Regional Water Planning Groups. 2003. http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/2001483395.pdf

[57] High Plains Underground Water Conservation District. http://www.hpwd.org/aquifers

[58] TWDB. 1995. Report 345, Aquifers of Texas. Austin, TX.

[59] Deeds, N.E., J.J. Harding, T.L. Jones, A. Singh, S. Hamlin, and R.R. Reedy. 2014. Conceptual Model for the High Plains Aquifer System Groundwater Availability Model. GAM report prepared for the Texas Water Development Board.

System	Formation	Aquifer
	Comanche Peak	
	Walnut	
	Antlers	
Triassic	Cooper Canyon	Upper Dockum
	Trujillo	
	Tecovas	Lower Dockum
	Santa Rosa	
Permian	Dewey Lake	
	Rustler	

Cretaceous-aged sediments of the Edwards-Trinity High Plains (ETHP) Aquifer directly underlie the Ogallala Formation in much of the central portion of the Southern High Plains, extending from New Mexico on the west to Garza County on the east and into the southern portions of Bailey and Lamb counties to the north and the northern portions of Gaines and Dawson counties to the south. These sediments are comprised of the Trinity, Fredericksburg, and Washita groups, consisting primarily of sandstone, shale, and limestone, with the sandstone and limestone being the principal water-bearing units. The most consistently productive formation of the ETHP Aquifer is the Antlers sandstone. The Edwards and Comanche Peak formations also occasionally yield high-producing wells in areas where the limestone contains fractures and solution cavities of high permeability. In places where the ETHP Aquifer is in hydraulic continuity with the overlying Ogallala Formation, wells provide moderate quantities of water, particularly from the limestone. Locally, the ETHP Aquifer may be an important aquifer where other water is not available; however, the Cretaceous-aged sediments generally do not constitute a large source of water for irrigation or municipal use.

Upper Triassic-aged rocks underlie the Cretaceous formations or directly underlie the Ogallala Formation in the Llano Estacado Region. The Dockum sediments are comprised of the Cooper Canyon, Tecovas, Trujillo, and Santa Rosa formations. The Cooper Canyon, Trujillo, and Tecovas formations consist chiefly of interbedded siltstone, mudstone, sandstone, and shale, while the Santa Rosa Formation consists mainly of medium to coarse conglomeratic sandstone. The formations of the Dockum Group are capable of yielding small to moderate quantities of water in many parts of the region, particularly in the coarser-grained Santa Rosa Formation. However, in most places, the water quality can be saline to briny and probably unsuitable for most purposes. There are some areas, particularly in Deaf Smith County, where the Dockum Aquifer produces good supplies of fresh water.

Below the Triassic, rocks of Permian Age underlie the entire area and consist chiefly of red sandstone and shale containing numerous beds of gypsum and dolomite. The Permian Blaine Aquifer is considered a minor aquifer in Texas and is located at the east end of the High Plains in the northeast corner of Motley County. The Permian rocks are not a significant source of water in the Llano Estacado Region. Water in these rocks contains gypsum and salts, making it generally unsuitable for domestic use. However, livestock use this water in the Rolling Plains area.

1.5.2 Surface Water

Although the Llano Estacado Region lies within four river basins, there is little surface water. Dams have been built to take advantage of what surface water exists. In other segments of rivers, surface water amounts to a trickle. Little, if any, water leaves the region via streamflow. Following are descriptions of the region's surface water resources by basin.

The Llano Estacado Region includes the upstream parts of four major river basins (Brazos, Canadian, Colorado, and Red) (Figure 1.5~~Figure 1.5~~ and Figure 1.7). Within the Llano Estacado Region, most streams and rivers are intermittent. Almost no water flows out of the region via rivers.

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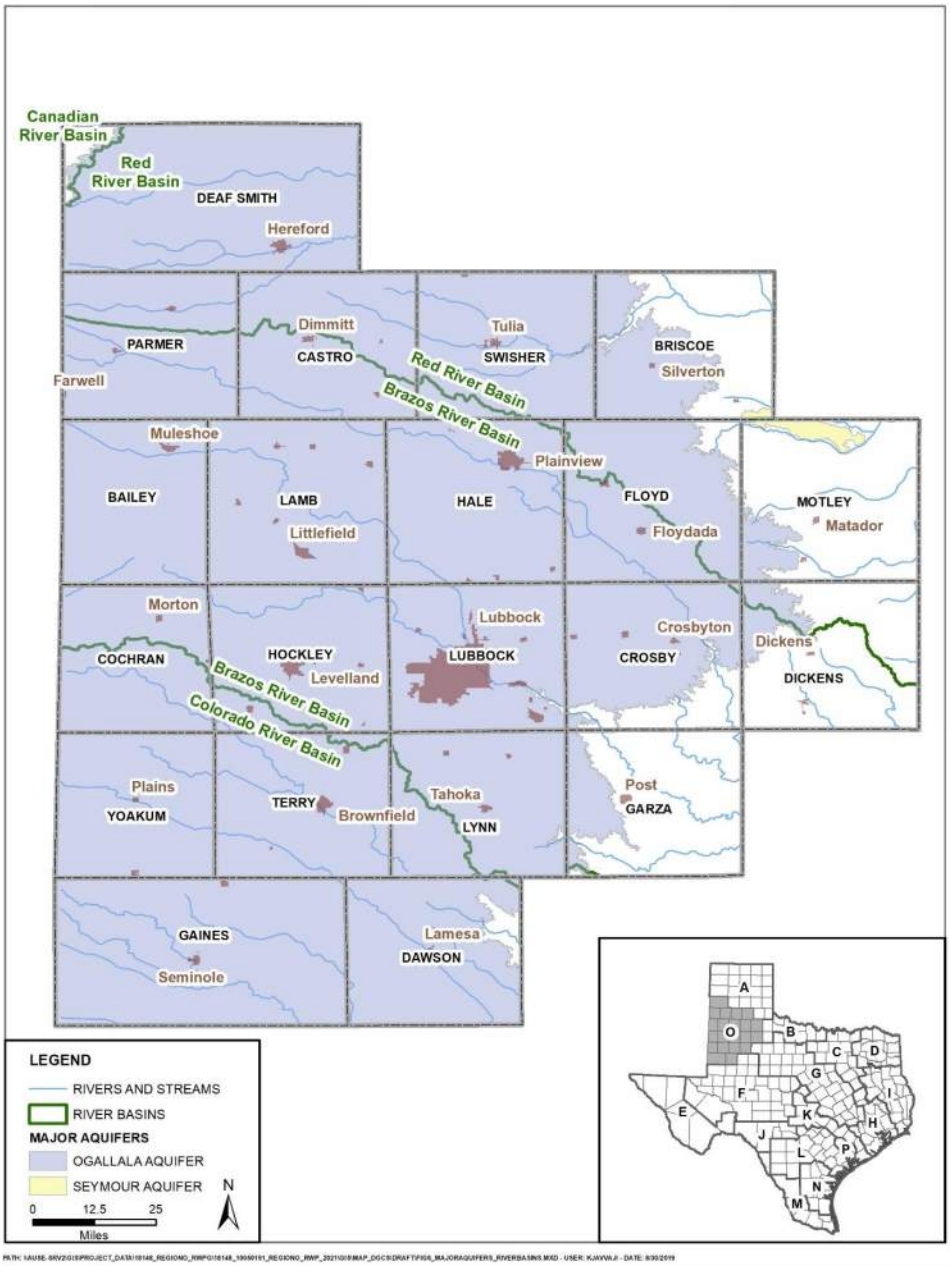

Figure 1.5. Major Aquifers and River Basin Boundaries of the Llano Estacado Region

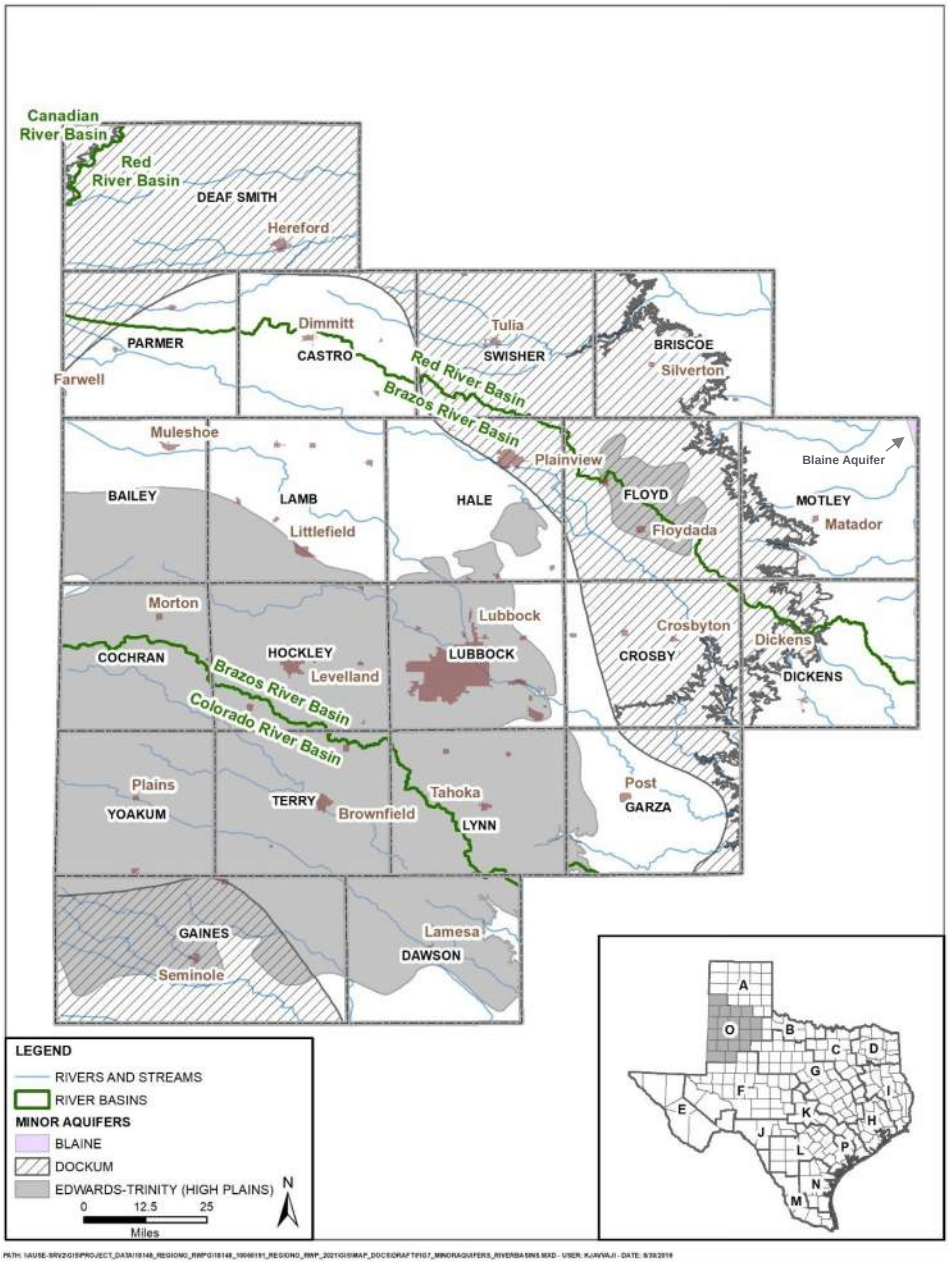

Figure 1.6. Minor Aquifers and River Basin Boundaries of the Llano Estacado Region

