2026 PANHANDLE WATER PLAN

Initially Prepared Plan / Volume I / Main Report

INITIALLY PREPARED PLAN. VOLUME I. MAIN REPORT.

2026 PANHANDLE WATER PLAN
INITIALLY PREPARED PLAN

MARCH 2025

Prepared for:

PANHANDLE WATER PLANNING GROUP

DRAFT	DRAFT
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PREFACE

In 1997, the 75th Texas Legislature passed Senate Bill One, legislation designed to address Texas water issues. Senate Bill One put in place a grass-roots regional process to plan for the future water needs of all Texans. To implement this process, the Texas Water Development Board created 16 regional water planning groups across the state and established regulations governing regional planning efforts. This plan presents the results of this process for the Panhandle Water Planning Area that represents 21 counties in the Texas Panhandle.

In accordance with the State planning guidelines, the regional water plan includes ten specific chapters. In addition to the ten required sections, this report also includes appendices providing more detailed information on the planning efforts. The elements contained in this plan meet Texas Water Development Board regional planning requirements and guidelines.

2026 Panhandle Water Plan Chapters

1. Planning Area Description
2. Current and Projected Population and Water Demand
3. Evaluation of Regional Water Supplies
4. Identification of Water Needs
5. Water Management Strategies
6. Impacts of the Regional Water Plan
7. Drought Response Information, Activities and Recommendations
8. Regulatory, Administrative and Legislative Recommendations
9. Implementation and Comparison to Previous Regional Water Plan
10. Plan Adoption and Public Participation

The *2026 Panhandle Water Plan* represents the culmination of five years of working together with the PWPG, regional and local water providers, and the public. As you read this water plan, the PWPG would like you to keep in mind the following points:

- The *2026 Panhandle Water Plan* presents a comprehensive overview of the water supply issues in the region. It does not predict or forecast future water droughts or floods.
- This plan is a living document that will change as new data become available that better represent the demands on our water resources, available supplies from these resources, and the water supply projects that are being pursued.
- The report presents planning level analyses of the recommended water management strategies. Additional engineering studies and design will be needed prior to the implementation of the strategies.
- The specific surpluses and needs shown in the plan should be treated with caution because their development requires certain assumptions that may or may not come to fruition.
- The PWPG has no authority to regulate water supplies or implement water management strategies. The identified water management strategies are assumed to be implemented by the respective water user.

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2026 PANHANDLE WATER PLAN. VOLUME II. APPENDICES.

LIST OF ACRONYMS

Acronym	Name	Meaning
ASR	Aquifer Storage and Recovery	A type of water management strategy that stores water underground for future extraction and use
CRMWA	Canadian River Municipal Water Authority	Water authority that operates Lake Meredith and a well field in Roberts County.
DFC	Desired Future Condition	Criteria for which is used to define the amount of available groundwater from an aquifer.
GAM	Groundwater Availability Model	Numerical groundwater flow model. GAMs are used to determine the aquifer response to pumping scenarios. These are the preferred models to assess groundwater availability.
GCD	Groundwater Conservation District	Generic term for all or individual state recognized Districts that oversee the groundwater resources within a specified political boundary.
GMA	Groundwater Management Area	Sixteen GMAs in Texas. Tasked by the Legislature to define the desired future conditions for major and minor aquifers within the GMA.
MAG	Modeled Available Groundwater	The MAG is determined by the TWDB based on the DFC approved by the GMA. Once the MAG is established, this value must be used as the available groundwater in regional water planning.
MWP	Major Water Provider	A WUG or WWP of particular significance to the region’s water supply as determined by the regional water planning group.
PDWD	Palo Duro Water District	Water district that operates Palo Duro Reservoir in Hansford County.
PGMA	Priority Groundwater Management Area	Area designated by TCEQ for purposes of protecting the groundwater resources within the area.
PWPA	Panhandle Water Planning Area	The 21-county area in the Texas Panhandle that comprises the regional water planning area for this plan. Also referred to as Region A.
PWPG	Panhandle Water Planning Group	Regional planning group comprised of representatives from diverse interest groups. Responsible for development of five year regional water plans in the Texas Panhandle.

Acronym	Name	Meaning
RWPG	Regional Water Planning Group	The generic term for the planning groups that oversee the regional water plan development in each respective region in the State of Texas
SB1	Senate Bill One	Legislation passed by the 75th Texas Legislature that is the basis for the current regional water planning process.
SB2	Senate Bill 2	Legislation passed by the 77th Texas Legislature that built on policies created in SB1.
TCEQ	Texas Commission on Environmental Quality	Texas Agency charged with oversight of Texas surface water rights and WAM program.
TWDB	Texas Water Development Board	Texas Agency charged with oversight of regional water plan development and oversight of GCDs
WAM	Water Availability Model	Computer model of a river watershed that evaluates surface water availability based on Texas water rights.
WMS	Water Management Strategy	Strategies available to RWPG to meet water needs identified in the regional water plan.
WUG	Water User Group	A group that uses water. Six major types of WUGs: municipal, manufacturing, mining, steam electric power, irrigation and livestock.
WWP	Wholesale Water Provider	Entity that has or is expected to have contracts to sell wholesale water.

EXECUTIVE SUMMARY

Introduction

Executive Summary Related Documents

- Attachment ES 1: County Summaries
- Appendix I: TWDB Database

In 1997, Senate Bill 1 (SB1) began a comprehensive water planning and management effort using a "bottom up" approach to ensure that the water needs of all Texans are met as we entered the 21st Century. Regional water plans map out how to conserve water supplies, meet future water supply needs and respond to future droughts in the planning areas. The Panhandle Water Planning Group (PWPG) was formed to develop a 50-year regional water plan for the Panhandle Water Planning Area (PWPA). Since the initiation of this process, the PWPG has overseen the development of five regional water plans. This plan is the sixth regional water plan, which is an update of the 2021 Regional Water Plan for the PWPA.

The 2026 Panhandle Water Plan consists of 10 chapters that identify the water needs in the region and then maps out a path to conserve water supplies, meet future water supply needs, and respond to future droughts. Associated data necessary in developing the plan is included in several appendices. All of the TWDB rules, guidance, and regulations were followed and compliance with them is documented in **Appendix E**. The plan's required database (DB27) reports can be accessed through the TWDB Database Reports application at https://www3.twdb.texas.gov/apps/SARA/reports/list and following the steps below.

1. Enter '2026 Regional Water Plan' into the "Report Name" field to filter to all DB27 reports associated with the 2026 Regional Water Plans
2. Click on the report name hyperlink to load the desired report
3. Enter the planning region letter parameter, click view report

The tables available for access in DB27 are listed below.

1. WUG Population
2. WUG Water Demand
3. Source Availability
4. WUG Existing Water Supply
5. WUG Needs/Surplus
6. WUG Second-Tier Identified Water Need
7. WUG Data Comparison to 2021 RWP
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9. WUG Unmet Needs
10. Recommended WUG Water Management Strategies
11. Recommended Projects Associated with Water Management Strategies
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17. Sponsored Recommended WMS Supplies Unallocated to WUGs
18. MWP Existing sales and Transfers
19. MWP WMS Summary

The 2026 Panhandle Initially Prepared Water Plan was developed under the direction of the Panhandle Water Planning Group and adopted by the planning group on February 18, 2025. This report presents the results of a five-year planning effort to develop a plan for water supply for the region through 2080.

Planning Area Description

The PWPA consists of a 21-county area that includes Armstrong, Carson, Childress, Collingsworth, Dallam, Donley, Gray, Hall, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Potter, Randall, Roberts, Sherman, and Wheeler Counties (see **Figure ES-1**).

The economy and water use in the PWPA is heavily driven by agriculture and supporting agribusiness and manufacturing. The petroleum industry and tourism continue to contribute to the regional economy. As such the major water uses include irrigation, agricultural production, petroleum refining, food processing and kindred, chemical and allied products, and electric power generation.

Non-agricultural water use is generally provided through cities, wholesale water providers or developed directly from underlying aquifers.

Population and Water Demand Projections

In 2020, the region accounted for 1.4 percent of the State's total population and approximately 15 percent of the State's annual water demand. Projections show total water use for the region will decline over the 2030-2080 period, primarily due to an expected reduction in agricultural irrigation water requirements. Irrigation water use is expected to decline because of projected insufficient quantities of groundwater to meet future irrigation water demands, implementation of conservation practices, advances in plant breeding, implementation of new crop varieties, and the use of more efficient irrigation technology.

Figure ES-1: Cities in the PWPA

Regional population is expected to grow from 407,985 in 2030 to 470,326 in 2080. Much of this growth is located in larger cities and surrounding rural areas. Projections for water demand indicate that total annual water usage in the PWPA will decrease from 2,154,499 acre-feet in 2030 to 1,741,572 acre-feet in 2080. Hartley County has the highest projected water use of 414,117 acre-feet per year in 2030 decreasing to 285,725 acre-feet per year by 2080. Dallam County and Sherman County demands are slightly less but similar in demand levels. For all three of these counties, irrigation use accounts for approximately 94-98 percent of the demand. Only Randall County has substantial projected increases in demand during the planning period. This is due to the projected increases in municipal demand associated with Amarillo and surrounding areas. The remaining 21 counties are projected to have slight increase, flat or decreased projected water demand during the planning period, which is mostly attributed to declining irrigation demands.

PWPA Major Water Providers

- City of Amarillo
- Greenbelt Municipal and Industrial Water Authority (Greenbelt MIWA)
- Canadian River Municipal Water Authority (CRMWA)
- City of Borger

Table ES-1: Projected Population and Water Demands in PWPA

	2030	2040	2050	2060	2070	2080
Population	407,985	426,366	439,607	449,783	460,031	470,326
Water User Group	**Water Demands (ac ft/yr)**					
Irrigation	1,938,018	1,938,018	1,803,413	1,686,459	1,577,427	1,497,833
Livestock	55,766	58,665	59,266	59,883	60,511	61,158
Manufacturing	46,497	48,217	49,999	51,848	53,766	55,755
Mining	9,677	9,726	9,776	9,829	9,885	9,943
Municipal	89,541	92,961	95,607	97,655	99,751	101,883
Steam Electric Power	15,000	15,000	15,000	15,000	15,000	15,000
Total	**2,154,499**	**2,162,587**	**2,033,061**	**1,920,674**	**1,816,340**	**1,741,572**

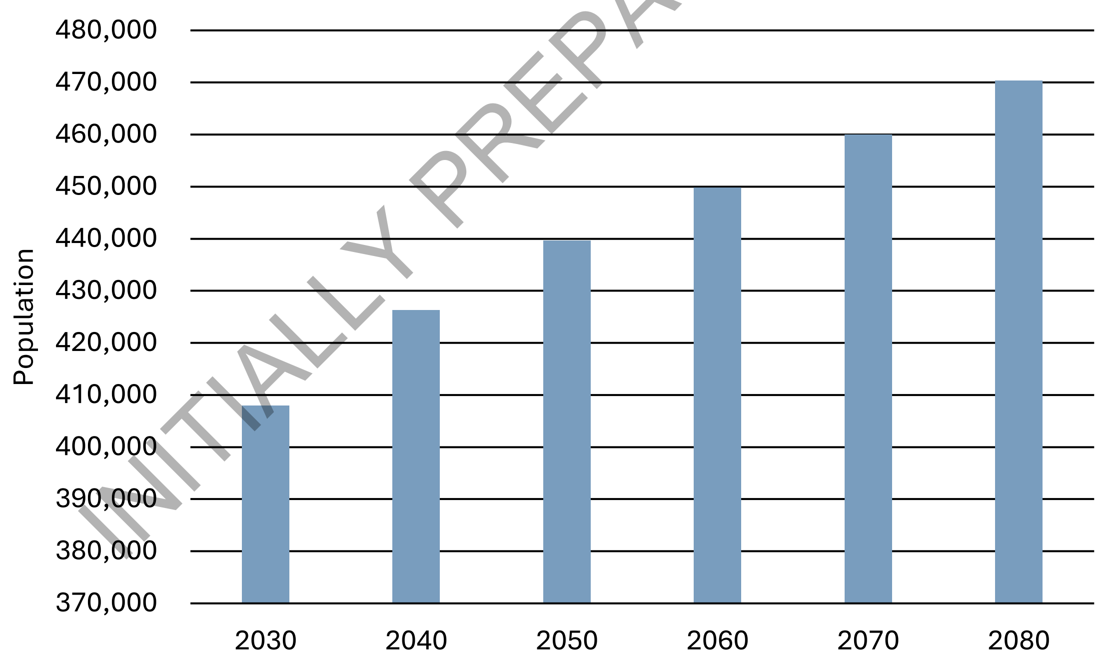


Figure ES-2: PWPA Population

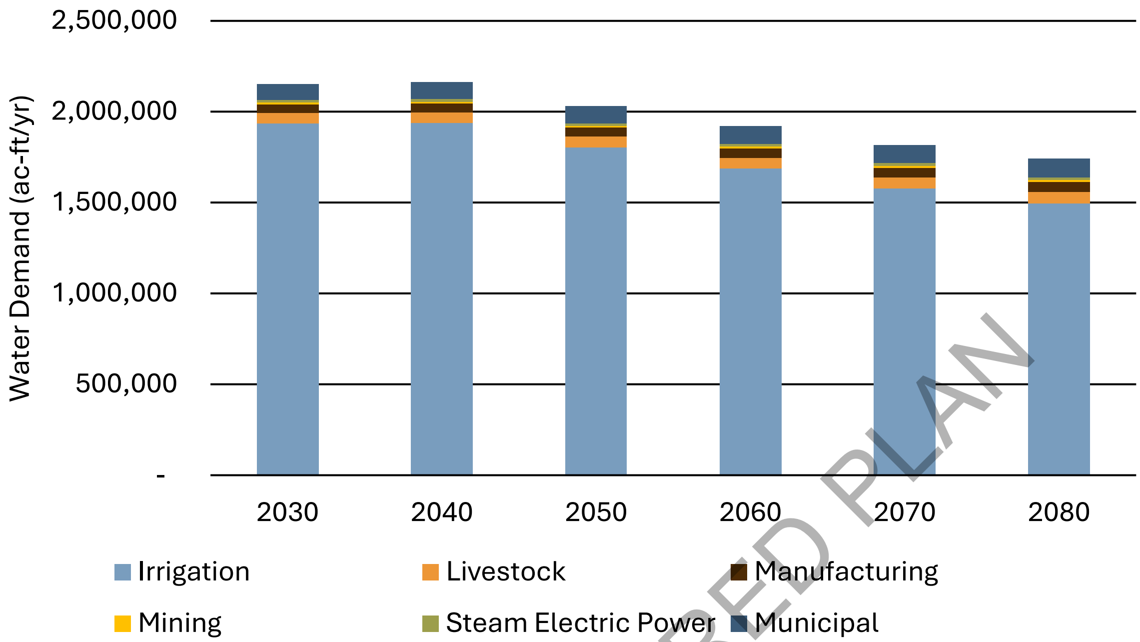


Figure ES-3: Projected Demands in the PWPA

Water Supply Analysis

The PWPA is located within portions of the Canadian River Basin and Red River Basin. In 2020, only one percent of the total water use in the PWPA came from surface water sources. There are three major reservoirs in the PWPA: Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir. According to the TCEQ's State of Texas Water Quality Inventory, the principal water quality problems in the Canadian and Red River Basins are elevated dissolved solids, nutrients, nitrates and dissolved metals.

Water Supply in PWPA

- 2 River Basins: Red River, Canadian River
- 2 Major aquifers: Ogallala & Seymour
- 3 Minor aquifers: Dockum, Blaine & Rita Blanca
- 4 Billion acre feet per year of supply

Surface water supplies in the region were determined through water availability models (WAM) and other hydrologic modeling of the Red and Canadian Basins. The challenge with determining reliable surface water supply in the PWPA is that the region is in critical drought conditions. Record low inflows in the Canadian and upper Red River Basins have severely impacted water availability in the region. For planning purposes, estimates of reliable supply from Lake Meredith and Greenbelt Reservoir were assessed based on extended hydrology through 2017. For Palo Duro Reservoir, the current yield was estimated using a mass balance reservoir model with hydrology through 2022. This resulted in changes to available surface water supplies in the region (see **Table ES-2**). Lake Meredith and Greenbelt Reservoir are shown to have similar reliability to that shown in the 2021 Plan. For both Lake Meredith and Greenbelt Reservoir, this 2026 Plan uses the one-year safe yield for supply availability, which is defined as the amount of water that can be diverted annually, leaving a minimum of a one-year supply in reserve during the critical period. Palo Duro Reservoir has no supply under a safe yield analysis.

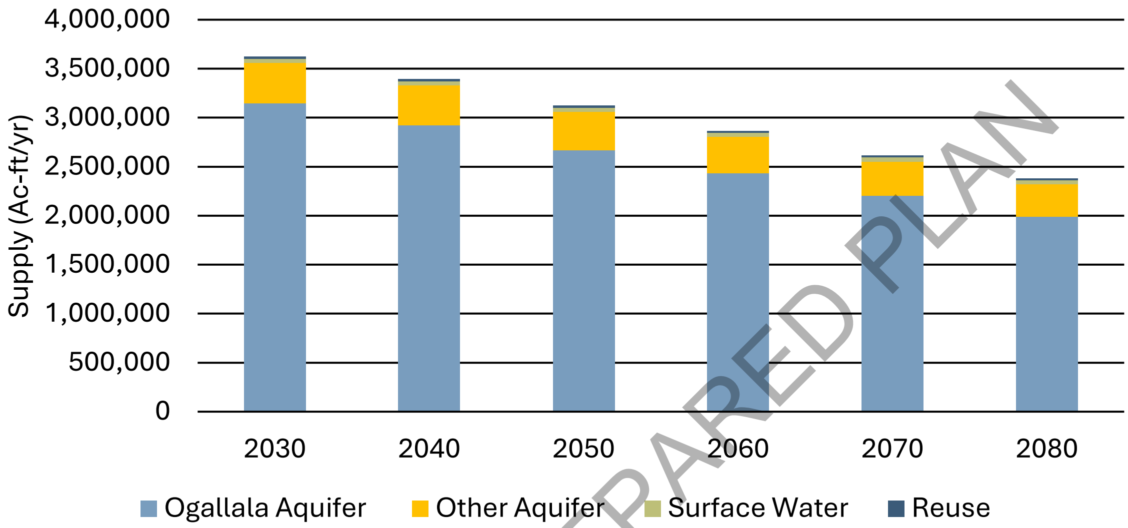


Figure ES-4: Total Available Supplies in the PWPA[1]

Groundwater sources in the PWPA include two major and three minor aquifers. These include the Ogallala, Seymour, Blaine, Dockum, and Rita Blanca aquifers. The Rita Blanca aquifer underlies the Ogallala aquifer in the northwestern part of the region, and it was analyzed as part of the Ogallala aquifer. Groundwater availability in the PWPA is based on desired future conditions as adopted through the joint planning process. These desired future conditions were modeled using available groundwater models to determine the annual availability from these sources. In total, the PWPA has over 3.5 million acre-feet per year of groundwater in 2030. The Ogallala aquifer constitutes about 88 percent of the total groundwater availability in the PWPA. This is consistent with the use of these resources. However, in the southern and southwestern part of the region the Ogallala is either not present or only partially present, which necessitates the reliance on other groundwater sources.

[1] The total available supply is the reliable supply from sources in the PWPA. This differs from the developed water that is currently available to water users in the PWPA. Developed water considers infrastructure and availability to deliver the water to the end user.

Table ES-2: Available Water Supplies in the PWPA

Source	Supply (ac ft/yr)					
	2030	2040	2050	2060	2070	2080
Lake Meredith[1]	12,000	10,500	9,000	7,500	6,000	4,500
Greenbelt Lake[2]	3,140	2,970	2,800	2,592	2,383	2,175
Palo Duro Reservoir[2,3]	0	0	0	0	0	0
Canadian Run-of-River	298	298	298	298	298	298
Red Run-of-River	1,561	1,561	1,561	1,561	1,561	1,561
Total Surface Water	**16,999**	**15,329**	**13,659**	**11,951**	**10,242**	**8,534**
Ogallala Aquifer	3,148,015	2,924,013	2,669,506	2,435,130	2,205,795	1,991,106
Seymour Aquifer	51,488	51,498	53,333	51,431	50,660	53,052
Blaine Aquifer	31,404	31,404	31,404	31,404	31,404	31,404
Dockum Aquifer	326,541	321,453	304,182	284,240	259,902	241,087
Other Aquifers	2,753	2,753	2,753	2,753	2,753	2,753
Total Groundwater	**3,560,201**	**3,331,121**	**3,061,178**	**2,804,958**	**2,550,514**	**2,319,402**
Local Supply	13,192	13,192	13,192	13,192	13,192	13,192
Direct Reuse	21,147	21,152	21,150	21,146	21,142	21,139
Total Supply in PWPA	**3,615,271**	**3,385,599**	**3,114,865**	**2,857,623**	**2,602,154**	**2,370,013**

[1]Reliable supply is shown for Lake Meredith, as was used for planning purposes.
[2]One-year safe yield is shown for Greenbelt Reservoir and Palo Duro Reservoir. These supply values were used for planning purposes.
[3]No Current Infrastructure

Table ES-3: Developed Water Supplies in the PWPA

Water User Group	Existing Supplies (ac ft/yr)					
	2030	2040	2050	2060	2070	2080
Irrigation	1,515,776	1,394,945	1,284,329	1,188,187	1,103,974	1,041,679
Livestock	49,055	49,753	50,139	50,537	50,942	51,351
Manufacturing	45,131	44,861	44,896	44,841	45,317	44,040
Mining	9,677	9,726	9,776	9,829	9,885	9,943
Municipal	86,737	81,663	78,003	73,632	71,168	69,038
Steam Electric Power	15,000	15,000	15,000	15,000	15,000	15,000
Total	**1,721,376**	**1,595,948**	**1,482,143**	**1,382,026**	**1,296,286**	**1,231,051**

Water Supply Needs and Strategies

To assess the water supplies needs in the PWPA, water was allocated to the users considering geographical availabilities, infrastructure constraints and contractual limits, as appropriate. With these considerations, the projected developed supplies total about 1.7 million acre-feet per year in 2030, which is about 50 percent of the total available supply. This indicates that there is plenty of water available to users in the PWPA that simply has not been developed (**Table ES-4**). However, for some users the available water cannot be economically produced for the intended use. This is the case for irrigation users that rely on locally developed supplies and cannot use water that is located many miles away.

Considering the developed supplies, water demands exceed the supplies on a regional basis by 433,043 acre-feet per year in 2030, increasing to 513,956 acre-feet per year by 2080. Typically, the counties with the largest needs are those with large irrigation demands. There are 18 counties with 33 water user groups with projected water needs during the planning period.

Figure ES-5 shows the projected net water needs by county (this includes both needs and surplus supplies). **Figure ES-6** summarizes only the needs by use type (no surpluses are considered).

Table ES-4: Unallocated (Undeveloped) Water Supplies in the PWPA

Source	Supply (ac ft/yr)					
	2030	2040	2050	2060	2070	2080
Lake Meredith	18,548	19,368	19,971	20,725	21,500	22,272
Greenbelt Lake	1,687	1,537	1,396	1,210	1,023	822
Palo Duro Reservoir[1]	0	0	0	0	0	0
Total Surface	**20,235**	**20,905**	**21,367**	**21,935**	**22,523**	**23,094**
Ogallala Aquifer	1,571,894	1,470,833	1,329,915	1,192,104	1,046,089	897,680
Seymour Aquifer	3,060	3,309	3,299	3,285	3,260	3,245
Blaine Aquifer	14,724	14,722	14,712	14,701	14,689	14,677
Dockum Aquifer	292,074	288,401	272,567	253,519	230,068	211,844
Other Aquifers	776	776	776	776	776	776
Total Groundwater	**1,882,528**	**1,778,041**	**1,621,269**	**1,464,385**	**1,294,882**	**1,128,222**
Other Supplies	3,732	4,805	5,686	6,376	7,064	7,746
Total Supply	**1,906,495**	**1,803,751**	**1,648,322**	**1,492,697**	**1,324,468**	**1,159,062**

[1]No Current Infrastructure

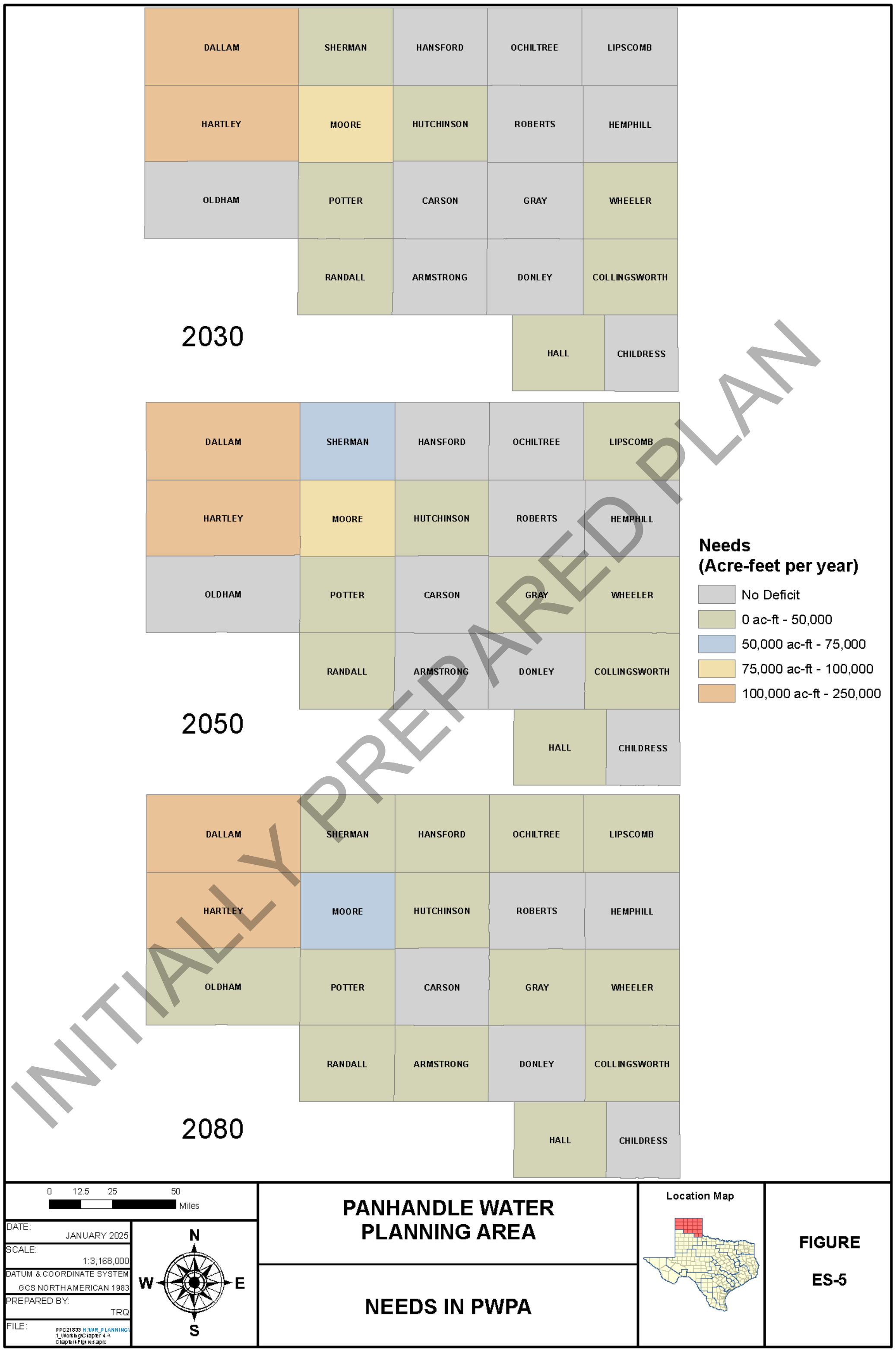


Figure ES-5: Needs in PWPA for Planning Period Year 2030 – Year 2080

Table ES-5: Projected Water Needs in the PWPA

Water User Group	Water Needs (ac ft/yr)					
	2030	2040	2050	2060	2070	2080
Municipal	4,748	12,422	18,725	25,116	29,493	33,790
Irrigation	427,488	552,889	524,337	498,292	473,453	456,154
Livestock	9,285	11,430	11,597	11,768	11,943	12,122
Manufacturing	1,522	3,521	5,269	7,182	8,624	11,890
Mining	-	-	-	-	-	-
Steam Electric Power	-	-	-	-	-	-
Total	**443,043**	**580,263**	**559,928**	**542,358**	**523,513**	**513,956**

Conservation and demand management are important strategies to meet the projected needs and offset dependence on expanding supply development. The PWPA considers conservation a priority and crucial in maintaining future supplies. Water infrastructure strategies were developed to meet the needs that could not be met through conservation.

Strategies were developed for water user groups in the context of their current supply sources, previous supply studies and available supply within the PWPA. Each water need considered conservation as a first strategy to offset the water need for that user. To help ensure supplies for the future in the PWPA, conservation is a recommended strategy for all municipalities and irrigation water use, whether the user had a need or not.

Most of the water supply in the PWPA is from groundwater, and for many of the identified needs, potentially feasible strategies include development of new groundwater supplies or further developing an existing well field. A total of 110 strategies (73 strategies are conservation) are recommended to meet the water needs in the PWPA. These strategies are listed in **Table ES-6**. Summaries of the recommended water supply plans for MWPs and WUGs are included in **Chapter 5C** and **5D**, respectively.

Evaluation of Potentially Feasible Strategies

All potentially feasible strategies were evaluated with respect to:

- Quantity, reliability and cost
- Environmental factors
- Impacts on water resources and other water management strategies
- Impacts on agriculture and natural resources
- Other relevant factors such as: key water quality, regulatory requirements, political and local issues, implementation time, recreational impacts and socioeconomic benefits or impacts

Table ES-6: Recommended Strategies

Water User Group	Water Management Strategy	Plan Chapter
Municipal Water Users	Municipal Conservation	5B
Irrigation Water Users	Irrigation Conservation	5B
Amarillo	Advanced Metering Infrastructure	5B
Amarillo	Aquifer Storage and Recovery	5C
Amarillo	Direct Potable Reuse	5C
Amarillo	Develop Potter/Carson County Well Field	5C
Amarillo	Develop Roberts County Well Field	5C
Booker	Develop Ogallala Aquifer Supplies	5D
Borger	Acquisition of TCW Well Field and System	5C
Borger	Develop Ogallala Aquifer Supplies	5C
Cactus	Develop Ogallala Aquifer Supplies	5C
Canadian	Develop Ogallala Aquifer Supplies	5D
CRMWA	Aquifer Storage and Recovery	5C
CRMWA	Desalination of Lake Meredith Water	5C
CRMWA	Replace Well Capacity	5C
CRMWA	Expand Capacity for CRMWA II	5C
CRMWA	Brush Control	5C
CRMWA	Linear Well Field	5C
Canyon	Develop Dockum Aquifer Supplies	5D
Canyon	Develop Ogallala Aquifer Supplies	5D
County-Other, Hall (Brice-Lesley)	Advanced Metering Infrastructure	5B
Dumas	Develop Ogallala Aquifer Supplies	5D
Fritch	Develop Ogallala Aquifer Supplies	5D
Greenbelt MIWA	Develop Ogallala Aquifer in Donley County	5C
Gruver	Develop Ogallala Aquifer Supplies	5D
Livestock, Hartley	Develop Dockum Aquifer Supplies	5D
Livestock, Hartley	Develop Ogallala Aquifer Supplies	5D
Livestock, Moore	Develop Ogallala Aquifer Supplies	5D
Livestock, Moore	Develop Dockum Aquifer Supplies	5D
Miami	Develop Ogallala Aquifer Supplies	5D
Moore County Manufacturing	Develop Dockum Aquifer Supplies	5D
Moore County Manufacturing	Develop Ogallala Aquifer Supplies	5D
Pampa	Aquifer Storage and Recovery	5D
Panhandle	Develop Ogallala Aquifer Supplies	5D
Perryton	Develop Ogallala Aquifer Supplies	5D
Shamrock	Develop Ogallala Aquifer Supplies	5D
Stinnett	Develop Ogallala Aquifer Supplies	5D
Stratford	Develop Ogallala Aquifer Supplies	5D

Water User Group	Water Management Strategy	Plan Chapter
Wellington	Nitrate Treatment	5D
Wheeler	Develop Ogallala Aquifer Supplies	5D

Collectively, conservation is expected to provide approximately 439,331 acre-feet per year of water savings to users in the PWPA by 2080 as shown in **Figure ES-6**. New groundwater development is recommended to provide approximately 86,000 acre-feet per year in 2030, increasing to approximately 123,000 acre-feet per year by 2080, with additional new groundwater supplies provided to users outside of the PWPA. These two strategy types account for about 98 percent of the supplies from the recommended water management strategies to water user groups. Other strategies include aquifer storage and recovery, direct potable reuse, brush control and water quality improvements. Supplies developed by the major water providers that are not assigned to a water user group are not included in these totals. This includes additional groundwater developed by CRMWA and Greenbelt MIWA. The total cost of projects associated with water management strategies in Region A throughout the planning period is $3,118,654,365.

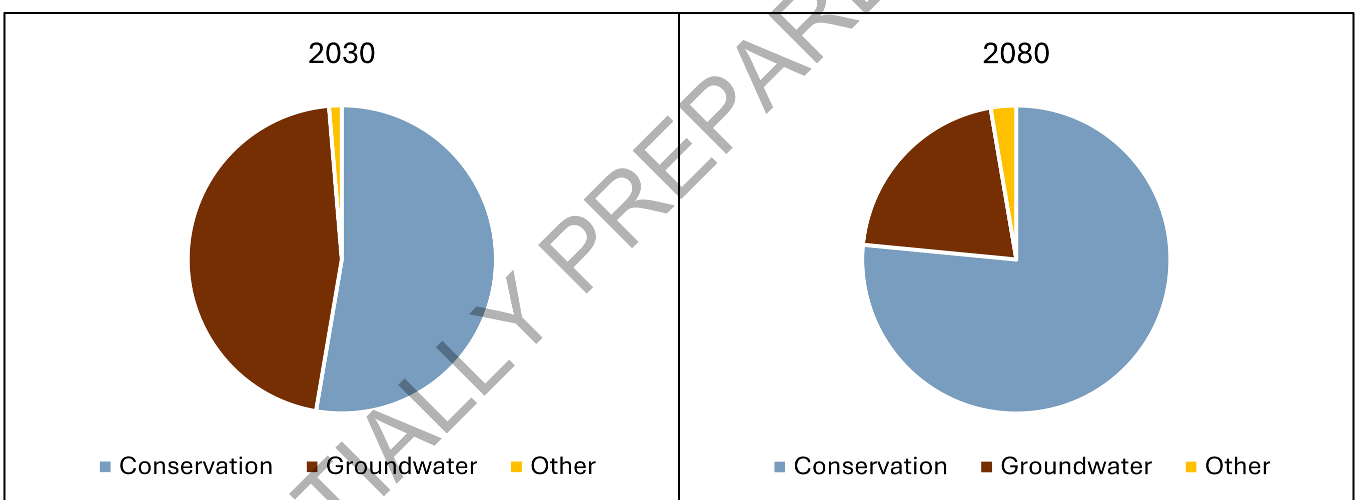


Figure ES-6: Percentage by Water Management Strategy Type, by Volume

Table ES-7: Unmet Water Needs in the PWPA, ac-ft/yr

County	WUG	2030	2040	2050	2060	2070	2080
Armstrong	Irrigation	0	0	0	0	(148)	(551)
Collingsworth	Irrigation	(14,416)	(14,749)	(13,561)	(12,119)	(11,471)	(11,423)
Dallam	Irrigation	(105,103)	(117,658)	(98,377)	(79,760)	(64,692)	(52,286)
Hall	Irrigation	(14,536)	(9,756)	(9,194)	(8,631)	(8,112)	(7,475)
Hartley	Irrigation	(154,700)	(186,470)	(160,847)	(136,832)	(116,977)	(99,439)
Moore	Cactus Municipal Water System	0	0	0	(105)	(211)	(322)
Moore	Manufacturing	0	0	(168)	(893)	(1,852)	(3,004)
Moore	Livestock	0	0	(538)	(2,449)	(4,222)	(5,923)
Moore	Irrigation	(57,601)	(51,037)	(40,924)	(30,477)	(21,192)	(12,504)
Oldham	Irrigation	(128)	0	0	0	0	0
Randall	Irrigation	0	(458)	(2,044)	(3,275)	(4,675)	(5,871)
Sherman	Irrigation	(18,912)	(21,352)	(5,536)	0	0	0
	Total	**(365,396)**	**(401,480)**	**(331,189)**	**(274,541)**	**(233,552)**	**(198,798)**

Key Findings and Recommendations

- Water quality concerns in Lake Meredith make it crucial for CRMWA to continue to develop their groundwater supplies.
- Large irrigation needs are concentrated in three counties: Dallam, Moore, and Hartley. Seven other counties also have irrigation needs. Most of these needs are due to limited groundwater supply for irrigated agriculture. The recommended strategies are conservation.
- There are unmet municipal, manufacturing, and livestock needs in Moore County due to declining MAGs.
- Limited ground water supplies in the southeast part of the region provide few options for new supply development.
- Three major water providers are projected to have needs over the planning period. The recommended strategies for each provider are to develop additional groundwater, along with other strategies for Amarillo and CRMWA.
- Conservation is critical strategy to the region, as it can be used to reduce water needs as well as preserve limited water sources for future generations.

County Summary Pages

Detailed descriptions of water resource planning issues for each county within the PWPA are included in **Attachment ES-1**.

ATTACHMENT ES-1

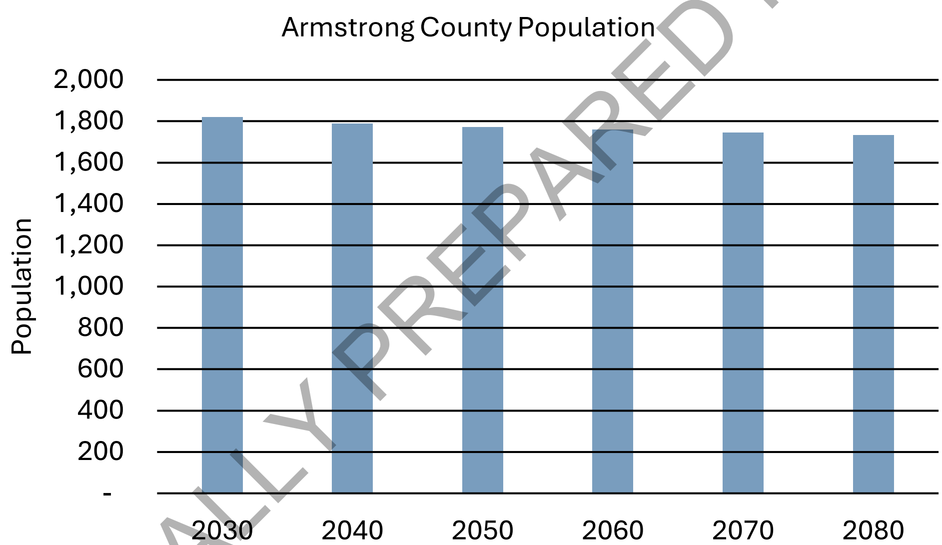
COUNTY SUMMARIES

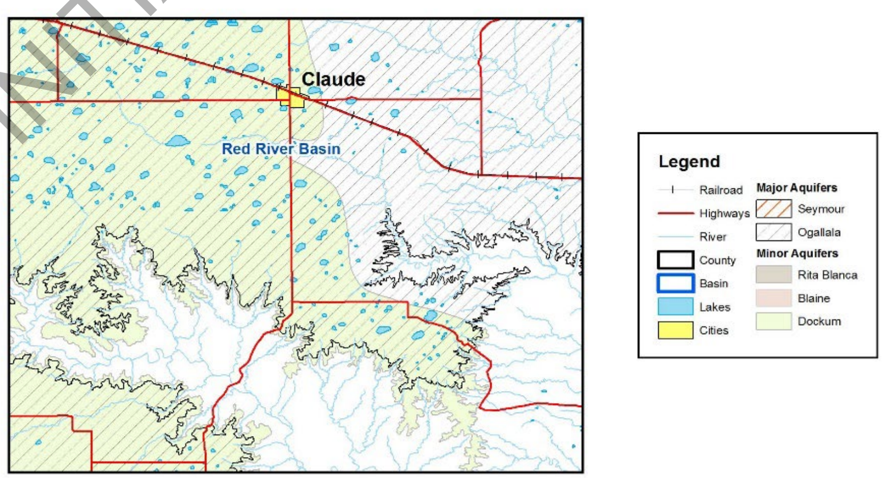
ARMSTRONG COUNTY SUMMARY PAGE

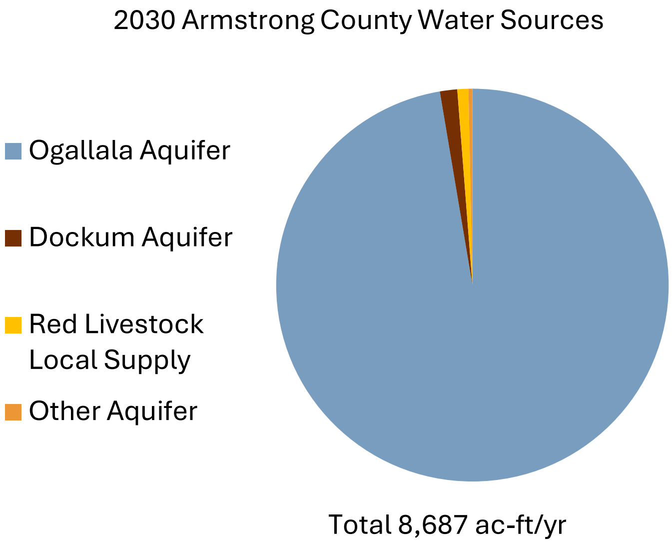
Who are my representatives?

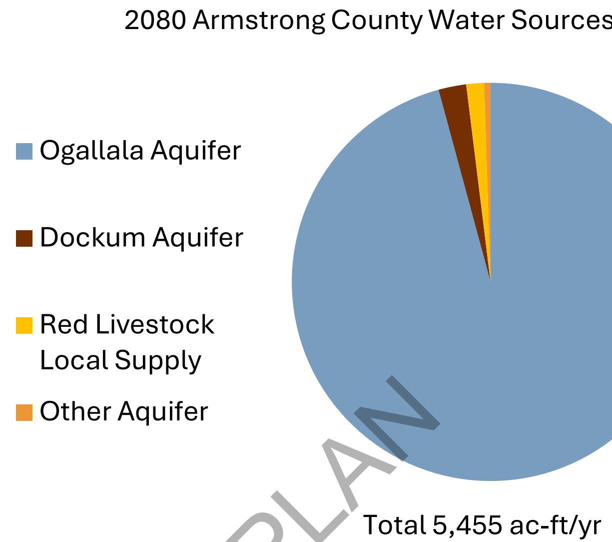
Ben Weinheimer - Texas Cattle Feeders Association
Brent Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Danny Krienke - GMA #1, North Plains GCD
Jason Coleman - High Plains UWCD No. 1
Britney Britten - Panhandle GCD

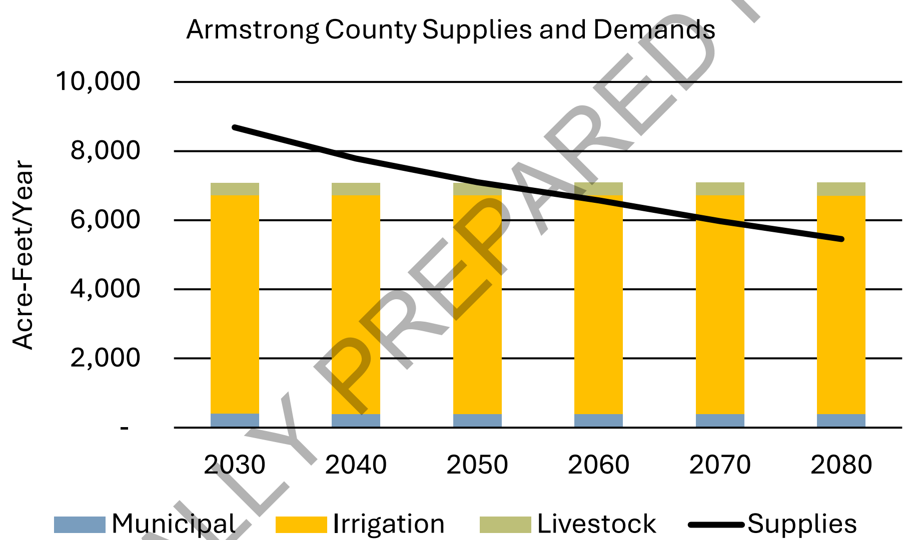
County Seat: City of Claude
Economy: Agribusiness, Tourism
What is the source of my water? Ogallala, Dockum Aquifers











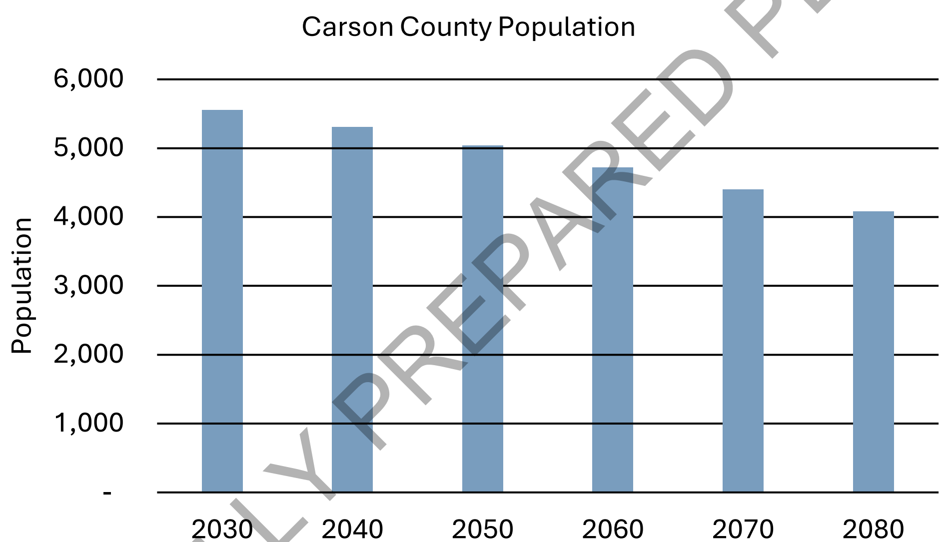
WATER USER GROUP	STRATEGY
Claude	Conservation
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Demands in this Category
Livestock	No Water Need Identified
Mining	No Demands in this Category
Steam Electric Power	No Demands in this Category

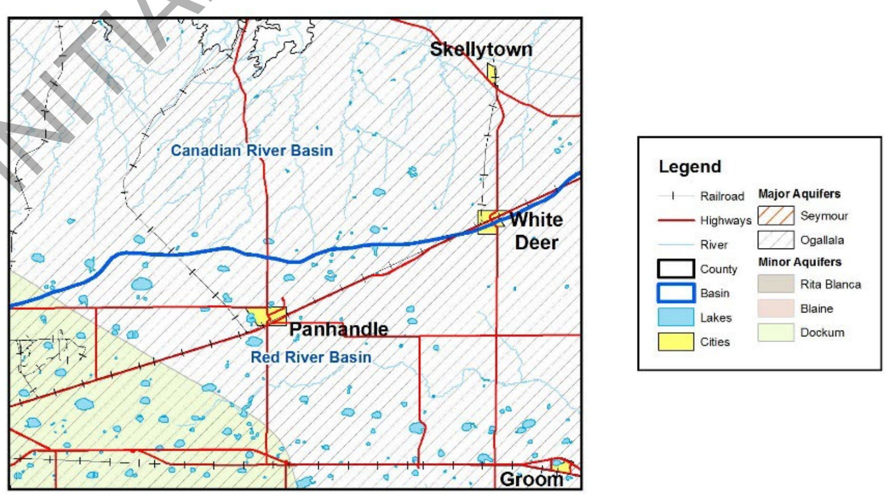
CARSON COUNTY SUMMARY PAGE

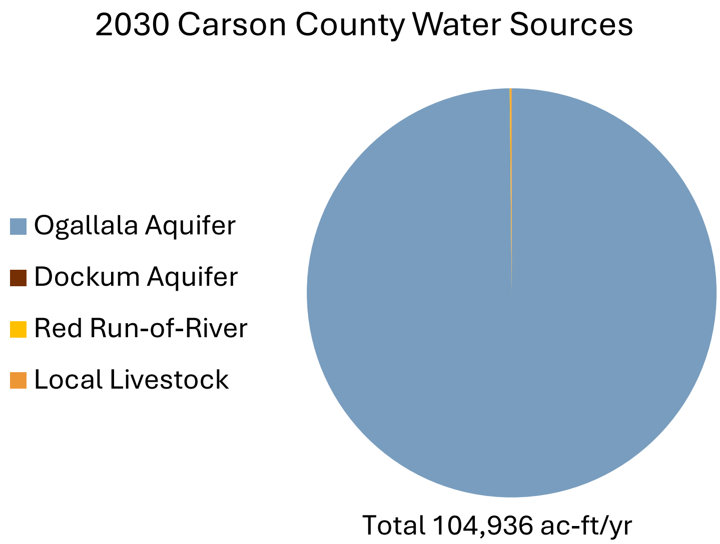
Who are my representatives?

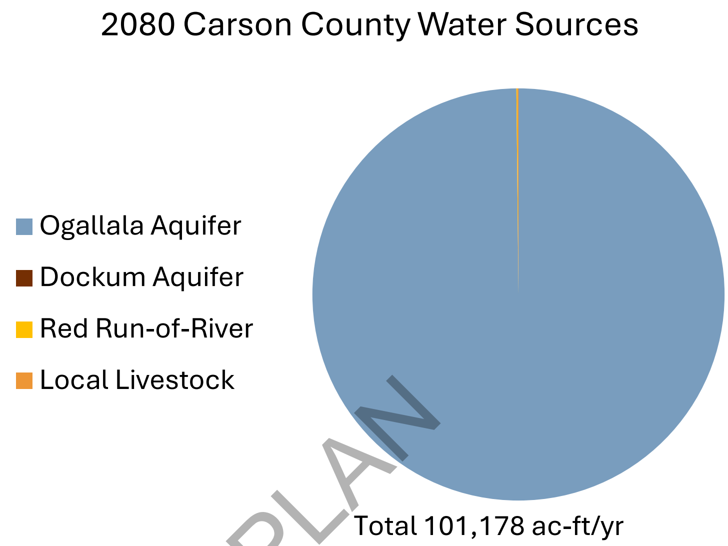
Ben Weinheimer	- Texas Cattle Feeders Association
Brent Auvermann	- Texas A&M AgriLife
Glen Green	- Xcel Energy
Danny Krienke	- GMA #1, North Plains GCD
Britney Britten	- Panhandle GCD

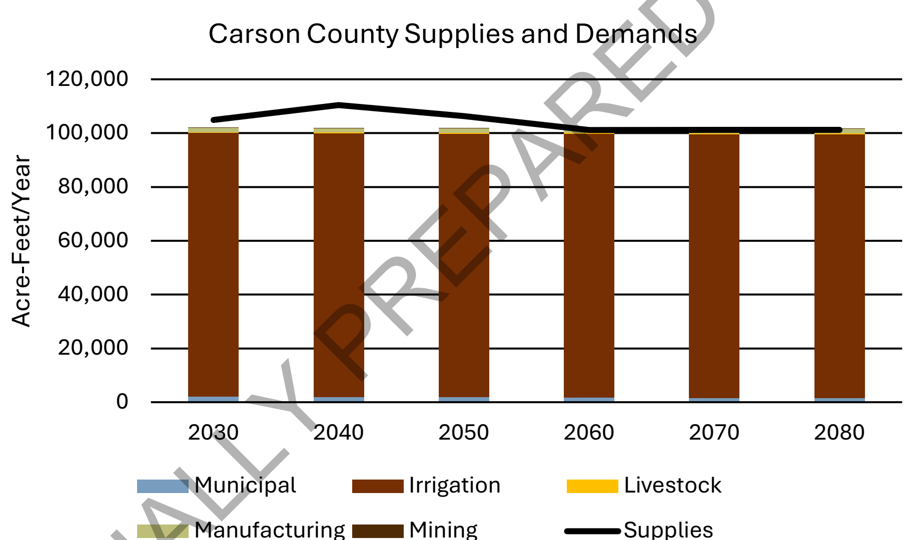
County Seat: City of Panhandle
Economy: Agribusiness, Petroleum
What is the source of my water? Ogallala Aquifer











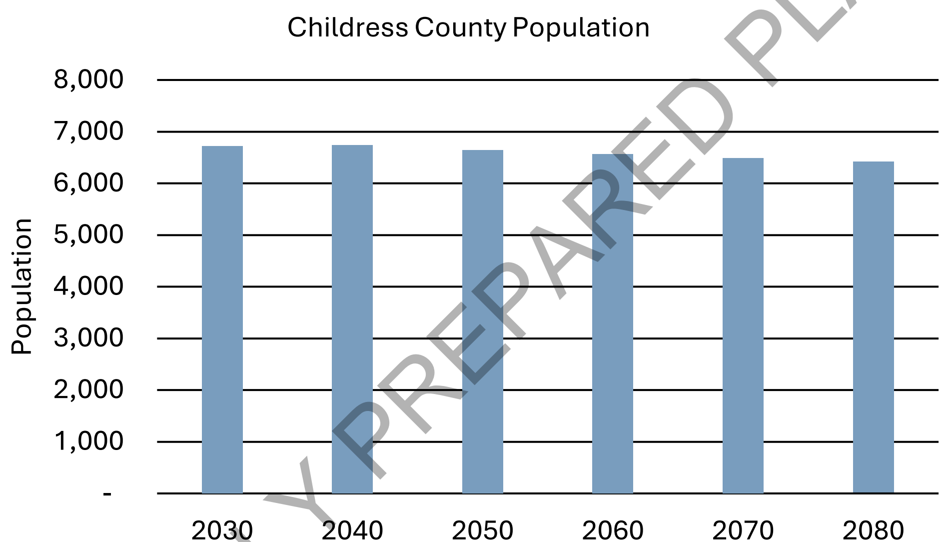
WATER USER GROUP	STRATEGY
Groom	Conservation
Panhandle	Conservation, Water Audit & Leak Repair, New Well(s)
White Deer	Conservation
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Water Need Identified
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

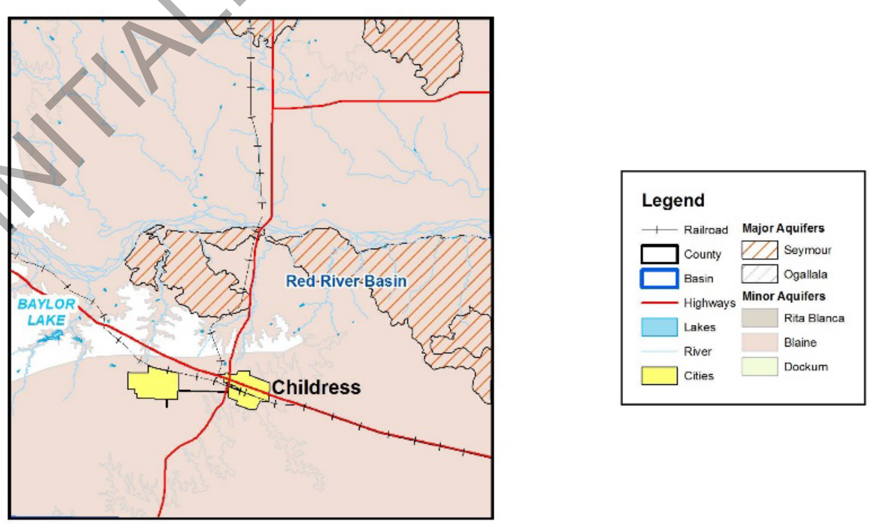
CHILDRESS COUNTY SUMMARY PAGE

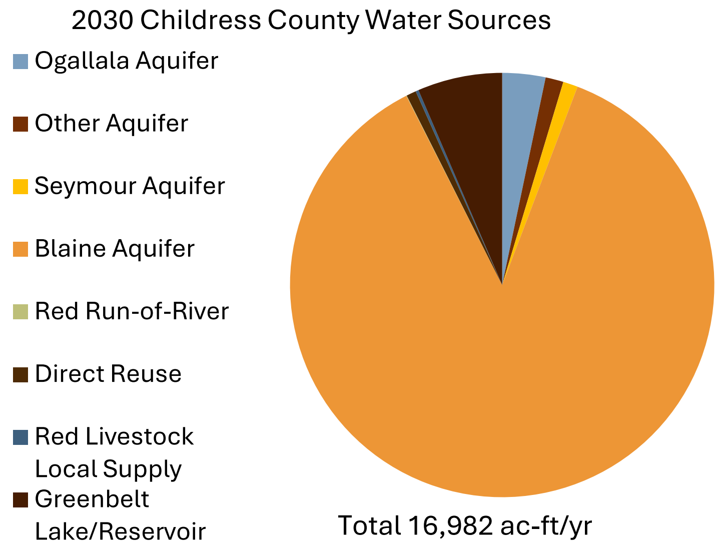
Who are my representatives?

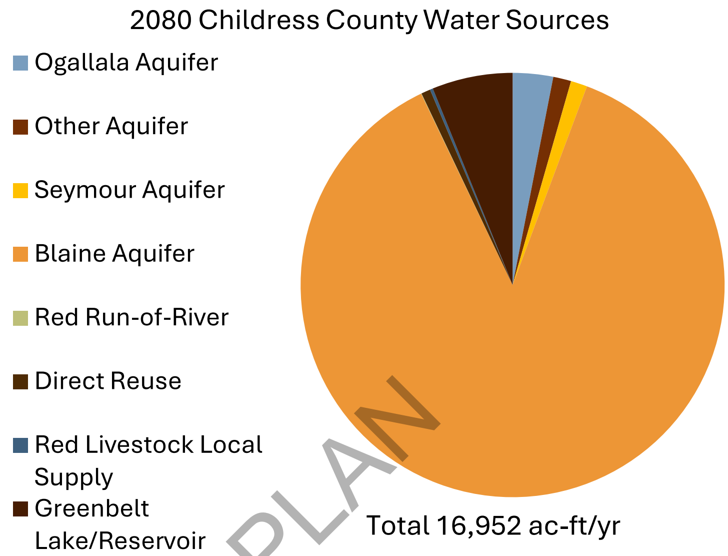
Ben Weinheimer - Texas Cattle Feeders Association
Brent Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Whitney Weibe - GMA #6, Mesquite GCD

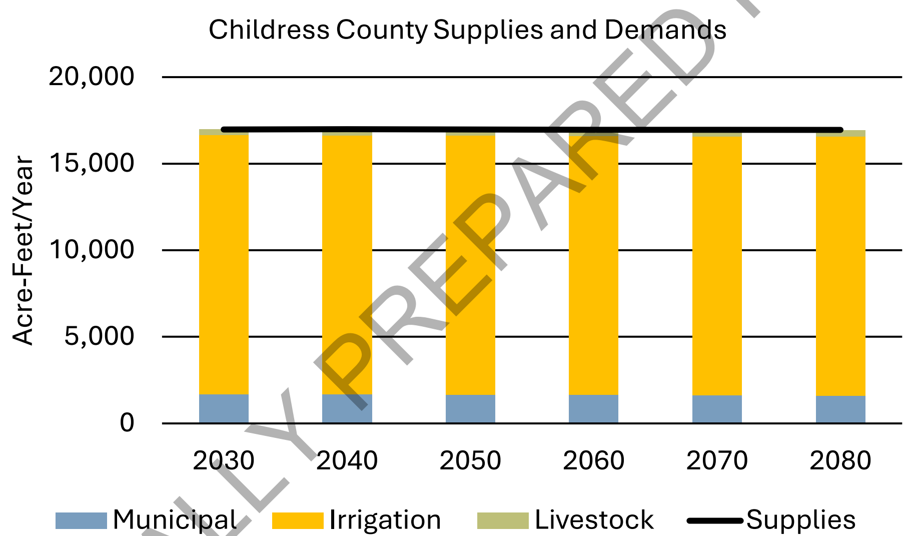
County Seat: City of Childress
Economy: Agribusiness, Tour
What is the source of my water? Ogallala, Seymour, Blaine Aquifers, Greenbelt Reservoir











WATER USER GROUP	STRATEGY
Childress	Conservation
Red River Authority of Texas	Conservation
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Demands in this Category
Livestock	No Water Need Identified
Mining	No Demands in this Category
Steam Electric Power	No Demands in this Category

COLLINGSWORTH COUNTY SUMMARY PAGE

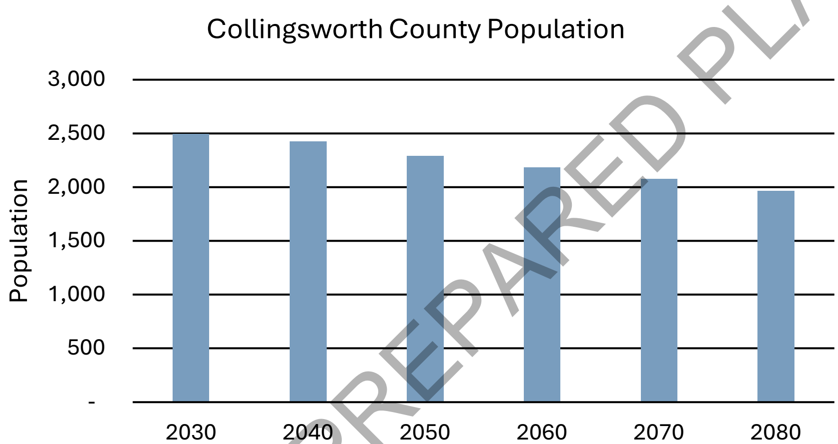
Who are my representatives?

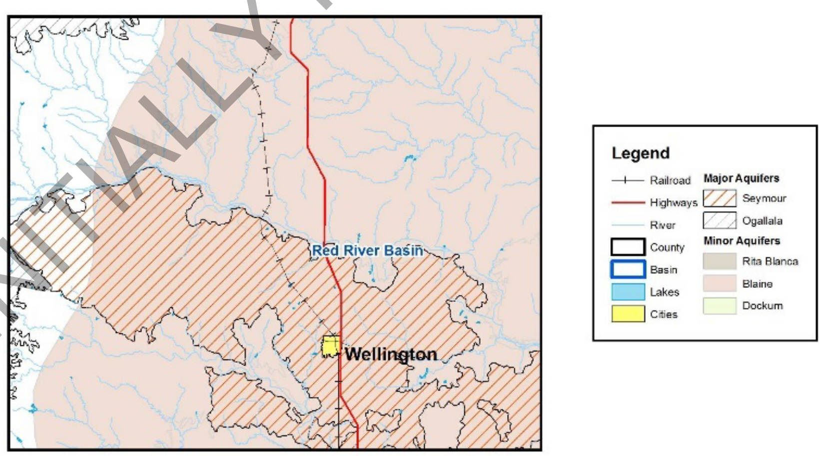
Ben Weinheimer - Texas Cattle Feeders Association Brent
Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Joe Baumgardner - Farmer
Whitney Wiebe - GMA #6, Mesquite GCD

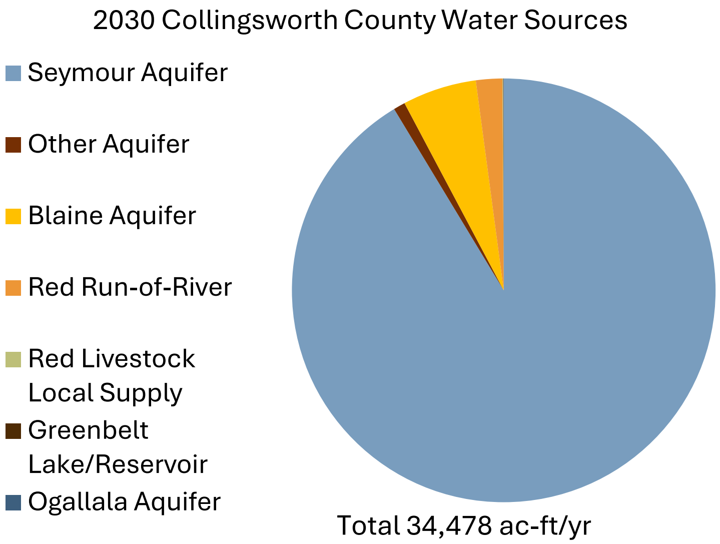
County Seat: City of Wellington

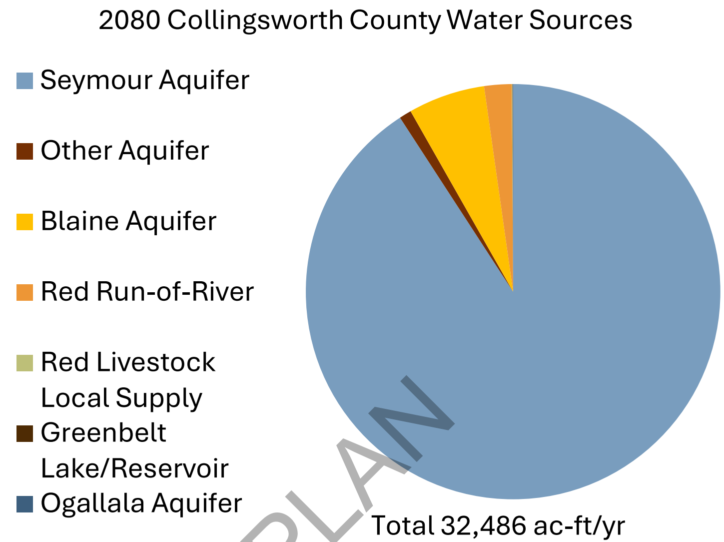
Economy: Agribusiness

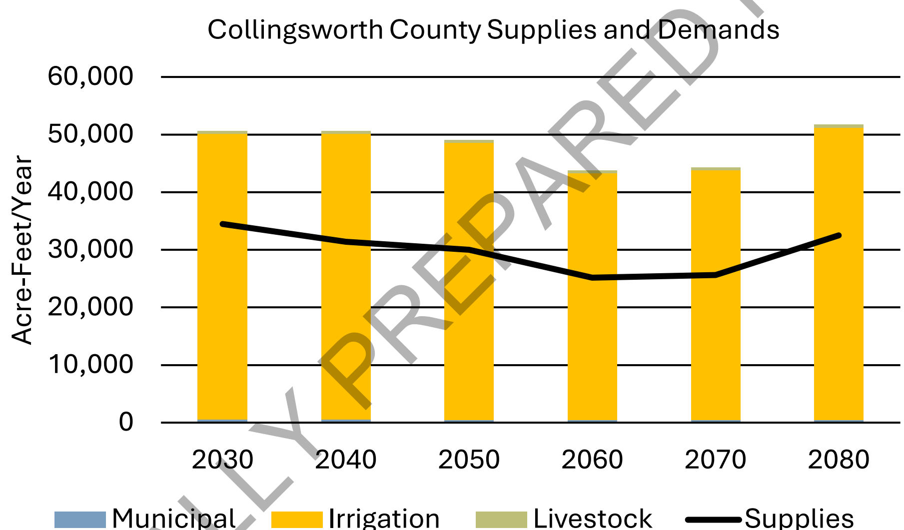
What is the source of my water? Seymour, Blaine Aquifers











WATER USER GROUP	STRATEGY
Wellington	Conservation, Water Quality Improvements
Red River Authority of Texas	Conservation
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Demands in this Category
Livestock	No Water Need Identified
Mining	No Demands in this Category
Steam Electric Power	No Demands in this Category

DALLAM COUNTY SUMMARY PAGE

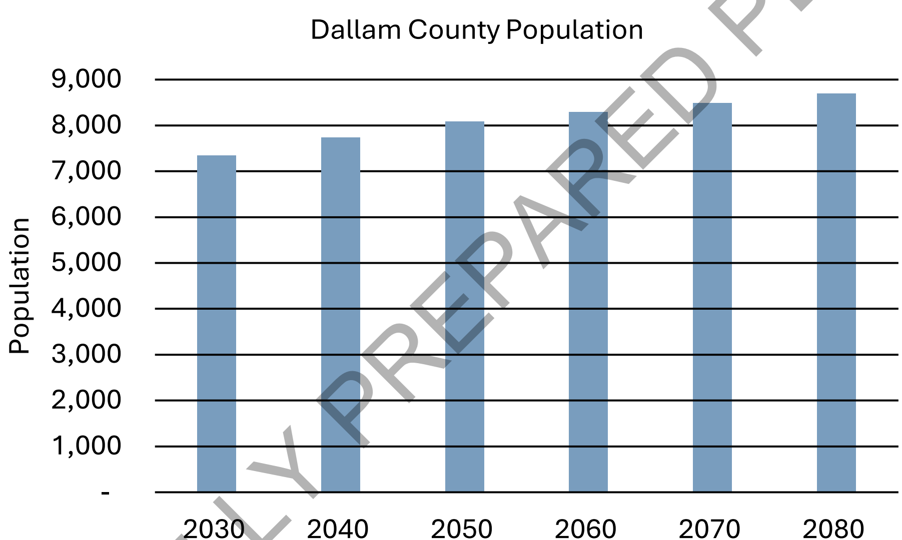
Who are my representatives?

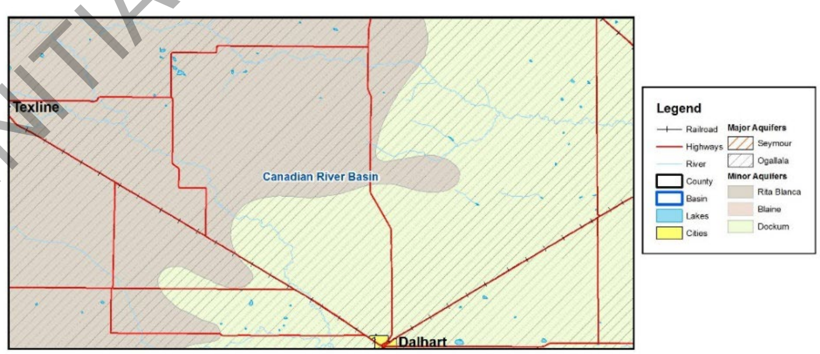
Ben Weinheimer	- Texas Cattle Feeders Association Brent
Auvermann	- Texas A&M AgriLife
Glen Green	- Xcel Energy
Rusty Gilmore	- Water Well Driller
Danny Krienke	- GMA #1, North Plains GCD
Janet Guthrie	- North Plains GCD

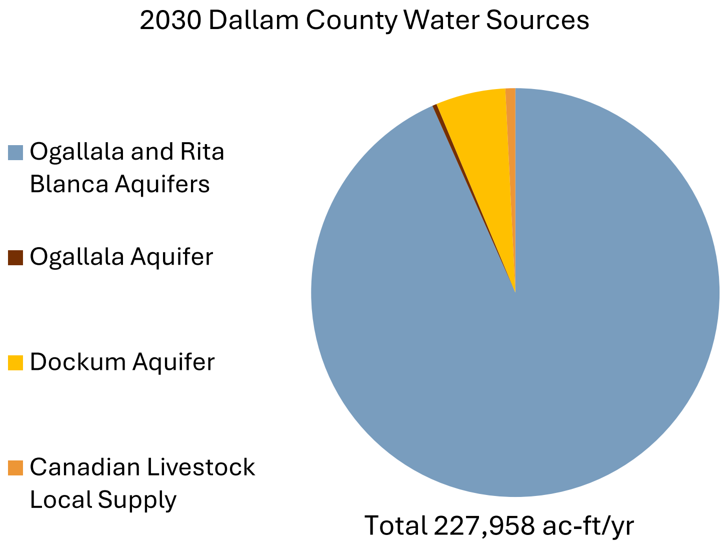
County Seat: City of Dalhart

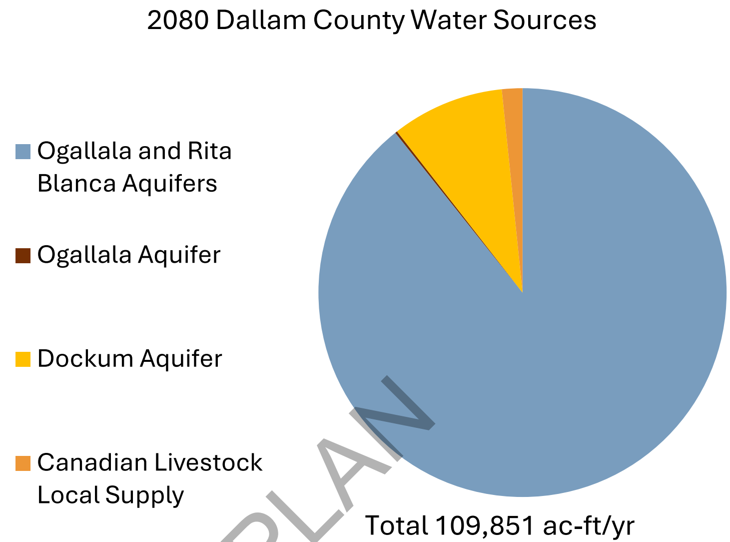
Economy: Agribusiness, Manufacturing, Tourism

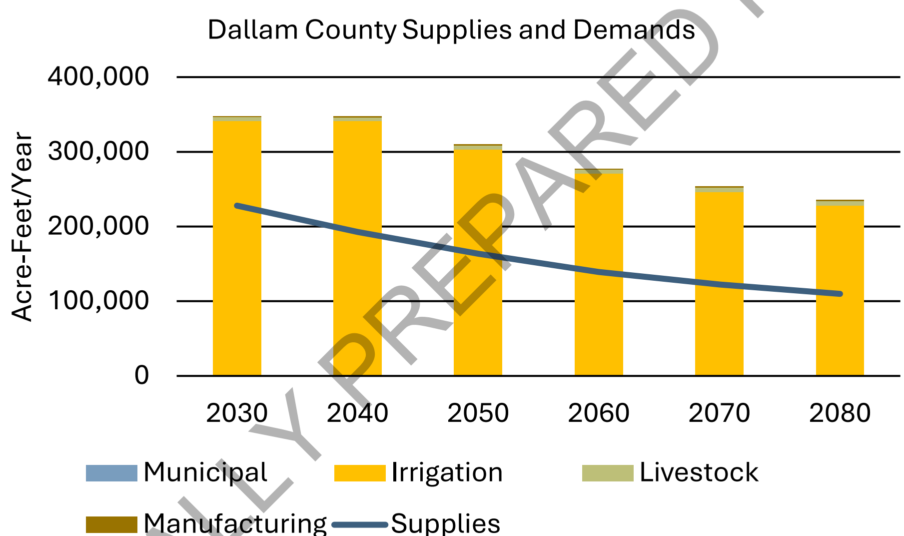
What is the source of my water? Ogallala, Dockum Aquifers





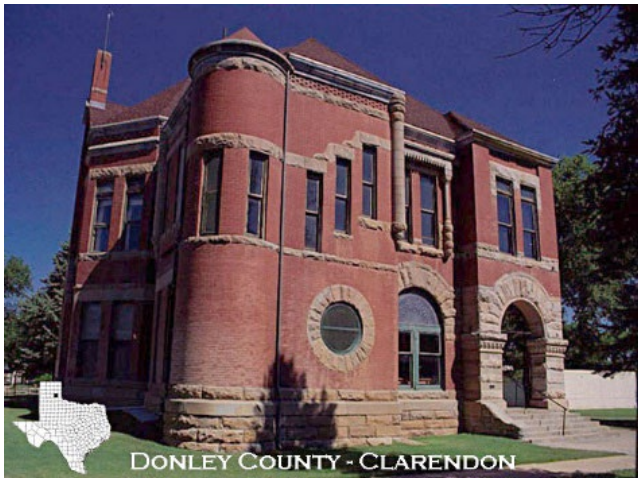






WATER USER GROUP	STRATEGY
Dalhart	Conservation
Texline	Conservation
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Water Need Identified
Livestock	No Water Need Identified
Mining	No Demands in this Category
Steam Electric Power	No Demands in this Category

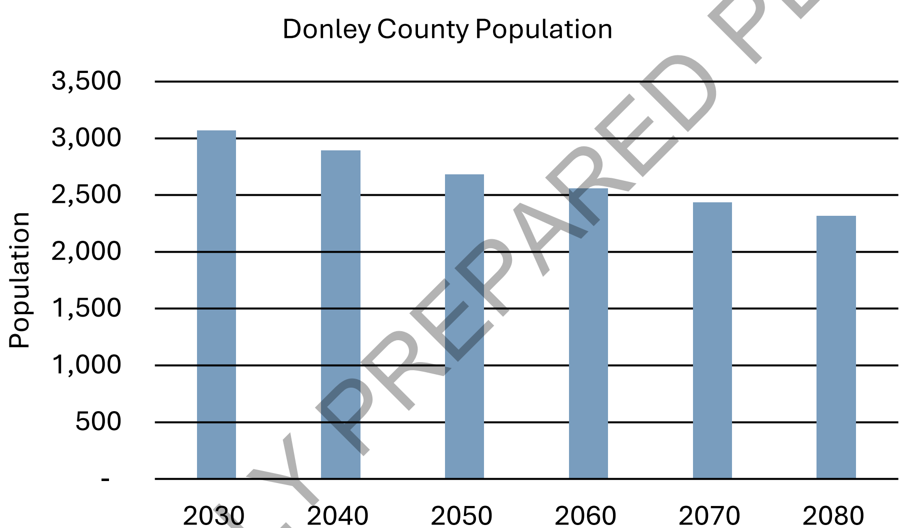
DONLEY COUNTY SUMMARY PAGE

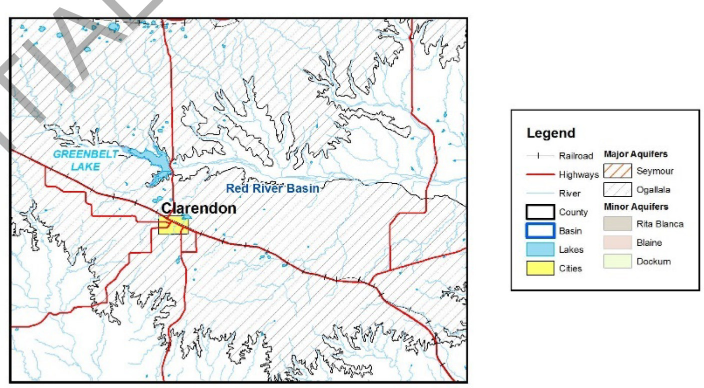


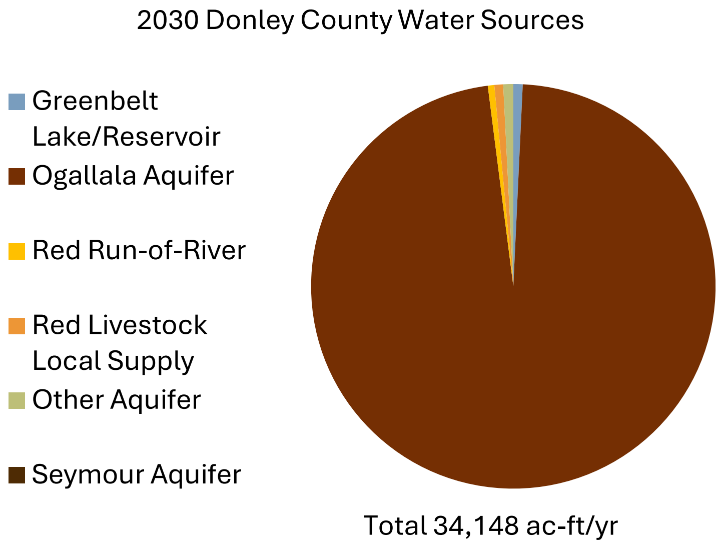
Who are my representatives?

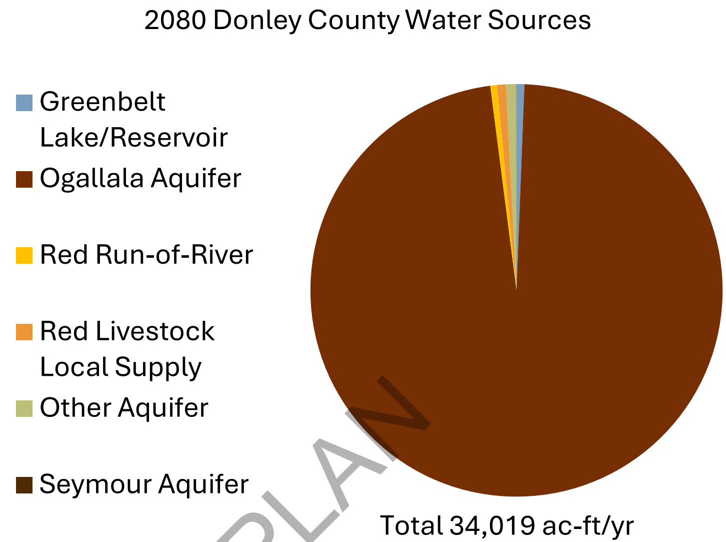
Ben Weinheimer - Texas Cattle Feeders Association
Brent Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Danny Krienke - GMA #1, North Plains GCD
Britney Britten - Panhandle GCD
Jason Coleman - High Plains UWCD No. 1

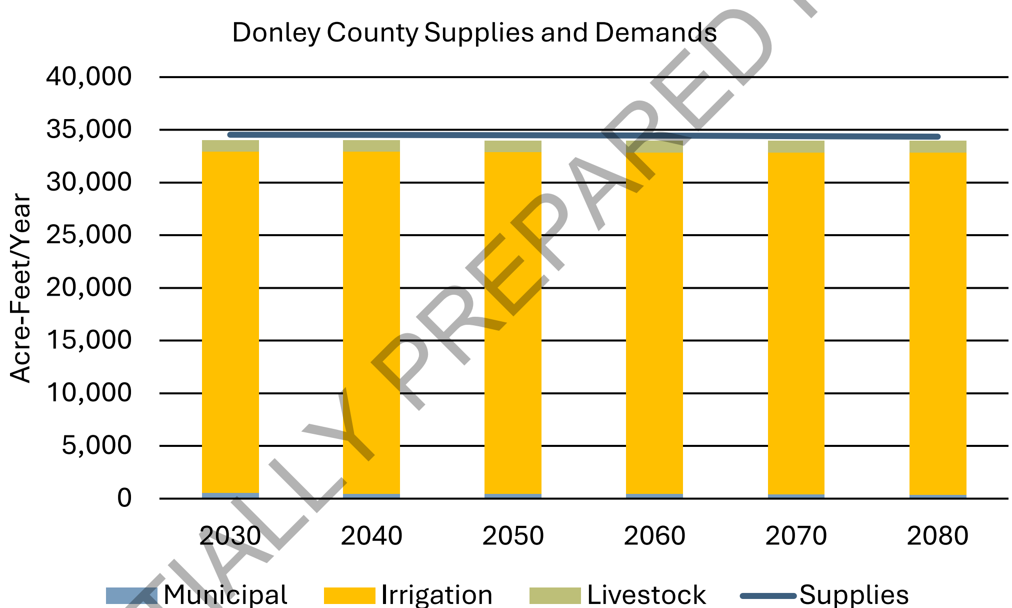
County Seat: City of Clarendon
Economy: Agribusiness, Tourism
What is the source of my water? Ogallala Aquifer, Greenbelt Reservoir











WATER USER GROUP	STRATEGY
Clarendon	Conservation
Red River Authority of Texas	Conservation
County-Other	No Water Need Identified
Irrigation	No Water Need Identified
Manufacturing	No Demands in this Category
Livestock	No Water Need Identified
Mining	No Demands in this Category
Steam Electric Power	No Demands in this Category

GRAY COUNTY SUMMARY PAGE

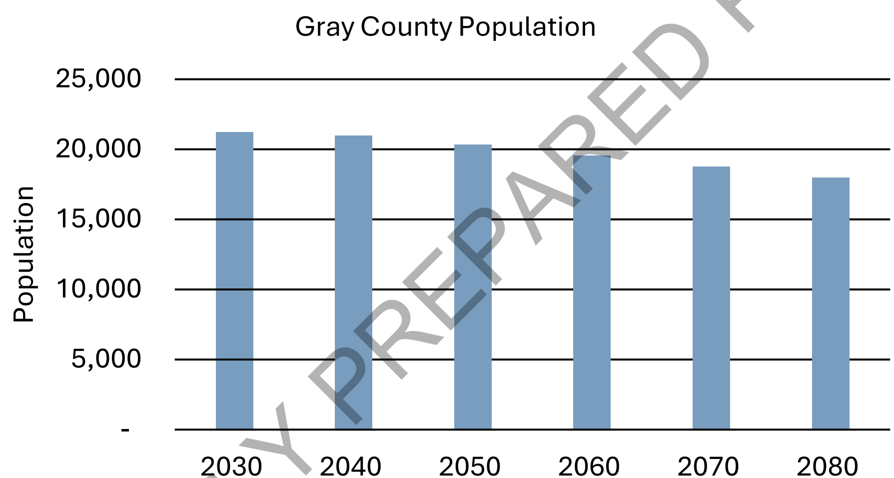
Who are my representatives?

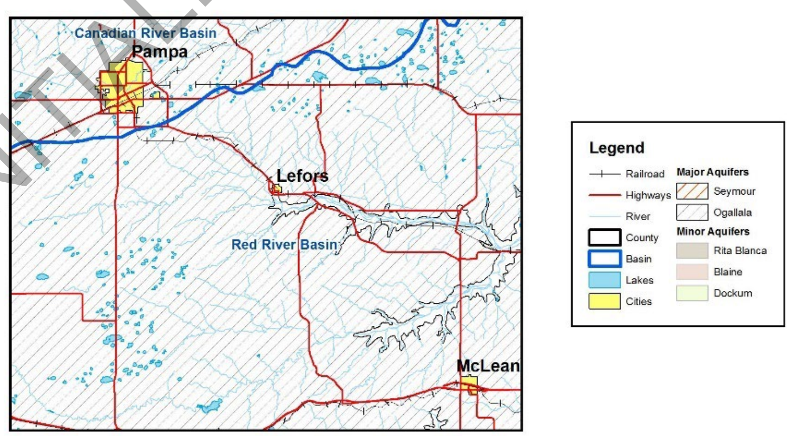
Ben Weinheimer - Texas Cattle Feeders Association Brent
Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Danny Krienke - GMA #1, North Plains GCD
Britney Britten - Panhandle GCD

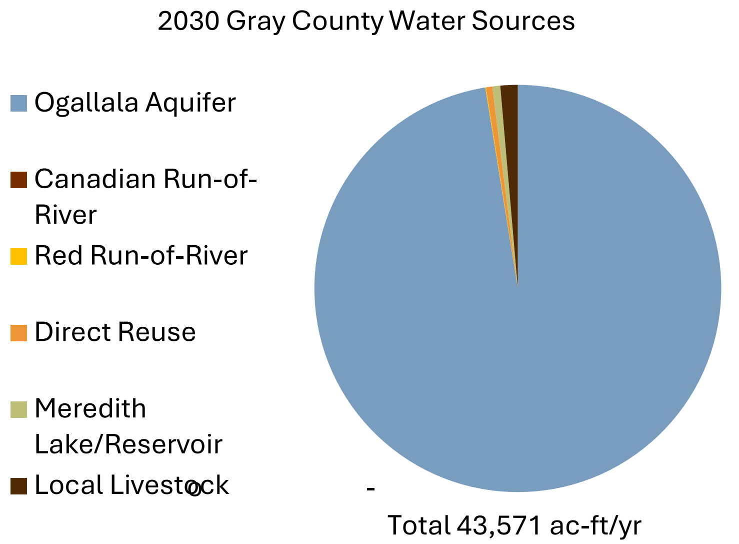
County Seat: City of Pampa

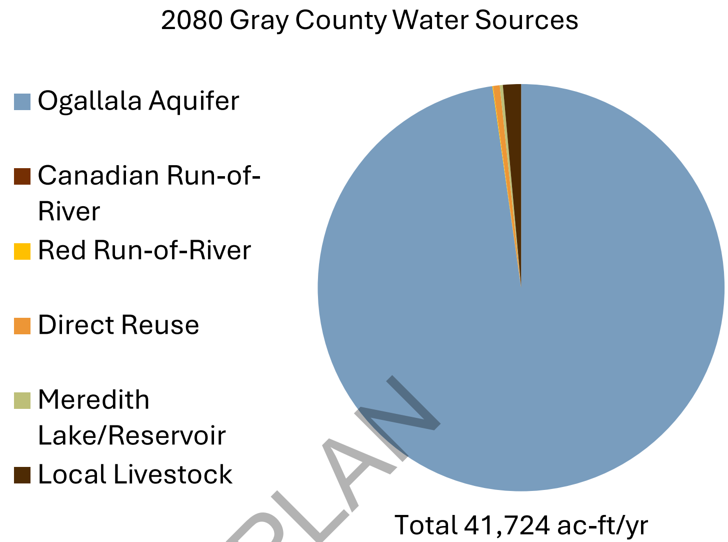
Economy: Agribusiness, Manufacturing, Tourism

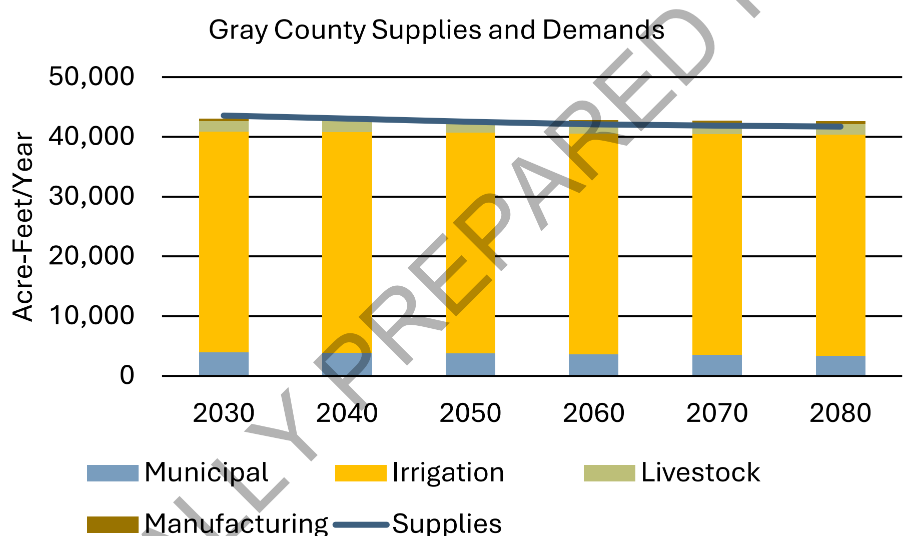
What is the source of my water? Ogallala Aquifer, Lake Meredith











WATER USER GROUP	STRATEGY
McLean	Conservation, New Well(s)
Pampa	Conservation, New Well(s), Contractual Supply From CRMWA, ASR
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Water Need Identified
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

HALL COUNTY SUMMARY PAGE

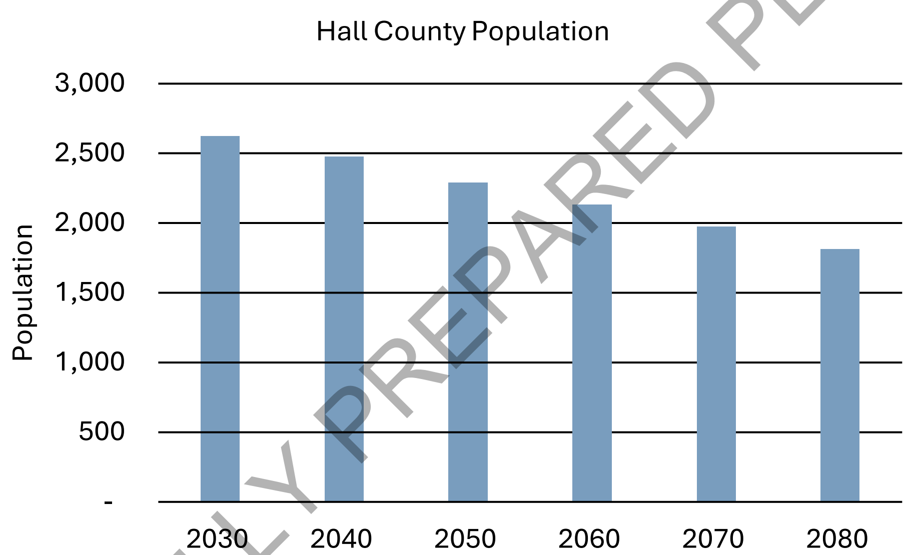
Who are my representatives?

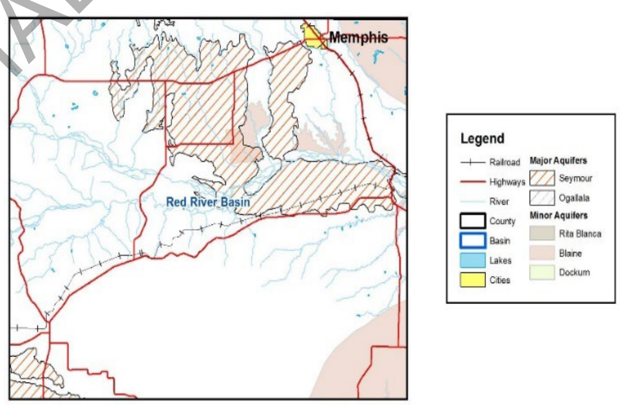
Ben Weinheimer - Texas Cattle Feeders Association Brent
Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Whitney Wiebe - GMA #6, Mesquite GCD

County Seat: City of Memphis

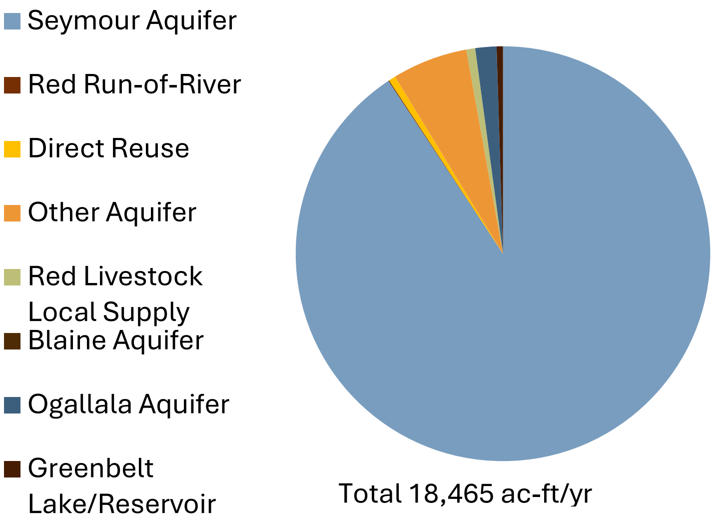
Economy: Agribusiness

What is the source of my water? Ogallala, Seymour Aquifers, Greenbelt Reservoir

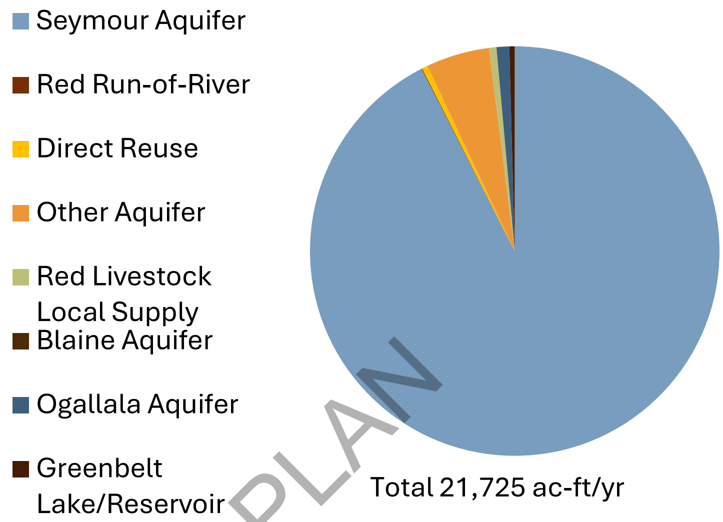




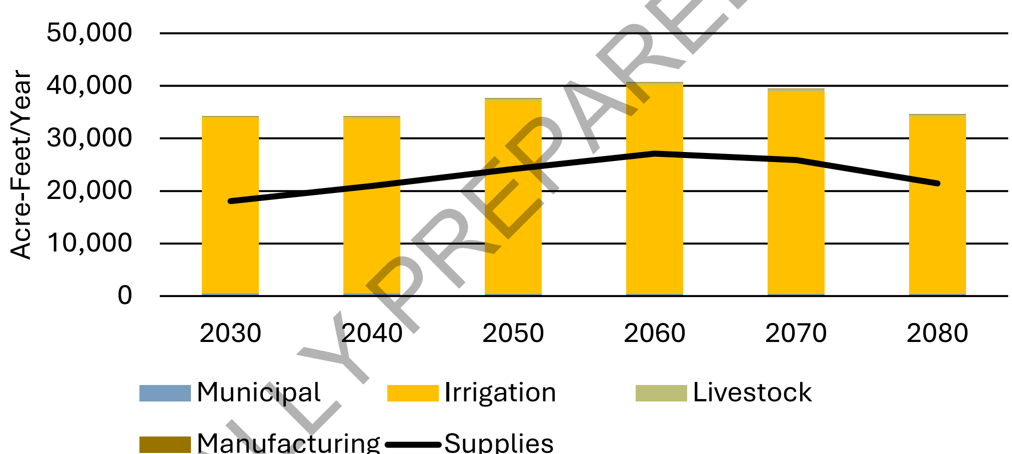
2030 Hall County Water Sources



2080 Hall County Water Sources



Hall County Supplies and Demands



WATER USER GROUP	STRATEGY
Memphis	Conservation
Red River Authority of Texas	Conservation
Turkey	Conservation, New Well(s)
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Water Need Identified
Livestock	No Water Need Identified
Mining	No Demands in this Category
Steam Electric Power	No Demands in this Category

HANSFORD COUNTY SUMMARY PAGE

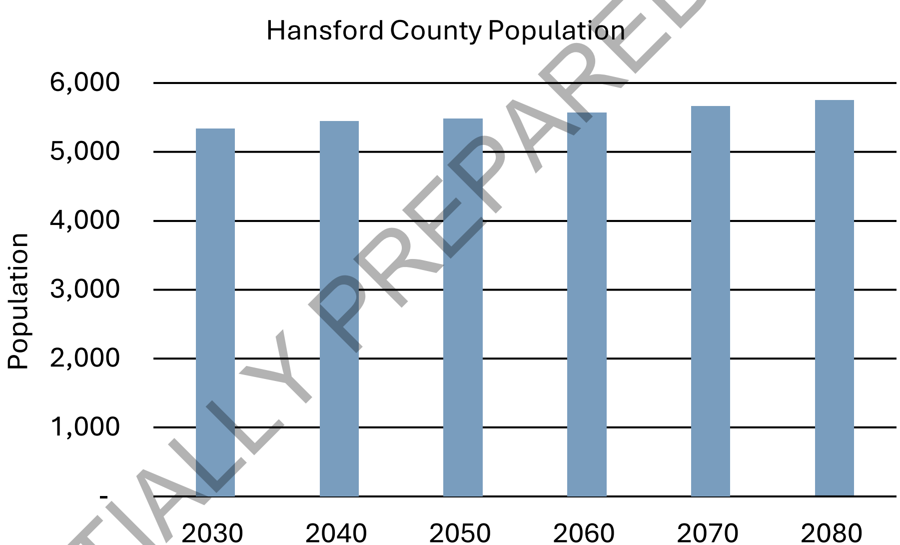
Who are my representatives?

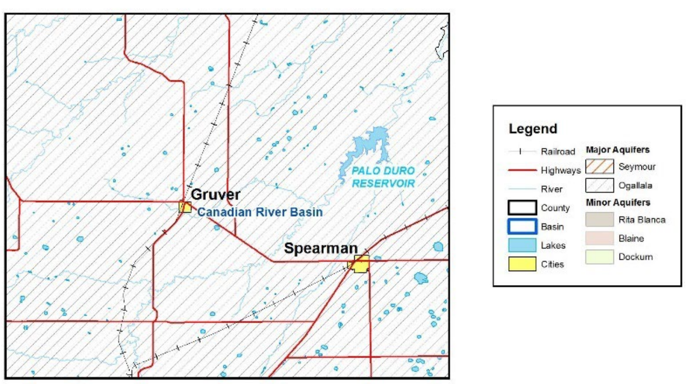
Ben Weinheimer	- Texas Cattle Feeders Association
Brent Auvermann	- Texas A&M AgriLife
Glen Green	- Xcel Energy
Danny Krienke	- GMA #1, North Plains GCD
Janet Guthrie	- North Plains GCD

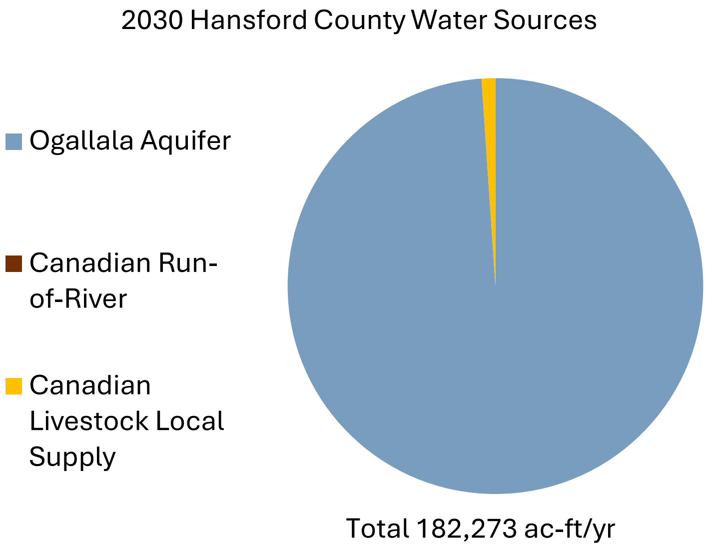
County Seat: City of Spearman

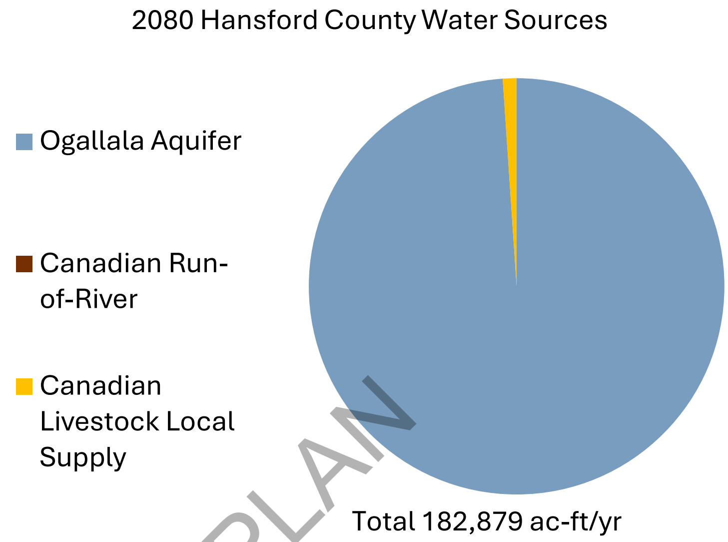
Economy: Agribusiness, Petroleum

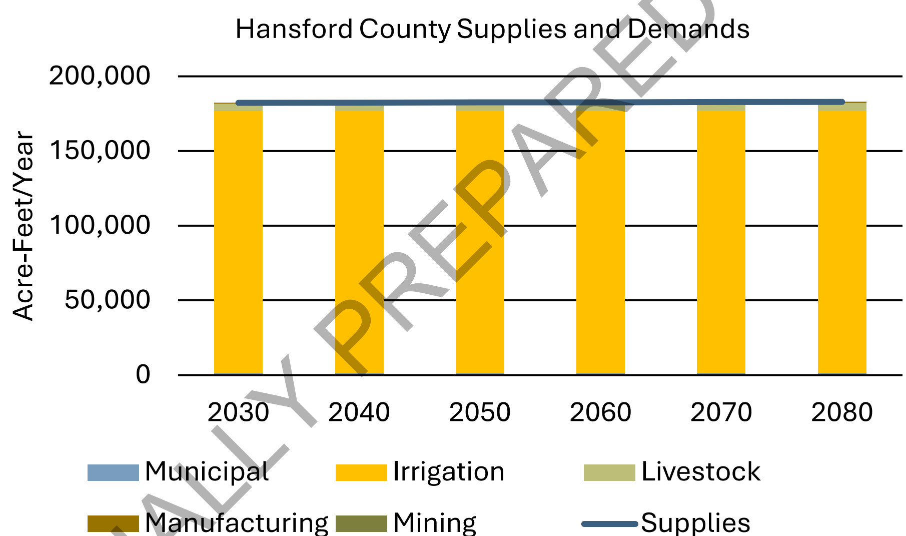
What is the source of my water? Ogallala Aquifer











WATER USER GROUP	STRATEGY
Gruver	Conservation, New Well(s)
Spearman	Conservation
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Water Need Identified
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

HARTLEY COUNTY SUMMARY PAGE

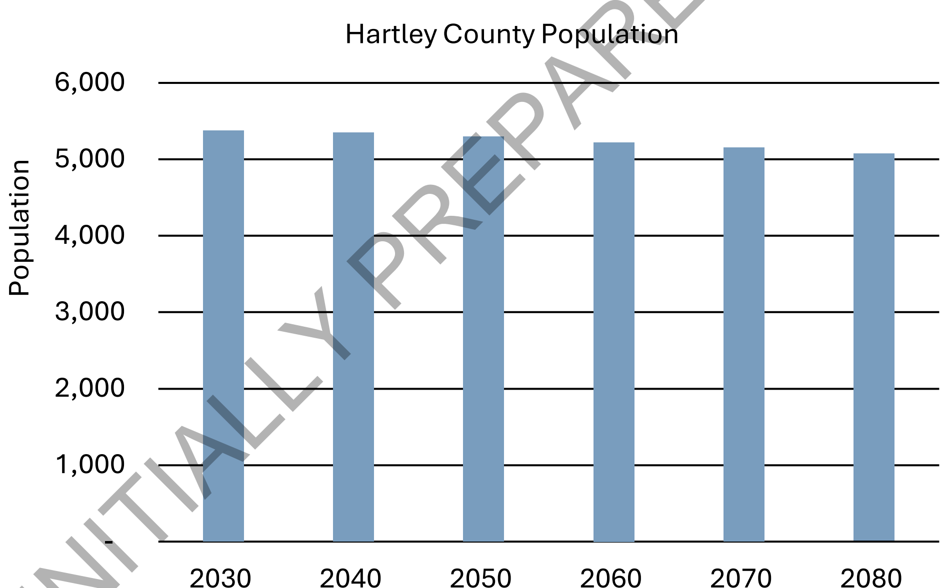
Who are my representatives?

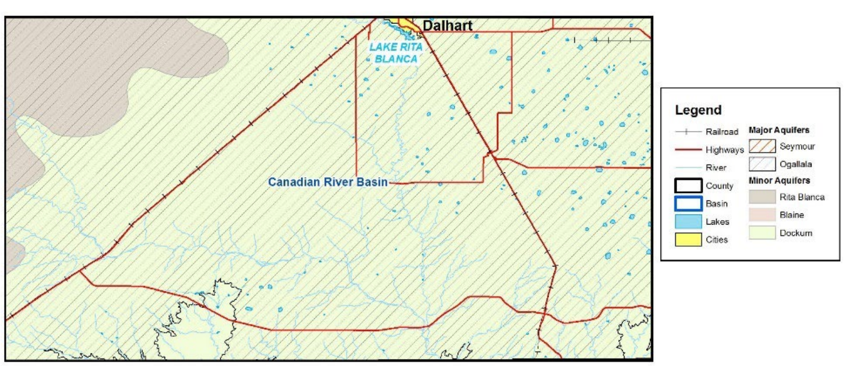
Ben Weinheimer - Texas Cattle Feeders Association
Brent Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Danny Krienke - GMA #1, North Plains GCD
Janet Guthrie - North Plains GCD

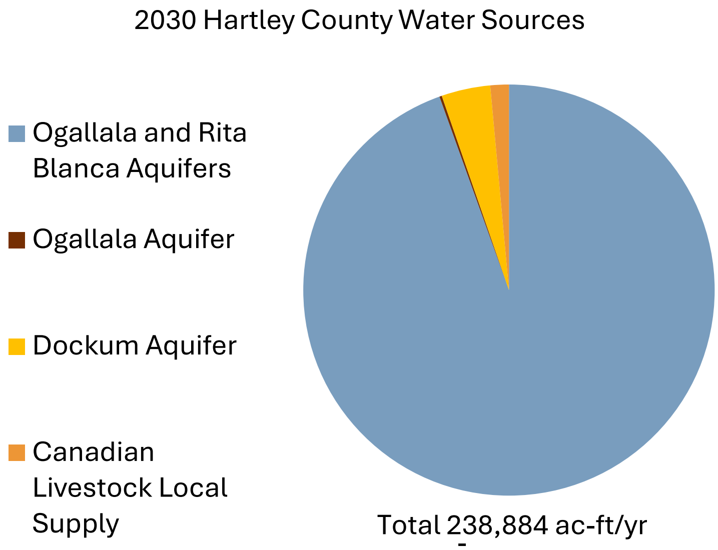
County Seat: City of Channing

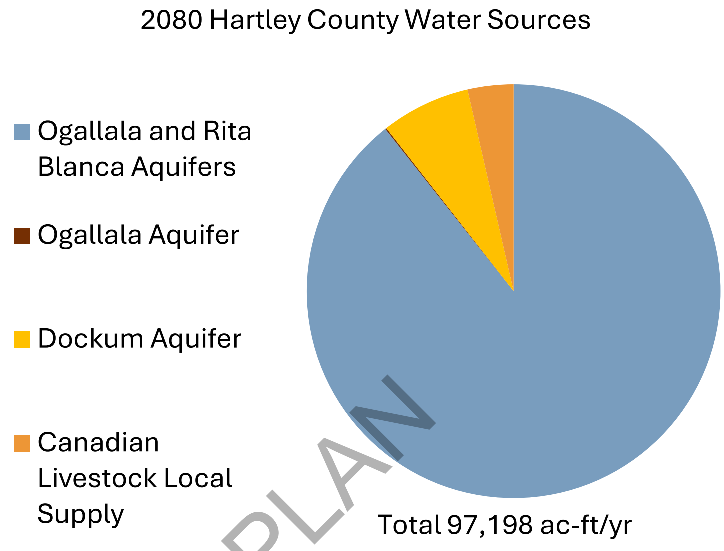
Economy: Agribusiness, Manufacturing, Petroleum

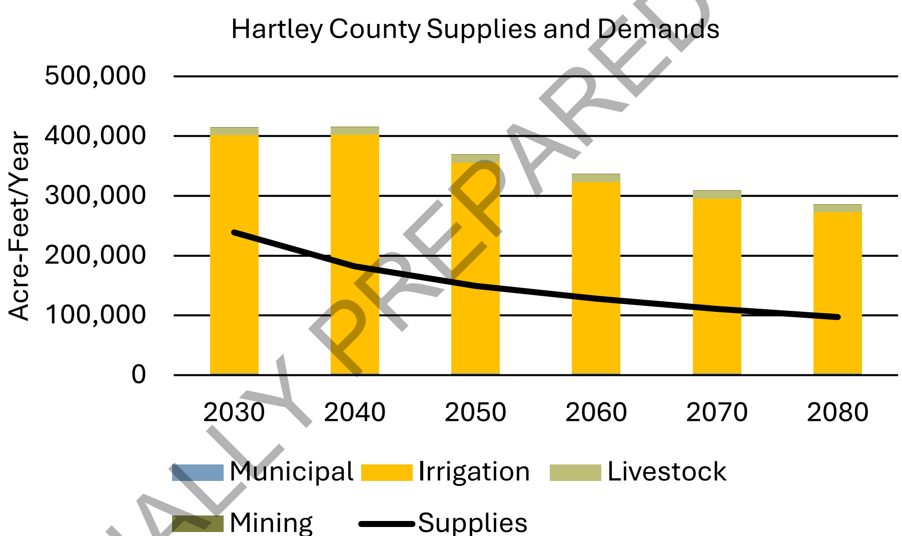
What is the source of my water? Ogallala, Dockum Aquifers











WATER USER GROUP	STRATEGY
Dalhart	Conservation
Hartley	Conservation
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Demands in this Category
Livestock	New Well(s)
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

HEMPHILL COUNTY SUMMARY PAGE

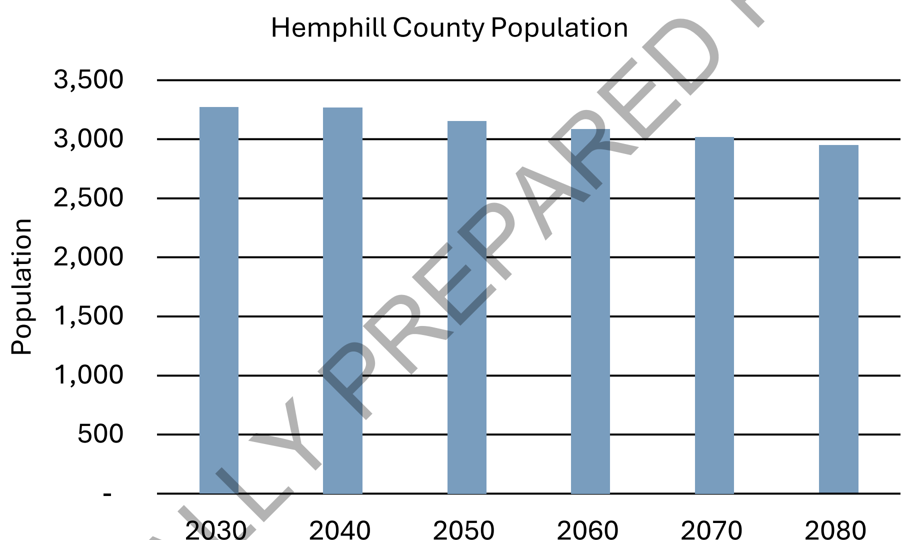
Who are my representatives?

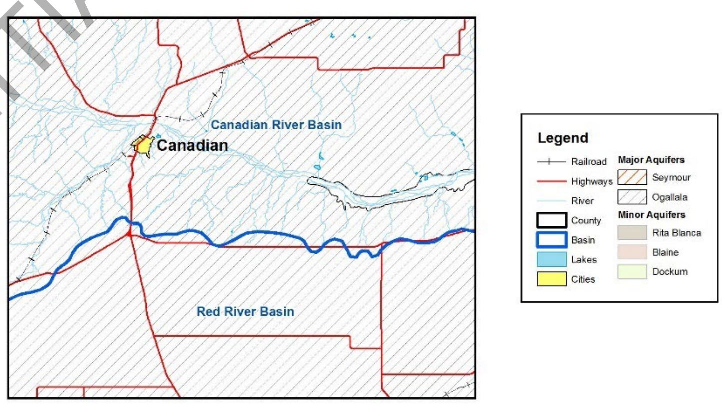
Ben Weinheimer - Texas Cattle Feeders Association
Brent Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Danny Krienke - GMA #1, North Plains GCD
Christa Perry - Hemphill County UWCD

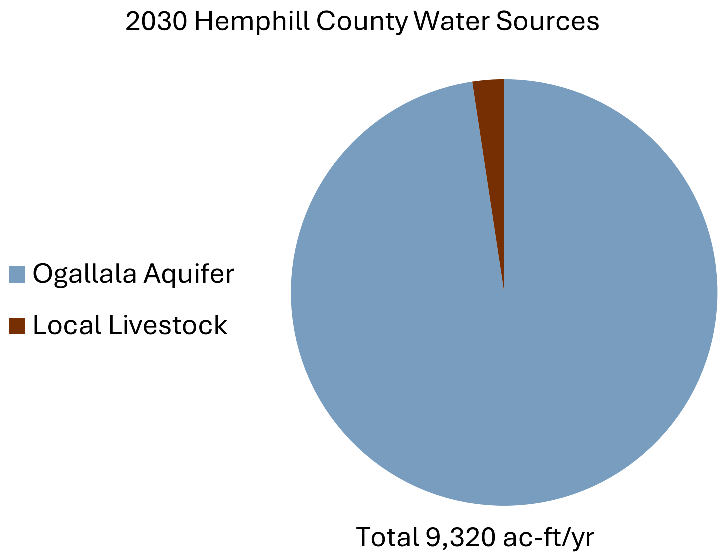
County Seat: City of Canadian

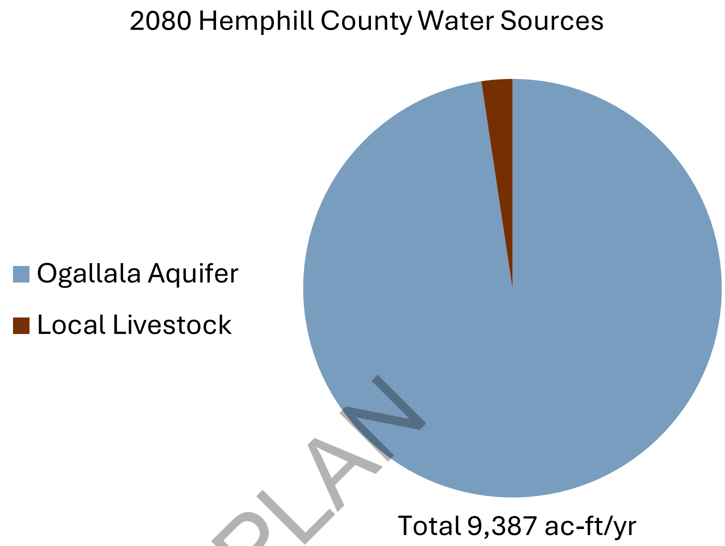
Economy: Agribusiness, Petroleum

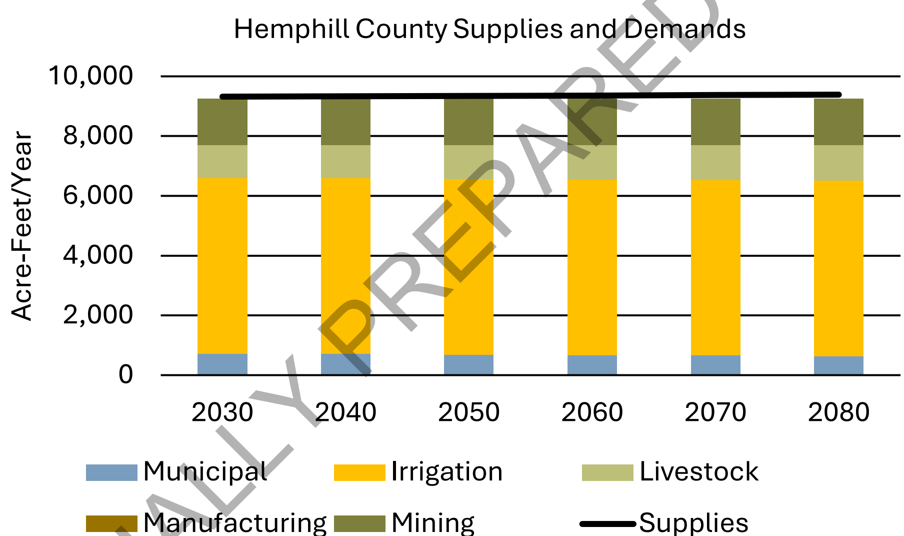
What is the source of my water? Ogallala Aquifer











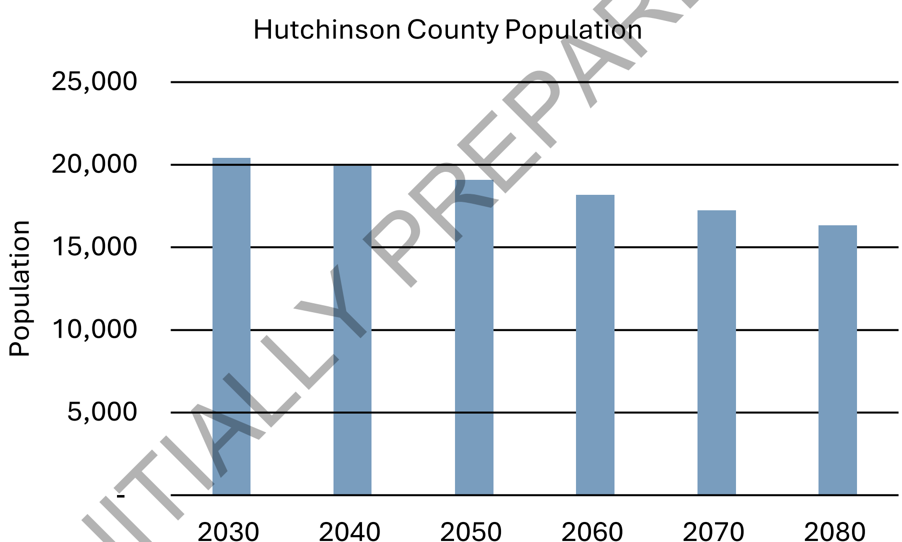
WATER USER GROUP	STRATEGY
Canadian	Conservation, New Well(s)
County-Other	No Water Need Identified
Irrigation	No Water Need Identified
Manufacturing	No Water Need Identified
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

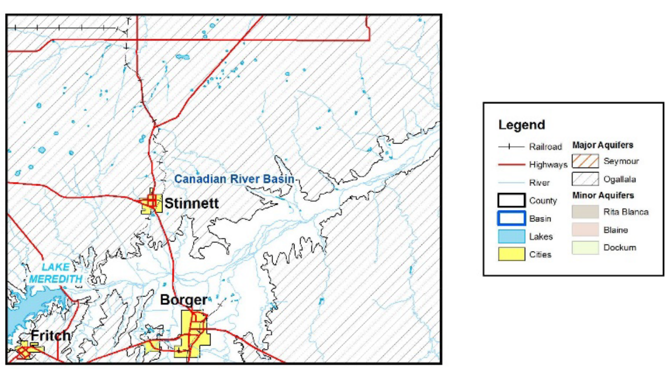
HUTCHINSON COUNTY SUMMARY PAGE

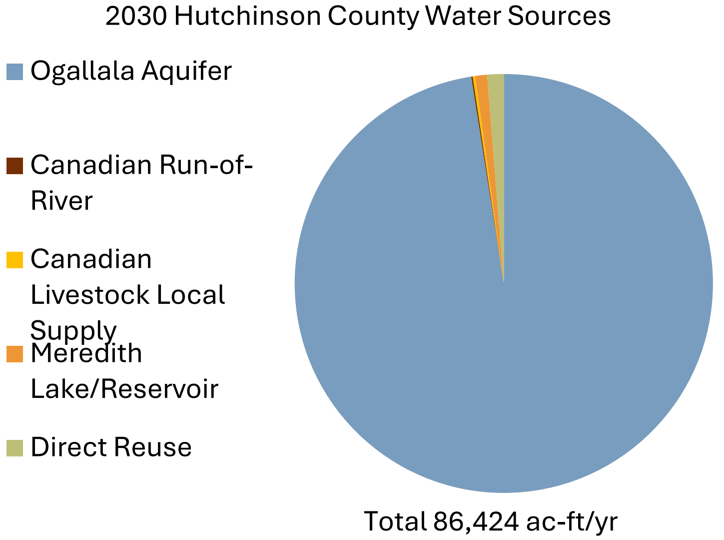
Who are my representatives?

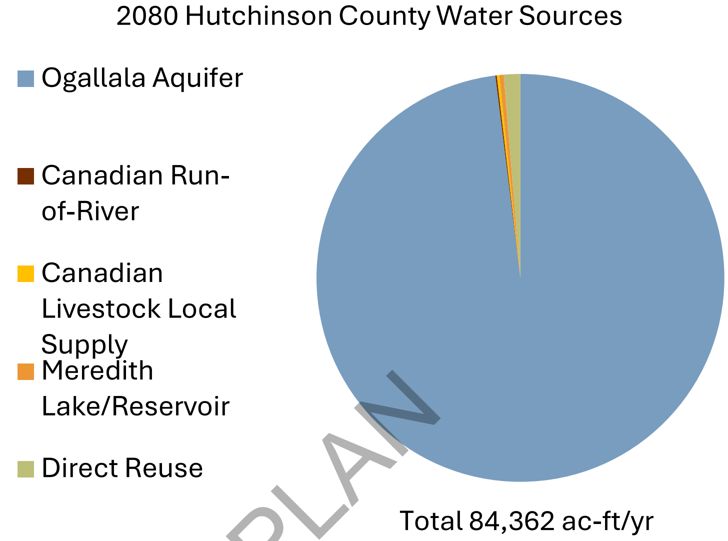
Ben Weinheimer	- Texas Cattle Feeders Association
Brent Auvermann	- Texas A&M AgriLife
Glen Green	- Xcel Energy
Dean Cooke	- TCW Supply
Danny Krienke	- GMA #1, North Plains GCD
Janet Guthrie	- North Plains GCD
Britney Britten	- Panhandle GCD
Drew Satterwhite	- CRMWA
Spencer Cave	- Phillips 66

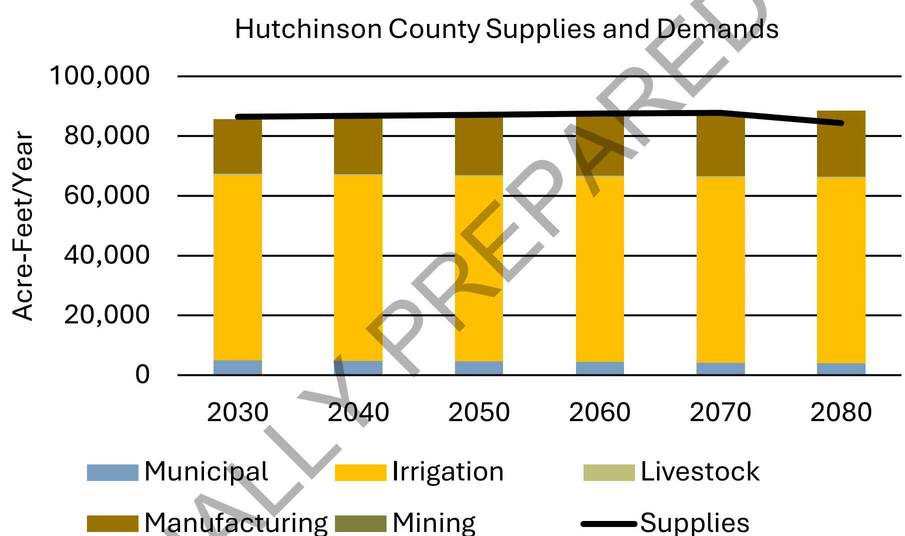
County Seat: City of Stinnett
Economy: Agribusiness, Manufacturing, Petroleum, Tourism
What is the source of my water? Ogallala Aquifer, Reuse











WATER USER GROUP	STRATEGY
Borger	Conservation, Contractual supplies from CRMWA, New Well(s)
Fritch	Conservation, New Well(s)
Stinnett	Conservation, New Well(s)
TCW Water Supply Inc.	Conservation
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	Contractual Supply from Borger
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

LIPSCOMB COUNTY SUMMARY PAGE

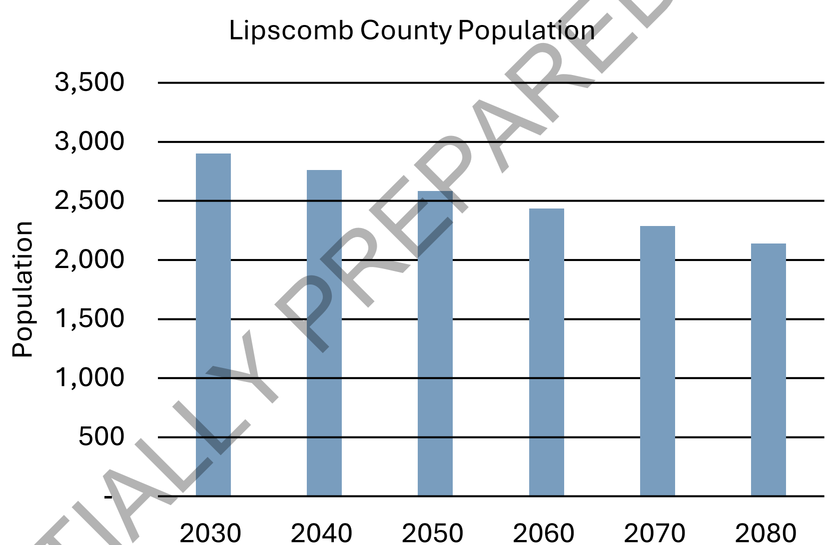
Who are my representatives?

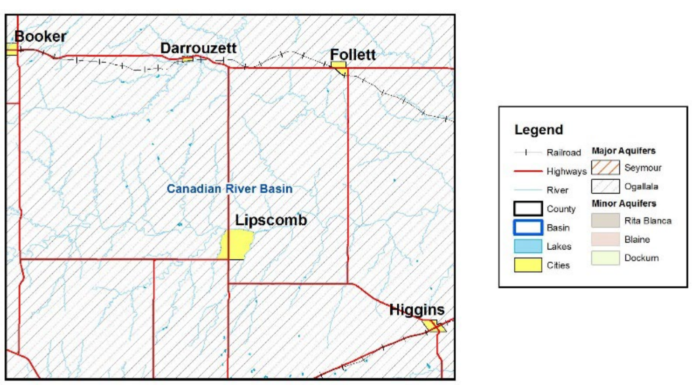
Ben Weinheimer	- Texas Cattle Feeders Association
Brent Auvermann	- Texas A&M AgriLife
Glen Green	- Xcel Energy
Janet Tregellas	- Farm/Ranch
Danny Krienke	- GMA #1, North Plains GCD
Janet Guthrie	- North Plains GCD

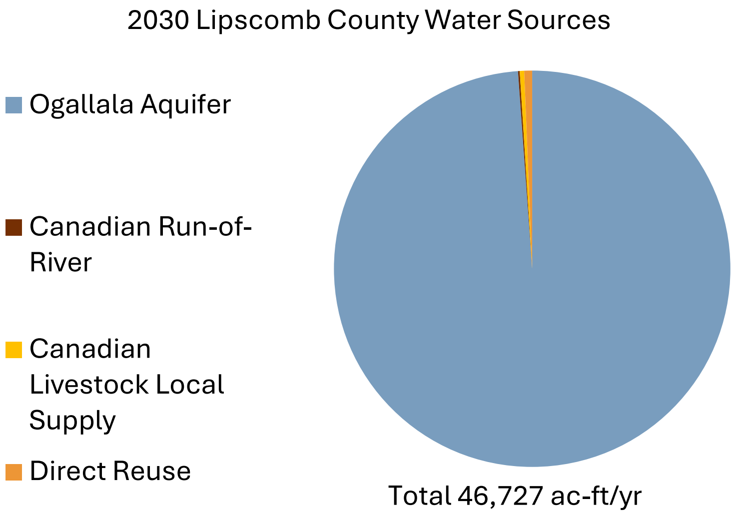
County Seat: City of Lipscomb

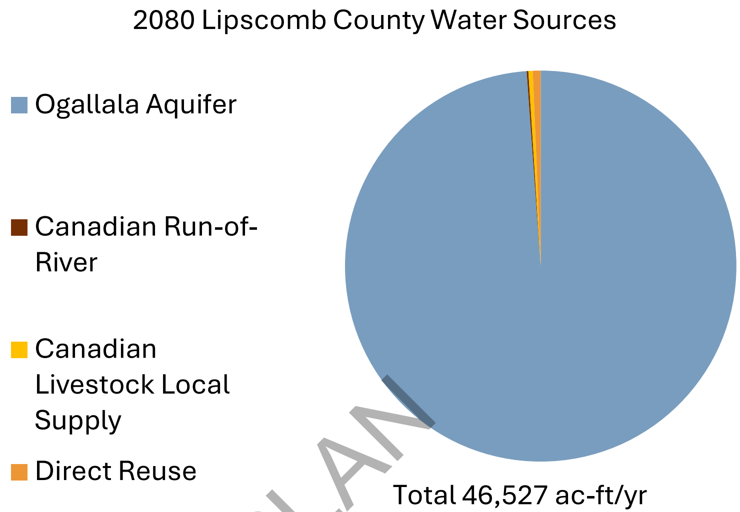
Economy: Agribusiness, Petroleum

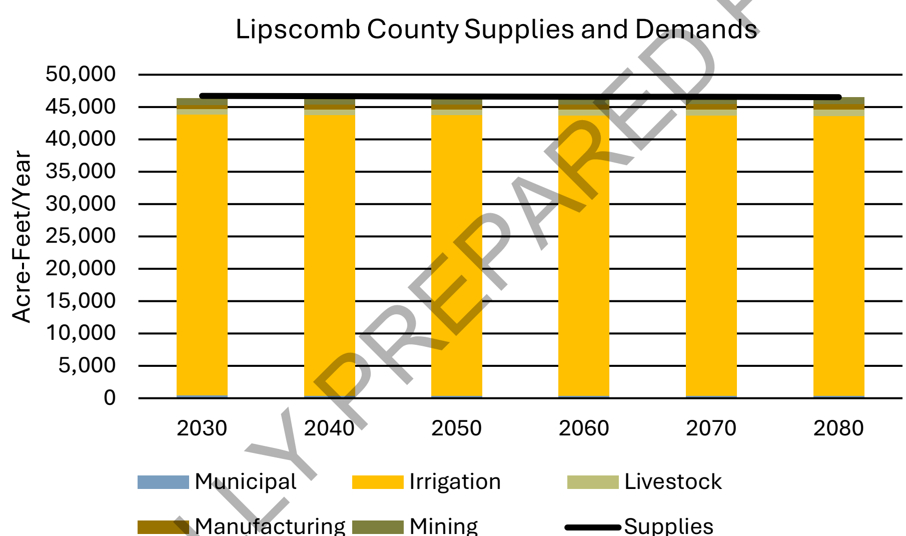
What is the source of my water? Ogallala Aquifer











WATER USER GROUP	STRATEGY
Booker	Conservation, New Well(s)
Darrouzett	Conservation, Water Audit & Leak Repair
Follett	Conservation
Higgins	Conservation, Water Audit & Leak Repair
County-Other	No Water Need Identified
Irrigation	No Water Need Identified
Manufacturing	Contractual Supply from Booker
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

MOORE COUNTY SUMMARY PAGE

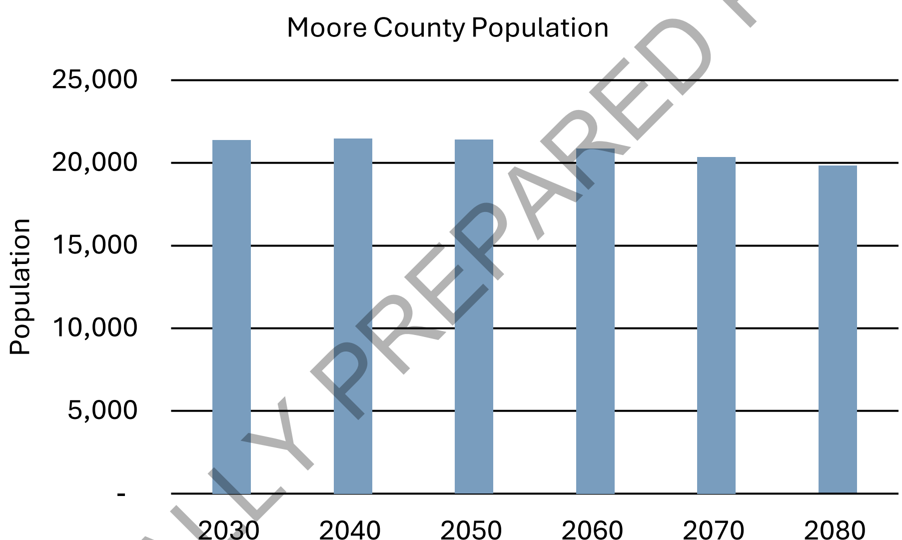
Who are my representatives?

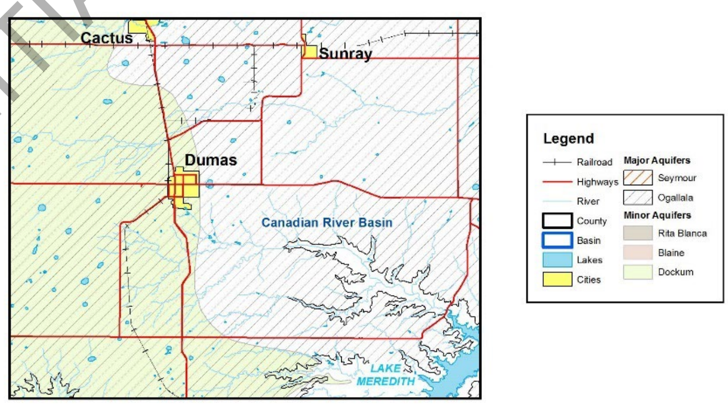
Ben Weinheimer	- Texas Cattle Feeders Association
Brent Auvermann	- Texas A&M AgriLife
Glen Green	- Xcel Energy
Danny Krienke	- GMA #1, North Plains GCD
Janet Guthrie	- North Plains GCD

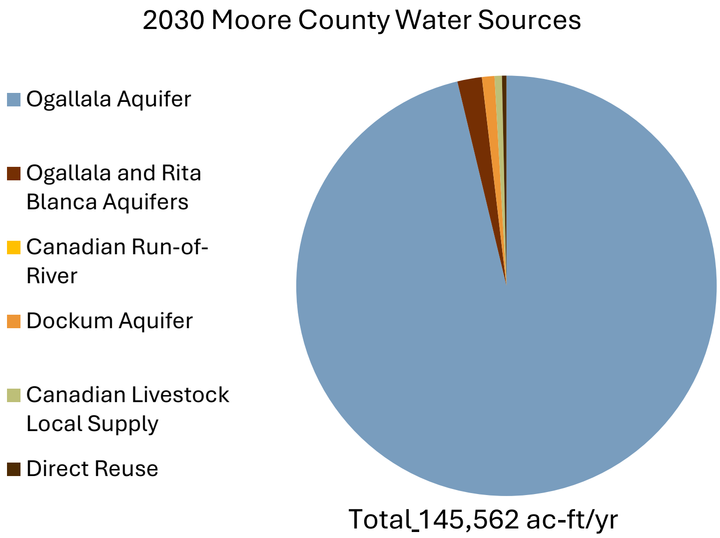
County Seat: City of Dumas

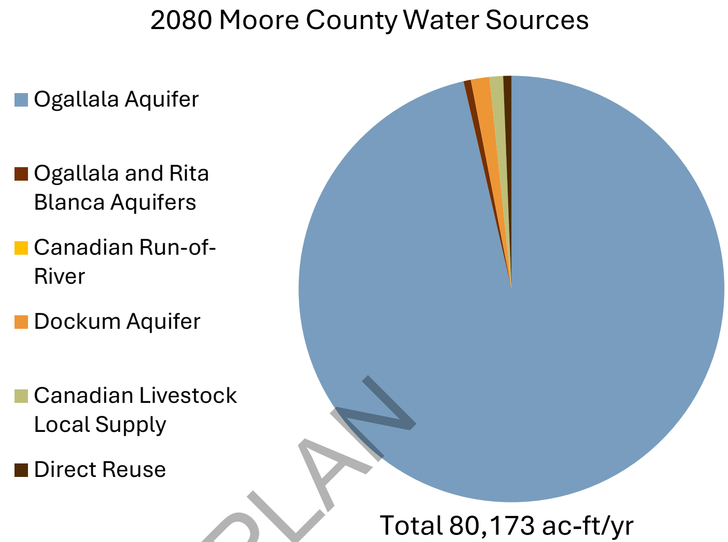
Economy: Agribusiness, Petroleum

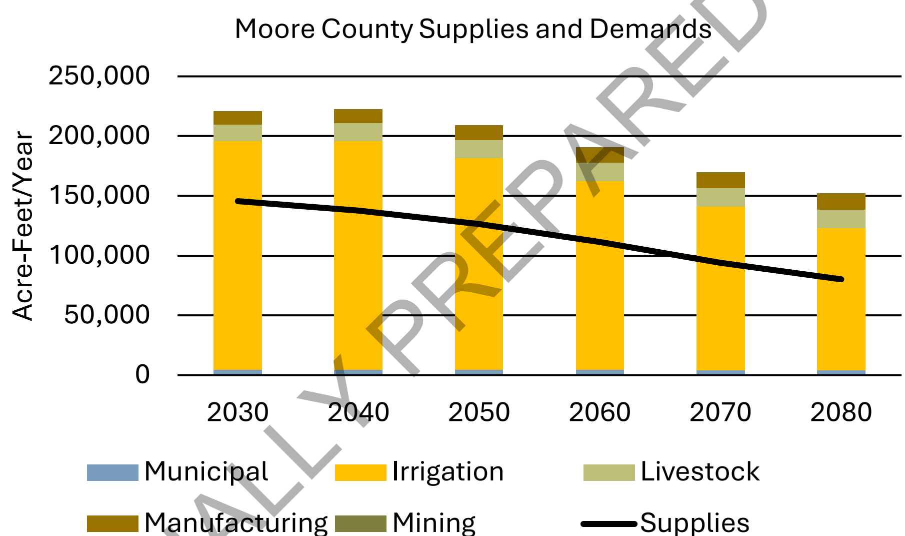
What is the source of my water? Ogallala Aquifer











WATER USER GROUP	STRATEGY
Cactus	Conservation, New Well(s)
Dumas	Conservation, New Well(s)
Fritch	Conservation, New Well(s)
Sunray	Conservation
County-Other	Purchase Supply from Dumas
Irrigation	Conservation
Manufacturing	Purchase Supply from Cactus, New Well(s)
Livestock	New Well(s)
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

OCHILTREE COUNTY SUMMARY PAGE

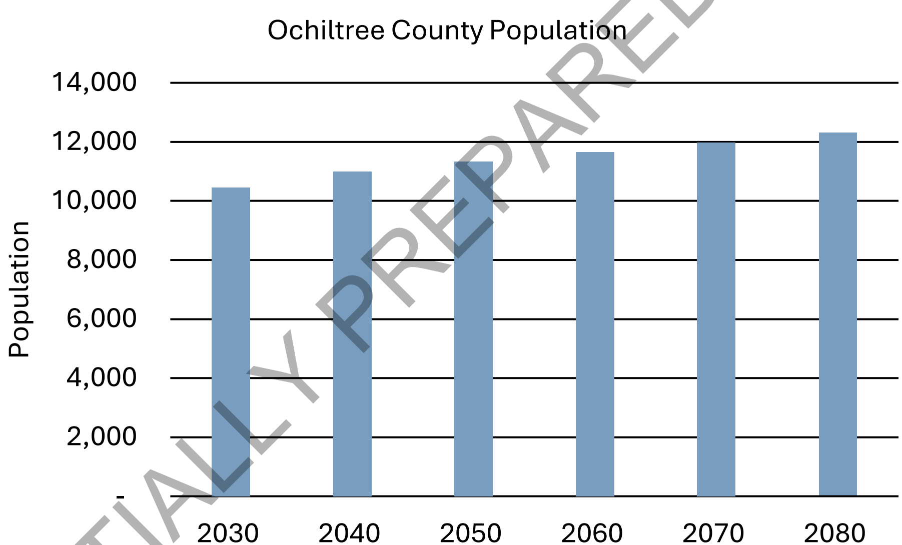
Who are my representatives?

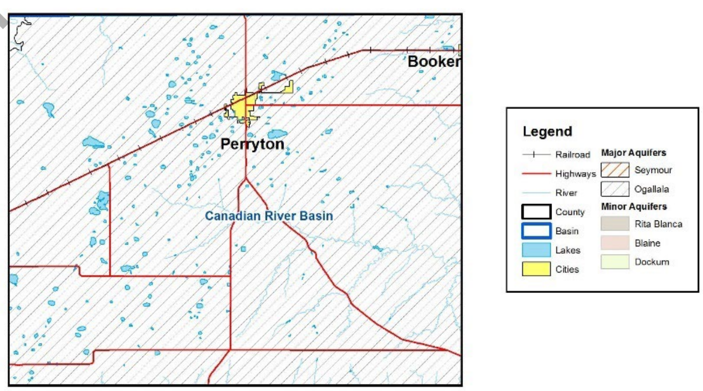
Ben Weinheimer	- Texas Cattle Feeders Association
Brent Auvermann	- Texas A&M AgriLife
Glen Green	- Xcel Energy
David Landis	- City of Perryton
Danny Krienke	- GMA #1, North Plains GCD
Janet Guthrie	- North Plains GCD

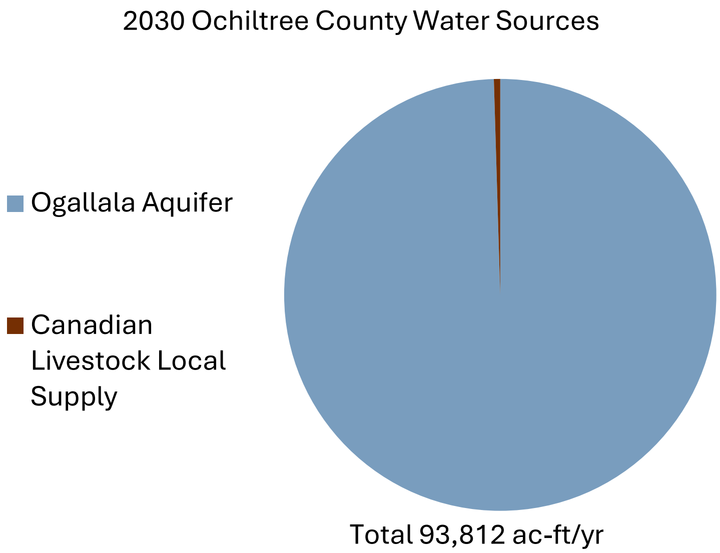
County Seat: City of Perryton

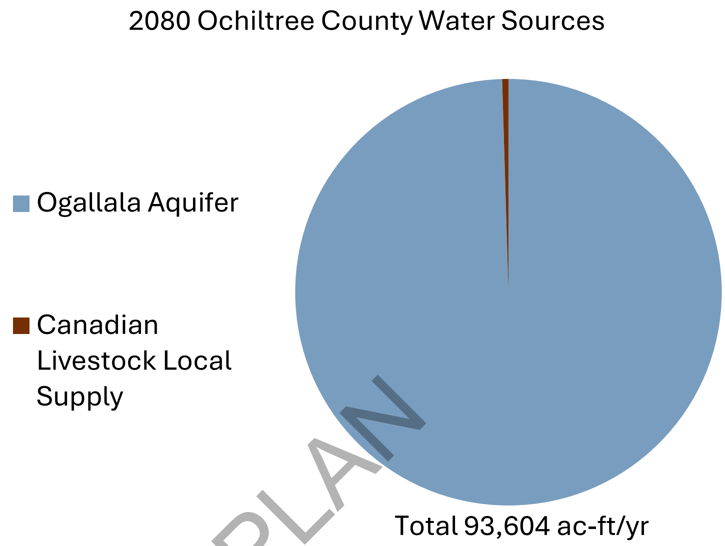
Economy: Agribusiness, Petroleum

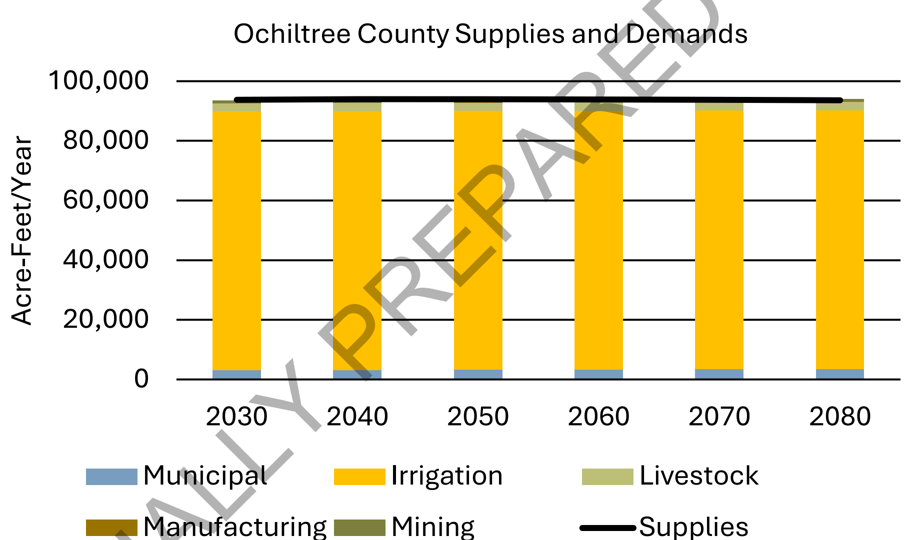
What is the source of my water? Ogallala Aquifer











WATER USER GROUP	STRATEGY
Perryton	Conservation, New Well(s)
Booker	Conservation, New Well(s)
County-Other	No Water Need Identified
Irrigation	No Water Need Identified
Manufacturing	No Water Need Identified
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

OLDHAM COUNTY SUMMARY PAGE

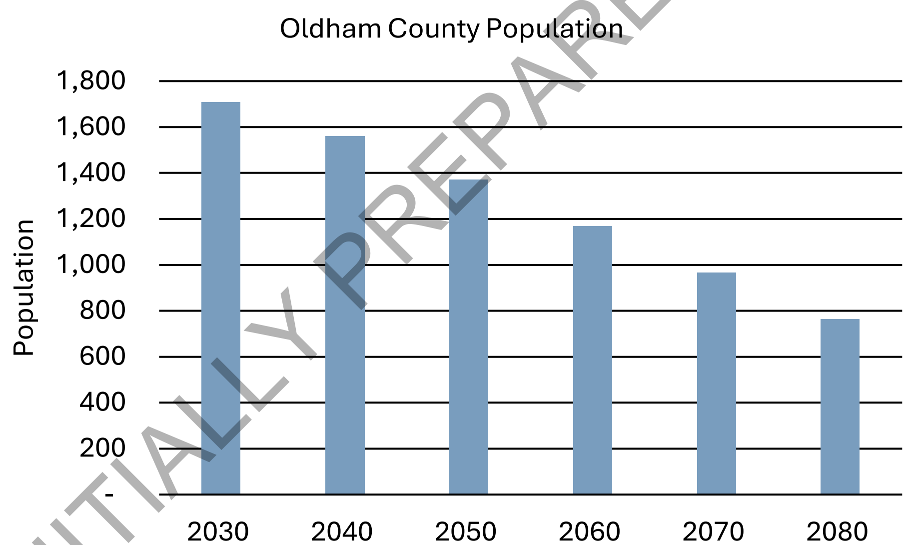
Who are my representatives?

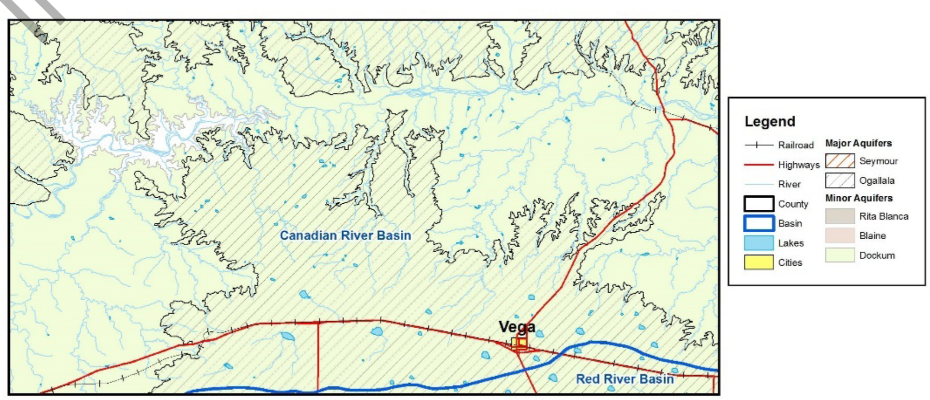
Ben Weinheimer - Texas Cattle Feeders Association
Brent Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Danny Krienke - GMA #1, North Plains GCD

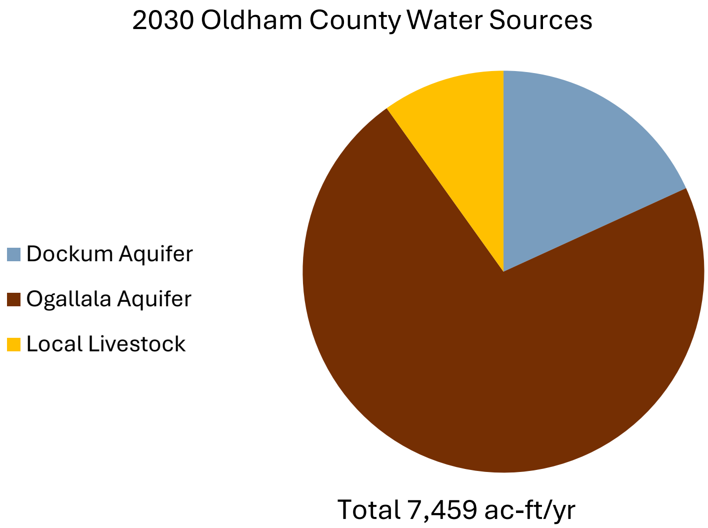
County Seat: City of Vega

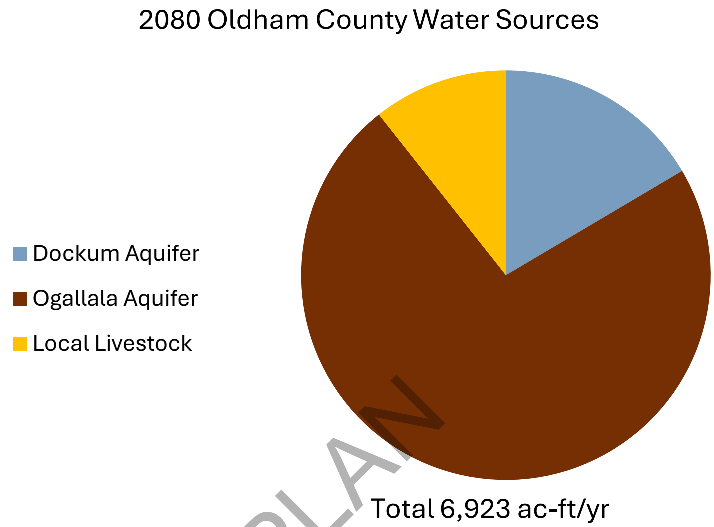
Economy: Agribusiness

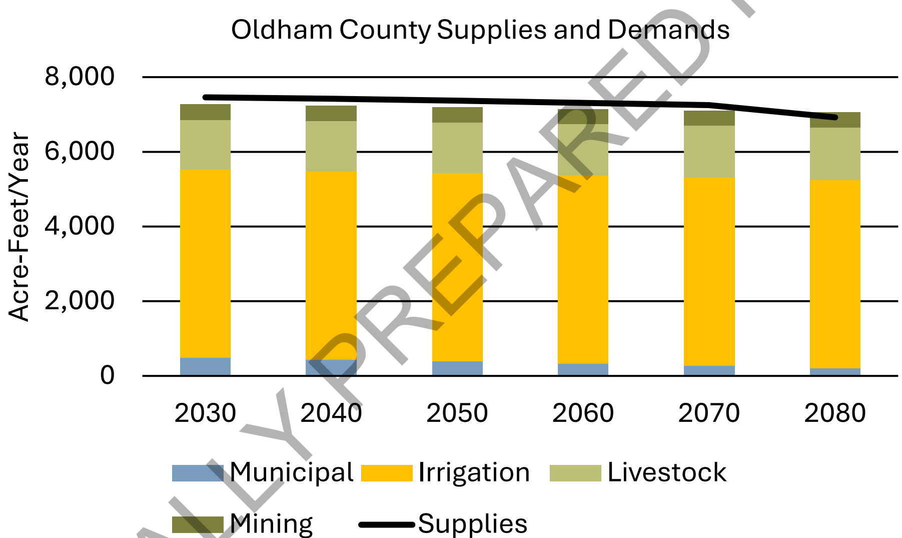
What is the source of my water? Ogallala, Dockum Aquifers











WATER USER GROUP	STRATEGY
Vega	Conservation, Water Audit & Leak Repair
County-Other	Conservation
Irrigation	Conservation
Manufacturing	No Demands in this Category
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

POTTER COUNTY SUMMARY PAGE

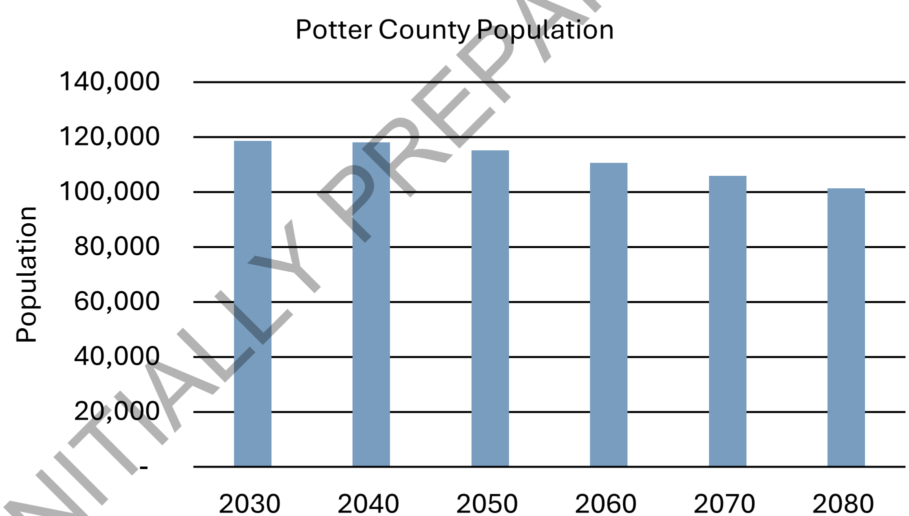
Who are my representatives?

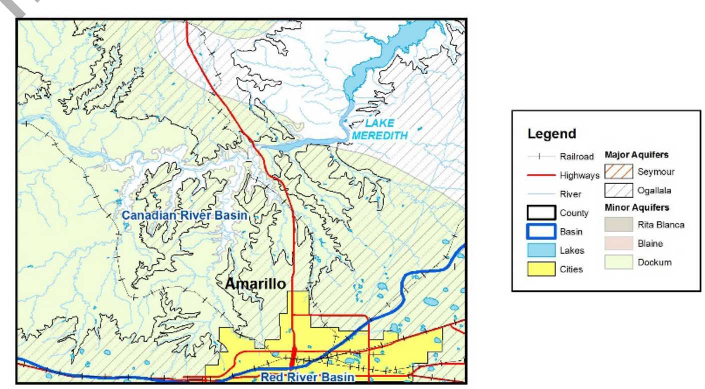
Ben Weinheimer - Texas Cattle Feeders Association
Brent Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Floyd Hartman - City of Amarillo
Danny Krienke - GMA #1, North Plains GCD
Gary Wayne Marek - Conservation & Production Research Laboratory
Herman Berngen - Hilmar Cheese Company
Megan Eikner - Texas A&M AgriLife Research & Extension Center
Britney Britten - Panhandle GCD
Jason Coleman - High Plains UWCD No. 1

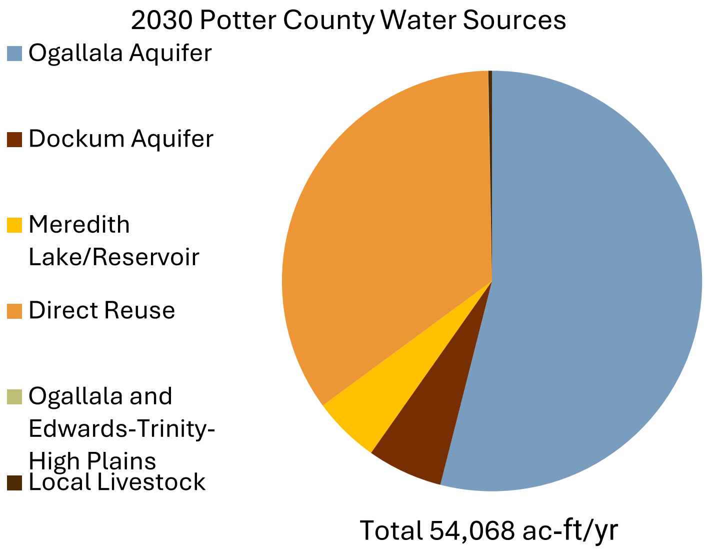
County Seat: City of Amarillo

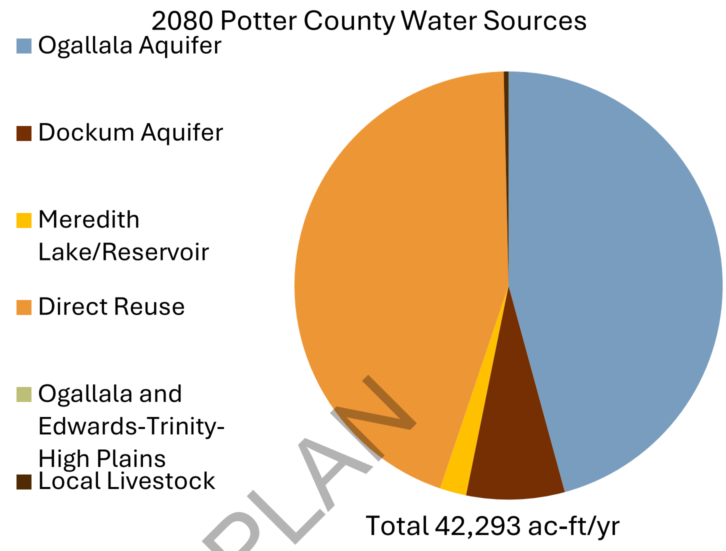
Economy: Agribusiness, Manufacturing, Petroleum, Tourism

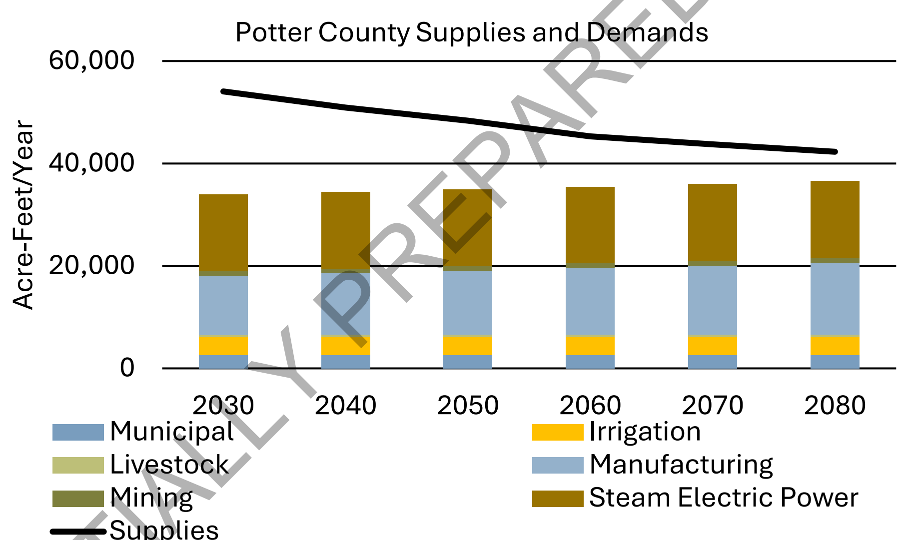
What is the source of my water? Ogallala, Dockum Aquifers, Reuse, Lake Meredith











WATER USER GROUP	WATER MANAGEMENT STRATEGY
Amarillo	Advanced Metering Infrastructure, Conservation, Potter Co./Carson Co. Well Field, Roberts Co. Well Field, Contractual Supply from CRMWA, Direct Potable Reuse
County-Other	Conservation
Irrigation	No Water Need Identified
Manufacturing	New Well(s)
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Water Need Identified

RANDALL COUNTY SUMMARY PAGE

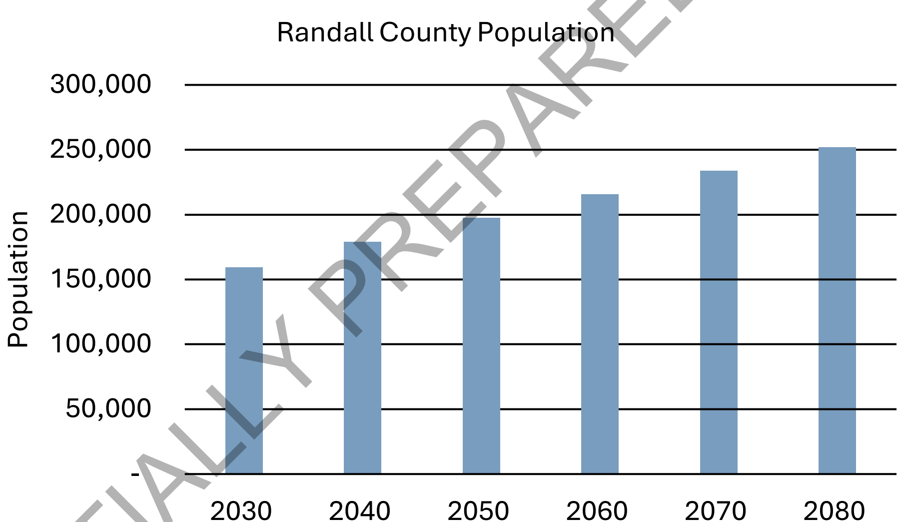
Who are my representatives?

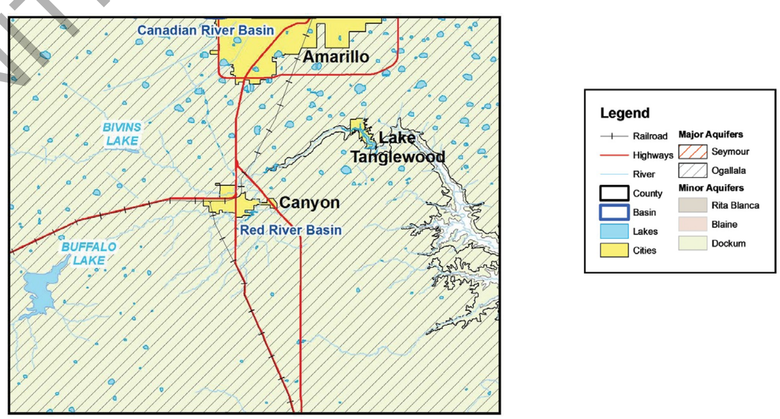
Ben Weinheimer - Texas Cattle Feeders Association Brent
Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Floyd Hartman - City of Amarillo
Danny Krienke - GMA #1, North Plains GCD
Jason Shubert - Talon/LPE
Jason Coleman - High Plains UWCD No. 1

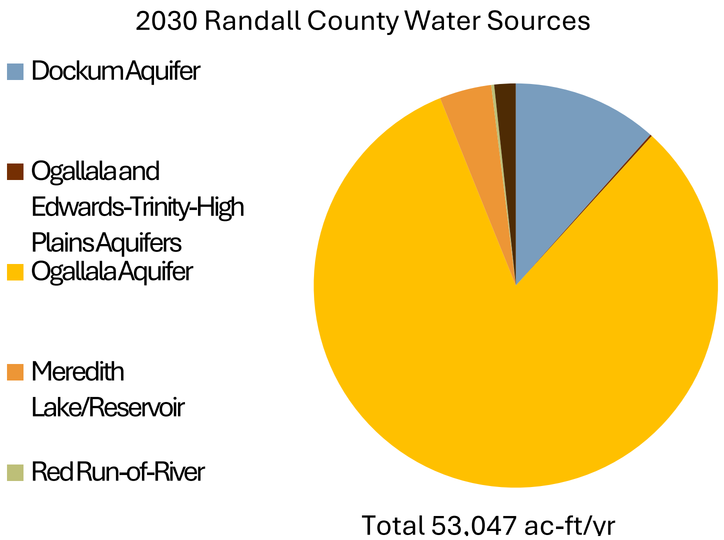
County Seat: City of Canyon

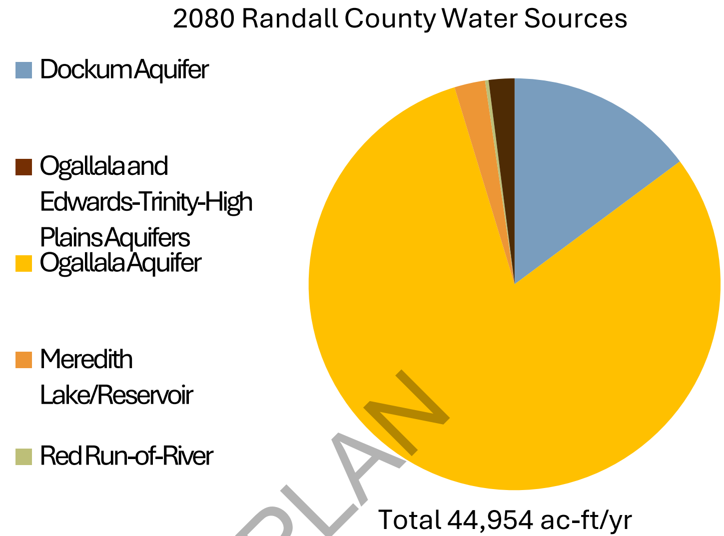
Economy: Agribusiness, Manufacturing, Tourism

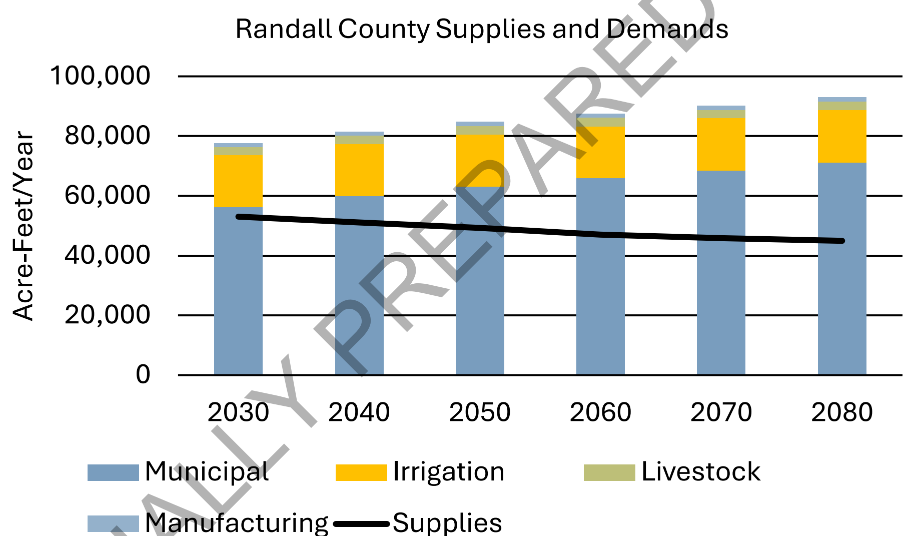
What is the source of my water? Ogallala, Dockum Aquifers, Reuse, Lake Meredith











WATER USER GROUP	STRATEGY
Amarillo	Advanced Metering Infrastructure, Conservation, Water Audit & Leak Repair, Potter Co./Carson Co. Well Field, Roberts Co. Well Field, Contractual Supply from CRMWA, Direct Potable Reuse
Canyon	Conservation, New Well(s), Contractual Supply through Amarillo
Lake Tanglewood	Conservation
County-Other	Contractual Supply from Amarillo
Irrigation	Conservation
Manufacturing	Contractual Supply from Amarillo
Livestock	No Water Need Identified
Mining	No Demands in this Category
Steam Electric Power	No Demands in this Category

ROBERTS COUNTY SUMMARY PAGE

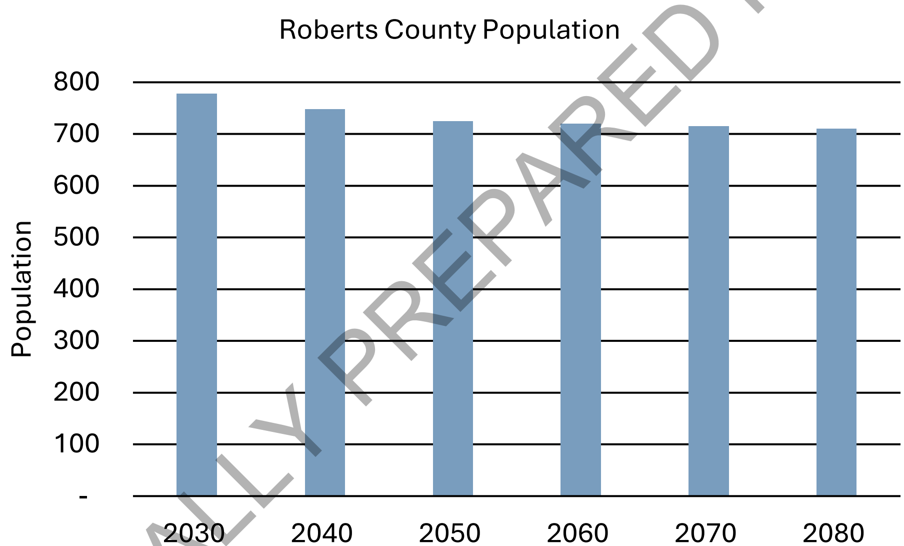
Who are my representatives?

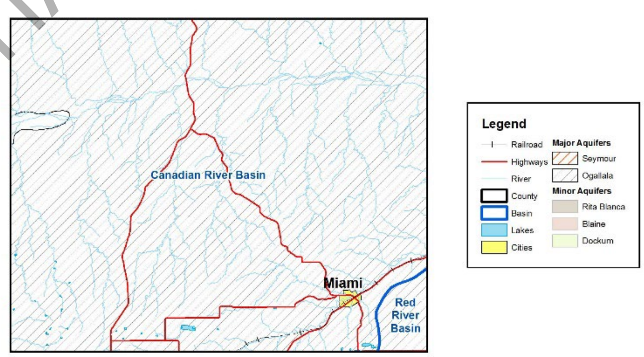
Ben Weinheimer - Texas Cattle Feeders Association Brent
Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Judge Vernon Cook - Retired (Roberts County)
Danny Krienke - GMA #1, North Plains GCD
Britney Britten - Panhandle GCD

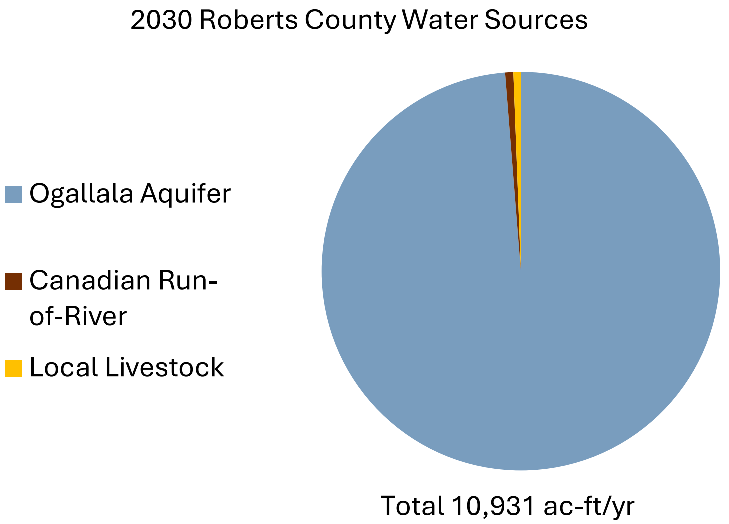
County Seat: City of Miami

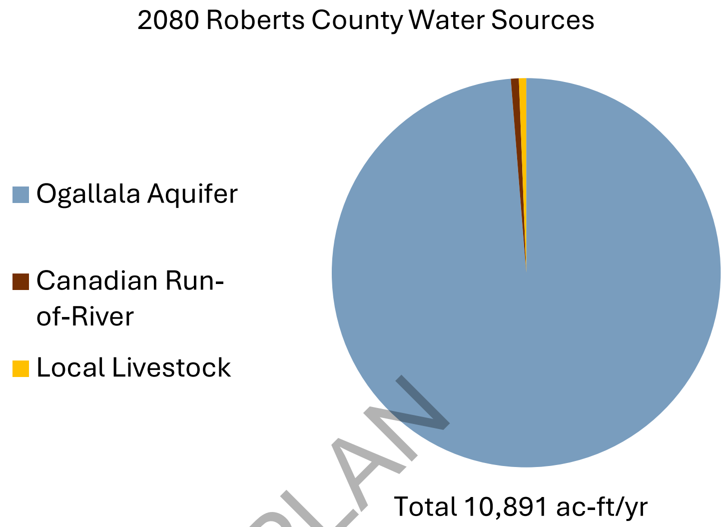
Economy: Agribusiness, Petroleum

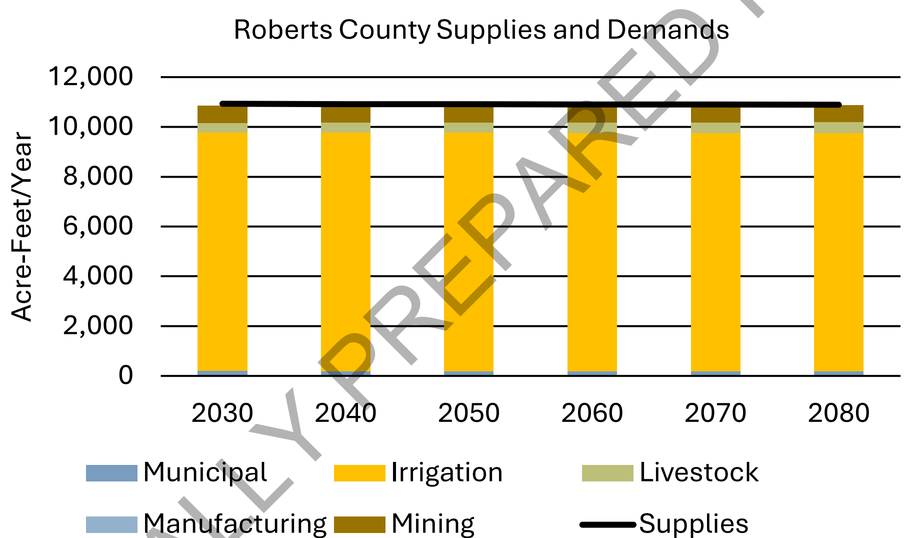
What is the source of my water? Ogallala Aquifer











WATER USER GROUP	STRATEGY
Miami	Conservation, New Well(s)
County-Other	No Water Need Identified
Irrigation	No Water Need Identified
Manufacturing	No Demands in This Category
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

SHERMAN COUNTY SUMMARY PAGE

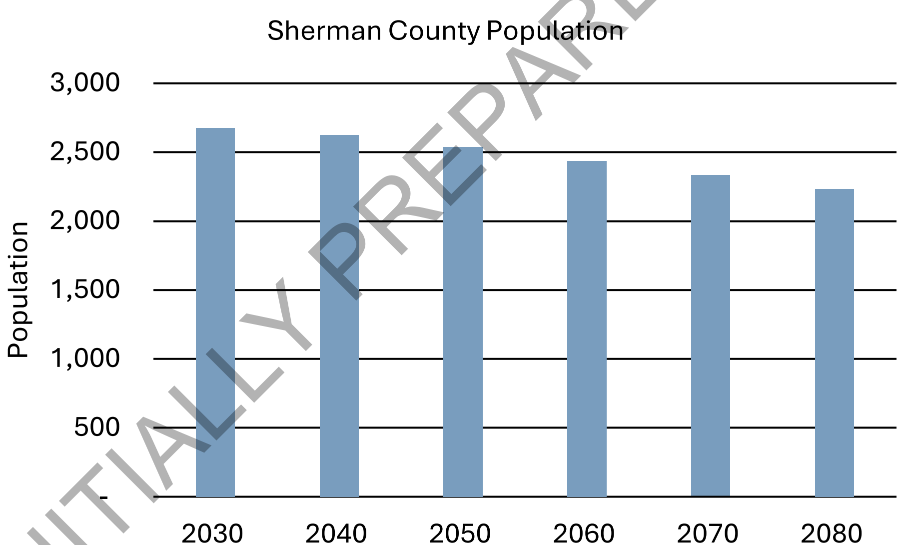
Who are my representatives?

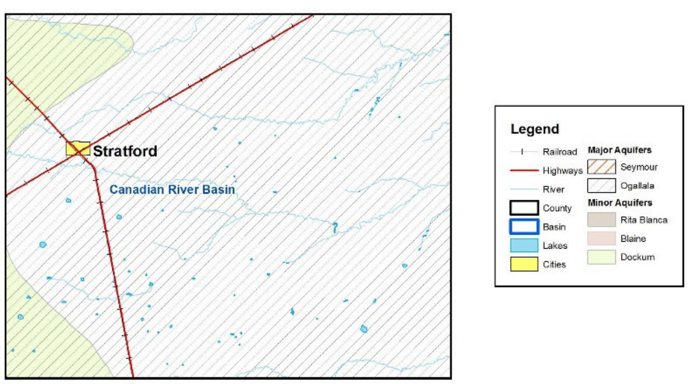
Ben Weinheimer - Texas Cattle Feeders Association Brent
Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Danny Krienke - GMA #1, North Plains GCD
Janet Guthrie - North Plains GCD

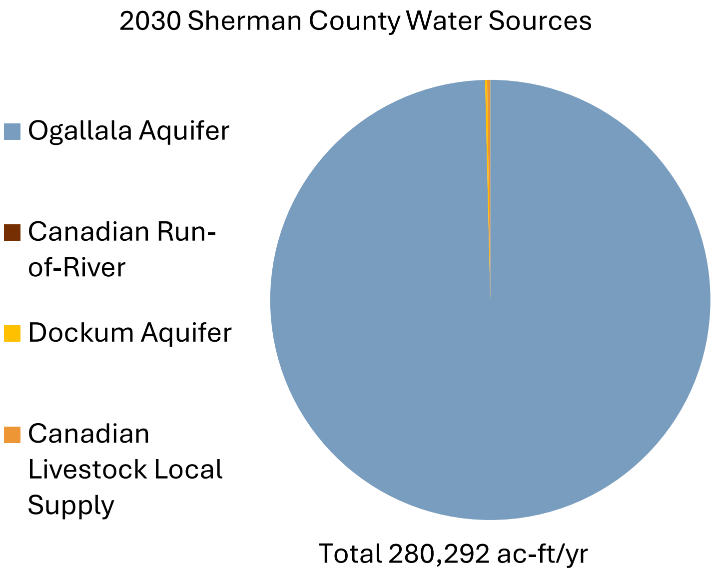
County Seat: City of Stratford

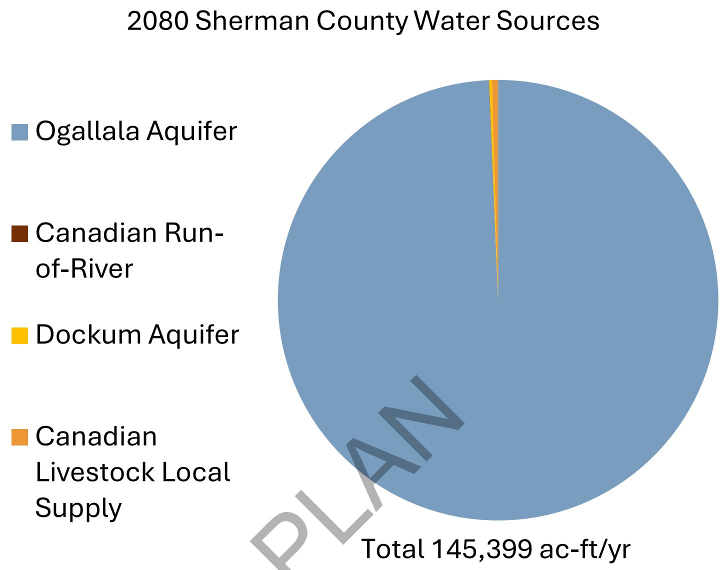
Economy: Agribusiness, Petroleum

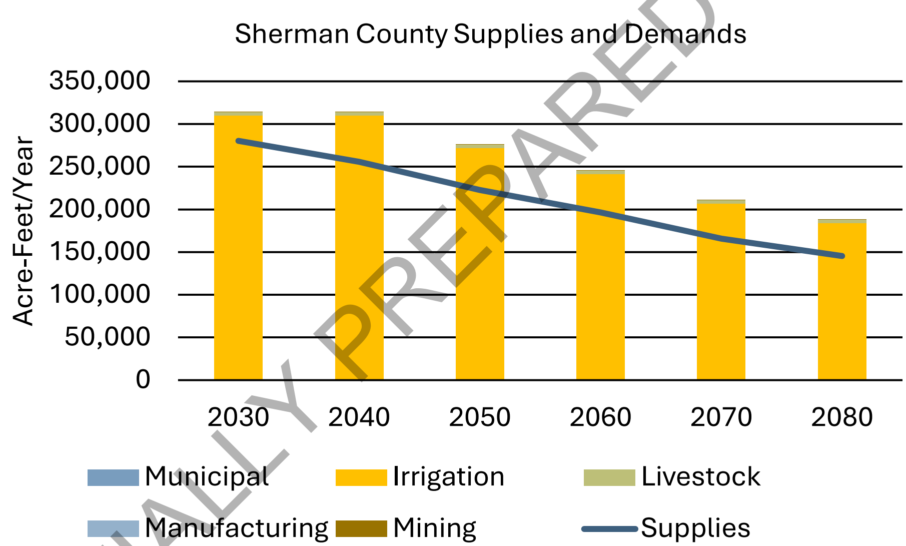
What is the source of my water? Ogallala Aquifer











WATER USER GROUP	STRATEGY
Stratford	Conservation, New Well(s)
Texhoma	No Water Need Identified
County-Other	No Water Need Identified
Irrigation	Conservation
Manufacturing	No Water Need Identified
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

WHEELER COUNTY SUMMARY PAGE

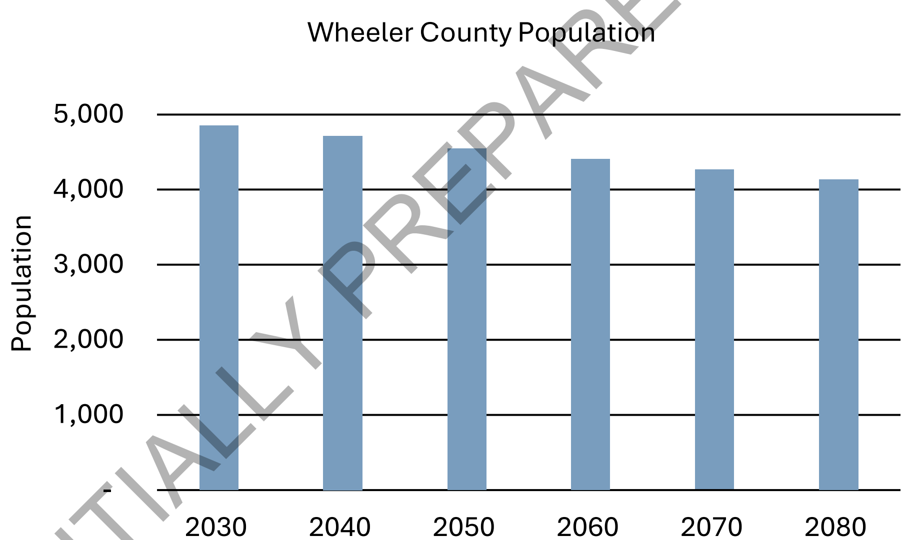
Who are my representatives?

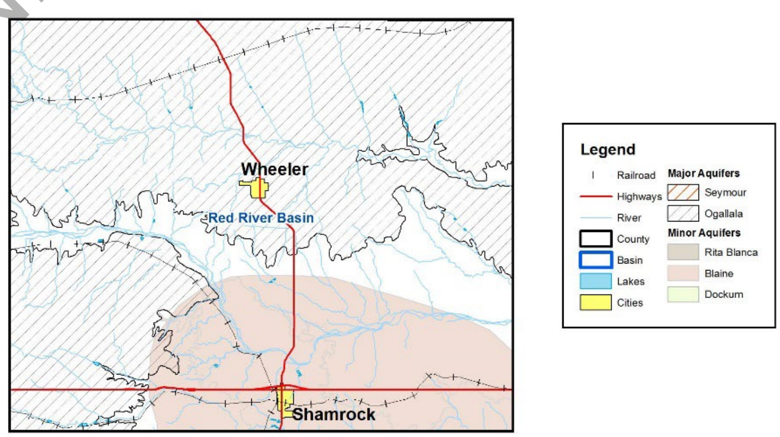
Ben Weinheimer - Texas Cattle Feeders Association Brent
Auvermann - Texas A&M AgriLife
Glen Green - Xcel Energy
Danny Krienke - GMA #1, North Plains GCD
Britney Britten - Panhandle GCD

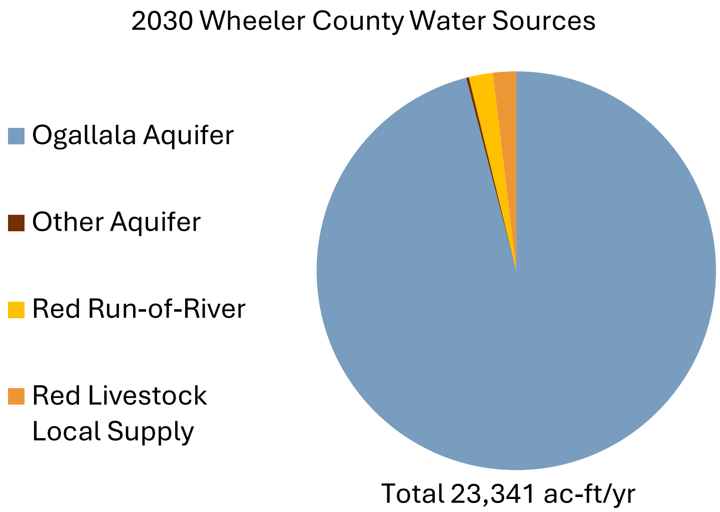
County Seat: City of Wheeler

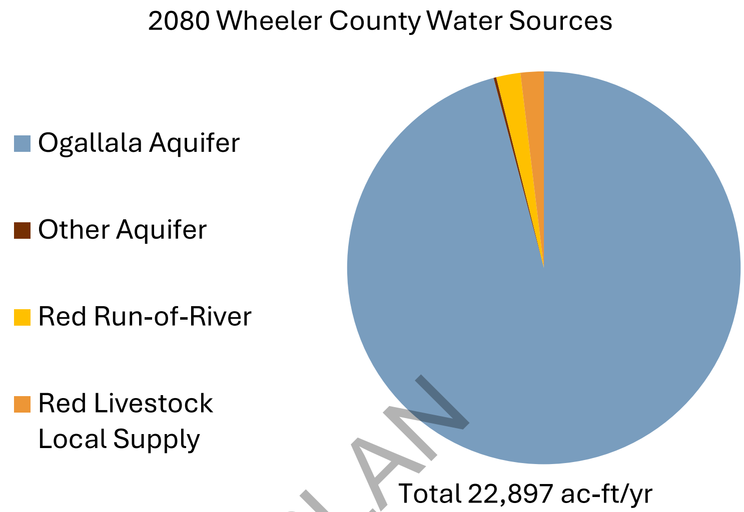
Economy: Agribusiness, Petroleum, Tourism

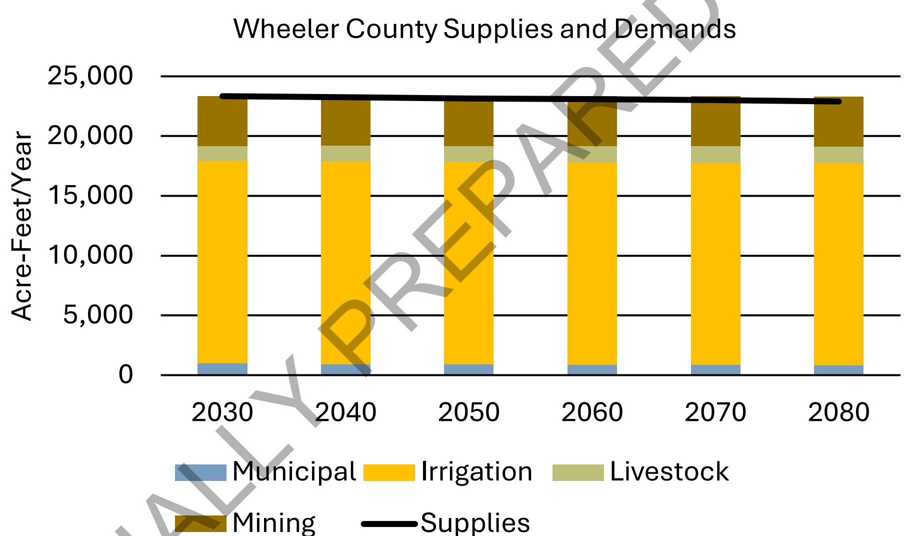
What is the source of my water? Ogallala, Blaine Aquifer











WATER USER GROUP	STRATEGY
Shamrock	Conservation, New Well(s)
Wheeler	Conservation, New Well(s)
County-Other	No Water Need Identified
Irrigation	No Water Need Identified
Manufacturing	No Demands in this Category
Livestock	No Water Need Identified
Mining	No Water Need Identified
Steam Electric Power	No Demands in this Category

1 PLANNING AREA DESCRIPTION

1.1 Introduction

In 1997, the 75th Texas Legislature passed Senate Bill One (SB1). The bill was designed to address Texas water supply needs associated with drought of record conditions. SB1 put in place a grass-roots regional planning process to plan for the water needs of all Texans in the next century. To implement this planning process, the Texas Water Development Board (TWDB) created 16 regional water planning areas (RWPA) across the state and established guidelines and rules governing regional planning efforts. The Panhandle Water Planning Area (PWPA) is located in the northern panhandle of Texas (**Figure 1-1**). It is comprised of 21 counties with similar characteristics and water sources.

PWPA at a Glance:

- 21 Counties
- Mostly rural, with more than half of the region's population in Amarillo
- Major cities include Amarillo, Borger, Canyon, Dumas, and Pampa
- Agriculture is driving economic force, with major crops including corn, wheat, and grain sorghum
- Climate is characterized by rapid and large temperature changes, wind, low humidity, and relatively low rainfall
- 98 percent of total regional water use is from groundwater (primarily Ogallala); 92 percent is used for agriculture
- 4 Major Water Providers
- 6 Groundwater Conservation Districts and 2 Groundwater Management Areas
- 2 Major Aquifers and 3 Minor Aquifers
- 3 Major Reservoirs

The regional water planning groups created pursuant to SB1 are tasked to direct the regional planning process. TWDB regulations require each regional planning group to include representatives of 12 designated interest groups. Additional interest groups may be added at the discretion of the planning group. The Panhandle Water Planning Group (PWPG) added "higher education" as an interest group. **Table 1-1** shows the members of the PWPG and the interests they represent. The PWPG hired a team of consultants to conduct technical analyses and prepare the regional water plan under the supervision of the planning group. The consulting team includes Freese and Nichols, Inc., Texas A&M AgriLife Research and Extension Center at Amarillo (AgriLife), and Intera. The Panhandle Regional Planning Commission (PRPC) serves as the political subdivision and contractor.

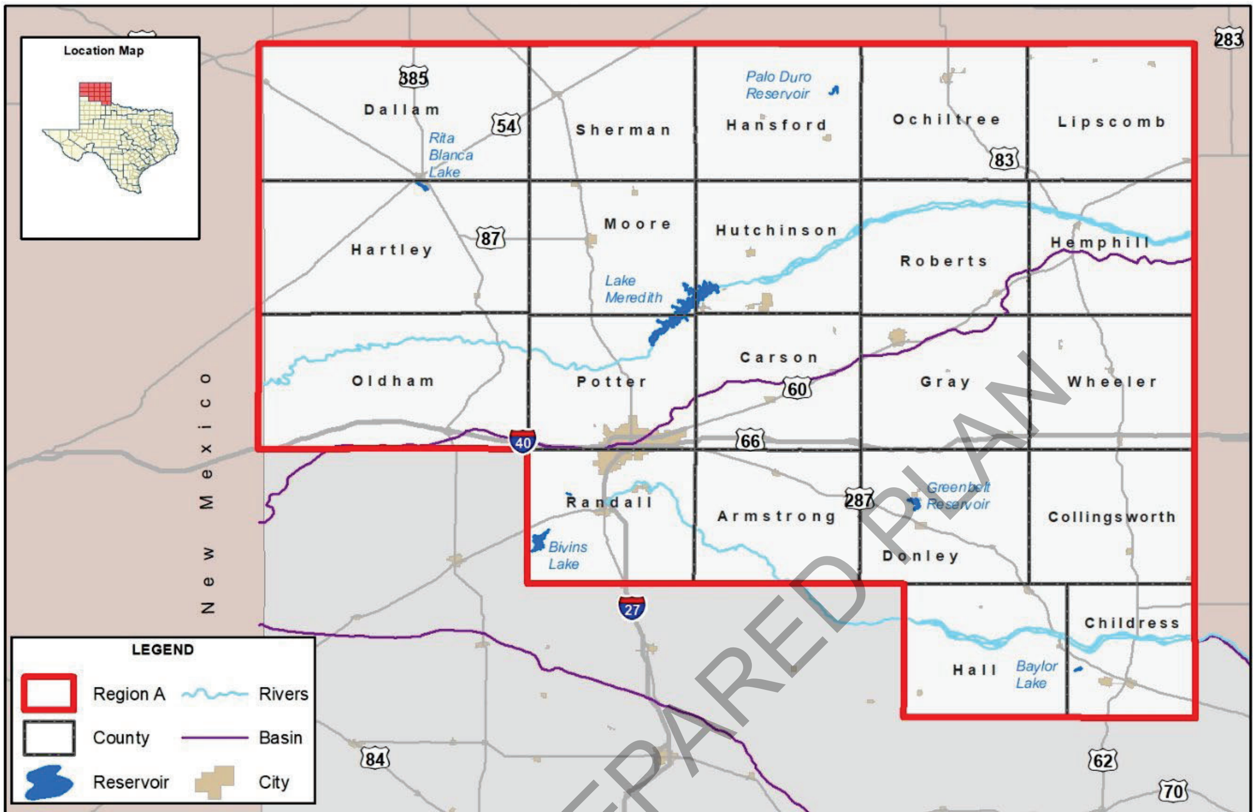


Figure 1-1: Panhandle Water Planning Area

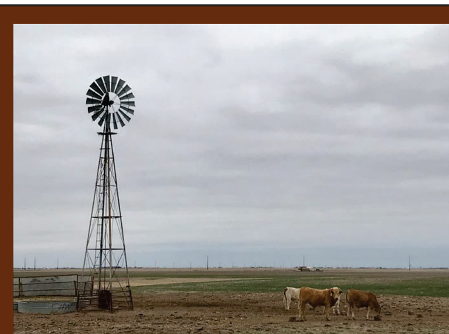
Table 1-1: Voting Members of the Panhandle Water Planning Group

Interest	Name[1]	Entity	County (Location of Interest)
Public	Megan Eikner	Texas A&M AgriLife Research and Extension Center	PWPA
Counties	Judge Vernon Cook	Retired (Roberts County)	Roberts
Municipalities	Floyd Hartman	City of Amarillo	Potter and Randall
	David Landis	City of Perryton	Ochiltree
Industries	Spencer Cave	Phillips 66	Hutchinson
	Herman Berngen	Hilmar Cheese	PWPA
Agricultural	Ben Weinheimer	Texas Cattle Feeders Association	PWPA
	Joe Baumgardner	Farmer	Collingsworth
	Janet Tregellas	Farm/Ranch	Lipscomb

Interest	Name[1]	Entity	County (Location of Interest)
Environmental	Dr. Howell	Texas A&M AgriLife	PWPA
	Dr. Gary Marek	Conservation and Production Research Laboratory	PWPA
	Jason Shubert	Talon	Potter
Small Businesses	Rusty Gilmore	Water Well Driller	Dallam
Electrical Generating Utilities	Glen Green	Xcel Energy	Potter (serves entire region)
River Authorities	Drew Satterwhite	Canadian River MWA	Multiple counties
Water Districts	Christa Perry	Hemphill County UWCD	Hemphill
	Jason Coleman	High Plains UWCD	Potter, Randall and Armstrong
	Britney Britten	Panhandle GCD	Multiple counties
	Janet Guthrie	North Plains GCD	Multiple counties
Water Utilities	Dean Cooke	TCW Supply	Hutchinson
Groundwater Management Areas	Danny Krienke	GMA#1	Ochiltree and 17 other counties
	Whitney Weibe	GMA#6	Collingsworth, Childress and Hall
Higher Education	Brent Auvermann	Texas A&M AgriLife Research and Extension Center at Amarillo	PWPA

[1] Non-voting members and former members who contributed to this plan are listed in **Tables 10-1** and **10-2** in **Chapter 10**.





The PWPA consists of a 21-county area that includes Armstrong, Carson, Childress, Collingsworth, Dallam, Donley, Gray, Hall, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Potter, Randall, Roberts, Sherman, and Wheeler Counties. This is the sixth regional water supply plan that has been developed for the PWPA since the passage and implementation of SB1.

This plan is a complete update of the 2021 Panhandle Regional Water Plan. Every chapter has been reviewed and updated. Some of the new and/or changed information in this plan include:

Organization of Water Plan:

1. Planning Area Description
2. Current and Projected Population and Water Demand
3. Evaluation of Regional Water Supplies
4. Identification of Water Needs
5. Water Management Strategies
6. Impacts of the Regional Water Plan
7. Drought Response Information, Activities and Recommendations
8. Regulatory, Administrative and Legislative Recommendations
9. Implementation and Comparison to Previous Regional Water Plan
10. Plan Adoption and Public Participation

- Designation of Major Water Providers
- Updated water demand projections through 2080 (Agriculture, Industrial and Municipal)
- Updated water supplies, including updated Modeled Available Groundwater values for groundwater and updated Red River WAM for surface water
- Reassessment of water supplies to users and water needs
- Evaluation of new water management strategies, including designation of alternate strategies
- Updated Legislative and other recommendations

1.2 Senate Bills 1 and 2

SB1 was a result of increased awareness of the vulnerability of Texas to drought and to the limits of existing water supplies to meet increasing demands as population grows. According to the most recent population projections, Texas' population is expected to exceed its 2020 level of 29 million, growing to more than 52 million by 2080. Many areas of the state continue to be impacted by water needs.

SB1 established a "bottom up" water planning process by allowing individual representatives of various interest groups to serve as members of Regional Water Planning Groups (RWPGs) charged to prepare regional water plans for their respective areas. The TWDB established 16 distinct planning areas that are directed by volunteers leading diverse RWPGs. The plans developed by the RWPGs detail how to conserve water supplies, meet future water supply needs and respond to future droughts in the planning areas and are designed to ensure that the water needs of all Texans are met.

Senate Bill 2 (SB2), enacted in 2001 by the 77th Legislature, built on policies created in SB1. There were several new requirements and improvements called for within SB2, including:

- Use of the results of state-led water availability models for both ground and surface water
- Provide for conservation as a water management strategy
- Evaluate the impacts of water management strategies on water quality
- Consider recommendations from conservation and drought management plans

The sixth round of planning culminates with the 2026 Regional Water Plan, which is to be submitted to TWDB by October 20, 2025. The TWDB must then approve and incorporate these plans into an all-inclusive state plan. The plans will continue to be updated every five years.

1.3 Regional Water Planning Area

The PWPA is among the largest water-consuming regions in the State, with 94 percent of water used for agricultural purposes in 2021. According to the 2021 TWDB population estimate, the Texas state population was approximately 29.5 million people. The PWPA accounted for 1.3 percent of the total state population in 2021 and approximately 15 percent of the State's annual water demand. The TWDB projects that total water use for the region will decline over the 2030-2080 period, primarily due to an expected reduction in agricultural irrigation water use. Future irrigation water use is expected to decline due to a combination of factors, including projected insufficient quantities of groundwater to meet irrigation water demands, implementation of conservation practices, including new crop types and the use of more efficient irrigation technology.

The PWPG is composed of 23 members (**Table 1-1**), who collectively represent the interest of the public, industry, agriculture, environment, river authorities, counties, municipalities, water districts, water utilities, small business, electrical generation, higher education, and groundwater management areas. Six non-voting members also serve as federal and state agency representatives and neighboring regional water planning region liaisons. The PRPC serves as the political subdivision and contracting agency for the PWPA.

1.3.1 Population

The PWPA population is centered in major cities with some rural counties having total populations less than 5,000 people. The PWPA population is expected to grow from 407,985 in 2030 to 470,326 in 2080. **Table 1-2** and **Figure 1-2** show the cities with populations greater than 10,000 in the PWPA. **Table 1-3** presents the historical decadal populations by county for the region.

Table 1-2: Cities with Populations Greater than 10,000

City	2020 Population
Amarillo	199,371
Borger	12,164
Canyon	14,770
Dumas	14,726
Pampa	17,358

Source: 2020 Census

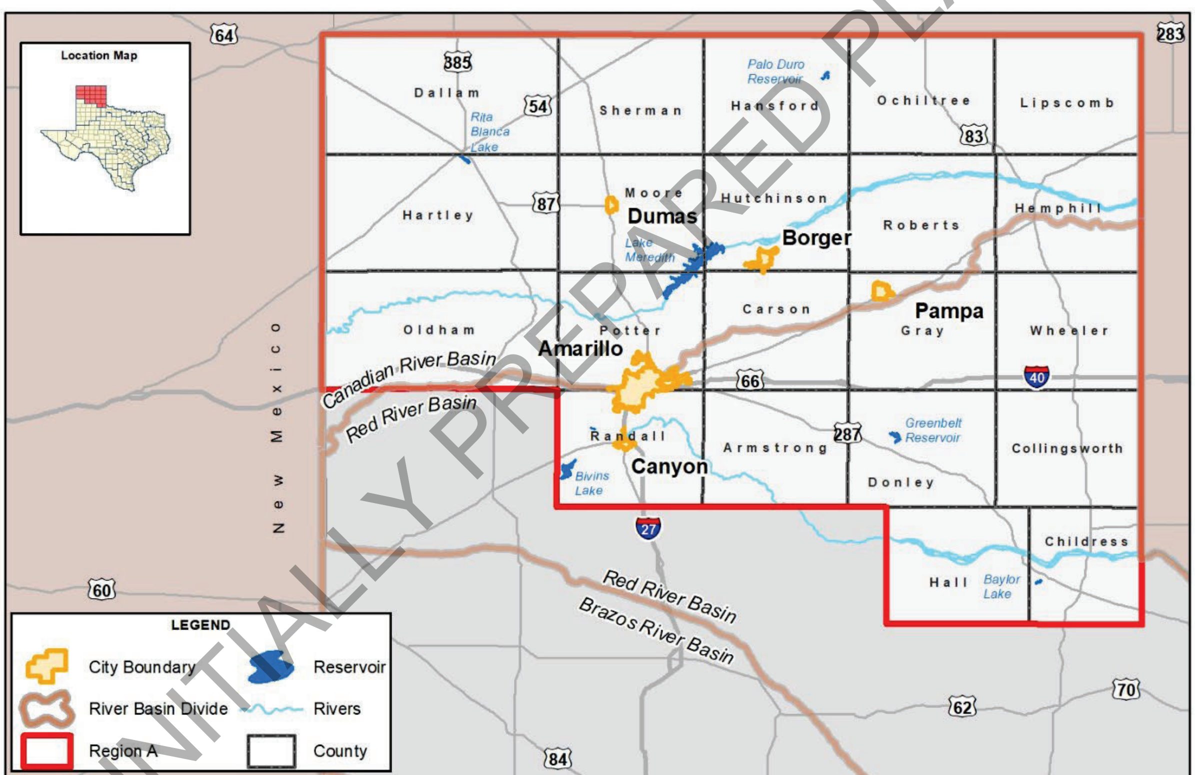


Figure 1-2: Major Cities in the PWPA (>10,000)

Table 1-3: Historical Population of PWPA Counties

County	1960	1970	1980	1990	2000	2010	2020
Armstrong	1,966	1,895	1,994	2,021	2,153	1,901	1,848
Carson	7,781	6,358	6,672	6,576	6,503	6,182	5,807
Childress	8,421	6,605	6,950	5,953	7,697	7,041	6,664
Collingsworth	6,276	4,755	4,648	3,573	3,206	3,057	2,652
Dallam	6,302	6,012	6,531	5,461	6,213	6,703	7,115
Donley	4,449	3,641	4,075	3,696	3,814	3,677	3,258
Gray	31,535	26,949	26,386	23,967	22,742	22,535	21,227
Hall	7,322	6,015	5,594	3,905	3,782	3,353	2,825
Hansford	6,208	6,351	6,209	5,848	5,369	5,613	5,285
Hartley	2,171	2,782	3,987	3,634	5,538	6,062	5,382
Hemphill	3,185	3,084	5,304	3,720	3,353	3,807	3,382
Hutchinson	34,419	24,443	26,304	25,689	23,864	22,150	20,617
Lipscomb	3,406	3,486	3,766	3,143	3,050	3,302	3,059
Moore	14,773	14,060	16,575	17,865	20,123	21,904	21,358
Ochiltree	9,380	9,704	9,588	9,128	9,001	10,223	10,015
Oldham	1,928	2,258	2,283	2,278	2,183	2,052	1,758
Potter	115,580	90,511	98,637	97,874	113,655	121,073	118,525
Randall	33,913	53,885	75,062	89,673	104,176	120,725	140,753
Roberts	1,075	967	1,187	1,025	887	929	827
Sherman	2,605	3,657	3,174	2,858	3,184	3,034	2,782
Wheeler	7,947	6,434	7,137	5,879	5,289	5,410	4,990
PWPA Total	**310,642**	**283,852**	**322,063**	**323,766**	**355,782**	**380,733**	**390,129**

1.3.2 Economic Activities

Table 1-4 shows the economic activity by county in the PWPA. The economy of the PWPA can be summarized in the following broad categories: agribusiness, manufacturing, energy, and tourism. Major water-using activities include irrigation, agricultural production, exploration production and refining of oil and gas resources, food processing, chemical and allied products, and electric power generation. The average household income for counties in the PWPA is shown for the year 2022, with the median for the PWPA around $63,000. Payroll data for 2022 show the total payroll in the PWPA to exceed $9 billion, with 45 percent of the payroll reported in Potter County.