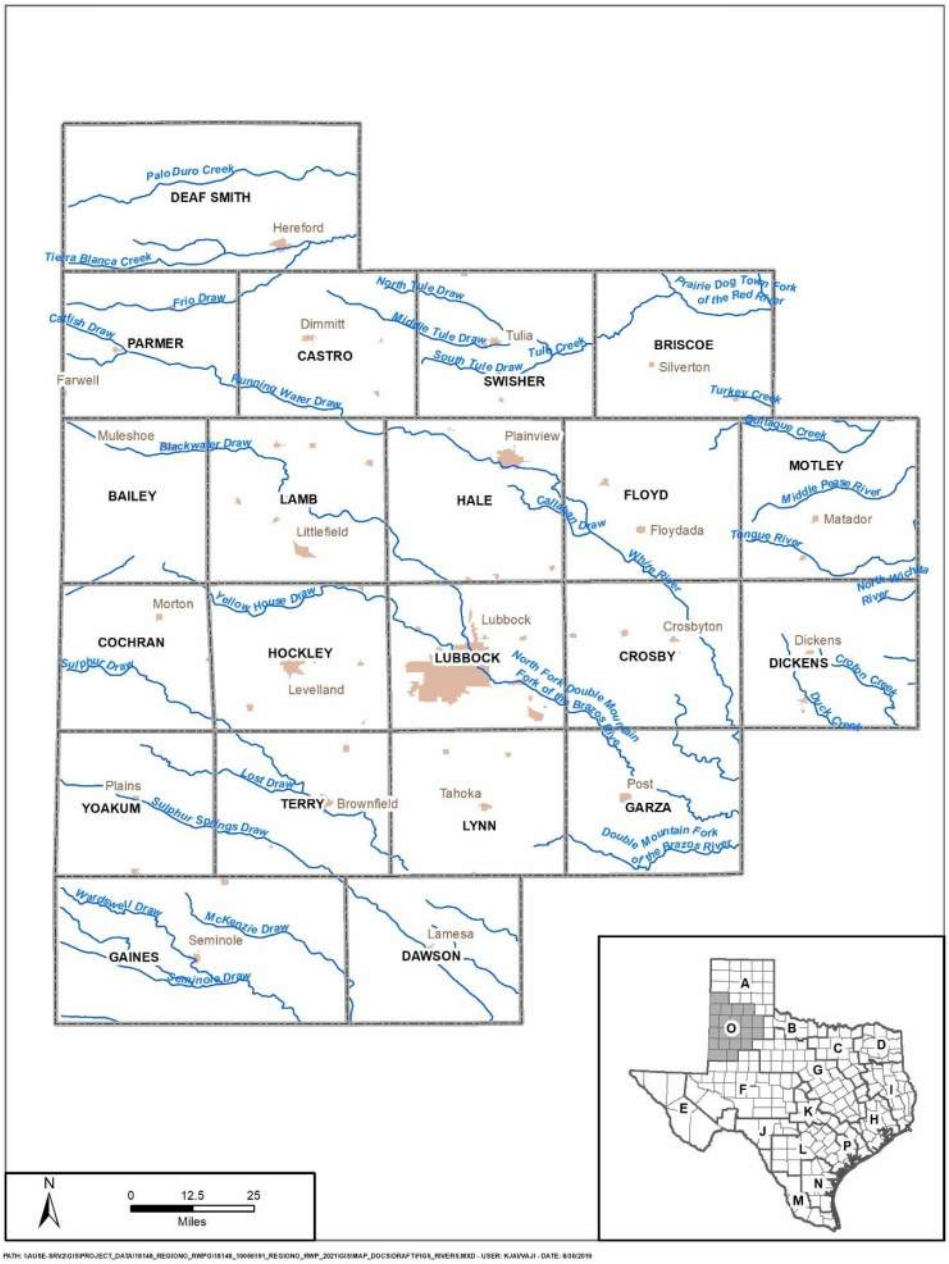

Figure 1.7. Rivers of the Llano Estacado Region

Canadian River Basin

Beginning in northeastern New Mexico, the Canadian River flows eastward across the Texas Panhandle into Oklahoma and merges with the Arkansas River in eastern Oklahoma. Total drainage area of the basin is 12,700 square miles, of which 94 square miles are located in the Llano Estacado Region. Most of its course across the Panhandle is in a deep gorge. A tributary dips into Texas' northern Panhandle and then flows to a confluence with the main channel in Oklahoma. Lake Meredith, formed by the Sanford Dam on the Canadian River provides water for 11 Panhandle cities, including Brownfield, Lamesa, Levelland, Lubbock, O'Donnell, Plainview, Slaton, and Tahoka within the Llano Estacado Region.

Red River Basin

In the Llano Estacado Region, the Red River Basin is bounded on the north by the Canadian River Basin and on the south by the Brazos River Basin. The Red River Basin extends from the headwaters in eastern Curry County, New Mexico, across the Texas High Plains to the southwestern corner of Oklahoma, near Childress, Texas, where the river becomes the Texas-Oklahoma border. The Red River Basin encompasses 6,681 square miles in the region.

The uppermost tributary of the Red River in Texas is Tierra Blanca Creek, which rises in Curry County, New Mexico, and drains into the Prairie Dog Town Fork a few miles east of Canyon. However, these tributaries do not supply significant quantities of water to water users of the Llano Estacado Region. Major population centers located in the basin include the cities of Hereford (Deaf Smith County) and Tulia (Swisher County).

Brazos River Basin

In the Llano Estacado Region, the Brazos River Basin is bounded on the north by the Red River Basin and on the south by the Colorado River Basin and includes 8,732 square miles in the Llano Estacado Region. In the region, the Brazos River rises in three upper forks, the Double Mountain, Salt, and Clear Forks of the Brazos. However, the Brazos River proper is considered to begin where the Double Mountain and Salt Forks flow together in Stonewall County, east of the Llano Estacado Region. Major population centers located in the basin include the cities of Muleshoe (Bailey County), Littlefield (Lamb County), Plainview (Hale County), Levelland (Hockley County), Lubbock and Slaton (Lubbock County), and Post (Garza County). Lake Alan Henry (LAH) on the Double Mountain Fork in southeastern Garza County was built in 1993 to supply municipal water and industrial water to Lubbock.

Colorado River Basin

In the Llano Estacado Region, the Colorado River Basin is bounded on the north by the Brazos River Basin and on the south by the Rio Grande Basin. The Colorado River Basin contains 4,787 square miles in the Llano Estacado Region. The headwaters of the Colorado River occur in eastern New Mexico, and the river course is to the southeast across Texas approximately 600 miles, discharging into Matagorda Bay and the Gulf of Mexico. However, there is little flow within the Llano Estacado Region. Major population centers of the region that are located in the basin include the cities of Brownfield (Terry County), Denver City (Yoakum County), Lamesa (Dawson County), and Seminole (Gaines County). However, neither the Colorado River nor its tributaries supply water to any of these cities.

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Developed Surface Water Resources

Development of surface water supply sources has been limited in the Llano Estacado Region simply because the area does not have flowing streams of any significance. However, four water storage projects are located nearby and supply water for municipal and industrial uses within the region. These four water storage projects are Lake Meredith, Mackenzie Reservoir, White River Lake, and LAH. Those cities that do not receive water from these reservoirs rely on groundwater to supply their water needs for both municipal and non-municipal purposes.

Lake Meredith

Lake Meredith, located in the Panhandle Region (Region A) in the Canadian River Basin in Potter, Moore, and Hutchinson counties, has a total storage capacity of 864,400 acre-feet (ac-ft) and can supply approximately 81,100 ac-ft of water per year when at conservation pool elevation[60]. Results from the 1995 TWDB hydrographic survey[61] indicate Lake Meredith encompasses around 16,411 surface acres and contains a volume of 817,970 ac-ft at the normal pool elevation of 2936.5 feet. The storage volume calculated by the 1995 TWDB survey is approximately 2.5 percent less than the 1980 sediment re-survey information for the lake. The lowest gated outlet invert elevation is at elevation 2850.0 feet resulting in a dead pool storage volume of 38,414 ac-ft. The conservation storage capacity of the lake is limited to 500,000 ac-ft in accordance with the interstate Canadian River Compact. Associated, supplemental projects to supply groundwater from Roberts County in the Panhandle Region have been implemented increase reliability and improve the quality of currently contracted supplies.

Mackenzie Reservoir

Mackenzie Reservoir is located in the Red River Basin in Swisher and Briscoe counties, and supplies water to Silverton, Tulia, Floydada, and Lockney. The reservoir has a total storage capacity of 45,500 ac-ft and can supply approximately 5,200 ac-ft of water per year when at conservation pool elevation. During recent dry conditions, Lake Mackenzie was unable to meet its contracted demands.

White River Lake

White River Lake is located in the Brazos River Basin in the southeast corner of Crosby County. It is owned and operated by the White River Municipal Water District (WRMWD), which supplies water to Ralls, Spur, Post, and Crosbyton. The lake has a surface area of 1,808 acres at conservation pool elevation, a drainage area of 173 square miles, and a total storage capacity of 44,897 ac-ft, and a water right of 6,000 ac-ft/yr. WRMWD purchased groundwater rights and drilled wells to supply its customers should the water levels in the reservoir drop below the level at which water can be removed.

Lake Alan Henry

LAH is located on the Double Mountain Fork of the Brazos River in Garza and Kent counties and is owned by the City of Lubbock. It is a critical, strategic water resource for the City of Lubbock,

[60] CRMWA. 2019. Lake Meredith. https://www.crmwa.com/lake-meredith

[61] TWDB. 2003. Volumetric Survey of Lake Meredith http://www.twdb.texas.gov/surfacewater/surveys/completed/files/meredith/1995-06/Meredith1995_FinalReport.pdf?d=3066.6349999955855

supplying drinking water to approximately 300,000 people and to industries in the South Plains. In 2017, LAH provided 19 percent of the water supply for the city. In the future, LAH may comprise up to 40 percent of the city's water supply.

The lake has a total storage capacity of 96,206 ac-ft and a firm yield of approximately 21,400 ac-ft per year based on the current (2017) area-capacity curves and sediment accumulation rates published in the September 2018 TWDB survey report[62].