The PWPA has an economy that spans major industries ranging from agriculture to technology. The region's economy is beginning to diversify based on regional, statewide, and national trends to meet local needs and the broad needs of the country. The region benefits from a low unemployment rate compared to the rest of Texas and the country. National and statewide initiatives in renewable energy and technology also have a significant influence on the economic

Table 1-4: Economic Activities of Counties in the PWPA

	Total Annual Wages[1]($)	Median household income[2] ($)	Employment[1] (population)	Major Economic Activities			
County	2022	2022	2022	Agribusiness	Manufacturing	Petroleum	Tourism
Armstrong	23,314,847	70,417	477	X			X
Carson	534,713,562	83,199	5,810	X		X	
Childress	154,519,453	56,063	2,774	X			X
Collingsworth	36,940,559	52,045	798	X			
Dallam	245,667,202	71,969	4,443	X	X		X
Donley	36,195,472	51,711	934	X	X		X
Gray	412,236,849	54,463	7,363	X	X	X	
Hall	28,088,434	43,873	815	X			
Hansford	127,986,729	62,350	2,304	X		X	
Hartley	122,550,580	78,065	2,538	X	X	X	
Hemphill	90,063,977	67,798	1,538	X		X	X
Hutchinson	545,462,107	62,211	7,868	X	X	X	X
Lipscomb	63,213,574	71,625	1,200	X		X	
Moore	673,656,517	59,041	11,917	X		X	
Ochiltree	223,126,860	62,240	4,134	X		X	
Oldham	39,773,270	71,103	864	X			
Potter	4,276,705,024	50,661	77,295	X	X	X	X
Randall	1,793,497,955	76,744	35,321	X	X		X
Roberts	16,532,226	62,667	236	X		X	
Sherman	58,131,759	66,169	1,096	X			X
Wheeler	72,337,679	58,158	1,731	X		X	X
Total	**9,574,714,635**		**171,456**				
Average	**455,938,792**	**63,456**					

[1] 2022 Quarterly Census of Employment and Wages Annual Averages (Ownerships: Total, All Ownerships)
[2] United States Census Bureau 2022 American Community Survey 5-year Estimates

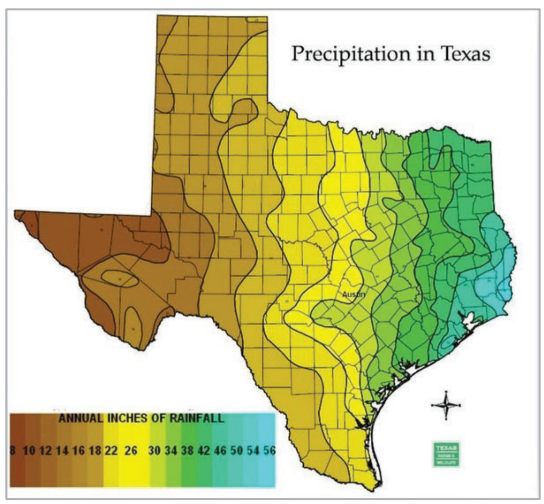
activity of the region, with this field rapidly evolving from a growing niche into one of the key industries in the region. Infrastructure issues related to waste disposal and water resources are also key external factors related to the economic viability of the PWPA.

Oil, cattle, and production agriculture have historically driven the PWPA's economy. Developing industries include wind energy, higher education, technology, and tourism. Examples include:

- Electric Reliability Council of Texas (ERCOT) Competitive Renewable Energy Zones (CREZ), multi-billion dollar investments to transfer the PWPA's renewable energy into the ERCOT power grid. Many governmental entities are starting to see great increases in tax income resulting from new wind projects coming online. This trend is expected to continue to rapidly expand.
- Texas Tech School of Veterinary Medicine, which will add hundreds of jobs to the region and began educating veterinary students in 2021.
- Bell Helicopter, an employer of hundreds of jobs in the region currently and potentially hundreds more.
- Hodgetown, a multi-purpose event venue in Amarillo, which reported a ten percent increase in sales tax revenue, partially attributed to Hodgetown.

1.3.3 Climate

The climate of the PWPA is characterized by rapid, large temperature changes, wind, and low humidity. The PWPA receives relatively little precipitation, with almost 75 percent of the region's total rainfall occurring between April to September. Snowfall averages 16.6 inches annually in Amarillo with heavy snowfall of 10 inches or more occurring approximately every five years (NWS, 2015). According to the National Climatic Data Center, the average yearly temperature and precipitation measured at the City of Amarillo are 57.3 degrees Fahrenheit and 20.13 inches of rainfall.



The PWPA is subject to rapid and large temperature changes, especially during the winter months when cold fronts from the northern Rocky Mountain and Plains states sweep across the area. Temperature drops of 50 to 60 degrees within a 12-hour period are not uncommon. Temperature drops of 40 degrees have occurred within a few minutes.

Humidity averages are low, occasionally dropping below 20 percent in the spring. Low humidity moderates the effect of high summer afternoon temperatures, permits evaporative cooling systems to be very effective, and provides many pleasant evenings and nights. Severe local storms are infrequent, although a few thunderstorms with damaging hail, lightning, and wind in a highly localized area occur most years, usually in spring and summer. These storms are often accompanied by very heavy rain, which produces local flooding, particularly of roads and streets.

1.4 Major Water Providers

The term Major Water Provider (MWP) was established in rules for the development of the 2022 State Water Plan to allow RWPGs to establish a list of large water providers for which the Plan reports information specific to the MWP. MWPs are defined in 31 TAC §357.10(19) as follows:

"A WUG or WWP 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 PWPA has designated four MWPs:

- Canadian River Municipal Water Authority
- City of Amarillo
- City of Borger
- Greenbelt Municipal and Industrial Water Authority

1.4.1 Canadian River Municipal Water Authority (CRMWA)

CRMWA was created in 1953 by the Texas Legislature for the purpose of distributing water from the Canadian River Project, in compliance with the Canadian River Compact between Texas, New Mexico, and Oklahoma. The Bureau of Reclamation began construction on the project in 1962 and completed Lake Meredith in 1965. Under the tristate compact, Texas is entitled to store up to 500,000 acre-feet of water in conservation storage. CRMWA received a permit from the State of Texas to impound that water and to divert up to 100,000 acre-feet of water a year for use by the member cities and 51,200 acre-feet for use by industries. Eleven cities formed CRMWA with the following three in the PWPA: Amarillo, Borger and Pampa. The remaining eight are in the Llano Estacado RWPA: Plainview, Lubbock, Slaton, Brownfield, Levelland, Lamesa, Tahoka, and O'Donnell. CRMWA serves approximately 550,000 urban residents and provides water to Borger and Pampa in the Canadian Basin; and Amarillo in the Canadian and Red River basins.

CRMWA is also the largest holder of groundwater rights in Texas. It holds water rights to 456,993 acres in Roberts and adjacent counties. CRMWA has developed a portion of these rights and plans to expand this well field to provide additional supplies to supplement available water from Lake Meredith.

1.4.2 City of Amarillo

The City of Amarillo is the largest city in the PWPA. It currently operates a water system with an average production of 51 million gallons per day to serve approximately 200,000 people. The City gets its water from several active well fields, and an allocation of water from CRMWA that is composed of a blend of Roberts County groundwater and surface water from Lake Meredith. Amarillo supplies wholesale water to the City of Canyon, Palo Duro Canyon State Park and manufacturing. It also supplies reuse water to Xcel Energy for Steam Electric Power needs.

1.4.3 City of Borger

The City of Borger, located in Hutchinson County, currently serves approximately 13,000 people. The source of supply for Borger is groundwater wells, reuse, and an allocation of water from CRMWA that includes Roberts County groundwater and surface water from Lake Meredith. Borger supplies wholesale water to TCW Supply (through a trade agreement with Conoco Phillips) and manufacturing needs.

1.4.4 Greenbelt Municipal and Industrial Water Authority (Greenbelt MIWA)

The Greenbelt MIWA provides water from Greenbelt Reservoir on the Salt Fork of the Red River and the Ogallala Aquifer in Donley County. The Greenbelt MIWA is located in Donley County and provides water to local municipalities through an extensive delivery system, including a 121-mile pipeline. There are five member cities, including Clarendon, Hedley, and Childress in the PWPA and Quanah and Crowell in the Region B planning area. The Red River Authority is a non-voting member of the Greenbelt MIWA.

1.5 Sources of Water

Water supplies in the PWPA include both surface and groundwater sources. Statutes and regulations governing the quantity and quality of water in Texas differ according to source of the supply (**Table 1-5**). Surface water is owned, appropriated, held in trust, and protected by the state on behalf of all citizens, while groundwater is subject to right of capture by the surface landowner. Except as noted below, legal restrictions are not imposed by the State of Texas on landowners regarding withdrawal that would bar them from exercising their right of capture of groundwater from wells on and beneath their property.

Water Related Facts for PWPA:

Two river basins: Red River, Canadian River
Two major aquifers: Ogallala & Seymour
Three minor aquifers: Dockum, Blaine & Rita Blanca
Precipitation ranges from 15 inches in the west to 22 inches in the east.
Groundwater recharge occurs primarily by infiltration.

Table 1-5: Summary of Policies Affecting Water Quality and Quantity in PWPA

	General Policy Affecting:	
Type of Water	Water Quantity	Water Quality
Diffuse	Landowner control	TCEQ (urban and industrial), TSSWCB (agriculture and silviculture)
Surface	State (TCEQ) Canadian River Interstate Compact Red River Interstate Compact	State (TCEQ) regulations Federal (EPA) regulations
Ground	Landowner right of capture; Groundwater District Rules	Groundwater District Rules State (TCEQ) Regulations Federal (EPA) regulations

1.5.1 Groundwater Regulation

As part of SB1, the Legislature established that groundwater conservation districts (GCDs) were the preferred entities for groundwater management in Texas. SB1 contained provisions that required the GCDs to prepare management plans. One of the key provisions of SB1 requires TCEQ to determine areas that warrant special consideration and for those areas to encourage the formation of a new GCD or the incorporation of these areas into existing districts. Each GCD is required to submit a water management plan to the TWDB for certification.

SB2 called for the creation of Groundwater Management Areas (GMAs) which were based largely on hydrogeologic and aquifer boundaries instead of political boundaries. The TWDB divided Texas into 16 GMAs, and most contain multiple GCDs. One of the purposes for GMAs was to manage groundwater resources on a more aquifer-wide basis. The PWPA contains two GMAs. GMA 1 covers all of the PWPA counties, with the exception of Childress, Collingsworth and Hall Counties. These counties are located within GMA 6.

The Texas Legislature enacted significant changes to the management of groundwater resources in Texas with the passage of House Bill 1763 (HB 1763) in 2005. A main goal of HB 1763 was to clarify the authority and conflicts between GCDs and RWPGs. The new law clarified that GCDs would be responsible for aquifer planning and developing the amount of groundwater available for use. To accomplish this, the law directed that all GCDs within each GMA to meet and participate in joint groundwater planning efforts. The focus of joint groundwater planning was to determine the Desired Future Conditions (DFCs) for the groundwater resources within the GMA boundaries (before September 1, 2010, and at least once every 5 years after that). The most recent DFCs were developed in 2022. The TWDB was also required to calculate the Modeled Available Groundwater (MAG) for the DFC.

In 2011, Senate Bill 660 required that GMA representatives must participate within each applicable RWPG. It also required the Regional Water Plans to be consistent with the DFCs in place when the regional plans are developed. To implement this requirement, the TWDB developed a policy that the MAG was the maximum amount of groundwater that could be planned for in terms of existing water supply and recommended strategies within a RWPA.

GCDs have played a major role in the management of water resources in the PWPA. Parts or all of 20 counties in the PWPA study area are included in the six groundwater districts shown in **Figure 1-3** and presented in **Table 1-6**. The county of Oldham and portions of Randall, Hutchinson, Moore, and Hartley Counties are not included in a groundwater district. The GCDs work together within the framework of the GMAs to set DFCs which consider the balance between groundwater demands and the need to conserve and preserve groundwater in the region. The GCDs must set goals and objectives consistent with the DFCs adopted by the GMAs. To achieve these goals, GCDs can regulate well spacing, well size, well construction, well production, well closure, and monitoring and protection of groundwater quality.

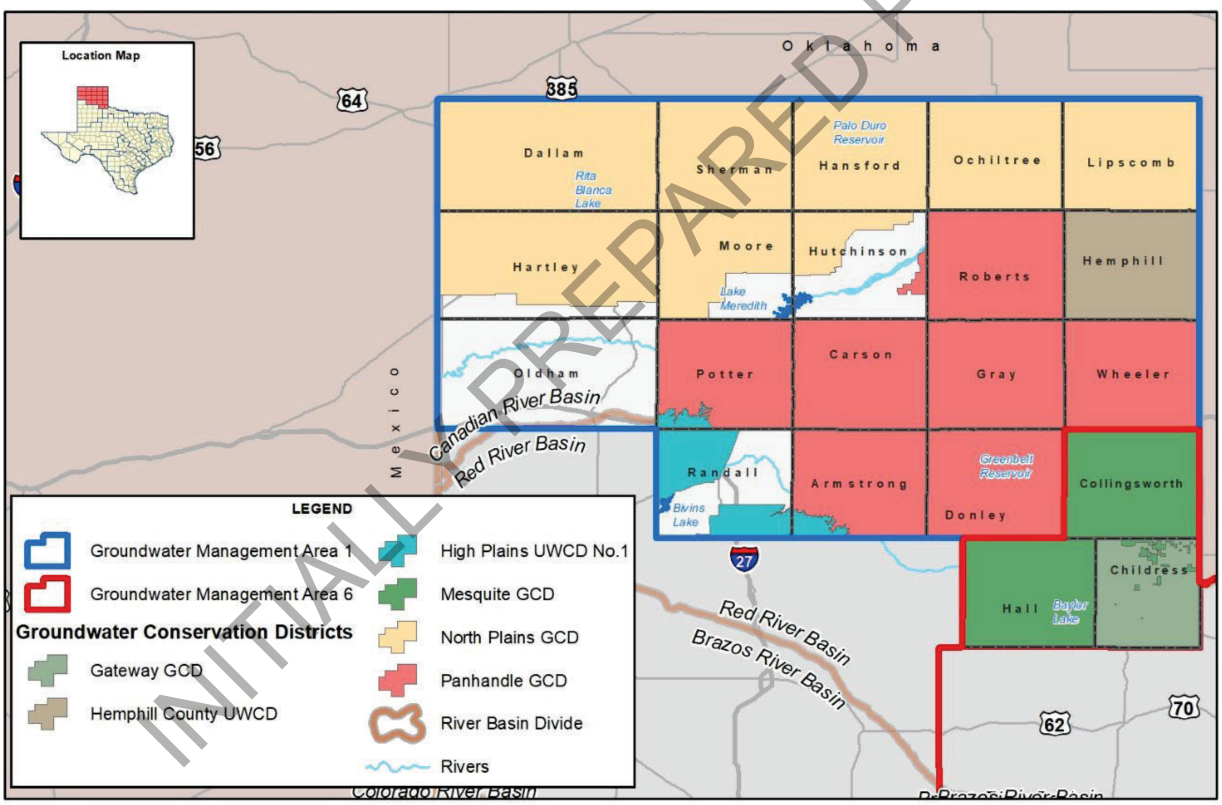


Figure 1-3: Groundwater Conservation Districts and Management Areas in PWPA

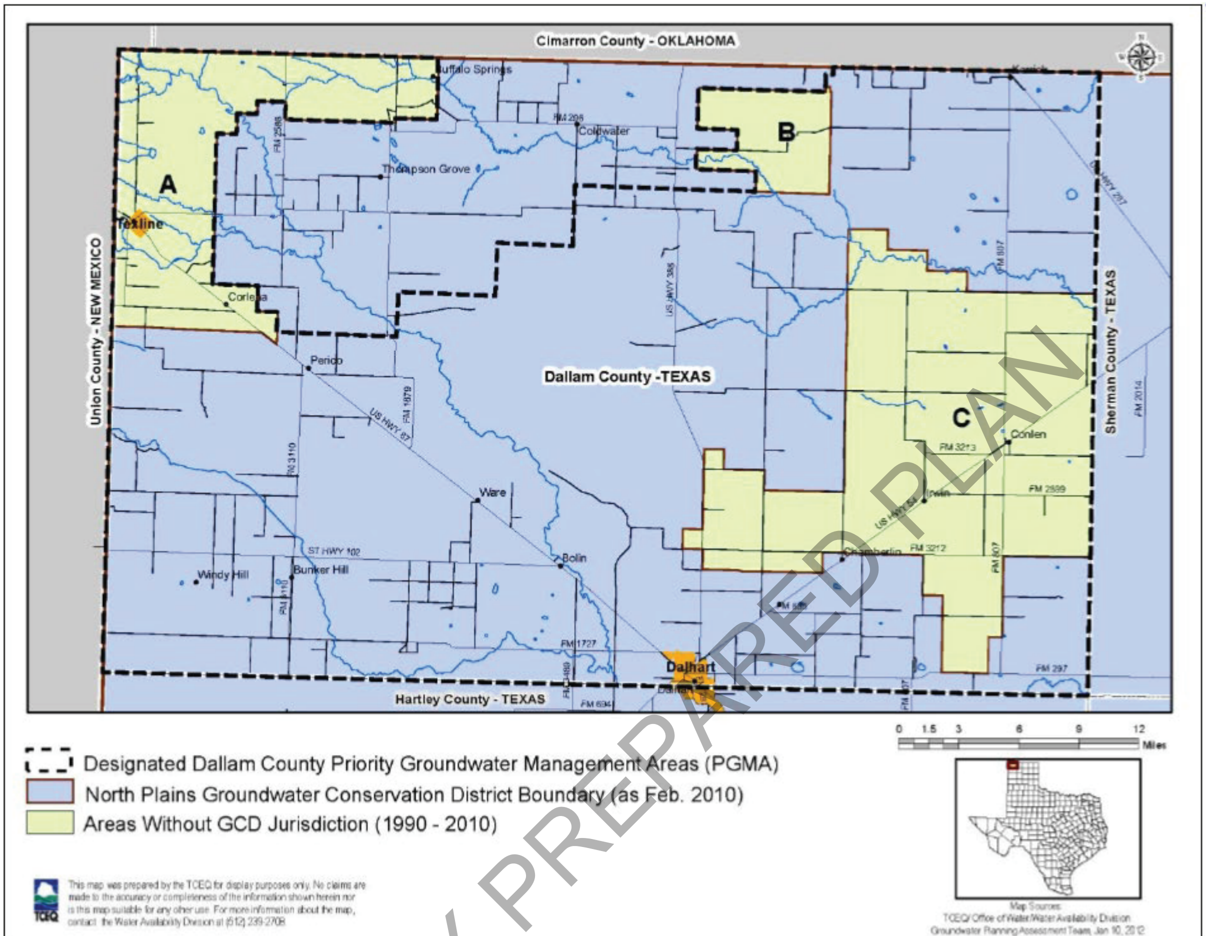
Table 1-6: Groundwater Conservation Districts in PWPA

Groundwater District	Counties Served in PWPA	Aquifers
North Plains GCD	Moore, Hutchinson, Sherman, Hartley, Dallam, Hansford, Ochiltree, Lipscomb	Ogallala Rita Blanca Dockum
Panhandle GCD	Carson, Roberts, Gray, Donley, Armstrong, Potter, Hutchinson, Wheeler	Ogallala Dockum Blaine Seymour Whitehorse
Mesquite GCD	Collingsworth, Hall	Seymour Blaine
Hemphill County UGWD	Hemphill	Ogallala
High Plains UGWD	Potter, Randall, Armstrong	Ogallala Dockum
Gateway GCD	Childress	Seymour Blaine

For areas within the state that are not regulated by a GCD, the state has the authority to designate as a Priority Groundwater Management Area (PGMA) for purposes of protecting the groundwater resources within the area. This process is initiated by the TCEQ, which designates a PGMA when an area is experiencing critical groundwater problems or is expected to do so within 25 years. These problems include shortages of surface water or groundwater, land subsidence resulting from groundwater withdrawal, or contamination of groundwater supplies. Once an area is designated a PGMA, landowners have two years to create a GCD. Otherwise, the TCEQ is required to create a GCD or to recommend that the area be added to an existing district. The PGMA process is completely independent of the current GMA process and each process has different goals. PGMAs also authorize county commissioners within the PGMA to promulgate groundwater restrictions.

In December 2008, the TCEQ Executive Director recommended that Dallam County PGMA Areas A, B and C (**Figure 1-4**) be added to the North Plains GCD. After a contested case hearing, the TCEQ issued an Order dated February 17, 2010. The Order directed that the District vote to add Areas A, B and C and conduct an election within each area. Elections were held in November. The propositions did not pass. Some landowners then petitioned for inclusion in the North Plains GCD and approximately 9,100 acres were added to the District via landowner petitions, leaving approximately 400 square miles outside the jurisdiction of a GCD.

With passage of SB 313 in 2011, the TCEQ was authorized to add PGMA areas to any previously recommended GCD. All remaining Dallam County areas that were previously outside of a GCD were added to the North Plains GCD in 2012. The groundwater within the Dallam County PGMA is currently regulated by the North Plains GCD, and to the PWPG's knowledge, there are no additional restrictions promulgated by the Dallam County Commissioners Court.



Source: TCEQ

Figure 1-4: Dallam County PGMA Boundary

1.5.2 Aquifers

There are two major aquifers in the PWPA, the Ogallala and Seymour aquifers (**Figure 1-5**), and three minor aquifers, Blaine, Rita Blanca, and Dockum (**Figure 1-6**). The Whitehorse Formation is recognized by local residents as a regional supply source. All aquifers serve as water sources for various uses in the PWPA.

Ogallala Aquifer

The Ogallala aquifer is the major water-bearing formation of the PWPA. Vertical hydrologic communication occurs between the overlying Quaternary Blackwater Draw Formation where present and the Cretaceous which lies directly below the Ogallala in a portion of the planning region. Although many communities use water from the Ogallala aquifer as their primary source for drinking water, more than 90 percent of the water obtained from the Ogallala is used for irrigation.

The Ogallala supports the major irrigated agricultural production and processing base, as well as the region's municipal and industrial water needs. Water-table elevations generally dip at a similar rate as the land surface and dip from the northwest to the southeast. The aquifer is recharged by precipitation and runoff that drains to lakes, rivers, playas, and streams.

The Ogallala is composed primarily of sand, gravel, clay, and silt deposited during the Tertiary Period. Groundwater, under water-table conditions, moves very slowly through the Ogallala Formation in a southeasterly direction toward the caprock edge or eastern escarpment of the High Plains. Saturated thickness of the aquifer is variable across the region but is greatest where sediments have filled previously eroded drainage channels. Well yields range from as little as 10 gpm to more than 1,000 gpm.

Recharge to the Ogallala occurs primarily by infiltration of precipitation from the surface and, to a lesser extent, by upward leakage from underlying formations. Research has indicated variable recharge over the Ogallala aquifer in the PWPA, with much of the area experiencing little to no recharge. The special study on recharge in the eastern counties in the PWPA confirmed the relatively low levels of recharge to the Ogallala (BEG, 2009). This study found recharge rates of 0 to 1.9 inches per year, with the greatest recharge occurring beneath irrigated agriculture. Playa basins also appear to be a contributing factor for the majority of water naturally recharged to the aquifer.

Since the expansion of irrigated agriculture in the mid-1940s, greater amounts of water have been pumped from the aquifer than have been recharged. As a result, some areas have experienced water level declines in excess of 150 feet from predevelopment to 2010 within the PWPA and will continue to drop into the future. Conservation efforts, implementation of efficient irrigation technologies, crop research, reduced commodity prices and increased power costs have resulted in a reduction in the rate of water level declines.

The quality of Ogallala water is controlled by the composition of the recharge water and the geologic features and deposits above and within the aquifer. According to the results of a study of the Ogallala aquifer (Nativ, 1988) the TDS concentration of the Ogallala in the vicinity of the PWPA averaged 429 mg/L. The major constituent, bicarbonate, averaged 278 mg/L, while minor constituents such as sulfate, calcium, sodium, chloride, and potassium averaged from 8 mg/L to 66 mg/L (Nativ, 1988). During the second round of regional water planning the PWPA conducted a study to build a cross sectional model to evaluate salinity and water quality changes associated with aquifer drawdown in Roberts County. Simulated increases in total dissolved solids were greater than reported by others. Localized increases in total dissolved solids were <500 mg/l with local total dissolved solids averages <10 mg/l increase per year.

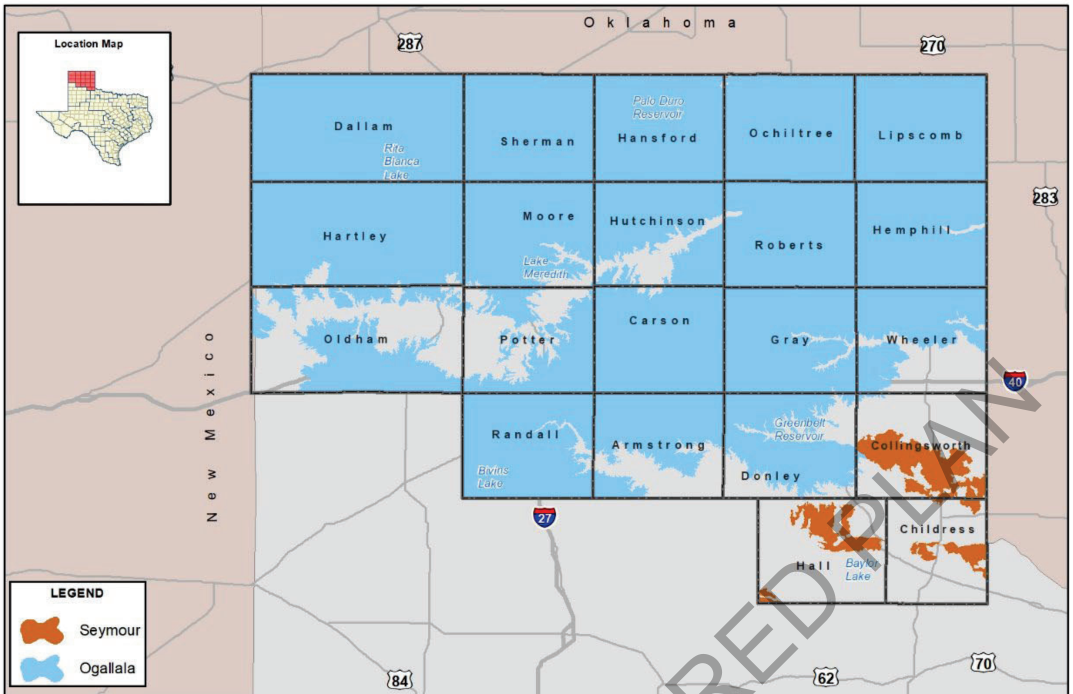


Figure 1-5: Major Aquifers in the PWPA

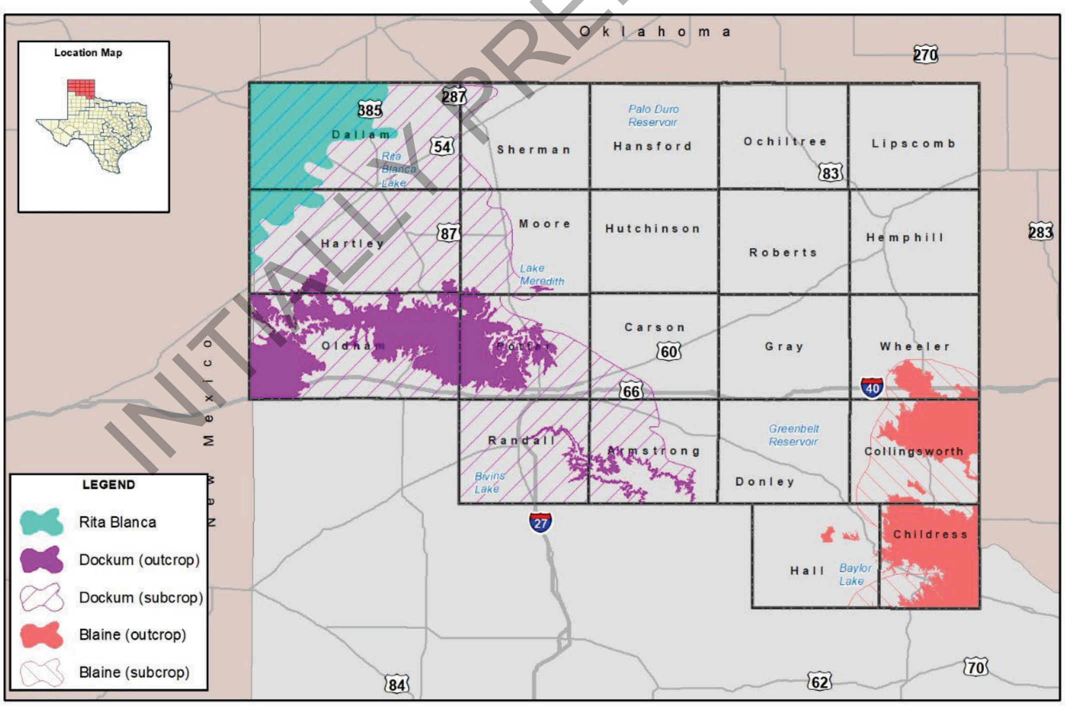


Figure 1-6: Minor Aquifers in the PWPA

Seymour Aquifer

The Seymour is a major aquifer located in north central Texas and some Panhandle counties. The aquifer consists of isolated areas of alluvium that are erosional remnants of a larger area or areas. Although most accumulations are less than 100 feet thick, a few isolated spots in Collingsworth County may exceed 300 feet. These thick accumulations overlie buried stream channels or sinkholes in underlying formations. This aquifer is under water-table conditions in most of its extent, but artesian conditions may occur where the water-bearing zone is overlain by clay.

Fresh to slightly saline groundwater recoverable from storage from all these scattered alluvial aquifers is estimated to be 3.8 million acre-feet, based on the assumption that 75 percent of the total storage is recoverable. Within the PWPA, the estimated recoverable storage is 285,000 acre-feet based on 75 percent of the total storage. Annual effective recharge to the aquifer is approximately 215,200 acre-feet, or five percent of the average annual precipitation that falls on the aquifer outcrop. No significant long-term water-level declines have occurred in areas supplied by groundwater from the Seymour aquifer. The lower, more permeable part of the aquifer produces the greatest amount of groundwater. Yields of wells average about 300 gallons per minute (gpm) and range from less than 100 gpm to as much as 1,300 gpm.

Water quality in these alluvial remnants generally ranges from fresh to slightly saline, although a few higher salinity problems may occur. The salinity has increased in many heavily pumped areas to the point where the water has become unsuitable for domestic uses. Brine pollution from earlier oil-field activities has resulted in localized contamination of formerly fresh ground- and surface-water supplies. Nitrate concentrations in excess of primary drinking-water standards are widespread in the Seymour groundwater (TWDB, 1995).

Dockum Aquifer

The Dockum is a minor aquifer which underlies the Ogallala aquifer and extends laterally into parts of West Texas and New Mexico. The primary water-bearing zone in the Dockum Group, commonly called the “Santa Rosa,” consists of up to 700 feet of sand and conglomerate interbedded with layers of silt and shale. Aquifer permeability is typically low, and well yields normally do not exceed 300 gal/min (Ashworth & Hopkins, 1995). Recharge to the Dockum aquifer is negligible except in the outcrop areas, where approximately 31,000 acre-feet is estimated to occur annually over the entire formation. Recharge in the PWPA is expected to be less.

Concentrations of TDS in the Dockum aquifer range from less than 1,000 mg/L in the eastern outcrop of the aquifer to more than 20,000 mg/L in the deeper parts of the formation to the west. The highest water quality in the Dockum occurs in the shallowest portions of the aquifer and along outcrops at the perimeter. The Dockum underlying Potter, Moore, Carson, Armstrong, and Randall Counties has a TDS content of around 1,000 mg/L (TWDB, 2003). The lowest water quality (highest salinity) occurs outside of the PWPA. Dockum water, used for municipal supply by several cities, often contains chloride, sulfate, and dissolved solids that are near or exceed EPA/State secondary drinking-water standards (Ashworth & Hopkins, 1995).

Rita Blanca Aquifer

The Rita Blanca is a minor aquifer which underlies the Ogallala Formation in western Dallam and Hartley Counties in the northwest corner of the Texas Panhandle. The portion of the aquifer located in the PWPA makes up a small part of a large aquifer system that extends into Oklahoma, Colorado, and New Mexico.

Groundwater produced from wells completed within the Rita Blanca aquifer is moderately to very hard and fresh to slightly saline. Dissolved-solids concentrations range from 400 mg/L to approximately 1,100 mg/L.

Recharge to the aquifer in Texas occurs by leakage through the Ogallala and by lateral flow from portions of the aquifer system in New Mexico and Oklahoma. Effective recharge and recoverable storage for the Rita Blanca have not been quantified but, historically, have been included with regional recharge and storage estimates for the Ogallala aquifer. Aquifer water-level declines in excess of 50 feet have occurred in some irrigated areas from the early 1970s to the middle 1980s. These declines were the result of pumpage which exceeded effective recharge. Evidence of aquifer declines included the disappearance of many springs in the northern part of Dallam County that once contributed to the constant flow in creeks that are now ephemeral. Since the middle 1980s, the rate of decline has generally slowed. In some areas water-level rises have occurred.

Blaine Aquifer

The Blaine is a minor aquifer located in portions of Wheeler, Collingsworth, and Childress Counties of the RWPA and extends into western Oklahoma. Saturated thickness of the formation in its northern region varies from approximately 10 to 300 feet. Recharge to the aquifer travels along solution channels which contribute to its overall poor water quality. Dissolved solids concentrations increase with depth and in natural discharge areas at the surface, but contain water with TDS concentrations less than 10,000 mg/L. The primary use is for irrigation of highly salt-tolerant crops, with yields varying from a few gallons per minute (gpm) to more than 1,500 gpm (Ashworth and Hopkins, 1995).

Whitehorse Aquifer

The Whitehorse is a Permian aquifer occurring in beds of shale, sand, gypsum, anhydrite, and dolomite. It is an important source of water in and near the outcrop area around Wheeler County. Wells in the Whitehorse aquifer often pump large quantities of fine sand and require screens for larger yields. Water from the Whitehorse is generally used for irrigation, but other uses include domestic and livestock. Dissolved solids range from approximately 400 mg/L to just less than 2,700 mg/L, with better water quality generally occurring in the areas of recharge from the Ogallala (Maderak, 1973). The Whitehorse, not recognized by the State of Texas as a minor aquifer, is considered “Other Aquifer” in this plan.

1.5.3 Springs

Springs are an important transition between groundwater and surface water bodies. A study by the TWDB (1973) identified 281 major and historically significant springs within the state of Texas, 16 of which were located in the PWPA. As observed throughout the state, spring flows in the PWPA have generally declined during the last century due to a variety of reasons including land use practices, increasing demands, droughts, and the development of deep-water irrigation wells. Springs identified by the TWDB study in Donley, Hartley, Oldham, Potter, and Wheeler Counties derive from the Ogallala Formation. The Blaine and Whitehorse Formations produced springs in Collingsworth and Wheeler Counties, and one alluvial spring was identified in Collingsworth County. Brune's Springs of Texas report indicates that many of the region's major springs were already in decline due to irrigation pumping in the 1970s. It is anticipated that many of these springs have continued to decline over the past 30 years. The information on the current status of springs is difficult to assess as many are on private property.

1.5.4 Surface Water

The PWPA is located within portions of the Canadian River and Red River Basins. These two river systems and associated impoundments shown in **Figure 1-7** provide surface water for municipal, agricultural, and industrial users in the area. In 2020, one percent of total water use within the PWPA was from surface water sources. This plan and its implementation are not expected to have any impact to navigable waters or navigation within the state.

Surface Water Management and Classification

The TCEQ is the agency charged with the management of surface water quality and quantity. Water quantity for the state is managed by a permitting system administered by the Office of Water of TCEQ.

Table 1-7 shows that permitted surface water rights greater than 1,000 acre-feet per year total 177,690 acre-feet per year for both the Canadian River Basin and the Red River Basin and actual reported use in 2021.

Water quality is managed statewide through the Texas Clean Rivers Program (TCRP) and locally through TCRP partners such as the CRMWA and Red River Authority. According to the TCEQ's 2022 Texas Integrated Report (TCEQ, 2022), the principal water quality problems in the Canadian River Basin are elevated dissolved solids, nutrients, and dissolved metals. Natural conditions including the presence of saline springs, seeps, and gypsum outcrops contribute to dissolved solids in most surface waters of the PWPA and elevated metals in localized areas. Elevated nutrients are most often associated with municipal discharge of treated wastewater to surface waters.

Water bodies which are determined by TCEQ as not meeting Texas Surface Water Quality Standards are included on the State of Texas Clean Water Act Section 303(d) list. Eleven segments in the PWPA were identified on the final 2022 303(d) list and are shown in **Table 1-8**. All eleven segments are classified by TCEQ as low priority and may be scheduled for Total Maximum Daily Load (TMDL) development (**Table 1-8**).

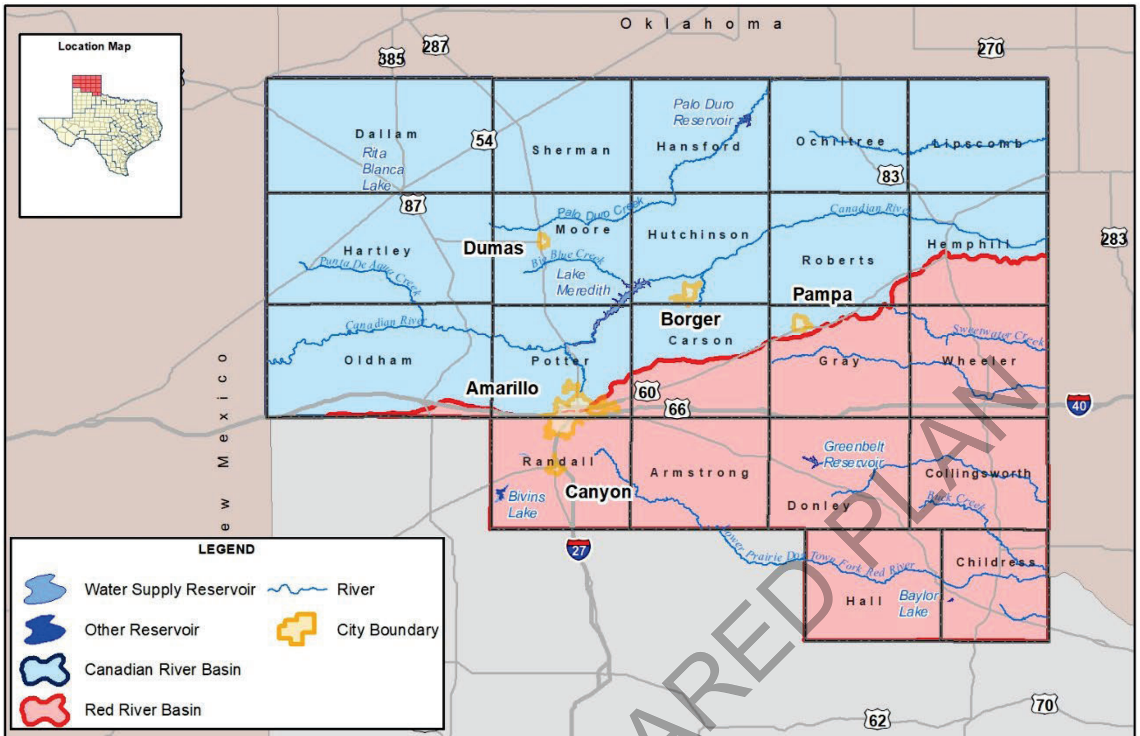


Figure 1-7: Surface Water Features in the PWPA

Table 1-7: Individual Water Rights in the PWPA for Permitted and Actual Use (Greater Than or Equal to 1,000 ac-ft)

County	Water Right Holder	Water Source	Use	Permitted Amount	Use in 2021 (ac ft)
Hutchinson	CRMWA	Lake Meredith	Municipal	100,000	14,181
			Industrial	51,200	
Hansford	PDWD	Palo Duro Reservoir	Municipal	10,460	0
Donley	Greenbelt MIWA	Greenbelt Reservoir	Municipal	14,530	1,943*
			Industrial	500	
			Irrigation	250	
			Mining	750	
Total				**177,690**	

Source: Provided by the water rights holders.
*Fiscal year May 2021 to April 2022

Table 1-8: 2022 303d Listed Segments in the PWPA

Canadian River Below Lake Meredith	0101	X							
Dixon Creek	0101A	X			X				
Lake Meredith	0102			X		X	X	X	
Canadian River above Lake Meredith	0103						X		
Rita Blanca Lake	0105		X		X				
East Amarillo Creek	0103A	X							
Wolf Creek	0104								X
Rock Creek	0101B	X							
South Groesbeck Creek	0206B	X							
Lower Prairie Dog Town Fork of Red River	0207	X							
Salt Fork Red River	0222	X							

Source: TCEQ, 2022

Agricultural and silvicultural nonpoint source water quality problems are managed statewide by the Texas State Soil and Water Conservation Board (TSSWCB) via local soil and water conservation districts. The TSSWCB has a regional office in Hale Center and a field office in Canyon. The Senate Bill 503 process established in 1993 authorizes TSSWCB to work individually with landowners on a volunteer basis to develop and implement site-specific water quality management plans. Conversely, urban and industrial nonpoint source water quality management plans are under the jurisdiction of the TCEQ.

Canadian River Basin

Approximately 13,000 square miles of the Canadian River Basin are located in the PWPA. There are three major reservoirs in the Texas portion of the Basin: Lake Meredith, Palo Duro Reservoir, and Rita Blanca Lake are used for municipal and recreation purposes. Other important reservoirs in the basin include Lake Marvin near the City of Canadian in Hemphill County and Lake Fryer near Perryton in Ochiltree County.

From the Texas-New Mexico state line eastward, the Canadian River enters an area known as the Canadian River Breaks, a narrow strip of rough and broken land extensively dissected by tributaries of the Canadian River. Elevations in the northwestern portion of the basin extend to 4,400 feet MSL in Dallam County. Elevations in the eastern portion of the basin range from 2,175 feet MSL in the riverbed at the Texas-Oklahoma border to 2,400 feet MSL in Lipscomb County. Land use in the Texas portion of the Canadian River watershed is predominantly irrigated and dryland farming and cattle ranching.

Average annual precipitation of the Texas portion of the basin varies from 15 inches near the New Mexico border to 22 inches near the eastern state boundary with Oklahoma. Streamflow has been measured near Amarillo, Texas just upstream of Lake Meredith since 1992 (USGS gage 07227500), and averages 92 cubic feet per second (cfs), or approximately 67,000 acre-feet per year. Streamflow has been measured on Palo Duro Creek just upstream of Palo Duro Reservoir since 1999 (USGS gage 07233500), and averages 3 cfs, or approximately 2,000 acre-feet per year.

Due to the scarcity of local surface water supplies, any additional water needed for the basin will likely come from groundwater or reuse of present supplies. In recent years, the region has experienced record low inflows to Lake Meredith and Palo Duro Reservoir, which prompted increased reliance on groundwater.

In order to maintain the continued suitability of water from Lake Meredith for municipal and manufacturing purposes, the Bureau of Reclamation and the CRMWA jointly constructed an injection well salinity control project near Logan, New Mexico. The injection well field, operated by the CRMWA, is disposing of brine pumped from other wells along the Canadian River near Logan.

Red River Basin

The Red River Basin is bounded on the north by the Canadian River Basin and on the south by the Brazos, Trinity, and Sulphur river basins. The Red River extends from the northeast corner of the State, along the Texas/Arkansas and Texas/Oklahoma state borders, across the Texas Panhandle to its headwaters in eastern New Mexico. The Red River Basin has a drainage area of 48,030 square miles, of which 24,463 square miles occur within Texas. Greenbelt Reservoir is the only surface water lake in the Red River Basin used within the PWPA.

The main stem of the Red River has a total length of 1,217 river miles. The North Fork of the Red River forms near Pampa, Texas and the Salt Fork of the Red River forms about 26 miles east of Amarillo, Texas. Both forks exit Texas into Oklahoma and join the Red River, individually, about 17 miles north of Vernon, Texas. Palo Duro Creek forms near Canyon, Texas and becomes Prairie Dog Town Fork to the east, which in turn becomes the Red River at the 100th meridian. The watershed in Texas receives an average annual precipitation varying from 15 inches near the New Mexico border to 55 inches near the Arkansas border.

1.5.5 Reuse Supplies

There is a total of approximately 23,000 acre-feet per year of wastewater effluent that is being reused in the PWPA. The City of Amarillo sells most of its treated effluent to Xcel Energy for steam electric power use, which is the largest user of reuse supplies. Xcel Energy in turn reuses its wastewater effluent for irrigation purposes. The City of Borger also sells its wastewater for industrial purposes. There are several other cities in the PWPA that currently use their wastewater for irrigation purposes, including the irrigation of city lands and local golf courses. **Table 1-9** shows the seller, recipient and amount used.

Table 1-9: Reuse Supplies in the PWPA

Seller/ User	Recipient	County of Use	Current Use (ac ft/yr)
Amarillo	Steam Electric Power*	Potter	15,000
Amarillo	Inflows to Lake Tanglewood*	Randall	1,682
Borger	Manufacturing	Hutchinson	1,100
Childress	Irrigation	Childress	127
Dumas	Irrigation	Moore	190
IBP	Irrigation*	Potter	700
Ingram Concrete	Manufacturing	Potter	174
JBS Swift	Manufacturing	Potter	156
Memphis	Irrigation	Hall	59
Pampa	Irrigation	Gray	290
Perryton	Irrigation	Ochiltree	725
Tyson Meats	Manufacturing	Potter	1,422
Valero	Manufacturing	Moore	330
Xcel Energy	Irrigation*	Potter	1,500
Total			**23,455**

Source: Water Use Survey Reuse Report for 2020, TWDB
*Self-reported use for 2026 PWPA water plan

Total Water Use in PWPA:

- 2015 was the year with the lowest water use since TWDB began reporting regional water use in 2000, and 2011 was the year with the highest water use.

- Total regional water use over the past five years averaged about 2.1 million acre-feet per year.

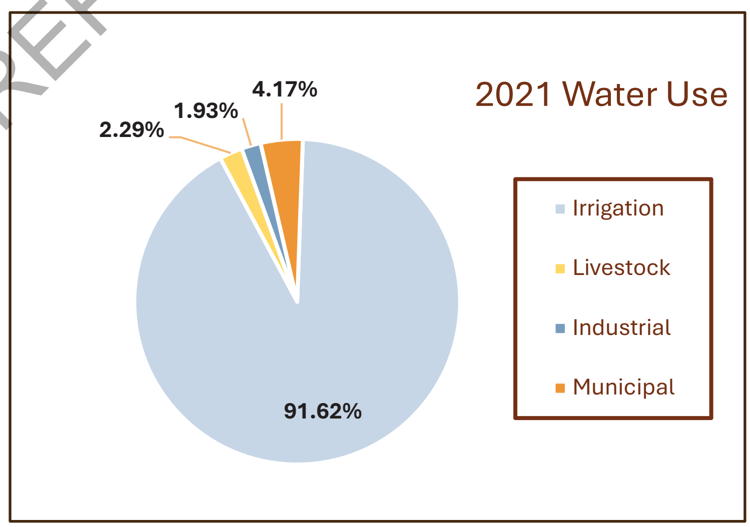
- Irrigation continues to be the largest water user and mining is the smallest water use in the region.

1.6 Current Water Uses and Demand Centers

Water use in the PWPA may be divided into three major categories – municipal, industrial, and agricultural. Industrial water use includes mining, manufacturing, and power generation activities. Agricultural water use includes irrigation and livestock. In 2021, municipal water use in the PWPA accounted for 4 percent of total water use, industrial water use accounted for 2 percent of total water use, and agricultural water use accounted for 91.62 percent of total water use. This compares with estimates from 2010, which showed that municipal water use in the PWPA accounted for 4 percent of total water use, industrial water use accounted for 4 percent of total water use, and agricultural water use accounted for 92 percent of total water use.

1.6.1 Municipal Use

The TWDB estimates that during 2021, the total municipal water use in the PWPA was 88,109 acre-feet, which is approximately 4 percent of total water use within the region. The amount of water used for municipal purposes is closely tied to population centers. Potter and Randall Counties, which contain the City of Amarillo, comprised 66.6 percent of the municipal water use in the PWPA, while ten counties (Armstrong, Carson, Collingsworth, Donley, Hall, Hemphill, Lipscomb, Oldham, Roberts, and Sherman) comprise approximately 7 percent.



CRMWA provides water to the cities of Amarillo, Borger, and Pampa in the PWPA. Beginning in late 2001, CRMWA began furnishing a blend of water from Lake Meredith and from groundwater. Member cities supplement CRMWA supplies with groundwater from their own wells. In 2021, approximately 79 percent of the water delivered by CRMWA to member cities was groundwater. The remaining 21 percent was surface water. For a period from 2012 through most of 2014 CRMWA relied solely on groundwater due to low lake levels at Lake Meredith but has since made diversions from Lake Meredith. Water usage by CRMWA member cities in 2021 is summarized in **Table 1-10**.

Table 1-10: Water Used by CRMWA Member Cities in the PWPA during 2021

City	Municipal Water Supplied by CRMWA (ac-ft/yr)		
	Surface Water CRMWA	Groundwater CRMWA	Total
Amarillo	7,467	21,481	**28,948**
Borger	763	2,850	**3,613**
Pampa	466	2,113	**2,579**
Total	**8,696**	**26,444**	**35,140**

Greenbelt MIWA provides surface water from Greenbelt Reservoir for municipal, industrial, mining and irrigation uses. In the 2021 -2022 fiscal year (May to April), Greenbelt MIWA supplied 1,943 acre-feet of water to the cities of Childress, Clarendon, Hedley, and to the Red River Authority for use in the PWPA. Approximately 1,000 acre-feet were provided to entities for use in Region B.

1.6.2 Industrial Use

Industrial use includes mining, manufacturing, and power generation, and accounted for approximately 40,835 acre-feet in 2021.

Mining

Based on TWDB data, mining water use totaled approximately 965 acre-feet for the entire region in 2021, approximately 2.4 percent of the total industrial water used. Oldham County had the highest use with 536 acre-feet (TWDB, 2021). Other recent mining activities associated with the development of natural gas in the eastern portion of the PWPA has increased mining water use for Hemphill, Lipscomb, Ochiltree, Roberts and Wheeler Counties.

Manufacturing

According to the TWDB, manufacturing water use totaled approximately 28,747 acre-feet for the entire region in 2021, approximately 70.4 percent of the total industrial water used. Hutchinson County had the highest use with 11,432 acre-feet.

Power Generation

Water demand for power generation use includes only water consumed during the power generation process (typically losses due to evaporation during cooling) for the purpose of selling electricity. Water needs for power generation that is part of a manufacturing facility is included in the manufacturing water needs. According to the TWDB, Potter was the only county to have reported water use for power generation activities in 2021. Water use of 11,123 acre-feet accounts for approximately 27.2 percent of the total industrial water use for that year.

Xcel Energy, the main supplier of electricity in the PWPA, estimates that total water use for power generation at approximately 15,000 acre-feet per year for their facilities. Xcel currently uses wastewater from Amarillo for cooling and is considering reuse of wastewater from Plainview and

Pampa, as well as cities outside of the PWPA to meet the increasing demand of water for power generation for its Texas facilities.

1.6.3 Agricultural Use

Land Use

Agricultural land use in the PWPA includes irrigated cropland, dryland cropland, and pastureland. According to the 2022 Census of Agriculture estimates, 12.5 million acres have been devoted to agricultural production with 8.7 million acres in permanent pasture and the remaining 3.8 million acres utilized as cropland. The 2001 through 2021 PWPA water plans provide historical estimates of irrigated acreages. In the 2021 plan a three-year average of the annual irrigated acreage planted reported to the Farm Service Agency (FSA) was used to estimate the irrigated acreage by county (**Table 1-11**). The variation in irrigated acreage between plans can be related to several factors such as: weather; profitability; land leaving because a lack of water; land leaving the conservation reserve program (CRP) and reentering irrigated production; and pastureland being converted to irrigated production. As appropriate, irrigated land that was identified as not reporting acreage to FSA was added into the estimates of irrigated land in the appropriate county. In the 2021 planning effort it was estimated that 1.5 million irrigated crop acres were within the PWPA, with seven counties (Carson, Dallam, Hansford, Hartley, Moore, Ochiltree and Sherman) accounting for 82 percent of the irrigated acreage. Several irrigated crops are grown within the region, with four primary crops (corn, cotton, sorghum, and wheat) being reported as being planted on more than 88 percent of the irrigated acreage.

Irrigation

As part of this study, the Texas A&M AgriLife Research and Extension Service in Amarillo (Texas A&M AgriLife) developed updated irrigated agriculture water demands in the PWPA. Irrigation for crop production represents the most significant use of water and accounts for approximately 92 percent of all water use within the PWPA in 2021. According to TWDB data, use of irrigation water totaled approximately 1.9 million acre-feet in 2021. Five counties (Dallam, Hansford, Hartley, Moore, and Sherman) accounted for approximately 76 percent of the total irrigation water applied in 2021 (TWDB, 2024).

Table 1-11: Reported Irrigated Acreage by County and Water Plan

County Name	2001 RWP	2006 RWP	2011 RWP	2016 RWP	2021 RWP
Armstrong	9,476	12,233	4,813	4,828	6,379
Carson	93,010	96,966	54,940	58,204	77,111
Childress	3,486	9,640	8,392	10,560	13,971
Collingsworth	20,789	21,459	36,252	36,854	39,203
Dallam	284,588	251,606	232,707	294,502	249,198
Donley	12,543	18,268	21,766	22,390	26,819
Gray	35,041	29,409	21,901	22,298	30,440
Hall	15,787	20,212	22,423	23,236	25,162
Hansford	193,117	127,128	122,447	132,913	146,204
Hartley	139,290	216,022	210,890	255,623	278,004
Hemphill	4,421	3,179	1,982	3,032	10,348
Hutchinson	28,253	61,292	36,295	35,520	35,520
Lipscomb	24,640	12,241	19,012	20,015	34,561
Moore	171,405	156,302	140,832	142,470	144,123
Ochiltree	57,459	96,929	59,607	59,634	72,165
Oldham	30,182	4,607	3,917	3,986	4,376
Potter	28,219	5,616	2,859	2,587	1,361
Randall	46,855	28,953	20,883	20,489	15,424
Roberts	8,332	18,442	5,665	5,633	6,856
Sherman	152,205	235,347	180,208	184,844	227,943
Wheeler	4,340	9,572	10,873	11,326	12,972
Total	**1,363,438**	**1,435,423**	**1,218,664**	**1,350,944**	**1,458,140**

Source: Farm Service Agency and previous Panhandle Regional Water Plans

Livestock

Texas is the nation's leading livestock producer, accounting for approximately 11 percent of the total United States production. Although livestock production is an important component of the Texas economy, the industry consumes a relatively small amount of water as compared to irrigated cropland in the region. In 2021, livestock water use was estimated to account for 2.29 percent of the total agricultural water use in the region.

Estimating livestock water consumption consists of estimating water consumption for a livestock unit and the total number of head for each livestock unit. The Texas Agricultural Statistics service and the Census of Agriculture provide some of the current and historical numbers of livestock by livestock type and county used in the region. However, due to disclosure reasons, inventory numbers of confined livestock operations (CLOs) are generally not available from these sources. The region being home to more than 1.4 million fed beef, 560,000 hogs and 300,000 dairy cows make it one of the most concentrated areas in the country for CLOs. Texas A&M AgriLife, working together with representatives of the livestock industry including CLOs, university experts and secondary data, developed updated data on livestock inventories by type and county, water-use rates, estimated in gallons per day per head, for each type of livestock: cattle, poultry, sheep and lambs, hogs and pigs, horses, and goats. Water-use rates are then multiplied by the number of head for each livestock type for each county.

Water requirements of livestock are influenced by type and size of animal, feed intake and composition, rate of gain, condition of pregnancy, activity, ambient temperature, and water quality (Chirase et al., 1997). The estimate of total use for livestock watering is based on the total number of livestock in the region and application of a uniform water consumption rate for each type of animal. The different species of livestock considered for the PWPA livestock demands include beef cows and calves, feedlot cattle, dairy cattle, and stockers on pasture winter or summer, poultry, and hogs and pigs.

Total livestock water use for the PWPA in 2021 was estimated at 48,331 acre-feet. Four counties (Dallam, Hansford, Hartley, and Sherman) accounted for approximately 58 percent of total livestock water use in the PWPA. With the growth of the dairy industry in Moore County, livestock water use in the PWPA is expected to exceed 55,000 acre-feet by 2030.

Summary of Water Use in PWPA

Total water use in the PWPA has ranged from 2 million to 2.2 million acre-feet per year over the past five years. Of this amount, over 90 percent is for irrigated agriculture. Industrial water use, which includes manufacturing and mining, accounts for less than two percent of the total water use. Municipal use is heavily concentrated in the more urban areas with the city of Amarillo and surrounding areas accounting for more than half the total municipal use in the PWPA. A summary of the reported water use by county in 2021 is shown in **Table 1-12**.

Table 1-12: Reported 2021 Water Use in the PWPA (ac-ft/yr)

County	MUN	IND	IRR	STK	Total
Armstrong	335	0	6,375	647	7,357
Carson	1,120	693	55,718	342	57,873
Childress	1,452	0	14,323	248	16,023
Collingsworth	664	0	44,335	340	45,339
Dallam	1,657	40	334,465	5,272	341,434
Donley	493	0	19,748	963	21,204
Gray	3,812	321	21,151	1,836	27,120
Hall	791	0	28,924	507	30,222
Hansford	1,251	50	227,453	5,338	234,092
Hartley	1,202	0	384,535	9,459	395,196
Hemphill	566	0	4,275	1,116	5,957
Hutchinson	4,948	11,518	70,661	471	87,598
Lipscomb	684	582	45,917	1,389	48,572
Moore	4,768	7,973	219,817	4,516	237,074
Ochiltree	2,811	0	104,221	3,646	110,678
Oldham	671	536	4,954	1,485	7,646
Potter	27,831	18,388	4,410	474	51,103
Randall	30,850	729	17,221	3,702	52,502
Roberts	222	1	5,820	347	6,390
Sherman	528	0	310,824	5,217	316,569
Wheeler	1,413	4	12,078	1,016	14,511
Total	**88,069**	**40,835**	**1,937,225**	**48,331**	**2,114,460**

Source: TWDB, 2024

1.7 Natural Resources

1.7.1 Natural Region

A natural region is classified primarily on the common characteristics of climate, soil, landforms, microclimates, plant communities, watersheds, and native plants and animals. The PWPA includes the Rolling Plains and the High Plains natural regions (**Figure 1-8**). The Rolling Plains is the larger of the two regions. It includes three subregions: the Mesquite Plains, Escarpment Breaks, and the Canadian Breaks. The Mesquite Plains subregion is gently rolling with mesquite brush and short grasses. Steep slopes, cliffs, and canyons occurring below the edge of the High Plains Caprock comprise the Escarpment Breaks subregion. The Breaks are a transition zone between the High Plains grasslands and the mesquite savanna of the Rolling Plains. The Canadian Breaks subregion is similar to the Escarpment Breaks, but also includes the floodplain and sandhills of the Canadian River in the northern Panhandle. The Rolling Plains Region, together with the High Plains Region, is the southern end of the Great Plains of the Central United States.

The Canadian, the Colorado, the Red, and the Concho Rivers begin in the western portions of the Rolling Plains and the breaks of the Caprock Escarpment. Excessive grazing and other historical agricultural practices have caused considerable damage to this region.

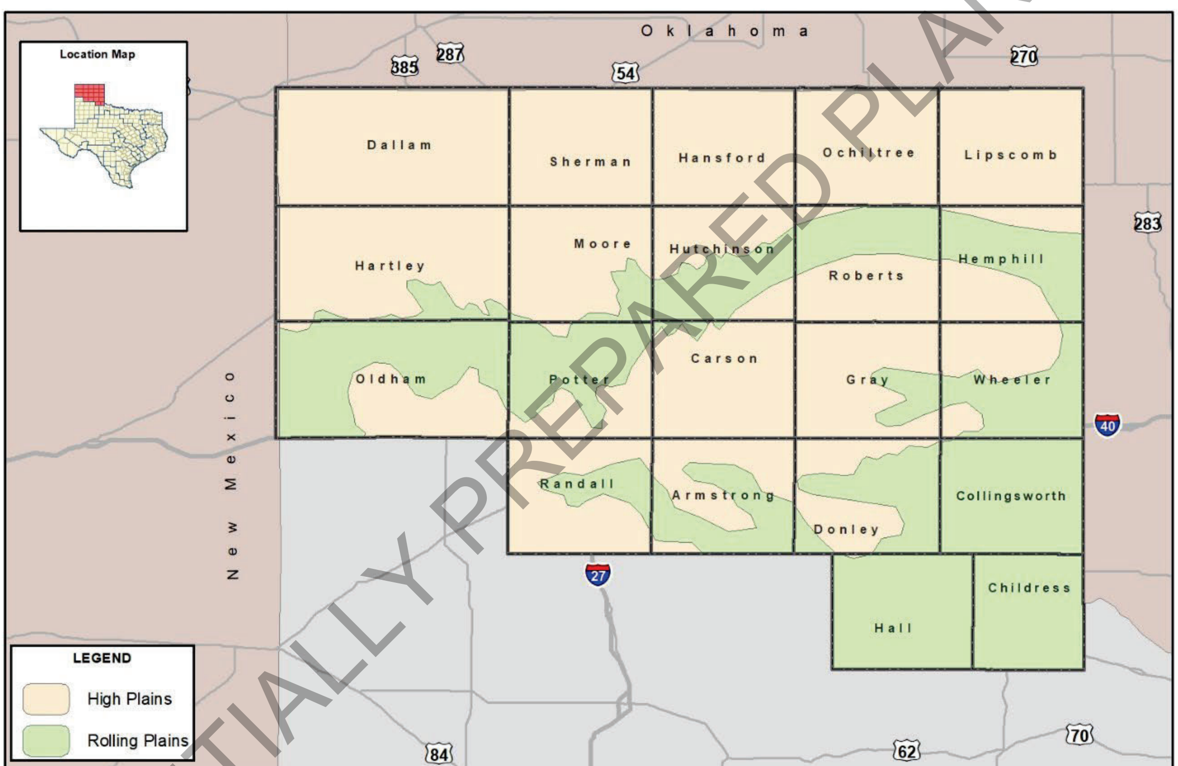


Figure 1-8: Natural Regions in the PWPA

1.7.2 Regional Vegetation

The PWPA is located in two vegetation regions which generally correspond to the natural regions described in the previous section – the High Plains and Rolling Plains. **Figure 1-9** illustrates the types of vegetation characteristic of the PWPA. The vegetation of the High Plains is variously classified as mixed prairie, shortgrass prairie, and in some locations on deep, sandy soils as tallgrass prairie. Blue grama, buffalo grass, and galleta are the principal vegetation on the clay and clay loam sites. Characteristic grasses on sandy loam soils are little bluestem, western wheatgrass, sideoats grama, and sand dropseed, while shinnery oak and sand sagebrush are restricted to sandy sites. The High Plains are characteristically free from brush, but sand sagebrush and western honey mesquite, along with prickly pear and yucca, have invaded the sandy and sandy loam areas. Several species of dropseeds are abundant on coarse sands. Various aquatic species such as curltop smartweed are associated with the playa lakes (TAMU, 1999b).

Generally, as a result of overgrazing and abandonment of cropland, woody invaders such as mesquite, lotebush, prickly pear, algerita, tasajillo, and others are common on all soils. Shinnery oak and sand sagebrush invade the sandy lands while redberry juniper has spread from rocky slopes to grassland areas. Western ragweed and annual broomweed are also common invaders (TAMU, 1999b).


Salt Cedar

Brush encroachment is a concern in the Canadian River Breaks and the North Rolling Plains (the eastern panhandle counties of Collingsworth, Hall, Donley, and Wheeler). Brush canopies range from light to heavy in these counties and in the Canadian River Breaks (Potter, Moore, and Oldham Counties especially). The major species of concern is mesquite, which has been shown to be increasing in plant population virtually everywhere it is found. Other species that are encroaching are sand sagebrush, sand shinoak, and yucca. Salt cedar, a phreatophyte, now infests much of the Canadian River stream banks and has moved out onto the adjacent river terraces. Plants such as salt cedar are likely to use much more water than the upland species brush. According to the NRCS Resource Data and Concerns files in the local field offices, there are approximately 1,200,000 acres of brushy species that would be classified as medium to high priority for treatment within the PWPA.

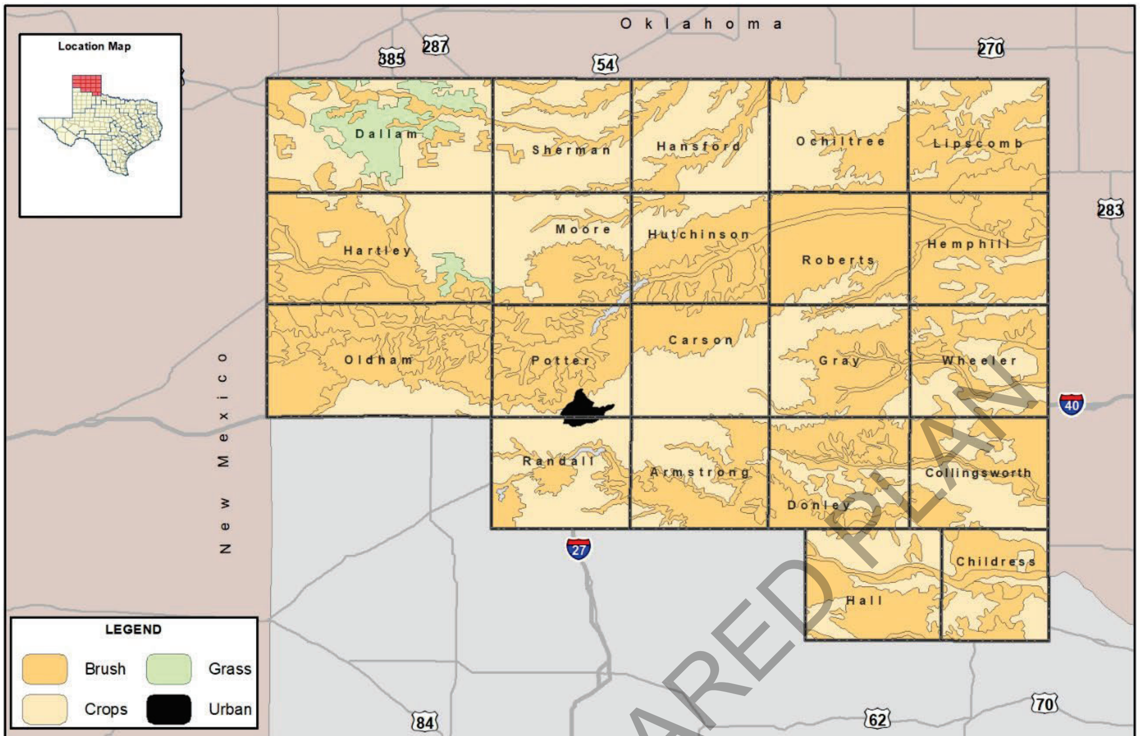


Figure 1-9: Regional Vegetation in the PWPA

A program initiated through the Texas State Soil and Water Conservation Board (TSSWCB) included a study of the feasibility of brush management in eight Texas watersheds, including portions of the Canadian River Basin. The studies, completed in 2010, focused on economic aspects and potential changes in water availability related to brush management. For the Canadian River Basin, the study examined the water availability benefits of controlling moderate to heavy concentrations of mesquite and mixed brush. CRMWA, in partnership with local landowners, TSSWCB and the NRCS have targeted thousands of acres for removal of brush. Between 2010 and 2011 the Legislature has approved over $4.5 million for controlling invasive brush through herbicidal spraying. Research has shown that removing one acre of salt cedar equals 2 to 5 acre-feet per year of water savings and to date, over 16,850 acres have been treated.

1.7.3 Regional Geology

The geology of the Panhandle is composed of sandstone and shale beds of the Cenozoic, Mesozoic and Paleozoic Ages. Major geologic systems which are found in the PWPA include the Tertiary, Triassic, Cretaceous, and Permian (**Figure 1-10**). Throughout the PWPA, the outcropping geology consists of eastward-dipping Permian, Triassic and Tertiary age sandstone, shale, limestone, dolomite and gypsum. The Tertiary Ogallala Group can be found along the western section of the PWPA and includes the Birdwell/Couch Formation.

In the Southern High Plains, the Ogallala formation was deposited by ancient rivers that once flowed west to east from the mountains of New Mexico. Remnant paleo-valleys such as the Winkler, Simanola, and Portales valleys have been identified and mapped by geologists that have studied the area. These valleys were sequentially abandoned as the Pecos Valley formed and provided a new path to the Rio Grande and ultimately to the Gulf of Mexico. The water contained within the Ogallala sands and gravels deposited by these ancient streams were subsequently covered and preserved by aeolian deposits, such as the Blackwater Draw formation.

The eastern portion of the PWPA includes the Ogallala, Dockum, Quartermaster, Whitehorse, and Pease River groups. The Dockum Group formation includes the Santa Rosa, Trujillo, and Chinle Formations. The Whitehorse Group formations are undifferentiated in the west due to widespread solution, collapse, and erosional features. The Blaine Gypsum is the primary formation within the Pease River Group (AAPG, 1979).

1.7.4 Mined Resources

Natural resources that are mined in the PWPA (**Table 1-13**) are primarily oil and natural gas. Technical advances in natural gas development have increased mining activities in the Woodford Shale formation, which lies in the northeastern part of the region within the Anadarko Basin. Non-petroleum mined products include sand, gravel, caliche, stone, and helium. Three counties (Dallam, Hall, and Randall) reportedly do not have any significant mining production.

Table 1-13: Mined Products for Counties in the PWPA

County	Sand	Gravel	Caliche	Stone	Oil	Gas	Helium
Armstrong	X	X					
Carson					X	X	
Childress					X		
Collingsworth					X	X	
Dallam							
Donley						X	
Gray					X	X	
Hall							
Hansford				X	X	X	X
Hartley					X	X	
Hemphill					X	X	
Hutchinson	X	X			X	X	
Lipscomb					X	X	
Moore					X	X	X

County	Sand	Gravel	Caliche	Stone	Oil	Gas	Helium
Ochiltree		X	X		X	X	
Oldham	X	X		X	X	X	
Potter					X	X	
Randall							
Roberts					X	X	
Sherman					X	X	
Wheeler					X	X	

Source: Ramos, 2000

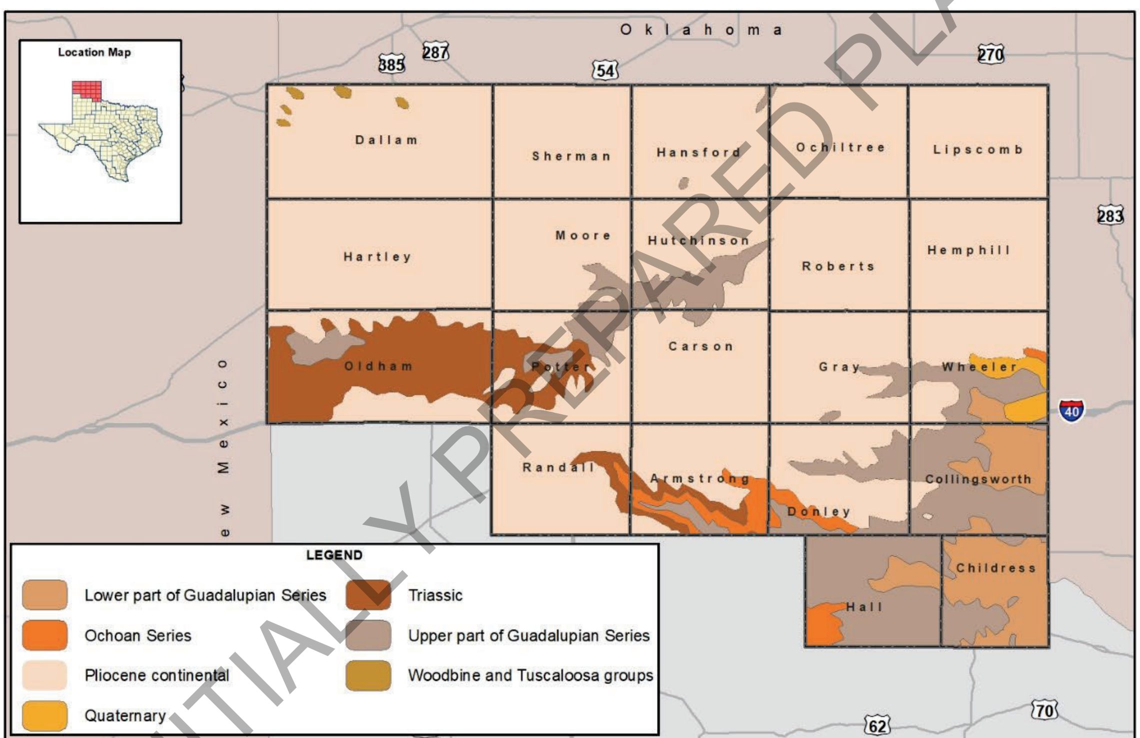


Figure 1-10: Regional Geology of the PWPA

1.7.5 Soils

Soils of the High Plains formed under grass cover in Rocky Mountain outwash and sediment of variable sand, silt, clay, and lime content (Runkles, 1968). Calcium carbonate and, to some extent, gypsum are present in most soil profiles, and rainfall has been insufficient to leach these carbonates from the soil profiles. Many of the surface soils are moderately alkaline to calcareous and low in organic matter. The major soil associations found in the PWPA may be characterized as nearly level or outwash soils (**Figure 1-11**). Most of the nearly level soils in the PWPA have loamy surfaces and clayey subsoils. The major associations involving these nearly level soils are:

- Pullman-Olton-Mansker
- Sherm-Gruver-Sunray
- Dallam-Sunray-Dumas
- Sunray-Conlen-Gruver

Much of the irrigation is on these soils because they are highly productive if sufficient water is available. Much of the eastern portion of the PWPA is characterized by red to brown soils formed from outwash of the clayey to silty red beds. Many of these soils have loamy surface layers and loamy subsoils. Some are shallow over indurated caliche. The major associations included in these outwash soils are:

- Mansker-Berda-Potter
- Woodward-Quinlan-Vernon
- Miles-Springer-Woodward

Infiltration rate of soils used as cropland is primarily affected by soil properties such as texture, structure, aggregate stability, and salinity status. Surface crusting tendencies and organic matter content, which are influenced by tillage management, play an important role in influencing infiltration rates. High soil density in the lower tillage zone (plow pan) restricts hydraulic conductivity and consequent irrigation application rates in many soils, thus enhancing runoff. Irrigation water quality also influences infiltration rate over time, especially with regard to total salinity, sodium concentration, and organic matter content when wastewater is used. Infiltration rates can vary significantly within a field and over time due to soil differences and cultural practices.

The nearly level soils are finer textured and have a restrictive horizon below the plowed layer that greatly reduces water intake after initial wetting to below 0.06 inches per hour (1.5 mm/hr). This profoundly affects soil management and irrigation practices. Root zone permeabilities for most other soils are usually well above 0.2 inches per hour (5 mm/hr). Plant available water holding capacities (i.e., difference in water content between field capacity at –0.33 bars matric potential and wilting point at –15 bars) varies from 0.7 to 2.4 inches per foot within the root zone. Soils with loam, silt loam, and clay load textures generally have higher water holding capacities than sandier soils. Each additional inch of plant available water in the soil at planting time can boost crop yields significantly. Therefore, soil water storage during a fallow season is an important consideration.

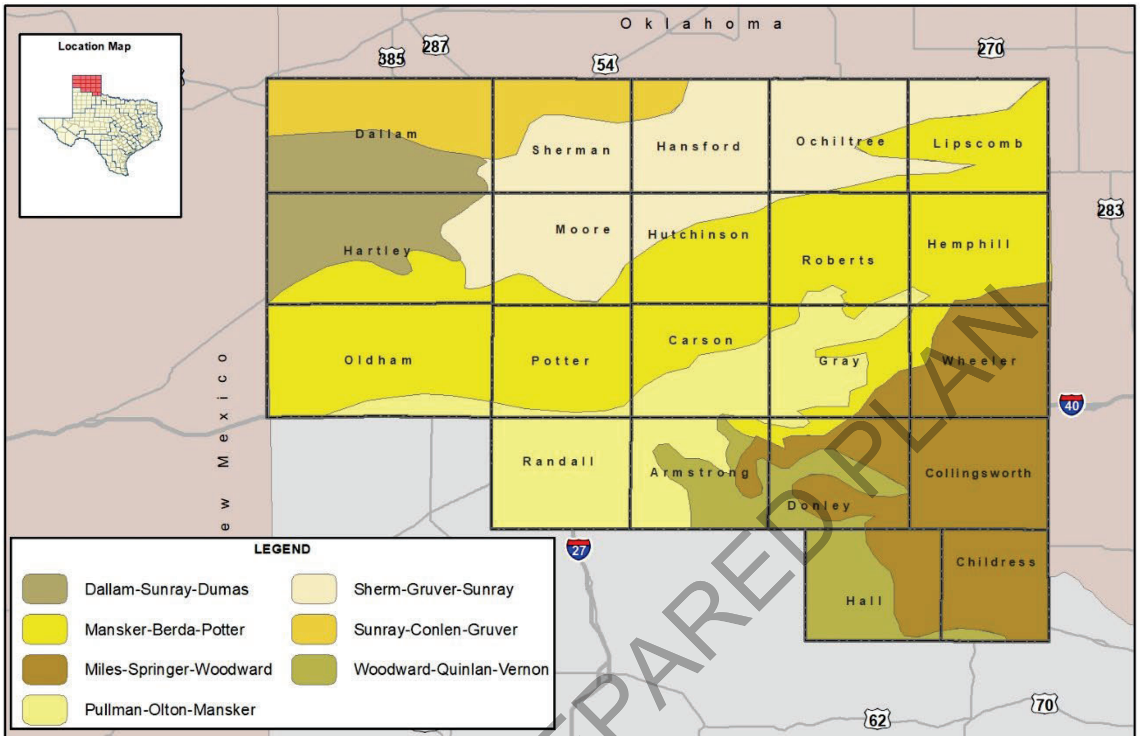


Figure 1-11: Regional Soils of the PWPA

1.7.6 Wetlands

Wetlands are especially valued because of their location on the landscape, the wide variety of functions they perform, and the uniqueness of their plant and animal communities. Ecologically, wetlands can provide high quality habitat in the form of foraging and nesting areas for wildlife and spawning and nursery habitat for fish.

The most visible and abundant wetland features within the PWPA are playa basins. These are ephemeral wetlands found within the region and throughout the Texas Panhandle. The Texas High Plains playa basins are an important element of surface hydrology and ecological diversity. Most playas are seasonally flooded basins, receiving their water only from rainfall or snowmelt. In good years, these shallow basins collect about three or four feet of water. Over time, the moisture either evaporates or filters through the soil to recharge the aquifer.

Playa basins in the High Plains have a variety of shapes and sizes which influence the rapidity of runoff and rates of water collection. Playas have relatively flat bottoms resulting in a relatively uniform water depth throughout most of the basin and are generally circular to oval in shape.

Typically, the soil in the playas is the Randall Clay. In addition to their biological importance as wetlands, playas provide local recharge to the Ogallala aquifer.

Playa basins may supply excellent cover to resident wildlife. These formations provide mesic sites in a semi-arid region and therefore are likely to support a richer, denser vegetative cover than surrounding areas. Moreover, the perpetual flooding and drying of the basins promotes the growth of plants such as smartweeds, barnyard grass, and cattails that provide both food and cover. The concentric zonation of plant species and communities in response to varying moisture levels in basin soils enhances interspersion of habitat types. Playas offer the most significant wetland habitats in the southern quarter of the Central Flyway for migrating and wintering birds. Up to two million ducks and hundreds of thousands of geese take winter refuge here. Shorebirds, wading birds, game birds, hawks and owls, and a variety of mammals also find shelter and sustenance in playas (TPWD, 1999). The abundance of playas in counties of the PWPA varies considerably with some counties having none and others with up to 3 percent of the county covered by playas (**Table 1-14**).

Table 1-14: Physical Characteristics of Playas in the PWPA

County	Number of Playa Lakes	Total Playa Area (acres)	Percent of County Area	Largest Playa (acres)	Smallest Playa (acres)	Average Perimeter (miles)
Armstrong	994	15,356	2.62%	348	0.002	0.54
Carson	595	15,074	2.55%	409	0.000	0.67
Childress	7	116	0.03%	24	7.478	0.64
Collingsworth	0	0	0.00%	0	0.000	0.00
Dallam	262	4,471	0.46%	141	0.000	0.54
Donley	109	1,978	0.33%	181	1.274	0.56
Gray	792	13,529	2.28%	237	0.018	0.51
Hall	0	0	0.00%	0	0.000	0.00
Hansford	381	7,483	1.27%	444	0.003	0.49
Hartley	222	4,281	0.46%	131	0.062	0.52
Hemphill	9	102	0.02%	34	2.301	0.47
Hutchinson	191	3,129	0.55%	116	0.000	0.50
Lipscomb	19	225	0.04%	36	2.652	0.54
Moore	214	5,036	0.86%	246	0.083	0.61
Ochiltree	693	16,263	2.76%	527	0.131	0.58
Oldham	173	4,249	0.44%	195	0.000	0.67
Potter	118	3,472	0.59%	406	0.063	0.61
Randall	594	13,373	2.26%	201	0.117	0.77

County	Number of Playa Lakes	Total Playa Area (acres)	Percent of County Area	Largest Playa (acres)	Smallest Playa (acres)	Average Perimeter (miles)
Roberts	109	1,350	0.23%	278	0.933	0.44
Sherman	218	4,202	0.71%	163	0.114	0.55
Wheeler	0	0	0.00%	0	0.000	0.00
Total	**5,700**	**113,689**	**0.98%**	**527**	**<1**	**0.49**

Source: Playa Lakes Joint Venture, 2015

1.7.7 Aquatic Resources

Rivers and reservoirs within the planning area are recognized as important ecological resources. These are sources of diverse aquatic flora and fauna. Important river systems in the planning area are the Canadian River and the Red River. Reservoirs in the PWPA include Lake Meredith, Palo Duro Reservoir, Rita Blanca Lake, Marvin Lake, and Fryer Lake in the Canadian River Basin, and Greenbelt Reservoir, Bivens Reservoir, McClellan Lake, Lake Tanglewood, Baylor Lake, Lake Childress, and Buffalo Lake in the Red River Basin.

The high salinity of some of the area's surface and groundwater resources, largely due to natural salt deposits, presents a challenge to natural resource planners and managers. Municipal, agricultural, and industrial water users strive to lower the salinity of certain surface-water supplies for higher uses. One method for this is by intercepting and disposing of the naturally saline flows of certain streams, usually originating from natural salt springs and seeps, in order to improve the quality of downstream surface-water supplies. There are several such chloride control projects, both existing and proposed, in the study area.

Ecologically Unique Resources

SB1 requires that the State Water Plan identify river and stream segments of unique ecological value. The identification of such resources may be done regionally by each RWPG or by the state. Several criteria are used to identify streams with unique ecological values. These include biological and hydrologic functions, riparian conservation areas, high water quality, exceptional aquatic life, or high aesthetic quality. Also, stream or river segments where water development projects would have significant detrimental effects on state or federally listed threatened or endangered species may be considered ecologically unique. There are no designated ecologically unique resources in the PWPA.

1.7.8 Wildlife Resources

The abundance and diversity of wildlife in the PWPA is influenced by vegetation and topography, with areas of greater habitat diversity having the potential for more wildlife species. The Rolling Plains have a greater diversity of wildlife habitat, such as the Canadian Breaks and escarpment canyons. Mule deer, white-tailed deer, wild turkey are found along canyons and wooded streams.

Antelope occur on the undulating prairies of the Canadian Breaks area and on the level margins of the High Plains. A number of wildlife species occur throughout the PWPA, including various lizards and snakes, rodents, owls and hawks, coyote, skunks, raccoons, and feral hogs.

Land in the High Plains is generally used for rangeland and cropland and support pronghorn (antelope), prairie dogs, jackrabbits, coyotes, and small mammals. Playas and grain fields attract large numbers of migratory ducks, geese and sandhill cranes. Pheasants and scaled (blue) quail can be locally abundant near corn and other grain fields.

The presence or potential occurrence of threatened or endangered species is an important consideration in planning and implementing any water resource project or water management strategy. Both the state and federal governments have identified species that need protection. Species listed by the U.S. Fish and Wildlife Service (USFWS) are afforded the most legal protection, but the TPWD also has regulations governing state-listed species. **Table 1-15** contains the state or federally protected species which have the potential to occur within the PWPA. This list does not include species without official protection such as those proposed for listing or species that are considered rare or otherwise of special concern.

1.8 Threats and Constraints to Water Supply

Threats and constraints to water supply in the PWPA are related to surface water and groundwater sources. The actual and potential threats may be similar or unrelated for surface or groundwater. Because much of the water use in the PWPA is primarily for agriculture, some of the impacts of the constraints on water use may differ from those for water used for human consumption. However, in most cases the same water sources are used for both agricultural and potable water supply.

Issues that are of concern for water supply in the PWPA include aquifer depletions due to pumping that exceeds recharge; surface water and groundwater quality; invasive brush; and drought related needs for both surface water and groundwater. Potential degradation of water quality may supersede water quantity as a consideration in evaluating the amount of water available for a use. However, the increasing ability to use brackish groundwater for some applications (oil and gas operations, fracking, livestock) might help slow potential water quality degradation).

Most water used in the PWPA is supplied from the Ogallala, making aquifer depletion a potentially major constraint on future water supply in the region. Depletions lower the water levels, making pumping more expensive and reducing the potential available supply. Another potential constraint to both groundwater pumping and maintenance of stream flows relates to restrictions that could be implemented due to the presence of endangered or threatened species. The Federal listing of the Arkansas River Shiner as a threatened species has the potential to affect water resource projects as well as other activities in Hemphill, Hutchinson, Oldham, Potter, and Roberts Counties.

Drought is a major threat to surface water supplies in the PWPA and groundwater supplies that rely heavily on recharge (such as the Seymour aquifer). The Lake Meredith watershed is currently experiencing its lowest inflows since the reservoir was constructed. This impacts water supplies to users in both the PWPA and Llano Estacado Region. To better understand some of the factors contributing to the decline in inflows, a special study on the Lake Meredith watershed was conducted as part of the 2011 regional water plan. A concurrent study on drought in the Canadian River Basin was conducted by the Bureau of Reclamation, in conjunction with others. The findings of the studies indicated that changes in average precipitation and evaporation were not a factor in the low inflows to the reservoir. The changes in inflow are most likely associated with changes in reduced rainfall intensities, invasion of brush and changes in operations of Ute Reservoir. Changes in water use and practices in New Mexico may have an impact on flows in the Canadian River Basin, and ultimately water supply in Lake Meredith.

Potential contamination of groundwater may be associated with oil-field practices, including seepage of brines from pits into the groundwater; brine contamination from abandoned wells; and broken or poorly constructed well casings. Agricultural and other practices may have contributed to elevated nitrates in groundwater and surface water. Surface waters in the PWPA may also experience elevated salinity due to brines from oil-field operations, nutrients from municipal discharges, and other contaminants from industrial discharges. Other potential sources of contaminants include industrial facilities such as the Pantex plant near Amarillo; the Celanese plant at Pampa; an abandoned smelter site at Dumas; and concentrated animal feeding operations in various locations throughout the PWPA. However, most of these potential sources of contamination are regulated and monitored by TCEQ or other state agencies. Naturally occurring brine seeps also restrict the suitability of surface waters in some areas for certain uses.

Invasive brush has been shown to impact stream flows and water supplies. On-going efforts to control brush in the PWPA is discussed in **Section 1.7.2.**

Table 1-15: Threatened and Endangered Species in the PWPA

Species		Status*		County																				
Common Name	Scientific Name	Federal	State	Armstrong	Carson	Childress	Collingsworth	Dallam	Donley	Gray	Hall	Hansford	Hartley	Hemphill	Hutchinson	Lipscomb	Moore	Ochiltree	Oldham	Potter	Randall	Roberts	Sherman	Wheeler
Birds																								
Black Rail	*Laterallus jamaicensis*		T			S																		
Bald Eagle	*Haliaeetus leucocephalus*	R	R	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B		B	B	B	B
Common Black Hawk	*Buteogallus anthranus*		T																	S				
Interior Least Tern	*Sterna antilarrum athalossas*	R	R			B	B		B	B	B			B	B						B	B		B
Piping Plover	*Charadrius melodus*	T		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Rufa Red Knot	*Calidris canutus rufa*	T		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	E																	B					
White-Faced Ibis	*Plegadis chihi*		T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Whooping Crane	*Grus americana*	E	E			B	B							B	S	B		B				B		B
Fish																								
Arkansas River Shiner	*Notropis girardi*	T	T		B			B		B		B	B	B	B	B	B	B	B	B	B	B		
Peppered Chub	*Macrhybopsis tetranema*	E	E		B			B		B		B	B	B	B	B	B	B	B	B	B	B		
Prairie Chub	*Macrhybopsis australis*		T			S	S																	
Red River Pupfish	*Cyprinodon rubrofluviatilis*		T	S		S			S	S	S			S	S						S	S		S
Mammals																								
Black Bear	*Ursus americanus*		T	S	S			S					S											
Palo Duro Mouse	*Peromyscus truei comanche*		T	S	S				S											S	S			
Texas Kangaroo Rat	*Dipodomys elator*		T			S					S													
Reptiles																								
Texas Horned Lizard	*Phrynosoma cornutum*		T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

Status:
T - Threatened
E - Endangered
R - Recovery

Key:
F - Federal listings only (US Fish and Wildlife Service. 2020. Endangered Species List. http://www.fws.gov/endangered/)
S - State listings only (Texas Parks and Wildlife Department. 2020. Annotated County Lists of Rare Species. http://tpwd.texas.gov/gis/rtest/)
B - Both Federal and State listings

1.8.1 Drought of Record

The drought of record is commonly defined as the worst drought to occur in a region during the entire period of hydrologic and/or meteorological record keeping. For the PWPA, the region is currently in the drought of record. All three major reservoirs in the PWPA are currently in the critical drought period. For the Lake Meredith watershed, the drought began in 2000 and intensified from 2010 to 2015. After 2015 lake levels rose but the lake remains less than 45 percent capacity as of May 2024. The Greenbelt Reservoir watershed continues to see unprecedented drought with water levels at the lowest since it began to fill in 1967. Currently, Greenbelt Reservoir is at 10.8% full. More discussion on drought and droughts of record is presented in **Chapter 7**.

1.8.2 Drought Preparedness and Response

A summary of the drought preparedness and response is included in **Chapter 7**. As the PWPG is a planning body only, with no implementation authority, it should be carefully considered as to what appropriate drought response should be included in the Plan. Currently, local public water suppliers and water districts are required to have adopted a Drought Contingency Plan. These drought contingency plans contain drought responses unique to each specific entity. As these entities are the only ones who have the authority to manage their particular water supply or area of authority, it could be suggested that these are the only entities that can describe or implement a drought response.

Drought contingency plans are required by the TCEQ for wholesale water suppliers, irrigation districts and retail water suppliers. In addition to the individual entities' Drought Contingency Plans, the PWPG has prepared this regional water plan to be in general accordance with groundwater districts and net depletion rules and management goals.

1.9 Water Loss and Water Audit

For regional planning, retail public water utilities are required to complete and submit a water loss audit form to the TWDB. The first water loss audit reports were submitted to the TWDB by March 31, 2006. Entities with greater than 3,300 connections are now required to submit their water loss audit to TWDB on an annual basis. In addition, all other retail public suppliers are required to submit a water loss audit once every five years with the next scheduled audit due May 1, 2026. The water audit reporting requirements follow the International Water Association (IWA) and American Water Works Association (AWWA) Water Loss Control Committee methodology.

The primary purposes of a water audit loss are to account for all of the water being used and to identify potential areas where water can be saved. Water audits track multiple sources of water loss that are commonly described as apparent loss and real loss. Apparent loss is the paper loss of water. It includes losses associated with customer meters under-registering, billing adjustment and waivers, and unauthorized consumption. Real loss is the actual water loss of water from the system, and includes main breaks and leaks, customer service line breaks and leaks, and storage overflows. The sum of the apparent loss and the real loss make up the total water loss for a utility.

In the PWPA in 2021, twelve public water suppliers submitted a water loss audit to TWDB. The total real loss was calculated for each water supplier using a corrected input volume. The corrected input volume is water delivered divided by master meter accuracy, which represents the actual amount of water that was delivered to the utility. On a regional basis, the median percentage of total water loss for the PWPA, expressed as gallons per capita per day, is 11 percent. The amount of total water loss for cities, water supply corporations and municipal utility districts are within the range of acceptable water loss (less than or equal to 12 percent). **Table 1-16** summarizes the water loss audit information that was reported by the TWDB for 2021. Reductions in water loss is considered for municipal conservation in **Chapter 5**.

Table 1-16: Summary of PWPA TWDB Water Loss Audits

	Real Loss for WUGs with < 32 Connections per Mile (gal/mi/day)	Real Loss for WUGs with >= 32 Connections per Mile (gal/con/day)	Apparent Loss (gal/con/day)	Total GPCD	Water Loss GPCD
Median	886	33.5	9.1	187.5	23

Source: 2021 Water Loss Audit Dataset from TWDB

1.10 Water-Related Threats to Agricultural and Natural Resources

Water-related threats to agricultural and natural resources in the PWPA include insufficient groundwater water supplies and water quality concerns.

Most of the PWPA depends on groundwater for irrigation. Based on the findings of this plan, the projected agricultural demand exceeds the available groundwater supply in several counties. The inability to meet these demands threatens the region's agricultural resources, which is a major economic driver in the PWPA.

Water quality concerns for agriculture are largely limited to saltwater pollution, both from natural and man-made sources. As previously discussed, improperly abandoned oil and gas wells may contribute to salt contamination of local aquifers. In some areas, excessive pumping may cause naturally occurring poor quality water to migrate into freshwater zones. Water with high total dissolved solids and/or salt concentrations can limit crop production and crop types. Excessive salts can form a hardpan layer on the surface, limiting infiltration of applied water to crops.

Reservoir development, groundwater development and invasion by brush have altered natural stream flow patterns in the PWPA. Spring flows in the PWPA have generally declined over the past several decades. Much of the impact to springs is because of groundwater development, the spread of high water use plant species such as mesquite and salt cedar, or the loss of native grasses and other plant cover. High water use plant species have reduced reliable flows for many tributary streams. Reservoir development also changes natural hydrology by diminishing flood flows and capturing low flows. Continued depletion of the local aquifers will likely continue to impact base flows of local streams and rivers in the PWPA.

The recommended water management strategies in **Chapter 5** address the potential threats to agriculture and natural resources. Conservation is recommended for all irrigation water users to help alleviate groundwater stress. Elevated nitrate and chloride levels from water supplies in the Blaine and Seymour aquifers for municipalities are also addressed with water treatment strategies. Salt cedar removal in the Lake Meredith watershed is a recommended strategy to increase flow into the Canadian River, improve water quality, and improve habitat.

1.11 Summary of Existing Local and Regional Water Plans

1.11.1 Assessment of Potential Water Supplies for Greenbelt MIWA

In 2011, Greenbelt MIWA conducted a study on the reliability of Greenbelt Reservoir and identification of potential water sources to supplement the current surface water supplies. The study found that the lake is in current drought of record conditions, which make it difficult to determine the reliable supply with certainty. Evaluations of inflow to the lake found that local springs are critical to the reliable supply of the lake. Based on historical spring flows, it was determined that the reservoir could continue to supply water at the current level of about 3,850 acre-feet per year. Over time this may decrease due to impacts to spring flows and reductions in storage of the reservoir from sediment accumulation. The review of potential supplemental water sources recommended the development of groundwater from the Ogallala in northern Donley County. This source provides the highest reliability for a long-term supply.

Since completion of this study, Greenbelt MIWA has acquired water rights in Donley County, conducted an Engineering Feasibility Report for the wellfield, and authorized the design and construction of the project.

1.11.2 2021 Panhandle Regional Water Plan

This plan was the culmination of the effort of the PWPG and water users in the region to quantify water demands, assess available supplies to meet these demands and identify strategies to address potential water needs. During this process it was found that the projected demands exceeded the currently developed supplies on a regional basis by approximately 148,000 acre-feet per year in 2020, growing to approximately 378,000 acre-feet per year in 2070. Most of this need is associated with irrigation use in Dallam and Hartley Counties. There were 15 counties with 36 water user groups with projected water needs during the planning period. The largest needs were associated with irrigation use, followed by municipal and manufacturing.

There are supplies in the region that are not fully utilized, including untapped groundwater, which could possibly be used for some of the identified needs. Conservation and demand management are important strategies to meet the irrigation needs and offset dependence on expanding supply development. The PWPA considered conservation a priority in maintaining future supplies.

Most of the recommended strategies included development of additional groundwater supplies and/or conservation. The region has large quantities of undeveloped groundwater. This supply can easily be developed to meet most municipal water needs, but it is limited for irrigated agricultural due to geographical constraints. The primary strategy for irrigation needs was conservation. The total amount of potential water savings from recommended water conservation strategies (municipal and irrigation) in the PWPA was 146,700 acre-feet per year in 2020 and increasing to 573,800 acre-feet per year by 2070. Most of these savings were associated with recommendations for irrigated agriculture. Comparison of the 2021 Water Plan to this plan is presented in **Chapter 11**.

1.12 Existing Programs and Goals

1.12.1 Federal Programs

Clean Water Act

The 1972 Federal Water Pollution Control Act, which, as amended, is known as the Clean Water Act (CWA), is the federal law with the most impact on water quality protection in the PWPA. The CWA (1) establishes the framework for monitoring and controlling industrial and municipal point source discharges through the National Pollutant Discharge Elimination System (NPDES); (2) authorizes federal assistance for the construction of municipal wastewater treatment facilities; and (3) requires cities and certain industrial activities to obtain permits for stormwater or non-point source pollution (NPS) discharges. The CWA also includes provisions to protect specific aquatic resources. Section 303 of the CWA establishes a non-degradation policy for high quality waters and provides for establishment of state standards for receiving water quality. Section 401 of the CWA allows states to enforce water quality requirements for federal projects such as dams. Section 404 of the CWA provides safeguards for wetlands and other waters from the discharge of dredged or fill material. In accordance with Section 305 of the CWA, TCEQ prepares and submits to the U.S. Environmental Protection Agency a Water Quality Inventory. Other provisions protect particular types of ecosystems such as lakes (Section 314), estuaries (Section 320) and oceans (Section 403). Several of these provisions are relevant to specific water quality concerns in the PWPA.

Safe Drinking Water Act (SDWA)

The SDWA, passed in 1974 and amended in 1986 and 1996, allows the U.S. Environmental Protection Agency to set drinking water standards. These standards are divided into two categories: National Primary Drinking Water Regulations (primary standards that must be met by all public water suppliers) and National Secondary Water Regulations (secondary standards that are not enforceable but are recommended). Primary standards protect water quality by limiting contaminant levels that are known to adversely affect public health and are anticipated to occur in water. Secondary standards have been set to help control contaminants that may pose a cosmetic or aesthetic risk to water quality (e.g., taste, odor or color).

North American Waterfowl Management Playa Joint Ventures

The Playa Lakes Joint Venture -- a partnership of state and federal agencies, landowner's conservation groups and businesses -- was established in 1990 to coordinate habitat protection and enhancement efforts on the southern High Plains. Because the playa lakes region provides crucial wintering, migrating and breeding habitat for waterfowl in the Central Flyway, this is one of

10 priority efforts under the North American Waterfowl Management Plan, an agreement between the United States, Canada and Mexico to restore declining waterfowl populations across the continent.

Almost all of the 25,000 playas in Texas, Kansas, New Mexico, Oklahoma, and Colorado are privately owned, and much of the surrounding landscape is in agriculture. Programs are being developed that will provide incentives to private landowners to manage playas for waterfowl and other wildlife.

Joint Venture efforts focus on providing:

- Sufficient wetland acres to avoid undesirable concentrations of waterfowl that lead to disease outbreaks
- Enough feeding areas for both breeding and wintering birds
- Healthy upland and wetland habitats to maximize waterfowl production and winter survival

Agricultural Improvement Act of 2018

The 2018 Farm Bill, governing federal farm programs for the next five years, was signed into law in December 2018. After substantial changes were made in the Agricultural Act of 2014 from previous farm bills, the 2018 farm bill left all the provisions in place while only slightly modifying certain components. Overall, funding for the 2018 farm bill largely remained the same as the 2014 farm bill. All commodity provisions as well as the crop insurance programs were retained with minor modifications. These include Agricultural Risk Coverage (a shallow revenue loss program) and Price Loss Coverage, as well as new subsidized crop insurance products such as Stacked Income Protection Plan for cotton, and Supplemental Coverage Option.

However, funding reallocations in the conservation provisions may lead to positive water savings for the region. The nationwide cap on Conservation Reserve Program (CRP) acreage was increased from 24 to 27 million acres, which may keep irrigated acreage in the area enrolled in the CRP from leaving or entice additional irrigated acreage into the CRP. Funding or the EQIP program is scheduled to increase, reaching $2.025 billion by 2023 and the Regional Conservation Partnership Program received an increase to $300 million annually. Improvements in irrigation systems and water conservation strategies are priorities to receive funding from both programs, thus could potentially lead to additional water savings in the area.

1.12.2 Interstate Programs

Canadian River Compact

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 acre-feet of storage in Texas) until such time as

Oklahoma has acquired 300,000 acre-feet of conservation storage, at which time Texas' limitation shall be 200,000 acre-feet 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 below Conchas Dam, provided that the amount of conservation storage in New Mexico available for impounding waters originating below Conchas Dam shall be limited to 200,000 acre-feet. Water originating from the North Canadian River in Texas is limited to domestic and municipal use.

Red River Compact

The Red River Compact was entered into by the states of Arkansas, Oklahoma, Louisiana and Texas for the purpose of apportioning the water of the Red River and its tributaries. The Red River is defined as the stream below the crossing of the Texas-Oklahoma state boundary at longitude 100 degrees west. Reach I is defined as the Red River and its tributaries from the New Mexico-Texas state boundary to Denison Dam, which is the reach that falls in the PWPA.

In Reach I, four subbasins are defined and the annual flow within the subbasins located within the PWPA is apportioned as follows:

- Subbasin 1 (Buck Creek, Sand Creek, Salt Fork Red River, Elm Creek, North Fork Red River, Sweetwater Creek and Washita River, together will all their tributaries within Texas west of the 100th Meridian) - 60 percent to Texas and 40 percent to Oklahoma.

- Subbasin 3 (Tributaries of the Red River in Texas, beginning from Dennison Dam and upstream to include Prairie Dog Town Fork Red River) - Texas has free and unrestricted use of water in Subbasin 3.

1.12.3 State Programs

The TCEQ is the state lead agency for water resource protection, administering both state and federally mandated programs, such as the Resource Conservation and Recovery Act; the Clean Water Act; the Comprehensive Environmental Response, Compensation Liability and Recovery Act; the Safe Drinking Water Act; and state management plan development for prevention of pesticide contamination of groundwater under the Federal Insecticide, Fungicide, and Rodenticide Act. The TCEQ conducts regulatory groundwater protection programs that focus on: (1) prevention of contamination; and (2) identification, assessment, and remediation of existing problems (TCEQ, 1997).

Texas Pollutant Discharge Elimination System (TPDES) Program

The TPDES is the state program to carry out the National Pollutant Discharge Elimination System (NPDES) promulgated under the Clean Water Act. The Railroad Commission of Texas maintains authority in Texas over discharges associated with oil, gas, and geothermal exploration and development activities. The TPDES program covers all permitting, inspection, public assistance, and enforcement associated with:

- discharges of industrial or municipal waste
- discharges and land application of manure from concentrated animal feeding operations
- discharges of industrial and construction site storm water
- discharges of storm water associated with city storm sewers
- oversight of municipal pretreatment programs
- disposal and use of sewage sludge

Texas Clean Rivers Program (TCRP)

The TCRP was established with the promulgation of the Texas Clean Rivers Act of 1991. TCRP provides for biennial assessments of water quality to identify and prioritize water quality problems within each watershed and subwatershed. In addition, TCRP seeks to develop solutions to water quality problems identified during each assessment.

State Authority and Programs for Water Supply

Following are major State Water departments that may have relevance to municipal, industrial, agricultural, and utility water users (TCEQ, 2014):

- TCEQ, Office of Water – water availability, water planning, water quality and water supply
- TCEQ, Office of Compliance and Enforcement – remediation, field operation, support, enforcement
- Public Utilities Commission – Public Water Supplier reporting and database
- Texas Department of Licensing and Regulations – licenses well drilling operators
- Groundwater Districts - regulate aspects of groundwater use and conservation such as well spacing, size, construction, closure, and the monitoring and protection of groundwater quality
- TWDB, Water Science and Conservation Division – conservation and innovative technologies, surface water resources, and groundwater
- TWDB, Water Supply and Infrastructure Division – regional water planning and development, program administration, water use and projections

Notable state programs for water quality protection includes: (a) wellhead protection areas; and (b) Texas Wetlands Conservation Plan.

Wellhead Protection Areas

The Texas Water Code provides for a wellhead source water protection zone around public water supply wells extending to activities within a 0.25-mile radius. Specific types of sources of potential contamination within this wellhead/source water protection zone may be further restricted by

TCEQ rule or regulation. For example, wellhead/source water protection zones have been designated for many public water supply wells within or near Pantex (May and Block, 1997). More specific information on well head protection zones is available from TCEQ.

The Texas Water Code further provides for all wells to be designed and constructed according to TCEQ well construction standards (30 TAC 290). These standards require new wells to be encased with concrete extending down to a depth of 20 feet, or to the water table or a restrictive layer, whichever is the lesser. An impervious concrete seal must extend at least 2 feet laterally around the well head and a riser installed at least 1 foot high above the impervious seal.

Texas Wetlands Conservation Plan

The State Wetlands Conservation Plan is an outgrowth of the National Wetlands Policy Forum, which was convened in 1987 at the request of the Environmental Protection Agency. In September 1994, a Statewide Scoping Meeting was held that led to the development of the Texas Wetlands Conservation Plan. The primary principles identified during the Plan's development were: 1) improve the transfer of information between agencies, groups and citizens; 2) develop incentives that encourage landowners to conserve wetlands on their property; and 3) increase the assessment of wetlands projects and research on conservation options. Additionally, the five general categories of wetlands issues identified during the development process were: 1) education; 2) economic incentives; 3) conservation; 4) private ownership; and 5) governmental relations. The Plan was finalized in the spring of 1997.

Water for Texas (2022)

Texas Water Code, §16.051 states that: The State Water Plan shall provide for the orderly development, management, and conservation of water resources and preparation for and response to drought conditions, in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of the entire State. The Water for Texas Plan was adopted by the TWDB.

The 2022 State Water Plan was a culmination of a 5-year effort by local, regional, and State representatives. One of the more unique aspects in regional water planning is the broad level of public involvement that occurs throughout the process. Numerous public meetings and hearings, along with technical assistance and support from the State's natural resource agencies, (TWDB, TPWD, Texas Department of Agriculture [TDA], and TCEQ), demonstrate the broad commitment of Texas to ensuring adequate water supplies to meet future needs. To ensure that as many individuals and organizations as possible would have an opportunity to provide comments on the draft 2022 State Water Plan, public meetings were held across Texas.

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2 POPULATION AND WATER DEMANDS

In November 2023, the Texas Water Development Board (TWDB) approved population and water demand projections for the Panhandle Water Planning Area (PWPA) for use in the 2026 Regional Water Plan. The TWDB initially provided two draft population projections using a 1.0 and 0.5 migration scenario developed by the Texas Demographic Center (TDC). As part of this regional water planning update, these projections were reviewed by the region and revised as needed. The PWPG selected migration scenario 1.0 for Armstrong and Randall Counties and scenario 0.5 for the remaining counties. Modifications were made to projected populations for Borger and Pampa Municipal Water System water user groups (WUGs) and to baseline gallons per capita per day (GPCD) for 14 WUGs. Municipal population and GPCD modifications resulted in water demand modifications. Changes were also made for the irrigation, livestock, manufacturing, and steam electric power water demands.

The TWDB distributes its population and demand projections by Water User Groups. Each WUG has an associated water demand that is aggregated on a county/basin basis. Only municipal WUGs have population projections.

Other categories of water users include wholesale water providers and major water providers. A wholesale water provider (WWP) can be a utility, river authority, water district or other entity that sells water wholesale to another entity (such as a different water user group or another wholesale provider). If a wholesale provider also sells water retail, then the provider is considered both a water user group and wholesale provider (e.g., Amarillo Water Utility). A major water provider (MWP) is a WUG or WWP of particular significance to the region's water supply as determined by the Panhandle Water Planning Group (PWPG). This entity may provide water for any use category.

A Water User Group (WUG) is:

- Privately-owned utilities that provide an average of more than 100 acre-feet per year for municipal use for all owned water systems
- Water systems serving institutions or facilities owned by the state or federal government that provide more than 100 acre feet per year for municipal use
- All other retail public utilities that provide more than 100 acre-feet per year for municipal use
- Rural/unincorporated areas of municipal water use, known as County Other (aggregated on a county/basin basis)
- Manufacturing (aggregated on a county/basin basis)
- Steam electric power (aggregated on a county/basin basis)
- Mining (aggregated on a county/basin basis)
- Irrigation (aggregated on a county/basin basis)
- Livestock (aggregated on a county/basin basis)

All projections in this chapter are aggregated by the county where the water is used. Projected demands on water sources are addressed in **Chapter 3**. Specifically, expected demands on the Ogallala aquifer by county are included in **Table 3-17**. Demands on other sources are accounted for through the allocation of water supplies to users and recommended water management strategies.

This chapter documents the projected estimates of population and water demands of WUGs in the PWPA, as well as the demands on designated major water providers. Projections divided by WUG, county and basin may be found in the tables at the end of this chapter **(Attachment 2-1**). The projections were developed by decade and cover the period from 2030 to 2080.

2.1 Population Projections

In 2020, the population of the State of Texas was approximately 29.1 million people. The population of the PWPA in 2020 was estimated to be 396,182 (2020 US Census Bureau). This represents approximately 1.4 percent of the state's population. Most of the region's population is in Potter and Randall Counties, which contains Amarillo. The remaining population in the PWPA is distributed among the other 19 counties, ranging from populations of less than 1,000 in Roberts County to over 20,000 in Gray, Hutchison, and Moore Counties.

For the 2026 regional water plans, municipal water users are defined based on the service area boundary rather than city boundaries. For most of the cities in the PWPA, the city boundary and service area boundary are the same or very similar. The initial population projections for each WUG relied on several sources, including the 2020 U.S. Census, water connections data, and self-reported data to the TWDB and Texas Commission on Environmental Quality (TCEQ). Modifications were made to projected populations for Borger and Pampa Municipal Water System water user groups (WUGs).

The population for the PWPA is projected to increase from 407,985 in 2030 to 470,326 in 2080, or an average annual growth rate of 0.31 percent. As shown on **Table 2-1**, most of the region's projected growth is expected to occur in Randall County. Other counties showing increases in population include Dallam, Hansford, and Ochiltree counties. The 2030 population and 2080 population projections by county are shown in **Figure 2-1**.

Table 2-1: PWPA Population by County from 2030 to 2080

County Name	2030	2040	2050	2060	2070	2080
Armstrong	1,819	1,789	1,773	1,760	1,747	1,734
Carson	5,555	5,311	5,037	4,718	4,400	4,083
Childress	6,721	6,736	6,638	6,563	6,488	6,413
Collingsworth	2,498	2,426	2,290	2,182	2,074	1,966
Dallam	7,353	7,734	8,086	8,289	8,491	8,693
Donley	3,070	2,893	2,683	2,560	2,437	2,314
Gray	21,243	20,982	20,339	19,553	18,769	17,986
Hall	2,622	2,478	2,290	2,131	1,972	1,813
Hansford	5,333	5,448	5,483	5,571	5,659	5,747
Hartley	5,377	5,350	5,298	5,224	5,150	5,076
Hemphill	3,273	3,268	3,154	3,087	3,020	2,953
Hutchinson	20,414	19,914	19,076	18,157	17,241	16,326
Lipscomb	2,903	2,763	2,584	2,435	2,286	2,137
Moore	21,383	21,482	21,392	20,870	20,350	19,831
Ochiltree	10,458	10,999	11,341	11,664	11,986	12,307
Oldham	1,708	1,559	1,371	1,168	966	764
Potter	118,628	118,038	115,217	110,549	105,894	101,248
Randall	159,318	179,106	197,748	215,738	233,780	251,857
Roberts	778	748	725	720	715	710
Sherman	2,677	2,623	2,537	2,436	2,335	2,234
Wheeler	4,854	4,719	4,545	4,408	4,271	4,134
Total	**407,985**	**426,366**	**439,607**	**449,783**	**460,031**	**470,326**

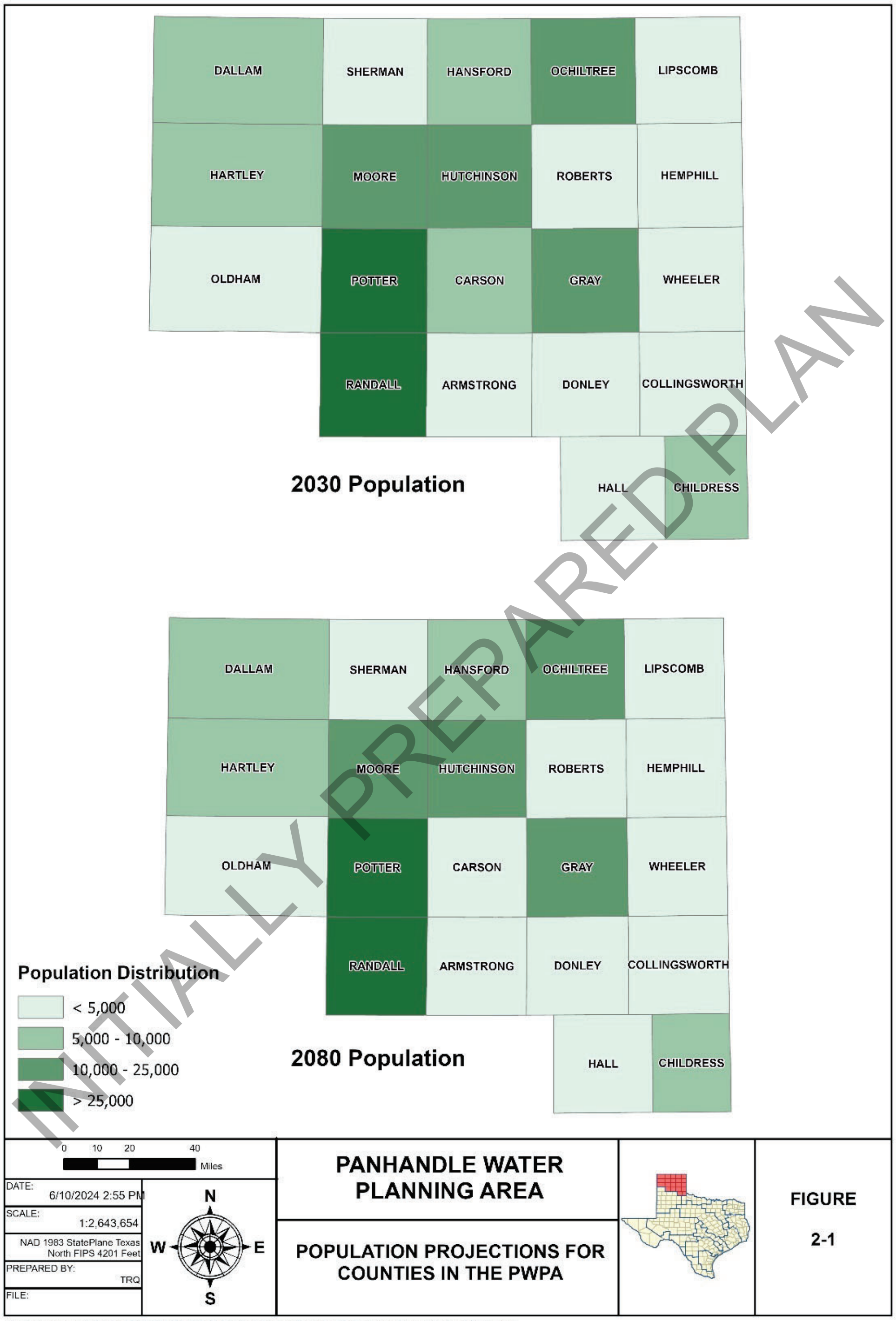


Figure 2-1: PWPA Population by County

2.2 Historical Water Use and Projected Water Demand

Water use in the PWPA during 2020 totaled over 2.2 million acre-feet, or approximately 15 percent of the state total. Three counties in the PWPA, Dallam, Hartley, and Sherman, reported water use of over 300,000 acre-feet with a combined water use of nearly 1.1 million acre-feet in 2020. Water use by these three counties represents approximately half of the total water use in the PWPA during 2020. Projections for water demand indicate that total water usage in the PWPA will be approximately 2.1 million acre-feet in 2030, and then decline over time to 1.7 million acre-feet by 2080 (**Figure 2-2**) due largely to reductions in agricultural use. Most of the water will continue to be used in the three large agricultural counties noted above. **Figure 2-3** shows the distribution of total water demands by county. The largest water use in the PWPA is for agricultural purposes, followed by municipal water use.

Figure 2-4 shows the distribution of water demand by use type. Tables at the end of this chapter contain detailed information on projected water use by municipal, manufacturing, mining, irrigation, livestock, and steam-electric water users (see **Attachment 2-1**).

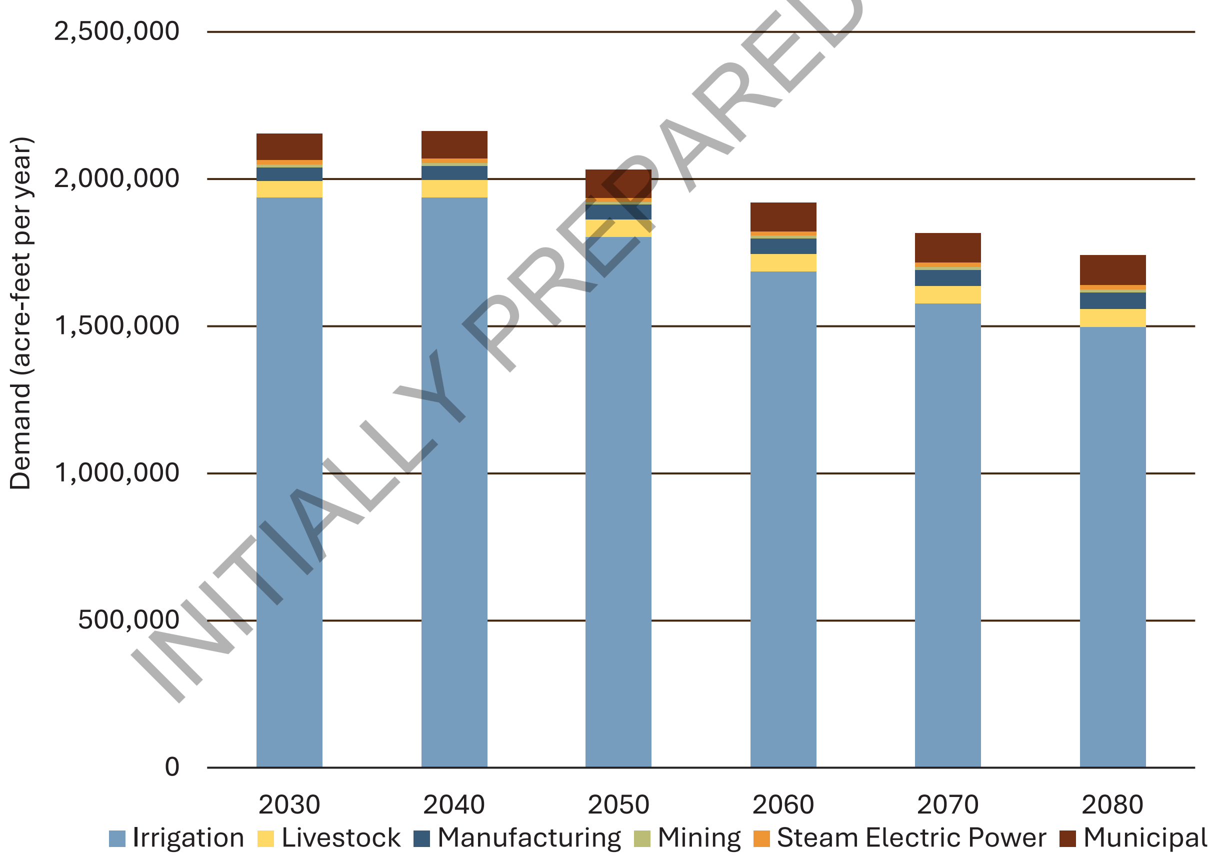


Figure 2-2: Total Water Use for PWPA from 2030 to 2080

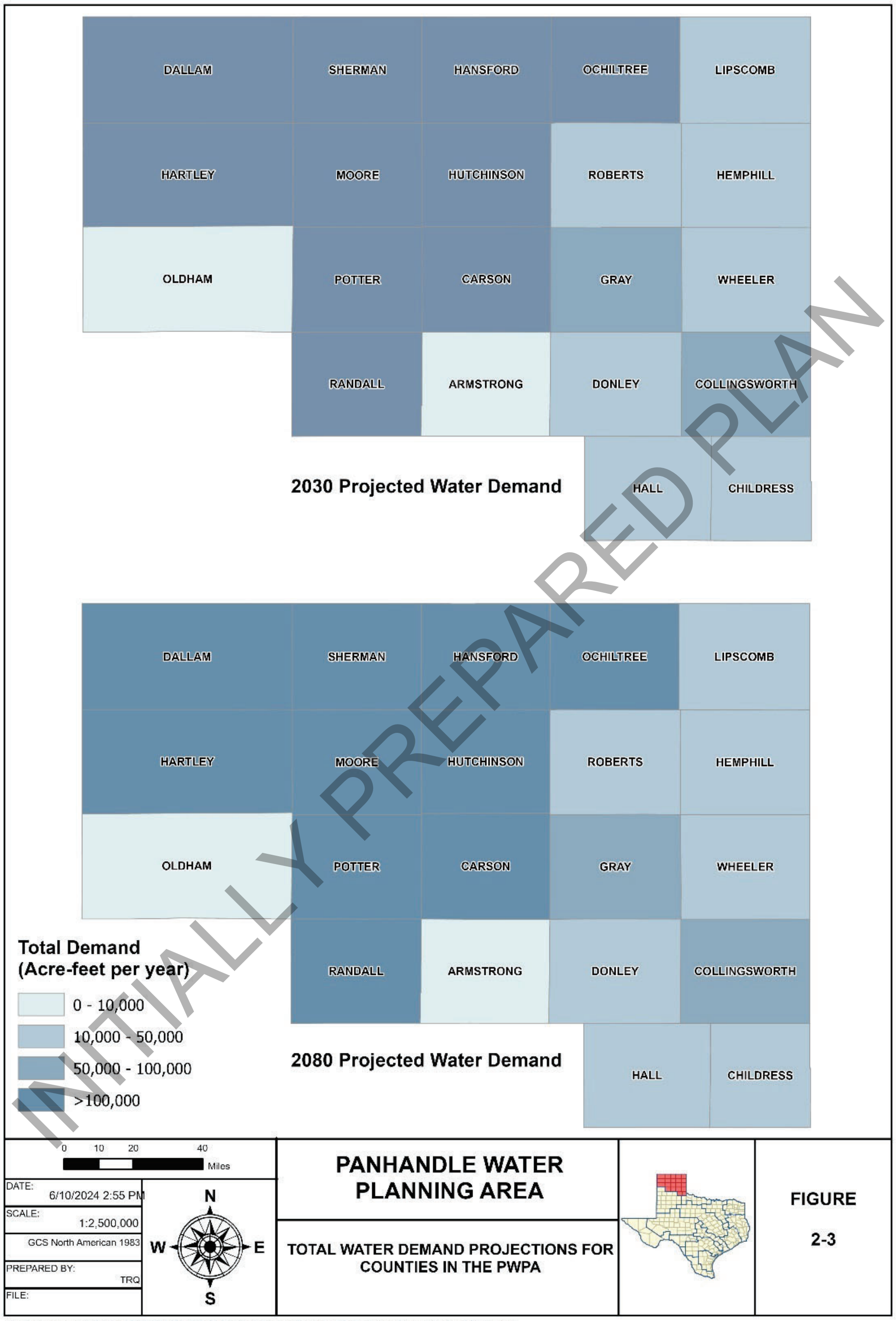
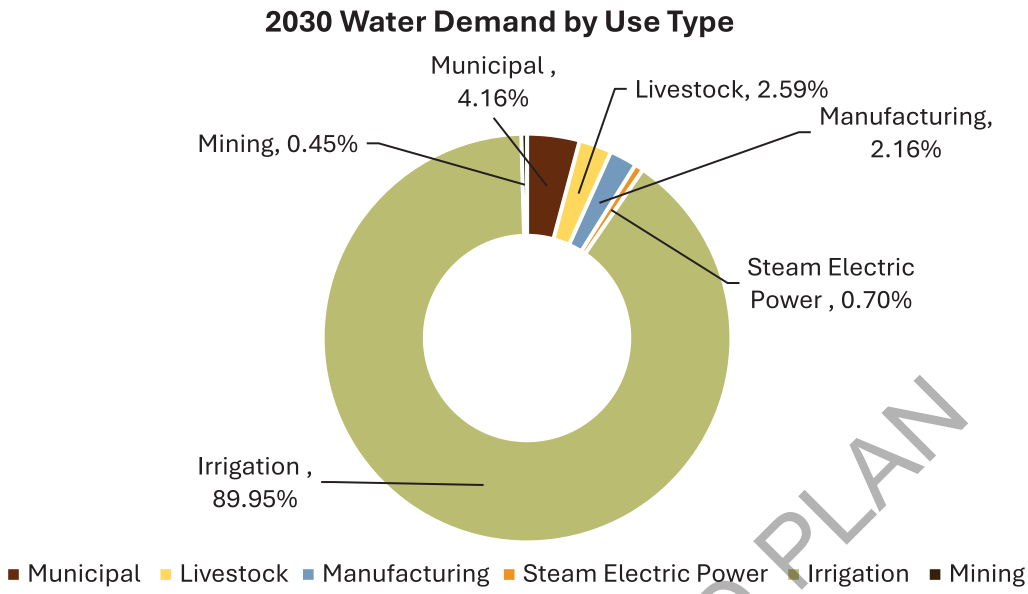


Figure 2-3: Total Projected Water Demand by County



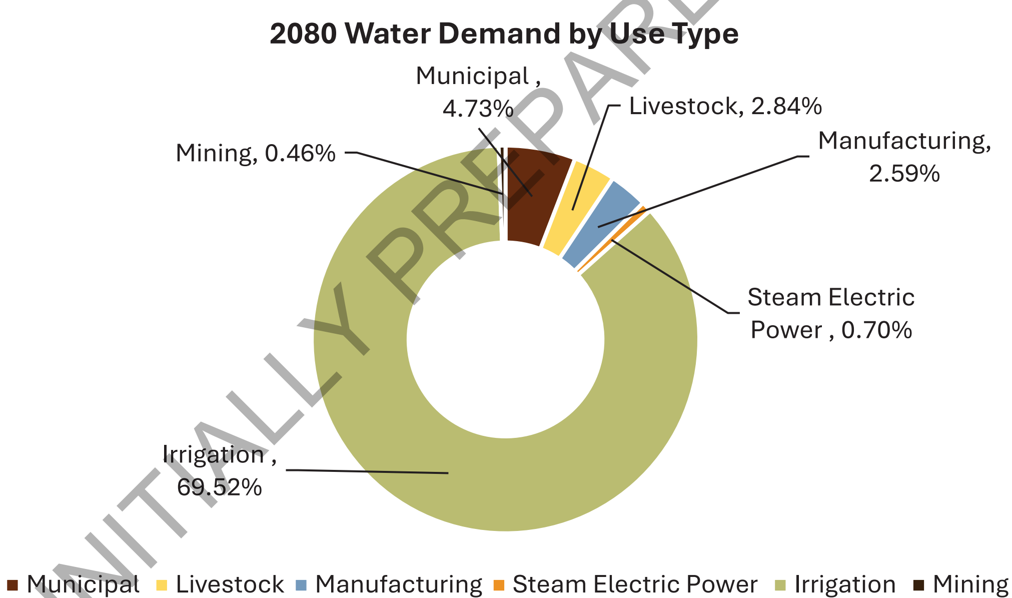


Figure 2-4: Water Demand by Use Type

2.3 Municipal Water Demands

The distribution of municipal water use in the PWPA corresponds closely to the distribution of population centers in the PWPA. Projections of municipal water demands are calculated based on estimated changes in populations for cities and rural areas and on estimates of daily per capita water use. In general, the historical dry year 2011 (with adjustments for accumulated historical plumbing code savings) was used as the basis for per capita water use. Through implementation of the Plumbing Code Fixture Act, per capita water use is estimated to decrease for each decade of the planning period under the assumption that water efficient appliances and plumbing fixtures will be installed and result in lower water use. These conservation savings by county are shown in **Table 2-2**. On a regional basis, the total amount of municipal water savings associated with water efficient appliances and plumbing fixtures is estimated to be approximately 2,800 acre-feet per year by 2080.

Table 2-2: Municipal Water Savings Incorporated into Demands

County	Water Savings (ac-ft/ yr)					
	2030	2040	2050	2060	2070	2080
Armstrong	9	11	10	11	10	10
Carson	29	31	31	29	27	27
Childress	38	41	41	40	40	40
Collingsworth	13	13	15	14	12	11
Dallam	38	46	47	49	49	51
Donley	18	18	16	15	15	15
Gray	116	130	126	120	114	109
Hall	15	14	14	14	12	11
Hansford	28	32	33	33	35	34
Hartley	26	32	31	29	29	30
Hemphill	17	19	21	20	18	19
Hutchinson	111	122	118	112	107	101
Lipscomb	17	16	16	14	14	13
Moore	112	128	127	125	122	119
Ochiltree	54	66	68	71	72	75
Oldham	9	9	9	7	6	4
Potter	642	723	706	677	649	621
Randall	842	1,067	1,179	1,287	1,393	1,501
Roberts	5	5	3	4	3	3
Sherman	13	14	14	14	13	13
Wheeler	27	30	27	26	27	26
Total	**2,179**	**2,567**	**2,652**	**2,711**	**2,767**	**2,833**

Municipal water use in the PWPA accounts for approximately 4 percent of total water use in the PWPA in 2030. With the projected population growth, the municipal water demand for the PWPA is projected to increase from 89,541 acre-feet in 2030 to 101,883 acre-feet in 2080. As shown in **Table 2-2**, per person water usage is estimated to decline due to municipal conservation over the planning horizon. However, population growth causes an overall increase in municipal water demand through 2080. There is approximately a 14 percent increase in municipal water demand. Randall County represents most of the municipal water use increase over the planning period. The population and municipal water demand in the City of Amarillo is the main contributor to the increase in Randall County. **Figure 2-5** shows the increasing trend in projected municipal water demand for users in the PWPA through 2080. **Figure 2-6** shows the municipal use by county.

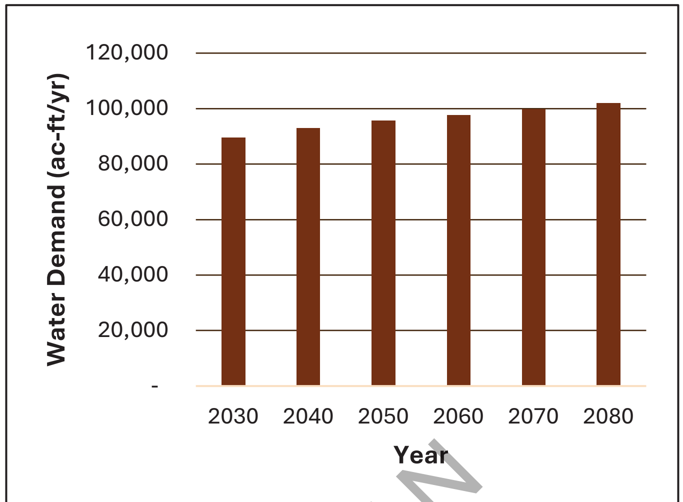


Figure 2-5: Projected Municipal Water Demand

2.4 Industrial Water Demands

The TWDB defines industrial water use as water required in the production process of manufactured products, including water used by employees for drinking and sanitation purposes. The industrial use category includes manufacturing, steam power generation, and mining. Each of these categories is discussed below. **Figure 2-7** shows the total industrial water demand in the PWPA by county for years 2030 and 2080.

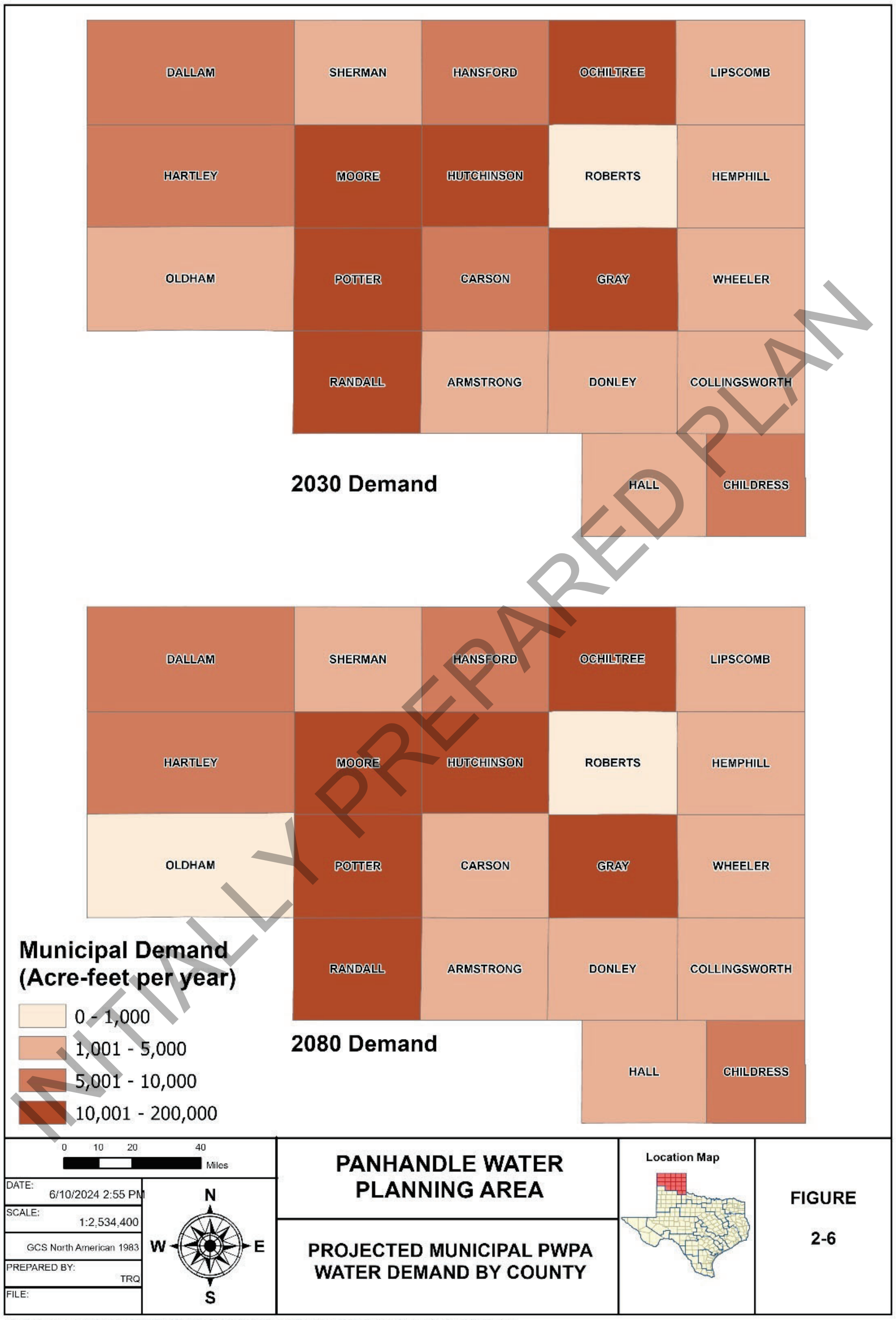


Figure 2-6: Projected Municipal Water Demand by County

Figure 2-7: Projected Industrial Water Use in the PWPA

2.4.1 Manufacturing

Most of the manufacturing industries in the PWPA are associated with agribusiness or energy production (oil and gas). There are thirteen counties in the region with manufacturing water use. The larger users are in Hutchinson, Moore, and Potter Counties. Manufacturing demands for 2030 are estimated by the TWDB based on highest historical reported use from 2015 to 2019 and employment growth data over the last ten years. For each planning decade after 2030, a statewide manufacturing growth rate of 0.37 percent was applied.

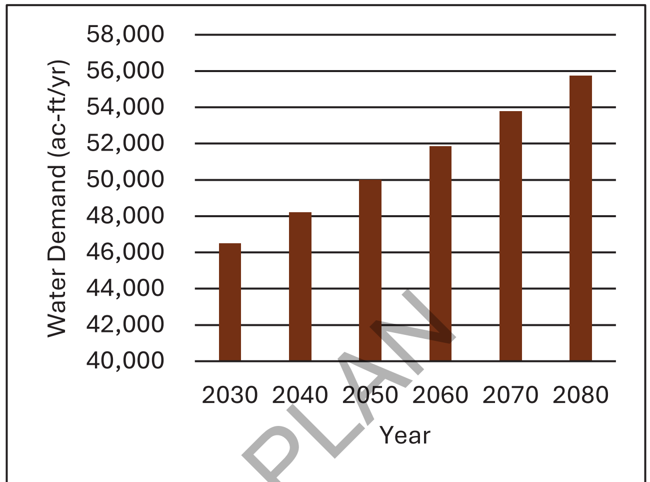


Figure 2-8: Projected Manufacturing Water Demand

Figure 2-8 shows the total projected water demand of manufacturing users in the PWPA through 2080. Total manufacturing water demand for the PWPA is projected to increase from 46,497 acre-feet in 2030 to 55,755 acre-feet by 2080. Manufacturing water use represents about 2 to 3 percent of the total water use in the PWPA over the planning period.

2.4.2 Steam Electric Power

Xcel Energy has a power generation plant in Potter County that accounts for all the current water use by power generators in the PWPA. There are no new facilities currently being considered for development. As a result, only demands for this facility are included in the PWPA power generation projections. These projections are shown to hold constant at 15,000 acre-feet per year over the planning horizon.

2.4.3 Mining

Mining activities in the PWPA consist primarily of oil and gas extraction and removal of industrial minerals such as sand, gravel, and gypsum. **Figure 2-9** shows the projected water demands for mining in the PWPA. There are only three counties with known aggregate mining: Oldham, Potter and Wheeler counties. Mining in the other counties is associated with oil and gas. Technological advancements in natural gas development have increased mining activities in the Woodford Shale Formation in the Panhandle Region. This has resulted in increased mining water use in several northeastern counties in the region. These activities are expected to continue over the planning period.

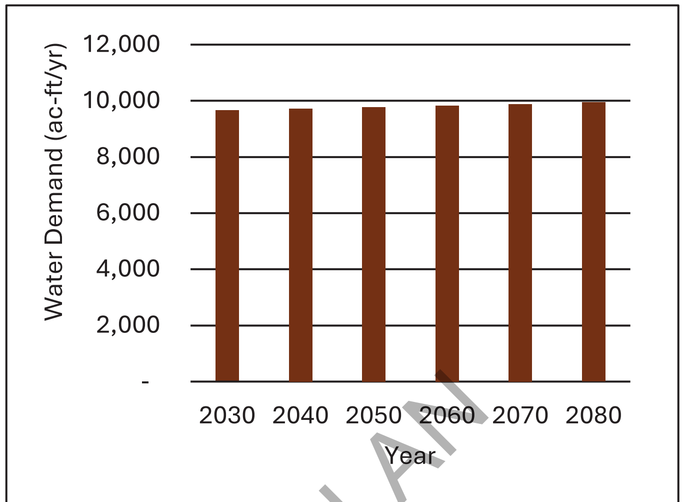


Figure 2-9: Projected Mining Water Demand

Mining water use is projected for 13 counties in the PWPA, totaling 9,677 acre-feet in 2030 to 9,943 acre-feet in 2080. Mining water use represents a small fraction of the total water use in the region (less than 1 percent).

2.5 Agricultural Water Demands

Agricultural water demands include water used for irrigation purposes and water for livestock production. It does not include water for processing agricultural or livestock products. This demand is included under manufacturing. Agricultural water use accounts for approximately 93 percent of the total water demand in the PWPA in 2030 and reduces to about 72 percent by 2080.

Figure 2-10 shows the agricultural water use by county in the region. The largest agricultural water users are in Dallam, Hartley, Hansford, Moore, and Sherman Counties.

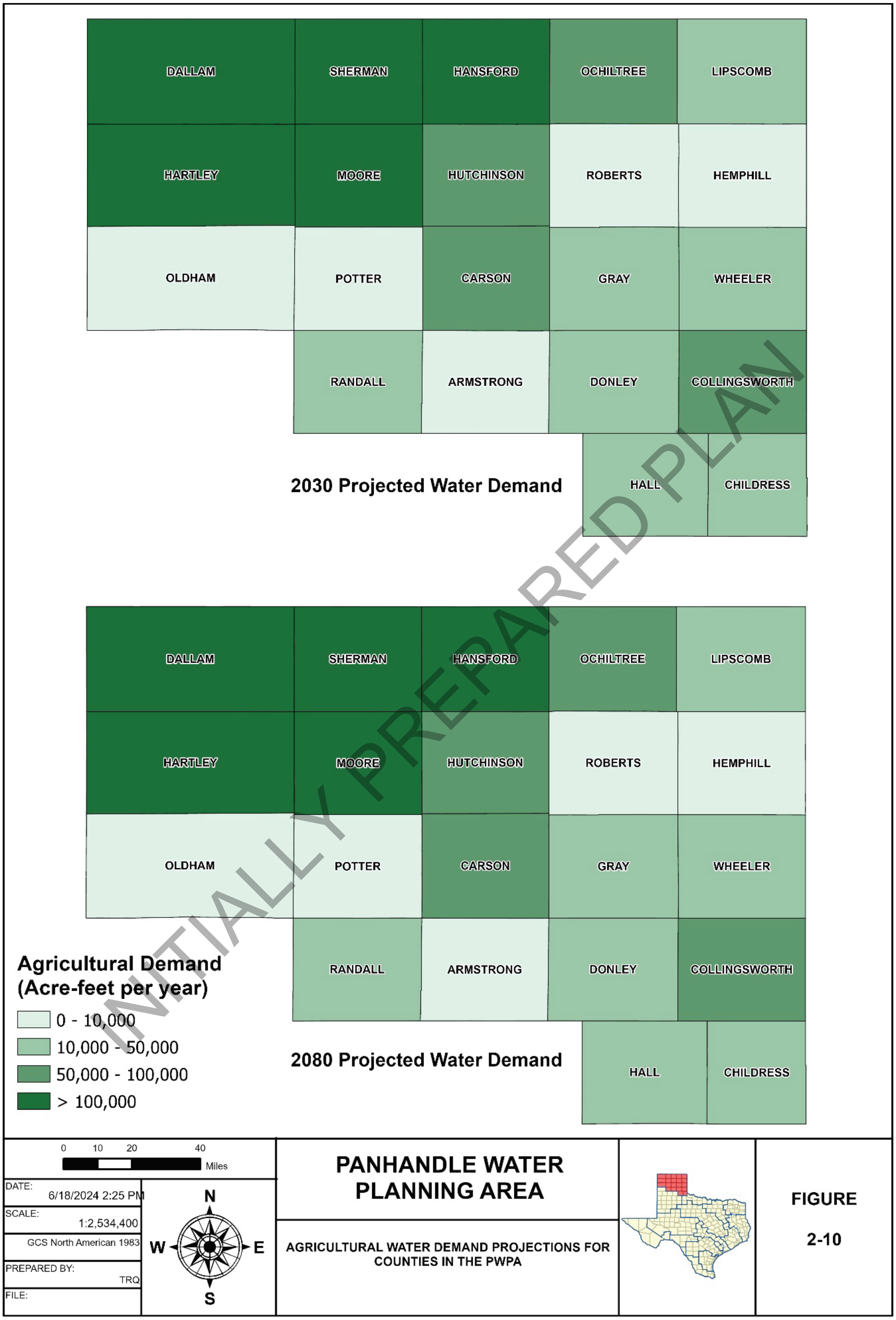


Figure 2-10: Projected Agricultural Water Use by County

2.5.1 Irrigation Water Demands

Irrigation water use accounts for most of the water used in the PWPA. The baseline irrigation estimates were developed using a ten-year running average of historical water use reported by the TWDB and adjusted based on GCD data. This provides a realistic demand that incorporates dry to wet years. Since nearly all the irrigation water is groundwater, it was assumed that the irrigation demand would remain at similar levels if there was sufficient groundwater. As groundwater availabilities decline, the irrigation demand would also decline. Therefore, the projections for 2030 through 2080 reflect the projected trends in groundwater availability. For most counties there are no decreases in the projected irrigation demands. Irrigation demands decline in four counties: Dallam, Hartley, Moore, and Sherman. Based on this analysis, the irrigation water demand in the PWPA is expected to be 1,938,018 acre-feet in 2030, declining to 1,497,833 acre-feet by 2080 as shown in **Figure 2-11**. The agricultural demand report is provided in **Appendix A**.

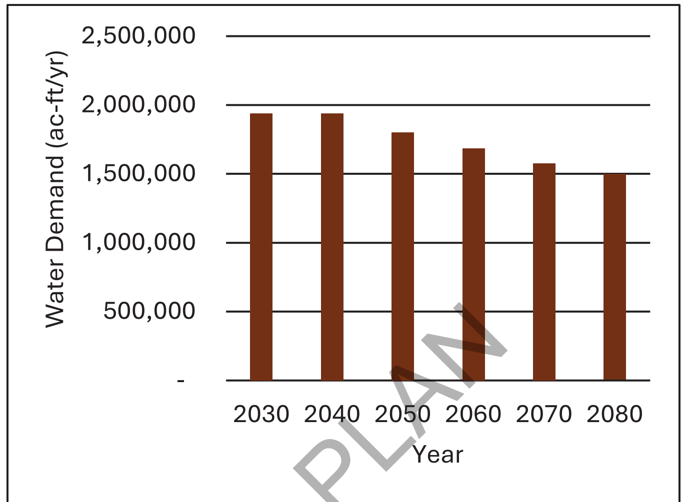


Figure 2-11: Projected Water Use for Irrigation

2.5.2 Livestock Water Demands

Livestock water use is part of the total agricultural demand in the PWPA. While comprising only about 2 to 3 percent of the region's current water use, livestock production is an important component of the overall economy of the PWPA. Changes to types of livestock production impact not only this demand sector but also associated agribusinesses. Due to recent trends in future livestock production, the demands for livestock water use were reviewed and updated by Texas A&M AgriLife. The report is included in **Appendix A**. **Figure 2-12** shows the projected livestock demand.

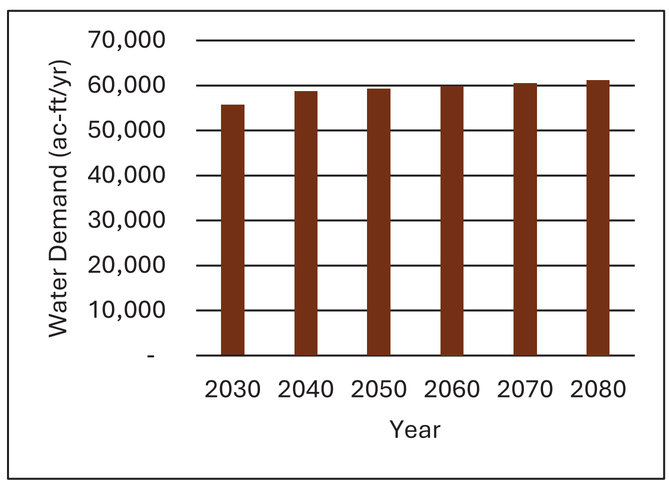


Figure 2-12: Projected Livestock Water Demands

New projections developed by Texas A&M AgriLife included the most recent inventories of various livestock species for each county, estimates of annual industry growth rates, and updated regional species-level water use estimates. Future trends were developed with input from the PWPG Agricultural Committee.

Inventories of current livestock production, along with estimates of water use by species, result in an estimated livestock use of 55,766 acre-feet in 2030 and increasing to 61,158 acre-feet per year by 2080. The largest livestock water use group is the dairy industry with an annual usage of about 24,400 acre-feet per year by 2040 and remaining steady through 2080. Fed cattle follow closely behind with a projected total water use of 22,800 by 2080. These two user groups account for 77 percent of projected livestock water use throughout the planning period. Overall, water use in the PWPA livestock sector is predicted to increase nearly 10 percent from 2030 to 2080.

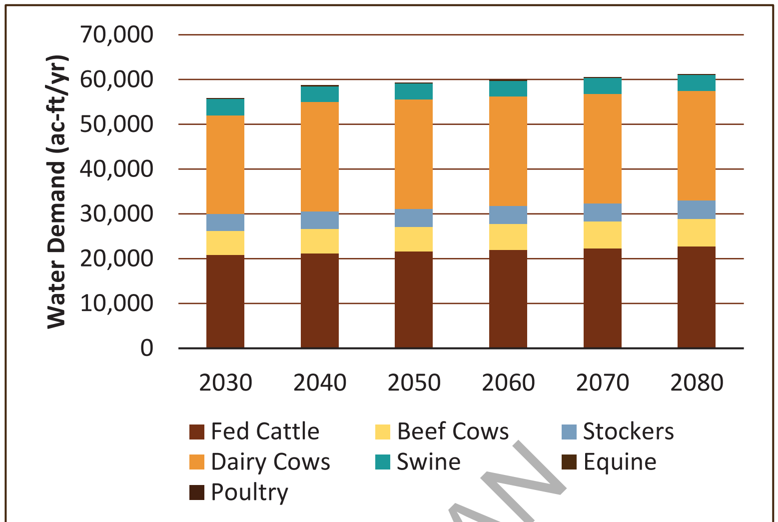


Figure 2-13: Demand by Major Livestock Type

Figure 2-13 illustrates the water demand by major livestock category for the planning period. Detailed livestock population and water demand data is contained in the Texas A&M AgriLife report in **Appendix A**.

2.5.3 Uncertainty in Agricultural Demand Projections

The methodology used to develop the agricultural water demands is based on estimates of current production and expected trends in the agricultural sectors. These trends are contingent upon many factors, including changing market conditions, government subsidies, and availability of resources. Commodity and fuel prices also play important roles in agricultural water demands. These economic factors are often the driving force in the types of crops planted, irrigated acreage and ultimately the amount of water needed. These trends can result in both location and quantity changes to demands on the region's water sources and will need to be monitored and updated for subsequent planning efforts.

Irrigation Water Demand Uncertainty

Irrigation demands in four counties are projected to decline over time due to declining groundwater availability. How these declining water levels affect irrigation demand will depend upon many factors, including economic considerations of irrigation improvements and profitability of produced crops.

2.6 Major Water Providers

The category of Major Water Provider (MWP) was created to identify water providers of significance to the region. This could include entities that provide large quantities of water, either retail or wholesale, or provide water to a large geographic area. The planning groups could also consider other factors that warranted designation. The PWPG has designated four MWPs in the region. These include the Canadian River Municipal Water Authority (CRMWA), cities of Amarillo, and Borger, and Greenbelt Municipal and Industrial Water Authority (Greenbelt MIWA). Descriptions of each of these water providers are provided in **Section 1.4** of this plan.

PWPA Major Water Providers

- City of Amarillo
- Greenbelt Municipal and Industrial Water Authority (Greenbelt MIWA)
- Canadian River Municipal Water Authority (CRMWA)
- City of Borger

CRMWA and Greenbelt MIWA provide water to customers in the PWPA and adjoining regions. CRMWA provides water to customer cities in the Llano Estacado Water Planning Region (Region O) and Greenbelt MIWA provides water to customers in Region B. The following discussions represent the projected water demand on each of the PWPA's MWPs. These demands include current contractual obligations and expected future demands of existing and potential future customers. **Attachment 2-2** contains projected water demands for each of these MWPs broken down by category of use for each decade.

2.6.1 City of Amarillo

In 2030, the City of Amarillo is projected to provide approximately 76,000 acre-feet of water to their retail service area and wholesale customers. Their customers include the City of Canyon, Texas Parks and Wildlife Department (Palo Duro State Park), and industrial use by ASARCO, Tyson, Owens Corning, Xcel Energy, and others. By 2080, Amarillo is expected to provide approximately 88,000 acre-feet per year to their retail service area and existing wholesale customers. Most of the increase in projected demand on Amarillo is associated with municipal growth within the city's service area and increased local manufacturing needs.

Table 2-3: Projected Water Demands for the City of Amarillo

Customers	Demands (ac-ft/yr)					
	2030	2040	2050	2060	2070	2080
City of Amarillo	46,830	49,513	51,716	53,441	55,161	56,866
City of Canyon	1,000	1,000	1,000	1,000	1,000	1,000
Palo Duro State Park (Randall County-Other)	25	25	25	25	25	25
Potter County Manufacturing	10,009	10,439	10,884	11,346	11,825	12,322
Randall County Manufacturing	1,231	1,277	1,324	1,373	1,424	1,477
Subtotal	**59,095**	**62,254**	**64,949**	**67,185**	**69,435**	**71,690**
Reuse Water Demand						
Instream flows to Lake Tanglewood	1,682	1,682	1,682	1,682	1,682	1,682
Xcel Energy (Steam Electric Power)	15,000	15,000	15,000	15,000	15,000	15,000

Customers	Demands (ac-ft/yr)					
	2030	2040	2050	2060	2070	2080
Subtotal	**16,682**	**16,682**	**16,682**	**16,682**	**16,682**	**16,682**
Total Demand	**75,777**	**78,936**	**81,631**	**83,867**	**86,117**	**88,372**

2.6.2 Greenbelt Municipal and Industrial Water Authority (Greenbelt MIWA)

Greenbelt MIWA provides water to four cities in the PWPA, three cities in Region B, and to the Red River Authority (RRA) for subsequent sales in both regions. Approximately 70 percent of the current demand on Greenbelt MIWA is from the cities of Childress, Clarendon, Hedley, and Memphis, and to the RRA for sales in the PWPA. The remaining sales are to the cities of Chillicothe, Crowell, and Quanah, and to the RRA in Region B. Greenbelt MIWA also supplies manufacturing demands in Region B. Demand projections for Greenbelt MIWA were developed based on each recipient's projected water demand and the percentage of the historical water demands that the Greenbelt MIWA had supplied. The demand for Greenbelt MIWA is expected to remain about the same with a slight decrease throughout the planning period.

Table 2-4: Projected Water Demands for Greenbelt MIWA

Customers	Demands (ac-ft/yr)					
	2030	2040	2050	2060	2070	2080
PWPA						
City of Childress	1,274	1,315	1,296	1,261	1,224	1,186
City of Clarendon	298	281	262	251	239	227
City of Memphis	37	37	37	37	37	37
Donley County-Other (City of Hedley)	56	56	56	56	56	56
Red River Authority - Childress County	382	358	352	361	369	378
Red River Authority - Collingsworth County	16	16	16	16	16	16
Red River Authority - Donley County	30	30	30	30	30	30
Red River Authority - Hall County	100	100	100	100	100	100
Region B						
City of Chillicothe	29	29	28	28	27	27
City of Crowell	120	119	117	115	113	110
Thalia	40	40	40	40	40	40
City of Quanah	347	343	340	336	331	327
Hardeman County Other	2	2	2	2	2	2
Hardeman Manufacturing	50	50	50	50	50	50
Red River Authority - Foard County	73	73	74	75	77	78
Red River Authority - Hardeman County	195	193	192	189	186	184
Red River Authority – Wilbarger County	7	7	7	7	7	7
Total Demand	**3,056**	**3,049**	**2,993**	**2,954**	**2,904**	**2,855**

2.6.3 Canadian River Municipal Water Authority (CRMWA)

CRMWA is the largest wholesale water provider in the PWPA. In 2030, CRMWA is projected to supply nearly 100,000 acre-feet of water to customers in the PWPA and Llano Estacado Region. CRMWA delivers water to Amarillo, Borger, and Pampa in the PWPA and to eight cities in the Llano Estacado Region, including Lubbock. Projected water demands on CRMWA through the planning period are anticipated to increase to approximately 118,000 acre-feet per year.

Table 2-5: Projected Water Demands for CRMWA

Customers	Demands (ac-ft/yr)					
	2030	2040	2050	2060	2070	2080
PWPA						
City of Amarillo	41,199	45,419	49,341	50,000	50,000	50,000
City of Borger	4,866	5,902	6,928	7,852	8,596	9,456
City of Pampa	2,242	2,242	2,242	2,423	2,617	2,623
Llano Estacado Region						
City of Brownfield	1,360	1,406	1,450	1,501	1,556	1,616
City of Lamesa	1,367	1,411	1,442	1,450	1,450	1,441
City of Levelland	1,990	1,998	1,988	1,978	1,968	1,961
City of Lubbock	40,810	46,736	47,000	47,000	47,000	47,000
City of ODonnell	102	99	98	95	92	87
City of Plainview	2,400	2,640	2,904	3,194	3,406	3,261
City of Slaton	760	720	687	647	611	575
Tahoka Public Water System	325	325	325	325	325	325
Total Demand	**97,422**	**108,899**	**114,405**	**116,465**	**117,621**	**118,345**

2.6.4 City of Borger

The City of Borger provides wholesale water to industrial customers in Hutchinson County and retail services to its city customers. Currently, the industrial demands on Borger total about 12,000 acre-feet per year, which accounts for about 67 percent of the manufacturing demand in Hutchinson County. TCW also provides wholesale water to industrial customers in Hutchinson County and retail services to its customers. TCW is considered a potential future customer of Borger by 2040.

Table 2-6: Projected Water Demands for the City of Borger

Customers	Demands (ac-ft/yr)					
	2030	2040	2050	2060	2070	2080
Borger	3,535	3,480	3,394	3,295	3,201	3,116
Hutchinson County Manufacturing	12,160	12,610	13,077	13,561	14,062	14,583
Potential Future Customers						
TCW	-	848	768	697	639	593
Hutchinson County Manufacturing	-	180	180	180	180	180
Total Existing Demand	**15,695**	**16,090**	**16,471**	**16,856**	**17,263**	**17,699**
Total Potential Demand	**15,695**	**17,118**	**17,419**	**17,733**	**18,082**	**18,472**

ATTACHMENT 2-1

POPULATION AND WATER DEMAND PROJECTIONS

DRAFT Region A Water User Group (WUG) Population

	WUG Population					
	2030	2040	2050	2060	2070	2080
Armstrong County Total	**1,819**	**1,789**	**1,773**	**1,760**	**1,747**	**1,734**
Armstrong County / Red Basin Total	**1,819**	**1,789**	**1,773**	**1,760**	**1,747**	**1,734**
Claude Municipal Water System	1,097	1,080	1,071	1,065	1,057	1,051
County-Other	722	709	702	695	690	683
Carson County Total	**5,555**	**5,311**	**5,037**	**4,718**	**4,400**	**4,083**
Carson County / Canadian Basin Total	**1,406**	**1,301**	**1,173**	**1,033**	**885**	**733**
Fritch	369	372	377	380	385	395
White Deer	323	294	258	220	179	136
County-Other	714	635	538	433	321	202
Carson County / Red Basin Total	**4,149**	**4,010**	**3,864**	**3,685**	**3,515**	**3,350**
Groom Municipal Water System	518	519	525	527	533	543
Panhandle Municipal Water System	2,233	2,238	2,265	2,276	2,302	2,347
White Deer	478	435	382	325	266	201
County-Other	920	818	692	557	414	259
Childress County Total	**6,721**	**6,736**	**6,638**	**6,563**	**6,488**	**6,413**
Childress County / Red Basin Total	**6,721**	**6,736**	**6,638**	**6,563**	**6,488**	**6,413**
Childress	5,031	5,206	5,133	4,991	4,844	4,697
Red River Authority of Texas*	1,585	1,491	1,466	1,501	1,537	1,574
County-Other	105	39	39	71	107	142
Collingsworth County Total	**2,498**	**2,426**	**2,290**	**2,182**	**2,074**	**1,966**
Collingsworth County / Red Basin Total	**2,498**	**2,426**	**2,290**	**2,182**	**2,074**	**1,966**
Red River Authority of Texas*	374	365	344	329	313	298
Wellington Municipal Water System	1,616	1,572	1,485	1,416	1,346	1,276
County-Other	508	489	461	437	415	392
Dallam County Total	**7,353**	**7,734**	**8,086**	**8,289**	**8,491**	**8,693**
Dallam County / Canadian Basin Total	**7,353**	**7,734**	**8,086**	**8,289**	**8,491**	**8,693**
Dalhart	5,670	6,027	6,379	6,752	7,143	7,551
Texline	433	449	463	478	494	511
County-Other	1,250	1,258	1,244	1,059	854	631
Donley County Total	**3,070**	**2,893**	**2,683**	**2,560**	**2,437**	**2,314**
Donley County / Red Basin Total	**3,070**	**2,893**	**2,683**	**2,560**	**2,437**	**2,314**
Clarendon	1,695	1,603	1,495	1,429	1,362	1,296
Red River Authority of Texas*	340	318	293	279	266	251

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Population

	WUG Population					
	2030	2040	2050	2060	2070	2080
County-Other	1,035	972	895	852	809	767
Gray County Total	**21,243**	**20,982**	**20,339**	**19,553**	**18,769**	**17,986**
Gray County / Canadian Basin Total	**19,158**	**18,826**	**18,330**	**17,794**	**17,310**	**16,887**
Pampa Municipal Water System	17,214	16,777	16,451	16,217	16,102	16,131
County-Other	1,944	2,049	1,879	1,577	1,208	756
Gray County / Red Basin Total	**2,085**	**2,156**	**2,009**	**1,759**	**1,459**	**1,099**
McLean Municipal Water Supply	636	628	608	583	558	535
County-Other	1,449	1,528	1,401	1,176	901	564
Hall County Total	**2,622**	**2,478**	**2,290**	**2,131**	**1,972**	**1,813**
Hall County / Red Basin Total	**2,622**	**2,478**	**2,290**	**2,131**	**1,972**	**1,813**
Memphis	1,849	1,752	1,639	1,532	1,425	1,317
Red River Authority of Texas*	211	201	187	175	163	151
Turkey Municipal Water System	252	236	211	193	176	160
County-Other	310	289	253	231	208	185
Hansford County Total	**5,333**	**5,448**	**5,483**	**5,571**	**5,659**	**5,747**
Hansford County / Canadian Basin Total	**5,333**	**5,448**	**5,483**	**5,571**	**5,659**	**5,747**
Gruver	1,143	1,168	1,176	1,193	1,211	1,229
Spearman Municipal Water System	3,072	3,139	3,158	3,211	3,264	3,316
County-Other	1,118	1,141	1,149	1,167	1,184	1,202
Hartley County Total	**5,377**	**5,350**	**5,298**	**5,224**	**5,150**	**5,076**
Hartley County / Canadian Basin Total	**5,377**	**5,350**	**5,298**	**5,224**	**5,150**	**5,076**
Dalhart	3,187	3,264	3,365	3,500	3,651	3,821
Hartley WSC	439	429	421	417	414	413
County-Other	1,751	1,657	1,512	1,307	1,085	842
Hemphill County Total	**3,273**	**3,268**	**3,154**	**3,087**	**3,020**	**2,953**
Hemphill County / Canadian Basin Total	**2,963**	**2,957**	**2,853**	**2,790**	**2,727**	**2,665**
Canadian	2,347	2,339	2,255	2,200	2,147	2,094
County-Other	616	618	598	590	580	571
Hemphill County / Red Basin Total	**310**	**311**	**301**	**297**	**293**	**288**
County-Other	310	311	301	297	293	288

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Population

	WUG Population					
	2030	2040	2050	2060	2070	2080
Hutchinson County Total	**20,414**	**19,914**	**19,076**	**18,157**	**17,241**	**16,326**
Hutchinson County / Canadian Basin Total	**20,414**	**19,914**	**19,076**	**18,157**	**17,241**	**16,326**
Borger	12,269	12,106	11,807	11,462	11,138	10,841
Fritch	3,308	3,021	2,767	2,546	2,364	2,222
Stinnett	1,590	1,424	1,280	1,157	1,054	972
TCW Supply	1,317	1,187	1,074	975	894	829
County-Other	1,930	2,176	2,148	2,017	1,791	1,462
Lipscomb County Total	**2,903**	**2,763**	**2,584**	**2,435**	**2,286**	**2,137**
Lipscomb County / Canadian Basin Total	**2,903**	**2,763**	**2,584**	**2,435**	**2,286**	**2,137**
Booker	1,203	1,143	1,068	1,003	940	876
Darrouzett	296	279	259	243	226	208
Follett	320	284	250	225	208	200
Higgins Municipal Water System	302	284	263	244	225	206
County-Other	782	773	744	720	687	647
Moore County Total	**21,383**	**21,482**	**21,392**	**20,870**	**20,350**	**19,831**
Moore County / Canadian Basin Total	**21,383**	**21,482**	**21,392**	**20,870**	**20,350**	**19,831**
Cactus Municipal Water System	2,993	3,007	2,996	2,922	2,849	2,777
Dumas	14,752	14,830	14,776	14,427	14,083	13,742
Fritch	124	124	123	124	124	124
Sunray	1,510	1,516	1,511	1,473	1,439	1,402
County-Other	2,004	2,005	1,986	1,924	1,855	1,786
Ochiltree County Total	**10,458**	**10,999**	**11,341**	**11,664**	**11,986**	**12,307**
Ochiltree County / Canadian Basin Total	**10,458**	**10,999**	**11,341**	**11,664**	**11,986**	**12,307**
Booker	20	21	21	21	21	21
Perryton Municipal Water System	8,574	9,017	9,300	9,565	9,829	10,094
County-Other	1,864	1,961	2,020	2,078	2,136	2,192
Oldham County Total	**1,708**	**1,559**	**1,371**	**1,168**	**966**	**764**
Oldham County / Canadian Basin Total	**1,495**	**1,380**	**1,231**	**1,071**	**912**	**754**
Vega	806	801	776	756	738	721
County-Other	689	579	455	315	174	33
Oldham County / Red Basin Total	**213**	**179**	**140**	**97**	**54**	**10**
County-Other	213	179	140	97	54	10

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Population

	WUG Population					
	2030	2040	2050	2060	2070	2080
Potter County Total	**118,628**	**118,038**	**115,217**	**110,549**	**105,894**	**101,248**
Potter County / Canadian Basin Total	**72,168**	**71,817**	**70,114**	**67,292**	**64,480**	**61,677**
Amarillo	62,616	62,165	60,464	57,714	54,928	52,088
County-Other	9,552	9,652	9,650	9,578	9,552	9,589
Potter County / Red Basin Total	**46,460**	**46,221**	**45,103**	**43,257**	**41,414**	**39,571**
Amarillo	41,104	40,809	39,692	37,886	36,057	34,194
County-Other	5,356	5,412	5,411	5,371	5,357	5,377
Randall County Total	**159,318**	**179,106**	**197,748**	**215,738**	**233,780**	**251,857**
Randall County / Red Basin Total	**159,318**	**179,106**	**197,748**	**215,738**	**233,780**	**251,857**
Amarillo	108,316	121,927	134,753	147,145	159,571	172,021
Canyon	16,546	18,442	20,225	21,930	23,642	25,357
Happy*	43	38	33	29	25	21
Lake Tanglewood	570	462	374	300	240	192
Siesta Estates	341	384	426	464	504	543
County-Other	33,502	37,853	41,937	45,870	49,798	53,723
Roberts County Total	**778**	**748**	**725**	**720**	**715**	**710**
Roberts County / Canadian Basin Total	**756**	**727**	**705**	**700**	**695**	**690**
Miami	499	478	465	459	454	449
County-Other	257	249	240	241	241	241
Roberts County / Red Basin Total	**22**	**21**	**20**	**20**	**20**	**20**
County-Other	22	21	20	20	20	20
Sherman County Total	**2,677**	**2,623**	**2,537**	**2,436**	**2,335**	**2,234**
Sherman County / Canadian Basin Total	**2,677**	**2,623**	**2,537**	**2,436**	**2,335**	**2,234**
Stratford	1,743	1,708	1,653	1,587	1,520	1,455
Texhoma	224	220	212	205	195	187
County-Other	710	695	672	644	620	592
Wheeler County Total	**4,854**	**4,719**	**4,545**	**4,408**	**4,271**	**4,134**
Wheeler County / Red Basin Total	**4,854**	**4,719**	**4,545**	**4,408**	**4,271**	**4,134**
Shamrock Municipal Water System	1,633	1,592	1,544	1,512	1,481	1,454
Wheeler	1,432	1,392	1,342	1,301	1,260	1,220
County-Other	1,789	1,735	1,659	1,595	1,530	1,460
Region A Population Total	**407,985**	**426,366**	**439,607**	**449,783**	**460,031**	**470,326**

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DRAFT Region A Water User Group (WUG) Population

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Demand

	WUG Demand (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Armstrong County Total	**7,079**	**7,079**	**7,084**	**7,089**	**7,094**	**7,099**
Armstrong County / Red Basin Total	**7,079**	**7,079**	**7,084**	**7,089**	**7,094**	**7,099**
Claude Municipal Water System	322	316	314	312	310	308
County-Other	88	86	85	84	83	82
Livestock	345	353	361	369	377	385
Irrigation	6,324	6,324	6,324	6,324	6,324	6,324
Carson County Total	**100,953**	**100,970**	**100,991**	**101,006**	**101,026**	**101,048**
Carson County / Canadian Basin Total	**25,869**	**25,856**	**25,839**	**25,823**	**25,805**	**25,785**
Fritch	99	99	100	101	103	105
White Deer	87	79	69	59	48	36
County-Other	90	80	68	55	41	25
Manufacturing	37	38	39	41	42	44
Livestock	187	191	194	198	202	206
Irrigation	25,369	25,369	25,369	25,369	25,369	25,369
Carson County / Red Basin Total	**75,084**	**75,114**	**75,152**	**75,183**	**75,221**	**75,263**
Groom Municipal Water System	159	159	161	161	163	166
Panhandle Municipal Water System	503	503	509	511	517	527
White Deer	128	116	102	87	71	54
County-Other	117	103	87	70	52	33
Manufacturing	1,460	1,514	1,570	1,628	1,689	1,751
Mining	3	3	3	3	3	3
Livestock	150	152	156	159	162	165
Irrigation	72,564	72,564	72,564	72,564	72,564	72,564
Childress County Total	**16,976**	**16,987**	**16,970**	**16,958**	**16,944**	**16,931**
Childress County / Red Basin Total	**16,976**	**16,987**	**16,970**	**16,958**	**16,944**	**16,931**
Childress	1,274	1,315	1,296	1,261	1,224	1,186
Red River Authority of Texas*	382	358	352	361	369	378
County-Other	21	8	8	14	21	28
Livestock	328	335	343	351	359	368
Irrigation	14,971	14,971	14,971	14,971	14,971	14,971
Collingsworth County Total	**50,608**	**50,603**	**49,058**	**43,833**	**44,291**	**51,692**
Collingsworth County / Red Basin Total	**50,608**	**50,603**	**49,058**	**43,833**	**44,291**	**51,692**
Red River Authority of Texas*	90	88	83	79	75	72
Wellington Municipal Water System	358	348	328	313	298	282

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DRAFT Region A Water User Group (WUG) Demand

	WUG Demand (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
County-Other	104	100	94	89	85	80
Livestock	462	473	484	496	508	520
Irrigation	49,594	49,594	48,069	42,856	43,325	50,738
Dallam County Total	**349,186**	**349,596**	**311,927**	**279,642**	**255,665**	**237,693**
Dallam County / Canadian Basin Total	**349,186**	**349,596**	**311,927**	**279,642**	**255,665**	**237,693**
Dalhart	1,692	1,795	1,899	2,011	2,127	2,248
Texline	166	171	177	182	188	195
County-Other	144	144	142	121	98	72
Manufacturing	1,333	1,382	1,433	1,486	1,541	1,598
Livestock	5,222	5,475	5,543	5,613	5,684	5,757
Irrigation	340,629	340,629	302,733	270,229	246,027	227,823
Donley County Total	**34,028**	**34,006**	**33,983**	**33,975**	**33,967**	**33,958**
Donley County / Red Basin Total	**34,028**	**34,006**	**33,983**	**33,975**	**33,967**	**33,958**
Clarendon	298	281	262	251	239	227
Red River Authority of Texas*	82	76	70	67	64	60
County-Other	144	134	124	118	112	106
Livestock	1,064	1,075	1,087	1,099	1,112	1,125
Irrigation	32,440	32,440	32,440	32,440	32,440	32,440
Gray County Total	**42,991**	**42,991**	**42,898**	**42,786**	**42,677**	**42,572**
Gray County / Canadian Basin Total	**13,931**	**13,882**	**13,808**	**13,731**	**13,667**	**13,615**
Pampa Municipal Water System	3,207	3,114	3,054	3,010	2,989	2,994
County-Other	318	334	306	257	197	123
Manufacturing	344	357	369	383	397	412
Livestock	454	469	471	473	476	478
Irrigation	9,608	9,608	9,608	9,608	9,608	9,608
Gray County / Red Basin Total	**29,060**	**29,109**	**29,090**	**29,055**	**29,010**	**28,957**
McLean Municipal Water Supply	170	168	162	156	149	143
County-Other	238	249	228	191	147	92
Manufacturing	3	3	4	4	4	4
Livestock	1,305	1,345	1,352	1,360	1,366	1,374
Irrigation	27,344	27,344	27,344	27,344	27,344	27,344

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DRAFT Region A Water User Group (WUG) Demand

	WUG Demand (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Hall County Total	**34,194**	**34,173**	**37,581**	**40,660**	**39,370**	**34,603**
Hall County / Red Basin Total	**34,194**	**34,173**	**37,581**	**40,660**	**39,370**	**34,603**
Memphis	296	280	261	244	227	210
Red River Authority of Texas*	51	48	45	42	39	36
Turkey Municipal Water System	89	84	75	68	62	57
County-Other	91	85	74	68	61	54
Manufacturing	1	1	1	1	1	1
Livestock	341	350	358	367	376	385
Irrigation	33,325	33,325	36,767	39,870	38,604	33,860
Hansford County Total	**182,211**	**182,350**	**182,475**	**182,618**	**182,761**	**182,910**
Hansford County / Canadian Basin Total	**182,211**	**182,350**	**182,475**	**182,618**	**182,761**	**182,910**
Gruver	381	388	391	397	402	408
Spearman Municipal Water System	858	875	880	895	909	924
County-Other	129	131	132	134	136	138
Manufacturing	359	372	386	400	415	430
Mining	93	93	93	93	93	93
Livestock	4,705	4,805	4,907	5,013	5,120	5,231
Irrigation	175,686	175,686	175,686	175,686	175,686	175,686
Hartley County Total	**412,425**	**413,312**	**367,432**	**334,325**	**306,358**	**283,477**
Hartley County / Canadian Basin Total	**412,425**	**413,312**	**367,432**	**334,325**	**306,358**	**283,477**
Dalhart	951	972	1,002	1,042	1,087	1,138
Hartley WSC	168	163	160	159	158	157
County-Other	323	304	277	240	199	154
Mining	85	85	85	85	85	85
Livestock	11,784	12,674	12,782	12,892	13,005	13,120
Irrigation	399,114	399,114	353,126	319,907	291,824	268,823
Hemphill County Total	**9,245**	**9,255**	**9,244**	**9,244**	**9,245**	**9,245**
Hemphill County / Canadian Basin Total	**6,387**	**6,392**	**6,376**	**6,370**	**6,365**	**6,360**
Canadian	601	597	575	561	548	534
County-Other	78	78	75	74	73	72
Mining	1,011	1,011	1,011	1,011	1,011	1,011
Livestock	642	651	660	669	678	688
Irrigation	4,055	4,055	4,055	4,055	4,055	4,055

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DRAFT Region A Water User Group (WUG) Demand

	WUG Demand (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Hemphill County / Red Basin Total	**2,858**	**2,863**	**2,868**	**2,874**	**2,880**	**2,885**
County-Other	40	39	38	38	37	36
Manufacturing	1	1	1	1	1	1
Mining	544	544	544	544	544	544
Livestock	451	457	463	469	476	482
Irrigation	1,822	1,822	1,822	1,822	1,822	1,822
Hutchinson County Total	**86,600**	**87,041**	**87,481**	**87,947**	**88,463**	**89,033**
Hutchinson County / Canadian Basin Total	**86,600**	**87,041**	**87,481**	**87,947**	**88,463**	**89,033**
Borger	3,535	3,480	3,394	3,295	3,201	3,116
Fritch	883	805	737	678	630	592
Stinnett	357	319	286	259	236	217
TCW Supply	942	848	768	697	639	593
County-Other	197	219	216	203	180	147
Manufacturing	18,231	18,906	19,606	20,331	21,083	21,863
Mining	67	67	67	67	67	67
Livestock	522	531	541	551	561	572
Irrigation	61,866	61,866	61,866	61,866	61,866	61,866
Lipscomb County Total	**46,720**	**46,722**	**46,712**	**46,713**	**46,715**	**46,718**
Lipscomb County / Canadian Basin Total	**46,720**	**46,722**	**46,712**	**46,713**	**46,715**	**46,718**
Booker	337	320	299	281	263	245
Darrouzett	84	79	74	69	64	59
Follett	95	84	74	67	62	59
Higgins Municipal Water System	87	82	75	70	65	59
County-Other	183	180	173	168	160	151
Manufacturing	708	734	761	789	818	848
Mining	1,018	1,018	1,018	1,018	1,018	1,018
Livestock	859	876	889	902	916	930
Irrigation	43,349	43,349	43,349	43,349	43,349	43,349
Moore County Total	**220,858**	**222,530**	**208,873**	**190,389**	**169,304**	**151,822**
Moore County / Canadian Basin Total	**220,858**	**222,530**	**208,873**	**190,389**	**169,304**	**151,822**
Cactus Municipal Water System	857	859	855	834	813	793
Dumas	3,032	3,038	3,027	2,956	2,885	2,815
Fritch	33	33	33	33	33	33
Sunray	337	338	337	328	321	312
County-Other	261	257	255	247	238	229

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DRAFT Region A Water User Group (WUG) Demand

	WUG Demand (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Manufacturing	11,139	11,551	11,978	12,421	12,881	13,358
Mining	33	33	33	33	33	33
Livestock	13,844	15,099	15,158	15,219	15,281	15,345
Irrigation	191,322	191,322	177,197	158,318	136,819	118,904
Ochiltree County Total	**93,086**	**93,262**	**93,384**	**93,501**	**93,620**	**93,738**
Ochiltree County / Canadian Basin Total	**93,086**	**93,262**	**93,384**	**93,501**	**93,620**	**93,738**
Booker	6	6	6	6	6	6
Perryton Municipal Water System	2,452	2,572	2,653	2,728	2,804	2,879
County-Other	279	291	300	308	317	325
Manufacturing	34	35	36	37	38	39
Mining	797	797	797	797	797	797
Livestock	2,835	2,878	2,909	2,942	2,975	3,009
Irrigation	86,683	86,683	86,683	86,683	86,683	86,683
Oldham County Total	**7,266**	**7,236**	**7,195**	**7,151**	**7,106**	**7,063**
Oldham County / Canadian Basin Total	**2,876**	**2,851**	**2,817**	**2,782**	**2,745**	**2,710**
Vega	224	222	215	210	205	200
County-Other	201	169	132	92	50	10
Mining	312	312	312	312	312	312
Livestock	929	938	948	958	968	978
Irrigation	1,210	1,210	1,210	1,210	1,210	1,210
Oldham County / Red Basin Total	**4,390**	**4,385**	**4,378**	**4,369**	**4,361**	**4,353**
County-Other	62	52	41	28	16	3
Mining	104	104	104	104	104	104
Livestock	394	399	403	407	411	416
Irrigation	3,830	3,830	3,830	3,830	3,830	3,830
Potter County Total	**56,849**	**57,116**	**57,000**	**56,504**	**56,026**	**55,566**
Potter County / Canadian Basin Total	**33,693**	**33,621**	**33,312**	**32,760**	**32,214**	**31,666**
Amarillo	13,829	13,686	13,312	12,706	12,093	11,467
County-Other	1,661	1,670	1,670	1,657	1,653	1,659
Manufacturing	679	704	730	757	785	814
Mining	478	508	539	572	607	643
Steam Electric Power	15,000	15,000	15,000	15,000	15,000	15,000
Livestock	344	351	359	366	374	381

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DRAFT Region A Water User Group (WUG) Demand

	WUG Demand (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Irrigation	1,702	1,702	1,702	1,702	1,702	1,702
Potter County / Red Basin Total	**23,156**	**23,495**	**23,688**	**23,744**	**23,812**	**23,900**
Amarillo	9,078	8,984	8,738	8,341	7,938	7,528
County-Other	931	937	936	930	927	931
Manufacturing	10,930	11,335	11,754	12,189	12,640	13,108
Mining	285	304	322	342	362	384
Livestock	162	165	168	172	175	179
Irrigation	1,770	1,770	1,770	1,770	1,770	1,770
Randall County Total	**54,764**	**58,783**	**62,676**	**66,440**	**70,224**	**74,018**
Randall County / Red Basin Total	**54,764**	**58,783**	**62,676**	**66,440**	**70,224**	**74,018**
Amarillo	23,923	26,843	29,666	32,394	35,130	37,871
Canyon	3,988	4,434	4,862	5,272	5,684	6,096
Happy*	6	6	5	4	4	3
Lake Tanglewood	254	205	166	133	107	85
Siesta Estates	119	134	149	162	176	190
County-Other	5,018	5,645	6,254	6,841	7,427	8,012
Manufacturing	1,236	1,282	1,329	1,378	1,429	1,482
Livestock	2,778	2,792	2,803	2,814	2,825	2,837
Irrigation	17,442	17,442	17,442	17,442	17,442	17,442
Roberts County Total	**10,845**	**10,846**	**10,851**	**10,858**	**10,867**	**10,876**
Roberts County / Canadian Basin Total	**10,348**	**10,348**	**10,354**	**10,361**	**10,369**	**10,378**
Miami	180	172	168	165	164	162
County-Other	30	29	29	29	29	29
Mining	684	684	684	684	684	684
Livestock	368	377	387	397	406	417
Irrigation	9,086	9,086	9,086	9,086	9,086	9,086
Roberts County / Red Basin Total	**497**	**498**	**497**	**497**	**498**	**498**
County-Other	3	3	2	2	2	2
Livestock	16	17	17	17	18	18
Irrigation	478	478	478	478	478	478
Sherman County Total	**314,269**	**314,373**	**275,903**	**245,701**	**211,293**	**188,194**
Sherman County / Canadian Basin Total	**314,269**	**314,373**	**275,903**	**245,701**	**211,293**	**188,194**
Stratford	567	555	537	515	493	472

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DRAFT Region A Water User Group (WUG) Demand

	WUG Demand (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Texhoma	85	83	80	77	74	71
County-Other	116	113	109	105	101	96
Manufacturing	2	2	2	2	2	2
Mining	7	7	7	7	7	7
Livestock	3,970	4,091	4,159	4,228	4,300	4,373
Irrigation	309,522	309,522	271,009	240,767	206,316	183,173
Wheeler County Total	**23,346**	**23,356**	**23,342**	**23,333**	**23,324**	**23,316**
Wheeler County / Red Basin Total	**23,346**	**23,356**	**23,342**	**23,333**	**23,324**	**23,316**
Shamrock Municipal Water System	282	274	266	260	255	250
Wheeler	435	422	407	395	382	370
County-Other	255	245	235	226	216	206
Mining	4,156	4,156	4,157	4,157	4,158	4,158
Livestock	1,305	1,346	1,364	1,382	1,400	1,419
Irrigation	16,913	16,913	16,913	16,913	16,913	16,913
Region A Demand Total	**2,154,499**	**2,162,587**	**2,033,060**	**1,920,673**	**1,816,340**	**1,741,572**

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ATTACHMENT 2-2

WATER DEMANDS BY DECADE AND CATEGORY OF USE FOR MAJOR WATER PROVIDERS

Major Water Provider Demands by Category of Use in Each Decade

Major Water Provider	Category of Use	Demands (Ac-Ft/Yr)					
		2030	2040	2050	2060	2070	2080
Amarillo	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	11,240	11,716	12,208	12,719	13,249	13,799
	Mining	0	0	0	0	0	0
	Municipal	49,537	52,220	54,423	56,148	57,868	59,573
	Steam Electric Power	15,000	15,000	15,000	15,000	15,000	15,000
	Total	**75,777**	**78,936**	**81,631**	**83,867**	**86,117**	**88,372**
Borger[1]	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	12,160	12,610	13,077	13,561	14,062	14,583
	Mining	0	0	0	0	0	0
	Municipal	3,535	3,480	3,394	3,295	3,201	3,116
	Steam Electric Power	0	0	0	0	0	0
	Total	**15,695**	**16,090**	**16,471**	**16,856**	**17,263**	**17,699**
CRMWA	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	97,421	108,898	114,404	116,465	117,621	118,345
	Steam Electric Power	0	0	0	0	0	0
	Total	**97,421**	**108,898**	**114,404**	**116,465**	**117,621**	**118,345**
Greenbelt MIWA	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	50	50	50	50	50	50
	Mining	0	0	0	0	0	0
	Municipal	3,006	2,999	2,949	2,904	2,854	2,805
	Steam Electric Power	0	0	0	0	0	0
	Total	**3,056**	**3,049**	**2,999**	**2,954**	**2,904**	**2,855**

[1]Does not include potential future customer demands, as TCW Supply and their customer demands are met by TCW's existing supplies.

3 EVALUATION OF REGIONAL WATER SUPPLIES

This chapter presents an evaluation of water supplies available to the Panhandle region for use during a repeat of the drought of record. This evaluation consists of two major components: 1) evaluation of available water from sources located within the region, and 2) evaluation of the amount of water that is currently available to water user groups within the region. **Section 3.1** focuses on the first component: availability by source. **Section 3.2** discusses the availability of supplies to water user groups and major water providers.

3.1 Water Supplies by Source

3.1.1 Groundwater Regulation in Texas and the PWPA

The history of groundwater regulations in Texas is discussed in **Chapter 1**, **Section 1.5.1** and emphasizes the role of Groundwater Conservation Districts (GCDs) as the preferred method of groundwater management in the state. This section discusses how groundwater regulation affects water supply planning. Specifically, one of the significant changes to the management of groundwater resources in Texas was the passage of House Bill 1763 (HB 1763) in 2005. This law is the foundation for the joint planning between GCDs, Groundwater Management Areas (GMAs) and RWPGs for the purpose of water supply planning (**Figure 3-1**). Key to the joint planning effort is the development of Desired Future Conditions (DFCs) for groundwater resources and the resulting Modeled Available Groundwater (MAG) volumes.

Desired Future Conditions are defined by statute to be "the desired, quantified condition of groundwater resources (such as water levels, spring flows, or volumes) within a management area at one or more specified future times as defined by participating groundwater conservation districts within a groundwater management area as part of the joint groundwater planning process." DFCs are quantifiable management goals for the future that describe the condition of the aquifer that appropriately balances the use of the aquifer to meet water demands with conservation. The most

Definitions

Desired Future Conditions (DFC): Quantifiable management goals that reflect what the GCDs want to protect in their area, typically measured as groundwater levels, water quality, and/or spring flow.

Modeled Available Groundwater (MAG): Groundwater determined to be available during the planning period, based on the DFC. Used as a cap on groundwater production that is applied in regional planning on a county basis.

Groundwater Availability Model (GAM): Computer model used to translate an area's goals for its groundwater into an amount of groundwater that is available during the planning period.

Reservoir Firm Yield: The amount of water that could be relied on during the drought of record, which is the period from the last time the reservoir spills before reaching its minimum content to the next time the reservoir spills.

Reservoir Safe Yield: The amount of water that can be diverted annually, leaving a minimum of a one year supply in reserve during the critical period.

common DFCs are based on the volume of groundwater in storage over time, water levels (limiting decline within the aquifer), water quality (limiting deterioration of quality) or spring flow (defining a minimum flow to sustain).

After the DFCs are determined by the GMAs, the TWDB performs quantitative analyses to determine the amount of groundwater available for production consistent with the DFC. For aquifers where a Groundwater Availability Model (GAM) exists, the GAM is typically used to develop the MAG. The MAG estimated through this process is then used by RWPGs as the available groundwater for the planning period. For all the major and minor aquifers in the PWPA with DFCs, GAMs were used to develop MAG values. For aquifers or local groundwater that are not listed as a minor or major aquifer, the water availability is based on historical use and available hydrogeological records.

TWDB technical guidelines for the current round of planning establishes that the MAG (within each county and basin) is the maximum amount of groundwater that can be used for existing uses and new strategies in Regional Water Plans. In other words, the MAG volumes are a cap on groundwater production for regional water planning purposes.

3.1.2 Groundwater Supplies

Two major aquifers, the Ogallala and Seymour, and three minor aquifers, the Blaine, Dockum, and Rita Blanca supply the majority of water uses in the PWPA. The Ogallala aquifer supplies the predominant share of groundwater, with additional supplies obtained from the remaining aquifers.

The region contains two GMAs. GMA 1 covers all the PWPA counties, except for Childress, Collingsworth and Hall Counties. These counties are located within GMA 6. In August 2021, the GMA 1 adopted desired future conditions (DFCs) for the combined Ogallala/ Rita Blanca aquifer system. In GMA 1 only, the planning cycle for the model runs is from 2018 to 2080, and these are the years for DFC comparison. The adopted DFCs for the Ogallala/Rita Blanca state that the aquifers shall have 40 percent of the aquifer storage remaining for each 50-year period between 2018 and 2080 for the four western counties (Dallam, Hartley, Sherman and Moore), 80 percent of the storage remaining in Hemphill County, and 50 percent of the storage remaining in the other counties in the GMA, except for Randall, and those portions of Armstrong and Potter Counties located within the High Plains UWCD. In these areas, the DFC is approximately 20 feet of total average drawdown for each 50-year period between 2012 and 2080.

For the Dockum Aquifer, the DFC states that average water level decline shall be no more than 30 feet for each 50-year period between 2018 and 2080 in Carson and Oldham Counties, and in the portions of Armstrong and Potter Counties within the Panhandle GCD. In Dallam, Hartley, Moore and Sherman Counties, at least 40 percent of the available drawdown should remain for each 50-year period between 2018 and 2080. Total average drawdown of approximately 40 feet shall remain for each 50-year period between 2012 and 2080 in Randall County, and in the portions of Armstrong and Potter counites within the High Plains UWCD. The Blaine aquifer in Wheeler County was designated to be non-relevant for planning purposes.

GMA 6 contains three counties that are entirely within the PWPA: Childress, Collingsworth and Hall. GMA 6 adopted DFCs for the portions of the Blaine and Seymour aquifers that fall within these counties. The Seymour and Blaine aquifers are the only major and minor aquifers that the GMA 6 DFCs address in PWPA as the Ogallala does not underlie these three counties, except for a very small area in western Collingsworth County.

GMA 6 has divided the Seymour into separate sections (Pods) for DFC designation purposes. The Pod numbers for the Seymour aquifer appear on the inset map located in the section below about the Seymour aquifer. The DFC for the portions of Seymour Pods 1, 2 and 3 that are within the Mesquite and Gateway GCDs in Childress, Collingsworth and Hall Counties (Mesquite GCD) require that no more than 33 feet of drawdown in Childress and Collingsworth Counties, and 15 feet in Hall County between 2010 and 2080. For the portion of Seymour Pod 4, located in the Gateway GCD in Childress County, the adopted DFC requires that total decline in water levels will not exceed one foot over the 2010 to 2080 period.

The Blaine aquifer DFC for the part of Childress County north of the Red River, located in the Mesquite GCD, all of Collingsworth and Hall Counties, also located within the Mesquite GCD, and that part of Childress County north of the Red River located in the Gateway GCD is that the total decline in water levels will be no more than 9 feet during the period from 2010 to 2080. For the part of Childress County south of the Red River, located in the Mesquite & Gateway GCDs, the total decline in water levels should be no more than 2 feet during the period from 2010 to 2080.

The current groundwater availability model for the Ogallala/Rita Blanca and Dockum aquifers in Texas is the High Plains Aquifer System (HPAS) GAM (INTERA, 2015). This GAM was used by GMA 1 for development of DFCs and was used by TWDB as the best available science for the aquifer for development of MAGs.

In GMA 6, the current MAG volumes of water available from the Seymour, Blaine and Dockum aquifers were determined as described in GAM Run 21-011 MAG (Harding, 2022). In GMA 6, available supplies of groundwater from the Dockum aquifer were determined using the HPAS GAM. These GAM runs and resulting MAGs are the basis of groundwater availability in the 2021 Regional Water Plan.

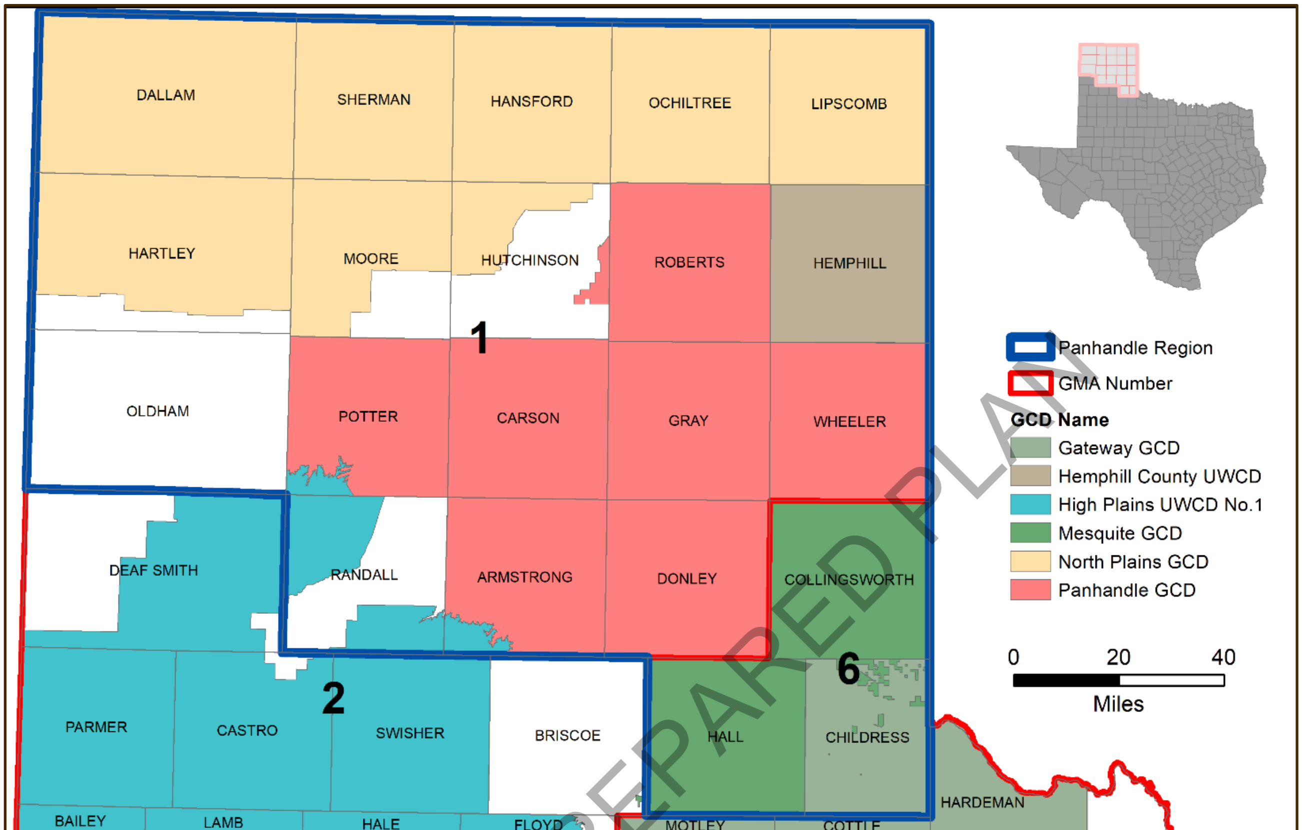


Figure 3-1: Groundwater Conservation Districts and Groundwater Management Areas

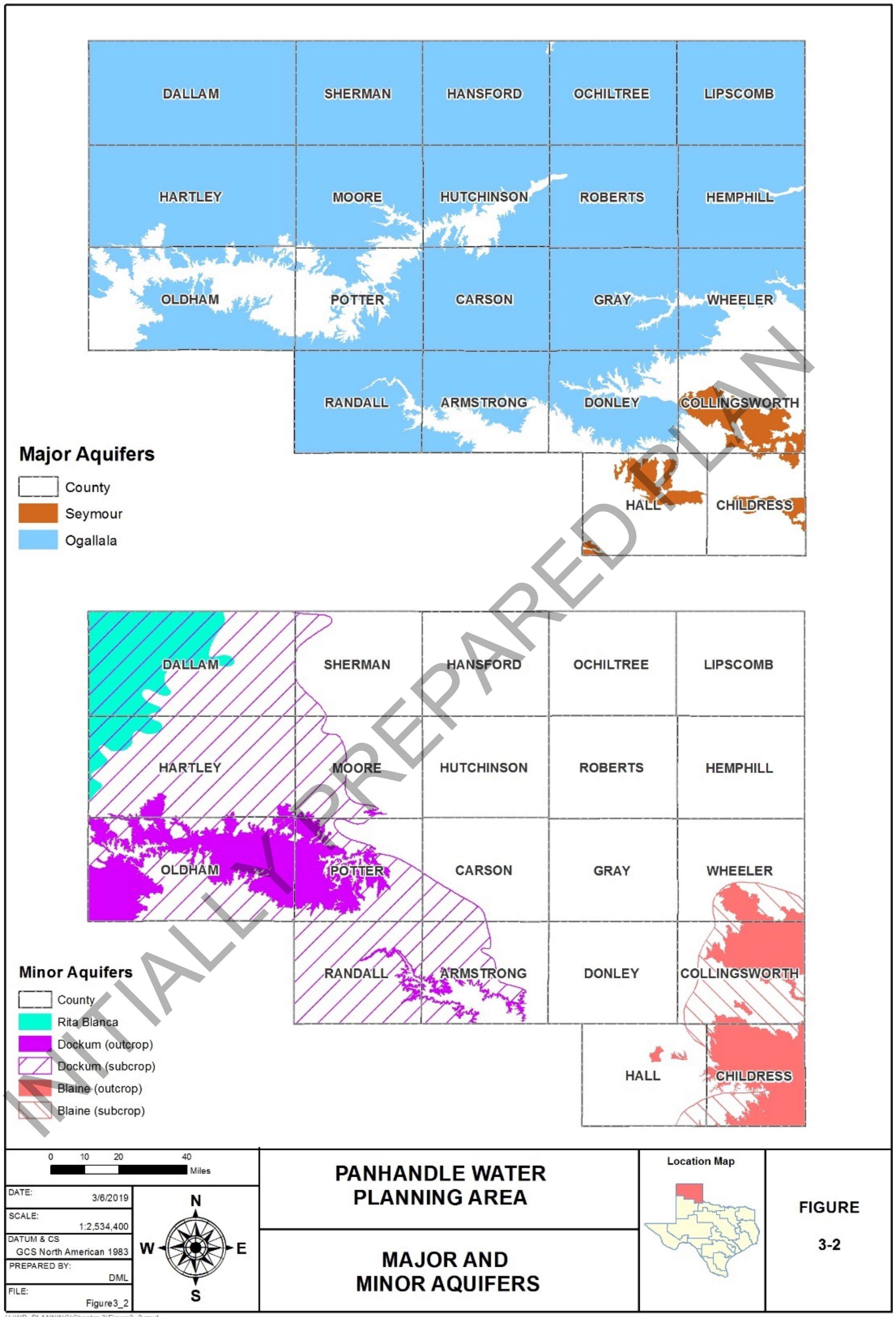
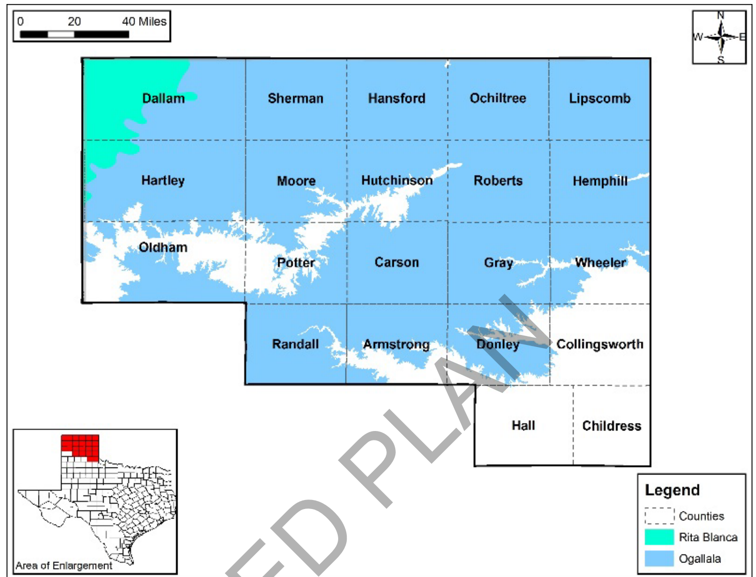


Figure 3-2: Major and Minor Aquifers

Ogallala/ Rita Blanca Aquifer

The Ogallala aquifer is present in all counties in the PWPA except for Childress, Collingsworth, and Hall Counties and is the region's largest source of water. (There is tiny sliver of Ogallala in western Collingsworth County, however, it has been declared to be non-relevant.)



The Ogallala aquifer in the study area consists of Tertiary-age alluvial fan, fluvial, lacustrine, and eolian deposits derived from erosion of the Rocky Mountains. The Ogallala unconformably overlies Permian, Triassic, and other Mesozoic formations and in turn may be covered by Quaternary fluvial, lacustrine, and eolian deposits (Dutton et. al. 2000a). Recharge to the Ogallala is limited.

The Rita Blanca is a minor aquifer that underlies the Ogallala Formation and extends into New Mexico, Oklahoma, and Colorado. The portion of the aquifer which underlies the PWPA is located in western Dallam and Hartley Counties. Groundwater in the Rita Blanca occurs in sand and gravel formations of Cretaceous and Jurassic Age. The Romeroville Sandstone of the Dakota Group yields small quantities of water, whereas the Cretaceous Mesa Rica and Lytle Sandstones yield small to large quantities of water. Small quantities of groundwater are also located in the Jurassic Exeter Sandstone and sandy sections of the Morrison Formation (Ashworth & Hopkins, 1995).

Recharge to the aquifer occurs by lateral flow from portions of the aquifer system in New Mexico and Colorado and by downward leakage from the Ogallala. Supplies from the Rita Blanca were modeled in the Ogallala GAM and these supplies are included in Ogallala availability numbers.

Table 3-1 presents the Ogallala and Rita Blanca MAG volumes (in acre-feet per year) by county, aquifer and river basin for planning years 2030 through 2080. MAG volumes are the largest amount of water that can be withdrawn from a given source without violating DFCs. **Table 3-1** includes county aquifer combinations where a DFC has been defined by a GCD/GMA and the MAG subsequently has been determined by the TWDB using the GAM. As shown in **Table 3-1**, the total Ogallala/Rita Blanca MAGs in the PWPA range from 3,148,015 acre-feet per year (ac-ft/yr) in 2030 to 1,991,106 acre-feet per year by 2080. **Figure 3-3** shows the Ogallala MAGs by county for planning decades 2030, 2050 and 2080.