Playa Lakes

Runoff in the region is collected in approximately 15,500 playa lakes located within the Llano Estacado Region[63,64] (Figure 1.8). Playa lakes are naturally occurring depressions in the landscape of the Southern High Plains that provide the internal drainage for much of the region. Playa watersheds are closed systems, with playa floors representing the deepest parts of the watershed. Some playa floors are defined as wetlands by the presence of hydric, vertisol clay soil, usually Randall Clay, and despite being surrounded by intensive agricultural activities, the playa lakes perform many functions beneficial to humans and biota of the region.

Playa lakes comprise approximately 2 percent of the total land surface within the region. Most playa lakes are ephemeral, holding water only during and for a short period after rains, unless augmented by irrigation tailwater or urban runoff. Values for annual net lake surface evaporation range from a high of 54 inches per year for the southern portion of the region to a low of 45 inches per year in the north. TPWD describes playa lakes with the following excerpts of their description of "Panhandle Playa Lakes."[65]

> *Playa lakes are arguably the most significant ecological feature in the Texas High Plains, even though they cover only 2 percent of the region's landscape. Playa lakes are shallow, circular-shaped wetlands that are primarily filled by rainfall, although some playa lakes found in cropland settings may also receive water from irrigation runoff. Playa lakes average slightly more than 15 acres in size. Although larger playa lakes may exceed 800 acres, most (around 87 percent) are smaller than 30 acres.*
>
> *Once the subject of much debate, mounting evidence points to playa lakes as a critical recharge source for the Ogallala aquifer. Playa lakes filter and recharge as much as 95 percent of the water collected in the southern portion of the aquifer. Recharge occurs both through playa lakes and along the perimeter (or annual rings) of playa lakes. Recharge occurring through playa lakes flows downward through large cracks in the clay lining. These cracks eventually swell shut and become impermeable as the clay absorbs*

[62] TWDB. 2017. Volumetric Survey of Alan Henry Reservoir. https://www.waterdatafortexas.org/reservoirs/individual/alan-henry/rating-curve/TWDB/2017-08-01

[63] Guthery, F.S., F.C. Bryant, B. Kramer, A. Stoecker, and M. Dvoracek. 1981. "Playa Assessment Study", U.S. Water and Power Resources Service, Southwest Region, Amarillo, Texas.

[64] Playa Lakes Joint Venture, 2020. http://pljv.org/

[65] Texas Parks and Wildlife. Panhandle Playa Lakes https://tpwd.texas.gov/landwater/land/habitats/high_plains/wetlands/playa.phtml

water following a rain. Recharge occurring along playa perimeters takes place after rainfall events leave flood-water standing outside the clay-lined basins.

In times of abundant rainfall, they collect water and form lakes. Playa lakes have little elevation change as one proceeds across them in a horizontal gradient; playa floors are flat.

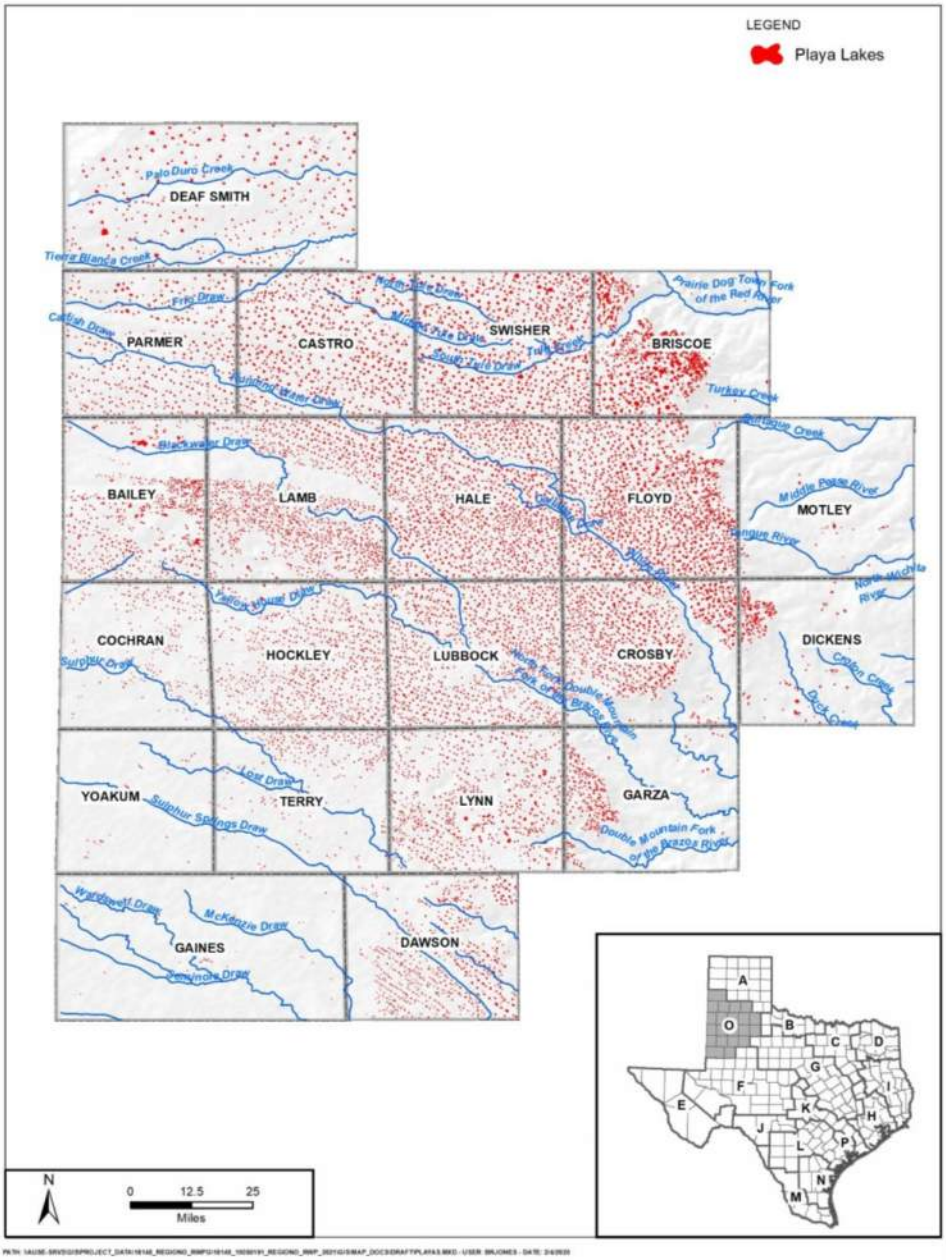

Figure 1.8. Playa Lakes of the Llano Estacado Region

1.5.3 Springs

According to the TWDB's "Major and Historical Springs of Texas," there are four active springs located within the Llano Estacado Region (Hylsey, Roaring, Buffalo, and Couch Springs).[66] Hylsey Springs is located approximately 9 miles north of Vigo Park within Palo Duro Canyon in Briscoe County. Hylsey Springs produces water from the Santa Rosa Sandstone, which is the primary water-bearing unit of the Dockum Aquifer. Roaring Springs is located approximately 4 miles south of the Town of Roaring Springs in Motley County. Roaring Springs produces water from the Santa Rosa Sandstone (Dockum Aquifer) and the Ogallala Aquifer. Buffalo Springs is located approximately 9 miles southeast of the City of Lubbock. Buffalo Springs produces water from the ETHP Aquifer. Couch Springs, located approximately 8 miles east of Crosbyton in Crosby County, produces water from the Ogallala Aquifer. In addition, groundwater discharge to the Jim Bertram Lake System in the City of Lubbock has been confirmed, and additional seeps are often noted further downstream on the North Fork of the Double Mountain Fork of the Brazos River (North Fork)[67].

1.5.4 Reuse

Currently limited reuse occurs within the Llano Estacado Region. According to data provided by the TCEQ[68], four reuse authorizations exist in the region: one facility each in Dawson and Lubbock counties and two facilities in Hockley County. Additional reuse options are recommended to meet future water needs, as described in Chapter 5.

1.6 Major Water Providers

Commented [SJ5]: Grady to Update

In response to the TWDB's new fifth cycle of planning requirements in 31 TAC § 357.30(4), the LERWPG designated five MWPs.

The Texas Water Code (TWC), Chapter 357.10(19) defines an MWP as follows:

> *"Major Water Provider (MWP)—A Water User Group or a Wholesale Water Provider of particular significance to the region's water supply as determined by the Regional Water Planning Group. This may include public or private entities that provide water for any water use category."*

The five MWPs designated by the LERWPG are the City of Lubbock, Canadian River Municipal Water Authority (CRMWA), Mackenzie Municipal Water Authority (MMWA), WRMWD, and the Red River Authority (RRA).

1.6.1 City of Lubbock

The City of Lubbock has four wholesale customers.

- Area in County-Other, Garza,
- Area in County-Other, Lubbock,
- Town of Ransom Canyon, and

[66] TWDB. 1975. "Major and Historical Springs of Texas (Report No. 189)," March 1975.

[67] Ken Rainwater, Texas Tech University, 2020. Personal communication, February 18, 2020.

[68] Paul Brochi, Water Quality Division, TCEQ. 2019. Personal communication, April 18, 2019.

- City of Shallowater.

1.6.2 Canadian River Municipal Water Authority

In 1953, the Texas Legislature authorized CRMWA to organize as a legal entity and independent political subdivision of Texas for the purpose of implementing the Canadian River Project, which had been authorized by Congress in 1950. Eleven cities formed the authority: Amarillo, Borger, Pampa, Plainview, Lubbock, Slaton, Brownfield, Levelland, Lamesa, Tahoka, and O'Donnell. Under a tri-state compact, Texas was entitled to impound up to 500,000 ac-ft of water[69] in conservation storage in the (South) Canadian River Basin. CRMWA obtained a permit from the State of Texas to impound the water as allowed by the compact.[70] A dam was constructed on the Canadian River 9 miles west of Borger, Texas, and an aqueduct was constructed to deliver water from the reservoir to the member cities. The dam crossing the Canadian River 9 miles west of Borger is 226 feet high and 6,380 feet long. The aqueduct system, with 322 miles of pipeline, ten pumping plants, and three regulating reservoirs, has furnished municipal and industrial water to the cities of the authority since 1968. CRMWA acquired groundwater rights from property located in the Panhandle Region (Region A) and developed the John C. Williams Aqueduct & Wellfield to improve the quality and increase the quantity of water delivered via its aqueduct to its member cities. Since the end of 2001, a blend of surface water and groundwater has been supplied to the CRMWA member cities.

1.6.3 Mackenzie Municipal Water Authority

The MMWA was created in 1965 to manage and operate Lake Mackenzie. It consists of Floydada, Lockney, Silverton, and Tulia, each with allocated contracts.

- Floydada: 155 ac-ft/yr
- Lockney: 75 ac-ft/yr
- Silverton: 128 ac-ft/yr
- Tulia: 210 ac-ft/yr

Sometimes due to low lake levels, the MMWA is unable to deliver the full contracted allocation to its member cities as happened in 2014. Tulia and Floydada have existing city wells that are able to supply these cities with water if there is not surface water available. Silverton is working on developing new city wells. Lockney has developed wells in the ETHP Aquifer. Currently, Tulia is working on the infrastructure to run water from Tulia to Silverton.