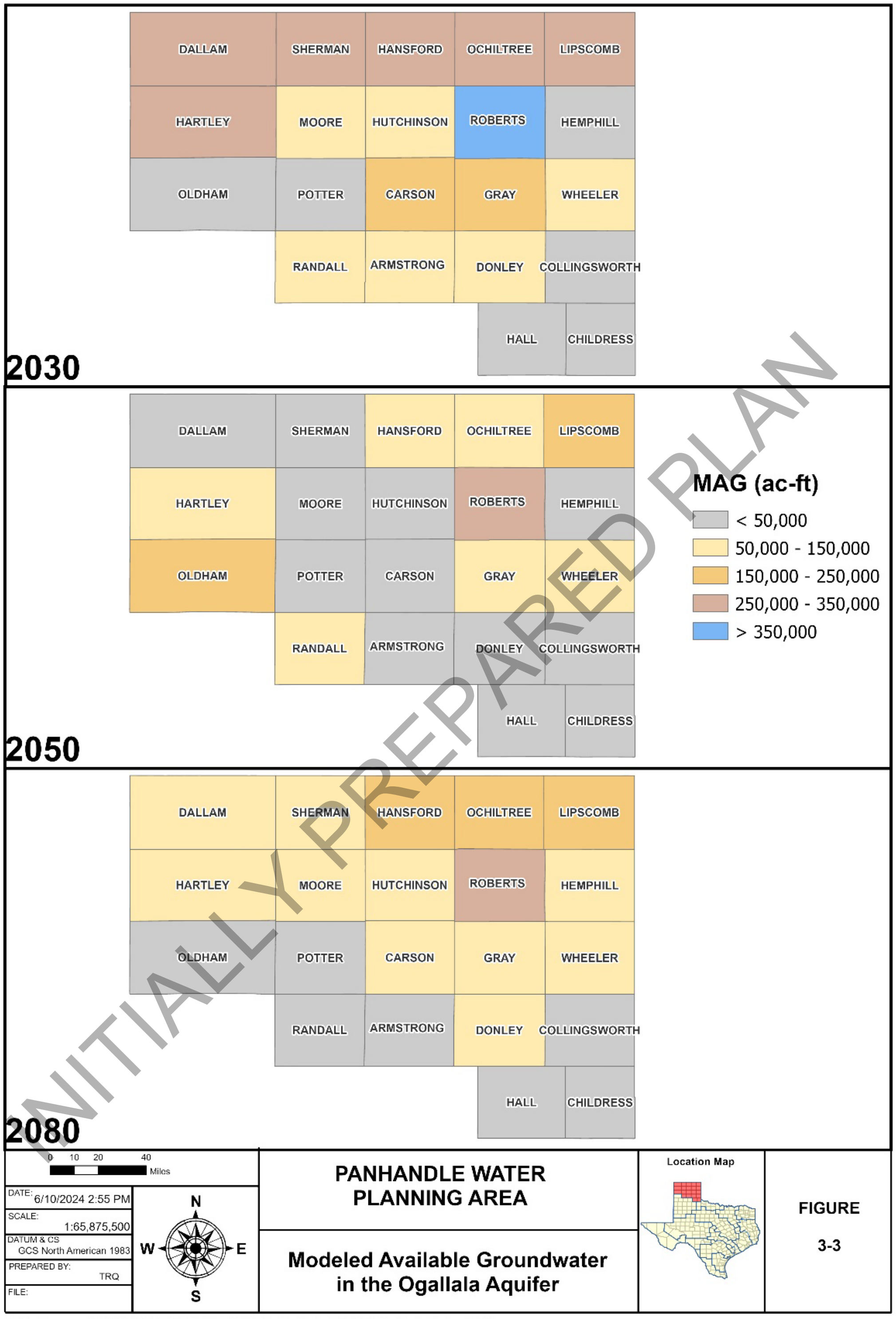


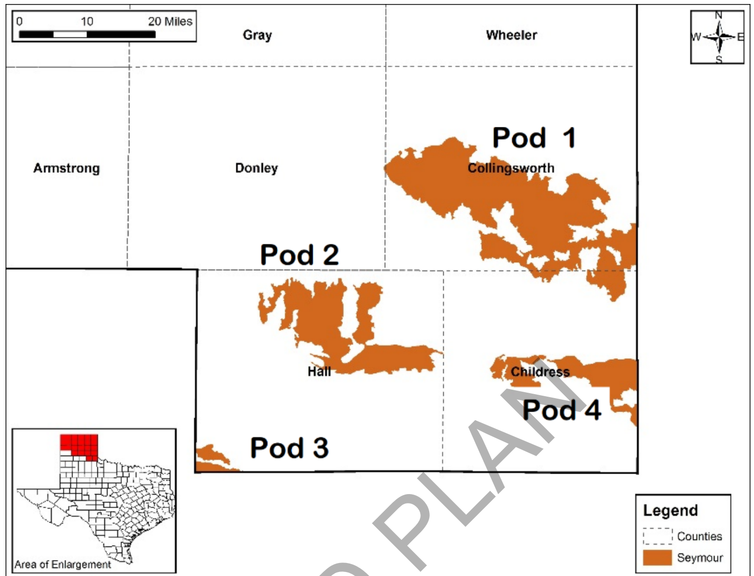
Figure 3-3: Modeled Available Groundwater in the Ogallala Aquifer (ac-ft)

Table 3-1: Modeled Available Groundwater in the Ogallala/Rita Blanca Aquifer (ac-ft/yr)

County	Basin	2030	2040	2050	2060	2070	2080
Armstrong	Red	56,439	48,764	42,118	36,270	31,653	27,923
Carson	Canadian	68,193	66,220	62,132	57,975	54,708	49,565
	Red	97,831	93,536	87,636	83,276	79,657	72,209
Dallam	Canadian	269,575	228,726	194,888	165,787	144,360	128,259
Donley	Red	78,267	77,157	72,601	67,032	60,915	53,337
Gray	Canadian	46,240	43,480	39,643	36,480	33,394	30,628
	Red	135,408	130,122	120,739	110,565	100,408	91,308
Hansford	Canadian	295,700	281,612	264,290	247,744	229,800	211,464
Hartley	Canadian	286,610	223,388	184,199	157,553	136,012	118,786
Hemphill	Canadian	24,975	29,168	32,388	34,729	36,110	37,074
	Red	20,841	23,040	23,233	23,310	23,147	23,103
Hutchinson	Canadian	123,745	118,005	110,304	103,014	96,847	90,893
Lipscomb	Canadian	270,819	263,478	249,968	235,561	218,975	201,984
Moore	Canadian	149,426	142,152	129,861	113,256	94,363	78,645
Ochiltree	Canadian	259,973	247,274	231,502	215,617	199,324	181,295
Oldham	Canadian	34,871	32,845	28,578	23,948	19,789	16,869
	Red	4,196	3,347	2,641	2,096	1,604	1,172
Potter	Canadian	14,672	13,137	11,036	9,214	7,648	6,337
	Red	10,111	8,815	7,490	6,027	4,417	3,286
Randall	Red	70,551	60,509	50,310	41,377	34,191	28,047
Roberts	Canadian	386,950	372,064	346,908	322,461	297,068	267,425
	Red	22,350	22,866	22,427	21,648	20,461	19,169
Sherman	Canadian	287,657	261,521	226,142	198,338	166,675	145,399
Wheeler	Red	132,615	132,787	128,472	121,852	114,269	106,929
Total		**3,148,015**	**2,924,013**	**2,669,506**	**2,435,130**	**2,205,795**	**1,991,106**

Source: GAM Run GR21-007_MAG Report developed by TWDB.

Seymour Aquifer



The Seymour is a major aquifer located in north central Texas and some Panhandle counties. For the PWPA, the Seymour is located entirely within the Red River Basin in Childress, Collingsworth and Hall Counties. Groundwater in the Seymour formation is found in unconsolidated sediments representing erosional remnants from the High Plains. The saturated thickness of the Seymour Formation is less than 100 feet throughout its extent and is typically less than 50 feet thick in the PWPA. Nearly all recharge to the aquifer is a result of direct infiltration of precipitation on the land surface. Surface streams are at a lower elevation than water levels in the Seymour aquifer and do not contribute to the recharge. Leakage from underlying aquifers also appears to be insignificant (Duffin, 1992).

Table 3-2 presents the Seymour aquifer MAG volumes (in acre-feet per year) by county, aquifer and river basin for planning years 2030 through 2080 (GAM Run 21-011_MAG). MAG volumes are the largest amount of water that can be withdrawn from a given source without violating DFCs. **Table 3-2** includes county aquifer combinations where a DFC has been defined by a GCD/GMA and the MAG subsequently has been determined by the TWDB using the GAM. As shown on **Table 3-2**, the total Seymour MAGs in the PWPA range from 51,488 acre-feet per year in 2030 to 53,052 acre-feet per year in 2080.

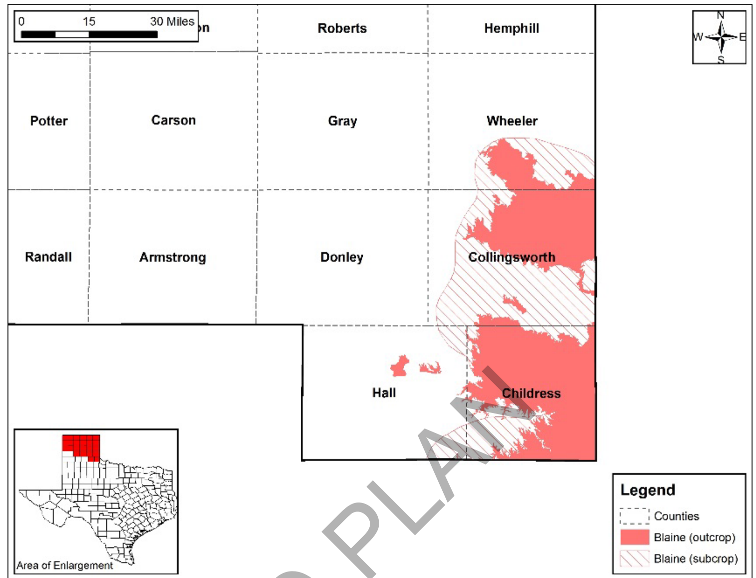
Table 3-2: Modeled Available Groundwater in the Seymour Aquifer (ac-ft/yr)

County	Basin	2030	2040	2050	2060	2070	2080
Childress	Red	3,245	3,307	3,307	3,307	3,296	3,296
Collingsworth	Red	31,492	28,579	27,165	22,334	22,769	29,639
Hall	Red	16,751	19,612	22,861	25,790	24,595	20,117
Total		**51,488**	**51,498**	**53,333**	**51,431**	**50,660**	**53,052**

Source: 2021 GAM Run 21-011_MAG Report developed by TWDB

Blaine Aquifer

The Blaine Formation is considered a minor aquifer and is composed of anhydrite and gypsum with interbedded dolomite and clay. Water occurs primarily under water-table conditions in numerous solution channels. Natural salinity in the aquifer from halite dissolution and upward migration of deeper, more saline waters limits the water quality of this aquifer. The aquifer is located in four counties in the PWPA, including, Childress, Collingsworth, a small portion of Hall, and Wheeler. It lies completely within the Red River basin.



Effective recharge to the Blaine is estimated to be 91,500 acre-feet per year throughout its extent in the PWPA (TWDB, 2005). Precipitation in the outcrop area is the primary source of recharge. Annual effective recharge is estimated to be five percent of the mean annual precipitation, with higher recharge rates occurring in areas with sandy soil surface layers. No significant long-term water level declines have yet been identified in the Blaine aquifer. Declines that have occurred are due to heavy irrigation use and are quickly recharged after seasonal rainfall (TWDB, 1997).

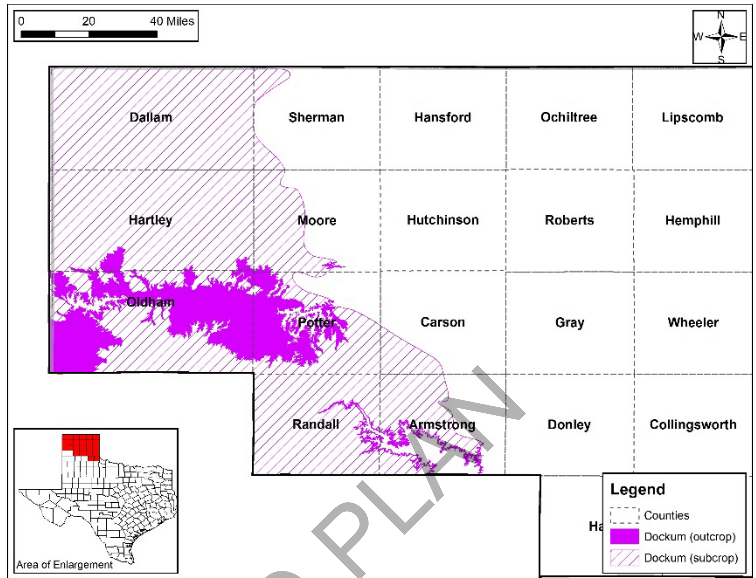
Table 3-3 presents the MAG volumes (in acre-feet per year) by county, aquifer and river basin for planning years 2030 through 2080. As shown on **Table 3-3**, the total Blaine MAGs in the PWPA are 31,404 acre-feet per year between 2030 and 2080. The Blaine aquifer in Wheeler County was designated to be non-relevant for planning purposes.

Table 3-3: Modeled Available Groundwater in the Blaine Aquifer (ac-ft/yr)

County	Basin	2020	2030	2040	2050	2060	2070
Childress	Red	23,510	23,510	23,510	23,510	23,510	23,510
Collingsworth	Red	2,054	2,054	2,054	2,054	2,054	2,054
Hall	Red	5,840	5,840	5,840	5,840	5,840	5,840
Total		**31,404**	**31,404**	**31,404**	**31,404**	**31,404**	**31,404**

Source: 2021 GAM Run GR21-011_MAG Report developed by TWDB

Dockum Aquifer



The Dockum is a minor aquifer that underlies the Ogallala aquifer and extends laterally into parts of West Texas and New Mexico. The primary water-bearing zone in the Dockum Group, commonly called the "Santa Rosa", consists of up to 700 feet of sand and conglomerate interbedded with layers of silt and shale. Domestic use of the Dockum occurs in Oldham, Potter, and Randall Counties. The effective recharge rate to the Dockum aquifer is estimated to be 23,500 acre-feet per year and is primarily limited to outcrop areas. Oldham and Potter Counties are the main sources of recharge in the PWPA. Differences in chemical makeup of Ogallala and Dockum groundwater indicate that very little leakage (<0.188 in/year) occurs into the Dockum from the overlying Ogallala formation (BEG, 1986).

Table 3-4 presents the Dockum MAG volumes (in acre-feet per year) by county, aquifer and river basin for planning years 2030 through 2080. As shown on **Table 3-4**, the total Dockum MAGs in the PWPA decrease from 326,541 acre-feet per year in 2030 to 241,087 acre-feet per year in 2080.

Table 3-4: Modeled Available Groundwater in the Dockum Aquifer (ac-ft/yr)

County	Basin	2030	2040	2050	2060	2070	2080
Armstrong	Red	7,937	8,343	8,822	9,070	9,125	9,135
Carson	Canadian	0	0	0	0	0	0
	Red	6	6	6	6	6	6
Dallam	Canadian	15,522	14,700	14,019	13,513	12,895	12,415
Hartley	Canadian	64,591	64,147	60,766	56,662	52,208	48,142
Moore	Canadian	5,959	6,003	5,680	5,425	5,119	4,838
Oldham	Canadian	153,694	145,814	135,269	124,727	114,427	105,188
	Red	93	111	124	134	142	153
Potter	Canadian	38,004	38,158	37,268	36,186	34,990	33,815
	Red	2,352	2,101	2,010	1,976	1,943	1,928
Randall	Red	37,967	41,760	39,930	36,248	28,759	25,176
Sherman	Canadian	416	310	288	293	288	291
Total		**326,541**	**321,453**	**304,182**	**284,240**	**259,902**	**241,087**

Source: 2021 GAM Run GR21-007_MAG Report developed by TWDB

Other Aquifer

Within the PWPA, small quantities of water within the named aquifers were designated as "non-relevant" by the GMAs. However, the PWPA does have some groundwater supplies provided by aquifers designated as "other." Within six counties in the PWPA (Armstrong, Childress, Collingsworth, Donley, Hall and Wheeler), the groundwater supply associated with "Other aquifer" is from either the Quartermaster Formation, which underlies the Dockum, or the Permian Whitehorse-Artesia aquifer, which underlies the Quartermaster Formation and overlies the Blaine aquifer.

To calculate groundwater availability for these sources, the estimate of recoverable volume for the Whitehorse and Quartermaster formations was calculated using average depth from TWDB driller's logs for each county/formation and GIS coverage areas from the Geological Atlas of Texas outcrops for each of the counties/areas. The average well depth from recent driller's logs (2003-2017) was subtracted from the average water level that was measured at time of drilling to get an estimated saturated thickness for each county. The surface area was then multiplied by the estimated saturated thickness and a specific yield of 0.25% to get the estimated recoverable volume of water in storage. This method is the same as used during the last round of regional planning.

Table 3-5 presents the groundwater availability volumes for Other aquifer derived using this methodology. (Note that all of these counties are located in the Red River basin.) **Table 3-5** also shows the water availability for non-relevant portions of the Ogallala aquifer in Collingsworth County and the Blaine aquifer in Wheeler County. Historical use was used to estimate the availability for Wheeler County. However, there is no reported historical use from the Ogallala aquifer in Collingsworth County. The small quantity of water reported in **Table 3-5** for the non-relevant portion of the Ogallala aquifer in Collingsworth is based on estimates of the extent and depth of the aquifer in this county.

Table 3-5: Available Groundwater in Other and Non-Relevant Aquifers (ac-ft/yr)

Aquifer Status	County	Aquifer	Supply
Other	Armstrong	Whitehorse/ Quartermaster	370
	Childress		233
	Collingsworth		309
	Donley		479
	Hall		1,086
	Wheeler		276
	Total Other		**2,753**
Non-Relevant	Collingsworth	Ogallala	50
	Wheeler	Blaine	1,750
	Total Non-Relevant		**1,800**

3.1.3 Water Supply Reservoirs

Major surface water supplies in the PWPA include Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir (**Figure 3-4**). A brief description of each of the three major reservoirs is presented below in **Table 3-6**.

Table 3-6: Descriptive Information of Water Supply Reservoirs in the PWPA

	Palo Duro Reservoir	Lake Meredith	Greenbelt Reservoir
Owner/Operator	PDRA	CRMWA	GMIWA
Stream	Palo Duro Creek	Canadian River	Salt Fork Red River
Dam	Palo Duro	Sanford	Greenbelt
Use	Municipal	Municipal and Industrial; Flood Control; Sediment Storage	Municipal, Industrial, and Mining
Impoundment	January 1991	January 1965	December 1966
Conservation Storage (most recent survey)	60,897 ac-ft (1974)	817,970 ac-ft[1] (1995) (includes sediment storage)	59,110 ac-ft (1965)
Permitted Diversion	10,460 ac-ft/yr	151,200 ac-ft/yr	16,030 ac-ft/yr[2]

[1] The Canadian River Compact allows 500,000 ac-ft of conservation storage. Any water stored in excess of 500,000 ac-ft is subject to release at the call of the State of Oklahoma.

[2] Of this amount, 11,750 ac-ft/yr can be diverted directly from the lake, 4.030 ac-ft/yr diverted from Lelia Lake Creek, and 250 ac-ft/yr diverted directly from Salt Fork of the Red River.

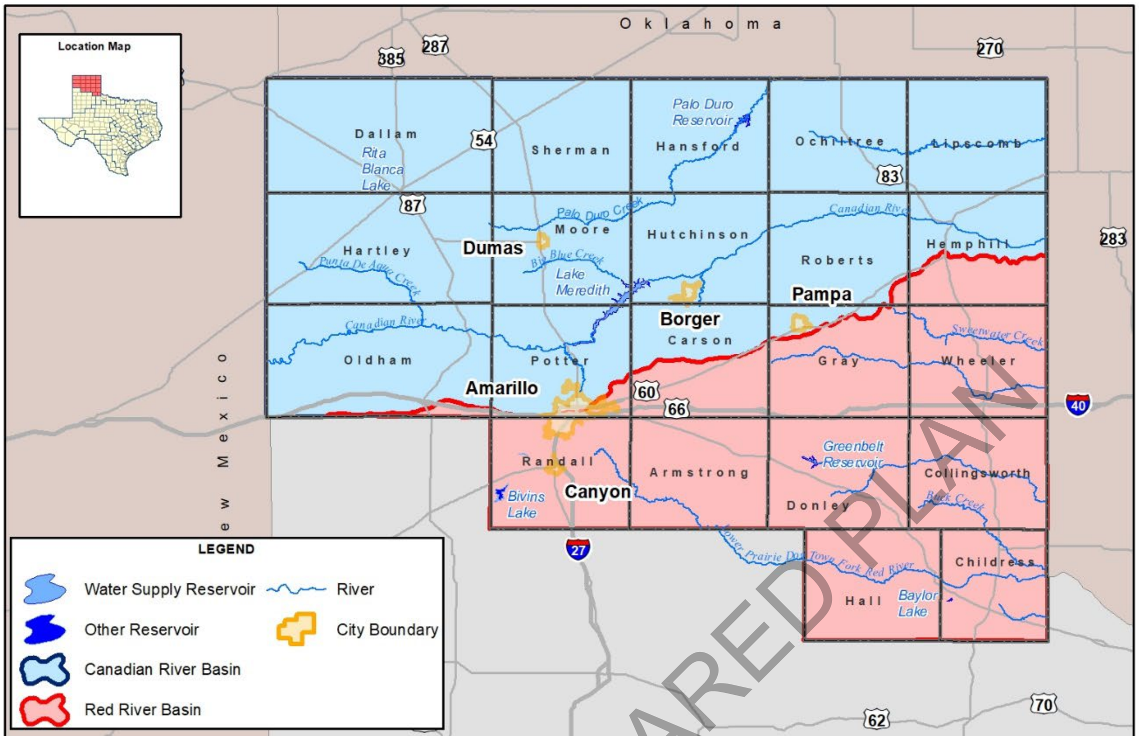


Figure 3-4: Surface Water Supplies in PWPA

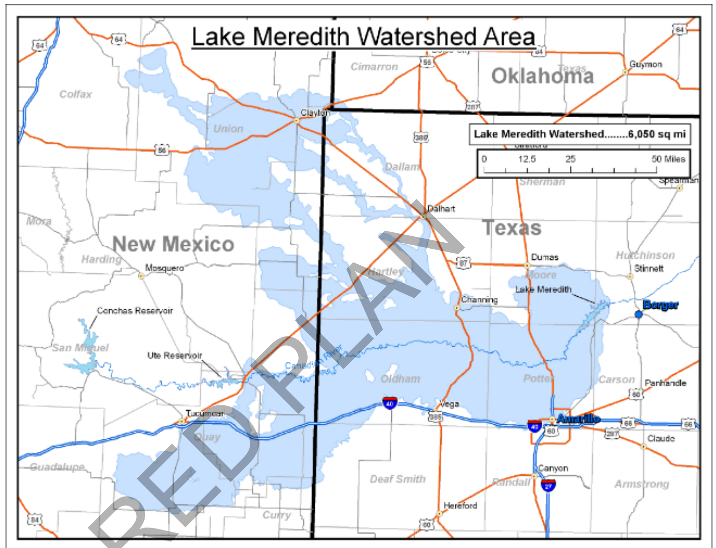
The available supply from a reservoir is often referred to as the reservoir yield. The firm yield for a reservoir is defined as the dependable water supply available during a critical drought. Ideally, the period of analysis for a yield study includes the entire critical drought period. This "critical period" of a reservoir is the time between the date of minimum content and the date of the last spill. If a reservoir has reached its minimum content but has not yet filled enough to spill, then it is considered to still be in its drought of record. A definition of the drought of record for each reservoir is essential to determine the yield or estimate of available water supply. (See **Chapter 7**, **Table 7-1** for critical period and drought of record of reservoirs in the PWPA.) The one-year safe yield is defined as the amount of water that can be diverted annually, leaving a minimum of a one-year supply in reserve during the critical period. Conservation storage is the storage volume that is available for diversions for water supply. It does not include storage capacity used for flood control and, in some cases, sediment accumulation.

The TWDB guidelines specify that the TCEQ-approved Water Availability Models (WAMs) are used to assess available supplies for regional water planning purposes. However, the Canadian River WAM (Lake Meredith and Palo Duro Reservoir) covers a period-of-record from 1948 to 1998 and do not include the recent drought, which is the new drought of record for much of the region. The reliable supply of surface water is reduced by a new drought of record. For this reason, a mass-balance reservoir model was used to estimate the yields of these reservoirs with hydrology covering a period from 1940 to 2017 for Lake Meredith and 1940 to 2022 for Palo Duro Reservoir.

The Red River WAM was recently updated and includes hydrology through 2017. This model was used for all supplies in the Red River Basin. A brief description of the reservoir supplies is presented below. Additional information on the WAMs can be found in **Appendix B**.

Lake Meredith

Lake Meredith is owned and operated by the Canadian River Municipal Water Authority (CRMWA). It was built by the Bureau of Reclamation with conservation storage of 500,000 acre-feet, limited by the Canadian River Compact. Impoundment of Lake Meredith began in January 1965, but hydrological and climatic conditions have prevented the reservoir from ever spilling. Most of the inflow to Lake Meredith originates below the Ute Reservoir in New Mexico. (TWDB, 1974)



Source: http://www.CRMWA.com

Several yield studies have been published for Lake Meredith since its construction in 1965 (HDR, 1987; Lee Wilson and Associates, 1993, Freese and Nichols, Inc., 2004). Both the HDR (1987) and Lee Wilson and Associates (1993) studies estimated the firm yield of Lake Meredith at about 76,000 acre-feet per year. The Freese and Nichols study (2004) for the 2006 Panhandle Water Plan reported the firm yield at 69,700 acre-feet per year.

Since about year 2000, the water levels in Lake Meredith have declined and the ability to use water from Lake Meredith has greatly diminished. For the 2011 Panhandle Regional Water Plan, a special study was conducted to assess the potential factors that may be contributing to the reduced water levels (Freese, 2010). This study confirmed that the Lake Meredith watershed is losing its ability to generate runoff and stream flow to the Canadian River, but no one factor or event appeared to be the major contributor. The study reported that a combination of factors, including reduced rainfall intensities, increasing shrubland and declining groundwater levels, may have resulted in tipping the hydrologic balance of the watershed to the point that inflows to Lake Meredith (generated below Ute Reservoir) is now about 20 percent of inflows observed in the 1940s. While the activities in the watershed above the Logan gage (New Mexico) cannot be ignored with respect to the total amount of inflow to Lake Meredith, there are changes in the watershed below Ute Reservoir that have contributed to reduced stream flows.

To estimate the supply from Lake Meredith for the 2026 Plan, firm yield and safe yield analyses were conducted using an Excel-based reservoir model. Input parameters for the model were compiled from several sources. Inflow and net evaporation data from 1940 to September 2004 came from the Canadian River Basin WAM updated for the 2006 Regional Plan (Canadian2000 WAM). The hydrology was extended to December 2017 based on CRMWA records. Estimated reservoir inflows from 2001 to 2013 averaged 35,000 ac-ft/yr and were substantially lower than the

1965 to 2000 average (120,000 ac-ft/yr), corresponding with declining reservoir storage and the recent critical drought (**Figure 3-5**). Inflows greater than 120,000 ac-ft/yr in 2015 and 2017 allowed the reservoir to partially recover. Since 2017, the lake continued to receive inflows (**Figure 3-6**), and as of May 2024, the lake is 43 percent full. Assuming critical drought conditions do not recur, the yield of Lake Meredith would be the same as estimated for the 2021 Plan. Based on projections of conservation storage, the firm yield and safe yield for Lake Meredith during the planning period are shown in **Table 3-7**.

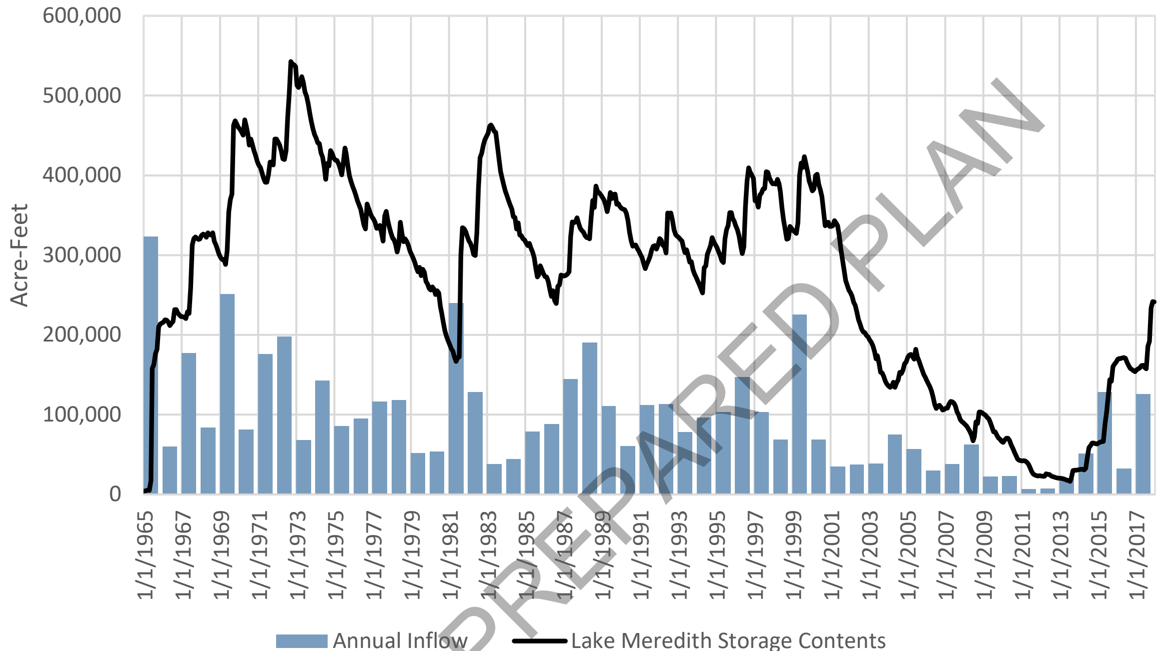
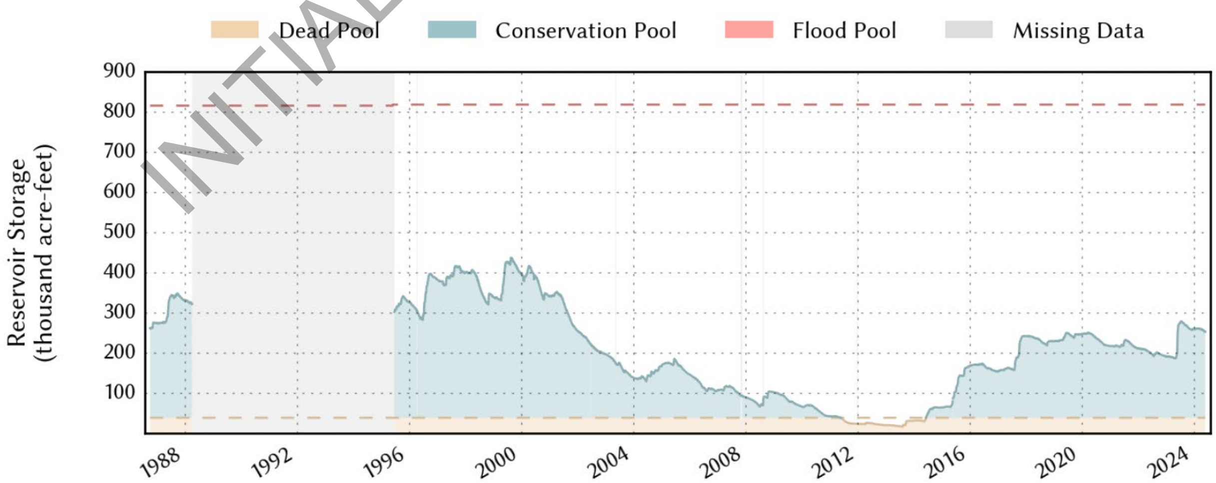


Figure 3-5: Annual Inflows and Historical Storage Contents for Lake Meredith (1965-2017)



Source: TWDB, www.waterdatafortexas.org

Figure 3-6: Historical Content for Lake Meredith (1987-May 2024)

Table 3-7: Projected Firm and Safe Yields of Lake Meredith

	2030	2040	2050	2060	2070	2080
Conservation Storage [1] (ac-ft)	500,000	500,000	500,000	500,000	500,000	500,000
Firm Yield (ac-ft/yr)	28,200	28,200	28,200	28,200	28,200	28,200
Safe Yield (ac-ft/yr)	24,600	24,600	24,600	24,600	24,600	24,600

[1] Limited by provisions of the Canadian River Compact

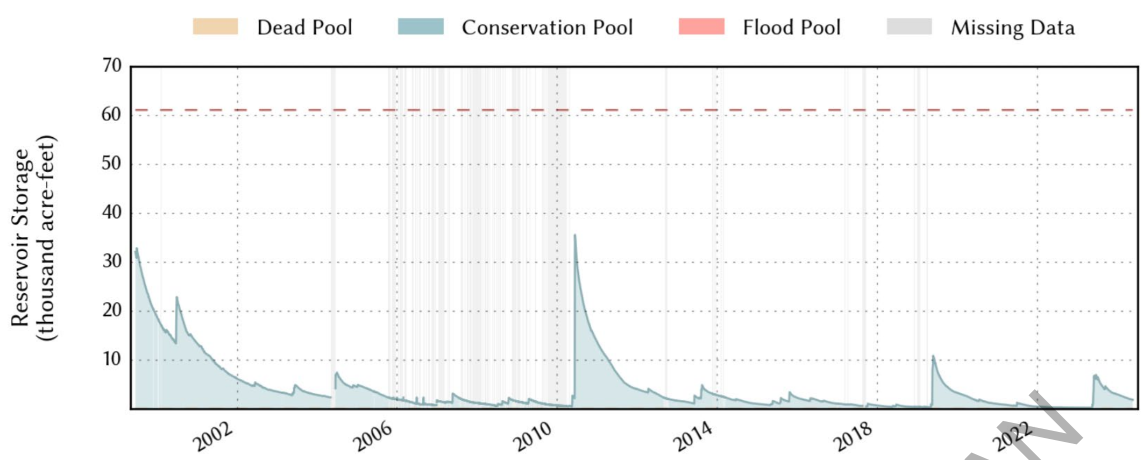
While the yield of Lake Meredith has substantially decreased over the past 20 years, the amount of usable water is less. During the extreme period of the most recent drought (2011 to 2013), CRMWA suspended diversions from the lake. The water quality had deteriorated such that it was difficult to blend with groundwater and meet federal and state standards. As the lake began to recover, diversions resumed but were much less than historical use. Since 2011, the diversions from Lake Meredith have averaged about 12,000 acre-feet per year due to water quality. Without significant inflows the water quality in the lake is expected to continue to deteriorate, further limiting its availability for water supply. Considering these factors the reliable supply of Lake Meredith for planning purposes is shown in **Table 3-8**.

Table 3-8 Reliable Supply of Lake Meredith

	2030	2040	2050	2060	2070	2080
Reliable Supply (ac-ft/yr)	12,000	10,500	9,000	7,500	6,000	4,500

Palo Duro Reservoir

The Palo Duro Water District owns and operates the Palo Duro Reservoir. It was built as a future water supply for its six member cities of Cactus, Dumas, Sunray, Spearman, Gruver, and Stinnett. The Water District is currently supported by Moore County, Hansford County, and the City of Stinnet. The reservoir is located on Palo Duro Creek in Hansford County, 12 miles north of Spearman. The original conservation storage capacity of the reservoir was estimated to be 60,897 acre-feet. The dam began impounding water in January 1991 but has never filled. High evaporative losses and apparent losses from the reservoir result in a cyclic pattern of water storage that has varied between a high of 30,000 acre-feet and less than 1,000 acre-feet. In May 2024 the lake was at 3 percent capacity (1,800 acre-feet).



Source: TWDB, www.waterdatafortexas.org

Figure 3-7: Historical Content for Palo Duro Reservoir (1999-May 2024)

A study by Freese and Nichols (1974) estimated the yield to be approximately 8,700 acre-feet per year. Subsequent yield analyses using the Canadian WAM (period of record from January 1940 to September 2004) estimated a firm yield of about 4,000 acre-feet per year. On-going drought has likely reduced the firm yield further. To estimate the current yield of Palo Duro Reservoir, a mass balance reservoir model was developed with hydrology through 2019. Adjustments to the model were made to account for losses through infiltration and leakage.

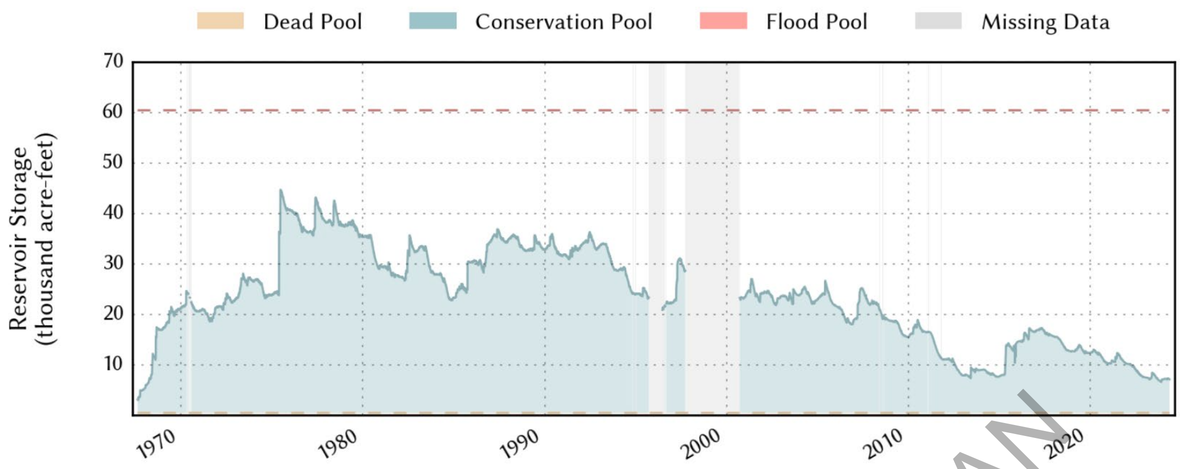
As the performance of the lake has demonstrated, the firm yield of the lake is very low and there is no supply under a safe yield analysis. For purposes of regional planning, it is assumed Palo Duro Reservoir has no reliable supply.

Table 3-9: Projected Yield and Available Supply of Palo Duro Reservoir

	2030	2040	2050	2060	2070	2080
Conservation Capacity (ac-ft)	57,062	56,182	55,302	54,422	53,542	52,662
Firm Yield (ac-ft/yr)	39	39	39	39	39	39
Available Supply (ac-ft/yr)	0	0	0	0	0	0

Greenbelt Reservoir

Greenbelt Reservoir is owned and operated by the Greenbelt Municipal and Industrial Water Authority (Greenbelt MIWA). It is located on the Salt Fork of the Red River near the city of Clarendon. Construction of Greenbelt Reservoir was completed in March 1968 and impoundment of water began in December 1966 (Freese and Nichols, 1978). The original storage capacity of Greenbelt was 59,100 acre-feet at the spillway elevation of 2,663.65 feet (TWDB, 1974). The reservoir has never filled. Historical storage reached a high point in 1975 and has trended significantly downward since then. As of May 2024, Greenbelt Reservoir is at 11 percent of its storage capacity.



Source: TWDB, www.waterdatafortexas.org

Figure 3-8: Historical Content for Greenbelt Reservoir (1968-May 2024)

Similar to Lake Meredith, Greenbelt Reservoir experienced declining water levels in response to the recent drought. A 2011 study by Freese and Nichols noted that the lake has historically relied on local springs for inflows, which has allowed the lake to recover following droughts. This is a critical component for the reliable supply for the reservoir. If the spring flow is impacted by drought or local groundwater use, the ability of Greenbelt Reservoir to recover from droughts may be impacted. Currently, the lake is at the lowest levels since it began to fill.

The TCEQ-approved Red River WAM was used to estimate the yields of Greenbelt Reservoir. The WAM was updated in 2021 and extended the period of record to 1948 through 2017. The extended hydrology in the updated WAM covers the most recent drought (2011 – 2015) but does not capture the current low inflows experienced in the last few years. A summary of the yield analyses is shown in **Table 3-10**.

Table 3-10: Projected Firm and Safe Yields of Greenbelt Reservoir

	2030	2040	2050	2060	2070	2080
Conservation Capacity (ac-ft)	48,628	46,606	44,584	42,562	40,540	38,518
Firm Yield (ac-ft/yr)	4,000	3,850	3,700	3,433	3,167	2,900
Safe Yield (ac-ft/yr)	3,140	2,970	2,800	2,592	2,383	2,175

3.1.4 Run of the River Supplies

According to the TCEQ water rights database there are 103 run-of-river water rights permit holders in the PWPA. Run of river supplies are diversions directly from a stream or river. In this Plan, reliable supply from a run-of-river right is defined as the minimum annual diversion from the TCEQ WAM simulation. **Table 3-11** summarizes these rights by county in the PWPA. The permitted diversions total 7,226 acre-feet per year. There are no individual run of river diversions that are greater 1,000 acre-feet/year (note: aggregated diversions total more than 1,000 acre-feet per year for some counties). The reliable supply from these sources is 1,859 acre-feet per year. A complete list of the water rights is included in **Appendix B**.

Table 3-11: Total Run of the River Water Rights by County in the PWPA (ac-ft/yr)

County	Basin Name	Permitted Diversion	Reliable Supply
Carson	Red	335[1]	69
Childress	Red	38.5	6
Collingsworth	Red	1,194	694
Dallam	Canadian	190	0
Donley	Red	464	177
Gray	Canadian	4	1
Gray	Red	130	24
Hall	Red	101	12
Hansford	Canadian	530	22
Hartley	Canadian	0	0
Hemphill	Canadian	0	0
Hemphill	Red	0	0
Hutchinson	Canadian	356[2]	98
Lipscomb	Canadian	122	66
Moore	Canadian	345	7
Ochiltree	Canadian	0	0
Oldham	Canadian	30	0
Potter	Canadian	349	0
Randall	Red	1,074	124
Roberts	Canadian	640	72
Sherman	Canadian	275	32
Wheeler	Red	1,048	455
Total		**7,226**	**1,859**

[1] 110 ac-ft/yr authorized recapture of produced groundwater is not included.
[2] 290 ac-ft/yr that may be diverted for non-consumptive uses is not included.

3.1.5 Other Potential Surface Water Sources

Nine minor reservoirs in the PWPA have been identified as other potential sources of surface water. These include Lake McClellan, Buffalo Lake, Lake Tanglewood, Rita Blanca Lake, Lake Marvin, Baylor Lake, Lake Childress, Lake Fryer, and Bivins Lake. The historical or current supply of these water bodies has not been quantified through yield studies. The following paragraphs discuss the available information about each of these water bodies. **Table 3-12** summarizes the descriptive information about each of the minor reservoirs.

Lake McClellan

Lake McClellan is located in the Red River Basin and is also known as McClellan Creek Lake. It was constructed on McClellan Creek twenty-five miles south of Pampa in southern Gray County. It was built in the late 1940's by the Panhandle Water Conservation Authority, primarily for soil conservation, flood control, recreation, and promotion of wildlife. The U.S. Forest Service has a recreational water right associated with McClellan Creek National Grassland (TCEQ, 2009). Lake McClellan has a capacity of 5,005 acre-feet (Breeding, 1999).

Buffalo Lake

Buffalo Lake is a reservoir impounded by Umbarger Dam, three miles south of the city of Umbarger on upper Tierra Blanca Creek in western Randall County. The reservoir is in the Red River basin. The original dam was built in 1938 by the Federal Farm Securities Administration to store water for recreational purposes. The lake's drainage area is 2,075 square miles, of which 1,500 square miles are probably noncontributing. Buffalo Lake has a water right for storage of 14,363 acre-feet, with no diversion rights. In 1982 and 1992, the low water dam was reworked to become a flood control structure. Several species of waterfowl use the lake as a winter refuge (Breeding, 1999).

Lake Tanglewood

Lake Tanglewood is located in the Red River Basin and is formed by an impoundment constructed in the early 1960's on Palo Duro Creek in northeastern Randall County. Lake Tanglewood, Inc., a small residential development is located along the lake shore (Breeding, 1999). Lake Tanglewood has a water right for storage of 4,897 acre-feet with a diversion right of 90 acre-feet per year for irrigation purposes (TCEQ, 2009). The lake is also used for recreational purposes. The city of Amarillo has a contract with Lake Tanglewood to discharge up to 1.5 MGD of wastewater effluent for instream flow purposes.

Rita Blanca Lake

Rita Blanca Lake is on Rita Blanca Creek, a tributary of the Canadian River, in the Canadian River basin three miles south of Dalhart in Hartley County. The Rita Blanca Lake project was started in 1938 by the WPA in association with the Panhandle Water Conservation Authority. In June 1951, Dalhart obtained a ninety-nine-year lease for the operation of the project as a recreational facility without any right of diversion (Breeding, 1999). The lake is currently owned by the Texas Parks and Wildlife Department and is operated and managed jointly by Hartley and Dallam county commissioners for recreational purposes. The two counties have joint recreational water rights. The lake has a capacity of 12,100 acre-feet and a surface area of 524 acres at an elevation of 3,860 feet above mean sea level. The drainage area above the dam is 1,062 square miles. The City of Dalhart discharges treated domestic wastewater to Rita Blanca Lake.

Lake Marvin

Lake Marvin, also known as Boggy Creek Lake, was constructed in the 1930s on Boggy Creek, in east central Hemphill County by the Panhandle Water Conservation Authority. The lake is in the Canadian River basin and was constructed for soil conservation, flood control, recreation, and promotion of wildlife (Breeding, 1999). The reservoir has a capacity of 553 acre-feet and is surrounded by the Panhandle National Grassland. The USFS has a water right for recreational use of Marvin Lake (TCEQ, 2009).

Table 3-12: Descriptive Information of Minor Reservoirs in the PWPA

Reservoir	Stream	River Basin	Use	Water Rights	Date of Impoundment	Capacity* (ac ft)
Lake McClellan	McClellan Creek	Red	soil conservation, flood control, recreation, promotion of wildlife	U.S. Forest Service (recreational)	1940s	5,005
Buffalo Lake	Tierra Blanca Creek	Red	flood control, promotion of wildlife	N/A	1938	18,121
Lake Tanglewood	Palo Duro Creek	Red	recreation, irrigation	Lake Tanglewood, Inc.	1960s	4,897
Rita Blanca Lake	Rita Blanca Creek	Canadian	recreation	Dallam & Hartley Counties (recreational)	1941	5,500
Lake Marvin	Boggy Creek	Canadian	soil conservation, flood control, recreation, promotion of wildlife	U.S. Forest Service (recreational)	1930s	553
Baylor Lake	Baylor Creek	Red	recreation	City of Childress (397 ac-ft/yr)	1949	7,820
Lake Childress	unnamed tributary to Baylor Creek	Red	N/A	N/A	1923	4,725
Lake Fryer	Wolf Creek	Canadian	soil conservation, flood control, recreation	N/A	1938	862
Bivins Lake	Palo Duro Creek	Red	ground water recharge	N/A	1926	5,122

Source: Breeding, 1999
*Permitted capacity (TCEQ, 2014)
N/A – data are not available

Baylor Lake

Baylor Lake is on Baylor Creek in the Red River Basin, ten miles northwest of Childress in western Childress County. The reservoir is owned and operated by the city of Childress. Although the City has water rights to divert up to 397 acre-feet per year from the reservoir (TCEQ, 2009), there is currently no infrastructure to divert water for municipal use. Construction of the earth fill dam was started on April 1, 1949 and completed in February 1950. Deliberate impoundment of water was begun in December 1949. Baylor Lake has a capacity of 9,220 acre-feet and a surface area of 610 acres at the operating elevation of 2,010 feet above mean sea level. The drainage area above the dam is forty square miles. (Breeding, 1999).

Lake Childress

Lake Childress is eight miles northwest of Childress in Childress County. This reservoir, built in 1923 on a tributary of Baylor Creek, in the Red River Basin, adjacent to Baylor Lake. In 1964 it was still part of the City of Childress' water supply system, as was the smaller Williams Reservoir to the southeast (Breeding, 1999). It is no longer used for water supply. The reservoir is permitted to store 4,725 acre-feet for recreational purposes (TCEQ, 2009).

Lake Fryer

Lake Fryer, originally known as Wolf Creek Lake, was formed by the construction of an earthen dam on Wolf Creek, in the Canadian River Basin, in eastern Ochiltree County. After the county purchased the site, construction on the dam was begun in 1938 by the Panhandle Water Conservation Authority. The dam was completed by the late summer of 1940. During the next few years Wolf Creek Lake was used primarily for soil conservation, flood control, and recreation. In 1947, a flash flood washed away the dam, but it was rebuilt in 1957. During the 1980s the lake and the surrounding park were owned and operated by Ochiltree County and included a Girl Scout camp and other recreational facilities (Breeding, 1999).

Bivens Lake

Bivens Lake, also known as Amarillo City Lake, is a reservoir formed by a dam on Palo Duro Creek, in the Red River Basin, ten miles southwest of Amarillo in western Randall County. It is owned and operated by the city of Amarillo to recharge the groundwater aquifer that supplies the City's well field. The project was started in 1926 and completed a year later. It has a capacity of 5,120 acre-feet and a surface area of 379 acres at the spillway crest elevation of 3,634.7 feet above mean sea level. Water is not diverted directly from the lake, but the water in storage recharges, by infiltration, a series of ten wells that are pumped for the City supply. Because runoff is insufficient to keep the lake full, on several occasions there has been no storage. The drainage area above the dam measures 982 square miles, of which 920 square miles are probably noncontributing (Breeding, 1999).

Playa Lakes

The most visible and abundant wetlands features within the PWPA are playa lakes. These are ephemeral wetlands which are an important element of surface hydrology and ecological diversity. Most playa lakes are seasonally flooded basins, receiving their water only from rainfall or snowmelt. Moisture loss occurs by evaporation and infiltration through the soil to underlying aquifers. In some years there is little to no water in the playa lakes of the PWPA.

Wetlands are especially valued because of the wide variety of functions they perform, and the uniqueness of their plant and animal communities. Ecologically, wetlands can provide high quality habitat in the form of foraging and nesting areas for wildlife and spawning and nursery habitat for fish. Approximately 5,450 playa lakes are located in the PWPA, covering approximately one percent of the surface area (NRCS, 2009). Playa lakes have a variety of sizes that influence the rapidity of runoff and rates of water collection. Playa lakes have relatively flat bottoms, resulting in a relatively uniform water depth, and are generally circular to oval in shape. Typically, the soil in the playa lakes is the Randall Clay.

Playa lakes also supply important habitat for resident wildlife. The lakes provide sites with a moderate amount of moisture in a semi-arid region and therefore are likely to support a richer, denser vegetative cover than surrounding areas. Moreover, the perpetual flooding and drying of the lakes promotes the growth of plants such as smartweeds, barnyard grass, and cattails that provide both food and cover. The concentric zonation of plant species and communities in response to varying moisture levels in lake soils enhances interspersion of habitat types. Playa lakes offer the most significant wetland habitats in the southern quarter of the Central Flyway (a bird migration route that generally follows the Great Plains in the U.S.) for migrating and wintering birds. Up to two million ducks and hundreds of thousands of geese take winter refuge here. Shorebirds, wading birds, game birds, hawks and owls, and a variety of mammals also find shelter and sustenance in playas. **Table 3-12** shows the estimated acreage and water storage for playa lakes in the PWPA.

Table 3-13: Acreage and Estimated Maximum Storage of Playa Lakes in the PWPA

County	Estimated Area[1] (acres)	Estimated Maximum Storage[2] (acre feet)
Armstrong	15,356	46,069
Carson	15,074	45,223
Childress	116	347
Collingsworth	0	0
Dallam	4,471	13,413
Donley	1,978	5,933
Gray	13,529	40,588
Hall	0	0
Hansford	7,483	22,449
Hartley	4,281	12,842
Hemphill	102	306
Hutchinson	3,129	9,388
Lipscomb	225	675
Moore	5,036	15,109
Ochiltree	16,263	48,788
Oldham	4,249	12,746
Potter	3,472	10,417
Randall	13,373	40,118
Roberts	1,350	4,051
Sherman	4,202	12,607
Wheeler	0	0
Total	**113,689**	**341,069**

[1] Playa Lakes Joint Venture, 2015

[2] Fish, et. al., 1997 (Based on average depth of 3 feet)

3.1.6 Reuse Supplies

Direct reuse is used in the PWPA for irrigation and industrial water uses. Currently, the largest producer of treated effluent for reuse is the City of Amarillo. Most of the City's wastewater is sold to Xcel Energy for steam electric power use. The City of Borger also sells a portion of its wastewater effluent for manufacturing and industrial use. Most of the other reuse in the PWPA is used for irrigation. A summary of the estimated direct reuse in the PWPA is shown in **Table 3-14**. Values are based on historical use amounts reported in the TWDB water use survey. For Amarillo, the direct reuse is estimated at 40 percent of Amarillo's municipal demand and Potter County manufacturing demands on Amarillo. There are no permitted indirect reuse projects in the PWPA.

Table 3-14: Direct Reuse in the PWPA (ac-ft/yr)

County	2030	2040	2050	2060	2070	2080
Armstrong	0	0	0	0	0	0
Carson	58	59	59	58	58	58
Childress	127	132	130	126	122	119
Collingsworth	52	54	55	57	58	60
Dallam	0	0	0	0	0	0
Donley	0	0	0	0	0	0
Gray	220	220	220	220	220	220
Hall	100	100	100	100	100	100
Hansford	0	0	0	0	0	0
Hartley	0	0	0	0	0	0
Hemphill	0	0	0	0	0	0
Hutchinson	1,100	1,100	1,100	1,100	1,100	1,100
Lipscomb	0	0	0	0	0	0
Moore	500	500	500	500	500	500
Ochiltree	0	0	0	0	0	0
Oldham	0	0	0	0	0	0
Potter	22,532	23,605	24,486	25,176	25,864	26,546
Randall	0	0	0	0	0	0
Roberts	0	0	0	0	0	0
Sherman	0	0	0	0	0	0
Wheeler	0	0	0	0	0	0
Total	**24,879**	**25,957**	**26,836**	**27,522**	**28,206**	**28,885**

3.1.7 Local Supplies

Local supplies are those surface water supplies that cannot be quantified from the WAM models. These include water sources that do not require a State water right permit, such as local stock ponds for livestock use. The amounts of available supplies for these uses are based on data collected by the TWDB on historical water use. The reliability of these supplies is predicated on the continuity of use. For planning purposes, the values represent 20 percent above the maximum historical reported use from 2010 to 2019. A summary of the local supplies by county is shown in **Table 3-15**.

Table 3-15: Summary of Local Supplies in the PWPA (ac-ft/yr)

	Livestock Local Supply					
County	2030	2040	2050	2060	2070	2080
Armstrong	79	79	79	79	79	79
Carson	96	96	96	96	96	96
Childress	38	38	38	38	38	38
Collingsworth	18	18	18	18	18	18
Dallam	1,786	1,786	1,786	1,786	1,786	1,786
Donley	240	240	240	240	240	240
Gray	600	600	600	600	600	600
Hall	128	128	128	128	128	128
Hansford	1,958	1,958	1,958	1,958	1,958	1,958
Hartley	3,480	3,480	3,480	3,480	3,480	3,480
Hemphill	223	223	223	223	223	223
Hutchinson	164	164	164	164	164	164
Lipscomb	168	168	168	168	168	168
Moore	823	823	823	823	823	823
Ochiltree	443	443	443	443	443	443
Oldham	737	737	737	737	737	737
Potter	154	154	154	154	154	154
Randall	908	908	908	908	908	908
Roberts	66	66	66	66	66	66
Sherman	646	646	646	646	646	646
Wheeler	437	437	437	437	437	437
Total	**13,192**	**13,192**	**13,192**	**13,192**	**13,192**	**13,192**

3.1.8 Summary of Water Supplies in the PWPA

The available water supplies in the PWPA total over 3.9 million acre-feet per year in 2030, decreasing to 2.7 million acre-feet per year by 2080 (**Table 3-16**). Surface water supplies are an important component of the available supply to counties where groundwater is limited. However, if the reliability of surface water supplies decreases due to on-going droughts, the reliance on groundwater will increase.

The supplies shown in **Table 3-16** and **Figure 3-9** represent the amount of water supply that is located in the PWPA and includes supplies that are currently developed and potential future supplies that could be developed. For reservoirs, the supply used for planning purposes is shown. For groundwater, the availabilities adopted by the PWPG are shown (MAGs for major and minor aquifers and adopted supplies for Other and Non-Relevant Aquifers). These values do not consider infrastructure constraints, contractual agreements, or the economic feasibility of developing these sources. They also do not consider the ultimate location of use (e.g., exports to Regions O and B). These values are reported by source location, which is the PWPA. In some counties the available groundwater supplies are significantly greater than the historical use. In other counties, current groundwater use exceeds the available supply. Consideration of the amount of water that is currently developed and available to water users in the PWPA is discussed in **Section 3.2**.

Table 3-16: Summary of Available Water Supplies in the PWPA (ac-ft/yr)

Source	2030	2040	2050	2060	2070	2080
Lake Meredith (reliable supply)	12,000	10,500	9,000	7,500	6,000	4,500
Greenbelt Lake (safe yield)	3,140	2,970	2,800	2,592	2,383	2,175
Palo Duro Reservoir* (safe yield)	0	0	0	0	0	0
Canadian Run-of-River	298	298	298	298	298	298
Red Run-of-River	1,561	1,561	1,561	1,561	1,561	1,561
Total Surface Water	**16,999**	**15,329**	**13,659**	**11,951**	**10,242**	**8,534**
Ogallala & Rita Blanca Aquifers	3,148,015	2,924,013	2,669,506	2,435,130	2,205,795	1,991,106
Seymour Aquifer	51,488	51,498	53,333	51,431	50,660	53,052
Blaine Aquifer	31,404	31,404	31,404	31,404	31,404	31,404
Dockum Aquifer	326,541	321,453	304,182	284,240	259,902	241,087
Other Aquifer	2,753	2,753	2,753	2,753	2,753	2,753
Total Groundwater	**3,560,201**	**3,331,121**	**3,061,178**	**2,804,958**	**2,550,514**	**2,319,402**
Local Supply	13,192	13,192	13,192	13,192	13,192	13,192
Direct Reuse	24,879	25,957	26,836	27,522	28,206	28,885
Total Supply in PWPA	**3,615,271**	**3,385,599**	**3,114,865**	**2,857,623**	**2,602,154**	**2,370,013**

*No current infrastructure

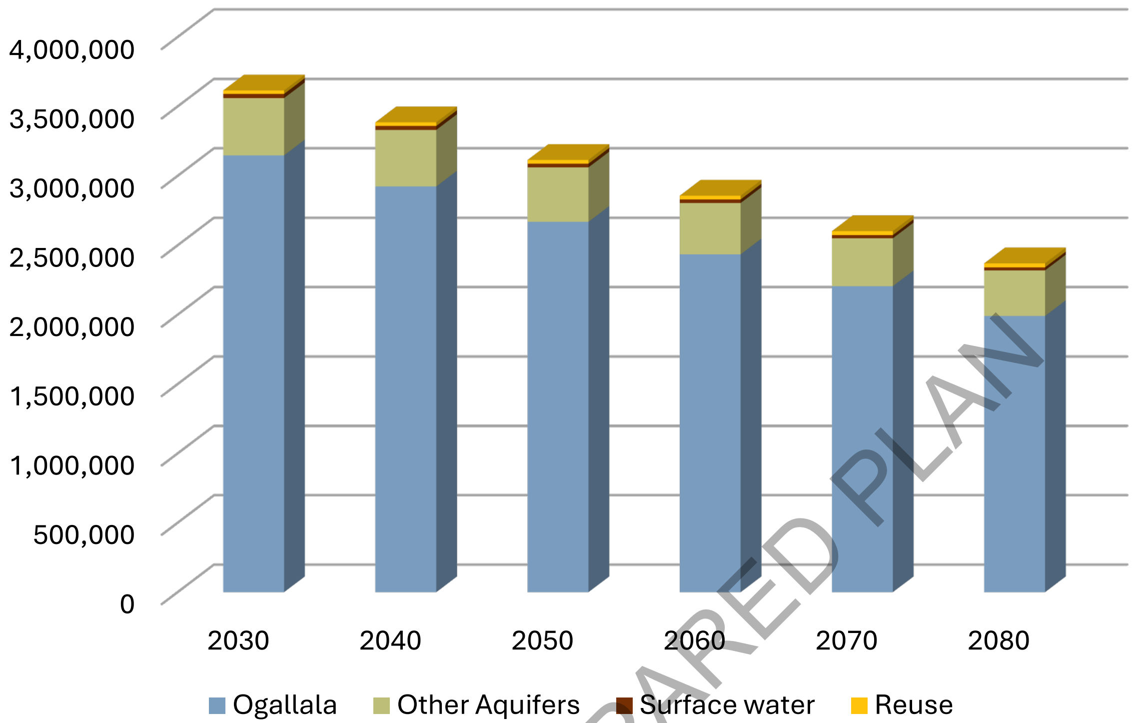


Figure 3-9: Summary of Available Supplies in PWPA

3.2 Currently Developed Supplies to Water User Groups

As part of the regional water planning process, water supplies are allocated to water user groups based on the most limiting factor to deliver or use the water. These limitations may include the availability of the water source (such as firm yield of a reservoir or the adopted aquifer storage depletion restriction), well field capacity, water rights permits, contractual agreements, delivery infrastructure constraints, and water treatment capacities where appropriate.

Appropriate constraints were identified for each of the PWPA water user groups. Agricultural water use considered locations of irrigable acreages and historical use data provided by the TWDB and local groundwater conservation districts (GCDs). For some counties irrigable acres are limited in extent across the county. Most of the crops in the PWPA are irrigated with groundwater. Allocations to other water user groups considered sales from wholesale water providers and historical water use as reported by the TWDB.

The allocation of water supplies also considers the source of water, the location of the water, and current imports and exports of water in the region. All water supplies from aquifers stated in this plan comply with the adopted MAG values or developed supplies for "Other aquifer".

It should be noted that in some cases, local GCD rules may be more restrictive in certain areas as permitting requirements based on geographic extent may limit withdrawals beyond the availability shown in this plan.

3.2.1 Allocation of Ogallala Supplies to Water Users

In the PWPA the Ogallala aquifer provides most of the water in the region and some water to users outside of the region. Considering the demands on this resource and the available supply determined for regional water planning, the demands exceed the supply in several counties in some decades. **Table 3-17** shows the projected demand on the Ogallala aquifer by county if there were no restrictions to supplies. As shown on this table the total demands on the Ogallala in 2030 exceed 1.5 million acre-feet.

Figure 3-10 shows the Northern Ogallala saturated thickness from the GAM run that was used to develop the MAGs at the beginning and end of the predictive simulations (years 2030 and 2080). By 2080, in conformance with the desired future conditions, there is a significant reduction of the aquifer saturated thickness in many PWPA counties, including Dallam, Hartley, Moore and Sherman Counties. The relatively thin saturated thickness in the heavily used portions of the aquifer in the future may result in these regions not being able to support current rates of irrigation pumping.

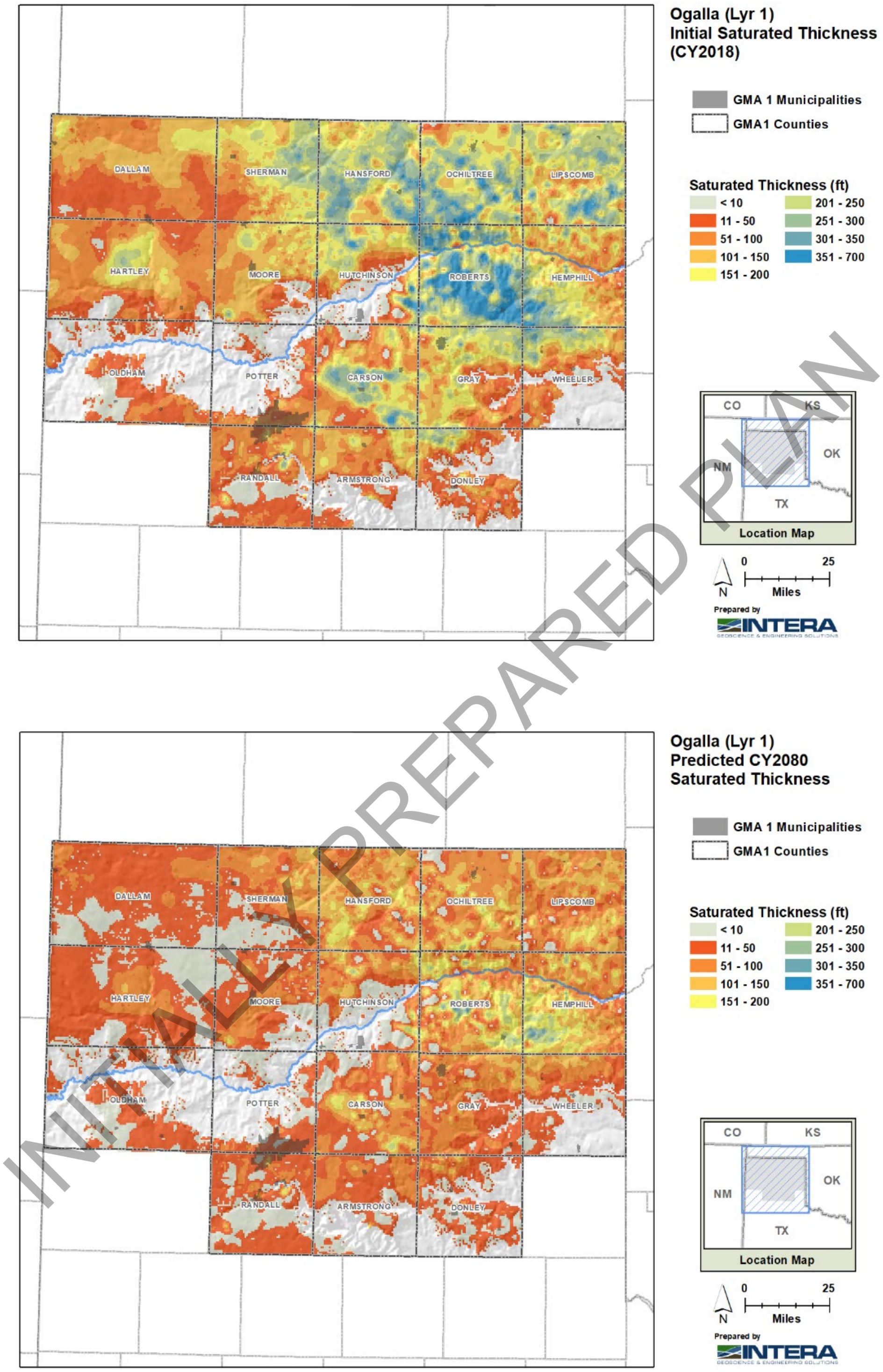


Figure 3-10: Ogallala Saturated Thickness Based on Modeled Available Groundwater

Table 3-17: Projected Total Demand on the Ogallala Aquifer within PWPA (ac-ft/yr)

County	2030	2040	2050	2060	2070	2080
Armstrong	6,851	6,852	6,857	6,862	6,867	6,872
Carson	118,543	118,290	117,834	117,521	117,391	117,076
Dallam	333,125	334,138	296,971	265,029	241,508	223,870
Donley	35,951	36,088	36,177	36,327	36,471	36,613
Gray	40,663	40,463	40,134	39,834	39,556	39,446
Hansford	180,253	180,392	180,517	180,660	180,803	180,952
Hartley	401,466	403,172	357,983	325,430	297,953	275,470
Hemphill	9,022	9,032	9,021	9,021	9,022	9,022
Hutchinson	74,046	73,296	72,532	71,877	71,432	70,908
Lipscomb	46,215	46,234	46,245	46,264	46,284	46,305
Moore	218,612	220,375	206,867	188,432	167,357	149,840
Ochiltree	92,980	93,139	93,240	93,339	93,440	93,540
Oldham	5,360	5,336	5,301	5,265	5,228	5,193
Potter	6,739	6,544	6,294	6,046	5,911	5,816
Randall	23,845	24,508	25,484	26,315	27,017	27,865
Roberts	96,201	109,179	116,190	119,757	133,622	135,856
Sherman	313,207	313,417	274,969	244,762	210,359	187,257
Wheeler	22,909	22,919	22,905	22,896	22,887	22,879
Total	**1,531,518**	**1,548,006**	**1,457,682**	**1,379,898**	**1,310,871**	**1,250,349**

Note: The demands on the Ogallala aquifer shown above represent an estimate of the total projected production from the Ogallala aquifer by county of source if supplies are not limited by the MAG or infrastructure.

The HPAS GAM was used to assist with the allocation of Ogallala water to irrigation and municipal users. Model grid cells were assigned to a specific user group using data provided by the GCDs, TCEQ, TWDB and Texas A&M AgriLife Research and Extension Center at Amarillo (Texas A&M Agrilife) as shown on **Figure 3-11**. A one grid cell buffer zone was applied to all irrigation areas and larger municipal well fields that were not surrounded by competing users. The availabilities were estimated based on the summation of the pumpage for the associated grid cells. For irrigation water users, the lesser of the demands or the availabilities were assigned to the irrigation WUG. Three counties were shown to have irrigation demands greater than the estimated water availability. These include Dallam, Hartley, and Moore Counties. The original model grid designations were performed on the old Northern Ogallala GAM and were transposed onto the new HPAS GAM. While the transfer between the models was relatively smooth, the HPAS GAM has a smaller cell size and has a slightly different rotation. This means that there was not a 1 to 1 transfer between the previous model designations and the new model. However, the majority of the cells do line up with the previous cell designations.

The allocation of Ogallala water to municipal water users considered several factors, including the availabilities determined using the Ogallala GAM, production capacities and information received from the water user. Allocations to other users (manufacturing, livestock and mining) were generally not constrained if there was sufficient supply in the county. Water supplies to manufacturing users that receive supply from a wholesale water provider were limited if the wholesale water provider did not have sufficient supplies.

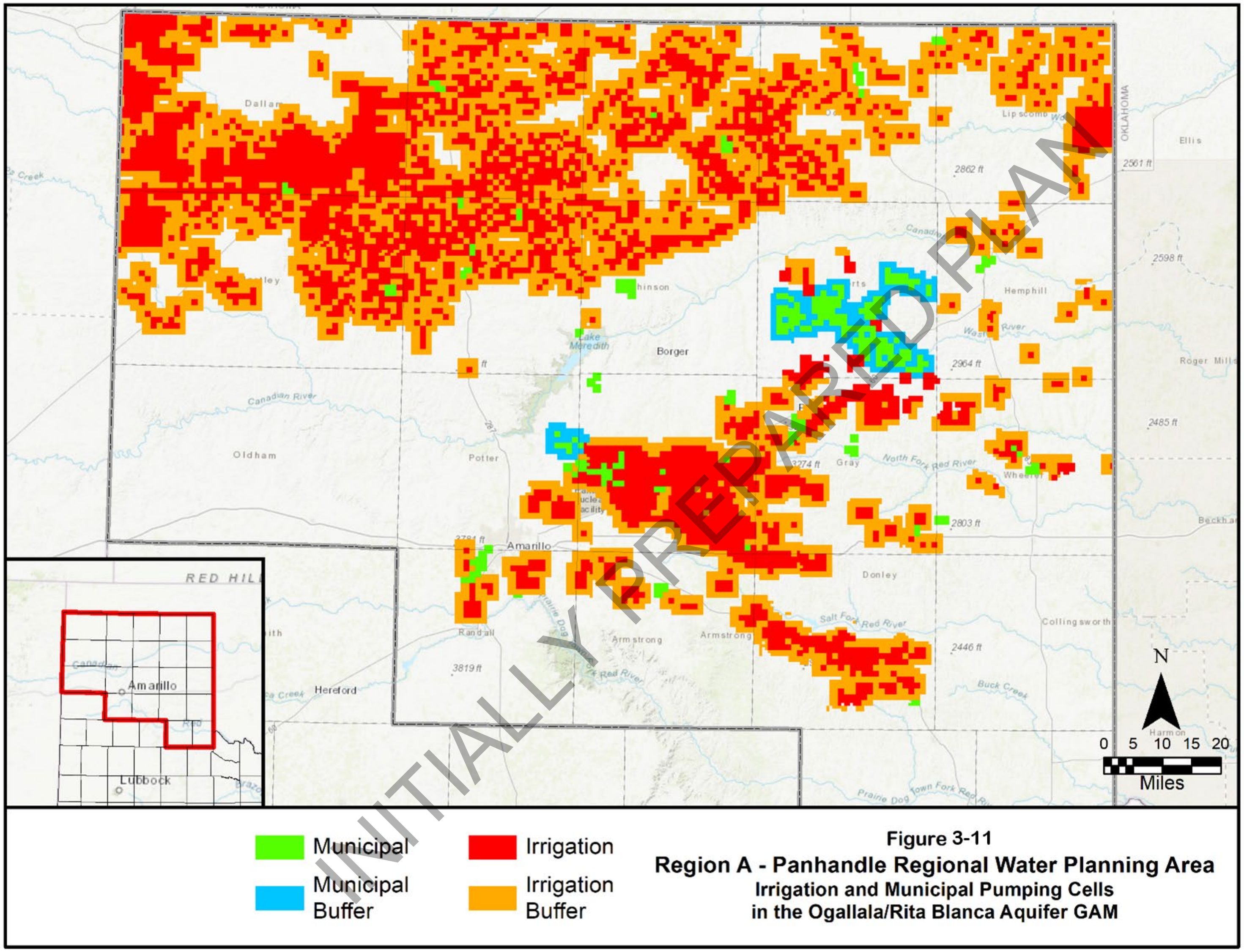


Figure 3-11: Irrigation and Municipal Pumping Cells in Ogallala Aquifer

3.2.2 Major Water Provider Supplies and Allocation to Users

As part of the water allocation process, water developed by major water providers is distributed to its customers, which are then assigned to the appropriate water user group. Generally, if the major provider has sufficient supplies to meet its contractual demands, the amount of the contracted water supply was allocated to the customer. If the total demand on the major provider exceeded its developed supplies, then the supplies were reduced proportionally to all customers. This reduction in supply was applied to each of the major provider's sources as appropriate. **Table 3-18** shows the water supplies available to major water providers in the PWPA. **Attachment 3-2** contains the water supplies for each of these MWPs broken down by category of use for each decade.

Table 3-18: Summary of Current Water Supplies to Major Water Providers

Major Provider	Source	Supply (ac ft/yr)					
		2030	**2040**	**2050**	**2060**	**2070**	**2080**
Amarillo	Direct Reuse	18,732	19,805	20,686	21,376	22,064	22,746
	Ogallala - Randall County	758	563	465	404	231	229
	Ogallala – Potter County	2,714	2,483	2,196	1,915	1,729	1,562
	Ogallala - Carson County	16,770	16,578	16,168	15,899	15,798	15,499
	Ogallala – Deaf Smith	100	50	50	0	0	0
	Dockum - Carson and Potter counties	642	643	642	643	638	622
	CRMWA[1]	32,942	29,948	27,924	24,584	23,591	22,666
	Total	**72,658**	**70,070**	**68,131**	**64,821**	**64,051**	**63,324**
CRMWA	Lake Meredith	12,000	10,500	9,000	7,500	6,000	4,500
	Ogallala - Roberts County	65,000	60,674	55,476	49,833	49,833	49,833
	Total	**77,000**	**71,174**	**64,476**	**57,333**	**55,833**	**54,333**
Borger	Ogallala - Hutchinson County	10,259	9,610	8,952	8,398	8,047	7,610
	Direct Reuse	1,100	1,100	1,100	1,100	1,100	1,100
	CRMWA[1]	2,995	3,265	3,652	3,926	4,225	4,126
	Total	**14,354**	**13,975**	**13,704**	**13,424**	**13,372**	**12,836**
Greenbelt MIWA	Ogallala – Donley County	1,600	1,577	1,484	1,370	1,245	1,090
	Greenbelt Reservoir	3,140	2,970	2,800	2,592	2,383	2,175
	Total	**4,740**	**4,547**	**4,284**	**3,962**	**3,628**	**3,265**

[1] The amount CRMWA sells to other Major Water Providers is included in the supplies reported for CRMWA.

3.2.3 Imports and Exports

A small amount of water is imported from Deaf Smith County to the PWPA from a well field owned by Amarillo. The town of Happy imports a small amount of water from the Dockum Aquifer in Swisher County. No other water is currently imported from outside of the PWPA to the region.

There are several exports of water to users in adjoining regions that are associated with sales from CRMWA and Greenbelt MIWA. CRMWA provides water to eleven cities, of which eight are located in the Llano Estacado RWPA (Region O). Water from Lake Meredith, when available, and CRMWA's Roberts County well field are exported to CRMWA's member and customer cities in the Llano Estacado RWPA. The Greenbelt MIWA owns and operates Greenbelt Reservoir. It also operates several wells in the Ogallala aquifer in Donley County. Water from these sources is exported to three cities and the Red River Authority in Region B. Approximately 38,000 acre-feet per year of water may be currently exported from the PWPA. With the development of additional supplies by CRMWA and Greenbelt MIWA, this is expected to increase. **Table 3-19** shows the existing supplies that are projected to be imported and exported from the region.

Table 3-19: Summary of Exports and Imports with other Regions (ac-ft/yr)

Source	2030	2040	2050	2060	2070	2080
Exports:						
Lake Meredith	5,948	5,268	4,371	3,625	2,900	2,172
Greenbelt Reservoir	570	559	551	550	546	549
Ogallala (Donley County)	293	297	293	292	287	276
Ogallala (Roberts County)	31,204	30,419	27,261	24,007	23,716	23,334
Total	**38,015**	**36,543**	**32,476**	**28,474**	**27,449**	**26,331**
Imports:						
Ogallala (Swisher County)	6	6	5	4	4	3
Total	**6**	**6**	**5**	**4**	**4**	**3**

Within the PWPA there are numerous transfers of water between counties. Most of these transfers are associated with municipal well fields that are located in one county and used in another county. **Table 3-20** shows the county locations of the imports and exports of water within the PWPA. Transfers of water from reservoirs are not considered in this table.

Table 3-20: Summary of Groundwater Exports and Imports within the PWPA (ac-ft/yr)

Export	Import	2030	2040	2050	2060	2070	2080
Carson	Hutchinson	883	811	744	660	585	519
	Moore	33	33	33	32	30	29
	Potter	9,341	8,818	8,199	7,665	7,248	6,771
	Randall	7,139	7,490	7,716	7,993	8,319	8,508
Dallam	Hartley	951	972	1,001	1,041	1,087	1,138
Donley	Childress	559	580	571	561	547	522
	Collingsworth	5	6	6	6	5	5
	Hall	305	291	272	255	237	218
Hartley	Moore	2,744	1,395	867	625	507	446
Lipscomb	Ochiltree	2	2	2	2	2	2
Potter	Randall	1,427	1,411	1,353	1,284	1,244	1,197
Roberts	Gray	1,521	1,265	1,093	1,035	1,100	1,088
	Hutchinson	2,203	2,572	3,058	3,431	3,829	3,829
	Potter	15,911	13,969	12,544	10,641	9,986	9,401
	Randall	12,746	12,327	12,169	11,350	11,649	11,934

3.2.4 Summary of Developed Supplies to Water User Groups

The currently developed supply in the PWPA consists mainly of groundwater, 98 percent of total supply, with small amounts of surface water from in-region reservoirs, local supplies and wastewater reuse. The Ogallala is the largest source of water in the PWPA, accounting for nearly 87 percent of the total supply in year 2030.

The total volume of the developed supply for water users in the PWPA in year 2030 is approximately 1,700,000 acre-feet per year and projected to decrease to around 1,500,000 by the year 2050 and ultimately to about 1,230,000 acre-feet per year in 2080. These supply volumes are shown in **Table 3-21**.

The developed supply is nearly half of the total available supply that could be developed. The amount of water that is not currently allocated to a water user is available for water management strategies or future water needs. A summary of the unallocated water supplies is presented in **Table 3-22** by source and shown by county in **Table 3-22** and **Figure 3-12**.

Table 3-21: Developed Water Supplies to Water User Groups in PWPA (ac-ft/yr)

Source	2020	2030	2040	2050	2060	2070
Lake Meredith[1]	6,052	5,232	4,629	3,875	3,100	2,328
Greenbelt Lake[1]	1,453	1,433	1,404	1,382	1,360	1,352
Palo Duro Reservoir[2]	0	0	0	0	0	0
Canadian River Run-of-River	298	298	298	298	298	298
Red River Run-of-River	1,561	1,561	1,561	1,561	1,561	1,561
Total Surface Water	**9,364**	**8,524**	**7,892**	**7,116**	**6,319**	**5,539**
Ogallala Aquifer[1]	1,576,121	1,453,180	1,339,591	1,243,026	1,159,706	1,093,426
Seymour Aquifer	48,428	48,363	50,198	48,302	47,549	49,948
Blaine Aquifer	16,680	16,675	16,677	16,680	16,684	16,687
Dockum Aquifer	33,967	32,552	31,115	30,221	29,334	28,743
Other Aquifer	1,977	1,977	1,977	1,977	1,977	1,977
Total Groundwater	**1,677,673**	**1,553,080**	**1,439,909**	**1,340,573**	**1,255,632**	**1,191,180**
Local Supply	13,192	13,192	13,192	13,192	13,192	13,192
Direct Reuse	21,147	21,152	21,150	21,146	21,142	21,139
Total Other Supplies	**34,339**	**34,344**	**34,342**	**34,338**	**34,334**	**34,331**
Total Supply	**1,721,376**	**1,595,948**	**1,482,143**	**1,382,026**	**1,296,286**	**1,231,051**

[1] Quantity of water allocated to PWPA users only. Supplies from these sources are also used in other regions. Supplies in excess of the allocations are assigned to the MWP and are not reported in this table.
[2] There is no currently available supply from Palo Duro Reservoir under a safe yield analysis and there is no infrastructure.

Table 3-22: Unallocated Water Supplies in PWPA (ac-ft/yr)

Source	2030	2040	2050	2060	2070	2080
Lake Meredith[1]	18,548	19,368	19,971	20,725	21,500	22,272
Greenbelt Lake[1]	1,687	1,537	1,396	1,210	1,023	822
Palo Duro Reservoir[1]	0	0	0	0	0	0
Canadian River Run-of-River	0	0	0	0	0	0
Red River Run-of-River	0	0	0	0	0	0
Total Surface Water	**20,235**	**20,905**	**21,367**	**21,935**	**22,523**	**23,094**
Ogallala Aquifer	1,571,894	1,470,833	1,329,915	1,192,104	1,046,089	897,680
Seymour Aquifer	3,060	3,309	3,299	3,285	3,260	3,245
Blaine Aquifer	14,724	14,722	14,712	14,701	14,689	14,677
Dockum Aquifer	292,074	288,401	272,567	253,519	230,068	211,844
Other Aquifer	776	776	776	776	776	776
Total Groundwater	**1,882,528**	**1,778,041**	**1,621,269**	**1,464,385**	**1,294,882**	**1,128,222**
Local Supply	0	0	0	0	0	0
Direct Reuse[1]	3,732	4,805	5,686	6,376	7,064	7,746
Total Other Supplies	**3,732**	**4,805**	**5,686**	**6,376**	**7,064**	**7,746**
Total Unallocated Supply	**1,906,495**	**1,803,751**	**1,648,322**	**1,492,697**	**1,324,468**	**1,159,062**

[1] The amounts shown are actually fully allocated to the respective water Authorities, but there is an unused surplus.

Table 3-23: Unallocated Water Supplies in PWPA by County (ac-ft/yr)

County	2030	2040	2050	2060	2070	2080
Armstrong	56,138	49,775	44,290	39,215	35,256	32,052
Carson	43,863	32,362	26,884	23,925	17,203	4,940
Childress	11,839	11,912	11,902	11,884	11,854	11,835
Collingsworth	106	280	270	263	256	248
Dallam	57,974	51,556	46,234	41,000	35,483	31,471
Donley	44,401	43,303	38,797	33,268	27,198	19,680
Gray	140,714	132,883	119,995	106,961	93,998	82,246
Hall	5,840	5,840	5,840	5,840	5,840	5,840
Hansford	115,407	101,204	83,765	67,097	49,029	30,565
Hartley	114,004	108,600	99,214	90,103	81,420	73,902
Hemphill	36,719	43,097	46,499	48,903	50,107	51,013
Hutchinson	42,561	36,678	28,932	21,464	15,238	12,538
Lipscomb	224,932	217,599	204,115	189,728	173,160	156,190
Moore	13,930	13,297	11,275	9,341	7,296	5,115
Ochiltree	166,298	153,496	137,722	121,928	105,805	87,935
Oldham	186,132	175,436	159,983	144,333	129,447	117,196
Potter	56,774	54,005	49,832	45,672	41,405	37,885
Randall	79,869	75,305	64,989	53,712	40,495	31,813
Roberts	366,126	354,015	329,698	306,885	280,203	249,589
Sherman	8,459	6,683	4,550	2,930	1,752	969
Wheeler	110,442	110,715	106,483	99,933	92,437	85,200
Total	**1,882,528**	**1,778,041**	**1,621,269**	**1,464,385**	**1,294,882**	**1,128,222**

Note: The amounts shown do not include surplus surface water or direct reuse supplies, which are technically fully allocated.

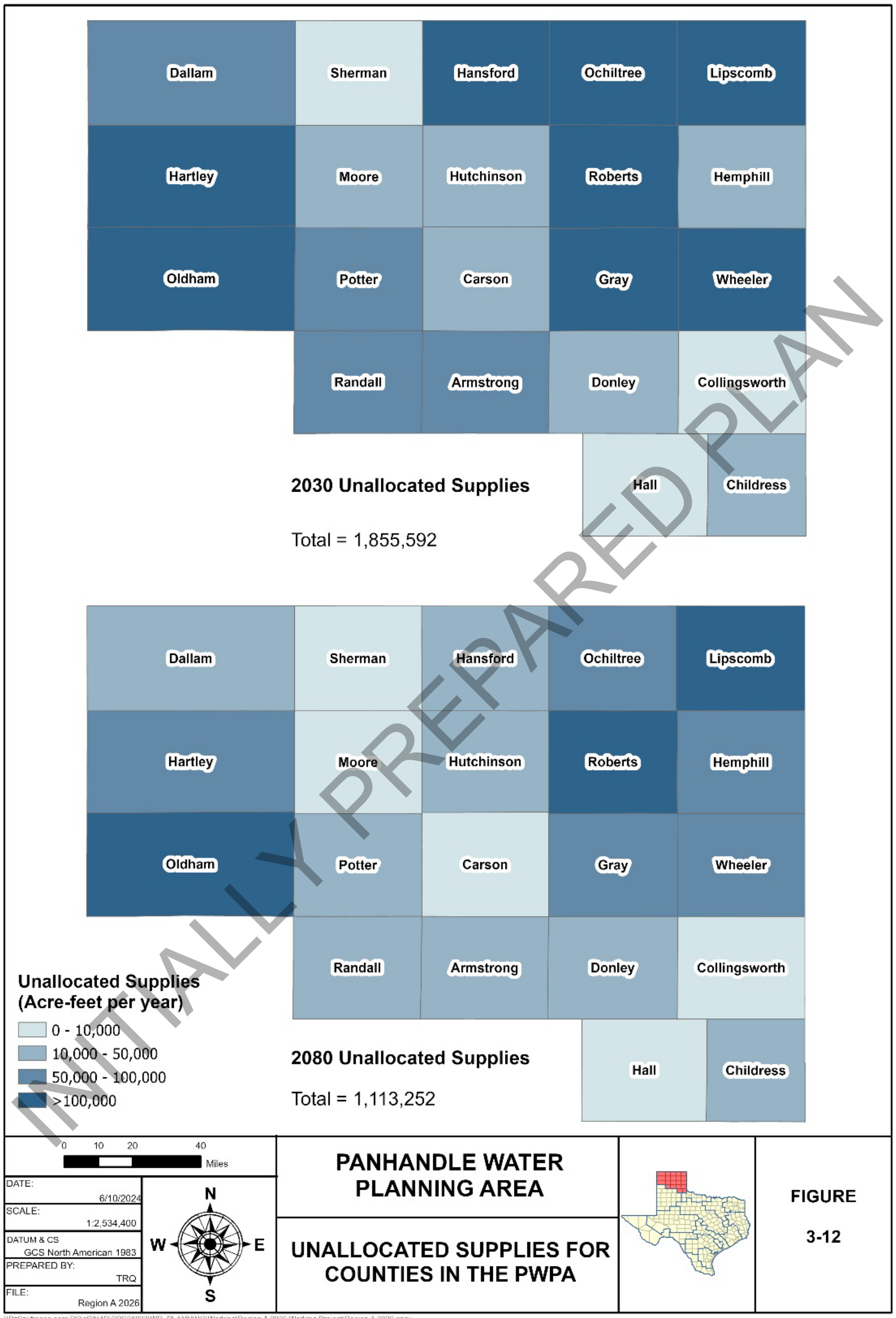


Figure 3-12: Unallocated Supplies by County

List of References

(1) Deeds, N.E., and Jigmond, M, 2015. *Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model*, prepared for the Texas Water Development Board.

(2) Duffin, G.L., and Beynon, B., 1992. *Evaluation of water resources in parts of the Rolling Prairies Region of North-Central Texas*, Texas Water Development Board Report 337.

(3) Dutton, A.R., 2004. *Adjustment of parameters to improve the calibration of the Og-n model of the Ogallala aquifer, Panhandle water planning area: prepared for Freese and Nichols, Inc. and Panhandle Water Planning Group*.

(4) Ewing, J., Jones, T.L., Pickens, J.F., Chastain-Howley, A., Dean, K.E., and Spear, A.A.,2004. *Final Report: Groundwater Availability Model for the Seymour aquifer*.

(5) TWDB, 2017. GAM Run 16-029 MAG: Modeled Available Groundwater for the aquifers in Groundwater Management Area 1.

(6) TWDB, 2017. GAM Run 16-031 MAG: Modeled Available Groundwater for the Seymour, Blaine, Ogallala, and Dockum aquifers in Groundwater Management Area 6.

ATTACHMENT 3-1

EXISTING WATER SUPPLIES TO WATER USER GROUPS
AND
MAJOR WATER PROVIDERS

DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Armstrong County WUG Total			**8,687**	**7,781**	**7,099**	**6,574**	**5,971**	**5,455**
Armstrong County / Red Basin WUG Total			**8,687**	**7,781**	**7,099**	**6,574**	**5,971**	**5,455**
Claude Municipal Water System	A	Ogallala Aquifer | Armstrong County	322	316	314	312	310	308
County-Other	A	Dockum Aquifer | Armstrong County	17	16	16	16	16	16
County-Other	A	Ogallala Aquifer | Armstrong County	71	70	69	68	67	66
Livestock	A	Dockum Aquifer | Armstrong County	104	104	104	104	104	104
Livestock	A	Local Surface Water Supply	79	79	79	79	79	79
Livestock	A	Ogallala Aquifer | Armstrong County	345	353	361	369	377	385
Livestock	A	Other Aquifer | Armstrong County	28	28	28	28	28	28
Irrigation	A	Dockum Aquifer | Armstrong County	3	3	3	3	3	3
Irrigation	A	Ogallala Aquifer | Armstrong County	7,718	6,812	6,125	5,595	4,987	4,466
Carson County WUG Total			**104,936**	**110,413**	**106,363**	**101,147**	**101,151**	**101,178**
Carson County / Canadian Basin WUG Total			**26,926**	**28,331**	**27,260**	**25,887**	**25,864**	**25,843**
Fritch	A	Ogallala Aquifer | Carson County	99	100	101	98	96	92
White Deer	A	Ogallala Aquifer | Carson County	93	84	75	67	61	54
County-Other	A	Ogallala Aquifer | Carson County	90	80	68	55	41	25
Manufacturing	A	Ogallala Aquifer | Carson County	37	38	39	41	42	44
Livestock	A	Local Surface Water Supply	53	53	53	53	53	53
Livestock	A	Ogallala Aquifer | Carson County	187	191	194	198	202	206
Irrigation	A	Dockum Aquifer | Carson County	1	1	1	1	1	1
Irrigation	A	Ogallala Aquifer | Carson County	26,348	27,766	26,711	25,356	25,350	25,350
Irrigation	A	Red Run-of-River	18	18	18	18	18	18

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Carson County / Red Basin WUG Total			**78,010**	**82,082**	**79,103**	**75,260**	**75,287**	**75,335**
Groom Municipal Water System	A	Ogallala Aquifer | Carson County	182	168	168	168	168	168
Panhandle Municipal Water System	A	Ogallala Aquifer | Carson County	503	503	509	511	517	527
White Deer	A	Ogallala Aquifer | Carson County	137	123	111	100	89	81
County-Other	A	Ogallala Aquifer | Carson County	117	103	87	70	52	33
Manufacturing	A	Ogallala Aquifer | Carson County	1,460	1,514	1,570	1,628	1,689	1,751
Mining	A	Ogallala Aquifer | Carson County	3	3	3	3	3	3
Livestock	A	Local Surface Water Supply	43	43	43	43	43	43
Livestock	A	Ogallala Aquifer | Carson County	150	152	156	159	162	165
Irrigation	A	Dockum Aquifer | Carson County	2	2	2	2	2	2
Irrigation	A	Ogallala Aquifer | Carson County	75,362	79,420	76,403	72,525	72,511	72,511
Irrigation	A	Red Run-of-River	51	51	51	51	51	51
Childress County WUG Total			**16,976**	**16,987**	**16,970**	**16,959**	**16,944**	**16,932**
Childress County / Red Basin WUG Total			**16,976**	**16,987**	**16,970**	**16,959**	**16,944**	**16,932**
Childress	A	Greenbelt Lake/Reservoir	844	859	847	825	804	790
Childress	A	Ogallala Aquifer | Donley County	430	456	449	436	420	396
Red River Authority of Texas*	A	Greenbelt Lake/Reservoir	253	234	230	237	242	253
Red River Authority of Texas*	A	Ogallala Aquifer | Donley County	129	124	122	125	127	126
County-Other	A	Other Aquifer | Childress County	1	1	1	1	1	1
County-Other	A	Seymour Aquifer | Childress County	20	7	7	13	20	27
Livestock	A	Blaine Aquifer | Childress County	105	112	120	128	136	145
Livestock	A	Local Surface Water Supply	38	38	38	38	38	38

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Livestock	A	Other Aquifer | Childress County	159	159	159	159	159	159
Livestock	A	Seymour Aquifer | Childress County	26	26	26	26	26	26
Irrigation	A	Blaine Aquifer | Childress County	14,627	14,623	14,624	14,628	14,632	14,635
Irrigation	A	Direct Reuse	127	131	130	126	122	119
Irrigation	A	Other Aquifer | Childress County	72	72	72	72	72	72
Irrigation	A	Red Run-of-River	6	6	6	6	6	6
Irrigation	A	Seymour Aquifer | Childress County	139	139	139	139	139	139
Collingsworth County WUG Total			**34,477**	**31,390**	**29,986**	**25,162**	**25,604**	**32,482**
Collingsworth County / Red Basin WUG Total			**34,477**	**31,390**	**29,986**	**25,162**	**25,604**	**32,482**
Red River Authority of Texas*	A	Greenbelt Lake/Reservoir	11	10	10	10	11	11
Red River Authority of Texas*	A	Ogallala Aquifer | Donley County	5	6	6	6	5	5
Red River Authority of Texas*	A	Seymour Aquifer | Collingsworth County	74	72	67	63	59	56
Wellington Municipal Water System	A	Seymour Aquifer | Collingsworth County	358	174	164	157	149	141
County-Other	A	Blaine Aquifer | Collingsworth County	6	6	6	5	5	5
County-Other	A	Other Aquifer | Collingsworth County	1	1	1	1	1	1
County-Other	A	Seymour Aquifer | Collingsworth County	97	93	87	83	79	74
Livestock	A	Blaine Aquifer | Collingsworth County	378	378	378	378	378	378
Livestock	A	Local Surface Water Supply	18	18	18	18	18	18
Livestock	A	Other Aquifer | Collingsworth County	47	58	69	81	93	105
Livestock	A	Seymour Aquifer | Collingsworth County	19	19	19	19	19	19
Irrigation	A	Blaine Aquifer | Collingsworth County	1,564	1,564	1,564	1,564	1,564	1,564

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Irrigation	A	Other Aquifer | Collingsworth County	261	250	239	227	215	203
Irrigation	A	Red Run-of-River	694	694	694	694	694	694
Irrigation	A	Seymour Aquifer | Collingsworth County	30,944	28,047	26,664	21,856	22,314	29,208
Dallam County WUG Total			**227,958**	**192,684**	**163,457**	**139,044**	**122,471**	**109,851**
Dallam County / Canadian Basin WUG Total			**227,958**	**192,684**	**163,457**	**139,044**	**122,471**	**109,851**
Dalhart	A	Dockum Aquifer | Dallam County	14	12	12	11	10	9
Dalhart	A	Ogallala and Rita Blanca Aquifers | Dallam County	1,678	1,783	1,887	2,000	2,117	2,239
Texline	A	Ogallala and Rita Blanca Aquifers | Dallam County	166	171	177	182	188	195
County-Other	A	Ogallala and Rita Blanca Aquifers | Dallam County	144	144	142	121	98	72
Manufacturing	A	Ogallala and Rita Blanca Aquifers | Dallam County	1,333	1,382	1,433	1,486	1,541	1,598
Livestock	A	Local Surface Water Supply	1,786	1,786	1,786	1,786	1,786	1,786
Livestock	A	Ogallala and Rita Blanca Aquifers | Dallam County	3,436	3,689	3,757	3,827	3,898	3,971
Irrigation	A	Dockum Aquifer | Dallam County	12,583	11,877	11,271	10,816	10,244	9,789
Irrigation	A	Ogallala and Rita Blanca Aquifers | Dallam County	206,818	171,840	142,992	118,815	102,589	90,192
Donley County WUG Total			**34,147**	**34,114**	**34,079**	**34,059**	**34,038**	**34,016**
Donley County / Red Basin WUG Total			**34,147**	**34,114**	**34,079**	**34,059**	**34,038**	**34,016**
Clarendon	A	Greenbelt Lake/Reservoir	197	184	171	164	157	151
Clarendon	A	Ogallala Aquifer | Donley County	101	97	91	87	82	76
Red River Authority of Texas*	A	Greenbelt Lake/Reservoir	20	20	20	20	20	20
Red River Authority of Texas*	A	Ogallala Aquifer | Donley County	62	56	50	47	44	40
County-Other	A	Greenbelt Lake/Reservoir	37	37	37	37	37	37
County-Other	A	Ogallala Aquifer | Donley County	107	97	87	81	75	69
Livestock	A	Local Surface Water Supply	240	240	240	240	240	240

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Livestock	A	Ogallala Aquifer | Donley County	671	671	671	671	671	671
Livestock	A	Other Aquifer | Donley County	272	272	272	272	272	272
Irrigation	A	Ogallala Aquifer | Donley County	32,263	32,263	32,263	32,263	32,263	32,263
Irrigation	A	Red Run-of-River	177	177	177	177	177	177
Gray County WUG Total			**43,571**	**43,042**	**42,500**	**42,120**	**41,884**	**41,724**
Gray County / Canadian Basin WUG Total			**14,438**	**13,871**	**13,350**	**13,007**	**12,817**	**12,713**
Pampa Municipal Water System	A	Meredith Lake/Reservoir	271	213	175	156	135	101
Pampa Municipal Water System	A	Ogallala Aquifer | Gray County	1,724	1,431	1,135	903	713	713
Pampa Municipal Water System	A	Ogallala Aquifer | Roberts County	1,521	1,265	1,093	1,035	1,100	1,088
County-Other	A	Ogallala Aquifer | Gray County	318	334	306	257	197	123
Manufacturing	A	Ogallala Aquifer | Gray County	516	530	541	555	569	584
Livestock	A	Local Surface Water Supply	155	155	155	155	155	155
Livestock	A	Ogallala Aquifer | Gray County	325	335	337	338	340	341
Irrigation	A	Canadian Run-of-River	0	0	0	0	0	0
Irrigation	A	Direct Reuse	57	57	57	57	57	57
Irrigation	A	Ogallala Aquifer | Gray County	9,545	9,545	9,545	9,545	9,545	9,545
Irrigation	A	Red Run-of-River	6	6	6	6	6	6
Gray County / Red Basin WUG Total			**29,133**	**29,171**	**29,150**	**29,113**	**29,067**	**29,011**
McLean Municipal Water Supply	A	Ogallala Aquifer | Gray County	170	168	162	156	149	143
County-Other	A	Ogallala Aquifer | Gray County	238	249	228	191	147	92
Manufacturing	A	Ogallala Aquifer | Gray County	5	4	6	6	6	6
Livestock	A	Local Surface Water Supply	445	445	445	445	445	445
Livestock	A	Ogallala Aquifer | Gray County	931	961	965	971	976	981

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year) 2030	2040	2050	2060	2070	2080
Irrigation	A	Canadian Run-of-River	1	1	1	1	1	1
Irrigation	A	Direct Reuse	163	163	163	163	163	163
Irrigation	A	Ogallala Aquifer | Gray County	27,162	27,162	27,162	27,162	27,162	27,162
Irrigation	A	Red Run-of-River	18	18	18	18	18	18
Hall County WUG Total			**18,473**	**21,318**	**24,548**	**27,460**	**26,248**	**21,753**
Hall County / Red Basin WUG Total			**18,473**	**21,318**	**24,548**	**27,460**	**26,248**	**21,753**
Memphis	A	Greenbelt Lake/Reservoir	25	24	24	24	24	25
Memphis	A	Ogallala Aquifer | Donley County	271	256	237	220	203	185
Red River Authority of Texas*	A	Greenbelt Lake/Reservoir	66	65	65	65	66	67
Red River Authority of Texas*	A	Ogallala Aquifer | Donley County	34	35	35	35	34	33
Red River Authority of Texas*	A	Seymour Aquifer | Hall County	10	10	10	13	14	30
Turkey Municipal Water System	A	Seymour Aquifer | Hall County	89	84	75	68	62	57
County-Other	A	Seymour Aquifer | Hall County	91	85	74	68	61	54
Manufacturing	A	Seymour Aquifer | Hall County	1	1	1	1	1	1
Livestock	A	Local Surface Water Supply	128	128	128	128	128	128
Livestock	A	Other Aquifer | Hall County	196	205	213	222	231	240
Livestock	A	Seymour Aquifer | Hall County	17	17	17	17	17	17
Irrigation	A	Direct Reuse	100	100	100	100	100	100
Irrigation	A	Other Aquifer | Hall County	890	881	873	864	855	846
Irrigation	A	Red Run-of-River	12	12	12	12	12	12
Irrigation	A	Seymour Aquifer | Hall County	16,543	19,415	22,684	25,623	24,440	19,958
Hansford County WUG Total			**182,273**	**182,388**	**182,505**	**182,627**	**182,751**	**182,879**
Hansford County / Canadian Basin WUG Total			**182,273**	**182,388**	**182,505**	**182,627**	**182,751**	**182,879**
Gruver	A	Ogallala Aquifer | Hansford County	301	301	301	301	301	301

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Spearman Municipal Water System	A	Ogallala Aquifer | Hansford County	1,000	1,000	1,000	1,000	1,000	1,000
County-Other	A	Ogallala Aquifer | Hansford County	129	131	132	134	136	138
Manufacturing	A	Ogallala Aquifer | Hansford County	359	372	386	400	415	430
Mining	A	Ogallala Aquifer | Hansford County	93	93	93	93	93	93
Livestock	A	Local Surface Water Supply	1,958	1,958	1,958	1,958	1,958	1,958
Livestock	A	Ogallala Aquifer | Hansford County	2,747	2,847	2,949	3,055	3,162	3,273
Irrigation	A	Canadian Run-of-River	22	22	22	22	22	22
Irrigation	A	Ogallala Aquifer | Hansford County	175,664	175,664	175,664	175,664	175,664	175,664
Hartley County WUG Total			**238,884**	**181,992**	**149,366**	**128,009**	**110,860**	**97,198**
Hartley County / Canadian Basin WUG Total			**238,884**	**181,992**	**149,366**	**128,009**	**110,860**	**97,198**
Dalhart	A	Dockum Aquifer | Dallam County	8	7	6	5	5	5
Dalhart	A	Ogallala and Rita Blanca Aquifers | Dallam County	943	965	996	1,037	1,082	1,133
Hartley WSC	A	Ogallala and Rita Blanca Aquifers | Hartley County	168	163	160	159	158	157
County-Other	A	Ogallala and Rita Blanca Aquifers | Hartley County	323	304	277	240	199	154
Mining	A	Ogallala and Rita Blanca Aquifers | Hartley County	85	85	85	85	85	85
Livestock	A	Dockum Aquifer | Hartley County	1,128	1,128	1,128	1,128	1,128	1,128
Livestock	A	Local Surface Water Supply	3,480	3,480	3,480	3,480	3,480	3,480
Livestock	A	Ogallala and Rita Blanca Aquifers | Hartley County	6,193	6,193	6,193	6,193	6,193	6,193
Irrigation	A	Dockum Aquifer | Hartley County	8,043	7,327	6,740	6,298	5,924	5,647
Irrigation	A	Ogallala and Rita Blanca Aquifers | Hartley County	218,513	162,340	130,301	109,384	92,606	79,216

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Hemphill County WUG Total			**9,320**	**9,334**	**9,345**	**9,359**	**9,373**	**9,387**
Hemphill County / Canadian Basin WUG Total			**6,461**	**6,470**	**6,476**	**6,484**	**6,492**	**6,501**
Canadian	A	Ogallala Aquifer | Hemphill County	675	675	675	675	675	675
County-Other	A	Ogallala Aquifer | Hemphill County	78	78	75	74	73	72
Mining	A	Ogallala Aquifer | Hemphill County	1,011	1,011	1,011	1,011	1,011	1,011
Livestock	A	Local Surface Water Supply	131	131	131	131	131	131
Livestock	A	Ogallala Aquifer | Hemphill County	511	520	529	538	547	557
Irrigation	A	Ogallala Aquifer | Hemphill County	4,055	4,055	4,055	4,055	4,055	4,055
Hemphill County / Red Basin WUG Total			**2,859**	**2,864**	**2,869**	**2,875**	**2,881**	**2,886**
County-Other	A	Ogallala Aquifer | Hemphill County	40	39	38	38	37	36
Manufacturing	A	Ogallala Aquifer | Hemphill County	2	2	2	2	2	2
Mining	A	Ogallala Aquifer | Hemphill County	544	544	544	544	544	544
Livestock	A	Local Surface Water Supply	92	92	92	92	92	92
Livestock	A	Ogallala Aquifer | Hemphill County	359	365	371	377	384	390
Irrigation	A	Ogallala Aquifer | Hemphill County	1,822	1,822	1,822	1,822	1,822	1,822
Hutchinson County WUG Total			**86,424**	**86,765**	**87,130**	**87,498**	**87,781**	**84,362**
Hutchinson County / Canadian Basin WUG Total			**86,424**	**86,765**	**87,130**	**87,498**	**87,781**	**84,362**
Borger	A	Meredith Lake/Reservoir	192	161	131	104	78	56
Borger	A	Ogallala Aquifer | Hutchinson County	2,485	2,231	1,977	1,756	1,594	1,429
Borger	A	Ogallala Aquifer | Roberts County	534	597	675	718	758	719
Fritch	A	Ogallala Aquifer | Carson County	883	811	744	660	585	519
Stinnett	A	Ogallala Aquifer | Hutchinson County	380	381	380	381	209	167

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
TCW Supply	A	Ogallala Aquifer | Hutchinson County	942	879	821	765	714	667
County-Other	A	Ogallala Aquifer | Hutchinson County	197	219	216	203	180	147
Manufacturing	A	Canadian Run-of-River	2	2	2	2	2	2
Manufacturing	A	Direct Reuse	1,100	1,100	1,100	1,100	1,100	1,100
Manufacturing	A	Meredith Lake/Reservoir	600	532	463	391	318	241
Manufacturing	A	Ogallala Aquifer | Hutchinson County	14,860	15,297	15,658	16,125	16,592	15,605
Manufacturing	A	Ogallala Aquifer | Roberts County	1,669	1,975	2,383	2,713	3,071	3,110
Mining	A	Ogallala Aquifer | Hutchinson County	67	67	67	67	67	67
Livestock	A	Local Surface Water Supply	164	164	164	164	164	164
Livestock	A	Ogallala Aquifer | Hutchinson County	483	483	483	483	483	483
Irrigation	A	Canadian Run-of-River	96	96	96	96	96	96
Irrigation	A	Ogallala Aquifer | Hutchinson County	61,770	61,770	61,770	61,770	61,770	59,790
Lipscomb County WUG Total			**46,727**	**46,698**	**46,649**	**46,605**	**46,570**	**46,527**
Lipscomb County / Canadian Basin WUG Total			**46,727**	**46,698**	**46,649**	**46,605**	**46,570**	**46,527**
Booker	A	Ogallala Aquifer | Lipscomb County	125	117	104	93	82	71
Booker	A	Ogallala Aquifer | Ochiltree County	139	122	104	87	75	62
Darrouzett	A	Ogallala Aquifer | Lipscomb County	84	79	74	69	64	59
Follett	A	Ogallala Aquifer | Lipscomb County	95	84	74	67	62	59
Higgins Municipal Water System	A	Ogallala Aquifer | Lipscomb County	87	82	75	70	65	59
County-Other	A	Ogallala Aquifer | Lipscomb County	183	180	173	168	160	151
Manufacturing	A	Direct Reuse	300	300	300	300	300	300
Manufacturing	A	Ogallala Aquifer | Lipscomb County	151	158	161	161	163	162
Manufacturing	A	Ogallala Aquifer | Ochiltree County	169	165	160	153	148	139

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Mining	A	Ogallala Aquifer | Lipscomb County	1,018	1,018	1,018	1,018	1,018	1,018
Livestock	A	Local Surface Water Supply	168	168	168	168	168	168
Livestock	A	Ogallala Aquifer | Lipscomb County	859	876	889	902	916	930
Irrigation	A	Canadian Run-of-River	66	66	66	66	66	66
Irrigation	A	Ogallala Aquifer | Lipscomb County	43,283	43,283	43,283	43,283	43,283	43,283
Moore County WUG Total			**145,562**	**137,616**	**126,496**	**111,327**	**94,053**	**80,173**
Moore County / Canadian Basin WUG Total			**145,562**	**137,616**	**126,496**	**111,327**	**94,053**	**80,173**
Cactus Municipal Water System	A	Ogallala Aquifer | Moore County	872	763	663	567	484	413
Dumas	A	Ogallala and Rita Blanca Aquifers | Hartley County	2,699	1,372	853	615	498	438
Dumas	A	Ogallala Aquifer | Moore County	661	662	661	662	639	508
Fritch	A	Ogallala Aquifer | Carson County	33	33	33	32	30	29
Sunray	A	Ogallala Aquifer | Moore County	457	459	457	459	365	353
County-Other	A	Ogallala and Rita Blanca Aquifers | Hartley County	45	23	14	10	9	8
County-Other	A	Ogallala Aquifer | Moore County	216	234	241	237	229	221
Manufacturing	A	Ogallala Aquifer | Moore County	9,847	9,556	9,296	9,068	8,859	8,668
Manufacturing	A	Water Recycling	500	500	500	500	500	500
Mining	A	Ogallala Aquifer | Moore County	33	33	33	33	33	33
Livestock	A	Local Surface Water Supply	823	823	823	823	823	823
Livestock	A	Ogallala Aquifer | Moore County	4,719	4,719	4,719	4,719	4,719	4,719
Irrigation	A	Canadian Run-of-River	7	7	7	7	7	7
Irrigation	A	Dockum Aquifer | Moore County	1,390	1,299	1,150	1,101	1,091	1,126
Irrigation	A	Ogallala Aquifer | Moore County	123,260	117,133	107,046	92,494	75,767	62,327

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Ochiltree County WUG Total			**93,812**	**93,936**	**93,961**	**93,894**	**93,741**	**93,604**
Ochiltree County / Canadian Basin WUG Total			**93,812**	**93,936**	**93,961**	**93,894**	**93,741**	**93,604**
Booker	A	Ogallala Aquifer | Lipscomb County	2	2	2	2	2	2
Booker	A	Ogallala Aquifer | Ochiltree County	2	2	2	2	2	2
Perryton Municipal Water System	A	Ogallala Aquifer | Ochiltree County	2,737	2,805	2,789	2,680	2,484	2,304
County-Other	A	Ogallala Aquifer | Ochiltree County	279	291	300	308	317	325
Manufacturing	A	Ogallala Aquifer | Ochiltree County	34	35	36	37	38	39
Mining	A	Ogallala Aquifer | Ochiltree County	797	797	797	797	797	797
Livestock	A	Local Surface Water Supply	443	443	443	443	443	443
Livestock	A	Ogallala Aquifer | Ochiltree County	2,835	2,878	2,909	2,942	2,975	3,009
Irrigation	A	Ogallala Aquifer | Ochiltree County	86,683	86,683	86,683	86,683	86,683	86,683
Oldham County WUG Total			**7,459**	**7,418**	**7,366**	**7,309**	**7,252**	**6,923**
Oldham County / Canadian Basin WUG Total			**3,158**	**3,125**	**3,085**	**3,040**	**2,995**	**2,884**
Vega	A	Ogallala Aquifer | Oldham County	224	222	215	210	205	200
County-Other	A	Dockum Aquifer | Oldham County	172	145	113	78	42	8
County-Other	A	Ogallala Aquifer | Oldham County	29	24	20	14	8	2
Mining	A	Ogallala Aquifer | Oldham County	312	312	312	312	312	312
Livestock	A	Dockum Aquifer | Oldham County	533	532	533	533	533	532
Livestock	A	Local Surface Water Supply	517	517	517	517	517	517
Livestock	A	Ogallala Aquifer | Oldham County	238	240	242	243	245	246
Irrigation	A	Dockum Aquifer | Oldham County	89	89	89	89	89	89

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Irrigation	A	Ogallala Aquifer | Oldham County	1,044	1,044	1,044	1,044	1,044	978
Oldham County / Red Basin WUG Total			**4,301**	**4,293**	**4,281**	**4,269**	**4,257**	**4,039**
County-Other	A	Dockum Aquifer | Oldham County	53	44	35	24	14	3
County-Other	A	Ogallala Aquifer | Oldham County	9	8	6	4	2	0
Mining	A	Ogallala Aquifer | Oldham County	104	104	104	104	104	104
Livestock	A	Dockum Aquifer | Oldham County	226	227	226	226	226	227
Livestock	A	Local Surface Water Supply	220	220	220	220	220	220
Livestock	A	Ogallala Aquifer | Oldham County	101	102	102	103	103	104
Irrigation	A	Dockum Aquifer | Oldham County	283	283	283	283	283	283
Irrigation	A	Ogallala Aquifer | Oldham County	3,305	3,305	3,305	3,305	3,305	3,098
Potter County WUG Total			**54,401**	**51,161**	**48,535**	**45,457**	**43,822**	**42,354**
Potter County / Canadian Basin WUG Total			**32,514**	**30,943**	**29,620**	**28,098**	**27,210**	**26,422**
Amarillo	A	Dockum Aquifer | Carson County	1	1	1	1	1	1
Amarillo	A	Dockum Aquifer | Potter County	150	141	131	121	110	99
Amarillo	A	Meredith Lake/Reservoir	1,168	951	791	610	447	309
Amarillo	O	Ogallala and Edwards-Trinity-High Plains Aquifers | Deaf Smith County	24	11	10	0	0	0
Amarillo	A	Ogallala Aquifer | Carson County	3,924	3,645	3,314	3,007	2,751	2,479
Amarillo	A	Ogallala Aquifer | Potter County	635	546	450	362	301	250
Amarillo	A	Ogallala Aquifer | Randall County	177	124	95	77	40	37
Amarillo	A	Ogallala Aquifer | Roberts County	6,541	5,633	4,932	4,040	3,661	3,317
County-Other	A	Dockum Aquifer | Potter County	1,417	1,424	1,424	1,414	1,411	1,415

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
County-Other	A	Ogallala Aquifer | Potter County	243	246	246	243	242	243
Manufacturing	A	Direct Reuse	94	94	94	94	94	94
Manufacturing	A	Dockum Aquifer | Potter County	6	6	6	6	6	6
Manufacturing	A	Meredith Lake/Reservoir	49	42	38	32	26	19
Manufacturing	O	Ogallala and Edwards-Trinity-High Plains Aquifers | Deaf Smith County	1	0	0	0	0	0
Manufacturing	A	Ogallala Aquifer | Carson County	167	163	158	157	157	156
Manufacturing	A	Ogallala Aquifer | Potter County	47	44	42	39	37	36
Manufacturing	A	Ogallala Aquifer | Randall County	7	5	5	4	2	2
Manufacturing	A	Ogallala Aquifer | Roberts County	277	251	236	211	209	208
Mining	A	Ogallala Aquifer | Potter County	478	508	539	572	607	643
Steam Electric Power	A	Direct Reuse	15,000	15,000	15,000	15,000	15,000	15,000
Livestock	A	Dockum Aquifer | Potter County	25	25	25	25	25	25
Livestock	A	Local Surface Water Supply	105	105	105	105	105	105
Livestock	A	Ogallala Aquifer | Potter County	276	276	276	276	276	276
Irrigation	A	Direct Reuse	1,079	1,079	1,078	1,079	1,079	1,078
Irrigation	A	Dockum Aquifer | Potter County	263	280	291	298	303	306
Irrigation	A	Ogallala Aquifer | Potter County	360	343	333	325	320	318
Potter County / Red Basin WUG Total			**21,887**	**20,218**	**18,915**	**17,359**	**16,612**	**15,932**
Amarillo	A	Dockum Aquifer | Carson County	0	0	0	0	0	0
Amarillo	A	Dockum Aquifer | Potter County	98	93	86	79	73	65
Amarillo	A	Meredith Lake/Reservoir	766	624	519	400	294	203

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Amarillo	O	Ogallala and Edwards-Trinity-High Plains Aquifers | Deaf Smith County	15	7	7	0	0	0
Amarillo	A	Ogallala Aquifer | Carson County	2,576	2,392	2,175	1,973	1,806	1,628
Amarillo	A	Ogallala Aquifer | Potter County	417	358	295	238	198	164
Amarillo	A	Ogallala Aquifer | Randall County	117	81	63	50	26	24
Amarillo	A	Ogallala Aquifer | Roberts County	4,294	3,698	3,237	2,652	2,403	2,177
County-Other	A	Dockum Aquifer | Potter County	795	800	799	793	790	795
County-Other	A	Ogallala Aquifer | Potter County	137	137	137	137	137	137
Manufacturing	A	Direct Reuse	1,506	1,506	1,506	1,506	1,506	1,506
Manufacturing	A	Dockum Aquifer | Potter County	102	101	101	102	102	100
Manufacturing	A	Meredith Lake/Reservoir	796	683	609	512	412	313
Manufacturing	O	Ogallala and Edwards-Trinity-High Plains Aquifers | Deaf Smith County	16	8	8	0	0	0
Manufacturing	A	Ogallala Aquifer | Carson County	2,673	2,617	2,552	2,528	2,534	2,508
Manufacturing	A	Ogallala Aquifer | Potter County	755	714	668	626	599	574
Manufacturing	A	Ogallala Aquifer | Randall County	121	89	73	64	38	37
Manufacturing	A	Ogallala Aquifer | Roberts County	4,457	4,045	3,797	3,396	3,371	3,356
Mining	A	Ogallala Aquifer | Potter County	285	304	322	342	362	384
Livestock	A	Dockum Aquifer | Potter County	12	12	12	12	12	12
Livestock	A	Local Surface Water Supply	49	49	49	49	49	49
Livestock	A	Ogallala Aquifer | Potter County	130	130	130	130	130	130
Irrigation	A	Direct Reuse	1,121	1,121	1,122	1,121	1,121	1,122
Irrigation	A	Dockum Aquifer | Potter County	274	292	303	311	315	318

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Irrigation	A	Ogallala Aquifer | Potter County	375	357	345	338	334	330
Randall County WUG Total			**52,835**	**50,986**	**49,224**	**47,059**	**45,997**	**45,083**
Randall County / Red Basin WUG Total			**52,835**	**50,986**	**49,224**	**47,059**	**45,997**	**45,083**
Amarillo	A	Dockum Aquifer | Carson County	1	1	1	1	1	1
Amarillo	A	Dockum Aquifer | Potter County	259	276	292	309	322	327
Amarillo	A	Meredith Lake/Reservoir	2,020	1,866	1,764	1,555	1,299	1,018
Amarillo	O	Ogallala and Edwards-Trinity-High Plains Aquifers | Deaf Smith County	40	22	23	0	0	0
Amarillo	A	Ogallala Aquifer | Carson County	6,788	7,149	7,384	7,666	7,993	8,187
Amarillo	A	Ogallala Aquifer | Potter County	1,098	1,071	1,003	923	875	825
Amarillo	A	Ogallala Aquifer | Randall County	307	243	213	195	117	121
Amarillo	A	Ogallala Aquifer | Roberts County	11,316	11,047	10,991	10,298	10,636	10,955
Canyon	A	Dockum Aquifer | Potter County	11	10	10	10	9	9
Canyon	A	Dockum Aquifer | Randall County	1,780	1,691	1,606	1,526	1,450	1,378
Canyon	A	Meredith Lake/Reservoir	84	69	59	48	37	27
Canyon	O	Ogallala and Edwards-Trinity-High Plains Aquifers | Deaf Smith County	2	1	1	0	0	0
Canyon	A	Ogallala Aquifer | Carson County	284	266	249	237	227	216
Canyon	A	Ogallala Aquifer | Potter County	46	40	34	29	25	22
Canyon	A	Ogallala Aquifer | Randall County	1,513	1,434	1,361	1,292	1,225	1,164
Canyon	A	Ogallala Aquifer | Roberts County	473	412	371	318	303	289
Happy*	O	Dockum Aquifer | Swisher County	10	11	12	13	14	16
Lake Tanglewood	A	Dockum Aquifer | Randall County	500	500	500	500	500	500

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DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Lake Tanglewood	A	Ogallala Aquifer | Randall County	111	107	92	74	57	44
Siesta Estates	A	Dockum Aquifer | Randall County	119	134	149	162	176	190
County-Other	A	Dockum Aquifer | Randall County	2,018	2,270	2,515	2,751	2,987	3,222
County-Other	A	Meredith Lake/Reservoir	2	2	1	1	1	1
County-Other	A	Ogallala Aquifer | Carson County	8	6	6	6	6	6
County-Other	A	Ogallala Aquifer | Potter County	1	1	1	1	1	1
County-Other	A	Ogallala Aquifer | Randall County	3,000	3,375	3,739	4,090	4,440	4,790
County-Other	A	Ogallala Aquifer | Roberts County	12	10	9	8	8	7
Manufacturing	A	Dockum Aquifer | Potter County	13	13	13	13	13	13
Manufacturing	A	Meredith Lake/Reservoir	104	89	79	66	53	40
Manufacturing	O	Ogallala and Edwards-Trinity-High Plains Aquifers | Deaf Smith County	2	1	1	0	0	0
Manufacturing	A	Ogallala Aquifer | Carson County	350	340	330	325	324	319
Manufacturing	A	Ogallala Aquifer | Potter County	57	51	45	39	35	32
Manufacturing	A	Ogallala Aquifer | Randall County	21	17	14	13	10	10
Manufacturing	A	Ogallala Aquifer | Roberts County	582	526	491	437	431	427
Livestock	A	Dockum Aquifer | Randall County	543	543	543	543	543	543
Livestock	A	Local Surface Water Supply	908	908	908	908	908	908
Livestock	A	Ogallala Aquifer | Randall County	1,327	1,341	1,352	1,363	1,374	1,386
Irrigation	A	Dockum Aquifer | Randall County	1,026	1,043	817	743	691	664
Irrigation	A	Ogallala Aquifer | Randall County	15,975	13,976	12,121	10,472	8,782	7,301
Irrigation	A	Red Run-of-River	124	124	124	124	124	124

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Roberts County WUG Total			**10,931**	**10,920**	**10,911**	**10,905**	**10,900**	**10,891**
Roberts County / Canadian Basin WUG Total			**10,432**	**10,419**	**10,412**	**10,406**	**10,399**	**10,391**
Miami	A	Ogallala Aquifer | Roberts County	200	180	162	146	131	118
County-Other	A	Ogallala Aquifer | Roberts County	30	29	29	29	29	29
Mining	A	Ogallala Aquifer | Roberts County	684	684	684	684	684	684
Livestock	A	Local Surface Water Supply	64	63	64	64	63	64
Livestock	A	Ogallala Aquifer | Roberts County	368	377	387	397	406	410
Irrigation	A	Canadian Run-of-River	69	69	69	69	69	69
Irrigation	A	Ogallala Aquifer | Roberts County	9,017	9,017	9,017	9,017	9,017	9,017
Roberts County / Red Basin WUG Total			**499**	**501**	**499**	**499**	**501**	**500**
County-Other	A	Ogallala Aquifer | Roberts County	3	3	2	2	2	2
Livestock	A	Local Surface Water Supply	2	3	2	2	3	2
Livestock	A	Ogallala Aquifer | Roberts County	16	17	17	17	18	18
Irrigation	A	Canadian Run-of-River	3	3	3	3	3	3
Irrigation	A	Ogallala Aquifer | Roberts County	475	475	475	475	475	475
Sherman County WUG Total			**280,292**	**255,826**	**222,558**	**196,379**	**165,889**	**145,399**
Sherman County / Canadian Basin WUG Total			**280,292**	**255,826**	**222,558**	**196,379**	**165,889**	**145,399**
Stratford	A	Ogallala Aquifer | Sherman County	434	435	433	366	221	146
Texhoma	A	Ogallala Aquifer | Sherman County	85	83	80	77	74	71
County-Other	A	Ogallala Aquifer | Sherman County	116	113	109	105	101	96
Manufacturing	A	Ogallala Aquifer | Sherman County	2	2	2	2	2	2
Mining	A	Ogallala Aquifer | Sherman County	7	7	7	7	7	7
Livestock	A	Local Surface Water Supply	646	646	646	646	646	646

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Existing Water Supply

WUG Name	Source Region	Source Description	Existing Supply (acre-feet per year)					
			2030	2040	2050	2060	2070	2080
Livestock	A	Ogallala Aquifer | Sherman County	3,970	4,091	4,159	4,228	4,300	4,373
Irrigation	A	Canadian Run-of-River	32	32	32	32	32	32
Irrigation	A	Dockum Aquifer | Sherman County	416	310	288	293	288	291
Irrigation	A	Ogallala Aquifer | Sherman County	274,584	250,107	216,802	190,623	160,218	139,735
Wheeler County WUG Total			**23,341**	**23,240**	**23,157**	**23,087**	**23,000**	**22,897**
Wheeler County / Red Basin WUG Total			**23,341**	**23,240**	**23,157**	**23,087**	**23,000**	**22,897**
Shamrock Municipal Water System	A	Ogallala Aquifer | Wheeler County	314	276	272	262	210	123
Wheeler	A	Ogallala Aquifer | Wheeler County	398	304	216	147	103	78
County-Other	A	Ogallala Aquifer | Wheeler County	233	223	213	204	194	184
County-Other	A	Other Aquifer | Wheeler County	22	22	22	22	22	22
Mining	A	Ogallala Aquifer | Wheeler County	4,156	4,156	4,157	4,157	4,158	4,158
Livestock	A	Local Surface Water Supply	437	437	437	437	437	437
Livestock	A	Ogallala Aquifer | Wheeler County	840	881	899	917	935	954
Livestock	A	Other Aquifer | Wheeler County	28	28	28	28	28	28
Irrigation	A	Ogallala Aquifer | Wheeler County	16,458	16,458	16,458	16,458	16,458	16,458
Irrigation	A	Red Run-of-River	455	455	455	455	455	455
Region A WUG Existing Water Supply Total			**1,721,486**	**1,596,009**	**1,482,205**	**1,382,040**	**1,296,300**	**1,231,068**

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Major Water Provider (MWP) Existing Sales and Transfers

Major Water Providers are entities of particular significance to a region's water supply as defined by the Regional Water Planning Group (RWPG), and may be a Water User Group (WUG) entity, Wholesale Water Provider (WWP) entity , or both (WUG/WWP). Retail denotes WUG projected demands and existing water supplies used by the WUG. Wholesale denotes a WWP or WUG/WWP selling water to another entity.

Amarillo - WUG/WWP	**Water Volumes (acre-feet per year)**					
Data Description	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Projected Retail WUG Demands	46,830	49,513	51,716	53,441	55,161	56,866
Projected Wholesale Contract Demands	25,682	26,273	26,273	26,273	25,273	25,273
Total Projected Wholesale Contract and Retail Demands	**72,512**	**75,786**	**77,989**	**79,714**	**80,434**	**82,139**
Groundwater Sales to Retail Customers	38,778	36,539	34,703	31,992	31,314	30,657
Surface Water Sales to Retail Customers	3,954	3,441	3,074	2,565	2,040	1,530
Groundwater Sales to Wholesale Customers	10,157	9,399	8,881	8,228	8,103	7,990
Reuse Sales to Wholesale Customers	15,000	15,000	15,000	15,000	15,000	15,000
Surface Water Sales to Wholesale Customers	1,035	885	786	659	529	400
Total Wholesale and Retail Sales to Customers	**68,924**	**65,264**	**62,444**	**58,444**	**56,986**	**55,577**

Borger - WUG/WWP	**Water Volumes (acre-feet per year)**					
Data Description	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Projected Retail WUG Demands	3,535	3,480	3,394	3,295	3,201	3,116
Projected Wholesale Contract Demands	7,903	8,291	8,225	8,171	8,127	8,082
Total Projected Wholesale Contract and Retail Demands	**11,438**	**11,771**	**11,619**	**11,466**	**11,328**	**11,198**
Groundwater Sales to Retail Customers	3,019	2,828	2,652	2,474	2,352	2,148
Surface Water Sales to Retail Customers	192	161	131	104	78	56
Groundwater Sales to Wholesale Customers	9,443	9,354	9,358	9,355	9,524	9,291
Reuse Sales to Wholesale Customers	1,100	1,100	1,100	1,100	1,100	1,100
Surface Water Sales to Wholesale Customers	600	532	463	391	318	241
Total Wholesale and Retail Sales to Customers	**14,354**	**13,975**	**13,704**	**13,424**	**13,372**	**12,836**

Canadian River Municipal Water Authority - WWP	**Water Volumes (acre-feet per year)**					
Data Description	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Projected Wholesale Contract Demands	101,071	109,865	115,523	120,717	121,460	121,598
Total Projected Wholesale Contract and Retail Demands	**101,071**	**109,865**	**115,523**	**120,717**	**121,460**	**121,598**
Groundwater Sales to Wholesale Customers	62,881	59,878	55,476	49,833	49,668	48,987
Surface Water Sales to Wholesale Customers	12,000	10,500	9,000	7,500	6,000	4,500
Total Wholesale and Retail Sales to Customers	**74,881**	**70,378**	**64,476**	**57,333**	**55,668**	**53,487**

DRAFT Region A Major Water Provider (MWP) Existing Sales and Transfers

Greenbelt Municipal & Industrial Water Authority - WWP	Water Volumes (acre-feet per year)					
Data Description	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Projected Wholesale Contract Demands	3,894	3,910	3,924	3,741	3,794	3,849
Total Projected Wholesale Contract and Retail Demands	**3,894**	**3,910**	**3,924**	**3,741**	**3,794**	**3,849**
Groundwater Sales to Wholesale Customers	1,019	1,042	1,027	1,008	982	939
Surface Water Sales to Wholesale Customers	1,997	1,967	1,932	1,906	1,882	1,876
Total Wholesale and Retail Sales to Customers	**3,016**	**3,009**	**2,959**	**2,914**	**2,864**	**2,815**

ATTACHMENT 3-2

WATER SUPPLIES BY DECADE AND CATEGORY OF USE FOR MAJOR WATER PROVIDERS

Major Water Provider Supplies by Category of Use in Each Decade

Major Water Provider	Category of Use	Supply (Ac Ft/Yr)					
		2030	2040	2050	2060	2070	2080
Amarillo	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	10,257	9,459	8,920	8,224	8,013	7,810
	Mining	0	0	0	0	0	0
	Municipal	45,350	42,488	40,207	36,903	35,656	34,450
	Steam Electric Power	15,000	15,000	15,000	15,000	15,000	15,000
	Total	**70,607**	**66,947**	**64,127**	**60,127**	**58,669**	**57,260**
Borger	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	11,143	10,986	10,921	10,846	10,942	10,632
	Mining	0	0	0	0	0	0
	Municipal	3,211	2,989	2,783	2,578	2,430	2,204
	Steam Electric Power	0	0	0	0	0	0
	Total	**14,354**	**13,975**	**13,704**	**13,424**	**13,372**	**12,836**
CRMWA	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	74,881	70,378	64,476	57,333	55,668	53,487
	Steam Electric Power	0	0	0	0	0	0
	Total	**74,881**	**70,378**	**64,476**	**57,333**	**55,668**	**53,487**
Greenbelt MIWA	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	50	50	50	50	50	50
	Mining	0	0	0	0	0	0
	Municipal	3,006	2,999	2,949	2,904	2,854	2,805
	Steam Electric Power	0	0	0	0	0	0
	Total	**3,056**	**3,049**	**2,999**	**2,954**	**2,904**	**2,855**

4 IDENTIFICATION OF WATER NEEDS

4.1 Introduction

Water needs are identified by calculating the difference between currently available supplies developed in **Chapter 3** and the projected demands developed in **Chapter 2**. This chapter outlines first and second tier water needs scenarios, where the first tier needs are based on all supply limitations identified in **Chapter 3** and second tier needs are those needs after conservation and direct reuse strategies have been implemented.

This comparison of developed water supply to demands is made for the region, county, basin, major water provider, and water user group. If the projected demands for an entity exceed the developed supplies, then a need is identified (represented by a negative number). For some users, the supplies may exceed the demands (positive number). For groundwater users, this water is not considered surplus, but a supply that will be available for use after 2080.

4.2 First Tier Water Needs Analysis

As discussed in **Chapter 3**, the Texas Water Development Board (TWDB) specifies that the currently available supplies be defined as the most restrictive of current water rights, contracts and available yields for surface water and historical use and/or modeled available groundwater (MAG) for groundwater. For the Panhandle Water Planning Area (PWPA), geographical and hydrogeological constraints were also considered for irrigation and municipal users of the Ogallala aquifer. For some counties in the region, these constraints are more restrictive than current groundwater regulations. However, this approach provides a reasonable assessment of water demands that may exceed long-term availability.

Considering only developed and connected supplies for the PWPA, the projected need for the region in 2030 is approximately 433,000 acre-feet per year, which increases to a high of about 567,000 acre-feet per year by 2040 and then gradually declines to around 511,000 acre-feet by 2080 (**Table 4-1** and **Figure 4-1**). These numbers consider both surpluses and shortages. When considering only the shortages, the need for the region is 443,000 acre-feet per year in 2030, increasing to a high of 580,000 acre-feet per year by 2040 and declining to nearly 514,000 acre-feet by 2080.

Table 4-1: Comparison of Supplies and Demands for the PWPA (acre-feet per year)

	2030	2040	2050	2060	2070	2080
Supply	1,721,486	1,596,009	1,482,205	1,382,039	1,296,300	1,231,067
Demand	2,154,499	2,162,587	2,033,061	1,920,674	1,816,340	1,741,572
Surplus/Need[1]	(433,013)	(566,578)	(550,855)	(538,633)	(520,040)	(510,504)
Need Only[2]	(443,043)	(580,263)	(559,928)	(542,358)	(523,513)	(513,956)

1. This calculation aggregates surpluses and needs for all water users across the region.
2. Consideration of only the needs for individual entities.

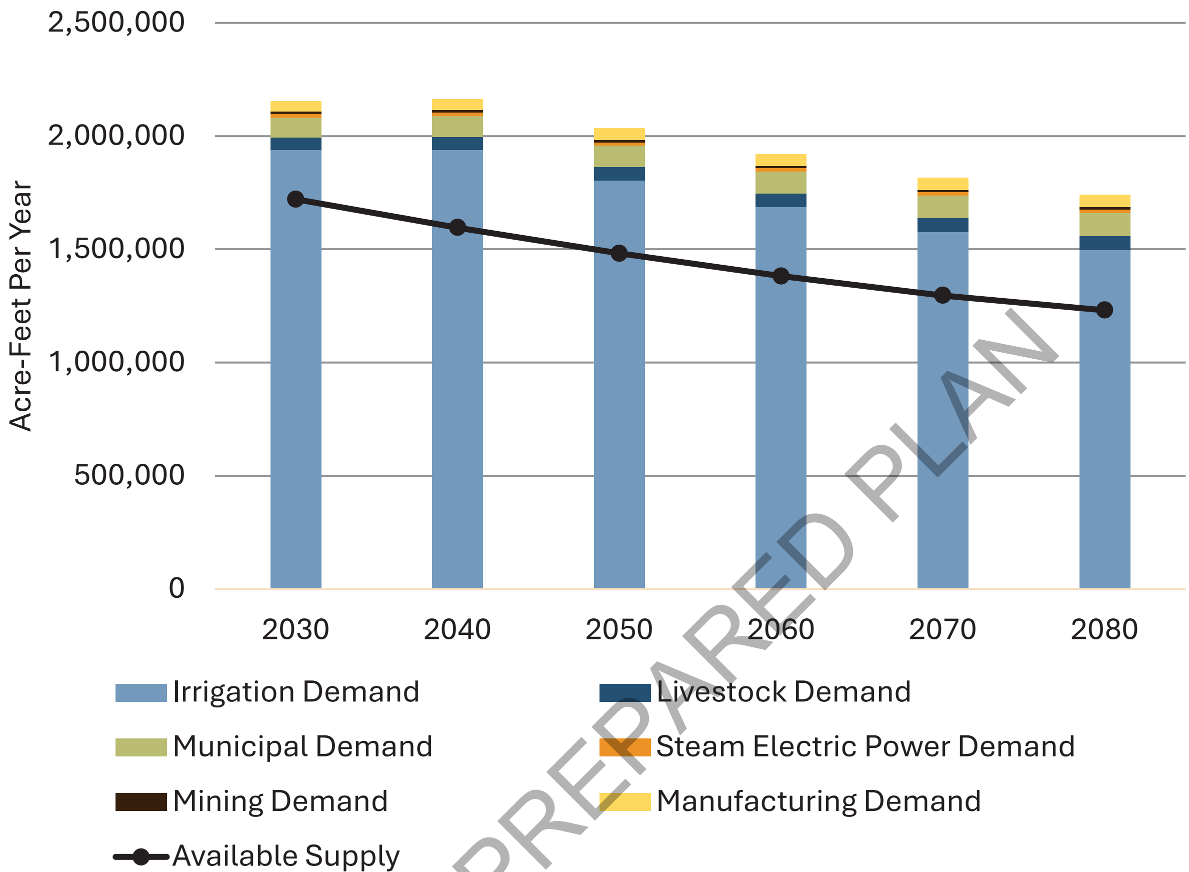

Figure 4-1: PWPA Supplies and Demands (acre-feet per year)

On a county-basis, there are five counties that do not show a need over the planning horizon: Carson, Childress, Donley, Hemphill and Roberts Counties. Of these counties, only Childress and Hemphill County have no water user group with a shortage. **Table 4-2** presents first tier water needs by county. **Figure 4-2** shows the spatial distribution of needs in the region for years 2023, 2050 and 2080. Typically, the counties with the largest needs are those with large irrigation demands. Based on this analysis, there are significant irrigation needs over the 50-year planning period. The municipal needs shown are attributed to growth, reduction of surface water supplies, limitations in developed water rights, or infrastructure limitations. A brief discussion of these needs is presented in the following section.

Table 4-2: Identification of Water Needs/Surplus by County (acre-feet per year)

County	Surplus (+) / Need (-)					
	2030	2040	2050	2060	2070	2080
Armstrong	1,608	702	15	(515)	(1,123)	(1,644)
Carson	3,983	9,443	5,372	141	125	130
Childress	-	-	-	1	-	1
Collingsworth	(16,131)	(19,213)	(19,072)	(18,671)	(18,687)	(19,210)
Dallam	(121,228)	(156,912)	(148,470)	(140,598)	(133,194)	(127,842)
Donley	119	108	96	84	71	58
Gray	580	51	(398)	(666)	(793)	(848)
Hall	(15,721)	(12,855)	(13,033)	(13,200)	(13,122)	(12,850)
Hansford	62	38	30	9	(10)	(31)
Hartley	(173,541)	(231,320)	(218,066)	(206,316)	(195,498)	(186,279)
Hemphill	75	79	101	115	128	142
Hutchinson	(176)	(276)	(351)	(449)	(682)	(4,671)
Lipscomb	7	(24)	(63)	(108)	(145)	(191)
Moore	(75,296)	(84,914)	(82,377)	(79,062)	(75,251)	(71,649)
Ochiltree	726	674	577	393	121	(134)
Oldham	193	182	171	158	146	(140)
Potter	(2,448)	(5,955)	(8,465)	(11,047)	(12,204)	(13,212)
Randall	(1,929)	(7,797)	(13,452)	(19,381)	(24,227)	(28,935)
Roberts	86	74	60	47	33	15
Sherman	(33,977)	(58,547)	(53,345)	(49,322)	(45,404)	(42,795)
Wheeler	(5)	(116)	(185)	(246)	(324)	(419)
Region Total	(433,013)	(566,578)	(550,855)	(538,633)	(520,040)	(510,504)

Note: Supply values are shown for the county in which it is used, which may differ from the county of the supply source.

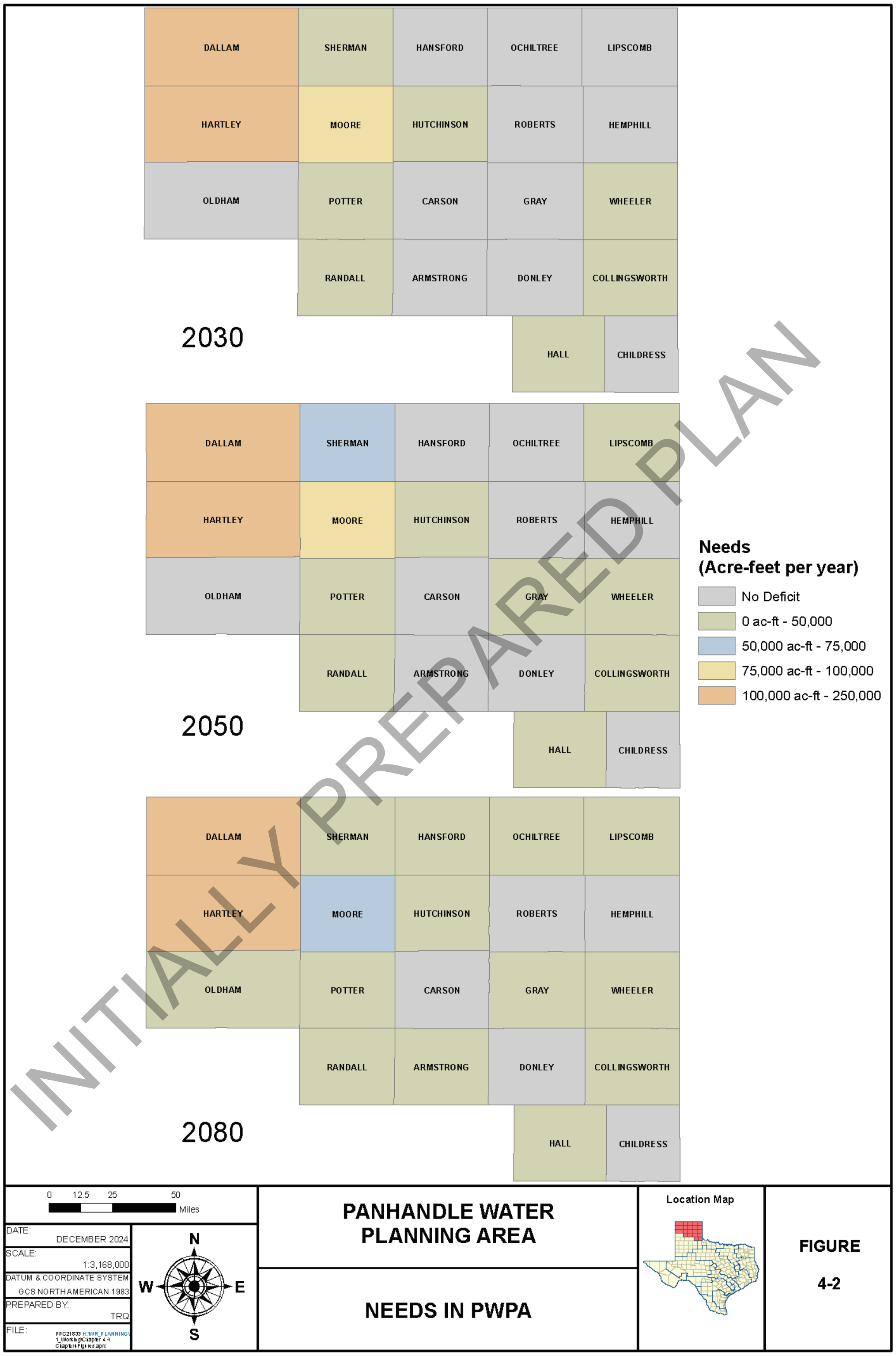

Figure 4-2: Needs in PWPA for Planning Period 2030 to 2080

4.2.1 Identified Needs for Water User Groups

A need occurs when developed supplies are not sufficient to meet projected demands. In the PWPA, there are forty water user groups with identified needs during the planning period. Of these, there are eighteen cities and county-other water users in seventeen counties that are projected to experience a water need by 2080. The largest needs are attributed to high irrigation use or significant increase in municipal demand and comparably limited groundwater resources in Dallam, Hartley, Moore, and Sherman Counties.

Total needs for all water user groups are projected to be approximately 443,043 acre-feet per year in 2030, increasing to 559,928 acre-feet per year in 2050 and approximately 513,900 acre-feet per year by 2080. In contrast to **Figure 4-1**, these numbers include only the needs (surpluses are set to zero). Irrigation represents approximately 96 percent of the needs in the 2030 projections and around 89 percent of the total need in 2080 with needs ranging from 427,488 to 456,154 acre-feet per year. The needs attributed to the other water use categories total approximately 57,802 acre-feet per year in 2080.

A summary of when the individual water user group needs begin by county and demand type is presented in **Table 4-3**.

Table 4-3: Decade Need Begins by County and Category

County	Irrigation	Municipal	Manufacturing	Mining	Steam Electric Power	Livestock
Armstrong	2050	-	-	-	-	-
Carson	-	2060	-	-	-	-
Childress	-	-	-	-	-	2040
Collingsworth	2030	-	-	-	-	-
Dallam	2030	-	-	-	-	-
Donley	-	-	-	-	-	-
Gray	-	2040	-	-	-	-
Hall	2030	-	-	-	-	-
Hansford	-	2030	-	-	-	-
Hartley	2030	-	-	-	-	2030
Hemphill	-	-	-	-	-	-
Hutchinson	2080	2030	2080	-	-	-
Lipscomb	-	2030	2030	-	-	-
Moore	2030	2040	2030	-	-	2030
Ochiltree	-	2030	-	-	-	-
Oldham	2030	-	-	-	-	-
Potter	-	2030	2030	-	-	-
Randall	2030	2030	2030	-	-	-
Roberts	-	2050	-	-	-	-
Sherman	2030	2030	-	-	-	-
Wheeler	-	2030	-	-	-	-

Irrigation

Irrigation needs are identified for ten counties: Armstrong, Collingsworth, Dallam, Hall, Hartley, Hutchinson, Moore, Oldham, Randall, and Sherman Counties (**Table 4-4**). Five of these counties rely heavily on the Ogallala for irrigation supplies (Armstrong, Dallam, Hartley, Hutchinson, Moore, Oldham, Randall, and Sherman Counties). Irrigators in Collingsworth and Hall Counties rely heavily on the Seymour Aquifer. Eight counties have needs starting in 2030 (**Table 4-4**).

Table 4-4: Projected Irrigation Needs in the PWPA (acre-feet per year)

County	2030	2040	2050	2060	2070	2080
Armstrong	0	0	(196)	(726)	(1,334)	(1,855)
Collingsworth	(16,131)	(19,039)	(18,908)	(18,515)	(18,538)	(19,069)
Dallam	(121,228)	(156,912)	(148,470)	(140,598)	(133,194)	(127,842)
Hall	(15,780)	(12,917)	(13,098)	(13,271)	(13,197)	(12,944)
Hartley	(172,558)	(229,447)	(216,085)	(204,225)	(193,294)	(183,960)
Hutchinson	0	0	0	0	0	(1,980)
Moore	(66,665)	(72,883)	(68,994)	(64,716)	(59,954)	(55,444)
Oldham	(319)	(319)	(319)	(319)	(319)	(592)
Randall	(317)	(2,299)	(4,380)	(6,103)	(7,845)	(9,353)
Sherman	(34,490)	(59,073)	(53,887)	(49,819)	(45,778)	(43,115)
Total	**(427,488)**	**(552,889)**	**(524,337)**	**(498,292)**	**(473,453)**	**(456,154)**

Municipal

Municipal supplies in the PWPA are typically groundwater while surface water is used in counties with limited groundwater and by MWPs and their customers. For some cities, there is additional groundwater supply, but it is not fully developed. A list of the municipalities indicating a need is presented in **Table 4-5**.

Table 4-5: Projected Municipal Needs in the PWPA (acre-feet per year)

Municipality	2030	2040	2050	2060	2070	2080
Amarillo	(4,098)	(9,533)	(13,939)	(18,884)	(21,807)	(24,679)
Booker	(75)	(83)	(93)	(103)	(108)	(114)
Borger	(324)	(491)	(611)	(717)	(771)	(912)
Cactus	0	(97)	(192)	(267)	(329)	(380)
Canyon	0	(511)	(1,171)	(1,812)	(2,408)	(2,991)
Dumas	0	(1,004)	(1,513)	(1,679)	(1,748)	(1,869)
Fritch	0	0	0	(22)	(55)	(90)
Gruver	(80)	(87)	(90)	(96)	(101)	(107)
Miami	0	0	(6)	(19)	(33)	(44)
Pampa	0	(205)	(651)	(916)	(1,041)	(1,092)
Perryton	0	0	0	(48)	(320)	(575)
Shamrock	0	0	0	0	(45)	(127)
Stinnett	0	0	0	0	(27)	(50)
Stratford	(133)	(120)	(104)	(149)	(272)	(326)

Municipality	2030	2040	2050	2060	2070	2080
Wellington Municipal Water System	0	(174)	(164)	(156)	(149)	(141)
Wheeler	(37)	(118)	(191)	(248)	(279)	(292)
Total	**(4,748)**	**(12,422)**	**(18,725)**	**(25,116)**	**(29,493)**	**(33,790)**

Manufacturing

There are five counties with manufacturing needs identified in the PWPA. Most manufacturing interests buy water from retail providers or develop their own groundwater supplies. For each of these counties, much of the need is associated with major water providers. For Moore County, these needs are the result of limited groundwater supplies for the city of Cactus. In Potter and Randall Counties, the needs are associated with needs identified with the city of Amarillo. In Hutchinson County, the need is associated with the city of Borger. In Lipscomb County, the need is associated with the city of Booker.

Table 4-6: Projected Manufacturing Needs in the PWPA (acre-feet per year)

County	2030	2040	2050	2060	2070	2080
Hutchinson	0	0	0	0	0	(1,805)
Lipscomb	(88)	(111)	(140)	(175)	(207)	(247)
Moore	(792)	(1,494)	(2,182)	(2,853)	(3,522)	(4,190)
Potter	(535)	(1,671)	(2,591)	(3,669)	(4,332)	(5,007)
Randall	(107)	(245)	(356)	(485)	(563)	(641)
Total	**(1,522)**	**(3,521)**	**(5,269)**	**(7,182)**	**(8,624)**	**(11,890)**

Mining

There are no mining needs in the PWPA.

Steam Electric Power

There are no steam electric needs in the PWPA.

Livestock

There are two counties (Hartley and Moore) with livestock needs identified in the PWPA. This is due largely to new dairy operations for which water supplies are not shown in historical use estimates. For most counties, water for livestock is from groundwater and/or local stock ponds. In the heavily pumped counties, there will be competition for groundwater supplies.

Table 4-7: Projected Livestock Needs in the PWPA (acre-feet per year)

County	2030	2040	2050	2060	2070	2080
Hartley	(983)	(1,873)	(1,981)	(2,091)	(2,204)	(2,319)
Moore	(8,302)	(9,557)	(9,616)	(9,677)	(9,739)	(9,803)
Total	**(9,285)**	**(11,430)**	**(11,597)**	**(11,768)**	**(11,943)**	**(12,122)**

4.2.2 Identified Needs for Major Water Providers

There are four major water providers located in the PWPA that sell water to wholesale customers. Of these entities, three are projected to have needs within the planning period: City of Amarillo, City of Borger, and Canadian River Municipal Water Authority (CRMWA). Much of the early needs are associated with the infrastructure constraints for current well field production. These needs increase over the planning cycle due to growth and reduced availability from the Ogallala aquifer with current well fields. **Table 4-8** shows the projected water supply needs for the major water providers in the PWPA. Whereas Amarillo and Borger are water user groups in addition to being wholesale water providers, CRMWA and Greenbelt MIWA are strictly wholesale water providers and do not have needs separate from those of their customers. Both CRMWA and Greenbelt MWIA plan to develop water management strategies to help meet their customers' needs and prepare for potential impacts from drought to their current water sources.

Table 4-8: Projected Needs for Major Providers in the PWPA (acre-feet per year)

Major Provider	2030	2040	2050	2060	2070	2080
Amarillo	(5,170)	(11,989)	(17,504)	(23,740)	(27,448)	(31,112)
Borger	(1,341)	(2,115)	(2,767)	(3,433)	(3,891)	(4,863)
CRMWA	(22,540)	(38,520)	(49,928)	(59,132)	(61,953)	(64,858)
Greenbelt MIWA	-	-	-	-	-	-

4.2.3 Summary of First Tier Water Needs

On a water user group basis, the total demands exceed the total developed supply starting in 2030, largely attributed to the geographical constraints of the demand centers and developed supplies. Most of the needs are associated with large irrigation demands that cannot be met with groundwater sources beneath currently irrigated lands. Other needs are due to limitations of infrastructure and/or growth. The evaluation of regional water supplies indicates that groundwater supplies could be further developed. However, often the needed infrastructure is not developed, or the potential source is not located near a water supply need. The first tier needs report provided by TWDB is provided in **Attachment 4-1**. **Attachment 4-2** shows the first tier needs of each Major Water Provider broken down by category of use for each decade. Both attachments are proved at the end of this chapter. The region's options and strategies to meet needs are explored in more detail in **Chapter 5** and the impacts of these strategies on water quality are discussed in **Chapter 6**.

4.3 Second Tier Water Needs Analysis

The second-tier water needs analysis compares currently available supplies with demands after reductions from conservation and direct reuse. Conservation and direct reuse are both considered water management strategies and are discussed further in **Chapter 5**. The second tier needs report provided by TWDB is provided in **Attachment 4-1**. **Attachment 4-2** shows the second tier needs of each Major Water Provider broken down by category of use for each decade. Both attachments are proved at the end of this chapter. In the PWPA, conservation was recommended for all municipal and irrigation water users. There is one recommended direct reuse project for Amarillo in the PWPA.

4.3.1 Summary of Second Tier Water Needs for Water User Groups

After the implementation of conservation strategies and direct reuse, the PWPA has a projected water need of 357,755 acre-feet per year in 2030. Most of this is associated with irrigated agriculture that has not fully realized the benefits of conservation. By 2080, the projected need in the PWPA above 225,000 acre-feet per year. This need is associated with municipal, manufacturing, livestock, and irrigation uses. A summary of the secondary needs by use type is shown in **Table 4-9**.

Table 4-9: Summary of Projected Secondary Needs by Use Type (acre-feet per year)

Use Type	2030	2040	2050	2060	2070	2080
Municipal	592	4,385	10,461	16,662	20,874	25,018
Manufacturing	1,522	3,522	5,269	7,182	8,624	11,890
Mining	0	0	0	0	0	0
Steam Electric Power	0	0	0	0	0	0
Livestock	9,285	11,430	11,597	11,768	11,943	12,122
Irrigation	346,356	379,670	322,903	271,094	205,927	177,045
Total	**357,755**	**399,007**	**350,230**	**306,706**	**247,368**	**226,075**

4.3.2 Summary of Secondary Tier Water Needs for Major Water Providers

The projected water needs for major water providers (MWP) after conservation and direct reuse is shown on **Table 4-10**. For providers that deliver water only to wholesale customers, the conservation savings were estimated as a part of the customer's conservation savings. However, it is uncertain whether those savings will reduce contractual demands on the MWP. For MWPs that also provide retail supplies, the conservation savings reflect the savings estimated for the water user group. Amarillo is the only MWP that has a recommended direct reuse strategy.

Table 4-10: Summary of Projected Secondary Needs for Major Water Providers (acre-feet per year)

Major Provider	2030	2040	2050	2060	2070	2080
Amarillo	1,072	3,803	9,114	15,189	18,735	22,239
Borger	1,303	2,078	2,731	3,397	3,857	4,830
CRMWA	19,837	35,489	46,582	55,547	58,140	60,831
Greenbelt MIWA	0	0	0	0	0	0

ATTACHMENT 4-1

FIRST AND SECOND TIER NEEDS

DRAFT Region A Water User Group (WUG) Needs or Surplus

WUG supplies and projected demands are entered for each of a WUG's region-county-basin divisions. The needs shown in the WUG Needs/Surplus report are calculated by first deducting the WUG split's projected demand from its total existing water supply volume. If the WUG split has a greater existing supply volume than projected demand in any given decade, this amount is considered a surplus volume. Surplus volumes are shown as positive values, and needs are shown as negative values in parentheses.

			Water Supply Needs or Surplus (acre-feet per year)					
WUG Name	**County**	**Basin**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Claude Municipal Water System	Armstrong	Red	0	0	0	0	0	0
County-Other	Armstrong	Red	0	0	0	0	0	0
Livestock	Armstrong	Red	211	211	211	211	211	211
Irrigation	Armstrong	Red	1,397	491	(196)	(726)	(1,334)	(1,855)
Fritch	Carson	Canadian	0	1	1	(3)	(7)	(13)
White Deer	Carson	Canadian	6	5	6	8	13	18
County-Other	Carson	Canadian	0	0	0	0	0	0
Manufacturing	Carson	Canadian	0	0	0	0	0	0
Livestock	Carson	Canadian	53	53	53	53	53	53
Irrigation	Carson	Canadian	998	2,416	1,361	6	0	0
Groom Municipal Water System	Carson	Red	23	9	7	7	5	2
Panhandle Municipal Water System	Carson	Red	0	0	0	0	0	0
White Deer	Carson	Red	9	7	9	13	18	27
County-Other	Carson	Red	0	0	0	0	0	0
Manufacturing	Carson	Red	0	0	0	0	0	0
Mining	Carson	Red	0	0	0	0	0	0
Livestock	Carson	Red	43	43	43	43	43	43
Irrigation	Carson	Red	2,851	6,909	3,892	14	0	0
Childress	Childress	Red	0	0	0	0	0	0
Red River Authority of Texas*	Childress	Red	0	(1)	(2)	1	(1)	(1)
County-Other	Childress	Red	0	0	0	0	0	0
Livestock	Childress	Red	0	0	0	0	0	0
Irrigation	Childress	Red	0	0	0	0	0	0
Red River Authority of Texas*	Collingsworth	Red	0	0	0	0	(1)	0
Wellington Municipal Water System	Collingsworth	Red	0	(174)	(164)	(156)	(149)	(141)
County-Other	Collingsworth	Red	0	0	0	0	0	0
Livestock	Collingsworth	Red	0	0	0	0	0	0

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Needs or Surplus

			Water Supply Needs or Surplus (acre-feet per year)					
WUG Name	**County**	**Basin**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Irrigation	Collingsworth	Red	(16,131)	(18,865)	(18,744)	(18,359)	(18,389)	(18,928)
Dalhart	Dallam	Canadian	0	0	0	0	0	0
Texline	Dallam	Canadian	0	0	0	0	0	0
County-Other	Dallam	Canadian	0	0	0	0	0	0
Manufacturing	Dallam	Canadian	0	0	0	0	0	0
Livestock	Dallam	Canadian	0	0	0	0	0	0
Irrigation	Dallam	Canadian	(121,228)	(156,912)	(148,470)	(140,598)	(133,194)	(127,842)
Clarendon	Donley	Red	0	0	0	0	0	0
Red River Authority of Texas*	Donley	Red	0	0	(1)	0	0	0
County-Other	Donley	Red	0	0	0	0	0	0
Livestock	Donley	Red	119	108	96	84	71	58
Irrigation	Donley	Red	0	0	0	0	0	0
Pampa Municipal Water System	Gray	Canadian	309	(205)	(651)	(916)	(1,041)	(1,092)
County-Other	Gray	Canadian	0	0	0	0	0	0
Manufacturing	Gray	Canadian	172	173	172	172	172	172
Livestock	Gray	Canadian	26	21	21	20	19	18
Irrigation	Gray	Canadian	0	0	0	0	0	0
McLean Municipal Water Supply	Gray	Red	0	0	0	0	0	0
County-Other	Gray	Red	0	0	0	0	0	0
Manufacturing	Gray	Red	2	1	2	2	2	2
Livestock	Gray	Red	71	61	58	56	55	52
Irrigation	Gray	Red	0	0	0	0	0	0
Memphis	Hall	Red	0	0	0	0	0	0
Red River Authority of Texas*	Hall	Red	59	62	65	71	75	94
Turkey Municipal Water System	Hall	Red	0	0	0	0	0	0
County-Other	Hall	Red	0	0	0	0	0	0
Manufacturing	Hall	Red	0	0	0	0	0	0
Livestock	Hall	Red	0	0	0	0	0	0
Irrigation	Hall	Red	(15,780)	(12,917)	(13,098)	(13,271)	(13,197)	(12,944)
Gruver	Hansford	Canadian	(80)	(87)	(90)	(96)	(101)	(107)
Spearman Municipal Water System	Hansford	Canadian	142	125	120	105	91	76
County-Other	Hansford	Canadian	0	0	0	0	0	0

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Needs or Surplus

			Water Supply Needs or Surplus (acre-feet per year)					
WUG Name	**County**	**Basin**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Manufacturing	Hansford	Canadian	0	0	0	0	0	0
Mining	Hansford	Canadian	0	0	0	0	0	0
Livestock	Hansford	Canadian	0	0	0	0	0	0
Irrigation	Hansford	Canadian	0	0	0	0	0	0
Dalhart	Hartley	Canadian	0	0	0	0	0	0
Hartley WSC	Hartley	Canadian	0	0	0	0	0	0
County-Other	Hartley	Canadian	0	0	0	0	0	0
Mining	Hartley	Canadian	0	0	0	0	0	0
Livestock	Hartley	Canadian	(983)	(1,873)	(1,981)	(2,091)	(2,204)	(2,319)
Irrigation	Hartley	Canadian	(172,558)	(229,447)	(216,085)	(204,225)	(193,294)	(183,960)
Canadian	Hemphill	Canadian	74	78	100	114	127	141
County-Other	Hemphill	Canadian	0	0	0	0	0	0
Mining	Hemphill	Canadian	0	0	0	0	0	0
Livestock	Hemphill	Canadian	0	0	0	0	0	0
Irrigation	Hemphill	Canadian	0	0	0	0	0	0
County-Other	Hemphill	Red	0	0	0	0	0	0
Manufacturing	Hemphill	Red	1	1	1	1	1	1
Mining	Hemphill	Red	0	0	0	0	0	0
Livestock	Hemphill	Red	0	0	0	0	0	0
Irrigation	Hemphill	Red	0	0	0	0	0	0
Borger	Hutchinson	Canadian	(324)	(491)	(611)	(717)	(771)	(912)
Fritch	Hutchinson	Canadian	0	6	7	(18)	(45)	(73)
Stinnett	Hutchinson	Canadian	23	62	94	122	(27)	(50)
TCW Supply	Hutchinson	Canadian	0	31	53	68	75	74
County-Other	Hutchinson	Canadian	0	0	0	0	0	0
Manufacturing	Hutchinson	Canadian	0	0	0	0	0	(1,805)
Mining	Hutchinson	Canadian	0	0	0	0	0	0
Livestock	Hutchinson	Canadian	125	116	106	96	86	75
Irrigation	Hutchinson	Canadian	0	0	0	0	0	(1,980)
Booker	Lipscomb	Canadian	(73)	(81)	(91)	(101)	(106)	(112)
Darrouzett	Lipscomb	Canadian	0	0	0	0	0	0
Follett	Lipscomb	Canadian	0	0	0	0	0	0
Higgins Municipal Water System	Lipscomb	Canadian	0	0	0	0	0	0
County-Other	Lipscomb	Canadian	0	0	0	0	0	0
Manufacturing	Lipscomb	Canadian	(88)	(111)	(140)	(175)	(207)	(247)
Mining	Lipscomb	Canadian	0	0	0	0	0	0
Livestock	Lipscomb	Canadian	168	168	168	168	168	168

*A single asterisk next to a WUG's name denotes that the WUG is split by two or more planning regions.

DRAFT Region A Water User Group (WUG) Needs or Surplus

			Water Supply Needs or Surplus (acre-feet per year)					
WUG Name	**County**	**Basin**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Irrigation	Lipscomb	Canadian	0	0	0	0	0	0
Cactus Municipal Water System	Moore	Canadian	15	(96)	(192)	(267)	(329)	(380)
Dumas	Moore	Canadian	328	(1,004)	(1,513)	(1,679)	(1,748)	(1,869)
Fritch	Moore	Canadian	0	0	0	(1)	(3)	(4)
Sunray	Moore	Canadian	120	121	120	131	44	41
County-Other	Moore	Canadian	0	0	0	0	0	0
Manufacturing	Moore	Canadian	(792)	(1,495)	(2,182)	(2,853)	(3,522)	(4,190)
Mining	Moore	Canadian	0	0	0	0	0	0
Livestock	Moore	Canadian	(8,302)	(9,557)	(9,616)	(9,677)	(9,739)	(9,803)
Irrigation	Moore	Canadian	(66,665)	(72,883)	(68,994)	(64,716)	(59,954)	(55,444)
Booker	Ochiltree	Canadian	(2)	(2)	(2)	(2)	(2)	(2)
Perryton Municipal Water System	Ochiltree	Canadian	285	233	136	(48)	(320)	(575)
County-Other	Ochiltree	Canadian	0	0	0	0	0	0
Manufacturing	Ochiltree	Canadian	0	0	0	0	0	0
Mining	Ochiltree	Canadian	0	0	0	0	0	0
Livestock	Ochiltree	Canadian	443	443	443	443	443	443
Irrigation	Ochiltree	Canadian	0	0	0	0	0	0
Vega	Oldham	Canadian	0	0	0	0	0	0
County-Other	Oldham	Canadian	0	0	1	0	0	0
Mining	Oldham	Canadian	0	0	0	0	0	0
Livestock	Oldham	Canadian	359	351	344	335	327	317
Irrigation	Oldham	Canadian	(77)	(77)	(77)	(77)	(77)	(143)
County-Other	Oldham	Red	0	0	0	0	0	0
Mining	Oldham	Red	0	0	0	0	0	0
Livestock	Oldham	Red	153	150	145	142	138	135
Irrigation	Oldham	Red	(242)	(242)	(242)	(242)	(242)	(449)
Amarillo	Potter	Canadian	(1,209)	(2,634)	(3,588)	(4,488)	(4,782)	(4,975)
County-Other	Potter	Canadian	(1)	0	0	0	0	(1)
Manufacturing	Potter	Canadian	(31)	(99)	(151)	(214)	(254)	(293)
Mining	Potter	Canadian	0	0	0	0	0	0
Steam Electric Power	Potter	Canadian	0	0	0	0	0	0
Livestock	Potter	Canadian	62	55	47	40	32	25
Irrigation	Potter	Canadian	0	0	0	0	0	0
Amarillo	Potter	Red	(795)	(1,731)	(2,356)	(2,949)	(3,138)	(3,267)
County-Other	Potter	Red	1	0	0	0	0	1

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DRAFT Region A Water User Group (WUG) Needs or Surplus

			Water Supply Needs or Surplus (acre-feet per year)					
WUG Name	**County**	**Basin**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Manufacturing	Potter	Red	(504)	(1,572)	(2,440)	(3,455)	(4,078)	(4,714)
Mining	Potter	Red	0	0	0	0	0	0
Livestock	Potter	Red	29	26	23	19	16	12
Irrigation	Potter	Red	0	0	0	0	0	0
Amarillo	Randall	Red	(2,094)	(5,168)	(7,995)	(11,447)	(13,887)	(16,437)
Canyon	Randall	Red	205	(511)	(1,171)	(1,812)	(2,408)	(2,991)
Happy*	Randall	Red	4	5	7	9	10	13
Lake Tanglewood	Randall	Red	357	402	426	441	450	459
Siesta Estates	Randall	Red	0	0	0	0	0	0
County-Other	Randall	Red	23	19	17	16	16	15
Manufacturing	Randall	Red	(107)	(245)	(356)	(485)	(563)	(641)
Livestock	Randall	Red	0	0	0	0	0	0
Irrigation	Randall	Red	(317)	(2,299)	(4,380)	(6,103)	(7,845)	(9,353)
Miami	Roberts	Canadian	20	8	(6)	(19)	(33)	(44)
County-Other	Roberts	Canadian	0	0	0	0	0	0
Mining	Roberts	Canadian	0	0	0	0	0	0
Livestock	Roberts	Canadian	64	63	64	64	63	57
Irrigation	Roberts	Canadian	0	0	0	0	0	0
County-Other	Roberts	Red	0	0	0	0	0	0
Livestock	Roberts	Red	2	3	2	2	3	2
Irrigation	Roberts	Red	0	0	0	0	0	0
Stratford	Sherman	Canadian	(133)	(120)	(104)	(149)	(272)	(326)
Texhoma	Sherman	Canadian	0	0	0	0	0	0
County-Other	Sherman	Canadian	0	0	0	0	0	0
Manufacturing	Sherman	Canadian	0	0	0	0	0	0
Mining	Sherman	Canadian	0	0	0	0	0	0
Livestock	Sherman	Canadian	646	646	646	646	646	646
Irrigation	Sherman	Canadian	(34,490)	(59,073)	(53,887)	(49,819)	(45,778)	(43,115)
Shamrock Municipal Water System	Wheeler	Red	32	2	6	2	(45)	(127)
Wheeler	Wheeler	Red	(37)	(118)	(191)	(248)	(279)	(292)
County-Other	Wheeler	Red	0	0	0	0	0	0
Mining	Wheeler	Red	0	0	0	0	0	0
Livestock	Wheeler	Red	0	0	0	0	0	0
Irrigation	Wheeler	Red	0	0	0	0	0	0

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DRAFT Region A Water User Group (WUG) Second-Tier Identified Water Needs

Second-tier needs are WUG split needs adjusted to include the implementation of recommended conservation and direct reuse water management strategies.

	WUG Second-Tier Needs (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Armstrong County WUG Total	**0**	**0**	**0**	**0**	**148**	**551**
Armstrong County / Red Basin WUG	**0**	**0**	**0**	**0**	**148**	**551**
Claude Municipal Water System	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	148	551
Carson County WUG Total	**0**	**0**	**0**	**3**	**7**	**13**
Carson County / Canadian Basin WUG	**0**	**0**	**0**	**3**	**7**	**13**
Fritch	0	0	0	3	7	13
White Deer	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Carson County / Red Basin WUG	**0**	**0**	**0**	**0**	**0**	**0**
Groom Municipal Water System	0	0	0	0	0	0
Panhandle Municipal Water System	0	0	0	0	0	0
White Deer	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0

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DRAFT Region A Water User Group (WUG) Second-Tier Identified Water Needs

	WUG Second-Tier Needs (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Childress County WUG Total	**0**	**0**	**0**	**0**	**0**	**0**
Childress County / Red Basin WUG	**0**	**0**	**0**	**0**	**0**	**0**
Childress	0	0	0	0	0	0
Red River Authority of Texas*	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Collingsworth County WUG Total	**14,416**	**14,744**	**13,556**	**12,115**	**11,467**	**11,419**
Collingsworth County / Red Basin WUG	**14,416**	**14,744**	**13,556**	**12,115**	**11,467**	**11,419**
Red River Authority of Texas*	0	0	0	0	0	0
Wellington Municipal Water System	0	169	159	152	145	137
County-Other	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	14,416	14,575	13,397	11,963	11,322	11,282
Dallam County WUG Total	**105,103**	**117,658**	**98,377**	**79,760**	**64,692**	**52,286**
Dallam County / Canadian Basin WUG	**105,103**	**117,658**	**98,377**	**79,760**	**64,692**	**52,286**
Dalhart	0	0	0	0	0	0
Texline	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	105,103	117,658	98,377	79,760	64,692	52,286
Donley County WUG Total	**0**	**0**	**0**	**0**	**0**	**0**
Donley County / Red Basin WUG	**0**	**0**	**0**	**0**	**0**	**0**
Clarendon	0	0	0	0	0	0
Red River Authority of Texas*	0	0	0	0	0	0

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DRAFT Region A Water User Group (WUG) Second-Tier Identified Water Needs

	WUG Second-Tier Needs (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Donley County / Red Basin WUG	**0**	**0**	**0**	**0**	**0**	**0**
County-Other	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Gray County WUG Total	**0**	**0**	**428**	**696**	**823**	**873**
Gray County / Canadian Basin WUG	**0**	**0**	**428**	**696**	**823**	**873**
Pampa Municipal Water System	0	0	428	696	823	873
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Gray County / Red Basin WUG	**0**	**0**	**0**	**0**	**0**	**0**
McLean Municipal Water Supply	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Hall County WUG Total	**14,536**	**9,756**	**9,194**	**8,631**	**8,112**	**7,475**
Hall County / Red Basin WUG	**14,536**	**9,756**	**9,194**	**8,631**	**8,112**	**7,475**
Memphis	0	0	0	0	0	0
Red River Authority of Texas*	0	0	0	0	0	0
Turkey Municipal Water System	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	14,536	9,756	9,194	8,631	8,112	7,475

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DRAFT Region A Water User Group (WUG) Second-Tier Identified Water Needs

	WUG Second-Tier Needs (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Hansford County WUG Total	**76**	**83**	**86**	**92**	**97**	**103**
Hansford County / Canadian Basin WUG	**76**	**83**	**86**	**92**	**97**	**103**
Gruver	76	83	86	92	97	103
Spearman Municipal Water System	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Hartley County WUG Total	**155,683**	**188,343**	**162,828**	**138,923**	**119,181**	**101,758**
Hartley County / Canadian Basin WUG	**155,683**	**188,343**	**162,828**	**138,923**	**119,181**	**101,758**
Dalhart	0	0	0	0	0	0
Hartley WSC	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	983	1,873	1,981	2,091	2,204	2,319
Irrigation	154,700	186,470	160,847	136,832	116,977	99,439
Hemphill County WUG Total	**0**	**0**	**0**	**0**	**0**	**0**
Hemphill County / Canadian Basin WUG	**0**	**0**	**0**	**0**	**0**	**0**
Canadian	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Hemphill County / Red Basin WUG	**0**	**0**	**0**	**0**	**0**	**0**
County-Other	0	0	0	0	0	0

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DRAFT Region A Water User Group (WUG) Second-Tier Identified Water Needs

	WUG Second-Tier Needs (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Hemphill County / Red Basin WUG	**0**	**0**	**0**	**0**	**0**	**0**
Manufacturing	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Hutchinson County WUG Total	**286**	**454**	**575**	**691**	**797**	**2,796**
Hutchinson County / Canadian Basin WUG	**286**	**454**	**575**	**691**	**797**	**2,796**
Borger	286	454	575	682	737	879
Fritch	0	0	0	9	36	65
Stinnett	0	0	0	0	24	47
TCW Supply	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	1,805
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Lipscomb County WUG Total	**157**	**188**	**228**	**273**	**310**	**356**
Lipscomb County / Canadian Basin WUG	**157**	**188**	**228**	**273**	**310**	**356**
Booker	69	77	88	98	103	109
Darrouzett	0	0	0	0	0	0
Follett	0	0	0	0	0	0
Higgins Municipal Water System	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	88	111	140	175	207	247
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0

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DRAFT Region A Water User Group (WUG) Second-Tier Identified Water Needs

	WUG Second-Tier Needs (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Lipscomb County / Canadian Basin WUG	**157**	**188**	**228**	**273**	**310**	**356**
Irrigation	0	0	0	0	0	0
Moore County WUG Total	**66,695**	**63,134**	**54,373**	**44,901**	**36,481**	**28,699**
Moore County / Canadian Basin WUG	**66,695**	**63,134**	**54,373**	**44,901**	**36,481**	**28,699**
Cactus Municipal Water System	0	87	183	258	320	371
Dumas	0	958	1,468	1,635	1,705	1,827
Fritch	0	0	0	1	3	4
Sunray	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	792	1,495	2,182	2,853	3,522	4,190
Mining	0	0	0	0	0	0
Livestock	8,302	9,557	9,616	9,677	9,739	9,803
Irrigation	57,601	51,037	40,924	30,477	21,192	12,504
Ochiltree County WUG Total	**2**	**2**	**2**	**21**	**292**	**546**
Ochiltree County / Canadian Basin WUG	**2**	**2**	**2**	**21**	**292**	**546**
Booker	2	2	2	2	2	2
Perryton Municipal Water System	0	0	0	19	290	544
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Oldham County WUG Total	**128**	**0**	**0**	**0**	**0**	**0**
Oldham County / Canadian Basin WUG	**31**	**0**	**0**	**0**	**0**	**0**
Vega	0	0	0	0	0	0

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DRAFT Region A Water User Group (WUG) Second-Tier Identified Water Needs

	WUG Second-Tier Needs (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Oldham County / Canadian Basin WUG	**31**	**0**	**0**	**0**	**0**	**0**
County-Other	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	31	0	0	0	0	0
Oldham County / Red Basin WUG	**97**	**0**	**0**	**0**	**0**	**0**
County-Other	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	97	0	0	0	0	0
Potter County WUG Total	**535**	**2,029**	**4,677**	**7,429**	**8,753**	**9,926**
Potter County / Canadian Basin WUG	**31**	**635**	**1,730**	**2,805**	**3,248**	**3,590**
Amarillo	0	570	1,613	2,626	3,029	3,332
County-Other	0	0	0	0	0	0
Manufacturing	31	65	117	179	219	258
Mining	0	0	0	0	0	0
Steam Electric Power	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Potter County / Red Basin WUG	**504**	**1,394**	**2,947**	**4,624**	**5,505**	**6,336**
Amarillo	0	375	1,059	1,725	1,988	2,189
County-Other	0	0	0	0	0	0
Manufacturing	504	1,019	1,888	2,899	3,517	4,147
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0

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DRAFT Region A Water User Group (WUG) Second-Tier Identified Water Needs

	WUG Second-Tier Needs (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Randall County WUG Total	**107**	**2,148**	**6,944**	**12,047**	**16,213**	**20,276**
Randall County / Red Basin WUG	**107**	**2,148**	**6,944**	**12,047**	**16,213**	**20,276**
Amarillo	0	1,119	3,590	6,698	8,796	11,009
Canyon	0	398	1,025	1,661	2,251	2,827
Happy*	0	0	0	0	0	0
Lake Tanglewood	0	0	0	0	0	0
Siesta Estates	0	0	0	0	0	0
County-Other	0	0	0	0	0	0
Manufacturing	107	173	285	413	491	569
Livestock	0	0	0	0	0	0
Irrigation	0	458	2,044	3,275	4,675	5,871
Roberts County WUG Total	**0**	**0**	**5**	**18**	**32**	**43**
Roberts County / Canadian Basin WUG	**0**	**0**	**5**	**18**	**32**	**43**
Miami	0	0	5	18	32	43
County-Other	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Roberts County / Red Basin WUG	**0**	**0**	**0**	**0**	**0**	**0**
County-Other	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Sherman County WUG Total	**19,040**	**21,467**	**5,635**	**144**	**267**	**322**
Sherman County / Canadian Basin WUG	**19,040**	**21,467**	**5,635**	**144**	**267**	**322**
Stratford	128	115	99	144	267	322
Texhoma	0	0	0	0	0	0

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DRAFT Region A Water User Group (WUG) Second-Tier Identified Water Needs

	WUG Second-Tier Needs (acre-feet per year)					
	2030	2040	2050	2060	2070	2080
Sherman County / Canadian Basin WUG	**19,040**	**21,467**	**5,635**	**144**	**267**	**322**
County-Other	0	0	0	0	0	0
Manufacturing	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	18,912	21,352	5,536	0	0	0
Wheeler County WUG Total	**33**	**114**	**187**	**244**	**315**	**411**
Wheeler County / Red Basin WUG	**33**	**114**	**187**	**244**	**315**	**411**
Shamrock Municipal Water System	0	0	0	0	40	123
Wheeler	33	114	187	244	275	288
County-Other	0	0	0	0	0	0
Mining	0	0	0	0	0	0
Livestock	0	0	0	0	0	0
Irrigation	0	0	0	0	0	0
Region A Second-Tier Needs Total	**376,797**	**420,120**	**357,095**	**305,988**	**267,987**	**237,853**

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ATTACHMENT 4-2

WATER NEEDS BY DECADE AND CATEGORY OF USE FOR MAJOR WATER PROVIDERS

Major Water Provider First Tier Needs by Category of Use in Each Decade

Major Water Provider	Category of Use	Needs (Ac Ft/Yr)					
		2030	2040	2050	2060	2070	2080
Amarillo	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	-983	-2,257	-3,288	-4,495	-5,236	-5,989
	Mining	0	0	0	0	0	0
	Municipal	-4,187	-9,732	-14,216	-19,245	-22,212	-25,123
	Steam Electric Power	0	0	0	0	0	0
	Total	**(5,170)**	**(11,989)**	**(17,504)**	**(23,740)**	**(27,448)**	**(31,112)**
Borger	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	-1,017	-1,624	-2,156	-2,715	-3,120	-3,951
	Mining	0	0	0	0	0	0
	Municipal	-324	-491	-611	-717	-771	-912
	Steam Electric Power	0	0	0	0	0	0
	Total	**(1,341)**	**(2,115)**	**(2,767)**	**(3,432)**	**(3,891)**	**(4,863)**
CRMWA	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	-22,540	-38,520	-49,928	-59,132	-61,953	-64,858
	Steam Electric Power	0	0	0	0	0	0
	Total	**(22,540)**	**(38,520)**	**(49,928)**	**(59,132)**	**(61,953)**	**(64,858)**
Greenbelt MIWA	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	0	0	0	0	0
	Steam Electric Power	0	0	0	0	0	0
	Total	**-**	**-**	**-**	**-**	**-**	**-**

Major Water Provider Second Tier Needs by Category of Use in Each Decade

Major Water Provider	Category of Use	Needs (Ac Ft/Yr) 2030	2040	2050	2060	2070	2080
Amarillo	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	-983	-1,598	-2,631	-3,832	-4,568	-5,315
	Mining	0	0	0	0	0	0
	Municipal	-89	-2,205	-6,483	-11,357	-14,167	-16,924
	Steam Electric Power	0	0	0	0	0	0
	Total	**(1,072)**	**(3,803)**	**(9,114)**	**(15,189)**	**(18,735)**	**(22,239)**
Borger	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	-1,017	-1,624	-2,156	-2,715	-3,120	-3,951
	Mining	0	0	0	0	0	0
	Municipal	-286	-454	-575	-682	-737	-879
	Steam Electric Power	0	0	0	0	0	0
	Total	**(1,303)**	**(2,078)**	**(2,731)**	**(3,397)**	**(3,857)**	**(4,830)**
CRMWA	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	-19,837	-35,489	-46,582	-55,547	-58,140	-60,831
	Steam Electric Power	0	0	0	0	0	0
	Total	**(19,837)**	**(35,489)**	**(46,582)**	**(55,547)**	**(58,140)**	**(60,831)**
Greenbelt MIWA	Irrigation	0	0	0	0	0	0
	Livestock	0	0	0	0	0	0
	Manufacturing	0	0	0	0	0	0
	Mining	0	0	0	0	0	0
	Municipal	0	0	0	0	0	0
	Steam Electric Power	0	0	0	0	0	0
	Total	**-**	**-**	**-**	**-**	**-**	**-**

5 WATER MANAGEMENT STRATEGIES

Chapter 5 identifies and discusses the water management strategies to meet identified water needs as outlined in **Chapter 4**. These needs are met through a variety of strategies that have been developed through coordination with the water users in PWPA.

There are 33 water user groups and four Major Water Providers (MWP) that are identified with a projected need over the planning period. As previously discussed, the largest quantities of water needs are associated with irrigated agriculture, but this plan also identified over 45,000 acre-feet per year of needs for municipal and manufacturing water use in the Panhandle Region by 2080. Additional water is needed to serve customers outside of the region.

Chapter 5

Chapter 5A: Identification of Water Management Strategies

Chapter 5B: Water Conservation

Chapter 5C: Major Water Provider Strategies

Chapter 5D: Water Management Strategies by County

Associated Appendices/Attachments

Appendix D: Water Management Strategy Cost Estimates

Attachment 5-1: List of potentially feasible strategies

Attachment 5-2: Strategy Evaluation Matrix and Quantified Environmental Impact Matrix

Attachment 5-3: Recommended municipal conservation goals

Chapter 5 is divided into four main parts. **Chapter 5A** discusses the types of potentially feasible water management strategies, the process used to develop the strategies, and the factors considered in evaluating the strategies. **Chapter 5B** discusses the water conservation strategies that were considered and recommended for the PWPA. This includes the identification and evaluation for municipal and irrigation conservation measures. **Chapter 5C** presents the recommended water management strategies for the four MWPs in the PWPA. **Chapter 5D** addresses the recommended strategies for each water user group with identified needs and summarizes the water management plans by county.

The water management strategies identified in the following subchapters are for water users with projected needs. For aggregated water users, such as “County-Other”, the identification of needs can be challenging due to the nature of the data evaluation. If water quantity or quality needs for smaller entities (municipal water users that provide less than 100 acre-feet of water per year) became known to the PWPG, strategies for these needs are also included in this plan. However, the PWPG considers the development of water strategies for smaller entities that may not show a need consistent with the Panhandle Water Plan.

The report assumes that management strategies to meet any identified needs are employed or implemented by the respective water user. The PWPG does not take responsibility in planning or implementing the strategies.

5A IDENTIFICATION OF POTENTIALLY FEASIBLE WATER MANAGEMENT STRATEGIES

This section provides a review of the types of water management strategies (WMS) considered for the PWPA and the approach for identifying the potentially feasible water management strategies for water users with needs. Once a list of potentially feasible strategies has been identified, the most feasible strategies are recommended for implementation. Alternative strategies can also be identified, in case the recommended strategies become unfeasible. Where appropriate, regional strategies to supply water were considered. These strategies are discussed in more detail in later subchapters. All strategies were evaluated under drought of record conditions. This subchapter identifies the potentially feasible strategies for water users and MWPs that were found to have a projected need in **Chapter 4**. Where applicable the following information was considered when evaluating existing supplies and WMSs:

- Publicly available plans for major agricultural, municipal, manufacturing, and commercial water users
- Local and regional water management plans
- Water availability requirements relating to Priority Groundwater Management Areas
- The Texas Clean Rivers Program
- The U.S. Clean Water Act
- Water management plans
- Other planning goals, including regionalization of water and wastewater services
- Input from water providers through surveys and meetings
- Any other information available from local or regional water planning studies

5A.1 Water Management Strategy Types

Identification of a supply source as a potentially feasible strategy depends on the availability of the source, the accessibility of the source to the entity developing the strategy, and the feasibility of developing a strategy from the source of supply. It should be noted that there can be potentially feasible strategies that are not identified through this process for an entity but could be identified in the future. The methodology to identify potentially feasible strategies and a list of the strategy types considered for each water user with a need is included in **Attachment 5-1**.

Water Management Strategy Categories

- Water Conservation
- Drought Management Measures
- Wastewater Reuse
- Management and/or Expanded Use of Existing Supplies
  - System Operation
  - Conjunctive Use of Groundwater and Surface Water
  - Reallocation of Reservoir Storage
  - Voluntary Redistribution of Water Resources
  - Voluntary Subordination of Existing Water Rights
  - Yield Enhancement
  - Water Quality Improvement
- New Supply Development
  - Surface Water Resources
  - Groundwater Resources
  - Brush Control
  - Desalination
  - Water Right Cancellation
  - Rainwater Harvesting
  - Aquifer Storage and Recovery (ASR)
  - Precipitation Enhancement
  - Interstate Water
- Interbasin Transfers
- Emergency Transfers of Water

The purpose of this chapter is to provide a big picture discussion on the various strategy types that were identified to potentially reduce the WUG/MWP needs.

While each of these strategy types were considered by the PWPA, not all were determined as viable options for addressing needs in the region. Some strategies were determined as unfeasible when the associated costs involved with implementation of the strategy outweighed the overall benefits. Such costs can include, but are not limited to, economic feasibility and negative impacts on other water users.

The strategy types (and associated subcategories) that were determined as potentially feasible strategies for entities within the PWPA are: 1) water conservation and drought management 2) wastewater reuse 3) expanded use of existing supplies (groundwater supplies, surface water supplies, local supplies, conjunctive use, water quality improvements, and voluntary transfer), 4) new groundwater supply development, including brackish groundwater desalination, 5) aquifer storage and recovery, 6) brush control, and 7) precipitation enhancement. Other strategies considered and discussed include groundwater enhancement (recharge through playa lakes) and an interstate surface water transfer project.

The potentially feasible strategy types determined not viable for long-term water supply for the PWPA and are not discussed further include water right cancellation, interbasin transfers, and emergency transfers of water. Water right cancellation and interbasin transfers are surface water strategies. There is little existing surface in the region and little to no unappropriated surface water. Neither of these strategies would provide reliable long-term supplies. Emergency transfers of water is a strategy typically employed during an emergency situation and is not considered a sustainable strategy for long-term water needs.

The sections below include a brief discussion of each of the strategy types considered for the PWPA and the specific application to the users in the region.

5A.1.1 Water Conservation and Drought Management

Water conservation is defined as methods and practices that reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses. Water conservation is typically viewed as long-term changes in water use that are incorporated into daily activities. Conversely, drought management is the temporary reduction in water use in direct response to a drought or water supply emergency. It is typically short-term and does not result in lasting changes. If drought management measures are used as water management strategies, there is little or no flexibility remaining should the drought exceed the previous drought of record conditions.

Water conservation is a valued water management strategy in the PWPA because it helps prolong the limited water resources in the region. It is recommended for municipal (only County-Other users with needs have conservation savings applied, all other municipal water user groups have conservation savings applied) and irrigation water users, whether the user has a defined need or not, and it is encouraged for all other users. Drought management is not a recommended strategy in the PWPA because it does not provide a long-term solution to water needs. This strategy is still an important option to water users for times when existing water supplies are threatened during drought and entities should develop drought contingency plans in accordance with Texas Administrative Code, Chapter 288 rules.

5A.1.2 Wastewater Reuse

Wastewater reuse utilizes treated wastewater effluent as either a replacement for an existing water supply (direct reuse) or utilizes treated wastewater that has been returned to a water supply resource (indirect reuse). Wastewater reuse is currently heavily utilized by industries that purchase wastewater effluent from larger municipalities. It is also used for limited agricultural irrigation. The largest producers of wastewater effluent are the larger cities, including Amarillo, Borger, Canyon, Dumas and Pampa. Currently, Amarillo sells most of its treated wastewater to Xcel Energy for cooling water. Borger also sells its wastewater to industrial customers. There may be potential to expand wastewater reuse in the PWPA, but the amounts may be limited due to the current level of use.

5A.1.3 Expanded Use of Existing Supplies

Expanded use of existing supplies includes seven subcategories ranging from selling developed water that is not currently used to enhancing existing supplies through operations, storage, treatment or other means. In the PWPA, three of the seven subcategories were determined potentially feasible. These include conjunctive use of groundwater and surface water, voluntary transfer (sales or contracts for developed water), and water quality improvements.

5A.1.4 Conjunctive Use of Groundwater and Surface Water

Conjunctive use is the operation of multiple sources of water to optimize the water resources for additional supply. In the PWPA, there are two MWPs that own and operate both surface water and groundwater sources: CRMWA and Greenbelt MIWA. Both entities intend to conjunctively use the surface water when available to meet demands and use additional groundwater to supplement surface water supplies during drought. This will help reduce evaporative losses associated with the surface water reservoirs, while still meeting demands with groundwater when less or no surface water is available. Generally, this is a recognized operational approach for current and future supplies.

5A.1.5 Voluntary Transfer

Voluntary transfer is redistribution of existing water supplies from one user to another through sales, leases, contracts, options, subordination or other similar types of agreements. Typically, the entity providing the water has determined that it does not need the water for the duration of the transfer. The transfer of water could be for a set period of years or a permanent transfer. Redistribution of water makes use of existing resources and provides a more immediate source of water. In the PWPA, there is little to no developed water that is available for redistribution without the development of additional strategies. This strategy is used to represent sales and contracts between a water provider and its customers. It can include current contractual obligations and potential future customers.

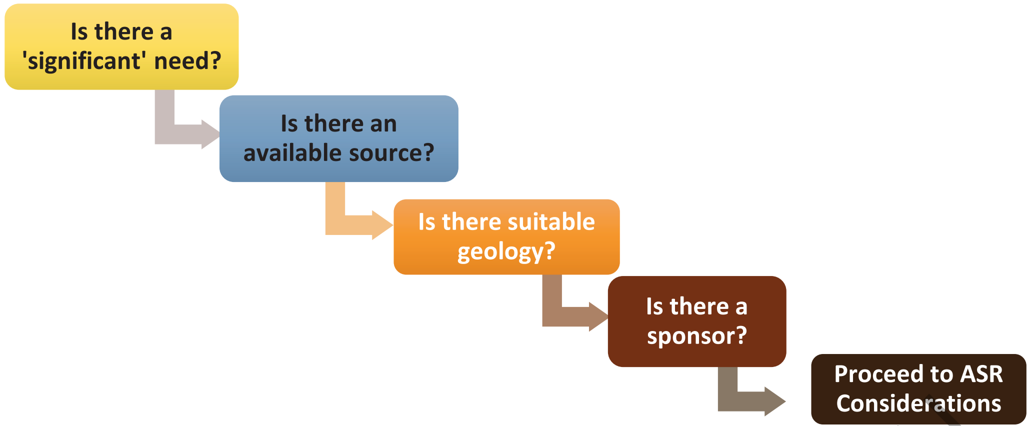
5A.1.6 Water Quality Improvements

Water quality improvements allow for the use of impaired water for municipal or other uses. In PWPA, there are areas with impaired water quality, specifically elevated nitrates and salts. Water quality improvement for these sources is typically accomplished through desalination treatment, such as reverse osmosis. Nitrates can also be treated using ion exchange. This strategy type would apply to treatment of other water quality parameters. This strategy is considered for users with sufficient water quantity, but impaired water quality.

5A.1.7 Aquifer Storage and Recovery (ASR)

Aquifer storage and recovery is a type of strategy that utilizes suitable geologic formations to store water until needed. The water to be stored can be introduced through enhanced recharge or more commonly injected through a well into the aquifer. If an injection well is used, Texas law requires that the water be treated to the same quality as the receiving aquifer. Source water for ASR can include excess surface water, treated wastewater, or groundwater from another aquifer. The benefit of this strategy in the PWPA is that it can better utilize available infrastructure (transmission and/or treatment) during low demand periods and store the water to minimize evaporation. This strategy requires the availability of a suitable geologic formation for storage of the water and the infrastructure to place the water into the aquifer and then recover the water when needed. This strategy must be considered for water users with a significant need as defined by the PWPG. For the PWPA, 5,000 acre-feet per year is used as the threshold for significant need. Two major water providers, CRMWA and Amarillo, meet this threshold. ASR is considered for CRMWA and Amarillo. As part of the CRMWA ASR strategy, the city of Pampa is considered as a participant in the ASR project.

ASR Decision Matrix



5A.1.8 New Groundwater Development

Groundwater accounts for approximately 97 percent of the total water use in the PWPA. Over much of the region, there is available groundwater for future development. Towards the southeast portion of the region, groundwater resources become more limited and there are water quality concerns. Even with these limitations, groundwater is a viable and cost-effective supply source for the PWPA. Most of municipal water users with a need during the planning period are expected to expand their current groundwater use or develop new groundwater supplies. **Table 5A-1**shows the amount of groundwater that is available for new groundwater development by aquifer. There are areas within the PWPA that have limited groundwater sources or are heavily using these sources. Counties that are near capacity in utilizing the fresh groundwater resources are Collingsworth, Hall, Hutchinson, Moore and Sherman Counties. Also, there is little groundwater available for future development in the heavily irrigated areas in Dallam and Hartley Counties. Potential users of new or expanded groundwater are presented by aquifer and county in **Table 5A-2**.

Table 5A-1: Available Groundwater Supplies for Strategies

Aquifer	Unallocated Supplies[1] (acre-feet)
Blaine Aquifer	14,724
Dockum Aquifer	292,062
Ogallala and Rita Blanca Aquifers	113,741
Ogallala Aquifer	1,395,673
Other Aquifer	776
Seymour Aquifer	3,060

[1] This is the amount of groundwater that is available for strategies in 2030.

Table 5A-2: Potential Users of New Groundwater

Source County	Ogallala/Rita Blanca	Dockum
Armstrong		
Carson	Panhandle, Amarillo, Fritch	
Childress		
Collingsworth		

Source County	Ogallala/Rita Blanca	Dockum
Dallam		
Donley	GMIWA	
Gray		
Hall		
Hansford	Gruver	
Hartley	Dumas, Livestock	Livestock
Hemphill	Canadian	
Hutchinson	Borger, Stinnett	
Lipscomb	Booker	
Moore	Cactus, Livestock, Manufacturing	Manufacturing
Ochiltree	Perryton	
Oldham		
Potter	Amarillo	
Randall	Canyon, Shamrock	Canyon
Roberts	CRMWA, Amarillo, Miami	
Sherman	Stratford	
Wheeler	Wheeler	

In addition to new groundwater development, the region considered groundwater recharge enhancement through playa lakes. There are approximately 5,700 playa lakes in the PWPA. Recharge enhancement through playa lakes is a considered strategy for the PWPA and is discussed in **Chapter 5D, Section 5.22**.

5A.1.9 Desalination and Water Quality Improvements

Desalination of brackish groundwater was considered potentially feasible, but due to the availability of non-brackish groundwater for users with a need, it was not considered for any user in the PWPA. Seawater desalination is not feasible because the PWPA is located more than 500 miles from the coast.

Impaired water quality affects both surface water and groundwater. Desalination of Lake Meredith water is considered a potentially feasible strategy for CRMWA. Both chloride control within the reservoir's watershed and direct treatment of the diverted water are considered. Advanced water treatment for groundwater users with elevated nitrates and/or salts (e.g., Seymour Aquifer) is also considered as potentially feasible.

5A.1.10 Brush Control

In 1985, the Texas Legislature authorized the Texas State Soil and Water Conservation Board (TSSWCB) to conduct a program for the "selective control, removal, or reduction of brush species that consume water to a degree that is detrimental to water conservation." In 1999 the TSSWCB began the Brush Control Program. In 2011, the 82nd legislature replaced the Brush Control Program with the Water Supply Enhancement Program (WSEP). The WSEP's purpose is to increase available surface and groundwater supplies through the selective control of brush species that are detrimental to water conservation.

WSEP considers priority watersheds across the state, the need for conservation within the territory of a proposed projection based on the State Water Plan and if the Regional Water Planning Group has identified brush control as a strategy in the State Water Plan as part of their competitive grant, cost sharing program. However, this program is currently not funded. There are three primary species of brush in the PWPA that are eligible for funding from the WSEP as shown in **Table 5A-3**.

The Lake Meredith watershed is a priority watershed for brush control. In 2000, the State sponsored a feasibility study of brush removal in the Canadian River downstream from Ute Reservoir to Lake Meredith, which indicated potential significant reductions in water loss from brush. Since then, CRMWA has helped sponsor brush removal in the Lake Meredith watershed. However, brush management must be an on-going strategy to continue to realize water savings. This strategy is a potentially feasible strategy for CRMWA and users of Lake Meredith.

Table 5A-3: Plant Water Use Rates

Plant	Water Use Per Tree (gallons/tree/day)	Water Savings (ac ft/ac/yr)
Juniper	46.8	0.14 – 0.33
Mesquite	44	0.05
Salt cedar	0.1 – 15	2 – 5

Source: Texas State Soil and Water Conservation Board Brush Control Program, 2010 Annual Report

5A.1.11 Precipitation Enhancement

Precipitation enhancement introduces seeding agents to stimulate clouds to generate more rainfall. This process is also commonly known as cloud seeding or weather modification. There is one active precipitation enhancement program in the PWPA. This program covers most of the counties in the Panhandle GCD. The benefits from increased rainfall through precipitation enhancement projects include increased agricultural production, decreased irrigation use, increased reservoir levels, increased and higher quality forage for livestock and wildlife, and fire and hail suppression. Due to its primary use for agricultural benefits in the PWPA, this strategy is considered as part of the irrigation conservation strategies and discussed in **Chapter 5B**.

5A.1.12 Interstate Water

Interstate water is a strategy that uses water from outside of Texas. The source of the water could be surface water or groundwater. The PWPA borders Oklahoma to the north and east and New Mexico to the west. Both states have limited water supplies and are unlikely to allow transfers of state water to Texas. However, there have been previous proposals of moving excess surface water from areas further east to the High Plains area. One federal study looked at moving water from the Missouri River watershed west to the PWPA. This concept was retained for review and consideration for the Panhandle Water Plan. It is discussed in **Chapter 5D, Section 5D.22**, under Regional Water Management Strategies.

5A.2 Evaluation Procedures

The consideration and selection of water management strategies for water user groups with needs followed TWDB guidelines and were conducted in open meetings within the PWPA. The PWPA consistently endorsed the highest level of conservation achievable for all water uses in the region. In addition, environmental impacts and the protection of the region's resources were a priority in the selection process. In the development of the water management strategies, existing water rights, water contracts, and option agreements are recognized and fully protected.

The potentially feasible strategies were evaluated in accordance with state guidance and evaluation criteria. Some considerations listed in Title 31§357.34, such as inter-basin transfers and third party impacts due to re-distribution of water rights, were not specifically reviewed because they were not applicable to strategies identified for the PWPA needs.

Evaluation Considerations

- Quantity, reliability, and cost
- Environmental factors, including effects on environmental water needs, wildlife habitat and cultural resources
- Impacts on water resources, such as playas and other water management strategies
- Impacts on agriculture and natural resources
- Other relevant factors

The definition of quantity is the amount of water the strategy would provide to the respective user group in acre-feet per year. This amount is considered with respect to the user's short-term and long-term needs. Reliability is an assessment of the availability of the specified water quantity to the user over time. If the quantity of water is available to the user all the time, then the strategy has a high reliability. If the quantity of water is contingent on other factors, reliability will be lower.

The assessment of cost for each strategy is expressed in dollars per acre-foot per year for water delivered and treated for the end user requirements. Calculations of these costs follow the Texas Water Development Board's guidelines for cost considerations and identify capital and annual costs by decade. Project capital costs are based on September 2023 price levels and include construction costs, engineering, land acquisition, mitigation, right-of-way, contingencies and other project costs associated with the respective strategy. Annual costs include power costs associated with transmission, water treatment costs, water purchase (if applicable), operation and maintenance, and other project-specific costs. Debt service for capital improvements was calculated over 20 years at a 3.5 percent interest rate. In the case of municipal and County-Other water needs, the cost estimates are only for development of the supply and delivery to the water utility's distribution system. There may be additional costs to distribute the water to the end users that are not represented in these estimates.

Potential impacts to sensitive environmental factors were considered for each strategy. Sensitive environmental factors may include wetlands, threatened and endangered species, unique wildlife habitats, and cultural resources. In most cases, a detailed evaluation could not be completed because a specific location for groundwater rights was not available. Therefore, a more detailed environmental assessment will be required before a strategy is implemented.

The impact on water resources considers the effects of the strategy on water quantity, quality, and use of the water resource. This review also evaluated whether the strategy would impact the water quantity and quality of other water management strategies identified.

A water management strategy could potentially impact agricultural production or local natural resources. Impacts to agriculture may include reduction in agricultural acreage, reduced water supply for irrigation, or impacts to water quality as it affects crop production. Various strategies may improve water quality, while others may have a negative impact. The impacts to natural resources may consider inundation of parklands, impacts to exploitable natural resources, recreational use of a natural resource, and other strategy-specific factors.

Other relevant factors include regulatory requirements, political and local issues, amount of time required to implement the strategy, recreational impacts of the strategy, and other socio-economic benefits or impacts.

Municipal and manufacturing strategies were developed to provide water of sufficient quantity and quality that is acceptable for its end use. Water quality affects water use options and treatment requirements. For the evaluations of the strategies, it was assumed that the water would meet existing state water quality requirements for the specified use. For example, a strategy that provided water for municipal supply would meet existing drinking water standards, while water used for mining may have a lower quality.

The evaluation of each strategy is quantified based on available data. This evaluation is documented in the evaluation matrices contained in **Attachment 5-2**.

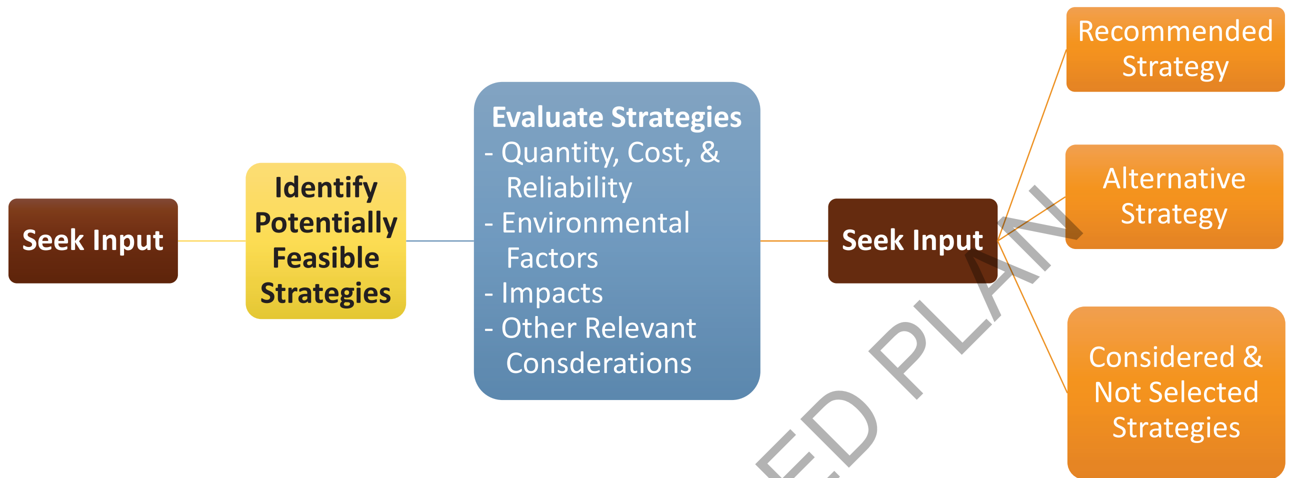
5A.2.1 Strategy Development Assumptions

Strategies were developed for water user groups in the context of their current supply sources, previous supply studies and available supply within reasonable vicinity of the need. As previously discussed, most of the water supply in the PWPA is from groundwater. For many of the identified needs, the potentially feasible strategies included development of new groundwater supplies or further development of an existing well field. Site-specific data were used when available. When specific well fields could not be identified, assumptions regarding the source aquifer, well capacity, depth of well, and relative distance to the user were developed. Other strategy assumptions were developed with the input of the strategy sponsor.

While the development of the strategies considered acquisition of water rights when needed, the implementation of any groundwater strategy will need to ensure an adequate quantity of groundwater rights while complying with all applicable water conservation district rules. For this plan, strategy supplies could not exceed the MAG. This results in some strategies with less water than originally intended by the sponsor. If the MAGs increase in future rounds of planning, the supplies for these strategies may be adjusted.