[69] Canadian River Compact. 1950. https://www.tceq.texas.gov/assets/public/permitting/watersupply/water_rights/canadian_river_compact_1950.pdf

[70] Canadian River Compact. 1950. https://www.tceq.texas.gov/assets/public/permitting/watersupply/water_rights/canadian_river_compact_1950.pdf Entered into by New Mexico, Oklahoma, and Texas, the compact guarantees that Oklahoma shall have free and unrestricted use of all waters of the Canadian River in Oklahoma and that Texas shall have free and unrestricted use of all water of the Canadian River in Texas subject to limitations upon storage of water (500,000 ac-ft of storage until such time as Oklahoma has acquired 300,000 ac-ft of conservation storage, at which time Texas's limitation shall be 200,000 ac-ft plus the amount stored in Oklahoma reservoirs). New Mexico shall have free and unrestricted use of all waters originating in the drainage basin of the Canadian River above Conchas Dam and free and unrestricted use of all waters originating in the drainage basin of the Canadian River.

1.6.4 White River Municipal Water District

The WRMWD was created in 1957 to manage and operate the White River Lake. It owns a well field, is capable of supplying groundwater, and is comprised of the following members: Crosbyton, Post, Ralls, Spur, and rural county members. Each city is allocated the following amounts.

- Crosbyton: 179 ac-ft/yr
- Post: 414 ac-ft/yr
- Ralls: 202 ac-ft/yr
- Spur: 224 ac-ft/yr
- Rural County: 51 ac-ft/yr

When lake levels are too low, the district will stop pumping from the lake. The WRMWD also has groundwater, which supplements the water when there is a shortage at the lake.

1.6.5 Red River Authority

The RRA supplies water to 33 independent community water systems (within a 15-county service area), most of which are located in the Panhandle Region (Region A) and Region B RWPAs. In the Llano Estacado Region, the RRA supplies water to parts of Dickens and Motley counties.

1.7 Agricultural and Natural Resources

Agricultural and natural resources of the Llano Estacado Region heavily dominate the region's economy. Most of the Llano Estacado Region is cultivated cropland. The main crops are cotton, wheat, corn, grain, sorghum, peanuts, soybeans, and hay. The main livestock raised are feedlot animals, cattle, calves, beef cows, milk cows, swine, sheep, lambs, and poultry. The economic impact of these resources is further described in Section 1.3.2.

1.7.1 Physiography, Soils, and Vegetation

The Southern High Plains of Texas, spanning much of the Llano Estacado Region, is the most southerly extent of the Southern Great Plains of the United States. The relatively level plateau of the Southern High Plains contains many shallow depressions, or playa lakes. Land uses from the National Land Cover Database (NLCD)[71] are depicted in Figure 1.9. Broken terrain exists in the northwest corner of the planning region and on the eastern side of the planning region, which is part of the Rolling Plains physiographic region, below the Caprock Escarpment.

According to State Soil Geographic (STATSGO) dataset[72], there are 51 different soil types in the region, most of which are suitable for irrigation (Figure 1.10 and Figure 1.11). Classification of the original High Plains vegetation was mixed prairie, shortgrass prairie, and, in some locations on deep sandy soils, tallgrass prairie. Blue grama (*Bouteloua gracilis*), buffalograss (*Bouteloua dactyloides*), and galleta (*Pleuraphis* sp.) were the principal natural vegetation on the clay and clay loam soils. Characteristic grasses on sandy loam soils were little bluestem (*Schizachyrium scoparium*), western

[71] https://www.mrlc.gov/data/nlcd-2016-land-cover-conus

[72] http://www.fsl.orst.edu/pnwerc/wrb/metadata/soils/statsgo.pdf

wheatgrass (*Pascopyrum smithii*), sideoats grama (*Bouteloua curtipendula*), and sand dropseed (*Sporobolus cryptandrus*).

The High Plains area is characteristically free from brush, but sand sagebrush (*Artemisia filifolia*), along with pricklypear (*Opuntia* sp.) and yucca (*Yucca* sp.), have invaded the ranchland that have sandy and sandy loam soils. Honey mesquite (*Prosopis glandulosa*) has invaded the ranchland on most soils in the region, and saltcedar (*Tamarix spp.*) is considered a prevalent invasive species along several waterways, including the Double Mountain Fork of the Brazos River upstream of LAH, where the City of Lubbock has been spraying to eliminate the invasive species since 2013. Several grass species of dropseeds are abundant on land containing coarse sandy soils. The playa depressions, which can contain several feet of water after heavy rains, support unique patterns of vegetation within their confines. Aquatic species, such as curlytop smartweed (*Persicaria lapathifolia*), are associated with the playa lakes.

DRAFT

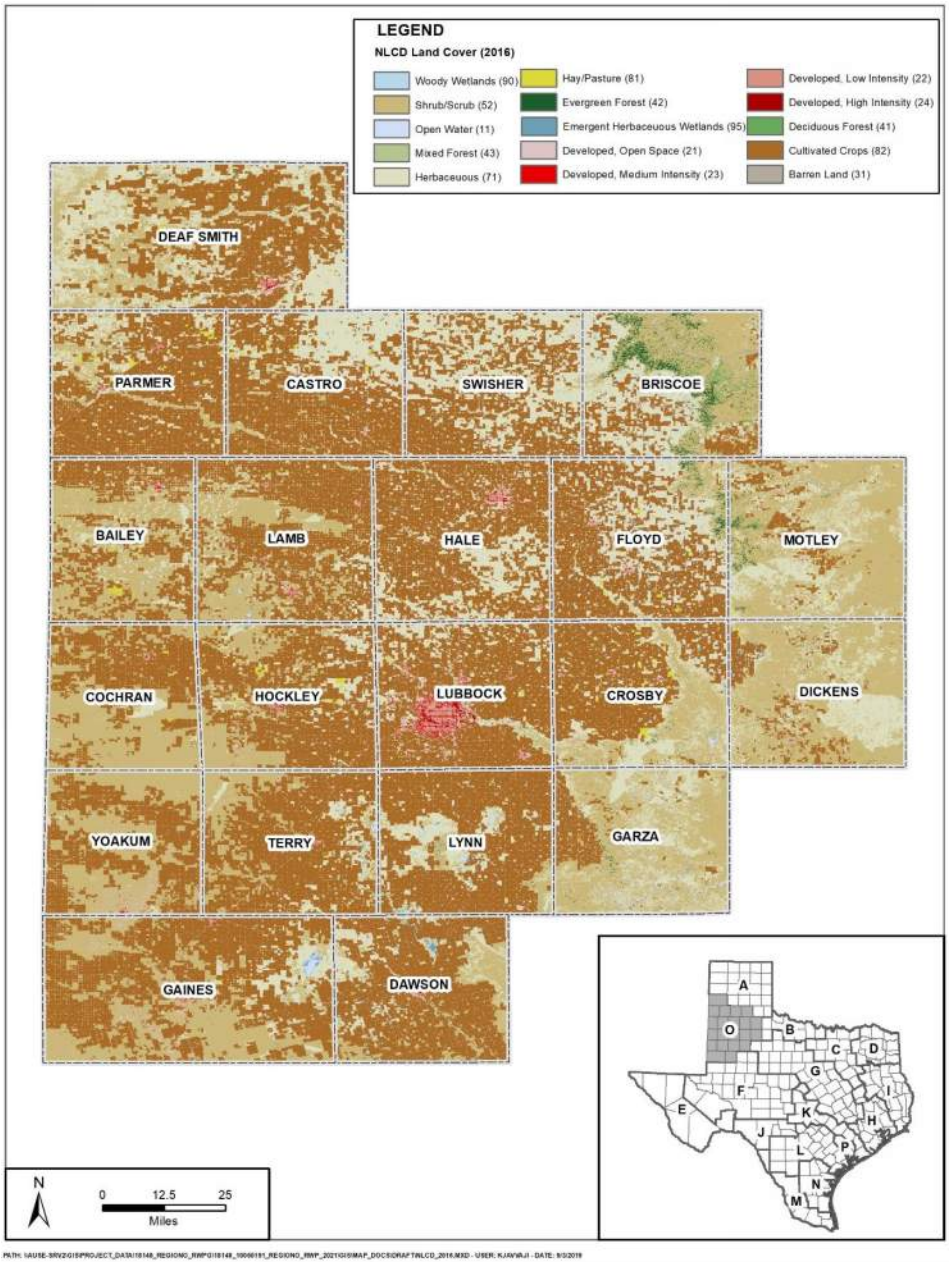

Figure 1.9. Land Use Covers (NLCD 2016)

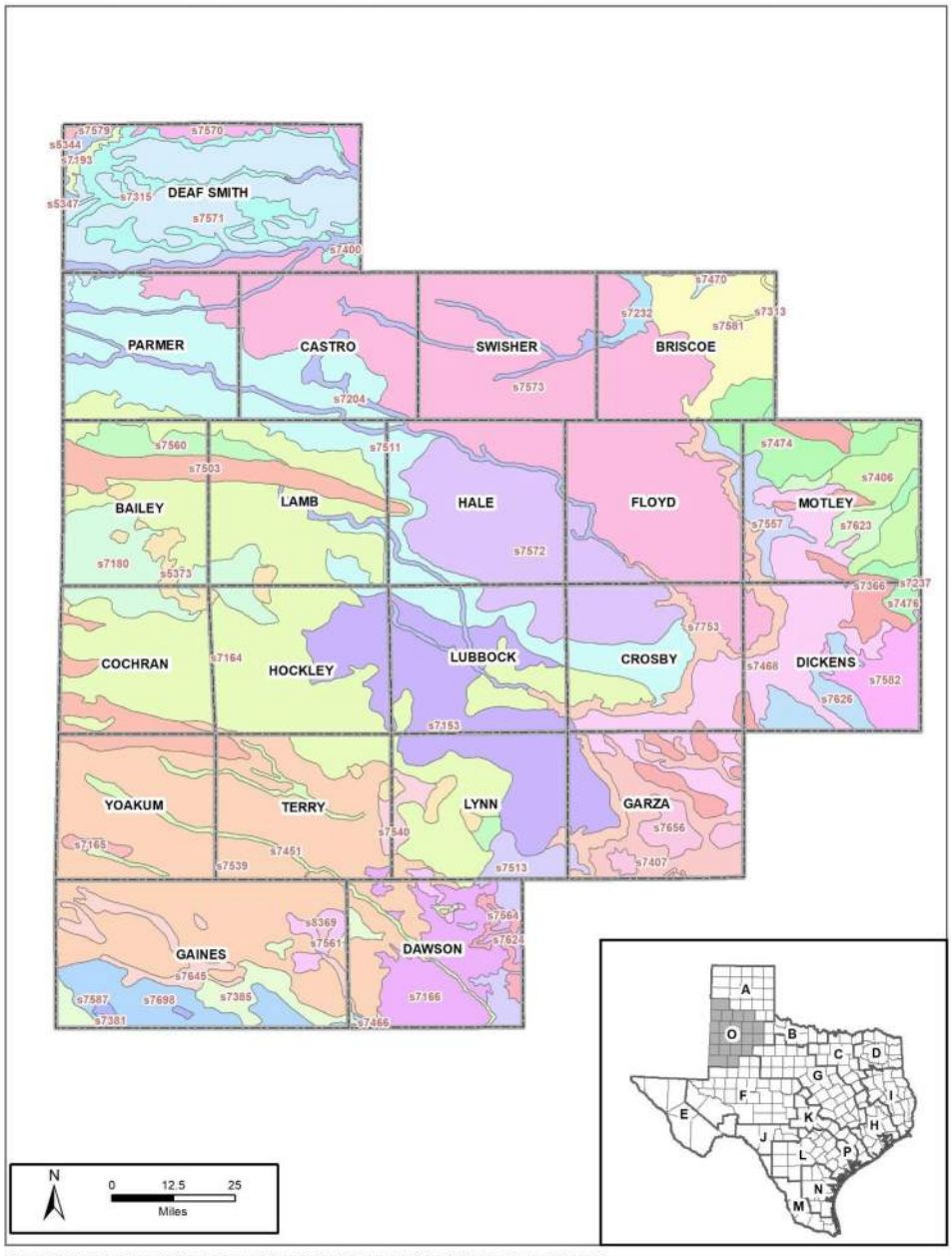

Figure 1.10. Soils of the Llano Estacado Region (Region O)