Water transmission lines were assumed to take the shortest route, following existing highways or roads where possible. For new well fields that are not specifically identified, an average transmission distance was assumed. Pipes were sized to deliver peak-day flows within reasonable pressure and velocity ranges. Water losses of 25 percent were included for strategies requiring reverse osmosis (RO) treatment (potable reuse or nitrate removal). Water losses associated with transmission were assumed to be negligible for regional planning purposes.

Process to Identify and Evaluate Water Management Strategies



5A.2.2 Strategy Costs

The cost estimates for water management strategies identify both capital and annual costs. Capital costs are based on standard unit costs provided by the TWDB for installed pipe, pump stations and standard treatment facilities developed from experience with similar projects throughout the State of Texas. If a project had more detailed costs, these costs were used. Assumptions for groundwater strategies include project location, well depth, and well capacity.

A more detailed explanation of the cost assumptions and summaries of the costs developed for each strategy are included in **Appendix D**.

5B WATER CONSERVATION

Water conservation is a demand management strategy that proactively reduces future water needs. Conservation facilitates more efficient use of existing water supplies and may delay the need to develop new water supplies. An expected level of conservation is included in the municipal demand projections from the Texas Water Development Board (TWDB) due to the natural replacement of less efficient plumbing fixtures with low flow fixtures, as mandated under the Plumbing Code. Irrigation water demands also include a declining demand over the planning horizon due to expected reduced use associated with more efficient water use, declining groundwater levels, and the transfers of water rights to other uses.

Water conservation strategies must be considered for all water users with a need. In the PWPA, this includes municipal, manufacturing, livestock and irrigation water users. All of the manufacturing water needs, except for a portion of those in Moore County, are associated with needs of a municipal water provider. Manufacturing needs in Moore County are associated with anticipated new facilities in this round of planning. Conservation strategies to reduce manufacturing water use are typically industry and process-specific and cannot be specified to meet county-wide needs. Wastewater reuse is a more general strategy that can be utilized by various industries for process water, and this strategy will be considered where appropriate. For municipal and irrigation users, additional conservation savings can potentially be achieved in the region through the implementation of conservation best management practices (BMPs). These additional conservation measures were considered for municipal (only County-Other users with needs were evaluated, all other municipal water user groups were evaluated) and irrigation water user groups in the Panhandle Water Planning Area (PWPA). The PWPA recognizes that it has no authority to implement, enforce, or regulate water conservation practices. These water conservation practices are intended to be guidelines. Water conservation strategies determined and implemented by the individual water user group supersede the recommendations in the Regional Water Plan (Plan) and are considered to meet regulatory requirements for consistency with the Plan.

Definitions

Conservation: "The development of water resources; and those practices, techniques, and technologies that will reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses." TAC §11.002(8)

Drought/Emergency Management: Temporary measures that are implemented when certain criteria are met and are terminated when these criteria are no longer met.

Best Management Practice: "Conservation measure or series of measures that is useful, proven, cost-effective, and generally accepted among conservation experts. In Texas, conservation BMPs are designed...as one alternative to meet future water needs." TWDB

5B.1 Municipal Conservation

Each public water supplier with 3,300 connections or holding a water right greater than 1,000 acre-feet per year is required to update and submit a Water Conservation Plan (WCP) to the Texas Commission on Environmental Quality (TCEQ) every five years. Also, entities with a financial obligation with the TWDB greater than $500,000 are also required to submit a water conservation plan to the TWDB. These plans are also to be submitted to the respective regional water planning group. In the PWPA, three new WCPs were submitted and considered in this round of planning in addition to the eight WCPs that were previously submitted. If a public water supplier serves over 5,000 people, they are additionally required to report water loss from the supply and distributions systems.

Both the water conservation plans and water loss audit reports for water suppliers in the PWPA were reviewed to help identify appropriate municipal water conservation measures. The data from the water loss audit reports for PWPA water providers are discussed in more detail in **Chapter 1** of this plan.

Thirteen water providers in the PWPA submitted water loss audits in 2022. Based on these reports, the average percentage of real water loss for the PWPA is approximately 15 percent, which is equivalent to the accepted range of water loss (15 percent for Cities). This level of water loss is likely due to the large service areas with low population densities characteristic of rural water supply corporations. For the water suppliers that fall under the water supply corporation category, there may be few cost-effective options in reducing water loss.

5B.1.1 Identification of Potentially Feasible Conservation BMPs

To assess the appropriateness of additional conservation BMPs for the PWPA during the 2016 planning cycle, 68 potential strategies were identified, and a screening level evaluation was conducted. Due to difference in the water needs and available resources between the larger municipalities and smaller rural areas, the screening evaluation was performed both for entities with populations less than 20,000 people and entities with population great than 20,000. In the PWPA, there are two entities that have populations greater than 20,000 during the planning period: Amarillo and Canyon.

The evaluation considered six criteria:

- Cost
- Potential Water Savings
- Time to Implement
- Public Acceptance
- Technical Feasibility
- Staff Resources

Each criterion was scored from 1 to 5 with 5 being the most favorable. Scores for all the criteria were then added to create a composite score. The strategies were then ranked and selected based on their composite score. For the current planning period, the evaluation from the 2016 Plan was updated as appropriate and used as a reference to identify potentially feasible conservation BMPs.

Selected Strategies for Entities under 20,000

Based on the screening level evaluation and requirements from the TCEQ, the following strategies were selected for consideration for entities in the PWPA with less than 20,000 people during every decade of the planning period:

- Education and Outreach
- Water Audits and Leak Repair

- Conservation – Oriented Rate Structure
- Water Waste Ordinance

Selected Strategies for Entities over 20,000

Based on the screening level evaluation and requirements from the TCEQ, the following strategies were selected for consideration for entities in the PWPA with more than 20,000 people during any decade of the planning period:

- Education and Outreach
- Water Audits and Leak Repair
- Conservation – Oriented Rate Structure
- Water Waste Ordinance
- Landscape Ordinance
- Time of Day Watering Limit

Each of the selected strategies above were considered and evaluated for the appropriate water user groups (greater than or less than 20,000). For the purposes of strategy evaluation, each household was assumed to have an average of three people. Additional assumptions were developed and used in the evaluation of the selected municipal conservation measures as described in **Section 5B.1.2**.

5B.1.2 Recommended Municipal Conservation Strategies

Published reports and previous studies were used to refine the description for the selected BMPs, including the potential water savings and costs. Water savings for some BMPs are difficult to estimate since there is little data for an extended time period. Also, most entities tend to implement a suite of strategies at the same time, which makes it difficult to estimate the individual water savings. These factors were considered in developing the assumptions defined below for each BMP. As more data become available through more rigorous water use tracking, the ability to estimate water conservation savings will improve.

Municipal Conservation Package

- Education and Outreach
- Water Audits and Leak Repair
- Conservation Oriented Rate Structure
- Water Waste Ordinance
- Landscape Ordinance (Cities> 20,000 population)
- Time of Day Watering Limit (Cities> 20,000 population)

Education and Outreach

Local officials would offer water conservation education to schools, civic associations, include information in water bills, provide pamphlets and other materials as appropriate. It was assumed that the education outreach programs would be needed throughout the planning period to maintain the water savings. It was assumed that education and outreach would save 5,000 gallons per household per year with a 30 percent adoption rate, i.e., assume that 30 percent of the customers respond to this measure by reducing water use. Per person costs were based on data obtained from municipalities and water providers. The costs for entities with populations less than 20,000 are greater on a per person basis than for the larger cities. In this case, education and outreach were assumed to cost $3.19 per person per year with a maximum cost of $15,000 for entities with populations less than 20,000. In contrast, education and outreach were assumed to cost $2.09 per person per year for entities with populations greater than 20,000.

Water Audits and Leak Repair

Local officials would perform a water audit system wide and create a program of leak detection and repair including infrastructure replacement as necessary. It was assumed that 20 percent of an entity's losses could be recovered through a water audit and leak repair program, and that the leak detection and repair program is an on-going activity to maintain the level of water loss reductions. This strategy was considered for all cities with greater than or equal to 15 percent losses and WSCs with losses greater than or equal to 25 percent. If no water loss data was available, this strategy was not considered.

Water Loss data was available for thirteen WUGs in the PWPA, with six WUGs meeting the requirements for implementation of Water Audits and Leak Repair BMP (Amarillo, Darrouzett, Higgins, Pampa, Panhandle, and Vega). Costs were estimated at $12 per person per year. If an entity's population was less than 20,000, then an estimated base cost of $5,000 was added to the total cost.

Rate Structure

Local officials would implement an increasing block rate structure where the unit cost of water increases as consumption increases. Increasing block rate structures discourage the inefficient use or waste of water. Many cities already have a non-promotional rate structure. This strategy assumes that the entity adopts a higher level of a non-promotional rate structure. It is assumed that increasing block rates would save 6,000 gallons per household per year and that 10 percent of the households would respond to this measure by reducing water use. Since it is likely that the entity would conduct the rate structure modifications themselves, this BMP has no additional costs to the water provider.

Water Waste Ordinance

Local officials would implement an ordinance prohibiting water waste such as watering of sidewalks and driveways or runoff into public streets. A water waste ordinance saves about 3,000 gallons per household per year. It is assumed that 50 percent of the households in entities with over 20,000 people and 30 percent of households in entities with less than 20,000 people would respond to this measure by not wasting water. Costs for this strategy would be those costs associated with enforcement. In this case, the costs associated with enforcement was estimated to be $11,600 for entities with over 20,000 people and $2,900 for entities with less than 20,000 people.

Landscape Ordinance (Population over 20,000)

Local officials would implement an ordinance that would promote residential plantings that conserve water for all new construction. This strategy is assumed to be implemented by 2040 and would only apply to new construction for both residential and commercial properties. This BMP would save 1,000 gallons per increased number of households per year. Costs for this strategy would be those costs associated with enforcement, which were estimated to be $11,600.

Time of Day Watering Limit (Population over 20,000)

Local officials would implement an ordinance prohibiting outdoor watering during the hottest part of the day when most of that water is lost (wasted) through evaporation. Many ordinances limit outdoor watering to between 6 p.m. and 10 a.m. on a year-round basis. It is assumed that time of day watering limits saves 1,000 gallons per household per year and 75 percent of the population would realize these savings (the other 25 percent is either not irrigating or already abide by this practice). Costs for this strategy would be those costs associated with enforcement, which were estimated to be $11,600.

5B.1.3 Evaluation of Municipal Conservation Strategies

Time Intended to Complete

This strategy is assumed to be implemented by the respective municipal WUG by 2030. To maintain the projected water savings, continued effort and funding will be required.

Quantity, Reliability and Cost

The water savings associated with municipal conservation vary depending on the potential of the entity's customers to reduce water use. For most water users in the PWPA, water that is conserved (i.e., not consumed) will further protect the natural resources for future use. The reliability is moderate because this strategy relies on actions of others (customers) and the willingness to change daily behaviors. The suite of recommended strategies focuses on the actions of the water provider, which have shown to be successful in reducing water consumption. The costs are low to moderate for larger entities and high for smaller entities. The capital costs are associated with the leak detection and repair strategy. For smaller entities, this strategy may not be cost effective. **Table 5B-1** shows the total water savings by provider and associated costs for each decade.

Environmental Factors

Potential environmental impacts associated with municipal conservation should be neutral to positive. Reductions in water use will preserve water for other uses, including potential environmental purposes.

Impacts to Agricultural and Natural Resources

Impacts to agricultural and rural areas should be neutral to positive. Conserved water by cities could provide additional supplies to agricultural and rural areas. Impacts to natural resources should be neutral to positive. Conserved water by cities would protect limited groundwater supplies for future use. If the water remains in the original source and is not used for other purposes, municipal conservation could help maintain existing water quality of these resources. High use of some water sources can possibly degrade water quality over time.

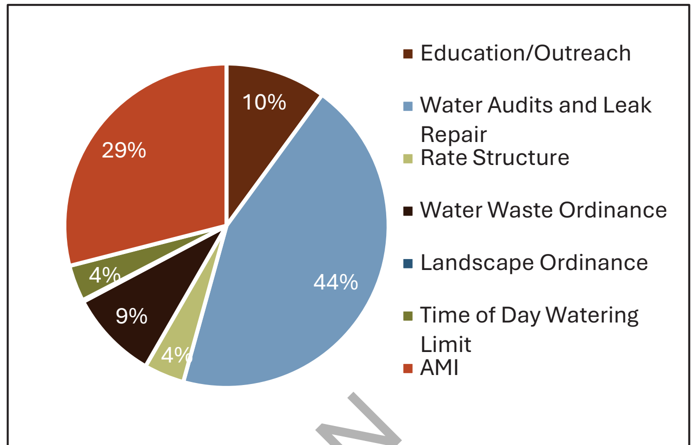
Impacts to Other Water Resources and Management Strategies

There are no known impacts to other water resources and management strategies.

5B.1.4 GPCD Goals

As part of House Bill (HB) 807, the regional planning groups are required to "set one or more specific goals for gallons water use per capita per day (gpcd) in each decade of the period covered by the plan for the municipal water user groups in the regional water planning area." It should be noted that these goals are different than the goals set by utilities as part of their TCEQ Water Conservation Plans (WCP). WCP goals are often based on multi-year averages. Per capita goals in this plan are intended as goals for dry year use, and thus, will generally be higher than the gpcd goal shown in an entity's WCP. The recommended goals are the dry year gpcd used for this Plan, after incorporating the recommended conservation savings. The gpcd goals for each municipal user in the PWPA are included as **Attachment 5-3** at the end of **Chapter 5**.

5B.1.5 Municipal Conservation Summary



Municipal BMPs

It is estimated that the municipal conservation strategy outlined in this memorandum will save, on a regional basis, over 5,000 acre-feet per year in 2030 and over 6,000 acre-feet per year in 2080 as shown in **Table 5B-1**. The unit costs vary considerably between water user groups depending on the population size, and implementation of a water audit and leak repair program for entities with high water losses. Generally, conservation programs are funded through a city's annual operating budget and are not capitalized. However, in some cases, an entity may choose to capitalize a portion or all of their program. These kinds of costs are difficult to estimate for each individual entity due to the wide variety of factors at play. For this plan, it is assumed that only water audits and leak repairs and Advanced Metering Infrastructure (AMI) are capitalized. However, all capital expenditures for conservation are considered consistent with the Panhandle Water Plan.

Estimates of total municipal conservation savings (including AMI and water audits and leak repairs) for PWPA water users are shown in **Table 5B-1**. This table shows the amount of water savings that are estimated through conservation water management strategies, which is above the amount assumed to be achieved through the Plumbing Act (see **Table 2-2**). **Table 5B-2** shows the estimated costs for municipal conservation (excluding AMI and water audits and leak repairs). The savings and costs associated with water audits and leak repairs are shown separately in **Table 5B-3** and those for AMI are shown on **Table 5B-4**.

Although water conservation is part of the culture of the region, the challenge for future water conservation activities in the PWPA will be the development of water conservation programs that are cost-effective, meet state mandates, and result in permanent real reductions in water use. Development of water conservation programs will be a particular challenge for smaller communities, which lack the financial and technical resources needed to develop and implement the programs. Any water conservation activities should consider the potential adverse impacts of lost revenues from water sales and the ability of communities to find alternative sources for those revenues. State financial and technical assistance will be required to meet state mandates for these communities.

Table 5B-1: Estimated Water Savings from Municipal Conservation (acre-feet per year)

Water User Group	2030	2040	2050	2060	2070	2080
Amarillo[1]	4,412	4,686	4,890	5,051	5,213	5,373
Booker	4	4	3	3	3	3
Borger	38	37	36	35	34	33
Cactus Municipal Water System	9	9	9	9	9	9
Canadian	7	7	7	7	7	6
Canyon	51	57	92	99	107	115
Childress	15	16	16	15	15	14
Clarendon	5	5	5	4	4	4
Claude Municipal Water System	3	3	3	3	3	3
Dalhart	27	29	30	31	33	35
Darrouzett	5	5	5	4	4	4
Dumas	45	46	45	44	43	42
Follett	1	1	1	1	1	1
Fritch	12	11	10	9	9	8
Groom Municipal Water System	2	2	2	2	2	2
Gruver	4	4	4	4	4	4
Hall County-Other (Brice-Lesley)	5	5	5	5	5	5
Happy[2]	-	-	-	-	-	-
Hartley WSC	1	1	1	1	1	1
Higgins Municipal Water System	7	6	6	6	5	5
Lake Tanglewood	2	1	1	1	1	1
McLean Municipal Water System	2	2	2	2	2	2
Memphis	6	5	5	5	4	4
Miami	2	1	1	1	1	1
Oldham County-Other	1	1	0	0	0	0
Pampa Municipal Water System	234	227	223	220	218	219
Panhandle Municipal Water System	28	28	28	28	29	29
Perryton Municipal Water System	26	28	29	29	30	31
Potter County-Other	29	30	30	29	29	29
Red River Authority of Texas	8	7	7	7	7	7
Shamrock Municipal Water System	32	31	30	29	29	28
Siesta Estates	1	1	1	1	2	2
Spearman Municipal Water System	9	10	10	10	10	10
Stinnett	5	4	4	4	3	3
Stratford	5	5	5	5	5	4
Sunray	5	5	5	5	4	4

Water User Group	2030	2040	2050	2060	2070	2080
TCW Supply	4	4	3	3	3	3
Texhoma	1	1	1	1	1	1
Texline	1	1	1	1	2	2
Turkey Municipal Water System	1	1	1	1	1	0
Vega	9	9	9	9	9	8
Wellington Municipal Water System	5	5	5	4	4	4
Wheeler	4	4	4	4	4	4
White Deer	2	2	2	2	1	1
Total	**5,075**	**5,347**	**5,577**	**5,733**	**5,901**	**6,064**

[1] Includes estimated savings from Advanced Metering Infrastructure (AMI).

[2] Happy was not evaluated in this analysis because its primary region is Region O.

Table 5B-2: Estimated Costs for Municipal Conservation

	2030	2040	2050	2060	2070	2080
PWPA Annual Cost	$836,713	$870,946	$946,115	$961,943	$978,137	$994,584
Annual Cost per acre-foot	$617	$609	$629	$626	$620	$616
Annual Cost per 1,000 gal	$1.89	$1.87	$1.93	$1.92	$1.90	$1.89

Table 5B-3: Estimated Costs and Water Savings from Water Audits and Leak Repairs

Water User Group	2030 Capital Cost	2050 Capital Cost	2080 Capital Cost	2030	2040	2050	2060	2070	2080
Amarillo	$52,753,000	$57,669,000	$61,437,000	2,031	2,148	2,243	2,318	2,393	2,466
Darrouzett	$169,000	$162,000	$152,000	4	4	4	3	3	3
Hall County-Other (Brice-Lesley)	$92,000	$92,000	$92,000	3	3	2	2	2	2
Higgins Municipal Water System	$171,000	$161,000	$152,000	6	5	5	5	4	4
Pampa Municipal Water System	$4,026,000	$3,944,000	$3,892,000	181	176	173	170	169	169
Panhandle Municipal Water System	$640,000	$648,000	$661,000	21	21	21	21	22	22
Shamrock Municipal Water System	$22,300,000	$22,300,000	$22,300,000	27	26	25	24	24	24
Vega	$294,000	$285,000	$276,000	7	7	7	7	7	6
Total	**$80,445,000**	**$85,260,000**	**$88,962,000**	2,280	2,390	2,480	2,550	2,624	2,696

Table 5B-4: Estimated Costs and Water Savings for AMI

	Capital Cost	2030	2040	2050	2060	2070	2080
Amarillo	$36,547,425	1,437	1,524	1,591	1,645	1,697	1,750
Hall County-Other (Brice-Lesley)	$80,000	2	2	2	2	2	2
Total	**$36,627,425**	**1,439**	**1,526**	**1,593**	**1,646**	**1,699**	**1,752**

5B.2 Agricultural Water Conservation

Agriculture is the largest user of water in the PWPA and accounted for 90 percent of the total water use in the PWPA in 2020. Most of the counties in the PWPA can meet the agricultural demands. There are ten counties showing needs in irrigation: Armstrong, Collingsworth, Dallam, Hall, Hartley, Hutchinson, Moore, Oldham, Randall, and Sherman. These needs are projected to reach 427,488 acre-feet per year in 2030 and increase to over 550,000 acre-feet per year in 2040. After 2040, the needs decline to 456,154 acre-feet per year by 2080. Given the limited renewability of aquifers in the area, there is no readily available water supply in or near the high demand irrigation counties that could be developed to fully meet these needs. Water management strategies for reducing irrigation demands for all 21 counties were examined by the PWPG Agricultural Committee. The primary strategies identified to address irrigation needs are demand reduction strategies (conservation). Nine agricultural water conservation strategies were identified by the PWPG and evaluated for quantities, costs and reliability. These strategies include irrigation scheduling, irrigation equipment changes, soil management, advances in plant breeding, conversion to dryland farming, changes to crop types, crop varieties that use less water, enhanced education, and irrigation deferral. Precipitation enhancement was evaluated as a strategy for areas that are actively engaged in this practice (Panhandle GCD counties). In addition, the PWPG identified three combinations of the conservation strategies for evaluation to minimize conflicting savings (e.g., irrigation equipment changes would not be employed on acreages identified for dryland conversion). These strategies (and the recommended combination of strategies) are summarized in **Section 5B.2.1** and evaluated in detail in **Appendix C**. There are no identified conservation strategies for livestock water use.

Agricultural Water Conservation Strategies Considered in PWPA

- Irrigation Scheduling
- Irrigation Equipment Changes
- Soil Management
- Advances in Plant Breeding
- Conversion to Dryland Farming
- Changes to Crop Type
- Changes to Crop Variety
- Enhanced Education
- Deferred Irrigation

A list of the potentially feasible irrigation strategies is shown in **Table 5B-5**. A synopsis of the potential water savings associated with all nine strategies is presented in **Section 5B.2.2** for the PWPA and each county. County evaluations for each strategy are found in **Appendix C**.

5B.2.1 Irrigation Strategies

Irrigation Scheduling

Irrigation scheduling refers to the process of allocating irrigation water according to crop requirements based on meteorological demands and field conditions with the intent to manage and conserve water, control disease infestations, and maximize farm profit. Proper and accurate irrigation scheduling is critical to ensure profitable agricultural production and conservation of the existing water resources. Soil water measurement-based methods, plant stress sensing-based methods, and weather-based methods are the common irrigation scheduling tools. The prevalent soil-based irrigation scheduling method utilized in the region today employs soil moisture probes that estimate soil moisture at different depths to schedule irrigation. The soil moisture probe and thermal sensor methods can allow for automation of irrigation scheduling by wireless connection of the sensors to respective irrigation systems. Proper and accurate irrigation scheduling can save up to 2 to 3 acre-inches of irrigation per year for corn. In this analysis, the water savings from this strategy is assumed to be 10 percent of the water applied for each crop seasonally.

The cost of irrigation scheduling can vary significantly depending on several factors including the level of service, equipment costs, and area served. More money tends to be invested in irrigation scheduling of higher value crops. A range of $13.25 to $16.75 per acre for irrigation scheduling was identified based on discussions with industry representatives, depending on the level of service. In this analysis, a $15.00 per acre annual cost was assumed for irrigation scheduling.

Change in Crop Variety

The evaporative demand for short season varieties can be significantly lower than that for long season varieties. Converting from long season varieties to short season varieties of corn and grain sorghum can be a useful water conservation strategy as they use less water than the conventional longer season varieties. Water savings may be enhanced by planting a short-season hybrid outside the normal production window, which can also help avoid high evaporative demand periods such as during the pollination period. A panel of industry and university experts convened for the 2021 Panhandle Water Plan was utilized as the basis for evaluating this strategy. Analysis of the estimates provided by the panel indicated that moving to short-season corn from full/mid-season varieties could save 3.7 ac-in per acre but would result in an estimated 18 percent yield loss. Changing to a short-season sorghum variety from full/mid-season varieties was estimated to save 6.2 ac-in but would result in a 32 percent yield reduction. It was estimated that 20 percent of both corn and sorghum acreage is currently planted to short-season varieties, which is expected to reach an adoption level of 50 percent by 2080.

The implementation cost of this water conservation strategy was assumed to be the compensation needed to account for the loss in yield. A partial budget analysis was conducted using the 2019-2023 Texas A&M AgriLife Crop and Livestock Budgets for the region. Results of the partial budgets indicate a net loss to producers (to include the savings in seed cost, pumping cost, fertilizer and harvest expense) of $98.01 per acre for corn and $80.97 per acre for sorghum for transition to short-season varieties.

Irrigation Equipment Changes

Current irrigation methods practiced in the Texas Panhandle are dominated by center pivot irrigation (MESA: Mid Elevation Spray Application, LESA: Low Elevation Spray Application, and LEPA: Low Elevation Precision Application). A small amount of acreage is irrigated through subsurface drip irrigation (SDI).The average application efficiency of MESA, LESA, LEPA is 78, 88, and 90 percent, respectively. These application efficiencies are the percentage of irrigation water that is used by the crop with the remainder being lost to runoff, evaporation or deep percolation. Switching from low efficiency irrigation systems such as MESA to more efficient irrigation systems such as LEPA and SDI improves the efficiency of irrigation system water use and can help conserve groundwater resources. Switching irrigation systems can be a costly strategy to conserve irrigation water, but that expense can be partially offset by the decrease in pumping cost. Also, converting established center pivot systems to LEPA using conversion kits is comparatively less expensive. Thus the water conservation strategy of changing irrigation equipment includes converting MESA and LESA to LEPA to improve application efficiency. The regional water savings estimate in 2023 from this strategy is 9.15 percent of the water applied for acres converted to the higher efficiency irrigation systems.

Results of the NPGCD Master Irrigator surveys indicate that 33.5 percent of the irrigation systems currently are either LEPA or SDI and 68.5 percent are either LESA or MESA. The PWPG-Agricultural Committee anticipates with appropriate incentives the conversion of LESA or MESA center pivots to more efficient systems could increase incrementally per decade reaching 90 percent by 2080.

Since nearly all of the high-efficiency irrigation systems are LEPA, the cost for implementing this strategy was assumed to be the cost of converting MESA or LESA systems to LEPA. The implementation cost of this strategy is estimated using the costs associated with the change in irrigation equipment required for each of the systems and their respective adoption rate. Based on 60 percent of the systems having 60-inch spacing between pivots and the remainder having 30-inch spacing, the average cost of conversion of $151.25 per acre.

Change in Crop Type

Incorporation of crops with lower water requirements can be an effective water conservation strategy. Corn, cotton, wheat, and grain sorghum are the four major crops in the Panhandle region accounting for about 90 percent of the irrigated acreage. Corn has one of the highest water requirements of any irrigated crop grown in the Texas High Plains because of a longer growing season than most other spring crops, which can adversely affect yield in limited moisture situations (Howell et al., 1996). The seasonal evaporative demand for corn is 28 to 32 inches, wheat is 26 to 28 inches, cotton is 13 to 27 inches, and for grain sorghum is 13 to 24 inches. To date, most of the water used for irrigation has been applied to high water use crops such as corn. On the other hand, cotton, wheat, and grain sorghum can tolerate lower moisture availability and are more suited to deficit irrigation practices. Considerable amounts of irrigation water can be saved by shifting from high water use crops like corn to lower water use crops like cotton, wheat or grain sorghum.

A survey of 25 producers and crop consultants was conducted to determine and/or validate actual water use per acre of corn and cotton during the 2016 to 2018 period. The survey indicated the application rates of 20.6 acre-inch to corn and 9.9 acre-inch to cotton per acre. A conservative average of 10 acre-inch was utilized to estimate water savings for this strategy with implementation of cotton production reaching 30 percent by 2080.

The cost of implementing this water conservation strategy is evaluated in terms of an "opportunity cost" expressed by the reduced land values which reflect the water availability required to produce crops. Land that has "good" water availability to support corn production is worth more compared to the land with "fair" availability of water that can support cotton, wheat, or grain sorghum. Hence the cost of adoption of this strategy for one acre of land is estimated as the difference between the average rental rate for irrigated cropland with good water availability ($211.25 per acre) and that of irrigated cropland with relatively weak water availability ($100 per acre) (ASFMRA, 2022; 2023). Therefore, $111.25 per acre was assumed to be the annual cost for implementation of this strategy.

Soil Management

Effective soil management practices can increase the efficiency of both irrigation and rainfall events, increase soil infiltration, reduce runoff, reduce evaporative loss, and conserve moisture available within the soil profile. Thus, these practices promote efficient use of the available water and enhance crop production and sustainability of the region's natural resources. Conservation tillage practices, furrow diking, and introduction of fallow and low water use crops in the crop rotation are the most important land management practices that can lead to water conservation within the region.

Conservation tillage is a term covering a wide range of tillage practices with the common characteristic of reduced soil and water loss. In this analysis, the water savings from adopting effective soil management strategy is assumed to be 1.75 acre-inches per acre.

Results of the NPGCD Master Irrigator surveys indicate conservation tillage in some form (minimum till, strip till or no-till) is practiced on nearly 84 percent of the irrigated land in the region. The PWPG projects an initial decadal increase of 1.5 percent, slowing in later years of the planning horizon until 92.5 percent of all irrigated acreage practices some sort of conservation tillage.

In this analysis the annualized cost difference between conventional and conservation tillage is assumed to be zero. While there is little to no difference in the annualized cost, it should be noted that the necessary chemical control costs and change in equipment such as the additional purchase of a strip tiller or no-till planter can impede the adoption process.

Conversion from Irrigated to Dryland Crops

Converting from an irrigated to dryland cropping system may be a viable economic alternative for some producers in the Panhandle on marginally irrigated lands or as a regional strategy to conserve water reserves. The primary dryland crops grown in the area are winter wheat, grain sorghum, and cotton. Conversion programs that provide incentives for dryland conversion, identifying and adopting crops that perform well in the region under rain fed conditions, and developing higher yielding heat- and drought-tolerant varieties will be critical in implementing this strategy. This analysis assumes 16 acre-inches per acre water savings by the adoption of this strategy over the entire region; however, the amount varies by county depending on crop composition.

Since the conversion of irrigated acreage to dryland production is measured from the baseline acreage (2021-2023 average), the 2023 baseline adoption rate was assumed to be 0 percent. Conversion of irrigated land to dryland was viewed by the PWPG Agricultural Committee as a limited-use strategy. The adopted conversion rate was assumed to be 2 percent per decade, reaching a total of 12 percent of the regional acreage by 2080.

The cost of implementing this water conservation strategy is evaluated in terms of reduced land values and was estimated as the difference between the average land values across all water availability categories for irrigated cropland at $3,166 per acre and that of dryland at $1,331 per acre. Therefore, the implementation cost to retire an acre of irrigated land was $1,835 assuming the land would be suitable for dryland production. It should be noted that the amount of compensation required for this strategy would vary considerably depending on the water availability on a specific piece of land and the value of the dryland acreage in that part of the region. Also, implementing this strategy would be detrimental to the regional economy because of the reduced production and decrease in inputs used.

Advances in Plant Breeding

Plant breeding has played a major role in increasing crop productivity and enhancing the efficiency of input such as irrigation. The adoption of drought resistant varieties with high water use efficiency can be a potential water conservation strategy. Drought resistant varieties for corn, cotton, and soybeans are expected to be released by 2030 followed and reduce water use by 5 percent. Additional drought resistant varieties could be released by 2040 that will improve drought and heat tolerance even more. This analysis assumes that the first round of drought resistant varieties will reduce water use by 5 percent and the second round of varieties will reduce the water use an additional 5 percent compared to current varieties.

The new drought tolerant varieties have yet to hit the market; therefore, the 2023 baseline adoption rate was assumed to be 0 percent. The adoption rate was projected to be 50 percent in the first decade of market deployment (2030 for all major crops) and escalate to 95 percent by the end of the planning horizon, assuming new varieties are cost effective, assuming new varieties are cost effective.

The implementation cost of this strategy assumed an additional cost of drought resistant seed estimated at a dollar for every one percent reduction in water use. It was assumed a 5 percent reduction in water use will cost $5 per acre and a 10 percent reduction will cost $10 per acre. Cost estimates were made after consultation with industry personnel and researchers working in the area. These costs were then multiplied with the annual total acreage for corn, cotton and soybeans, affected by incorporation of this strategy.

Irrigation Deferral

The irrigation deferral strategy involves a producer giving up their rights to irrigate for a specified time while receiving compensation for the loss in income. In this strategy, a producer would agree to give up his right to irrigate for a 5-year period and the producer would receive an annual payment as compensation. In evaluating this strategy, it was assumed the annual water savings would be 16.0 acre-inch per acre, which is the average water used by irrigated crops in the region.

It is assumed that 5 percent of the irrigated acreage would participate in this strategy by 2030 and this level (5%) would be maintained through 2080, as properties come into and out of the program.

The cost of implementing this strategy is the difference in the cash rental rates of average irrigated land and dryland in the area, resulting in an estimated compensation rate of $130.00 per acre.

Enhanced Education

This strategy would develop and maintain an educational system for irrigators to inform and accelerate the adoption of current and new irrigation strategies. The Master Irrigator training program, sponsored by the North Plains GCD, is an example of how this strategy could be implemented. A 3-year post graduate survey found that 85.7 percent of participants had improved their water efficiency and 55.4 percent had reduced water use.

For this strategy, irrigator training would be offered annually, rotating locations to foster greater participation. This could be supplemented with periodic short courses to maintain education and interest of the irrigators.

Water savings are estimated at 5 percent of the applied water on approximately 10 percent of the irrigated lands (represents acreages of participants). These savings are assumed for 10 years, then it is assumed the producers would adopt other water saving measures. The cost for the enhanced education program is $400,000 per year.

5B.2.2 Methodology

Water savings and implementation costs were estimated for each proposed water management strategy evaluated in the planning effort and described in **Section 5B.2.1**. Total costs represent both capital and operational costs. The year 2023 was selected as the baseline for evaluating strategies. Baseline adoption rates for strategies were estimated using secondary data sources. Producer surveys (2016-2024) conducted as a part of the North Plains GCD Master Irrigator project that encompassed more than 530,000 irrigated acres were invaluable in estimating baseline values for irrigation scheduling, irrigation systems and soil management strategies. Future adoption rates (2030 – 2080) were identified under the guidance of the PWPG Agricultural Committee and are shown in **Table 5B-5**. The water savings and direct cost of all strategies were evaluated over a 50-year planning horizon.

Table 5B-5: Possible Water Management Strategies for Reducing Irrigation Demands

Water Management Strategy	Water Savings (% of irrigation or ac-in/ac/yr)	Assumed Baseline Use 2023	Goal for Adoption						Cost	Cost Frequency
			2030	2040	2050	2060	2070	2080		
Irrigation Scheduling	10%	65.6%	70.0%	75.0%	80.0%	85.0%	90.0%	93.0%	$15.00	Annual
Irrigation Equipment Changes	MESA or LESA to LEPA 9.15%	33.4%	40.0%	50.0%	60.0%	70.0%	80.0%	90.0%	$151.25	One-time
Change in Crop Type	10	0.0%	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%	$111.25	Annual
Change in Crop Variety	Corn 3.7	20.0%	25.0%	30.0%	35.0%	40.0%	45.0%	50.0%	$98.01	Annual
	Sorghum 6.2								$80.97	Annual
Conversion to Dryland	16.0	0.0%	2.0%	4.0%	6.0%	8.0%	10.0%	12.0%	$1,835	One-time
Soil Management	1.75	83.4%	85.0%	86.5%	88.0%	89.5%	91.0%	92.5%	$ -	None

<table>
<tr><th rowspan="2">Water Management Strategy</th><th rowspan="2" colspan="2">Water Savings (% of irrigation or ac-in/ac/yr)</th><th rowspan="2">Assumed Baseline Use 2023</th><th colspan="6">Goal for Adoption</th><th rowspan="2">Cost</th><th rowspan="2">Cost Frequency</th></tr>
<tr><th>2030</th><th>2040</th><th>2050</th><th>2060</th><th>2070</th><th>2080</th></tr>
<tr><td>Irrigation Deferral</td><td colspan="2">16.0</td><td>0.0%</td><td>5.0%</td><td>5.0%</td><td>5.0%</td><td>5.0%</td><td>5.0%</td><td>5.0%</td><td>$130</td><td>Annual</td></tr>
<tr><td rowspan="2">Advances in Plant Breeding</td><td rowspan="2">Corn, Cotton, Soybean, Wheat, and Sorghum</td><td>Starting in 2030 5%</td><td rowspan="2">0.0%</td><td rowspan="2">50.0%</td><td rowspan="2">75.0%</td><td rowspan="2">85.0%</td><td rowspan="2">95.0%</td><td rowspan="2">95.0%</td><td rowspan="2">95.0%</td><td>$5</td><td rowspan="2">Annual</td></tr>
<tr><td>Starting in 2040 10%</td><td>$10</td></tr>
<tr><td>Enhanced Education</td><td colspan="2">5%</td><td>0.0%</td><td>10.0%</td><td>10.0%</td><td>10.0%</td><td>10.0%</td><td>10.0%</td><td>10.0%</td><td>$400,000</td><td>Annual</td></tr>
</table>

In addition to the nine identified strategies, the Agricultural Committee identified three combinations of the previously mentioned strategies that may likely be employed in irrigation deficit counties. The combinations of strategies are:

- changes in crop type, irrigation scheduling, and changes in irrigation equipment
- changes in crop variety, irrigation scheduling, and changes in irrigation equipment
- changes in crop type, advances in plant breeding, irrigation scheduling, changes in irrigation equipment, and enhanced education

Counties in PWPA with an Irrigation Need:

- Armstrong
- Collingsworth
- Dallam
- Hall
- Hartley
- Hutchinson
- Moore
- Oldham
- Randall
- Sherman

When implementing multiple strategies, the potential water savings are not additive in most instances. The cumulative water savings from use of multiple strategies were estimated using a stepwise procedure, considering changes in the baseline for adoption of additional strategies. The implementation costs for the strategy combinations are additive. The water savings of the three combinations of strategies using this methodology were determined for the ten counties showing an irrigation water deficit and the region.

There are several caveats to this analysis. First, the associated water savings with these strategies are "potential" water savings. In the absence of water use constraints, most of the strategies considered will simply increase gross receipts. In other words, the same amount of water may be applied but to increased acreages or second crops. Second, as noted above, potential water savings may be overestimated when combinations of strategies are implemented. For example, the savings associated with the implementation of irrigation equipment changes cannot be applied to irrigated land that is converted to dryland farming. Finally, the savings rely on individual producers adopting the recommended strategies at the recommended adoption rates.

Table 5B-6 shows the total estimated water savings and costs associated with proposed individual irrigation water conservation strategies and the three potential combinations for the region.

Table 5B-6: Potential Water Management Strategies for Reducing Irrigation Demands

Water Management Strategy	Regional Water Savings (ac ft/yr)						Total Cost	Unit Cost
	2030	2040	2050	2060	2070	2080	(million $)	($/ac-ft)
Irrigation Scheduling	8,527	18,217	27,907	37,598	47,288	53,102	$156.80	$112.37
Irrigation Equipment Changes	11,704	29,437	47,169	64,902	82,635	100,368	$102.33	$43.39
Change in Crop Type	20,331	40,662	60,993	81,324	101,655	121,986	$407.13	$133.50
Change in Crop Variety	11,258	22,515	33,773	45,030	56,288	67,545	$446.48	$264.40
Conversion to Dryland	38,760	77,521	116,281	155,041	193,802	232,562	$266.41	$45.82
Soil Management	3,388	6,563	9,739	12,915	16,091	19,267	$0.00	$0.00
Irrigation Deferral	96,901	96,901	96,901	96,901	96,901	96,901	$471.85	$97.39
Advances in Plant Breeding	41,798	125,394	142,113	158,833	158,833	158,833	$469.75	$74.92
Enhanced Education	9,690	9,690	9,690	9,690	9,690	9,690	$20.00	$41.28
Combination Strategies								
Crop Type, Irrigation Equipment, and Irrigation Scheduling	40,421	87,657	134,512	180,987	227,081	269,363	$666.25	$99.34
Crop Variety, Irrigation Equipment, and Irrigation Scheduling	31,387	69,681	107,684	145,397	182,821	216,414	$705.60	$131.40
Crop Type, Plant Breeding, Irrigation Equipment, Irrigation Scheduling, and Enhanced Education	91,683	221,471	284,130	346,240	391,491	433,268	$1,156.00	$86.59

5B.2.3 Recommended Combination

For the purposes of planning, the recommended irrigation strategy is the combination strategy that includes changes in crop type, advances in plant breeding, irrigation scheduling, changes in irrigation equipment, and enhanced education. This strategy will provide the greatest level of irrigation conservation for counties with water needs. Since the PWPG advocates conservation for all irrigators, counties without a need are recommended to adopt conservation measures that best meet their needs.

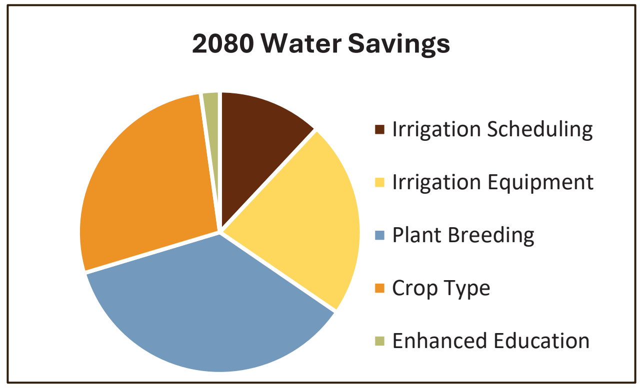
PWPA Recommended Combination:

- Change in Crop Type
- Advances in Plant Breeding
- Irrigation Scheduling
- Changes in Irrigation Equipment
- Enhanced Education

For planning purposes, the same combination of conservation measures is recommended for each county. The savings for individual strategies by county are included in **Appendix C**.

Table 5B-7 shows the savings associated with the recommended combination of strategies. **Table 5B-8** shows the cost of the recommended combination by county. On a regional basis in 2080, the

PWPA is projected to save approximately 433,000 acre-feet per year at a cost of $367 million per year. Over the 50-year period of implementation, the total cost could exceed $1.1 billion if each county implemented all five strategies to the level assumed in this analysis.



Weather modification (Precipitation Enhancement) is an on-going strategy for counties within the Panhandle GCD, which include Carson, Donley, Gray, Roberts, Wheeler and parts of Armstrong, Hutchinson, and Potter County. The benefits of weather modification are currently being realized today by these counties and the PWPG supports continued activities for precipitation enhancement within this area and any other areas within the PWPA that undertake such activities.

While these selected strategies are recommended by the PWPG, all irrigation conservation strategies are recognized and encouraged with the PWPA, and such strategies are considered consistent with this plan.

Table 5B-7: Estimated Water Savings from Recommended Combination by County

County	Water Savings (ac-ft/yr.)						Cumulative ac-ft over 50 years
	2030	2040	2050	2060	2070	2080	
Armstrong	280	685	871	1,056	1,186	1,304	**40,781**
Carson	5,213	12,553	16,164	19,743	22,384	24,851	**760,567**
Childress	567	1,444	1,781	2,114	2,314	2,486	**82,195**
Collingsworth	1,715	4,290	5,347	6,396	7,067	7,646	**248,149**
Dallam	16,125	39,254	50,093	60,838	68,502	75,556	**2,348,122**
Donley	1,112	2,649	3,414	4,173	4,739	5,244	**160,869**
Gray	1,640	3,909	5,056	6,193	7,048	7,835	**238,462**
Hall	1,244	3,161	3,904	4,640	5,085	5,469	**180,342**
Hansford	9,738	23,329	30,159	36,927	41,993	46,748	**1,421,456**
Hartley	17,858	42,977	55,238	67,393	76,317	84,521	**2,597,825**
Hemphill	147	341	445	549	630	701	**21,121**
Hutchinson	3,350	8,013	10,368	12,703	14,456	16,099	**488,901**
Lipscomb	1,318	2,991	3,977	4,956	5,760	6,482	**190,011**
Moore	9,064	21,846	28,070	34,239	38,762	42,940	**1,319,800**
Ochiltree	4,619	11,143	14,329	17,486	19,804	21,969	**673,802**
Oldham	191	464	592	719	810	891	**27,770**
Potter	101	242	309	377	426	468	**14,537**
Randall	752	1,841	2,336	2,828	3,170	3,482	**109,265**
Roberts	457	1,102	1,415	1,725	1,952	2,162	**66,516**
Sherman	15,578	37,721	48,351	58,887	66,532	73,626	**2,270,683**
Wheeler	614	1,518	1,909	2,298	2,558	2,788	**88,973**
Total	**91,683**	**221,471**	**284,130**	**346,240**	**391,491**	**433,268**	**13,350,146**

Table 5B-8: Estimated Cost for the Recommended Combination by County in the PWPA

County	Total Cost ($/yr.)						Cumulative cost over 50 years
	2030	2040	2050	2060	2070	2080	
Armstrong	$269,149	$633,248	$783,704	$934,160	$1,038,139	$1,125,940	**$3,658,401**
Carson	$5,103,089	$11,790,988	$15,024,902	$18,258,815	$20,732,371	$22,965,254	**$70,910,165**
Childress	$496,497	$1,229,225	$1,438,819	$1,648,413	$1,743,527	$1,800,596	**$6,556,482**
Collingsworth	$1,373,490	$3,326,311	$3,915,073	$4,503,835	$4,800,680	$4,982,958	**$17,919,390**
Dallam	$13,005,649	$30,107,573	$38,125,488	$46,143,403	$52,174,473	$57,542,466	**$179,556,586**
Donley	$961,151	$2,192,567	$2,706,821	$3,221,075	$3,588,018	$3,880,336	**$12,669,633**
Gray	$1,620,808	$3,712,800	$4,690,450	$5,668,100	$6,407,649	$7,052,728	**$22,099,807**
Hall	$903,047	$2,228,717	$2,610,604	$2,992,491	$3,168,487	$3,274,351	**$11,903,345**
Hansford	$9,936,815	$22,893,831	$29,289,931	$35,686,032	$40,636,052	$45,133,028	**$138,442,662**
Hartley	$15,363,363	$35,275,380	$44,679,033	$54,082,686	$61,222,087	$67,514,805	**$210,622,549**
Hemphill	$82,637	$182,098	$219,328	$256,558	$282,197	$298,581	**$1,022,817**
Hutchinson	$3,409,958	$7,841,318	$10,031,319	$12,221,321	$13,919,172	$15,457,905	**$47,423,088**
Lipscomb	$1,236,396	$2,681,109	$3,388,039	$4,094,969	$4,662,882	$5,124,787	**$16,063,395**
Moore	$8,984,394	$20,826,916	$26,216,058	$31,605,201	$35,592,195	$39,086,364	**$123,224,764**
Ochiltree	$4,601,497	$10,670,607	$13,552,890	$16,435,173	$18,614,943	$20,574,912	**$63,875,110**
Oldham	$175,393	$408,791	$501,876	$594,960	$658,302	$709,193	**$2,339,322**
Potter	$89,476	$205,570	$245,721	$285,873	$310,785	$326,955	**$1,137,424**
Randall	$750,475	$1,773,418	$2,179,764	$2,586,110	$2,858,596	$3,083,736	**$10,148,362**
Roberts	$435,989	$1,009,652	$1,274,019	$1,538,386	$1,735,427	$1,909,138	**$5,993,473**
Sherman	$13,219,311	$30,446,628	$38,874,042	$47,301,457	$53,797,005	$59,666,923	**$183,638,443**
Wheeler	$514,856	$1,226,570	$1,472,623	$1,718,677	$1,865,240	$1,972,309	**$6,797,966**
Total	**$86,533,442**	**$194,663,314**	**$245,220,505**	**$295,777,696**	**$333,808,228**	**$367,483,264**	**$1,156,003,184**

5B.2.4 Additional Irrigation Supply from Groundwater Wells

While the PWPG does not recommend new groundwater wells as a strategy to meet future irrigation needs during the planning period because of declining water levels, drilling of new wells is an option for individual producers who have not fully developed their water rights. Approximate cost estimates were developed to determine the expense associated with installing irrigation wells. **Table 5B-9** summarizes two scenarios: a pumping rate of less than and greater than 500 gallons per minute.

Table 5B-9: Estimated Costs of Irrigation Wells in the PWPA

Pumping Rate (gpm)	Well Depth (ft.)	Diameter (in.)	Well Cost	Equipment Cost	Total Cost
Less than 500	375	4 - 6	$50,000	$50,000	$100,000
Greater than 500	500	8	$100,000	$100,000	$200,000

[1] Assumes submersible pump and associated equipment

5B.3 Water Conservation Plans

Each public water supplier is required to update and submit a Water Conservation Plan (WCP) to the Texas Commission on Environmental Quality (TCEQ) every five years. Per Title 30, Part 1, Chapter 288, Subchapter A, Rule 288.2 of the Texas Administrative Code, some specific conservation strategies are required to be included as part of a water conservation plan. At a minimum each plan must include:

- Utility Profile that describes the entity, water system and water use data;
- Record management system that is capable of recording water use by different types of users;
- Quantified five-year and ten-year water savings goals;
- Metering device with a 5 percent accuracy to measure the amount of water diverted from the source of supply;
- A program for universal metering;
- Measures to determine and control water loss;
- A program of continuing public education and information regarding water conservation;
- A non-promotional water rate structure;
- A reservoir systems operation plan (if applicable);
- Means of implementation and enforcement, as evidenced by: a document indicating the adoption of the WCP, and a description of the authority where the water supplier will implement and enforce the WCP;
- Documentation of coordination with the regional water planning group.

If a public water supplier serves over 5,000 people, they are additionally required to have a conservation-oriented rate structure and a program of leak detection, repair, and water loss accounting for the water transmission, delivery, and distribution system.

The TCEQ also requires water conservation plans for all municipal and industrial water users with surface water rights of 1,000 acre-feet per year or more and irrigation water users with surface water rights of 10,000 acre-feet per year or more, and for all water users applying for a State water right. Water conservation plans may also be required for entities seeking State funding for water supply projects. Legislation passed in 2003 requires all conservation plans to specify quantifiable 5-year and 10-year conservation goals and targets. While these goals are not enforceable, they must be identified. In 2007 legislation was passed that requires all public water suppliers with greater than 3,300 connections to submit a conservation plan to the TCEQ. All updated water conservation plans were to be submitted to the Executive Director of the TCEQ by May 1, 2024. However, utilities can be off-cycle in which they are required to submit within 5 years of their unique deadline.

In the PWPA, six water suppliers hold municipal or industrial surface water rights in excess of 1,000 acre-feet per year or have more than 3,300 connections. There are no entities with surface irrigation water rights greater than 10,000 acre-feet per year. Each of these entities is required to develop and submit to the TCEQ a water conservation plan. Several water users have contracts with regional water providers for water of 1,000 acre-feet per year or more. Those wholesale providers are required to include a provision in their wholesale contracts that each wholesale customer develop and implement a water conservation plan. A list of the users in the PWPG required to submit water conservation plans is shown in **Table 5B-10**.

Table 5B-10: Water Users in the PWPA Required to Prepare Water Conservation Plans

Municipal and Industrial Water Users	Irrigation Water Users
City of Amarillo	None in PWPA
Canadian River Municipal Water Authority	
Greenbelt Municipal & Industrial Water Authority	
Palo Duro River District	
Borger	
Canyon	
Dumas	
Pampa	

There are numerous irrigation users pumping groundwater in excess of 10,000 acre-feet per year and these users are usually regulated through the local GCD which will issue well permits to the irrigators. The GCD is required to submit a groundwater management plan to the TWDB for approval. A groundwater management plan is a 10-year plan that describes a district's groundwater management goals. These goals include providing the most efficient use of groundwater, controlling and preventing waste of groundwater, controlling and preventing subsidence, addressing conjunctive surface water management issues, addressing natural resource issues, addressing drought conditions, and addressing conservation (§356.5 and §356.6, Texas Administrative Code, relating to Management Plan and Plan Submittal, respectively).

To assist entities in the PWPA with developing water conservation plans, model plans for municipal water users (wholesale or retail public water suppliers), industrial users and irrigation districts were developed considering the region's unique water issues. Each of these model plans address the latest TCEQ requirements and is intended to be modified by each user to best reflect the activities appropriate to the entity. These plans can be accessed through the PWPA website at www.panhandlewater.org. General model water conservation plan forms are also available from TCEQ in Microsoft Word and PDF formats.

The focus of the conservation activities for municipal water users in the PWPA are:

- Education and public awareness programs,
- Reduction of unaccounted for water through water audits and maintenance of water systems,
- Water rate structures and ordinances that discourage water waste.

Industrial water users include manufacturing and processing industries as well as smaller local manufacturers. Conservation activities associated with industries are site and industry-specific. Some industries can utilize brackish water supplies or wastewater effluent while others require only potable water. It is important in evaluating conservation strategies for industries to balance the water savings from conservation to economic benefits to the industry and the region.

The focus of the conservation activities for industrial users is:

- Evaluation of water saving equipment and processes, and
- Water rate structures that discourage water waste

5B.4 Other Conservation Recommendations

The PWPG encourages all water user groups to practice advanced conservation efforts to reduce water demand, not only during drought conditions, but as a goal in maintaining future supplies. This includes municipal, industrial and agricultural water users. As appropriate, municipal users should strive to reduce per capita water use to conserve the limited water resources of the region. The PWPG recognizes that some cities and rural communities may not achieve the recommended level of reductions, but many communities have the opportunity to increase their water savings.

With irrigated agriculture being the largest water user in the PWPA, this sector has the greatest opportunities for water reductions due to conservation. The plan recommends strategies that reduce the estimated irrigation water use by approximately 433,000 acre-feet per year by 2080. This represents a reduction of 31 percent of the projected 2080 demands. These strategies are specific to the region, but there may be additional strategies that are appropriate for selected crop type or irrigation practices. The PWPG supports the implementation of any and all measures that effectively reduce water for agricultural purposes.

The PWPG supports and encourages the collaboration of multiple entities across the region to promote water conservation. This could be accomplished with the assistance of regional organizations, such as the PRPC and GCDs. Consistent messaging is important in continuing to maintain and/or increase conservation levels in the region.

The TWDB provides a significant amount of information and services pertaining to water conservation that can be accessed at: http://www.twdb.texas.gov/conservation/.

5C WATER MANAGEMENT STRATEGIES FOR MAJOR WATER PROVIDERS

There are four major water providers located in the PWPA: CRMWA, Amarillo, Borger and Greenbelt MIWA. Each of these entities except for Greenbelt MIWA are projected to have needs within the planning period. With the on-going drought, the reliability of current supplies could be further impacted. Discussion of the water needs and recommended water management strategies for each of the major water providers follows.

5C.1 Canadian River Municipal Water Authority (CRMWA)

The CRMWA provides groundwater from Roberts County and surface water from Lake Meredith to users in the PWPA and entities in the Llano Estacado Region (Region O). The total available safe supply from the CRMWA system is 77,000 acre-feet per year in 2030, decreasing to 54,333 acre-feet per year by 2080 as groundwater becomes depleted within CRMWA's current well fields and Lake Meredith water quality continues to decline. Current demands on CRMWA are estimated at approximately 145,000 acre-feet per year in 2030 and increase to over 196,000 acre-feet per year by 2080. This results in near-term needs of 22,540 acre-feet per year and long-term needs of about 64,858 acre-feet per year. **Table 5C-1** lists the demands by customer, current supplies, and projected needs for CRMWA.

The potentially feasible strategies considered for CRMWA to meet these needs include:

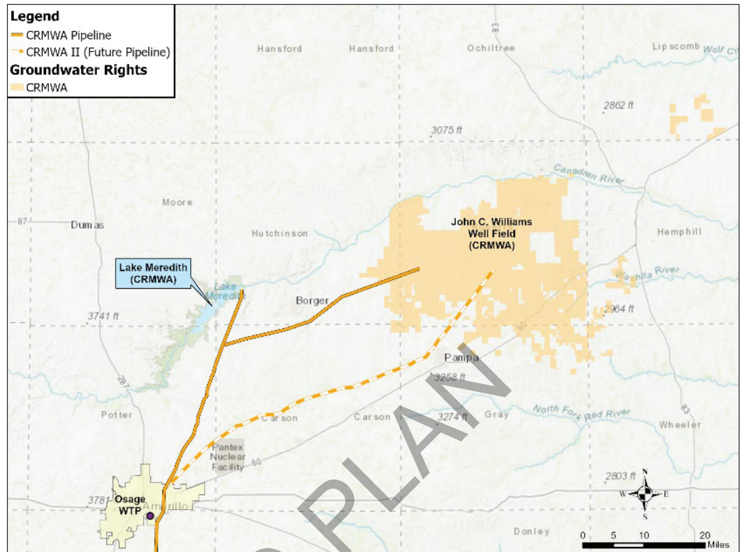
- Conservation of wholesale customers
- Expanded development of Roberts County well field with additional transmission
- Aquifer storage and recovery
- Linear wellfield along the existing transmission system in Region O
- Brush control in Lake Meredith watershed
- Advanced treatment of Lake Meredith water

Table 5C-1: Summary of Demands, Supplies, and Projected Needs for CRMWA

Customers	Demands (Ac-Ft/Yr)					
	2030	2040	2050	2060	2070	2080
PWPA						
City of Amarillo	41,199	45,419	49,340	50,000	50,000	50,000
City of Borger	4,866	5,902	6,928	7,852	8,596	9,456
City of Pampa	2,242	2,242	2,242	2,423	2,617	2,623
Region O:						
City of Brownfield	1,360	1,406	1,450	1,501	1,556	1,616
City of Lamesa	1,367	1,411	1,442	1,450	1,450	1,441
City of Levelland	1,990	1,998	1,988	1,978	1,968	1,961
City of Lubbock	40,810	46,736	47,000	47,000	47,000	47,000
City of O'Donnell	102	99	98	95	92	87
City of Planview	2,400	2,640	2,904	3,194	3,406	3,261
City of Slaton	760	720	687	647	611	575
City of Tahoka	325	325	325	325	325	325
Total	**97,421**	**108,898**	**114,404**	**116,465**	**117,621**	**118,345**
Sources	**Current Water Supply (Ac-Ft/Yr)**					
	2030	**2040**	**2050**	**2060**	**2070**	**2080**
Lake Meredith	12,000	10,500	9,000	7,500	6,000	4,500
Roberts County Groundwater	65,000	60,674	55,476	49,833	49,833	49,833
Total Current Supply	**77,000**	**71,174**	**64,476**	**57,333**	**55,833**	**54,333**
	Surplus or (Need) (Ac-Ft/Yr)					
	2030	**2040**	**2050**	**2060**	**2070**	**2080**
	(22,540)	(38,520)	(49,928)	(59,132)	(61,953)	(64,858)

Seven strategies identified for CRMWA are recommended for implementation: conservation by wholesale customers, replacement of well capacity, increased groundwater supplies and transmission capacity from Roberts County well field, advanced treatment of water from Lake Meredith, aquifer storage and recovery (includes Pampa and Amarillo well fields), linear well field along existing transmission system in Region O, and brush control within the Lake Meredith watershed. Since CRMWA is a wholesale water provider, conservation will be implemented by its customers. The associated savings are shown as demand reductions for CRMWA. Conservation measures and associated savings that are in the PWPA are discussed in **Chapter 5B**. The savings associated with customers in Region O (Llano Estacado Region) are discussed in the Llano Estacado water plan and are included in the total wholesale customer conservation savings for CRMWA in **Table 5C-2**. A brief description of each of the other strategies is presented below.

Expanded Development of Roberts County Well



Groundwater is an important water resource for CRMWA. It is used during times when water is limited from Lake Meredith due to the lack of inflows or impaired water quality. Water from Roberts County is blended with Lake Meredith water to provide supplies that can be treated through conventional treatment. With these uncertainties for Lake Meredith, CRMWA is proceeding to expand their groundwater production and delivery capacity to be able to provide all necessary supplies from groundwater if needed. CRMWA holds water rights to 456,993 acres in Roberts and adjacent counties. Presently, only a fraction of these rights is developed. The current capacity of the transmission system (CRMWA I) from the Roberts County well field is 65 MGD and CRMWA can deliver up to 69,000 acre-feet per year. The existing well field capacity is 80 MGD, and CRMWA is experiencing a reduction of about 0.5 MGD per year. This reduction is expected to slow down but over the course of the planning period, CRMWA will need to construct additional wells to replace lost groundwater supplies for the existing transmission system. It will also need to develop additional groundwater supplies and transmission capacity from the Roberts County well field to meet its projected needs. CRMWA plans to develop a second pipeline (CRMWA II) that would provide at a minimum 65,000 acre-feet per year without additional local storage during the lower demand months (assumes a peaking factor of 1.15). Some years, less water will be delivered from the well field as more water from Lake Meredith is used. With this project the total capacity from the Roberts County for CRMWA is increased to at least 130 MGD. It is assumed that a new 67-mile pipeline (CRMWA II) would be constructed from Roberts County to CRMWA's existing system with tie-ins to Amarillo's and Pampa's system. This strategy is currently costed for a 72-inch pipeline, but final sizing and capacity would be determined during design. Infrastructure needed to develop the water and transmission is detailed in the cost estimates in **Appendix D**.

Time Intended to Complete

Continued expansion of the Roberts County well field to fully utilize the existing transmission capacity is needed by 2030 and would be on-going through the planning period. The exact timing of CRMWA II is currently being discussed with CRMWA's member cities, but is expected to occur within the next decade. Additional wells are assumed to be needed over time to maintain the full capacities of the system.

Quantity, Reliability and Cost

The total quantity of water provided by this strategy would be about 80,000 acre-feet per year. This includes the development of 15,000 acre-feet per year of new groundwater supply for the existing pipeline and an additional 65,000 acre-feet per year for the new pipeline. Reliability of Ogallala supplies is moderate to high. There are significant quantities of untapped water supplies in

Roberts County, but the availability of this water also depends on other water users. Cost to expand the Roberts County well field is estimated at around $800 million. This represents the CRMWA II pipeline, and new wells to provide 80,000 acre-feet per year of supply, and well field piping.

Environmental Issues

The environmental issues associated with this water management strategy are for pipeline rights-of-way and sites for pumping plants and storage facilities. Since routes and sites can be selected to avoid sensitive wildlife habitat and cultural resources, there would be very little, if any, environmental issues of significant concern.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. There are other users that may compete for groundwater supplies, but there is sufficient water in Roberts County to support these demands.

Impact on Agriculture and Natural Resources

The expansion of the Roberts County well field and maintenance of the existing well field are expected to have minimal impacts on the agriculture and other natural resources. A small amount of agricultural lands may be affected by the transmission system associated with the well field, depending on the final transmission route.

Other Relevant Factors

There are no other identified relevant factors.

Aquifer Storage and Recovery

CRMWA currently has 65 MGD of capacity in the existing transmission system from the Roberts County Well Field. As CRMWA develops additional well field capacity in Roberts County and constructs the new CRMWA II pipeline, the maximum quantity of water that can be transported from the well field will increase to at least 130 MGD. The average annual supply from this system (including CRMWA II) is estimated at 113,000 acre-feet per year, based on system peaking factor of 1.15. This results in an average delivery of 101 MGD.

During non-peak periods, the capacity of the CRMWA transmission system is underutilized; yet during peak demand months, the ability to meet all CRMWA's customers' future peak demands may be limited. To address the need for increased peaking capacity in CRMWA's delivery system, available water from CRMWA's sources (Lake Meredith and/or Roberts County Well Field) could be treated and stored by the member cities during non-peak periods for future use during peak times. This strategy proposes to store excess non-peak water through an Aquifer Storage and Recovery program (ASR) that will utilize existing well fields and infrastructure. CRMWA will be conducting a feasibility study to further evaluate this strategy for all member cities.

For the purposes of this strategy it is assumed that the cities of Amarillo and Pampa will develop an ASR project at one of their well fields using water from CRMWA and possibly other sources. Each of these projects are discussed under Amarillo and Pampa, respectively. For CRMWA's customers in the Llano-Estacado regions, CRMWA will assist in sponsoring an ASR project. Water from this project could be used by all eight member cities in the Llano-Estacado region. The water would be treated at the Lubbock water treatment plant and stored at a nearby ASR site developed by CRMWA. Alternatively, each member city could utilize their existing well fields and treatment capacity. The cost components of this strategy assume a new ASR well field, which includes 14 injection wells and 13 recovery wells. Some of the injection wells may also be used for recovery. The strategy will also include transmission from the treatment plant to the ASR well field. Since this well field has not been sited, a 5-mile transmission line has been assumed as a placeholder. Defined improvements will be determined during the feasibility study sponsored by CRMWA. It should be noted that the City of Lubbock has developed a more detailed ASR strategy that will utilize water from CRMWA. However, the supplies for Lubbock's ASR strategy are based on the average annual supply from CRMWA's system with the assumed peaking factor. Additional water may become available to Lubbock with CRMWA's sponsored ASR project. The quantities and recipients will be refined during CRMWA's feasibility study.

Time to Implement

Supply will be available for the ASR project after CRMWA II is online in 2040.

Quantity, Reliability and Cost

The quantity will vary from year to year depending on the demand from the member cities and capacities of ASR well fields. The quantity of water that could be made available annually from the CRMWA-sponsored ASR project is 10,000 acre-feet per year. (Another 7,000 acre-feet per year of water from CRMWA would be available for ASR to users in the PWPA. These strategies are evaluated separately, but the total quantity of water supplied by this operation is shown with CRMWA.) If the water is stored over multiple years, additional supply may be available during drought. For purposes of this analysis, it is assumed that the water is stored and retrieved over one year. The source of this water would be Lake Meredith and/or the Ogallala aquifer in Roberts County. The actual amounts used from each source will vary by year based on demands and available supply in Lake Meredith.

Successful ASR development is highly reliable. It is possible to achieve 90-95% recovery efficiency, depending upon the natural hydraulic gradient of the receiving aquifer and competition from adjacent groundwater users. If the water is recharged and recovered over a relatively short period (e.g., one year), the likelihood of reduced reliability is low. The ASR project will increase the reliability of existing supplies by allowing storage of the supply during periods of low demand to meet high demands at a later time.

The quality of water is expected to be good. The ASR regulations for Texas specify that the quality of the recharge water must not degrade the quality of the receiving aquifer, which is generally good. The recovered ASR water would be treated to standards required by the end use. When recharge water is treated to meet drinking water standards prior to storage, the recovered water will only need simple re-disinfection prior to being distributed to end-users.

Cost estimates were developed for the application of ASR a single well field. A total of 27 wells for injection and recovery and 35,000 feet of well field piping were assumed for this strategy. No additional transmission costs to the end users are included in the strategy cost. If possible, existing infrastructure would be used to deliver the stored water. The feasibility study, when completed, would identify additional project components if needed. The strategy is estimated to cost $48 million.

Environmental Issues

Environmental impacts are expected to be low. The transmission system and the ASR facilities can be designed to avoid environmentally sensitive areas. As previously mentioned, the recharge water must not degrade the quality of the groundwater in the receiving aquifer. Therefore, environmental impacts to the receiving aquifer are expected to be minimal to none.

Impact on Water Resources and Other Management Strategies

This strategy should have a positive impact on other water management strategies by increasing reliability.

Impact on Agriculture and Natural Resources

The project should have no impact to agriculture or natural resources since it is utilizing existing water sources and existing infrastructure.

Other Relevant Factors

There are no other identified relevant factors.

Brush Control in Lake Meredith Watershed

CRMWA has an active salt cedar control program in the Lake Meredith watershed. The purpose of the program is to increase flow in the Canadian River, improve water quality and improve the habitat for the federally listed Arkansas River Shiner, which is known to inhabit this area. CRMWA has treated approximately 37,000 acres of salt cedar. Since 2020, CRMWA has spent over $400,000 on brush control. The salt cedar beetle was introduced into the Lake Meredith watershed several years ago and is becoming established. And could help control re-infestation. However, retreatment will likely still be needed. CRMWA is now in the on-going maintenance phase, which requires retreating of areas to control the growth and potential re-infestation of salt cedar. CRMWA is currently treating 500 acres each year. This strategy recommends that CRMWA continue with its program to control salt cedar in the Lake Meredith watershed and work with the State Water Supply Enhancement Program when this program is funded by the Legislature.

Time Intended to Complete

This strategy is on-going and would be implemented throughout the planning period.

Quantity, Reliability and Cost

The amount of water developed from brush control is difficult to estimate since there are so many factors that affect reservoir inflows, and Lake Meredith is benefiting from brush control that has been completed. For this plan, it is assumed that the amount of water made available from continuing treatment of brush is estimated at 5 acre-feet per year per acre of treatment for a total quantity of 2,500 acre-feet per year. This water would be realized through available supply in Lake Meredith and optimized with conjunctive use of CRMWA's groundwater sources. The reliability during drought is low. The annual costs are estimated at $100,000.

Environmental Issues

There is concern about the removal of brush for wildlife. However, with increased runoff to streams and lakes, this strategy would provide additional water for wildlife.

Impact on Water Resources and Other Management Strategies

This strategy should have a positive impact to Lake Meredith, and ultimately to CRMWA's available supplies.

Impact on Agriculture and Natural Resources

The removal of invasive brush will allow for the development of native grasslands and other agricultural uses. It should have a positive impact on natural resources.

Other Relevant Factors

There are no other identified relevant factors.

Advanced Treatment of Lake Meredith Supplies

CRMWA is currently conducting a feasibility study of desalination of Lake Meredith water, but the study is not complete. For regional water planning, it is assumed that an advanced treatment facility would produce up to 10,000 acre-feet of treated supplies. Some of the source water would include the higher salinity water that is not included in the existing Lake Meredith supply. The advanced treatment facility would be located near the intake of Lake Meredith to treat elevated chlorides and total dissolved solids. The waste stream would be piped about 10 miles upstream and discharged back into Lake Meredith. Alternatively, the waste stream could be injected in a brackish formation. Lake Meredith is located in an area where there is little potable groundwater (Canadian breaks).

Time Intended to Complete

This strategy would be implemented in 2040.

Quantity, Reliability and Cost

This strategy may provide some additional supplies above the current supplies used for regional planning. It also increases the reliability of those supplies during times when water quality impairments limit diversions from Lake Meredith, and it preserves groundwater supplies in Roberts County if more surface water is useable. The capital costs for this strategy are $196 million.

Environmental Issues

There is concern about the waste discharge stream from the advanced treatment process. As conceived, the salt stream would be discharged upstream into Lake Meredith. The discharge stream must not further impair the water quality of the stream segment.

Impact on Water Resources and Other Management Strategies

This strategy could increase salinity in Lake Meredith during very low inflow periods, however, the salts in the lake water would concentrate without this project due to evaporation. Lower salinity water to CRMWA's customers would improve the water quality and potentially reduce the required amount of groundwater needed for blending.

Impact on Agriculture and Natural Resources

The lower salinity source water could reduce the salinity in the wastewater effluent that is land applied for irrigation.

Other Relevant Factors

There are no other identified relevant factors.

Linear Well Field Along Existing Transmission System

CRMWA services numerous member cities with groundwater resources developed in the region. To enhance its capacity to supply water to user groups south of Lubbock, CRMWA plans to develop additional groundwater resources. This project will replenish the transmission system (CRMWA I) after delivering water to the City of Lubbock and other member cities further north. The initiative includes the construction of new transmission lines to connect the proposed well fields to the existing infrastructure.

CRMWA would plan to develop two well fields: one in Lubbock County and the other in Lynn County. Both will be situated in the Brazos River Basin, where the Ogallala and Edwards-Trinity Plateau Aquifers are expected to provide sufficient groundwater to meet project demands. Together, the well fields are projected to deliver approximately 2,700 acre-feet per year, assuming a peaking factor of 1.5. This capacity would increase the total water supply from Lubbock and Lynn Counties by 2.4 MGD without requiring additional local storage during low-demand months.

The Lynn County well field will require a 2-mile, 10-inch pipeline, while the Lubbock County well field will necessitate a 2-mile, 12-inch pipeline to connect to the existing transmission system. Detailed infrastructure requirements and cost estimates are provided in **Appendix D**.

Time Intended to Complete

The well fields in Lubbock and Lynn Counties can be developed either sequentially or simultaneously. The transmission system is anticipated to be operational by 2050. Over time, additional wells may be developed to sustain or increase system capacity.

Quantity, Reliability and Cost

The proposed well fields will supply approximately 2,700 acre-feet of water annually. The reliability of the Ogallala Aquifer for this purpose is considered moderate to high, as significant untapped water resources are available in Lubbock and Lynn Counties. However, availability depends on competing demands from other users.

The estimated cost of developing the well fields is $17 million. This figure includes the construction of transmission pipelines, the drilling of new wells to supply 2,700 acre-feet per year, and associated well field piping.

Environmental Issues

The environmental issues associated with this water management strategy are for pipeline rights-of-way and sites for pumping plants and storage facilities. Since routes and sites can be selected to avoid sensitive wildlife habitat and cultural resources, there would be very little, if any, environmental issues of significant concern.

Impact on Water Resources and Other Management Strategies

The increased groundwater extraction will contribute to continued depletion of the Ogallala Aquifer's storage. While there may be competition from other water users, current assessments indicate sufficient water availability in the project area to meet these demands without significantly affecting other management strategies.

Impact on Agriculture and Natural Resources

Expanding and maintaining the well fields is expected to have minimal impact on agricultural lands and natural resources. A small amount of agricultural land may be affected by the transmission pipelines, depending on the final routing.

Other Relevant Factors

There are no other identified relevant factors.

Summary for CRMWA

The recommended strategies for CRMWA would provide up to 89,180 acre-feet per year (including conservation from PWPA customers). CRMWA is planning transmission expansion (CRMWA II) by 2030 and well capacity replacement for CRMWA I and II before 2040. Based on this timing, CRMWA may not be able to fully meet contractual demands until after the CRMWA II pipeline from Roberts County well field is completed. The recommended strategies and quantities are shown in **Table 5C-2**. The costs for the strategies are summarized in **Table 5C-3**.

Table 5C-2: Recommended Water Management Strategies for CRMWA (Ac-Ft/Yr)

	2030	2040	2050	2060	2070	2080
Need	(22,540)	(38,520)	(49,928)	(59,132)	(61,953)	(64,858)
Recommended Strategies	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
PWPA Customer Conservation	2,703	2,979	3,250	3,451	3,639	3,813
ASR[1]	0	17,000	17,000	17,000	17,000	17,000
Expand GW and delivery capacity (CRMWA II)	65,000	65,000	65,000	60,674	55,476	55,476
Replace Well Capacity for CRMWA I and II	0	4,326	9,524	19,493	24,691	24,691
Brush Control	2,500	2,500	2,500	2,500	2,500	2,500
Desalination of Lake Meredith Water	0	10,000	10,000	10,000	10,000	10,000
Linear Well Field Along Existing Transmission System	0	0	2,700	2,700	2,700	2,700
Total from Strategies and Conservation	**70,203**	**78,357**	**88,070**	**95,452**	**97,180**	**98,894**

[1] Supply from ASR uses water developed from other strategies and is not included in the total.

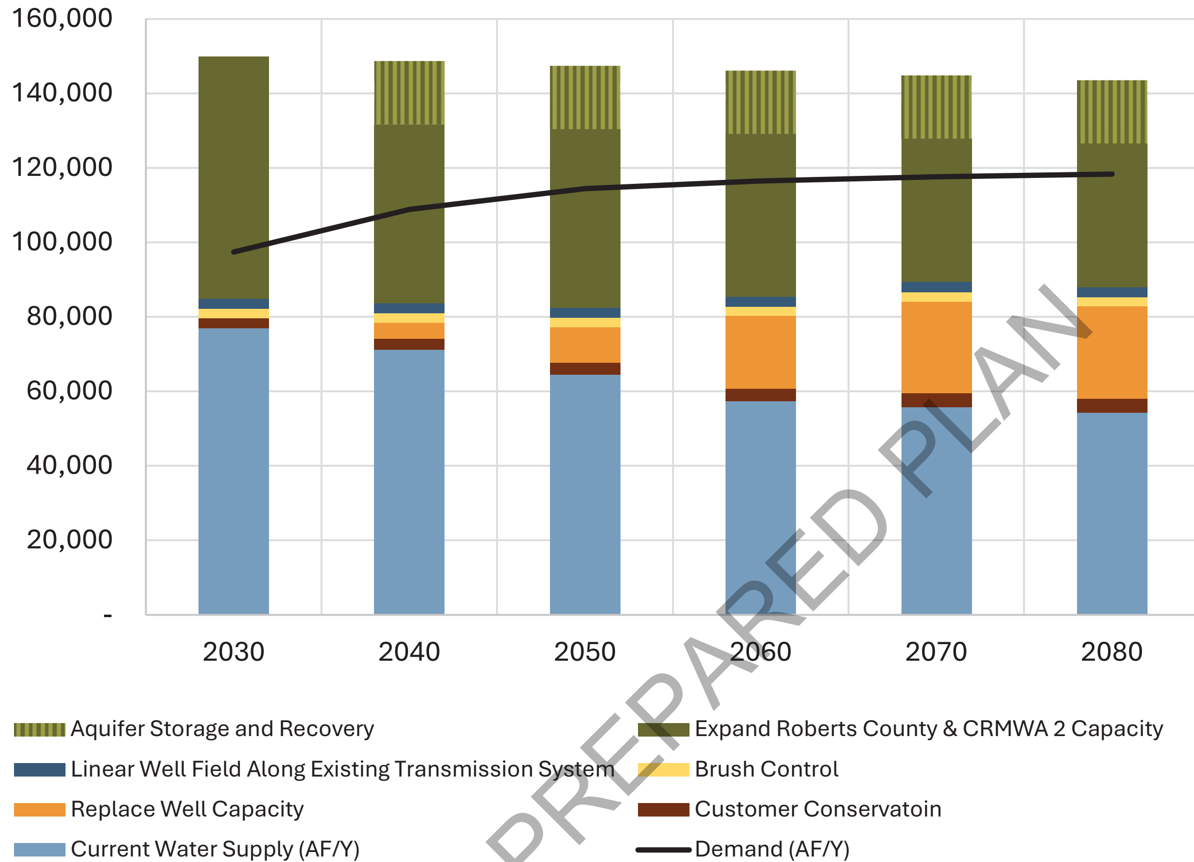


Figure 5C-1: Recommended Strategies for CRMWA

Table 5C-3: Summary of Costs for CRMWA's Recommended Strategies

Recommended Strategies	Capital Cost ($ Millions)	Annual Costs ($ Million)					
		2030	2040	2050	2060	2070	2080
Replace Well Capacity for CRMWA I	$35.60	$0.00	$2.76	$2.76	$0.26	$0.26	$0.26
Expand GW and delivery capacity (CRMWA II)[1]	$767.77	$68.53	$68.53	$14.85	$14.85	$14.85	$14.85
Linear Well Field Along Existing Transmission System	$17.07	$1.45	$1.45	$0.25	$0.25	$0.25	$0.25
Desalination of Lake Meredith Water	$196.19	$0.00	$33.25	$33.25	$19.45	$19.45	$19.45
Aquifer Storage and Recovery	$48.38	$0.00	$3.98	$3.98	$0.57	$0.57	$0.57
Brush Control	$0.00	$0.10	$0.10	$0.10	$0.10	$0.10	$0.10
Total from Strategies	**$1,065.01**	**$70.08**	**$110.06**	**$55.18**	**$35.48**	**$35.48**	**$35.48**

[1.] Costs presented here include the well field and all infrastructure necessary to transport the water to CRMWA's service area.

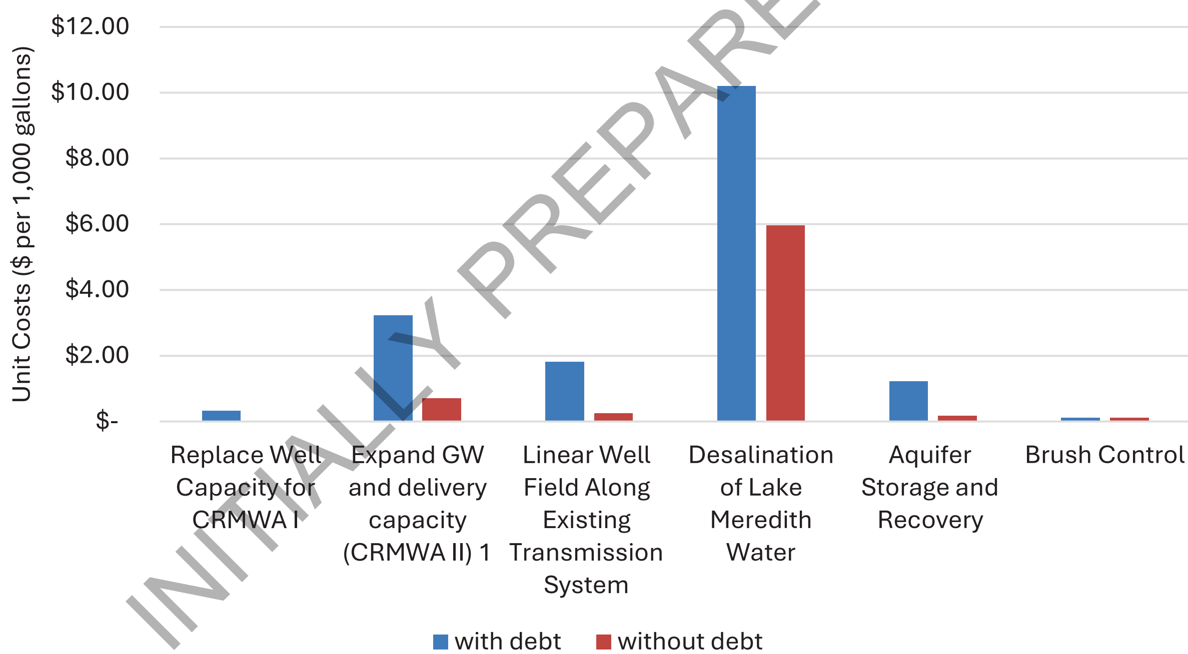


Figure 5C-2: Unit Costs for CRMWA Recommended Strategies

5C.2 City of Amarillo

The City of Amarillo provides water to municipal customers in Randall and Potter County, and most of the manufacturing water needs in Potter County with a small amount to manufacturing demands in Randall County. The City also has a contract to sell Xcel Energy treated wastewater effluent.

Amarillo owns water rights in Randall, Potter, Carson, Deaf Smith, Lipscomb, Ochiltree and Roberts County, but only a portion of these groundwater rights are developed. In addition, the City has a contract with CRMWA for water from Lake Meredith and Roberts County groundwater. The current delivery capacity for water from CRMWA is 42,987 acre-feet per year. CRMWA intends to increase this delivery capacity through the construction of its CRMWA II pipeline from Roberts County. Considering supplies from CRMWA and Amarillo's existing groundwater, the total estimated current supply for the City is 53,926 acre-feet per year of potable water and 18,732 acre-feet of treated wastewater effluent. Existing potable water supplies are projected to decrease to 40,578 acre-feet per year as groundwater supplies and Lake Meredith's reliability decline. Treated effluent is expected to increase over time and is currently supplied to Xcel Energy for steam electric power use and instream flow to Lake Tanglewood. Treated effluent made available to Xcel but not captured is discharged to nearby streams. Xcel Energy's contract with Amarillo is set to renew in 2040.

Table 5C-4 lists the projected demands by customer, the current sources of supply available, and the projected water needs. The projected needs are expected to begin in 2030 with a shortfall of about 5,000 acre-feet per year and increasing to over 31,000 acre-feet per year by 2080. Some of this need will be met when CRMWA develops additional groundwater in Roberts County to fully meet Amarillo's contractual demands. However, the City would still need to develop about 7,000 acre-feet of new water.

The City of Amarillo considered a wide array of strategies to meet the increased demands. The City realizes that it is important to be proactive and consider all potential sources of supplies. Potential sources include development and expansion of its existing groundwater rights holdings in Potter/Carson Counties and Roberts/Ochiltree Counties. Amarillo considered partnering with CRMWA to move its Roberts/Ochiltree water through the CRMWA II pipeline, but ultimately decided to pursue developing the water independently. The City is also planning to develop an aquifer storage and recovery project that will store water delivered from CRMWA and treated effluent. Treated effluent would come from the City's direct potable reuse strategy. Other potential sources of new supply for Amarillo include the use of water collected in playa lakes. This water could be used for non-potable use, but it would have low reliability and water quality could be a concern. At this time, it was decided not to include water from playa lakes as a potentially feasible strategy.

The recommended water management strategies for Amarillo include conservation strategies, obtain contractual supply from CRMWA, expansion of their Potter/Carson County well field, aquifer storage and recovery using direct potable reuse strategy and CRMWA supplies, and development of the Roberts County Well Field.

Table 5C-4: Summary of Demands, Supplies, and Projected Needs for Amarillo

	Demands (Ac Ft/Yr)					
Customers	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
City of Amarillo	46,830	49,513	51,716	53,441	55,161	56,866
Manufacturing - Potter County	10,009	10,439	10,884	11,346	11,825	12,322
City of Canyon	1,000	1,000	1,000	1,000	1,000	1,000
Manufacturing - Randall County	1,231	1,277	1,324	1,373	1,424	1,477
Palo Duro State Park	25	25	25	25	25	25
Steam Electric Power–Potter County	15,000	15,000	15,000	15,000	15,000	15,000
Instream Flows to Lake Tanglewood	1,682	1,682	1,682	1,682	1,682	1,682
Total Potable Demand	**59,095**	**62,254**	**64,949**	**67,185**	**69,435**	**71,690**
Total Non-Potable Demand	**16,682**	**16,682**	**16,682**	**16,682**	**16,682**	**16,682**
	Current Water Supply (Ac-Ft/Yr)					
Sources	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Ogallala - Randall County	758	563	465	404	231	229
Ogallala - Potter County	2,714	2,483	2,196	1,915	1,729	1,562
Ogallala - Carson County	16,770	16,578	16,168	15,899	15,798	15,499
Dockum - Carson County	3	3	3	3	3	3
Dockum - Potter County	639	640	639	640	635	619
CRMWA[1]	32,942	29,948	27,924	24,584	23,591	22,666
Ogallala - Deaf Smith	100	50	50	0	0	0
Reuse	18,732	19,805	20,686	21,376	22,064	22,746
Total Potable Supply	**53,926**	**50,265**	**47,445**	**43,445**	**41,987**	**40,578**
Total Reuse Supply	**18,732**	**19,805**	**20,686**	**21,376**	**22,064**	**22,746**
	Surplus or (Need) Before Strategies (Ac-Ft/Yr)					
	2030	**2040**	**2050**	**2060**	**2070**	**2080**
Potable	**(5,170)**	**(11,989)**	**(17,504)**	**(23,740)**	**(27,448)**	**(31,112)**
Non-Potable	**2,050**	**3,123**	**4,004**	**4,694**	**5,382**	**6,064**

[1] The amount CRMWA sells to other Major Water Providers is included in the supplies reported for CRMWA.

Develop Phase II of the Potter/Carson County Well Field (Ogallala aquifer)

The City of Amarillo has an existing well field in the Ogallala aquifer in Potter and Carson Counties. Amarillo intends to develop this strategy over time in two 20 MGD phases, with each phase providing approximately 10,000 acre-feet per year. Due to limitation of the MAG, the amount available for this strategy in 2070 and 2080 drops to 17,000 and 5,200 ac-ft respectively. While the MAG is limited in the later decades, there is a surplus in earlier decades. The surplus water in earlier decades could be available for use by Amarillo in 2070 and 2080. To provide this quantity of water, it is assumed that approximately 20 new wells will be drilled in Carson County and two new wells in Potter County (due to MAG limitations). The Carson County wells will be drilled to a depth of 450 feet and produce approximately 700 gallons per minute. The Potter County wells will be drilled to a depth of 600 feet and produce approximately 850 gallons per minute.

This project includes 30 miles of well field piping ranging from 10- to 36-inches in diameter. It is assumed that an additional transmission pipeline will be needed to move the water the city's existing infrastructure. For this plan, 10-miles of 36-inch pipeline and associated pumping facilities upgrades are included in the cost estimates to connect to Amarillo's existing transmission system.

Time Intended to Complete

The first 20 MGD phase of this project will be online by 2040. The second phase would be online by 2050.

Quantity, Reliability and Cost

Approximately 20,000 acre-feet per year of additional water will be obtained from the Potter/Carson County well field. The reliability of Ogallala supplies is moderate since there is currently competition for this supply with irrigators. The total capital cost for the Potter/Carson County well field is about $130 million.

Environmental Issues

The environmental impacts from groundwater development are expected to be low. Once the specific locations of additional wells and alignments associated with infrastructure are identified, a detailed evaluation to determine environmental impacts, if any, will need to be performed.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. There are other users that may compete for groundwater supplies in these counties including irrigation users that may be impacted by the development of this well field.

Impact on Agriculture and Natural Resources

The development of the proposed well fields is expected to have moderate impact on the agriculture and other natural resources. A small amount of agricultural lands may be affected by the transmission system associated with the well field, depending on the final transmission route.

Other Relevant Factors

There are no other identified relevant factors.

Develop Roberts County Well Field (Ogallala aquifer)

The City of Amarillo has unused groundwater rights in the Ogallala aquifer in Roberts and Ochiltree Counties. These rights are located the furthest from the city and will likely be developed after sources closer to Amarillo. As more supplies are needed, the city will develop its groundwater rights in Roberts County, followed by its rights in Ochiltree County. The strategy is referred to as the "Roberts County Well Field", however, over time it will include water supplies from Ochiltree County. It is assumed that the Roberts County strategy will be implemented in two phases, with Phase 1 being developed by 2065 and Phase 2 developed after the regional water planning horizon. This well field strategy assumes that approximately 11 new wells will be drilled in Roberts County, north of CRMWA's Roberts County water rights. The wells will be drilled to a depth of 600 feet and produce approximately 800 gallons per minute. This project includes well field piping ranging from 10- to 36-inches in diameter. The City will need to construct 75-miles of 36-inch pipeline to transport the water from Roberts County to Amarillo.

Time Intended to Complete

The Roberts County well field will be developed as additional supplies are needed. This is expected to occur by 2065. It is shown in the 2070 decade.

Quantity, Reliability and Cost

Approximately 11,200 acre-feet per year (20 MGD peak day) of additional water will be obtained from the Roberts County well field during the first phase. In Roberts County, the reliability of Ogallala supplies is moderate to high since there are large quantities of undeveloped supply in this county, though competing interests may be present. The total capital cost for the Roberts County well field is $526 million.

Environmental Issues

The environmental impacts from groundwater development are expected to be low. Once the specific locations of additional wells and alignments associated with infrastructure are identified, a detailed evaluation to determine environmental impacts, if any, will need to be performed.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. There are other users that may compete for groundwater supplies, but there is sufficient water in Roberts County to support these demands.

Impact on Agriculture and Natural Resources

The development of the proposed well fields are expected to have minimal impact on the agriculture and other natural resources. A small amount of agricultural lands may be affected by the transmission system associated with the well field, depending on the final transmission route.

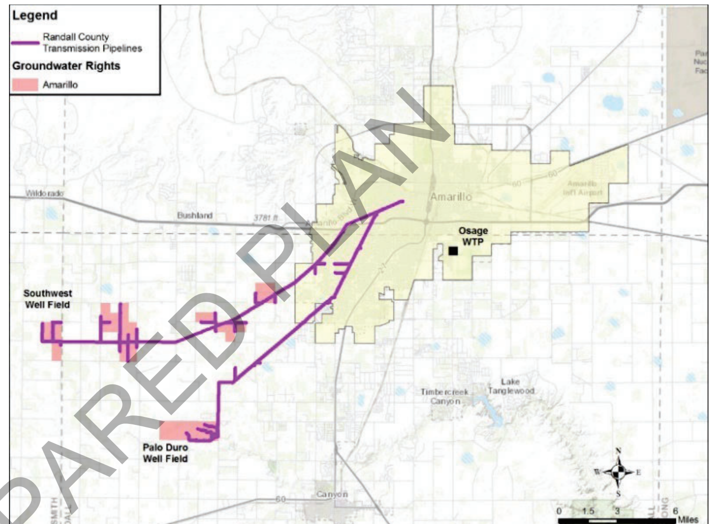
Other Relevant Factors

There are no other identified relevant factors.

Aquifer Storage and Recovery (ASR)

During non-peak periods, the capacity of Amarillo's transmission system is underutilized; yet during peak demand months, the ability to meet all of Amarillo's customers' future peak demands may be limited. To address the need for increased peaking capacity in the delivery system, available water from Amarillo's sources could be stored during non-peak periods for future use during peak times. This strategy proposes to store excess non-peak water through an Aquifer Storage and Recovery program (ASR) that will utilize existing well fields and infrastructure. Amarillo will be conducting a feasibility study to further evaluate this strategy.

For this strategy, it is assumed that the ASR project would be developed at Amarillo's Randall County well field. Amarillo currently has two existing 30-inch pipelines from the Randall County Well Fields to the City with a combined transmission capacity of 30 MGD; yet the City is only using a fraction of this capacity due to declining water levels. These lines could transport treated water from Amarillo's treatment plant to and from the well field. The cost components of this strategy include new well field piping, injection wells at the existing well fields, along with some pump improvements to move water to ASR injection wells.



This strategy assumes that sixteen 400-gpm 8-inch diameter wells will be required for ASR injection in Randall County. Existing wells would be used for recovery. It is assumed that no additional improvements are needed for the transmission system back to the City.

Time to Implement

Supply will be available for the ASR project by 2040.

Quantity, Reliability and Cost

The quantity will vary from year to year depending on demands and the capacities of ASR well fields. The quantity of water that would be made available from the ASR project is 10,000 acre-feet per year. The source of this water would be from CRMWA, which could include a combination of water from Lake Meredith and groundwater from Roberts County. Amarillo also may utilize treated wastewater for this strategy.

Successful ASR development is highly reliable. It is possible to achieve 90-95% recovery efficiency, depending upon the natural hydraulic gradient of the receiving aquifer and competition from adjacent groundwater users. If the water is recharged and recovered over a relatively short period (e.g., one year), the likelihood of reduced reliability is low. The ASR project will increase the reliability of existing supplies by allowing storage of the supply during periods of low demand to meet high demands at a later time.

The ASR project will increase the reliability of existing supplies by allowing storage of the supply during periods of low demand to meet high demands at a later time. The strategy is estimated to cost $29.2 million.

Environmental Issues

Environmental impacts are expected to be low. Since the recharge water must not degrade the quality of the groundwater in the receiving aquifer, environmental impacts to the receiving aquifer are expected to be minimal to none. If all the source water is groundwater, pre-treatment of the water before injection and storage may not be needed.

Impact on Water Resources and Other Management Strategies

This strategy should have a positive impact on other water management strategies by increasing reliability.

Impact on Agriculture and Natural Resources

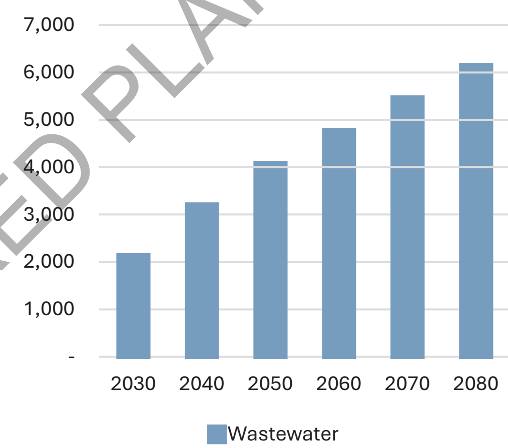
The project should have no impact to agriculture or natural resources since it is utilizing existing water sources and existing infrastructure.

Other Relevant Factors

There are no other identified relevant factors.

Direct Potable Reuse

The City of Amarillo is considering a project to treat their wastewater effluent to potable water status and then store the water in the ASR project discussed above. The strategy would treat between 3 and 5 MGD at the existing wastewater treatment plant with pre-treatment and reverse osmosis to produce 3,500 acre-feet per year of finished water. The water would then be transported to the Randall County well field using existing infrastructure (see **Section 5C.2.2**). The reject water from the treatment process would be discharged by a 7-mile pipeline to the Prairie Dog Town Fork of the Red River below.



Amarillo wastewater after current commitments (acre-feet per year)

Time Intended to Complete

This project is expected to be online by 2040, but it could be permitted and constructed earlier if needed.

Quantity, Reliability and Cost

Direct potable reuse would have moderate to high reliability. The capital cost for this project is approximately $112 million. If Amarillo is not able to discharge to a stream the cost for deep well injection could substantially increase the capital cost.

Environmental Issues

The greatest potential environmental impact is the quality of the discharge water. An initial review of the TDS stream standard for the Upper Prairie Dog Town Fork of the Red River is 2,000 mg/L. Additional studies would need to be conducted to determine the feasibility of discharging to the Prairie Dog Town Fork of the Red River.

Impact on Water Resources and Other Management Strategies

Amarillo is currently providing a significant amount of their direct reuse for steam electric cooling. Direct potable reuse could impact the amount of reuse available for steam electric power in Potter County. The demands for steam electric power cooling in Potter County are not expected to increase and additional reuse water will become available. However, this strategy would require making additional reclaimed water contractually available, and may require a reduction of commitment to the Xcel Energy contract which is set to be renewed in 2040.Impact on Agriculture and Natural Resources

Discharges to the Prairie Dog Town Fork of the Red River will need to be further evaluated to determine the impact to natural resources

Other Relevant Factors

This strategy would require extensive coordination with the TCEQ to obtain the necessary permits for use and discharge. It may also require a modification to the agreement with Xcel Energy for purchase of Amarillo's wastewater.

Summary of Recommended Strategies for Amarillo

The recommended strategies for Amarillo would provide over 59,000 acre-feet per year and fully meet the city's needs. More than 20,000 acre-feet per year will become available to Amarillo by 2040 after the CRMWA II pipeline is online and the city initiates Phase I of their Potter/Carson County Well Field. The recommended strategies and quantities are shown in **Table 5C-5** and on **Figure 5C-3**. The total capital cost for Amarillo is $798 million and the annual costs for the strategies are summarized in **Table 5C-6**. Unit costs are shown on **Figure 5C-4**.

Table 5C-5: Recommended Water Management Strategies for Amarillo (Ac-Ft/Yr)

	2030	2040	2050	2060	2070	2080
Surplus or (Need) – Potable Supply	(5,170)	(11,989)	(17,504)	(23,740)	(27,448)	(31,112)
	Supply from Strategy (Ac-Ft/Yr)					
Recommended Strategies	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Water Conservation	4,412	4,599	4,736	4,843	4,953	5,060
Supplies from CRMWA	5,762	12,058	17,196	20,489	20,871	21,182
Potter County Well Field – Phase 2	0	10,000	20,000	20,000	17,000	5,200
Roberts County Well Field	0	0	0	0	11,210	11,210
Aquifer Storage and Recovery (ASR)[1]	0	6,500	6,500	6,500	6,500	6,500
Direct Potable Reuse	0	3,500	3,500	3,500	3,500	3,500
Total from Strategies	**10,174**	**40,244**	**65,586**	**69,040**	**74,794**	**51,665**

[1] The ASR strategy would use supplies from other strategies and is not included in the total water quantities.

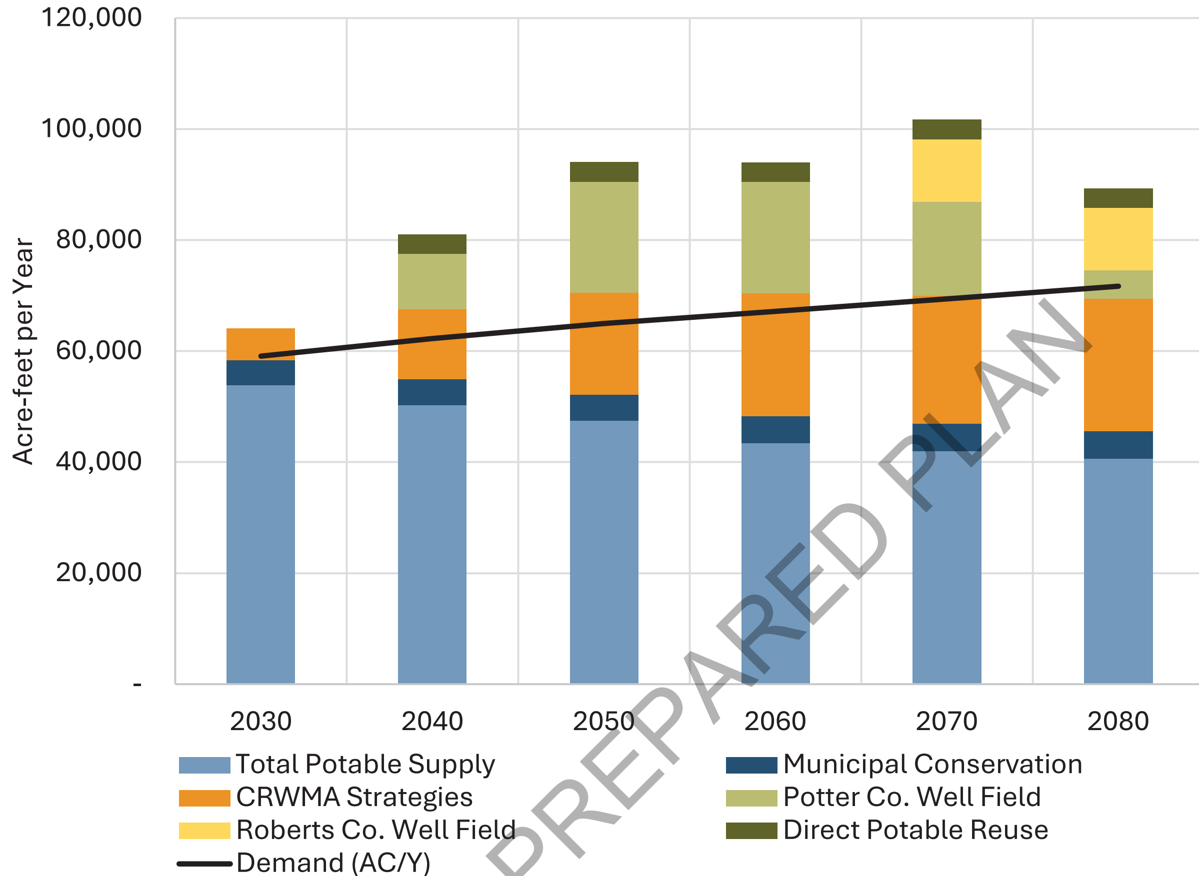


Figure 5C-3: Recommended Strategies for Amarillo

Table 5C-6: Summary of Costs for Recommended Strategies for Amarillo

Recommended Strategies	Capital Cost ($M)	Annual Costs ($ Million)					
		2030	2040	2050	2060	2070	2080
Water Conservation Package[1]	$208.41	$6.75	$6.79	$4.24	$4.25	$4.27	$4.29
Direct Potable Reuse	$112.06	$0.00	$18.19	$18.19	$10.31	$10.31	$10.31
Potter/Carson County Well Field	$130.30	$0.00	$6.08	$12.17	$7.59	$3.01	$3.01
Roberts County Well Field	$526.32	$0.00	$0.00	$0.00	$0.00	$43.95	$43.95
Aquifer Storage and Recovery	$29.20	$0.00	$2.86	$2.86	$0.80	$0.80	$0.80
Total from Strategies	**$797.89**	**$0.00**	**$27.13**	**$33.22**	**$18.70**	**$58.07**	**$58.07**

[1] Includes the capital and O&M costs associated with conservation programs, AMI, and water audits and leak repair.