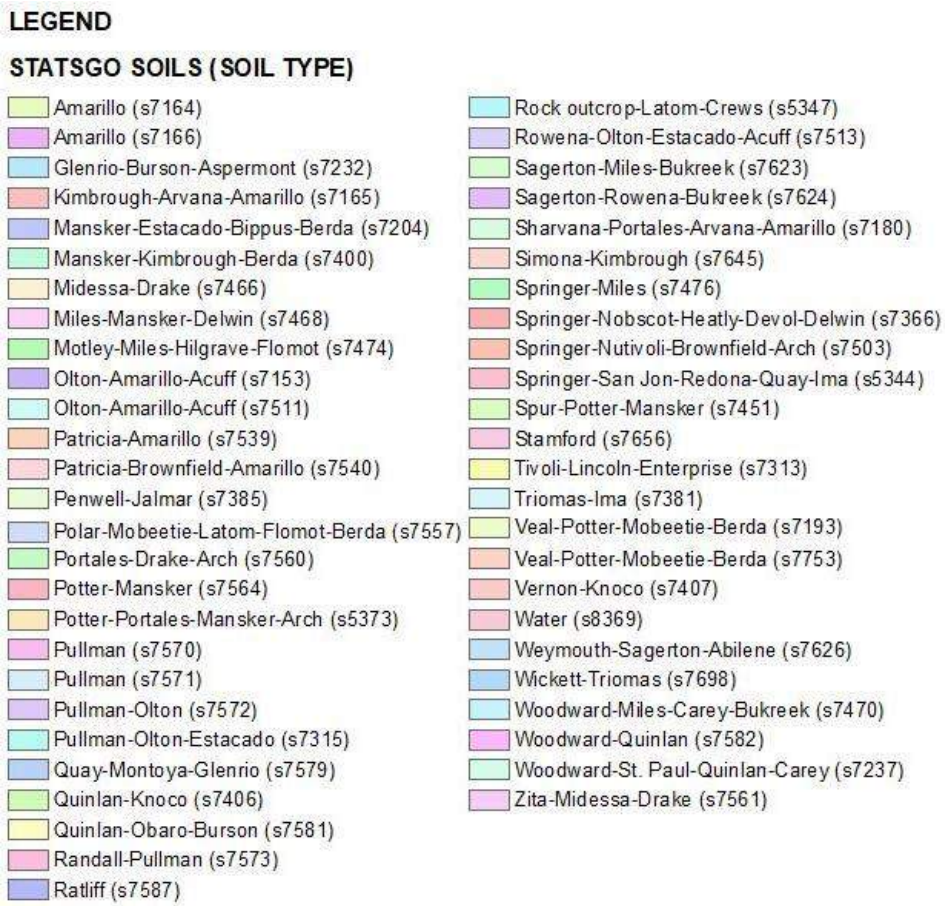

Figure 1.11. Soil Data of the Llano Estacado Region

1.7.2 Wildlife Resources

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In the Region O planning region, U.S. Fish and Wildlife (USFWS) has 13 federally-listed species[73] and TPWD has nine species state-listed species and many others identified as rare or species of concern but with no official listing.[74] Table 1-19~~Table 1-19~~ shows the species that are listed as endangered, threatened or rare for the 21 counties in the Region O planning area.

[73] USFWS. 2024. Information for Planning and Consultation. Accessed online on August 9, 2024 IPaC: Explore Location resources (fws.gov).

[74] TPWD. 2024. Rare, Threatened, and Endangered Species of Texas – Baily, Briscoe, Castro, Cochran, Crosby, Dawson, Deaf Smith, Dickens, Floyd, Gaines, Garza, Hale, Hockley, Lamb, Lubbock, Lynn, Motley, Parmer, Swisher, Terry, and Yoakum counties. Accessed online August 9, 2024 at http://tpwd.texas.gov/gis/rtest/

Table 1-19. Species Listed as Endangered, Threatened, Candidate, and Species of Greatest Conservation Need for the 21 counties in the Llano Estacado Region[75]

Common Name	Scientific Name	Summary of Habitat Preference	USFWS Status[61]	TPWD Status[62]	Potential Occurrence in Counties
Amphibians					
Woodhouse's toad	*Anaxyrus woodhousii*	A wide variety of terrestrial habitats are used, including forests, grasslands, and barrier island sand dunes. Aquatic habitats are equally varied.	--	--	Resident
Birds					
Bald eagle	*Haliaeetus leucocephalus*	Found primarily near rivers and large lakes	--	--	Resident
Black rail	*Laterallus jamaicensis*	Salt, brackish, and freshwater marshes, pond borders, wet meadows, and grassy swamps. Nests in or along marsh edges	T	T	Possible migrant
Chestnut-collared longspur	*Calcarius ornatus*	Occurs in open shortgrass settings especially in patches with some bare ground.	--	--	Resident
Franklin's gull	*Leucophaeus pipixcan*	Nests in marshes and along inland lakes. Winters along coast in bays, estuaries and along sandy beaches.	--	--	Possible migrant
Golden eagle	*Aquila chrysaetos*	Habitat description is not available at this time	--	--	Resident
Lark bunting	*Calamospiza melanocorys*	Overall, a generalist in most shortgrass settings including ones with some brushy components.	--	--	Resident
Lesser prairie chicken	*Tympanuchus pallidicinctus*	Arid grasslands, generally interspersed with shrubs	LE	--	Resident
Mountain plover	*Charadrius montanus*	Nest on high plains or shortgrass prairie.	--	--	Resident
Northern Aplomado falcon	*Falco femoralis septentrionalis*	Open country, especially savanna and open woodland and sometimes in very barren areas. Grassy plains and valleys.	LE	--	Resident
Piping plover	*Charadrius melodus*	Beaches, sandflats and dunes along the Gulf Coast.	LT	--	Possible migrant
Rufa red knot	*Calidris canutus rufa*	Primarily seacoasts on tidal flats and beaches, herbaceous wetland, and tidal flats/shore.	LT	--	Possible migrant
Sprague's pipit	*Anthus spragueii*	Habitat during migration and in winter consists of pastures and weedy fields.	--=	--	Possible migrant
Western burrowing owl	*Athene cunicularia hypugaea*	Open grassland, especially prairie, plains, and savanna	--	--	Resident

[75] TPWD. 2024. Rare, Threatened, and Endangered Species of Texas – Baily, Briscoe, Castro, Cochran, Crosby, Dawson, Deaf Smith, Dickens, Floyd, Gaines, Garza, Hale, Hockley, Lamb, Lubbock, Lynn, Motley, Parmer, Swisher, Terry, and Yoakum counties. Accessed online August 9, 2024 at http://tpwd.texas.gov/gis/rtest/

Common Name	Scientific Name	Summary of Habitat Preference	USFWS Status[61]	TPWD Status[62]	Potential Occurrence in Counties
White-faced ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields. Currently confined to near-coastal rookeries, nests in marshes.	--	T	Possible migrant
Crustaceans					
Salt playa fairy shrimp	*Phallocryptus sublettei*	Saline playa lakes ranging from a few meters to a kilometer in diameter; usually very shallow.	--	--	Resident
Fish					
Arkansas River shiner	*Notropis Girardi*	Canadian River. Typically found in turbid water over mostly silt and shifting sand substrates.	LT	--	Resident
Chub shiner	*Notropis potteri*	Brazos, Colorado, San Jacinto, and Trinity river basins. Found in flowing water with silt or sand substrate.	--	T	Resident
Peppered Chub	*Macrhybopsis tetranema*	Historically found thoughout Arkansas River basin but is now only found in portions of the upper Canadian River upstream of Lake Meredith. Flowing water over coarse sand and fine gravel substrates in streams.	LE	--	Resident
Red River pupfish	*Cyprinodon rubrofluviatilis*	Native to Red River and Brazons River basins where typically found in saline waters of main channels and in saline springs.	--	T	Resident
Red River shiner	*Notropis bairdi*	Red River basin, typically found in turbid waters of broad, shallow channels of main stream, over bottom of silt and shifting sand.	--	--	Resident
Sharpnose shiner	*Notropis oxyrhynchus*	Range now restricted to upper Brazos River system upstream from Possum Kingdom Lake. May be native to Red and Colorado River basins. Typically found in turbid water over mostly silt and shifting sand substrates.	LE	E	Resident
Smalleye shiner	*Notropis buccula*	Appears to now be restricted to upper Brazos River system upstream of Possum Kingdom Lake. Typically in turbid waters of broad, sandy channels of main stream.	LE	E	Resident
Texas shiner	*Notropis amabilis*	Typical habitat includes rocky or sandy runs as well as pools.	--	--	Resident

Common Name	Scientific Name	Summary of Habitat Preference	USFWS Status[61]	TPWD Status[62]	Potential Occurrence in Counties
Insects					
No accepted common name	*Cicindela fulgoris albilata*	Habitat description is not available at this time.	--	--	Resident
American bumblebee	*Bombus pensylvanicus*	Habitat description is not available at this time.	--	--	Resident
No common name	*Bombus variabilis*	Habitat description is not available at this time.	--	--	Resident
No common name	*Eupseudomorpha brillians*	Habitat description is not available at this time.	--	--	Resident
Comanche harvester ant	*Pogonomyrmex comanche*	Habitat description is not available at this time.	--	--	Resident
Monarch butterfly	*Danaus Plexippus*		C	--	Migrant
Mammals					
Big brown bat	*Eptesicus fuscus*	Any wooded areas or woodlands except south Texas. Riparian areas in west Texas.	--	--	Resident
Big free-tailed bat	*Nyctinomops macrotis*	Prefers to roost in crevices and cracks in high canyon walls	--	--	Resident
Black-tailed prairie dog	*Cynomys ludovicianus*	Dry, flat, short grassland with low, sparse vegetation	--	--	Resident
Cave myotis bat	*Myotis velifer*	Colonial and cave dwelling, also roosts in rock crevices, old buildings, under bridges, and old Cliff Swallow nests.	--	--	Resident
Eastern red bat	*Lasiurus borealis*	Found in a variety of habitats in Texas. Usually associated with wooded areas. Highly migratory.	--	--	Resident
Eastern spotted skunk	*Spilogale putorius*	Generalist, open fields, prairies, croplands, fencerows, woodlands, etc.	--	--	Resident
Hoary bat	*Lasiurus cinereus*	Commonly found in unforested parts of the state and lowland deserts. Highly migratory.	--	--	Resident
Kit fox	*Vulpes macrotis*	Open desert grassland; avoids rugged, rocky terrain and wooded areas.	--	--	Resident
Long-tailed weasel	*Mustela frenata*	Includes brushlands, fence rows, upland woods and bottomland hardwoods, forest edges and rocky desert scrub. Usually close to water.	--	--	Resident
Mountain lion	*Puma concolor*	Rugged mountains and riparian zones.	--	--	Resident
Palo Duro mouse	*Peromyscus truei comanche*	Rocky, juniper-mesquite covered slopes of steep-walled canyons.	--	T	Resident
Pronghorn	*Antilocapra americana*	Prefers hilly, plateau areas of open grassland. Desert grassland and desert-scrub.	--	--	Resident
Swift fox	*Vulpes velox*	Restricted to current and historic shortgrass prairie	--	--	Resident

Commented [LT7]: No summary of habitat preference?

Common Name	Scientific Name	Summary of Habitat Preference	USFWS Status[61]	TPWD Status[62]	Potential Occurrence in Counties
Texas kangaroo rat	*Dipodomys elator*	Sandy loam surface soils with some clay to support short grasses.	PE	T	Resident
Townsend's big-eared bat	*Corynorhinus townsendii*	Variety of habitats, including from desert scrub to pinyon-juniper woodland, consistently in areas with canyons or cliffs.	--	--	Resident
Tricolored bat	*Perimyotis subflavus*	Forest, woodland and riparian areas. Caves are important to this species.	PE	--	Resident
Western hog-nosed skunk	*Conepatus leuconotus*	Woodlands, grasslands, and deserts up to 7,200 feet. Most common in rugged, rocky canyon country.	--	--	Resident
Western small-footed myotis bat	*Myotis ciliolabrum*	Usually in wooded areas, also found in grassland and desert scrub habitats.	--	--	Resident
Western spotted skunk	*Spilogale gracilis*	Brushy canyons, rocky outcrops (rimrock) on hillsides and walls of canyons.	--	--	Resident
Mollusks					
Edwards Plateau liptooth	*Daedalochila gracilis*	Habitat description is not available at this time.	--	--	Resident
Reptiles					
Dunes sagebrush lizard	*Sceloporus arenicolus*	Active and semi-stabilized sand dunes, dwarf shin-oak sandhills with sagebrush and yucca with open blowouts.	LE	--	Resident
Eastern box turtle	*Terrapene carolina*	Inhabits forests, fields, forest-brush, and forest-field ecotones.	--	--	Resident
Gray-checkered whiptail	*Aspidoscelis dixoni*	The habitat comprises rocky plains, dry washes, canyon bottoms, and desert scrub.	--	--	Resident
Roundtail horned lizard	*Phrynosoma modestum*	Seems to prefer rocky or gravelly substrates in open areas that are sparsely vegetated.	--	--	Resident
Slender glass lizard	*Ophisaurus attenuatus*	Variety of grassland, woodland and scrub habitats and areas near streams and ponds. Often in areas with sandy soils.	--	--	Resident
Texas garter snake	*Thamnophis sirtalis annectens*	Habitats used include the grasslands and modified open areas in the vicinity of aquatic features, such as, ponds, streams or marshes.	--	--	Resident
Texas horned lizard	*Phrynosoma cornutum*	Open, arid, and semi-arid regions with sparse vegetation	--	T	Resident

Common Name	Scientific Name	Summary of Habitat Preference	USFWS Status[61]	TPWD Status[62]	Potential Occurrence in Counties
Texas map turtle	*Graptemys versa*	Primarily a river turtle but can be found in reservoirs. Found in deep and shallow water with sufficient basking sites.	--	--	Resident
Western box turtle	*Terrapene ornata*	Prairie grassland, pasture, fields, sandhills, and open woodland.	--	--	Resident
Western massasauga	*Sistrurus tergeminus*	Shortgrass or mixed grass prairie, with gravel or sandy soils. Often found associated with more mesic habitats within the arid landscape.	--	--	Resident
Western rattlesnake	*Crotalus viridis*	Dry desert and prairie grasslands, shrub desert rocky hillsides, edges of arid and semi-arid river breaks.	--	--	Resident
Plants					
Cienega false clappia-bush	*Pseudoclappia arenaria*	Mostly in alkali sacaton grasslands on alkaline, gypseous or saline soils of alluvial flats around desert wetlands.	--	--	Resident
Correll's wild-buckwheat	*Eriogonum correllii*	Occurs on clay mounds, caprock, and rocky ledges on caliche substrates.	--	--	Resident
Cory's ephedra	*Ephedra coryi*	Dune areas and dry grasslands in southern Plains Country.	--	--	Resident
Cory's evening-primrose	*Oenothera coryi*	Calcareous prairies in the Plains Country.	--	--	Resident
Jones' selenia	*Selenia jonesii*	Wet clayey soils of stream margins, playa lakes, and roadsides.	--	--	Resident
Mexican mud-plantain	*Heteranthera mexicana*	Wet clayey soils along margins of playas in the Panhandle	--	--	Resident
Prairie butterfly-weed	*Gaura triangulate*	Open sandy areas.	--	--	Resident
Sticky tansy aster	*Xanthisma viscidum*	Occurs on calcareous or sandy soils in Chihuahuan Desert shrublands or mesquite grasslands.	--	--	Resident
Tall plains spurge	*Euphorbia strictior*	Occurs in shortgrass grasslands on dry rocky or, more commonly, deep sandy sites.	--	--	Resident
Texas barberry	*Berberis swaseyi*	Shallow calcareous stony clay of upland grasslands/shrublands over limestone as well as in loamier soils in openly wooded canyons and on creek terraces.			

Commented [LT8]: Missing USFWS/TPWD statuses and county

Common Name	Scientific Name	Summary of Habitat Preference	USFWS Status[61]	TPWD Status[62]	Potential Occurrence in Counties

Notes:
Acronyms: USFWS = U.S. Fish & Wildlife Service; TPWD = Texas Parks and Wildlife Department;
Statuses: E = State-listed Endangered; T = State-listed Threatened; PE = Proposed Endangered; PT = Proposed Threatened; C = Candidate for Listing; LE = Federally-listed Endangered; LT Federally-listed Threatened.

Additionally, the Region O planning area overlaps USFWS designated critical habitat for the sharpnose shiner and the smalleye shiner.

1.8 Identified Water Quality Concerns

1.8.1 Groundwater Quality

Ogallala Aquifer

The chemical quality of water in the Ogallala aquifer is generally fresh; however, both dissolved solids and chloride concentrations increase from north to south.

Seymour Aquifer

Water quality in these alluvial remnants generally ranges from fresh to slightly saline. In Motley and Dickens counties, where the Seymour Aquifer is located within the Llano Estacado Region, high total dissolved solids (TDS) and nitrate concentrations can occur.

Edwards-Trinity (High Plains) Aquifer

Water quality in the aquifer is typically fresh to slightly saline and is generally poorer in quality than water in the overlying Ogallala Aquifer. Water quality deteriorates near the saline lakes in Lynn, Dawson, Terry, and Gaines counties.

Dockum Aquifer

Concentrations of dissolved solids in the groundwater range from less than 1,000 milligrams per liter (mg/L) near the eastern outcrop to more than 35,000 mg/L in the deeper parts of the aquifer in Gaines, Garza, Hockley, Lubbock, Lynn, and Terry counties. Relatively high sodium concentrations make the water undesirable for irrigation use in some areas, although this aquifer is used for irrigation in other areas. Within the aquifer, high concentrations of uranium, nitrates, radium-226, and radium-228 have exceeded the Texas primary drinking water standards. Irrigation and public supply use is limited to the areas of the Dockum Aquifer where water quality is acceptable. The cities of Dickens, Happy, Hereford, and Tulia use or have used water from the aquifer. In addition, some livestock feedlots use water from the aquifer as their primary water supply.

1.8.2 Surface Water Quality

The TCEQ's *Texas Integrated Report of Surface Water Quality* evaluates the quality of surface waters in the state, provides resource managers with a tool for making informed decisions when directing agency programs, and describes the status of Texas' natural waters based on historical data and the extent to which they attain the Texas Surface Water Quality Standards. The Texas integrated report satisfies the requirements of the federal Clean Water Act Sections 305(b) and

303(d). Surface water stream segments and impairments identified by TCEQ[76] are shown in Table 1-20.

Table 1-20. Surface Water Stream Segments Identified by TCEQ[77]

Stream Segment[1]	Stream Name	County	Segment Class[2]	Impairment	Category	Year First Listed
0229B	Tierra Blanca Creek	Deaf Smith	Unclassified	No	n/a	n/a
0207	Lower Prairie Dog Town Fork Red River	Briscoe	Classified	Bacteria in water (recreational use)	5b	2006
1240A	White River above White River Reservoir	Floyd Crosby	Unclassified	No	n/a	n/a
0220	Upper Pease/North Fork Pease River	Floyd Motley	Classified	No	n/a	n/a
0221	Middle Fork Pease River	Motley	Classified	Chloride in water Sulfate in water Total Dissolved Solids in water	5c	2020 2020 2020
0227	South Fork Pease River	Motley	Classified	No	n/a	n/a
1241A	North Fork Double Mountain Fork Brazos River	Lubbock Crosby Garza	Unclassified	Bacteria in water (recreational use)	5c	2004
1241C	Buffalo Springs Lake	Lubbock	Unclassified	No	n/a	n/a
1238	Salt Fork Brazos River	Crosby Garza	Classified	Bacteria in water (recreational use) Chloride in water	5c	2020 2002
1240	White River Lake	Crosby	Classified	Chloride in water Total dissolved solids in water	5b	2002 2006
1239	White River	Crosby Garza	Classified	No	n/a	n/a
0218	Wichita/North Fork Wichita River	Dickens	Classified	Bacteria in water (recreational use)	5c	2022
0226	South Fork Wichita River	Dickens	Classified	Excessive algal growth in water Chloride in water	5c	2020 2006
1238A	Croton Creek	Dickens	Unclassified	No	n/a	n/a
1238B	Duck Creek	Dickens	Unclassified	Bacteria in water (recreational use)	5b	2022
1241D	South Fork Double Mountain Fork Brazos River upstream of confluence with North Fork Double Mountain Fork	Lynn Garza	Unclassified	No	n/a	n/a
1241B	Lake Alan Henry	Garza	Unclassified	Mercury in edible tissue	5c	2010

[76] TCEQ Surface Water Quality Viewer. https://tceq.maps.arcgis.com/apps/webappviewer/index.html?id=b0ab6bac411a49189106064b70bbe778

[77] TCEQ. 2024. Draft 2024 Texas Integrated Report – Texas 303(d) List (Category 5). https://www.tceq.texas.gov/downloads/water-quality/assessment/integrated-report-2024/2024-303d

Stream Segment[1]	Stream Name	County	Segment Class[2]	Impairment	Category	Year First Listed

Order of stream segments is based on reviewing the TCEQ Surface Water Quality Viewer and reviewing county by county from north to south and west to east.

[1]Stream segments are individually defined by the TCEQ and assigned unique identification numbers. Stream segments are intended to have relatively homogeneous chemical, physical, and hydrological characteristics and provide a basic unit for assigning site-specific standards and for applying water quality management programs of the agency.

[2]Classified segments, also referred to as designated segments, refer to water bodies that are protected by site- specific criteria. Unclassified waters are those smaller water bodies that do not have site-specific water quality standards assigned to them, but instead are protected by general standards that apply to all surface waters in the state.

Canadian River Basin

The principal water quality problems in the Canadian River Basin are elevated TDS and chloride levels. The Canadian River at the New Mexico-Texas state line is moderately saline during low flow due to natural conditions. The high chloride levels affect water quality in Lake Meredith. CRMWA, owner of the lake, has implemented a chloride control project to alleviate this problem. Work to further reduce chlorides in the Canadian River Basin is ongoing.

Red River Basin

High concentrations of TDS, sulfate, and chloride are a general problem in most streams of the Red River Basin under low flow conditions. These high salt concentrations are caused, in large part, by natural conditions due to the presence of saltwater springs, seeps, and gypsum outcrops. Saltwater springs are located in the western portion of the basin in the upper reaches of the Wichita River, the North and South Forks of the Pease River and the Little Red, which is a tributary to the Prairie Dog Town Fork of the Red River. Gypsum outcrops are found in the area ranging westward from Wichita County to the High Plains Caprock Escarpment. The water in these areas usually contains extremely high levels of dissolved solids. At times, TDS are comparable to those found in seawater. However, the streams supply practically no water to the Llano Estacado Region.

Brazos River Basin

Water quality in most reaches of the upper Brazos River Basin is considered to be fresh, although in some areas of the upper basin, high concentrations of natural salt contribute salt loads to area streams and rivers. Primary sources of salt include the watersheds of the Double Mountain and Salt Forks of the river. The Brazos River segment from the confluence with the Salt Fork of the Brazos River in Kent County to White River Dam in Crosby County contains above average concentrations of chloride, sulfate, and TDS. As White River Lake is a source of water for some cities in the region, this quality condition is important to this regional water supply planning effort.

Colorado River Basin

The Colorado Basin flows from Dawson County to Matagorda Bay and the Gulf of Mexico. Due to a lack of perennially flowing streams in the upper Colorado River Basin, there are no regularly monitored water quality gauging stations along these streams (i.e., no water, no water quality concerns). There are no Llano Estacado Region reservoirs in this basin, and the one nearest to the Llano Estacado Region is J.B. Thomas, which has good water quality, but has had issues with TDS,

chloride, and sulfates. Downstream of the reservoir, there are some issues with chlorides, low dissolved oxygen, and fecal coliform bacteria[78].

1.8.3 Natural Chlorides

Chloride contamination of groundwater in the Ogallala Aquifer occurs in several of the southern counties in the Llano Estacado Region. Stormwater runoff collects in lake basins, as does water discharged from springs from the Ogallala Aquifer. When the water evaporates from the basins, the minerals remain. When these minerals dry, they can be dissolved in rainwater and enter the aquifer.

1.8.4 Saltwater Disposal

Oilfields developed throughout the Llano Estacado Region contribute brine to area aquifers, lakes, streams, and rivers. Collective efforts of several state and local agencies have led the oil industry to eliminate the evaporation pit method of brine disposal. By the 1980s, most of the produced oilfield brine, not used in secondary recovery operations, was being properly disposed of by injection into deep formations. Both injection and disposal operations are performed under permits issued by the Railroad Commission of Texas. However, residual salts contained in and on soils near disposal sites that were in existence prior to the 1980s continue to seep into groundwater aquifers in the general proximity of each active or inactive oilfield. Other contributing sources are identified as originating from failures of abandoned wells that were improperly plugged, commingling between saltwater injection zones and freshwater formations, and accidental spills.

1.8.5 Urban Stormwater Runoff

Stormwater runoff from city streets generated during a storm event is perceived as a source of possible contamination of surrounding playa lake basins. Water in urban playa lakes in Lubbock is regularly monitored.

1.8.6 Nutrients Associated with Agricultural Production

The semi-arid climate, uniform topography, low-permeability soils, large depth to groundwater, and gradually sloping terrain of the Llano Estacado Region restrict the movement of agricultural nutrients. The geographic features of the region, in combination with farm and livestock management practices, reduce the threat to surface water and groundwater quality.

1.9 Identified Threats to Agriculture and Natural Resources

The Llano Estacado Region's agricultural business relies on groundwater for irrigation and water for livestock. The most important threat to agricultural and natural resources is the continuing groundwater depletion in the region. The Llano Estacado Region also recognizes the following additional potential threats to agricultural and natural resources:

- Shortage of freshwater and economically accessible groundwater attributable to increased irrigation demands;

[78] LCRA, 2024. 2014 Basin Highlights Report. lcra.org/download/2024-lcra-basin-highlights-report/?wpdmdl=33817

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- Sedimentation of surface water resources;
- Spread of invasive species, including salt cedar, juniper, zebra mussels, and golden algae, into surface water resources;
- Drought impact on reservoir levels;
- Improper land management practices of playa lakes;
- Water quality changes due to pesticide and fertilizer runoff, livestock operations, and modification of native wetland vegetation;
- Potential impacts to threatened, endangered, and other species of concern; and
- Water quality changes due to leaking abandoned wells (oil, gas, and water) and related industry infrastructure (pipelines, tank batteries).

1.10 Existing Local and Regional Water Plans

1.10.1 Regional Water Planning

City of Lubbock's 2018 Strategic Water Supply Plan

Commented [JS9]: Lubbock has not updated yet (09/09/2024)

The City of Lubbock developed the 2018 Strategic Water Supply Plan (SWSP) to actively plan for future water supplies. The SWSP provides a "road map" to guide the development and implementation of cost-effective and sustainable water supplies over the next 100 years[79]. This 2018 SWSP includes multiple strategies to diversify the City of Lubbock's water supply portfolio to minimize risk associated with variable climatic conditions while emphasizing conservation efforts to delay expensive water supply projects. This 2018 SWSP is a comprehensive update of the 2013 SWSP and will be updated in the future as additional information about specific strategies becomes available or as conditions change.

1.10.2 State Water Planning

SB1 was enacted by the 75th Session of the Texas Legislature in 1997. It specified that water plans be developed for regions of Texas and that future regulatory and financing decisions of the TCEQ and the TWDB be consistent with approved regional water plans. Furthermore, SB1 specified that regional water planning groups submit a regional water plan by January 2001, and at least as frequently as every 5 years thereafter, for TWDB approval and inclusion in the state water plan.

2021 Llano Estacado Region Water PlanRegional water plans form the basis of the state water plan. The LERWPG approved the final 2021 Llano Estacado Region plan and it was submitted to the TWDB in September 2021. The strategies recommended by the 2021, and previous 2016, regional water plans for the Llano Estacado Region are shown in Table 1-21.

[79] City of Lubbock 2018. Strategic Water Supply Plan. https://ci.lubbock.tx.us/storage/images/4G1plUEKJzRJftCGkkPQyFewa9PVdySLl4ekNLWV.pdf

Table 1-21 Recommended Projects from 2016 and 2021 LERWPs[80]

Water Management Strategies	2016 Regional Water Plan	2021 Regional Water Plan
Municipal conservation	√	√
Agricultural conservation	√	√
Manufacturing conservation		√
Local groundwater development	√	√
Water reuse	√	√
Water Loss Reduction	√	
Brackish groundwater desalination	√	√
Bailey County Well Field Capacity Maintenance	√	√
Brackish Well Field at the South Water Treatment Plant	√	
CRMWA Aquifer Storage and Recovery	√	√
Direct Potable Reuse to North Water Treatment Plant		√
Jim Bertram Lake 7	√	√
Lake Alan Henry Phase 2	√	√
North Fork Scalping Operation	√	
South Lubbock Well Field	√	
Plainview Aquifer Storage and Recovery		√
South Garza Water Supply	√	
Seminole Groundwater Desalination (Alternative)		√
Brackish Supplemental Water Supply for Bailey County Well Field (Alternative)		√
Direct Potable Resue to South Water Treatment Plant (Alternative)		√
North Fork Diversion at CR 7300 (Alternative)		√
North Fork Diversion to Lake Alan Henry Pump Station (Alternative)		√
Post Reseroir (Alternative)		√
South Fork Discharge (Alternative)		√

WMS = water management strategy; CRMWA = Canadian River Municipal Water Authority

2022 State Water Plan

In *Water for Texas 2022 State Water Plan* (2022 State Water Plan)[81], the TWDB used information and recommendations from the 16 individual 2021 regional water plans developed by the regional water planning groups (RWPGs) established under SB1. In the State Water Plan, the TWDB acknowledges that each RWPG identified many of the same basic recommendations to meet future water demands. These recommendations include continuing regional planning funding, supporting groundwater conservation districts, controlling brush, reusing water, continuing support of

[80] TWDB. 2021. Llano Estacado Regional Water Plan. https://www.twdb.texas.gov/waterplanning/rwp/plans/2021/index.asp

[81] TWDB. 2022. State Water Plan: WATER FOR TEXAS. https://www.twdb.texas.gov/waterplanning/swp/2022/index.asp

groundwater availability modeling, providing conservation education, ongoing funding for groundwater supply projects, and supporting alternative water management strategies.

The 2022 State Water Plan projected a Llano Estacado Region water shortage of 1,500,000 ac-ft/yr in 2070[82]. The Llano Estacado Region had the highest unmet needs of any region in Texas, with most of this shortage occurring as irrigation needs. The 2022 State Water Plan recommended potential new water supply mostly in the form of existing supply made available through conservation and other water management strategies.

1.11 Historic Droughts of Record

In terms of severity and duration, the devastating drought of the 1950s is considered the drought of record (DOR) for most of Texas. In 1956, 244 of the 254 counties in the state were considered disaster areas. At that time, the 1950s drought included the second, third, and eighth driest years on record (1956, 1954, and 1951, respectively). This drought lasted almost a decade in many places and affected numerous states across the nation.

The Llano Estacado Region has experienced two recent droughts in 1996 and 2011 that were significant enough to necessitate considering them as DORs for the planning region. In 2011, severely decreased precipitation resulted in substantial declines in streamflow throughout Texas. Record high temperatures also occurred June through August leading to increased evaporation rates. The evaporation was so great that by August 4, 2011, state climatologist John Nielson-Gammon declared 2011 to be the worst 1-year drought on record in Texas[83]. The 2011 water year statewide annual precipitation was 11.27 inches, more than 2 inches less than the previous record low of 13.91 inches in 1956. In 2011, measured precipitation in the City of Lubbock equaled 5.86 inches, almost 3 inches less than the previous record of 8.73 inches in 1917[84].

1.12 Drought Preparations

Llano Estacado Region WUGs can prepare for drought by participating in the regional planning process, which attempts to meet projected water demands during a drought of severity equivalent to the DOR. In addition, WWPs and most municipalities develop individual drought contingency plans or emergency action plans to be implemented at each drought stage.

1.12.1 Overall Assessment of Local Drought Contingency Plans

Predicting the timing, severity and length of a drought is an inexact science; however, it is an inevitable component of the Texas climate. For this reason, it is critical to plan for these occurrences with policy outlining adjustments to the use, allocation, and conservation of water in response to

[82] TWDB. 2022. State Water Plan: WATER FOR TEXAS. Table https://www.twdb.texas.gov/waterplanning/swp/2022/index.asp

[83] Winters, K.E., 2013, A historical perspective on precipitation, drought severity, and streamflow in Texas during 1951-56 and 2011: U.S. Geological Survey Scientific Investigations Report 2013-5113, p. 1 http://pubs.usgs.gov/sir/2013/5113

[84] Nation Weather Service. 2011. NWS Lubbock 2011 Year End Summary. https://www.weather.gov/lub/events-2011-20111231-summary

drought conditions. Drought and other circumstances that interrupt the reliable supply or water quality of a source often lead to water shortages. During a drought period, there generally is a greater demand on the already decreased supply as individuals attempt to maintain landscape vegetation through irrigation because less rainfall is available. This added demand can further exacerbate a water supply shortage situation.

TCEQ requires wholesale public water suppliers, retail public water suppliers serving 3,300 connections or more, and irrigation districts to submit drought contingency plans. In accordance with the requirements of TAC §288(b), drought contingency plans (DCPs) must be updated every 5 years and adopted by retail public water providers. TCEQ defines a DCP as "A strategy or combination of strategies for temporary supply and demand management responses to temporary and potentially recurring water supply shortages and other water supply emergencies." [85] According to a TCEQ handbook[86], the underlying philosophy of drought contingency planning is that

- While often unpreventable, short-term water shortages and other water supply emergencies can be anticipated,
- The potential risks and impacts of drought or other emergency conditions can be considered and evaluated in advance of an actual event; and, most importantly,
- Response measures and best management practices (BMPs) can be determined with implementation procedures defined, again in advance, to avoid, minimize, or mitigate the risks and impacts of drought-related shortages and other emergencies.

Model DCPs are available on TCEQ's website; however, it is not possible to create a single DCP that will adequately address local concerns for entities throughout the State of Texas. The conditions that define a water shortage can be location specific and depend on the water supply source. For example, some communities rely on LAH, yet others rely on groundwater aquifer systems that are considered at risk under location-specific conditions. While the approach to planning may be different between entities, DCPs should include the following.

- Specific, quantified targets for water use reductions,
- Drought response stages,
- Triggers to begin and end each stage,
- Supply management measures,
- Demand management measures,
- Descriptions of drought indicators,
- Notification procedures,
- Enforcement procedures,
- Procedures for granting exceptions,
- Public input to the plan,
- Ongoing public education,
- Adoption of plan, and

[85] TCEQ. Retail and Wholesale Requirements for Water Conservation & Drought Contingency Plans http://www.twdb.texas.gov/conservation/training/archives/more-than-a-drop-workshop/doc/5_%20TCEQ%20Rules.pdf

[86] TCEQ. 2005. Handbook for Drought Contingency Planning for Retail Public Water Suppliers, Austin, Texas. April 2005.

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- Coordination with regional water planning groups.

For water suppliers such as those in Llano Estacado Region, the primary goal of DCP development is to have a plan that can ensure an uninterrupted supply of water in an amount that can satisfy essential human needs. A secondary but also important goal is to minimize negative impacts on quality of life, the economy, and the local environment. In order to meet these goals, action needs to be taken in an expedient, pre-determined procedure, requiring that an approved DCP be in place before drought conditions occur.

In accordance with TAC, most Llano Estacado Region entities have submitted DCPs to implement when local shortages occur. The Llano Estacado Region was able to obtain DCPs for multiple WUGs and WWPs. These plans identify multiple triggers for initiation and termination of drought stages, responses to be implemented and reduction targets based on each stage. The plans also include information regarding public notification procedures and enforcement measures.

1.12.2 Summary of Existing Triggers and Responses

Through timely implementation of drought response measures, it is possible to meet DCP goals by avoiding, minimizing, or mitigating risks and impacts of water shortages and drought. Therefore, DCPs are built around a collection of drought responses and triggers based on each drought stage. Stages are generally similar in DCPs, but can vary from entity to entity. Stage I will normally represent mild water shortage conditions and the severity of the situation will increase through the stages until emergency water conditions are reached and, in some cases, a water allocation stage is determined.

The LERWPG compiled stage, trigger, and response information from DCPs in the region and summarized in Chapter 6, including those from WUGs, WWPs, and other entities. Compliance in most of the DCPs in the region is voluntary under Stage I and mandatory under Stage II and Stage III. Most entities included a Stage IV and a few plans specify Stage V and/or Stage VI scenarios. Target reductions, triggers, and responses are included for most stages in DCPs for Llano Estacado Region entities.

1.13 TWDB Water Loss Audits

In accordance with 31 TAC§357.7(a)(1)(M), the 2026 LERWP includes information compiled by the TWDB from water loss audits performed by retail public utilities of the Llano Estacado Region pursuant to 31 TAC§358.6.

In addition, in accordance with 31 TAC 357.7 (a)(7)(A)(iv), the LERWPG shall consider strategies to address any issues identified in the information compiled by the TWDB from the water loss audits performed by retail public utilities pursuant to 31 TAC§358.6.

House Bill 3338 (HB 3338) required the TWDB to compile the information included in the water audits by type of retail public utility and by RWPA, and to provide that information to the regional planning groups for use in identifying appropriate water management strategies (WMSs) in the development of their regional water plan. Retail public water suppliers are required to submit to the TWDB a water loss audit once every 5 years. The water supplies that have an active financial obligation with the TWDB or have 3,300 connections must submit an audit annually. The TWDB

reported these data in the 2014, 2018, and 2022 water loss audits. The methodology used for the water loss audit forms relies upon self-reporting data provided by public utilities, and the self-reported data may then be unreliable and in need of further refinement. This water loss audit provides utilities with understanding of water loss in the distribution system and water loss over time.

The 2026 regional water planning development is based on utility-based planning for municipal WUGs, as delineated by water provider service areas, rather than political boundaries. The municipal WUGs include the following.

- Retail public utilities owned by a political subdivision providing more than 100 ac-ft/yr of water for municipal use;
- Privately-owned utilities that request inclusion as an individual WUG, provide more than 100 ac-ft/yr for municipal use for each owned water system, and are approved for inclusion as an individual WUG by the RWPG;
- State or federal-owned water systems that request inclusion as an individual WUG, provide more than 100 ac-ft/yr for municipal use, and approved for inclusion as an individual WUG by the RWPG; and
- Collective reporting units (CRU), or groups of retail public utilities that have a common association and are requested by the RWPG.

The TWDB provided the water loss data for 19 public utilities of the Llano Estacado Region that filed a water loss audit report for 2022 (Table 1-22). The City of Lubbock's 2023 data has been appended to the table because 2022 data was not reported and Lubbock represents the largest public utility in the region. Twenty five percent of the 20 total entities report total losses exceeding 15 percent. The total losses for these reporting WUGs range from 1.5 percent to 26 percent. In accordance with 31 TAC§357.30, the LERWPG has considered strategies to reduce water losses as further described in Chapter 5.

Table 1-22. Summary of Water Loss Percentages Based on 2022 TWDB Water Loss Report

Water User Group	County Name	Total Apparent Losses (gallons)	Total Real Losses (gallons)	Total Loss (%)
City of Quitaque	Briscoe	2,945,042	5,695,969	16.7
Silverton Municipal Water System	Briscoe	922,441	6,307,625	26.1
City of Lorenzo	Crosby	499,681	5,827,589	14.2
City of Dickens	Dickens	1,129,292	1,709,701	18.8
Valley WSC	Dickens	75,893	2,141,008	14.5
City of Lockney	Floyd	5,190,631	6,859,081	12.0
City of Seminole	Gaines	15,612,010	141,456,234	23.8
Plainview Municipal Water System	Hale	73,201,131	48,624,098	4.1
City of Anton	Hockley	4,230,481	13,746,891	24.2
City of Smyer	Hockley	357,493	2,412,332	14.3
City of Levelland	Hockley	15,335,327	99,313,102	13.8
City of Idalou	Lubbock	13,649,450	5,139,481	3.7
City of Shallowater	Lubbock	5,321,693	2,124,114	1.5
City of Wolfforth	Lubbock	4,458,966	5,493,974	1.8
City of New Deal	Lubbock	1,481,708	700,010	2.5
Lubbock Public Water System[1]	Lubbock	359,155,436	573,047,977	4.5
City of Wilson	Lynn	665,493	2,477,906	14.0

Water User Group	County Name	Total Apparent Losses (gallons)	Total Real Losses (gallons)	Total Loss (%)
City of New Home	Lynn	640,123	1,885,326	11.1
City of Tahoka	Lynn	2,041,125	4,654,080	3.7
City of Wellman	Terry	194,677	1,365,361	15.5

[1]Data from the 2023 Water Loss Report from TWDB
MWD = municipal water district; WSC = water supply corporation

1.14 Identification of Threats to Agricultural and Natural Resources and Water Management Strategy Evaluation

Regional water plan guidelines require identifying threats to agricultural and natural resources and discussions about how they will be addressed or affected by WMSs evaluated in the regional water plan. These environmental impacts include possible effects to agriculture, natural resources, wildlife habitat, cultural resources, and environmental water needs. Each WMS evaluation (presented in Chapter 5) includes a discussion of these environmental considerations and potential impacts associated with project implementation. The summary at the end of each WMS summary in Chapter 5 also includes water quality concerns and a table of wildlife species that could potentially be impacted by the proposed WMS.