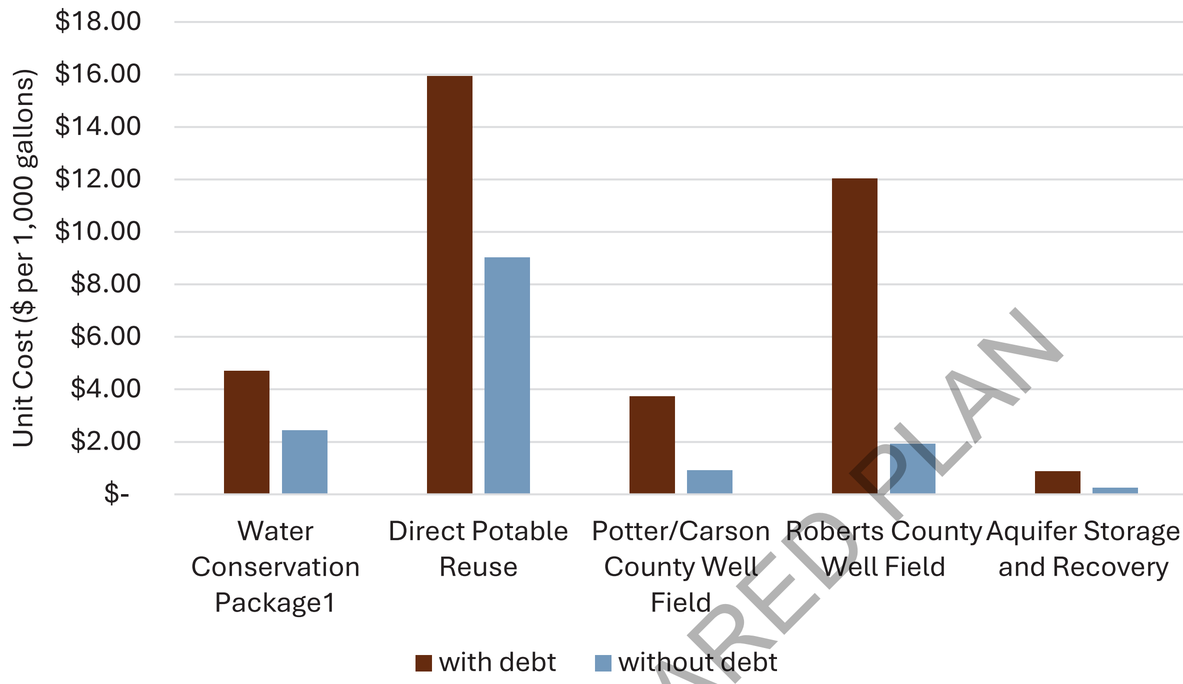


Figure 5C-4: Unit Costs for Amarillo Recommended Strategies

5C.3 City of Borger

The City of Borger provides water to customers in Hutchinson County, and Hutchinson County manufacturing. The city receives water from CRMWA and operates wells in the Ogallala aquifer in Hutchison County. The city has a complex arrangement of trading water with several industries to most efficiently supply water to its customers. The city also sells treated wastewater to its manufacturing customers. **Table 5C-7** lists the projected demands and supplies for the City of Borger and its customers.

Table 5C-7: Summary of Demands, Supplies and Needs for the City of Borger

	Demands (Ac-Ft/Yr)					
Customers	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
City of Borger	3,535	3,480	3,394	3,295	3,201	3,116
Hutchinson County Manufacturing	12,160	12,610	13,077	13,561	14,062	14,583
Total Demand	**15,695**	**16,090**	**16,471**	**16,856**	**17,263**	**17,699**
Potential Future Customer[1]						
TCW Supply	942	848	768	697	639	593
Manufacturing, Hutchinson	180	180	180	180	180	180
Total Potential Demand	**1,122**	**1,028**	**948**	**877**	**819**	**773**
	Current Water Supply (Ac-Ft/Yr)					
Sources	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Ogallala - Hutchinson Co.	10,259	9,610	8,952	8,398	8,047	7,610
CRMWA[2]	2,995	3,265	3,652	3,926	4,225	4,126
Reuse[3]	1,100	1,100	1,100	1,100	1,100	1,100
Total Supply	**14,354**	**13,975**	**13,704**	**13,424**	**13,372**	**12,836**
	Surplus or (Need) (Ac-Ft/Yr)					
	2030	**2040**	**2050**	**2060**	**2070**	**2080**
	(1,341)	**(2,115)**	**(2,767)**	**(3,432)**	**(3,891)**	**(4,863)**

1 TCW Supply and their customer demands are met by TCW's existing supplies.

2 The sources of water from CRMWA are shown on Table 5C-1.

3 Reuse supply is only available to manufacturing users in Hutchinson County.

The recommended strategies include implementing conservation measures, obtaining contractual supplies from CRMWA, developing additional groundwater in Hutchinson County, and acquiring TCW's well field and system. **Table 5C-8** shows the amount of water supply associated with each of the recommended strategies.

Drill Additional Groundwater Wells in Hutchinson County

The City of Borger plans to purchase additional groundwater rights in Hutchinson County from CRMWA. This strategy would add 2 MGD of supplies every 10 years with a 1.5 peaking factor.

Time Intended to Complete

The project is expected to be online by 2030, with supplies increasing over the planning cycle.

Quantity, Reliability and Cost

The total quantity of water provided by this strategy would be nearly 9,000 acre-feet per year by 2080. This includes the development of 2 MGD every 10 years.

Environmental Issues

The environmental impacts from groundwater development are expected to be low. Once the specific locations of additional wells and alignments associated with infrastructure are identified, a detailed evaluation to determine environmental impacts, if any, will need to be performed.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. There are other users that may compete for groundwater supplies, but there is sufficient water in Hutchinson County to support these demands.

Impact on Agriculture and Natural Resources

The development of the proposed well fields is expected to have minimal impact on the agriculture and other natural resources. A small amount of agricultural lands may be affected by the transmission system associated with the well field, depending on the final transmission route.

Other Relevant Factors

There are no other identified relevant factors.

Acquisition of TCW Well Field and System

The long-term future of TCW as a private water supply corporation is uncertain. For planning purposes, it is assumed that the City of Borger would serve TCW's current customers and acquire the utility's infrastructure and well field.

Time Intended to Complete

This project is expected to be online by 2040.

Quantity, Reliability and Cost

The total quantity of water provided by this strategy would be approximately 800 acre-feet per year.

Environmental Issues

No environmental impacts are expected as the infrastructure is in place. The only new infrastructure would be interconnection(s) to Borger's existing water system to ensure continued service to TCW's current customers.

Impact on Water Resources and Other Management Strategies

There should be no impacts to water resources or other water management strategies since these supplies are already developed.

Impact on Agriculture and Natural Resources

There should be no impacts on agriculture and natural resources since these supplies are already developed.

Other Relevant Factors

There are no other identified relevant factors.

Summary of Recommended Strategies for Borger

The recommended strategies for the City of Borger would provide up to 14,065 acre-feet per year by 2080 and fully meet the city's needs. The recommended strategies and quantities are shown in **Table 5C-8** and on **Figure 5C-5**. The costs for the strategies are summarized in **Table 5C-9**.

Table 5C-8: Recommended Strategies for Borger (Ac-Ft/Yr)

	2030	2040	2050	2060	2070	2080
Surplus or (Need)	(1,341)	(2,115)	(2,767)	(3,432)	(3,891)	(4,863)
Recommended Strategies	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
Municipal Conservation	38	37	36	35	34	33
Drill Additional Groundwater Wells	1,457	2,914	4,371	5,828	7,285	8,742
Supplies from CRMWA	1,827	2,473	3,044	3,610	3,960	4,760
Acquisition of TCW Well Field and System[1]	0	804	764	726	690	656
Total from Strategies	**3,284**	**5,387**	**7,415**	**9,438**	**11,245**	**13,502**

1 Amount shown is TCW Supply existing supplies, minus sales to Phillips, as it is uncertain if sales would continue post-acquisition.

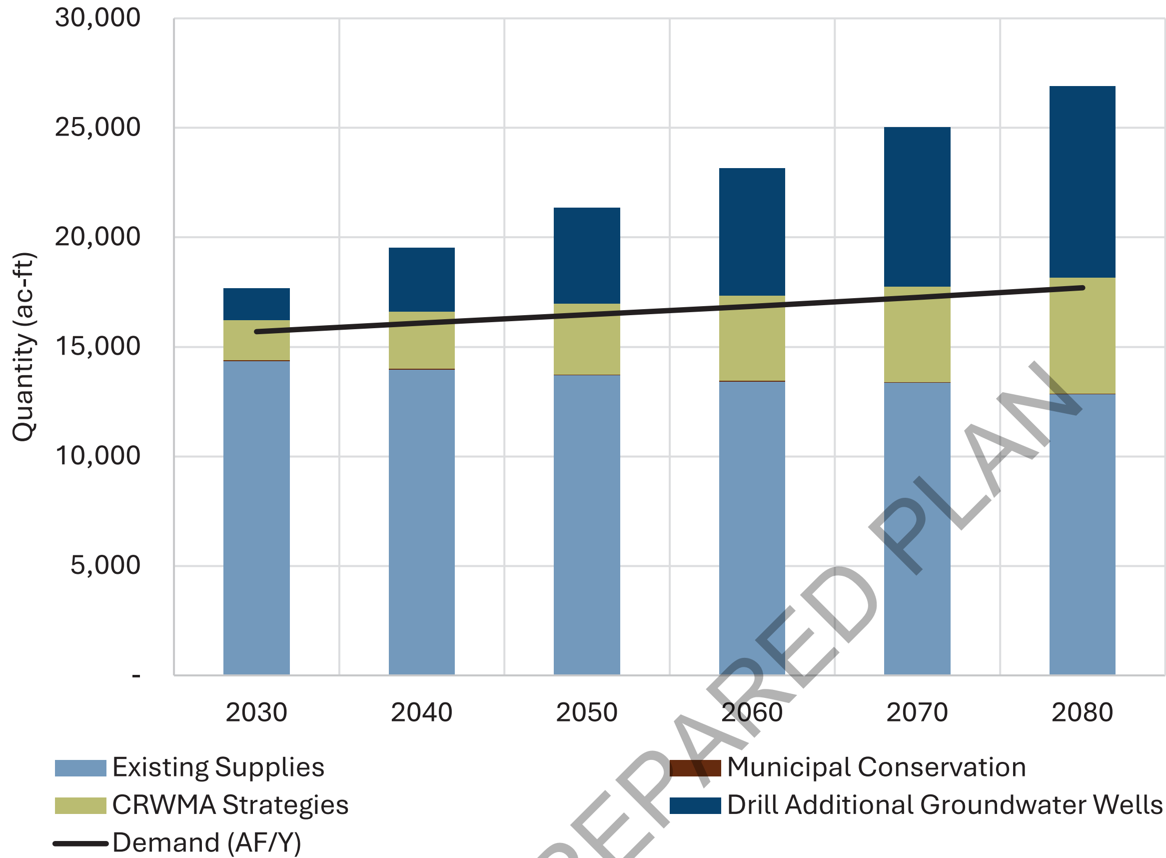


Figure 5C-5: Recommended Strategies for Borger

Table 5C-9: Summary of Costs for Recommended Strategies for Borger[1]

Recommended Strategies	Capital Cost ($ Million)	Annual Costs ($ Million)					
		2030	2040	2050	2060	2070	2080
Water Conservation	-	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
Drill Additional Groundwater Wells	$15.09	$1.51	$1.51	$0.45	$0.45	$0.45	$0.45
Acquisition of TCW Well Field and System[2]	$0.03	$0.00	$0.002	$0.002	$0.00	$0.00	$0.00
Total from Strategies	**$15.12**	**$1.47**	**$1.48**	**$0.41**	**$0.41**	**$0.41**	**$0.41**

1. Purchase of additional supplies from CRWMA does not include additional infrastructure and the purchase costs are already negotiated
2. Capital cost for Acquisition of TCW Well Field is a place holder for the connection to Borger's system. Acquisition/system purchase costs would be negotiated between the buyer and seller.

5C.4 Greenbelt Municipal and Industrial Water Authority

Greenbelt Municipal and Industrial Water Authority (Greenbelt MIWA) owns and operates Greenbelt Reservoir on the Salt Fork of the Red River. The MIWA also developed local groundwater supplies from the Ogallala aquifer. The Greenbelt MIWA is located in Donley County and provides water to local municipalities through an extensive delivery system, including a 121-mile aqueduct. There are five member cities, including Clarendon, Hedley, and Childress in the PWPA and Quanah and Crowell in the Region B planning area. The Red River Authority is a non-voting member of the Greenbelt MIWA.

Greenbelt MIWA's primary water source is Greenbelt Reservoir. The estimated reliable supply from the reservoir is about 3,140 acre-feet per year in 2030 and declining to 2,175 acre-feet per year over the planning period. Groundwater supplies are estimated at 1,600 acre-feet per year and are expected to decline to about 1,090 by 2080. Current projected demands on the MIWA are shown in **Table 5C-10** and are not expected to exceed 3,056 acre-feet per year over the planning period. Considering both the reservoir supplies and local groundwater supplies, Greenbelt MIWA is not expected to have water needs during this planning cycle.

Table 5C-10: Summary of Demands, Supplies and Needs for the Greenbelt MIWA

Customers	Demands (Ac-Ft/Yr)					
	2030	2040	2050	2060	2070	2080
City of Childress	1,274	1,315	1,296	1,261	1,224	1,186
City of Clarendon	298	281	262	251	239	227
City of Hedley	56	56	56	56	56	56
City of Memphis	37	37	37	37	37	37
Red River Authority - Childress County	382	358	352	361	369	378
Red River Authority - Collingsworth County	16	16	16	16	16	16
Red River Authority - Donley County	30	30	30	30	30	30
Red River Authority - Hall County	100	100	100	100	100	100
Region B						
City of Chillicothe	29	29	28	28	27	27
City of Crowell	120	119	117	115	113	110
Thalia	40	40	40	40	40	40
City of Quanah	347	343	340	336	331	327
Hardeman County Manufacturing	50	50	50	50	50	50
Hardeman County-Other	2	2	2	2	2	2
Red River Authority - Foard County	73	73	74	75	77	78
Red River Authority - Hardeman County	195	193	192	189	186	184
Red River Authority - Wilbarger County	7	7	7	7	7	7

Customers	Demands (Ac-Ft/Yr)					
	2030	2040	2050	2060	2070	2080
Total Demand	**3,056**	**3,049**	**2,999**	**2,954**	**2,904**	**2,855**
Sources	**Current Water Supply (Ac-Ft/Yr)**					
	2030	**2040**	**2050**	**2060**	**2070**	**2080**
Ogallala - Donley County	1,600	1,577	1,484	1,370	1,245	1,090
Greenbelt Reservoir	3,140	2,970	2,800	2,592	2,383	2,175
Total Current Water Supply	**4,740**	**4,547**	**4,284**	**3,962**	**3,628**	**3,265**
	Surplus or (Need) (Ac-Ft/Yr)					
	2030	**2040**	**2050**	**2060**	**2070**	**2080**
	1,684	**1,498**	**1,285**	**1,008**	**724**	**410**

While the projections indicate Greenbelt MIWA can meet its projected demands throughout the planning cycle, there are concerns regarding the reliability of the surface water supplies and the long-term reliability of the local groundwater. Greenbelt Reservoir is in current drought of record conditions. As the drought continues, the reliable supply may decrease. The on-going drought also increases the competition for local groundwater from nearby irrigators. With these uncertainties, Greenbelt is pursuing additional groundwater in northern Donley County. This additional supply will provide additional reliability to the Greenbelt MIWA's system. The recommended strategies for Greenbelt MIWA include conservation measures and associated savings for the wholesale customers (discussed in **Chapter 5B**) and the development of additional groundwater supplies in Donley County.

Develop Additional Supplies from the Ogallala Aquifer in Donley County

In 2013, a feasibility study was developed for the Greenbelt MIWA. The recommended strategy was to develop groundwater in North Donley County. Since that study was completed, Greenbelt MIWA has acquired 2,692 acres of water rights in Donley County. The MIWA is currently conducting preliminary studies and design of the project. It is expected that the strategy would include three 600 gpm wells, a pump station and ground storage tank and associated electrical and instrumentation. The groundwater would be transported by a 14-inch pipeline approximately 12 miles to the Greenbelt Water Treatment Plant site.

Time Intended to Complete

The project is intended to be online by 2030. It may be constructed in phases, but for planning purposes the full project size is shown to be online in 2030. This project will supplement existing supplies for Greenbelt MIWA.

Quantity, Reliability and Cost

The Greenbelt MIWA has purchased the groundwater rights necessary to provide 2,692 acre-feet annually. The quantity of water should be sufficient. Reliability of groundwater supply is moderate since there is competition for water from the Ogallala in Donley County. The capital cost is $30.5 million.

Environmental Issues

The environmental impacts from groundwater development are expected to be low. Once the specific locations of additional wells and alignments associated with infrastructure are identified, a detailed evaluation to determine environmental impacts, if any, will need to be performed.

Impact on Water Resources and Other Management Strategies

The proposed wells are located north of Greenbelt Reservoir in an area with some competition for groundwater for irrigation. The strategy should not significantly impact other water resources or management strategies.

Impact on Agriculture and Natural Resources

The recommended strategy is expected to have low impact on the agriculture and other natural resources. Pipeline routes follow existing roads where feasible.

Other Relevant Factors

Greenbelt MIWA will need to seek a groundwater permit from the Panhandle GCD.

Summary of Recommended Strategies for Greenbelt MIWA

Water conservation by Greenbelt MIWA customers will provide approximately 7-8 acre-feet per year in 2030. New wells in the Ogallala aquifer can provide an additional 2,600 acre-feet per year and could be completed by 2030. **Table 5C-11** shows the amount of supply from the recommended strategies. The total capital costs for the recommended strategies is $30.6 million as shown in **Table 5C-12**.

Table 5C-11: Recommended Water Management Strategies for Greenbelt MIWA (Ac-Ft/Yr)

	2030	2040	2050	2060	2070	2080
Surplus or (Need)	**1,684**	**1,498**	**1,285**	**1,008**	**724**	**410**
Recommended Strategies	**Supply from Strategy**					
	2030	**2040**	**2050**	**2060**	**2070**	**2080**
PWPA Customer Conservation	7	8	8	7	7	7
Region B Customer Conservation	0	0	0	0	0	0
Donley County Groundwater	2,692	2,692	2,692	2,692	2,692	2,692
Total from Strategies	**2,699**	**2,700**	**2,700**	**2,699**	**2,699**	**2,699**

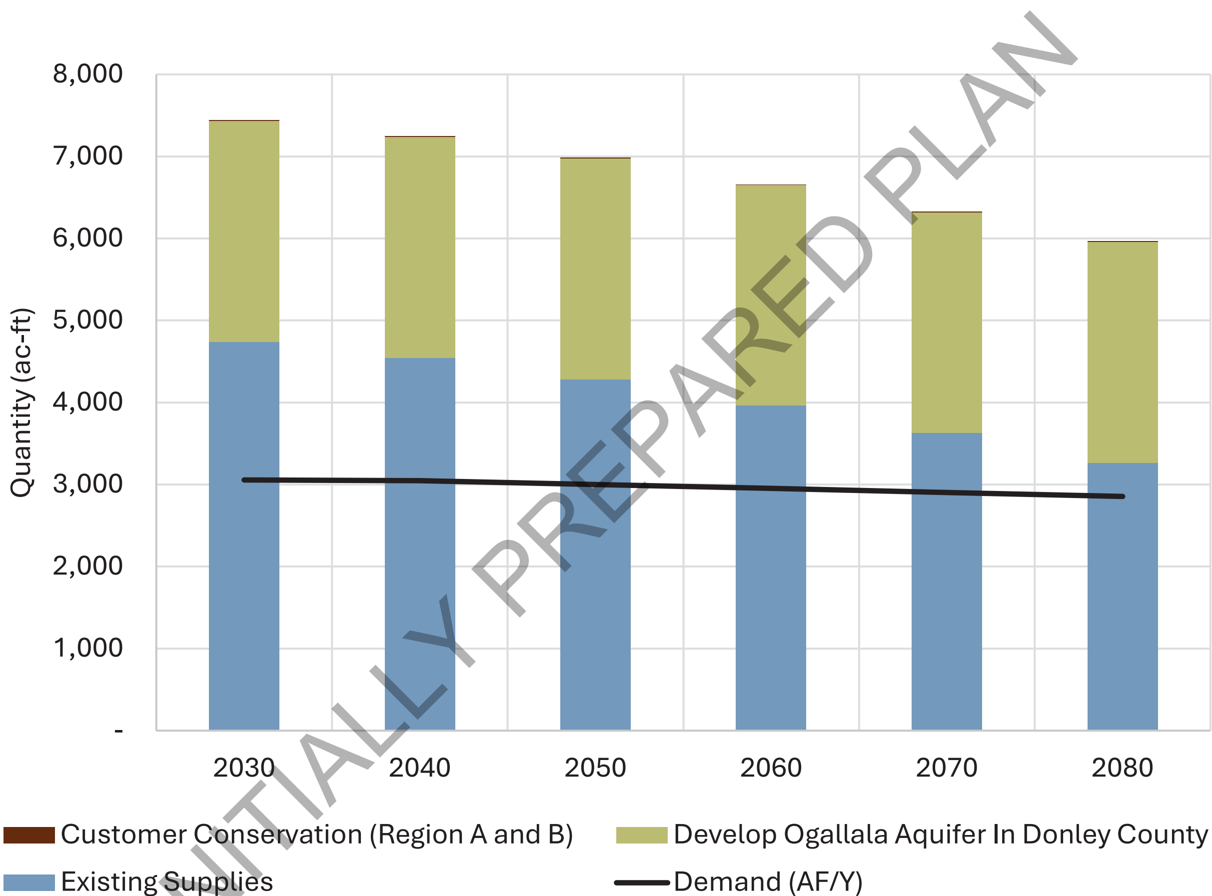
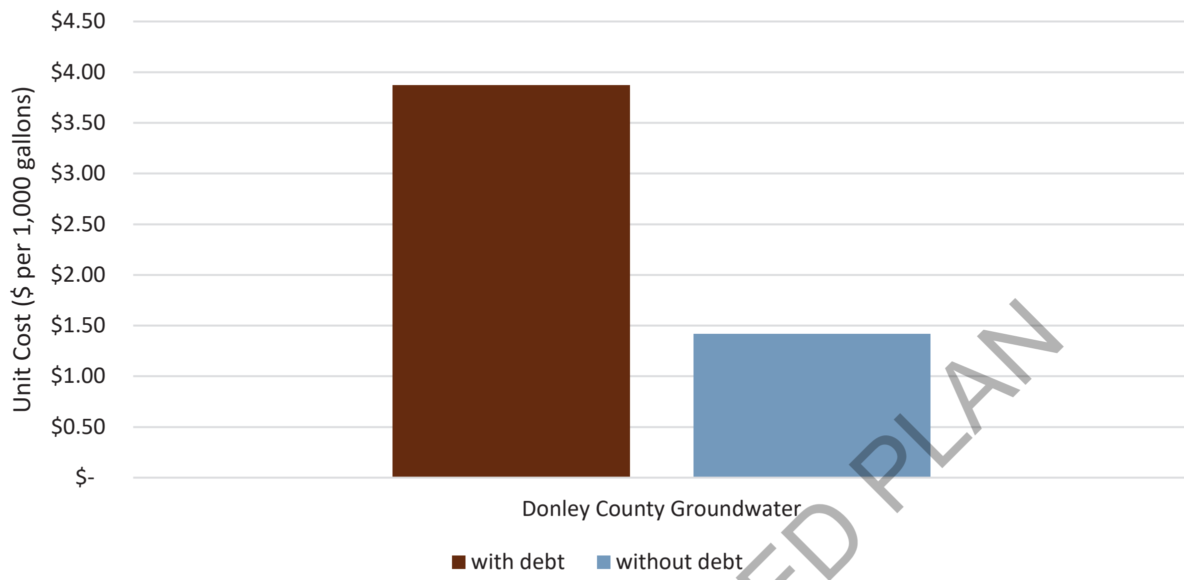


Figure 5C-6: Recommended Strategies for Greenbelt MIWA

Table 5C-12: Summary of Costs for Recommended Strategies for Greenbelt MIWA

Recommended Strategies	**Capital Cost ($ million)**	**Annual Costs ($million)**					
		2030	**2040**	**2050**	**2060**	**2070**	**2080**
Donley County Groundwater	$30.59	$3.40	$3.40	$1.25	$1.25	$1.25	$1.25
Total from Strategies	**$30.59**	**$3.40**	**$3.40**	**$1.25**	**$1.25**	**$1.25**	**$1.25**

Figure 5C-7: Unit Costs for Greenbelt MIWA Recommended Strategy



5C.5 Management Supply Factor

Based on TWDB regional planning guidance, a Management Supply Factor is to be provided for each major water provider. This management supply factor, commonly referred to as a safety factor, represents the margin of safety should supplies decrease or demands increase.

Management Supply Factor =

$$\frac{\text{Current Supplies + Strategies}}{\text{Total Demands}}$$

There are several factors that could affect the ability of a water provider to provide for projected needs, including:

- Climate change reduces the supply available from existing sources.
- The region experiences a drought more severe than the previous drought of record, which would reduce the supply available.
- One or more proposed management strategies cannot be developed or are developed more slowly than anticipated.
- Existing supplies become unusable due to invasive species, contamination or other factors.

The Management Supply Factors for the major water providers in the PWPA are shown on Table **Table 5C-13**.

Table 5C-13: Management Supply Factors for Major Water Providers

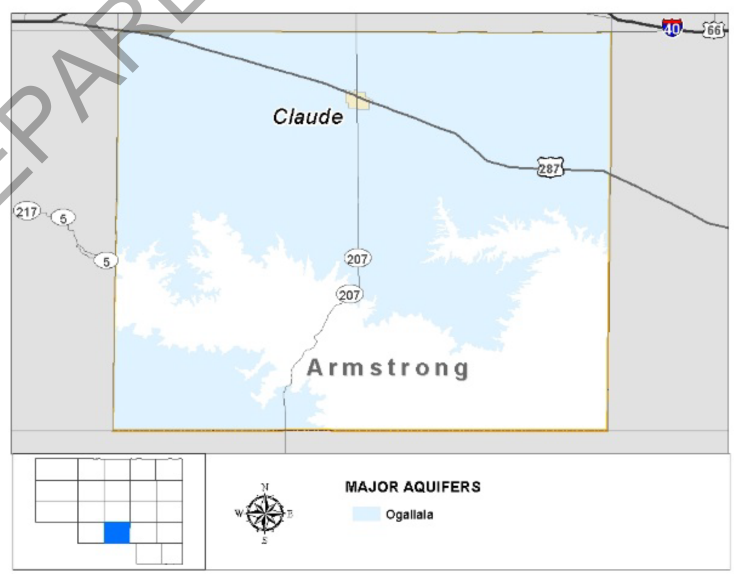
Major Provider		2030	2040	2050	2060	2070	2080
Amarillo	Potable	1.08	1.45	1.74	1.67	1.68	1.29
	Non-Potable	1.12	1.19	1.24	1.28	1.32	1.36
Borger	Both	1.12	1.20	1.28	1.36	1.43	1.49
CRMWA	Potable	1.51	1.37	1.33	1.31	1.30	1.29
Greenbelt MIWA	Potable	2.43	2.37	2.33	2.25	2.18	2.09

5D WATER MANAGEMENT STRATEGIES FOR WATER USERS BY COUNTY

There are twenty-one counties in the PWPA, of which nine show no needs after Municipal Conservation and Irrigation Conservation water management strategies. Water conservation is recommended for all municipal water users (except County-Other users without a need) and irrigation water users, whether the user has a defined need or not, and it is encouraged for all other users. The description and evaluation of these strategies are in **Chapter 5B**. They are not discussed in detail in this subchapter but are included in the county summary sections.

This subchapter discusses the water issues of each county and outlines the proposed water management strategies to meet the identified needs. For some counties, there are projected needs that cannot be met through an economically viable project. These “unmet needs” are also identified, if present, by county. Descriptions of water management strategies that are developed by a Major Water Provider are discussed in **Chapter 5C** and included in the county summary tables for completeness, as appropriate. The detailed costs are presented in **Appendix D** and a summary evaluation matrix is included as **Attachment 5-2**.

5D.1 Armstrong County



Armstrong County is located along the southern edge of the Northern Ogallala aquifer. The City of Claude, with a 2020 population of 1,114, is the largest city in the county, and has a projected total demand of 322 acre-feet per year in 2030 and 308 acre-feet per year in 2080.

Water users in Armstrong County obtain their current water supplies from the Ogallala aquifer, with a small amount coming from the Dockum aquifer and local surface water supply for livestock.

5D.1.1 Armstrong County Irrigation

The irrigation needs in Armstrong County peak at approximately 1,800 acre-feet per year over the planning period. A summary of the projected water needs and strategies for Armstrong County Irrigation is shown in **Table 5D-1**. The irrigation conservation strategy is discussed in **Section 5B.2**.

Table 5D-1: Recommended Water Strategies for Collingsworth County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2080	2080
Need		0	0	196	726	1,334	1,855
Recommended Strategies							
Irrigation Conservation	$0.38	280	685	871	1,056	1,186	1,304
Total	**$0.38**	**280**	**685**	**871**	**1,056**	**1,186**	**1,304**

5D.1.2 Armstrong County Summary

The primary source of water for Armstrong County is groundwater. These supplies have limited recharge and are generally finite in nature. To preserve these sources for future use, it is recommended that the City of Claude and local irrigators implement water conservation measures. A summary of the recommended water management plan for Armstrong County is shown in **Table 5D-2**.

Table 5D-2: Armstrong County Water Management Plan

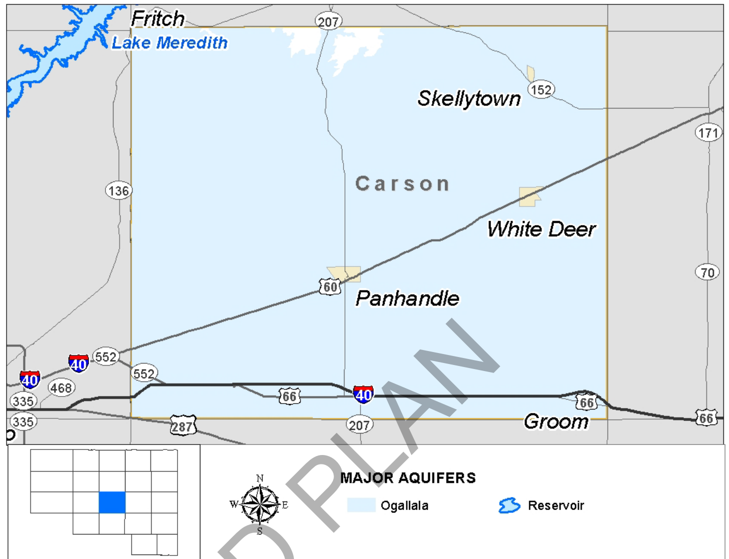
Water User Group	Current Supplies	Need	Recommended Water Management Strategies
Claude	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)
County-Other	Ogallala and Dockum aquifers	No	None
Irrigation	Ogallala and Dockum aquifers	Yes	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala, Dockum, Other aquifers and local supply (stock ponds)	No	None
Manufacturing	None	-	-
Mining	None	-	-
Steam Electric	None	-	-

Table 5D-3: Unmet Water Needs in Armstrong County (ac-ft/yr)

Water User Group	2030	2040	2050	2060	2070	2080
Irrigation	-	-	-	-	(148)	(551)

5D.2 Carson County

Carson County is in the center of the PWPA. The City of Panhandle, with a 2020 population of 2,272, is the largest city in the county, and has a projected total demand of 503 acre-feet per year in 2030 and 527 acre-feet per year in 2080.



Most of the water supplies for Carson County is obtained from the Northern Ogallala aquifer. Small amounts of surface water and reuse supplies are used for irrigation and livestock. The City of Amarillo also operates a large well field in western Carson County and has plans for expansion.

For Carson County, no entity is shown to have a need over the planning period.

5D.2.1 Panhandle

While the City of Panhandle does not have a projected need, conservation is recommended to reduce the demands on the limited resources in Carson County. The City of Panhandle is evaluating a groundwater source in the Ogallala aquifer to back up its current supplies.

The potential strategies for Panhandle are:

- Municipal Conservation (see **Section 5B.1**)
- Water Audit & Leak Repair (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

City of Panhandle is to develop additional groundwater from the Ogallala aquifer with new wells and associated transmission. For planning purposes, it is assumed that that two new wells and associated well field piping will be necessary to meet the City's water needs. These two new wells will provide approximately 600 acre-feet per year and will produce water approximately 680 feet below the surface. Minimal treatment such as chlorine disinfection will be required. In later decades, 2070 and 2080, the amount of water available to Panhandle is limited due to the MAG.

Time Intended to Complete

This strategy would be completed by 2030. The City may elect to drill the wells in phases if needed, but the strategy costs and supplies are developed for one phase.

Quantity, Reliability, and Cost

The quantity and reliability of water from this source is expected to be approximately 475 gpm per well and provide up to 600 acre-feet per year. Reliability of Ogallala supplies is high to moderate.

There is plenty of supply in Carson County, but there may be potential competing demands. The capital cost for the additional groundwater wells and collection piping is $2.5 million.

Environmental Issues

Long-term water quality of the Ogallala aquifer is unknown. Groundwater development from this source is expected to cause minimal environmental impacts.

Impact on Water Resources and Other Management Strategies

The quantity of water from this strategy is assumed to have a minimal impact on the Ogallala aquifer and other surrounding water resources.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategy.

Other Relevant Factors

There are no other identified relevant factors.

Table 5D-4: Recommended Water Strategies for Panhandle (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	N/A	7	7	7	7	7	7
Water Audit & Leak Repair	$1.9	21	21	21	21	22	22
Drill Additional Groundwater Well(s)	$2.5	600	600	600	600	0	0
Total	**$1.9**	**628**	**628**	**628**	**628**	**29**	**29**

5D.2.2 Carson County Summary

Carson County has no projected water need over the planning cycle. The county's primary source of water, Ogallala aquifer, has around 42,000 acre-feet per year of water that is not currently developed and could be used to meet water needs. Some of this water will be developed by Amarillo, but there are available supplies for Carson County.

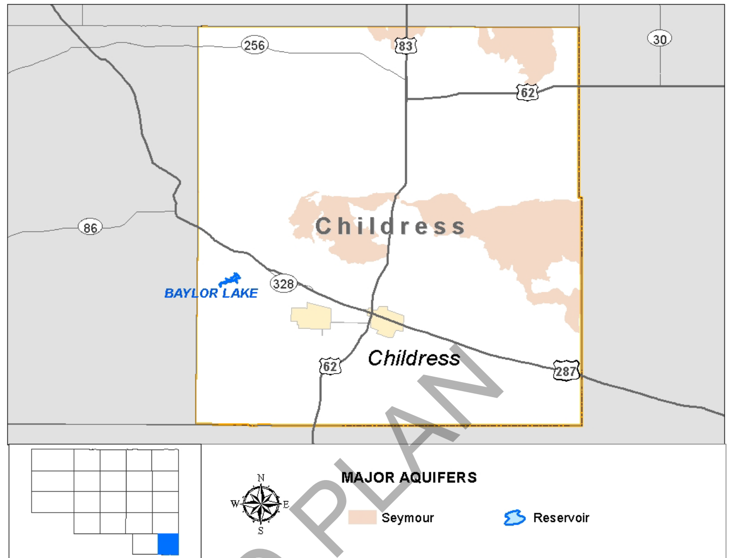
Table 5D-5: Carson County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Ogallala aquifer	No	None
Groom	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)
Irrigation	Ogallala aquifer, Dockum aquifer, reuse and surface water	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer	No	None
Mining	Ogallala aquifer	No	None
Panhandle	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**), Water audit & leak repair, Drill additional groundwater well(s)
Steam Electric	None	-	-
White Deer	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)

5D.3 Childress County

Childress County is in the far southeastern part of the PWPA. The City of Childress is the largest city in the county with a 2020 population of 4,879 and has a projected total demand of 1,274 acre-feet per year in 2030 decreasing to 1,186 acre-feet per year in 2080.

Groundwater sources in Childress County are limited. Municipal supplies are provided by the Greenbelt MIWA and small quantities of local groundwater. The Seymour and Blaine aquifers are the primary sources for agricultural use, along with small quantities from local surface water and reuse.



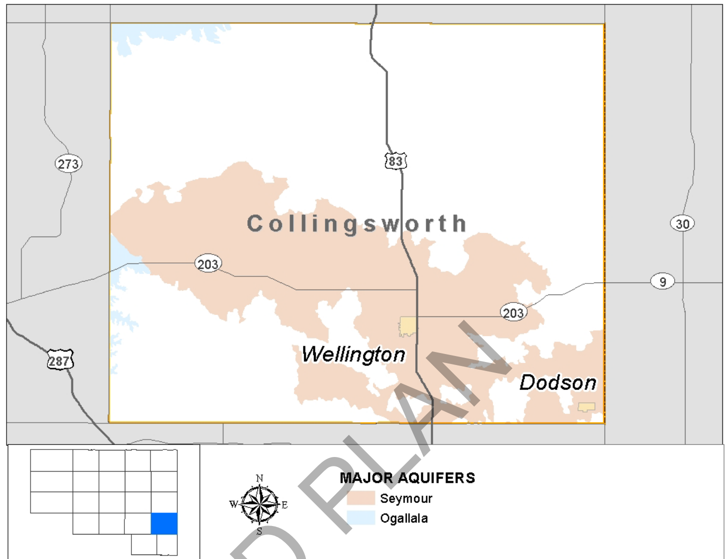
5D.3.1 Childress County Summary

A summary of the water plan for Childress County is shown in **Table 5D-6**.

Table 5D-6: Childress County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Childress	Greenbelt Reservoir and Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)
County-Other	Seymour and Other aquifer	No	None
Irrigation	Blaine, Seymour and Other aquifers, surface water, and reuse	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Blaine, Seymour and Other aquifers, and local supply (stock ponds)	No	None
Manufacturing	None	-	-
Mining	None	-	-
Red River Authority of Texas	Greenbelt Reservoir, Ogallala and Seymour aquifer	No	Municipal conservation (See **Chapter 5B**)
Steam Electric	None	-	-

5D.4 Collingsworth County



Collingsworth County is located on the southeastern border of the PWPA. The City of Wellington is the largest city in the county with a 2020 population of 1,713 and has a projected total demand of 358 acre-feet per year in 2030 decreasing to 282 acre-feet per year in 2080.

The primary source of water is groundwater from the Seymour and Blaine aquifers. Due to the poor water quality of the Blaine aquifer, most of the municipal supplies are obtained from the Seymour aquifer. Small amounts of groundwater are also obtained from undefined aquifers, known as Other Aquifer. Small quantities of surface water also are used in Collingsworth County for irrigation and livestock use. Irrigation also uses some reuse supplies. The Red River Authority receives water from Greenbelt MWIA.

Wellington has a projected need peaking at approximately 170 acre-feet per year during the planning horizon due to impaired water quality. The City of Wellington is planning to construct a nitrate removal system and develop additional groundwater supplies to improve the reliability of its current sources. Collingsworth County has a projected irrigation need of approximately 16,000 acre-feet per year in 2030, increasing to approximately 19,000 acre-feet per year in 2080.

5D.4.1 Wellington

The City of Wellington currently obtains its water supply from the Seymour aquifer in Collingsworth County. Due to elevated nitrates, the City needs advanced treatment to fully utilize this supply. Alternatively, the city would be receptive to receiving water from outside of the county if the opportunity arises.

For this plan, the potentially feasible water management strategies for Wellington are:

- Municipal Conservation (see **Section 5B.1**)
- Nitrate Treatment of Seymour Aquifer Supplies

Nitrate Treatment

This strategy assumes the development of advanced treatment facilities to treat the City of Wellington's current and future groundwater from the Seymour aquifer. Currently, the city is experiencing elevated nitrate levels in its water source. This strategy assumes that half of the City's groundwater would be treated by reverse osmosis or other method and then blended with the remaining supplies to reduce nitrate concentrations. This strategy assumes that a 0.5 MGD treatment facility would be constructed and the waste stream from the facility could be discharged to a local tributary of the Salt Fork of the Red River.

Time Intended to Complete

The City is experiencing water quality issues now. To address these issues, the strategy will be completed by 2040.

Quantity, Reliability, and Cost

This strategy will provide around 174 acre-feet per year of treated water that meets current drinking water standards. The capital cost is estimated at $4.3 million.

Environmental Issues

There may be environmental impacts with the discharge of the waste stream. This would need to be permitted by the State. At that time, environmental impacts would be assessed.

Impact on Water Resources and Other Management Strategies

There are no impacts on water resources or other management strategies.

Impact on Agriculture and Natural Resources

The strategy is expected to have no impact on agriculture and possible low impact to the receiving stream from the waste discharge. Any potential impacts of the waste discharge would be considered and mitigated during permitting.

Other Relevant Factors

There are no other identified relevant factors.

The recommended strategies for the City of Wellington are shown in **Table 5D-7**.

Table 5D-7: Recommended Strategies for Wellington (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	174	164	156	149	141
Recommended Strategies							
Municipal Conservation	N/A	5	5	5	4	4	4
Nitrate Treatment	$4.3	0	174	164	156	149	141
Total	**$4.3**	**5**	**179**	**169**	**160**	**153**	**145**

5D.4.2 Collingsworth County Irrigation

The irrigation needs in Collingsworth County peak at approximately 19,000 acre-feet per year over the planning period. A summary of the projected water needs and strategies for Collingsworth County Irrigation is shown in **Table 5D-8**. The irrigation conservation strategy is discussed in **Section 5B.2**.

Table 5D-8: Recommended Water Strategies for Collingsworth County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2080	2080
Need		16,131	19,039	18,908	18,515	18,538	19,069
Recommended Strategies							
Irrigation Conservation	$2.69	1,715	4,290	5,347	6,396	7,067	7,646
Total	**$2.69**	**1,715**	**4,290**	**5,347**	**6,396**	**7,067**	**7,646**

5D.4.3 Collingsworth County Summary

Collingsworth County has projected needs associated with water quality impairments. Water users in the county are also experiencing water quantity issues during drought. To address these issues, advanced treatment and conservation are recommended for the City of Wellington. Conservation is also recommended for Red River Authority of Texas and Collingsworth County Irrigation. A summary of the water plan for Collingsworth County is shown in **Table 5D-9**.

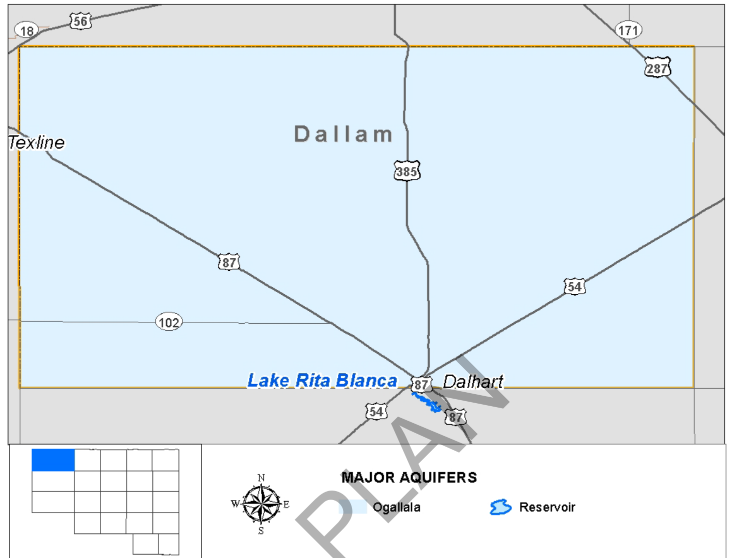
Table 5D-9: Collingsworth County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Blaine, Seymour and Other aquifers	No	None
Irrigation	Blaine, Seymour and Other aquifers, reuse and Red River water rights	Yes	Irrigation conservation (See **Chapter 5B**)
Livestock	Blaine, Seymour and Other aquifers and local supply (stock ponds)	No	None
Manufacturing	None	-	-
Mining	None	-	-
Red River Authority of Texas	Ogallala and Seymour aquifers, Greenbelt Reservoir	No	Municipal conservation (See **Chapter 5B**)
Steam Electric	None	-	-
Wellington	Seymour aquifer	Yes	Nitrate Treatment and Municipal conservation (See **Chapter 5B**)

Table 5D-10: Unmet Water Needs in Collingsworth County (ac-ft/yr)

Water User Group	2030	2040	2050	2060	2070	2080
Irrigation	(14,416)	(14,749)	(13,561)	(12,119)	(12,119)	(11,423)

5D.5 Dallam County



Dallam County is in the far northwestern part of the PWPA. Dalhart is the largest city in Dallam County with a 2020 population of approximately 8,700, of which about two-thirds are located in Dallam County. The remaining population is in Hartley County. Dalhart's projected total demand is 2,643 acre-feet per year in 2030 (1,692 of which is based out of Dallam County) growing to 3,386 acre-feet per year in 2080 (2,248 of which is based out of Dallam County).

Dallam County is one of the larger irrigation water users in the region. The primary source of water in the county is the Ogallala aquifer. Smaller quantities of groundwater from the Rita Blanca, Dockum aquifer and local livestock supply are also used in the county.

There is plenty of water available from the Ogallala aquifer in Dallam County, but the use is concentrated in the heavily irrigated areas, which results in large water declines over time. Due to the geographic constraints imposed by the water supply allocation process, there are projected needs for Dallam County Irrigation. The recommended strategies to meet the needs for Dallam County Irrigation is conservation, which is discussed in **Chapter 5B**. The potential strategies for Texline and Dalhart are discussed below.

5D.5.1 Dalhart

The City of Dalhart falls into two counties, Dallam and Hartley. Its current supplies are obtained from an existing well field in Dallam County. There is considerable competition for water from surrounding agricultural lands. The City of Dalhart has no need over the planning horizon, though conservation is recommended. The strategies considered include:

- Municipal Conservation (see **Section 5B.1**)

Table 5D-11: Recommended Water Strategies for Dalhart (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	N/A	27	29	30	31	33	35
Total	**N/A**	**27**	**29**	**30**	**31**	**33**	**35**

5D.5.2 Texline

The City of Texline currently obtains its water supply from the Ogallala-Rita Blanca aquifer. The Rita Blanca aquifer underlies the Ogallala aquifer in the northwest corner of Dallam County and is hydraulically connected. The City is shown to have no need over the planning horizon, though conservation is recommended. The potential strategies include:

- Municipal Conservation (see **Section 5B.1**)

Table 5D-12: Recommended Water Strategies for Texline (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	N/A	1	1	1	1	2	2
Total	**N/A**	**1**	**1**	**1**	**1**	**2**	**2**

5D.5.3 Dallam County Irrigation

The irrigation needs in Dallam County peak at over 156,000 acre-feet per year over the planning period. These needs cannot be fully met through conservation in the early decades. A summary of the projected water needs and strategies for Dallam County Irrigation is shown in **Table 5D-13**. The irrigation conservation strategy is discussed in **Section 5B.2**.

Table 5D-13: Recommended Water Strategies for Dallam County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		121,228	156,912	148,470	140,598	133,194	127,842
Recommended Strategies							
Irrigation Conservation	$15.58	16,125	39,254	50,093	60,838	68,502	75,556
Total	**$15.58**	16,125	39,254	50,093	60,838	68,502	75,556

5D.5.4 Dallam County Summary

Dallam County has a total projected water need of approximately 121,000 acre-feet per year in 2030 increasing to approximately 128,000 acre-feet per year in 2080. This need is associated with irrigation, which can be partially met through conservation. There is a projected unmet water need for Dallam County Irrigation of approximately 105,000 acre-feet per year in 2030, decreasing to approximately 52,000 acre-feet per year in 2080. The recommended water plan for Dallam County is shown in **Table 5D-14**. The unmet needs are shown in **Table 5D-15**.

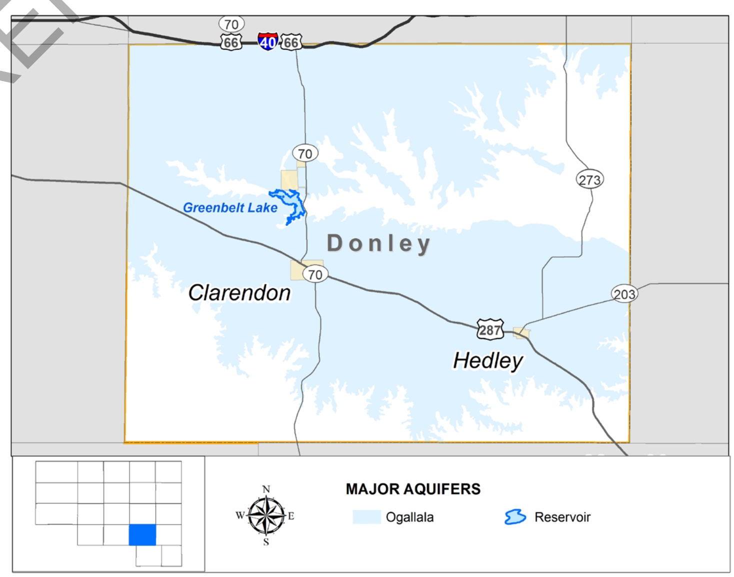
Table 5D-14: Dallam County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Ogallala aquifer	No	None
Dalhart	Ogallala/Rita Blanca and Dockum aquifers	No	Municipal conservation (See **Chapter 5B**)
Irrigation	Ogallala/Rita Blanca and Dockum aquifers	Yes	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala/ Rita Blanca aquifer and local supply (stock ponds)	No	None
Manufacturing	Ogallala/ Rita Blanca aquifer and Supplies from Texline	No	None
Mining	None	-	-
Steam Electric	None	-	-
Texline	Ogallala/ Rita Blanca aquifer	No	Municipal conservation (See **Chapter 5B**)

Table 5D-15: Unmet Water Needs in Dallam County (ac-ft/yr)

Water User Group	2030	2040	2050	2060	2070	2080
Irrigation	(105,103)	(117,658)	(98,377)	(79,760)	(64,692)	(52,286)

5D.6 Donley County



Donley County lies on the southwestern edge of the Ogallala aquifer. It is also home to the Greenbelt Reservoir. The largest city in Donley County is Clarendon, which has a 2020 population of about 1,800 and has a projected total demand of 298 acre-feet per year in 2030 and 227 acre-feet per year in 2080.

The majority of the water supply for Donley County is obtained from the Ogallala aquifer, with some surface water being used for municipal and agricultural purposes.

Though there are no WUGs within Donley County that have a need throughout the planning horizon, conservation is recommended. Conservation is also recommended for Donley County Irrigation, which is discussed in **Section 5B**.

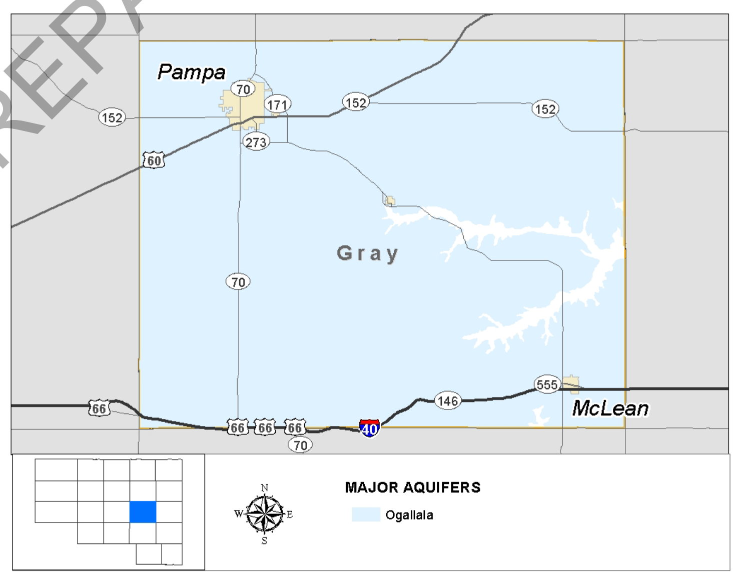
5D.6.1 Donley County Summary

Donley County does not have a projected need throughout the planning horizon. A summary of the water plan for Donley County is shown in **Table 5D-16**.

Table 5D-16: Donley County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Clarendon	Greenbelt Reservoir and Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)
County-Other	Ogallala aquifer and Greenbelt Reservoir	No	None
Irrigation	Ogallala aquifer and Red River water rights	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala and Other aquifers and local supply (stock ponds)	No	None
Manufacturing	None	-	-
Mining	None	-	-
Red River Authority of Texas	Ogallala aquifer and Greenbelt Reservoir	No	Municipal conservation (See **Chapter 5B**)
Steam Electric	None	-	-

5D.7 Gray County



Gray County is located in the center of the PWPA. The Ogallala aquifer underlies most of Gray County. This water resource is the primary source for most users in the county. The largest city in the county is Pampa, with a 2020 population of 17,358 and a projected total demand of 3,207 acre-feet per year in 2030 growing to 2,994 acre-feet per year in 2080. The City of Pampa is a member city of CRMWA, which provides water from its Roberts County well field and Lake Meredith to Pampa. Pampa also receives water from its own well field.

Only about a third of the total available supply from the Ogallala in Gray County is currently developed. There are sufficient developed supplies to meet most of the demands in the county. The City of Pampa is the only WUG identified with projected water needs. Most of Pampa's need is associated with the need for CRMWA, which will be met through strategies developed by CRMWA (see **Section 5C.1**).

5D.7.1 McLean

The City of McLean is located in southwestern Gray County. Its current water supply is from the Ogallala aquifer. The city is projected to have no water supply needs. The potentially feasible strategies for McLean include:

- Municipal Conservation (see **Section 5B.1**)

Table 5D-17: Recommended Water Strategies for McLean (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	N/A	2	2	2	2	2	2
Total	**N/A**	**2**	**2**	**2**	**2**	**2**	**2**

5D.7.2 Pampa

The City of Pampa provides water to customers in Gray County, including TDCJ, and Titan Specialties and other manufacturers. The city receives blended water from CRMWA and operates wells for groundwater from the Ogallala aquifer. A water need of 205 acre-feet per year is projected by 2040 and increasing to 1,902 acre-feet per year by 2080. Most of this need is associated with the need on CRMWA and will be met through strategies developed by CRMWA. Pampa is planning on further developing its own water supplies near the city. The potentially feasible strategies for Pampa include:

- Municipal Conservation (see **Section 5B.1**)
- Water Audit & Leak Repair (see **Section 5B.1**)
- Obtain contractual supplies from CRMWA (this is evaluated with CRMWA strategies in **Section 5C.1**)
- Aquifer Storage and Recovery

Aquifer Storage and Recovery

This strategy would use 500 acre-feet per year of water provided by CRMWA to Pampa in an effort to supplement supplies for member cities during high demand periods. The cost components of this strategy include new well field piping along with some pump improvements to move water to ASR injection wells. Depending on the source of water and its destination, water may be delivered directly from CRMWA's system to ASR wells in Pampa's existing well field. However, it is likely that the water will require treatment prior to injection and will be delivered from the Pampa water treatment plant. This strategy assumes that a minimum of two 870-gpm 10-inch diameter wells will be required for ASR injection in Pampa's well field.

Time to Implement

Supply will be available for the ASR project by 2040.

Quantity, Reliability and Cost

The quantity will vary from year to year depending on demands and the capacities of ASR well fields. The quantity of water that would be made available from the ASR project is 500 acre-feet per year. The source of this water would be from CRMWA's Ogallala aquifer well field in Roberts County and/or Lake Meredith.

Successful ASR development is highly reliable. It is possible to achieve 90-95% recovery efficiency, depending upon the natural hydraulic gradient of the receiving aquifer and competition from adjacent groundwater users. If the water is recharged and recovered over a relatively short period (e.g., one year), the likelihood of reduced reliability is low. The ASR project will increase the reliability of existing supplies by allowing storage of the supply during periods of low demand to meet high demands at a later time.

It was assumed that one-half mile of additional well field piping is needed along with pump improvements and injection wells. The strategy is estimated to cost $3.7 million.

Environmental Issues

Potential environmental impacts include water quality concerns for the receiving aquifer. Since not all source water is groundwater, pre-treatment of the water before injection and storage may be needed.

Impact on Water Resources and Other Management Strategies

This strategy should have a positive impact on other water management strategies by increasing reliability.

Impact on Agriculture and Natural Resources

The project should have no impact to agriculture or natural resources since it is utilizing existing water sources and existing infrastructure.

Other Relevant Factors

There are no other identified relevant factors.

A summary of the projected water needs and recommended strategies for Pampa is shown in **Table 5D-18**.

Table 5D-18: Recommended Water Strategies for Pampa (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	205	651	916	1,041	1,092
Recommended Strategies							
Municipal Conservation	N/A	53	51	50	50	49	50
Water Audit & Leak Repair	$11.8	181	176	173	170	169	169
CRMWA Supplies[1]	N/A	286	601	810	1,055	1,191	1,242
ASR	$3.7	0	500	500	500	500	500
Total	**$15.5**	**520**	**828**	**1,033**	**1,275**	**1,409**	**1,461**

1 Supplies shown for ASR include water received from CRMWA. These supplies are not included in the totals.

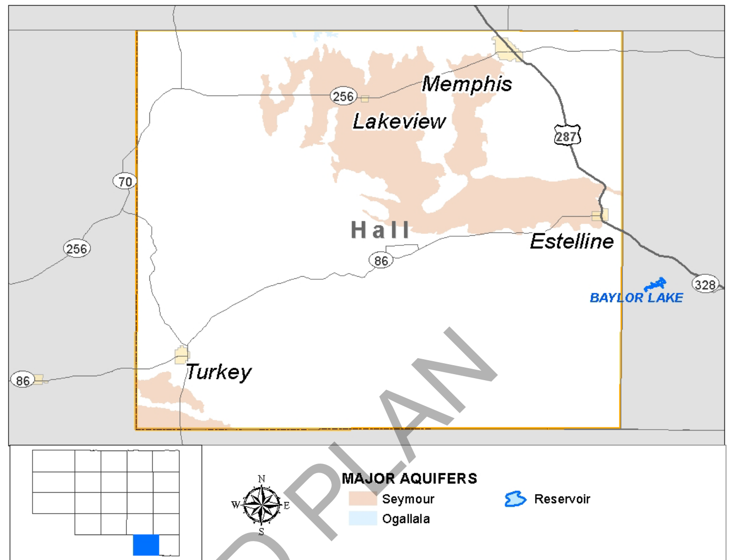
5D.7.3 Gray County Summary

Gray County has a total projected need of nearly 1,100 acre-feet per year by 2080. Much of this need can be met through conservation. The municipal needs are planned to be met through conservation, water audit and leak repair, aquifer storage and recovery, and additional supplies from CRMWA. The county's primary source of water, Ogallala aquifer, has over 120,000 acre-feet per year of water that is not currently developed and could be used to meet water needs. The recommended water plan for Gray County is shown in **Table 5D-19**.

Table 5D-19: Gray County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer, run-of-river, and reuse	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer	No	None
McLean	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)
Mining	None	-	-
Pampa	Ogallala aquifer and CRMWA system	Yes	Municipal conservation (See **Chapter 5B**), Water audit and leak repair, ASR and contracted supplies from CRMWA
Steam Electric	None	-	-

5D.8 Hall County



Hall County is located in the southern end of the PWPA. The largest city in the county is Memphis, with a 2020 population of 1,972 and a projected total demand of 296 acre-feet per year in 2030 and 210 acre-feet per year in 2080.

Hall County has limited water sources. The primary sources of water are the Seymour and Blaine aquifers. Both of these sources have water quality concerns, which limits their use for municipal purposes. There is little surface water in the region. For this reason, Memphis obtains its water from Donley County. There is also about 1,000 acre-feet per year of water that is obtained from the Whitehorse formation, which is listed as Other Aquifer in this plan.

Hall County has one WUG with needs during the planning horizon: Hall County Irrigation.

5D.8.1 Memphis

The City of Memphis currently obtains its water supply from the Ogallala aquifer in Donley County and purchases treated surface water from Greenbelt MIWA as needed. Memphis is not projected to have a need during the planning horizon, though conservation is recommended. The potential water management strategies for Memphis include:

- Municipal Conservation (see **Section 5B.1**)

Table 5D-20: Recommended Water Strategies for Memphis (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	N/A	6	5	5	5	4	4
Total	**N/A**	**6**	**5**	**5**	**5**	**4**	**4**

5D.8.2 Hall County – Other (Brice-Lesley)

Brice-Lesley WSC obtains water from the Seymour aquifer in Hall County. Brice-Lesley has plans to replace aging infrastructure and implement advanced metering infrastructure to mitigate water loss. Both strategies are demand reduction strategies and discussed under Municipal Conservation in **Section 5B.1**. The potential water management strategies for Brice-Lesley include:

- Municipal Conservation (see **Section 5B.1**)

Table 5D-21: Recommended Water Strategies for Hall County-Other (Brice-Lesley) (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation							
Water System Improvement	$0.09	3	3	3	3	3	3
Advanced Metering Infrastructure	$0.08	2	2	2	2	2	2
Total	**$0.17**	**5**	**5**	**5**	**5**	**5**	**5**

5D.8.3 Hall County Irrigation

The irrigation needs in Hall County begin at over 15,700 acre-feet per year in 2030 and reduce to 12,944 acre-feet per year in 2080. The recommended strategy to meet this need is conservation. A summary of the projected water needs and strategies for Hall County Irrigation is shown in

Table 5D-21. The irrigation conservation strategy is discussed in **Section 5B.2**

Table 5D-22: Recommended Water Strategies for Hall County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		15,780	12,917	13,908	13,271	13,197	12,944
Recommended Strategies							
Irrigation Conservation	$1.65	1,244	3,161	3,904	4,640	5,085	5,469
Total	**$1.65**	**1,244**	**3,161**	**3,904**	**4,640**	**5,085**	**5,469**

5D.8.4 Hall County Summary

Hall County has a total projected need of over 15,700 acre-feet per year in 2030, reducing to 12,944 acre-feet per year in 2080. Much of this need can be met through conservation in the later decades, but there is an unmet need for irrigation in 2030 and 2040. The municipal needs are planned to be met through conservation. The county's primary source of water, Seymour aquifer, has limited capacity (the MAG shows no additional water above what is currently developed). It also has known water quality concerns. The recommended water plan for Hall County is shown in **Table 5D-22**.

Table 5D-23: Hall County Water Management Plan

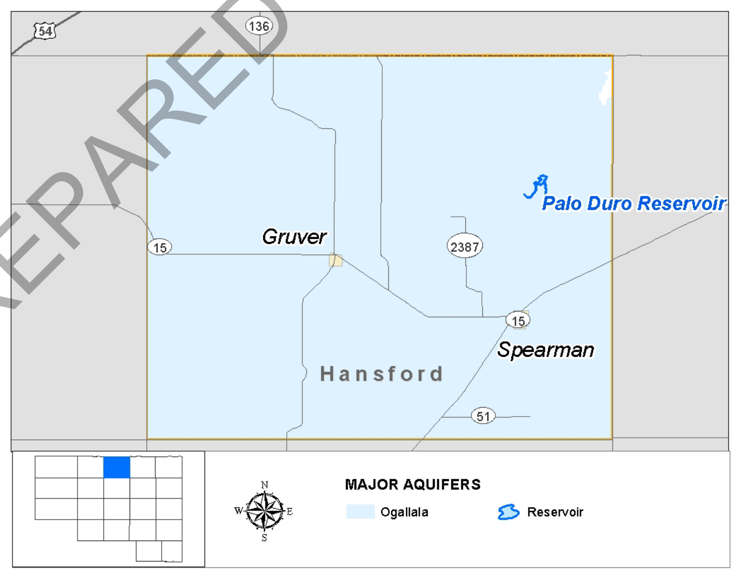
Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Seymour and Other aquifer	No	None
Irrigation	Seymour and Other aquifer, Red River water rights, and reuse	Yes	Irrigation conservation (See **Chapter 5B**)
Livestock	Seymour, Blaine and Other aquifers and local supply (stock ponds)	No	None
Manufacturing	Seymour Aquifer	No	None

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Memphis	Ogallala aquifer and Greenbelt reservoir	No	Municipal conservation (See **Chapter 5B**)
Mining	None	-	-
Red River Authority of Texas	Ogallala and Seymour aquifers, and Greenbelt Reservoir	No	Municipal conservation (See **Chapter 5B**)
Steam Electric	None	-	-
Turkey Municipal Water System	Seymour aquifer	No	Municipal conservation (See **Chapter 5B**)

Table 5D-24: Unmet Water Needs in Hall County (ac-ft/yr)

Water User Group	2030	2040	2050	2060	2070	2080
Irrigation	(14,536)	(9,756)	(9,194)	(8,631)	(8,112)	(7,475)

5D.9 Hansford County



Hansford County is located on the northern edge of the PWPA, along the border with Oklahoma. The largest city in the county is Spearman, with a 2020 population of 3,043 and a projected total demand of 858 acre-feet per year in 2030 increasing to 924 acre-feet per year in 2080.

Nearly all of the water supplies currently used in Hansford County are obtained from the Ogallala aquifer. The Palo Duro Reservoir is also located in Hansford County, but there is no infrastructure developed to transport the water. The larger municipalities include Spearman and Gruver. Both of these cities are member cities of the Palo Duro Water District (PDWD), but both currently obtain their water from the Ogallala aquifer.

There are sufficient supplies to meet most of the water demands in Hansford County. Gruver is the only WUG with projected needs due to declining water levels within the city's existing well field.

5D.9.1 Gruver

The City of Gruver currently obtains its water supply from the Ogallala aquifer in Hansford County. Based on the availability of the City's current wells, Gruver will need to develop additional supplies by 2030. Projected needs for Gruver range from 80 acre-feet per year in 2030 to 107 acre-feet per year in 2080. The City owns approximately 1,000 acres of undeveloped water rights. These water rights may be sufficient to meet the projected needs, pending competition for water from other users. The potential water management strategies for Gruver include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that one new well will be drilled to provide approximately 110 acre-feet per year. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. This well is assumed to be approximately 180 feet below the surface. The new well will be drilled near the City's existing wells. Well field piping will be installed to connect to the current collection system. There is no additional transmission to the City.

Time Intended to Complete

The well will be completed by 2030.

Quantity, Reliability and Cost

The quantity of water from this strategy should be able to produce 110 acre-feet per year with average well capacities of 265 gpm. Reliability of Ogallala supplies is moderate since availability depends on other water users. For cost purposes, it is assumed that the new well would be located within the existing well field. The capital cost for the additional groundwater well is approximately $1.0 million.

Environmental Issues

No significant environmental impact is expected for this strategy. The City already owns the water rights and no transmission system is included in this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

The recommended water strategies for Gruver are shown in **Table 5D-24**.

Table 5D-25: Recommended Water Strategies for Gruver (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		80	87	90	96	101	107
Recommended Strategies							
Municipal Conservation	N/A	4	4	4	4	4	4
Drill Additional Groundwater Well(s)	$1.0	110	110	110	110	110	110
Total	**$1.0**	**114**	**114**	**114**	**114**	**114**	**114**

5D.9.2 Spearman

The City of Spearman currently obtains its water supply from the Ogallala aquifer in Hansford County. The City shows no projected water needs over the planning horizon, though conservation is recommended. The potential water management strategies for Spearman include:

- Municipal Conservation (see **Section 5B.1**)

Table 5D-26: Recommended Water Strategies for Spearman (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	N/A	9	10	10	10	10	10
Total	**N/A**	**9**	**10**	**10**	**10**	**10**	**10**

5D.9.3 Hansford County Summary

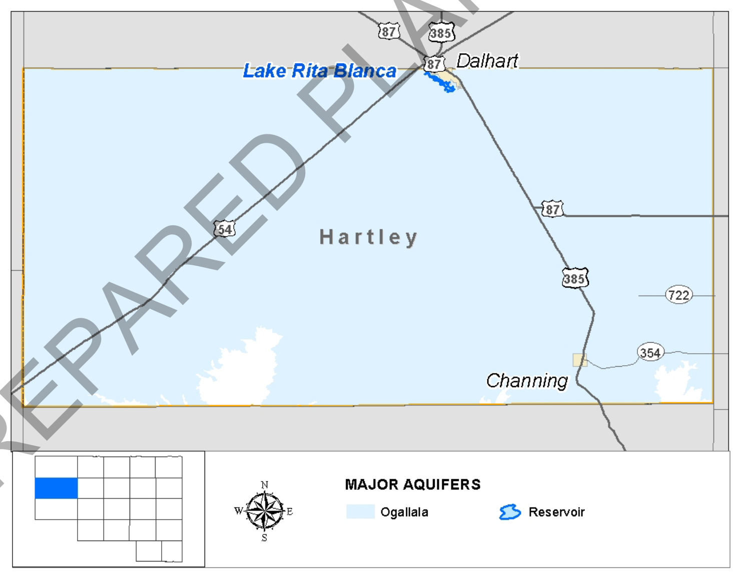
Hansford County has a total projected need of approximately 110 acre-feet per year by 2080. Much of this need can be met through conservation. The municipal needs are planned to be met through conservation and additional groundwater from the Ogallala aquifer. The county's primary source of water, Ogallala aquifer, has over 115,000 acre-feet per year of water that is not currently developed and could be used to meet water needs. The recommended water plan for Hansford County is shown in **Table 5D-26**.

Table 5D-27: Hansford County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Ogallala aquifer	No	None
Gruver	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)
Irrigation	Ogallala aquifer, Canadian River water rights	No	Irrigation conservation (See **Chapter 5B**)

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer	No	None
Mining	Ogallala aquifer	No	None
Spearman	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)
Steam Electric	None	-	-

5D.10 Hartley County



Hartley County is located in the far northwestern part of the PWPA. Dalhart is the largest city in Hartley County with a 2020 population of approximately 8,700, of which about one-third are located in Hartley County. The remaining population is in Dallam County.

Hartley County is one of the larger irrigation water users in the region. The primary source of water in the county is the Ogallala aquifer. Smaller quantities of groundwater from the Dockum aquifer and local livestock supply are also used in the county. There is plenty of water available from the Ogallala aquifer in Hartley County, but the use is concentrated in the heavily irrigated areas, which results in large water declines over time.

Due to the geographic constraints imposed by the water supply allocation process, there are projected needs for Hartley County Irrigation and Hartley County Livestock. The recommended strategies to meet the needs for irrigation is conservation, which is discussed in **Chapter 5B**. The recommended strategies for livestock is the drilling of additional groundwater wells.

5D.10.1 Hartley County Irrigation

The irrigation needs in Hartley County peak at over 229,000 acre-feet per year over the planning period. These needs cannot be fully met through conservation throughout the planning horizon. A summary of the projected water needs and strategies for Hartley County Irrigation is shown in **Table 5D-27**. The irrigation conservation strategy is discussed in **Section 5B.2**.

Table 5D-28: Recommended Water Strategies for Hartley County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		172,558	229,447	216,085	204,225	193,294	183,960
Recommended Strategies							
Irrigation Conservation	$19.89	17,858	42,977	55,238	67,393	76,317	84,521
Total	**$19.89**	**17,858**	**42,977**	**55,238**	**67,393**	**76,317**	**84,521**

5D.10.2 Hartley County Livestock

The livestock needs in Hartley County range from 983 acre-feet per year in 2030 to 2,319 acre-feet per year in 2080. It is assumed that these demands will be self-supplied through additional groundwater development.

The potential water management strategies for Hartley County Livestock include:

- Drill Additional Groundwater Well(s) – Dockum
- Drill Additional Groundwater Well(s) – Ogallala

Drill Additional Groundwater Well(s) – Dockum

This strategy assumes that multiple wells will be drilled near the location of need. It is assumed that the new water for Livestock will be from the Dockum aquifer. Since Livestock is an aggregated water user group, the number of wells and locations are difficult to assess. For purposes of this plan, the strategy has no transmission and minimal well field piping.

Time Intended to Complete

This strategy will likely be phased beginning in 2030, but the costs and quantities are developed in one phase.

Quantity, Reliability and Cost

The quantity of water from these wells should be able to produce a total of 1,200 acre-feet per year from the Dockum aquifer with average well capacities of 20 gpm. Reliability of Dockum supplies is moderate since availability depends on other water users. The capital cost for the additional groundwater wells is approximately $9.0 million.

Environmental Issues

No significant environmental impact is expected for this strategy. There is no transmission system included in this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on groundwater will continue to deplete the storage in the aquifers. Competition for water in Hartley County may impact other strategies. The MAG values were respected in developing these strategies, which should mitigate impacts.

Impact on Agriculture and Natural Resources

At the level of additional water development, no significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

Drill Additional Groundwater Well(s) – Ogallala

This strategy assumes that four new wells will be drilled near the location of need. It is assumed that the new water for Livestock will be from the Ogallala aquifer. Since Livestock is an aggregated water user group, the number of wells and locations are difficult to assess. For purposes of this plan, the strategy has no transmission and minimal well field piping.

Time Intended to Complete

This strategy will likely be phased beginning in 2030, but the costs and quantities are developed in one phase.

Quantity, Reliability and Cost

The quantity of water from these wells should be able to produce a total of 1,200 acre-feet per year from the Ogallala aquifer with average well capacities of 250 gpm. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for the additional groundwater wells is approximately $2.5 million.

Environmental Issues

No significant environmental impact is expected for this strategy. There is no transmission system included in this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on groundwater will continue to deplete the storage in the aquifers. Competition for water in Hartley County may impact other strategies. The MAG values were respected in developing these strategies, which should mitigate impacts.

Impact on Agriculture and Natural Resources

At the level of additional water development, no significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

The recommended strategies for Hartley County Livestock are shown in **Table 5D-28.**

Table 5D-29: Recommended Water Strategies for Hartley County Livestock (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		983	1,873	1,981	2,091	2,204	2,319
Recommended Strategies							
Drill Additional Groundwater Well - Dockum	$9.0	1,200	1,200	1,200	1,200	1,200	1,200
Drill Additional Groundwater Well - Ogallala	$2.5	1,200	1,200	1,200	1,200	1,200	1,200
Total	**$11.5**	**2,400**	**2,400**	**2,400**	**2,400**	**2,400**	**2,400**

5D.10.3 Hartley County Summary

Hartley County has a total projected water need of over 186,000 acre-feet per year by 2080. Much of this need can be met through conservation. However, not all of the need for Hartley County Irrigation can be met through conservation. There is a projected unmet water need for Irrigation of approximately 155,000 acre-feet per year in 2030, which decreases to approximately 100,000 acre-feet per year by 2080. The recommended water plan for Hartley County is shown in **Table 5D-29**. The unmet needs are shown in **Table 5D-30**.

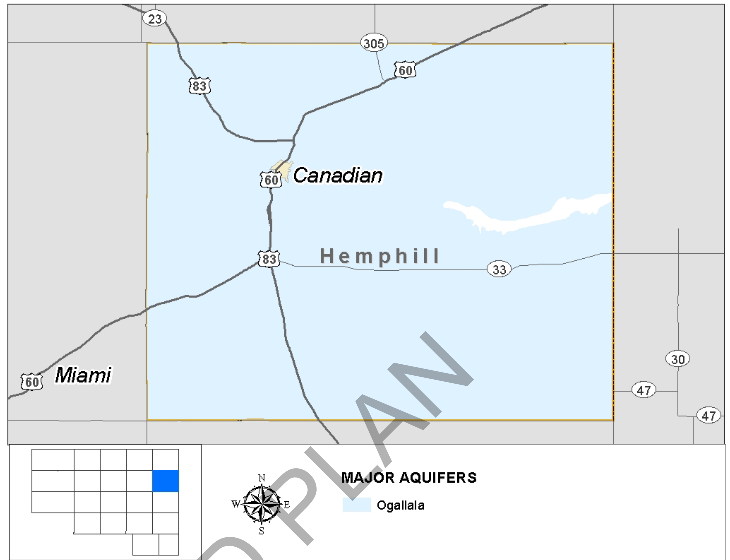
Table 5D-30: Hartley County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Ogallala aquifer	No	None
Dalhart	Ogallala and Dockum aquifers	No	Municipal conservation (See **Chapter 5B**)
Hartley WSC	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)
Irrigation	Ogallala and Dockum aquifers	Yes	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala and Dockum aquifers and local supply (stock ponds)	Yes	Drill additional groundwater well(s) – Dockum, Drill additional groundwater well(s) – Ogallala
Manufacturing	None	-	-
Mining	Ogallala and Rita Blanca aquifers	No	None
Steam Electric	None	-	-

Table 5D-31: Unmet Water Needs in Hartley County (ac-ft/yr)

Water User Group	2030	2040	2050	2060	2070	2080
Irrigation	(154,700)	(186,470)	(160,847)	(136,832)	(116,977)	(99,439)

5D.11 Hemphill County



Hemphill County is located along the eastern edge of the PWPA. The City of Canadian, with a 2020 population of 2,436, is the largest city in the county and has a projected total demand of 601 acre-feet per year in 2030 decreasing to 534 acre-feet per year in 2080.

Water users in Hemphill County obtain their current water supplies from the Ogallala aquifer, with a small amount coming from the local supplies for livestock.

Current sources of supply in Hemphill County are shown to be adequate with no projected water need over the planning period. However, Canadian intends to implement an additional groundwater well. It is also recommended that conservation be implemented for Canadian and irrigation to preserve supplies for future use.

5D.11.1 Canadian

While the City of Canadian does not have a projected need, conservation is recommended to reduce the demands on the limited resources in Hemphill County. The City is also evaluating a new groundwater source in the Ogallala aquifer to back up its current supplies.

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that a new well will be drilled to provide approximately 725 acre-feet per year. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. This well is assumed to be approximately 180 feet below the surface. The new well will be drilled near the City's existing wells. Well field piping will be installed to connect to the current collection system about 3,100 feet away. There is no additional transmission needed to the City.

Time Intended to Complete

The well will be completed by 2030.

Quantity, Reliability and Cost

The quantity of water from this strategy should be able to produce 725 acre-feet per year with average well capacities of 450 gpm. Reliability of Ogallala supplies is moderate since availability depends on other water users. For cost purposes, it is assumed that the new well would be located near the existing well field. The capital cost for the additional groundwater well is approximately $6.6 million.

Environmental Issues

No significant environmental impact is expected for this strategy. The City will need to purchase the water rights. The City would not actually own the land. No transmission system is included in this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. The MAG values were respected in developing these strategies, which should mitigate impacts.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

The recommended water strategies for Canadian are shown in **Table 5D-31**.

Table 5D-32: Recommended Water Strategies for Canadian (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	N/A	7	7	7	7	7	6
Drill Additional Groundwater Wells	$6.6	725	725	725	725	725	725
Total	**$6.6**	**732**	**732**	**732**	**732**	**732**	**731**

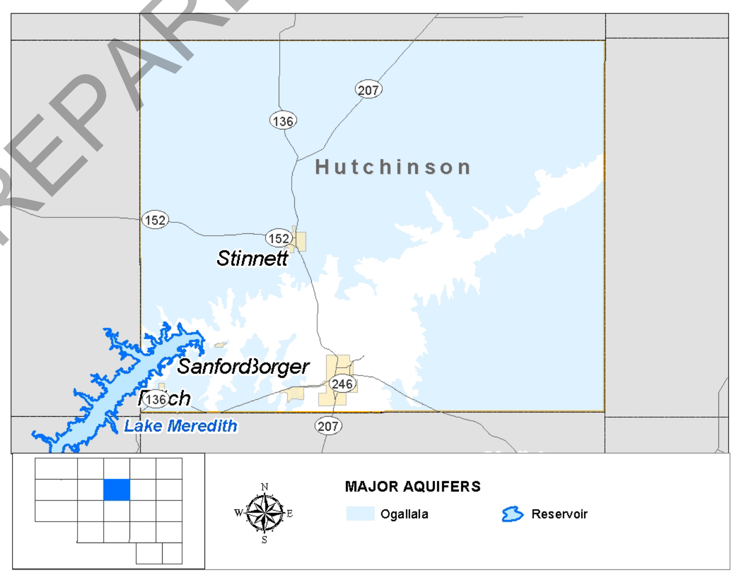
5D.11.2 Hemphill County Summary

Hemphill County shows no projected water needs throughout the planning horizon. The recommended water plan for Hemphill County is shown in **Table 5D-32**.

Table 5D-33: Hemphill County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Canadian	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**) and Drill Additional Groundwater Wells
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer	No	None
Mining	Ogallala aquifer	No	None
Steam Electric	None	-	-

5D.12 Hutchinson County



Hutchinson County is located in the center of the PWPA along the Canadian River break, with Lake Meredith located in the southwestern part of the county. The Ogallala aquifer underlies most of the county. The largest city in Hutchinson County is Borger, with a 2020 population of 12,164 and a projected total demand of 3,535 acre-feet per year in 2030 and 3,116 acre-feet per year in 2080.

The entities in Hutchinson County obtain their water from the Ogallala aquifer and CRMWA. Borger receives water from CRMWA and is also a Major Water Provider because it provides considerable supplies to manufacturing water users. The water supply plan for Borger is discussed in **Chapter 5C** but is also included in the summary of this section for completeness.

Hutchinson County is projected to have a small need beginning in 2030 and increasing to over 4,800 acre-feet per year by 2080. Most of this need is associated with irrigation and manufacturing needs within Hutchinson County. The City of Stinnett and City of Fritch are also projected to have needs over the planning period.

5D.12.1 Borger

The City of Borger is a Major Water Provider. The city currently obtains water from CRMWA and multiple well fields. Borger provides a significant portion of the manufacturing supplies in Hutchinson County. Borger has needs starting at 324 acre-feet per year in 2030, increasing to 912 acre-feet per year in 2080. Borger has recently developed additional groundwater to serve its retail and wholesale customers. The recommended water management strategies for the City of Borger are water conservation, contractual supplies from CRMWA, drill additional groundwater wells, and acquisition of TCW Well Field and System. Discussion of these strategies is found in **Section 5C.3**.

5D.12.2 Stinnett

The City of Stinnett currently obtains its water supply from the Ogallala aquifer. Due to declining well production of the city's current well field, Stinnett will need to develop additional supplies before 2070. Projected needs for Stinnett are 27 acre-feet per year by 2070 and 50 acre-feet per year by 2080. These needs can be met through additional groundwater development to replace reductions in capacities.

The potential water management strategies for Stinnett include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that one new well will be drilled to provide approximately 50 acre-feet per year. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. This well is assumed to be approximately 385 feet below the surface. It is assumed the new well would be drilled near the City's existing wells. Well field piping would be installed to connect to the current transmission system to the city. There is no additional transmission to the city.

Time Intended to Complete

The new well will be completed by 2070.

Quantity, Reliability and Cost

The quantity of water from this well should be able to produce 50 acre-feet per year with average well capacity of 625 gpm. Reliability of Ogallala supplies is moderate since availability depends on other water users. For cost purposes, it is assumed that the new well would be located within the existing well field. The capital cost for the additional groundwater well is approximately $1.6 million.

Environmental Issues

No significant environmental impact is expected for this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. The MAG values were respected in developing these strategies, which should mitigate impacts.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

The recommended strategies for Stinnett are shown in **Table 5D-33**.

Table 5D-34: Recommended Water Strategies for Stinnett (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	27	50
Recommended Strategies							
Municipal Conservation	N/A	5	4	4	4	3	3
Drill Additional Groundwater Well(s)	$1.6	0	0	0	0	50	50
Total	**$1.6**	**5**	**4**	**4**	**4**	**53**	**53**

5D.12.3 Fritch

The City of Fritch is located in southwest Hutchinson County and is currently obtaining its water supply from its own wells in the Ogallala aquifer in the county. Fritch is expected to need additional water to meet its demand by 2060. By 2080, the projected needs for Fritch are 90 acre-feet per year. The City is expected to meet the demands with groundwater.

The potential water management strategies for Fritch include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that one new well would be drilled to provide 100 acre-feet per year and is assumed to produce water from approximately 350 feet below the surface. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. The new well will be drilled near the City's existing wells in Hutchinson County. Well field piping will be installed to connect to the current collection system. The existing pipeline should have sufficient capacity to transport the water to the city.

Time Intended to Complete

The additional well will be completed by 2060. This project will likely be implemented in a single phase. For this plan, the strategy is shown in one phase.

Quantity, Reliability and Cost

The quantity of water from these strategies should be able to produce 100 acre-feet per year with a projected well capacity of 500 gpm. Reliability of Ogallala supplies is moderate since availability depends on competition with other water users. For cost purposes, it is assumed that the new well would be located within the existing well field. The capital cost for the additional groundwater well is approximately $1.4 million.

Environmental Issues

No significant environmental impact is expected for this strategy. The City already owns the water rights, and no transmission system is included in this strategy.

Impact on Water Resources and Other Management Strategies

Long-term water quality of the Ogallala aquifer in Hutchinson County is unknown. Throughout much of the aquifer, groundwater withdrawals exceed the amount of recharge, and water levels have declined consistently through time. This strategy will place additional demands on these sources, which will continue to deplete available storage. The strategy is not expected to have significant impacts on other management strategies.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

The recommended strategies for Fritch are shown in **Table 5D-34**.

Table 5D-35: Recommended Water Strategies for Fritch (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	22	55	90
Recommended Strategies							
Municipal Conservation	N/A	12	11	10	9	9	8
Drill Additional Groundwater Well(s)	$1.4	0	0	0	100	100	100
Total	**$1.4**	**12**	**11**	**10**	**109**	**109**	**108**

5D.12.4 TCW Supply

The TCW Supply obtains its water supply from the Ogallala aquifer in Hutchinson County. It also has an emergency connection with the city of Borger. It is expected that Borger will acquire the water utility during the planning period. For this plan TCW is planned for separately. TCW Supply shows no projected needs over the planning period, though conservation is recommended. The potential water management strategies include:

- Municipal Conservation (see **Section 5B.1**)

Table 5D-36: Recommended Water Strategies for TCW Supply (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	N/A	4	4	3	3	3	3
Total	**N/A**	**4**	**4**	**3**	**3**	**3**	**3**

5D.12.5 Hutchinson County Irrigation

Hutchinson County shows a projected irrigation need by 2080 which is expected to be met by conservation. A summary of the projected water needs and strategies for Hutchinson County Irrigation is shown in **Table 5D-36**. The irrigation conservation strategy is discussed in **Section 5B.2**.

Table 5D-37: Recommended Water Strategies for Hutchinson County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	1,980
Recommended Strategies							
Irrigation Conservation	$3.74	3,350	8,013	10,368	12,703	14,456	16,099
Total	**$3.74**	***3,350***	***8,013***	***10,368***	***12,703***	***14,456***	***16,099***

5D.12.6 Hutchinson County Manufacturing

Hutchinson County manufacturers currently obtain water directly from the Ogallala aquifer in Hutchinson County, Run-of-River supplies, and purchases reuse and treated water from TCW Supply, and the City of Borger. Hutchinson County manufacturing users do have a projected need by 2080, which is associated with shortage from the City of Borger. The needs for manufacturing in Hutchinson County will be met by the City of Borger, as Borger develops additional water supply. The strategies recommended for Borger are discussed in **Section 5C.3**.

Table 5D-38: Recommended Water Strategies for Hutchinson County Manufacturing (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	1,805
Recommended Strategies							
Additional Supplies from Borger	N/A	1,017	1,624	2,156	2,715	3,120	3,951
Total	**N/A**	**1,017**	**1,624**	**2,156**	**2,715**	**3,120**	**3,951**

5D.12.7 Hutchinson County Summary

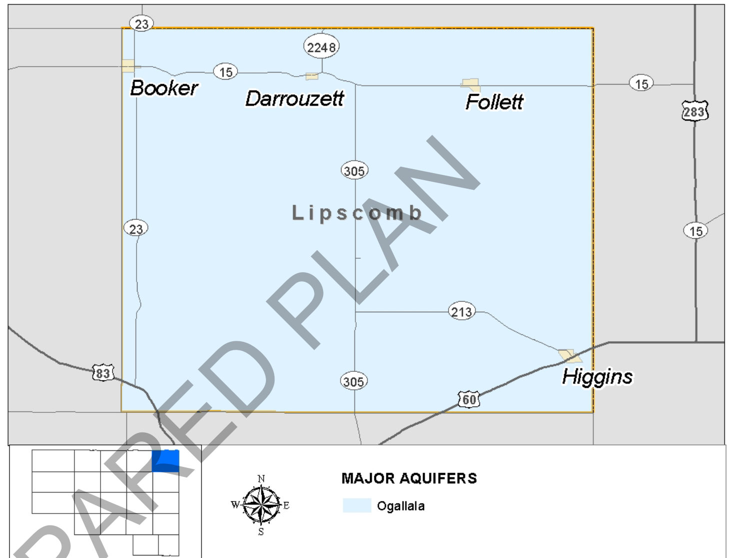
Hutchinson County can fully meet its projected needs through the development of water strategies by the Major Water Providers, Borger and CRMWA, the development of additional groundwater in the Ogallala, and conservation. **Table 5D-38** shows the recommended water plan for Hutchinson County.

Table 5D-39: Hutchinson County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Borger	Ogallala aquifer and CRMWA system	Yes	Municipal conservation (See **Chapter 5B**), drill additional groundwater wells, and contractual supplies from CRMWA
County-Other	Ogallala aquifer, Ground water purchased from Borger and TCW Supply	No	None
Fritch	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**) and drill additional groundwater wells
Irrigation	Ogallala aquifer and Canadian River water rights	Yes	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer, reuse, CRMWA system, City of Borger, TCW Supply, and Canadian River water rights	Yes	Purchase from Borger
Mining	Ogallala aquifer	No	None
Steam Electric	None	-	-

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Stinnett	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)
TCW Supply Inc.	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)

5D.13 Lipscomb County



Lipscomb County is located in the far northeastern corner of the PWPA. It is a predominantly rural county, with highest water demands associated with irrigated agriculture. The largest city in Lipscomb County is the City of Booker, with a 2020 population of 1,291. It lies on the county border with Ochiltree County and extends into Ochiltree County. Booker has a projected total demand of 343 acre-feet per year in 2030 (of which 93% is in Lipscomb County) decreasing to 251 acre-feet per year in 2080.

The Ogallala aquifer is the primary source of water for entities in Lipscomb County. Small quantities of local surface water are used for agricultural purposes. There are large quantities of undeveloped water in the Ogallala aquifer in Lipscomb County. Several major water providers own water rights in this county, including CRMWA and Amarillo, but these rights are currently undeveloped.

5D.13.1 Booker

The City of Booker lies in both Lipscomb and Ochiltree Counties. The City currently obtains its water supply from the Ogallala aquifer in Lipscomb County. The City sells water to its residents and manufacturing users in Lipscomb County. Based on the availability of the City's current wells, Booker will need to develop additional supplies before 2030. Projected needs for Booker (including customer sales to manufacturing) are 114 acre-feet per year by 2080. **Table 5D-39** gives a summary of Booker and customers. The potential water management strategies for Booker include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Table 5D-40: Summary for Booker and Customer

	2030	2040	2050	2060	2070	2080
Projected Population	**1,203**	**1,143**	**1,068**	**1,003**	**940**	**876**
Projected Water Demand						
Booker	343	326	305	287	269	251
Manufacturing, Lipscomb	408	434	461	489	518	548
Total Projected Water Demand	**751**	**760**	**766**	**776**	**787**	**799**
Current Available Water Supplies						
Booker	268	243	212	184	161	137
Manufacturing, Lipscomb	320	323	321	314	311	301
Total Current Supplies	**588**	**566**	**533**	**498**	**472**	**438**
Need (Demand - Current Supply)	**163**	**194**	**233**	**278**	**315**	**361**
Water Management Strategies						
Municipal Conservation	4	4	3	3	3	3
Drill Additional Groundwater Well(s)	312	289	260	225	193	153
Manufacturing, Lipscomb	88	111	140	175	207	247
Total Water Management Strategies	**404**	**404**	**403**	**403**	**403**	**403**
Booker Reserve (Shortage)	**241**	**210**	**170**	**125**	**88**	**42**

Drill Additional Groundwater Well(s)

This strategy assumes that one new well will be drilled to provide approximately 111 acre-feet per year. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. This well is assumed to be approximately 480 feet below the surface. The new well will be drilled near the City's existing wells. Well field piping will be installed to connect to the current collection system. There is no additional transmission to the city.

Time Intended to Complete

The well will be completed prior to 2030.

Quantity, Reliability and Cost

The quantity of water from this strategy should produce about 111 acre-feet per year with a projected well capacity of 500 gpm. Reliability of Ogallala supplies is high since there is large quantities of undeveloped supplies. The capital cost for the additional groundwater well is approximately $1.5 million.

Environmental Issues

No significant environmental impact is expected for this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer in the vicinity of the new well. These impacts are expected to be minor.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies. It is assumed that the new wells will be located near the city and not in agricultural areas.

Other Relevant Factors

There are no other identified relevant factors.

5D.13.2 Lipscomb County Manufacturing

Lipscomb County manufacturers currently get water supply from the City of Booker. The needs identified for manufacturing users in Lipscomb County are associated with the City of Booker. As Booker develops strategies to meet its demands, the needs for manufacturing in Lipscomb County will be met.

Table 5D-41: Recommended Water Strategies for Lipscomb County Manufacturing (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		88	111	140	175	207	247
Recommended Strategies							
Additional Supplies from Booker	N/A	88	111	140	175	207	247
Total	**N/A**	**88**	**111**	**140**	**175**	**207**	**247**

5D.13.3 Lipscomb County Summary

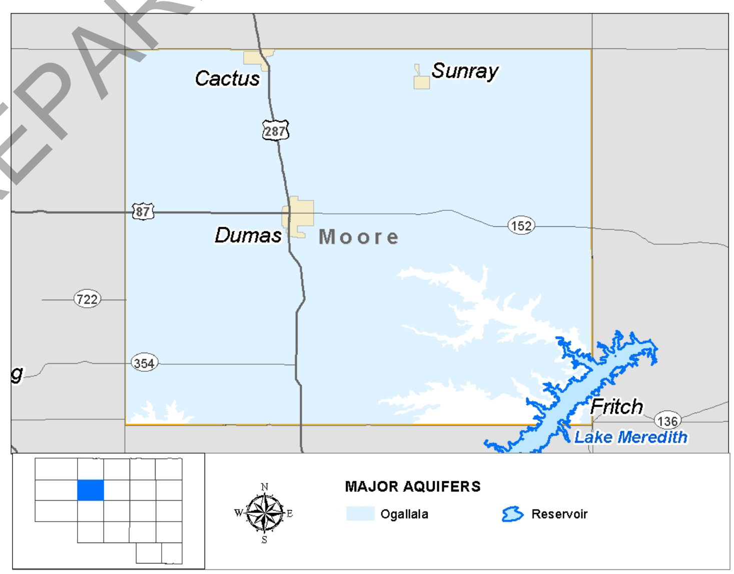
Lipscomb County has plenty of undeveloped water in the Ogallala aquifer. The needs identified for users in the county are associated with expected declines in production of existing wells. With further development of water from the Ogallala aquifer, Lipscomb County can fully meet its projected water needs. While irrigation does not have a need over the planning period, it is recommended that conservation measures identified in **Chapter 5B** be implemented to preserve the groundwater supplies for future use. **Table 5D-41** shows the recommended water plan for Lipscomb County.

Table 5D-42: Lipscomb County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Booker	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**)and drill additional groundwater well(s)
County-Other	Ogallala aquifer	No	None
Darrouzett	Ogallala aquifer	No	Municipal conservation , Water audit & leak repair savings (See **Chapter 5B**)

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Follett	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)
Higgins Municipal Water System	Ogallala aquifer	No	Municipal conservation, Water audit & leak repair savings (See **Chapter 5B**)
Irrigation	Ogallala aquifer and Canadian River water rights	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala aquifer and local supply (stock ponds and irrigation)	No	None
Manufacturing	Ogallala aquifer and reuse purchased through Booker	Yes	Purchase from Booker
Mining	Ogallala aquifer	No	None
Steam Electric	None	-	-

5D.14 Moore County



Moore County is located in the northwest portion of the PWPA. It is one of the four larger irrigation counties in the region. Agricultural water use accounts for about 90 percent of the water used in the county. Manufacturing demands in Moore County are second behind agricultural demands, with demands reaching over 13,000 acre-feet by 2080. The largest city in Moore County is Dumas with a 2020 population of 14,726 and a projected total water demand of 3,032 acre-feet per year in 2030 decreasing to 2,815 acre-feet per year in 2080.

The Ogallala aquifer provides nearly all of the water supplies in Moore County. The cities of Cactus, Dumas and Sunray are member cities of the PDWD, but they currently do not receive water from PDWD.

Due to the competition for water, Moore County is shown to have a need of approximately 76,000 acre-feet per year in 2030 and decreasing to approximately 71,700 acre-feet per year by 2080. Irrigation and livestock are the uses with the largest needs. Municipal use shows no need until 2040. The Ogallala aquifer cannot meet the county's need in the later decades. Further development of the Ogallala in the later decades is contingent upon water saved in earlier decades.

5D.14.1 Cactus

The City of Cactus in Moore County is a member of the PDWD and provides to manufacturing users in Moore County. The current supply for Cactus is the Ogallala aquifer in Moore County. Cactus is expected to need additional water supplies beginning in 2040 to serve its municipal and industrial customers. By 2080, the projected needs for Cactus are 2,168 acre-feet per year. Due to MAG limitations in Moore County Cactus is shown to have a need in 2050 after strategies. **Table 5D-42** gives a summary of Cactus and customers.

The potential water management strategies for Cactus include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Table 5D-43: Summary for Cactus and Customer

	2030	2040	2050	2060	2070	2080
Projected Population	**2,993**	**3,007**	**2,996**	**2,922**	**2,849**	**2,777**
Projected Water Demand						
Cactus	857	859	855	834	813	793
Manufacturing, Moore	3,072	3,195	3,323	3,456	3,594	3,737
Total Projected Water Demand	**3,929**	**4,054**	**4,178**	**4,290**	**4,407**	**4,530**
Current Available Water Supplies						
Cactus	872	763	663	567	484	413
Manufacturing, Moore	3,128	2,837	2,577	2,349	2,140	1,949
Total Current Supplies	**4,000**	**3,600**	**3,240**	**2,916**	**2,624**	**2,362**
Need (Demand - Current Supply)	**-**	**454**	**938**	**1,374**	**1,783**	**2,168**
Water Management Strategies						
Municipal Conservation	9	9	9	9	9	9
Develop Ogallala Aquifer Supplies	-	87	183	153	109	49
Manufacturing, Moore	-	358	658	656	498	235
Total Water Management Strategies	**9**	**454**	**850**	**818**	**616**	**293**
Cactus Reserve (Shortage)	**9**	**-**	**(88)**	**(556)**	**(1,167)**	**(1,875)**

Drill Additional Groundwater Well(s)

This strategy assumes a new wells would be drilled to provide approximately 841 acre-feet per year and are assumed to produce water from approximately 400 feet below the surface. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. The new wells will be drilled near the City's existing wells. Well field piping will be installed to connect to the current collection system. It is assumed that the existing pipeline is sufficient to transport the water to the city.

Time Intended to Complete

The additional well will be completed by 2040.

Quantity, Reliability and Cost

The quantity of water from these strategies should be able to produce 841 acre-feet per year with average well capacities of 750 gpm. Reliability of Ogallala supplies is moderate to moderate-low since availability depends on other water users and the well field is located in heavily irrigated area. For cost purposes, it is assumed that the new wells would be located within the existing well field. The capital cost for the additional groundwater well is approximately $2.0 million.

Environmental Issues

No significant environmental impact is expected for this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To be able to use this water resource, other users will need to reduce their demands. There is insufficient water available in Moore County in the later decades even with the reduction in irrigation water use associated with irrigation conservation. This strategy may impact other strategies that plan to develop Ogallala aquifer supplies in Moore County.

Impact on Agriculture and Natural Resources

Moderate impacts to agricultural use due to competition for water in the later decades. No significant impact on natural resources is expected for the recommended strategy. If additional water rights are needed, this strategy may reduce the irrigated acreage for farming. It is assumed that any purchase of water rights would be on a willing buyer-willing seller basis.

Other Relevant Factors

There are no other identified relevant factors.

5D.14.2 Dumas

The City of Dumas is located in Moore County and is the largest member city of the PDWD. Currently, Dumas obtains its water supply from its own wells in the Ogallala aquifer in Hartley and Moore County. Dumas is expected to need additional water to meet its demand throughout the planning period (2030-2080). By 2080, the projected needs for Dumas and its customers are 1,902 acre-feet per year. Dumas has approximately 27,800 acre-feet per year of undeveloped groundwater rights in Hartley County that will be used to meet its need. The city intends to fully meet its projected demands with groundwater. **Table 5D-43** gives a summary of Dumas and customer.

The potential water management strategies for Dumas include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Table 5D-44: Summary for Dumas and Customer

	2030	2040	2050	2060	2070	2080
Projected Population Supplied by Dumas						
Dumas	14,753	14,829	14,776	14,429	14,083	13,741
County-Other, Moore	385	390	390	390	390	390
Projected Water Demand						
Dumas	3,032	3,038	3,027	2,956	2,885	2,815
County-Other, Moore	50	50	50	50	50	50
Total Projected Water Demand	**3,082**	**3,088**	**3,077**	**3,006**	**2,935**	**2,865**
Current Available Water Supplies						
Dumas	3,360	2,034	1,514	1,277	1,137	946
County-Other, Moore	56	34	25	21	20	17
Total Current Supplies	**3,416**	**2,068**	**1,539**	**1,298**	**1,157**	**963**
Need (Demand - Current Supply)	**-**	**1,020**	**1,538**	**1,708**	**1,778**	**1,902**
Water Management Strategies						
Municipal Conservation	45	46	45	44	43	42
Develop Ogallala Aquifer Supplies	-	1,884	1,875	1,871	1,870	1,867
County-Other, Moore	-	16	25	29	30	33
Total Water Management Strategies	**45**	**1,946**	**1,945**	**1,944**	**1,943**	**1,942**
Dumas Reserve (Shortage)	**45**	**926**	**407**	**236**	**165**	**40**

Drill Additional Groundwater Well(s)

This strategy assumes that three new wells would be drilled to provide approximately 1,900 acre-feet per year and are assumed to produce water from approximately 440 feet below the surface. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. The new wells will be drilled near the City's existing wells in Hartley County. Well field piping will be installed to connect to the current collection system. It is assumed that the existing pipeline is sufficient to transport the water to the city, but a booster pump station may be needed.

Time Intended to Complete

Some of the additional wells will be completed by 2030. This project will likely be implemented in phases, with new wells coming online as needed. For this plan, the strategy is shown in two phases.

Quantity, Reliability and Cost

The quantity of water from these strategies should be able to produce 1,900 acre-feet per year with average well capacities of 690 gpm. Reliability of Ogallala supplies is moderate to moderate-low since availability depends on other water users and the well field is located in heavily irrigated area. For cost purposes, it is assumed that the new wells would be located within the existing well field. The capital cost for the additional groundwater well is approximately $5.1 million.

Environmental Issues

No significant environmental impact is expected for this strategy. The City already owns the water rights and no transmission system is included in this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To be able to use this water resource, other users will need to reduce their demands. There is insufficient water available in Moore County in the later decades even with the reduction in irrigation water use associated with irrigation conservation. This strategy may impact other strategies that plan to develop Ogallala aquifer supplies in Moore County.

Impact on Agriculture and Natural Resources

Moderate impacts to agricultural use due to competition for water in the later decades. No significant impact on natural resources is expected for the recommended strategy. If additional water rights are needed, this strategy may reduce the irrigated acreage for farming. It is assumed that any purchase of water rights would be on a willing buyer-willing seller basis.

Other Relevant Factors

There are no other identified relevant factors.

5D.14.3 Sunray

The City of Sunray currently obtains its water supply from the Ogallala aquifer in Moore County, and is also a member of PDWD. Current sources of supply in Sunray are shown to be adequate with no projected water need over the planning period. It is recommended that conservation be implemented to preserve supplies for future use.

The potential water management strategies for Sunray include:

- Municipal Conservation (see **Section 5B.1**)

Table 5D-45: Recommended Water Strategies for Sunray (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Municipal Conservation	N/A	5	5	5	5	4	4
Total	**N/A**	**5**	**5**	**5**	**5**	**4**	**4**

5D.14.4 Moore County-Other

Moore County-Other consists of rural water users that live outside of an incorporated town or in a town with a population of less than 500 people. Some water is provided to County-Other users from the City of Dumas. The majority of Moore County-Other supply is from unincorporated rural wells in the Ogallala aquifer. There is no shortage shown for Moore County-Other, but Dumas will provide contractual supplies to the entities.

Table 5D-46: Recommended Water Strategies for Moore County-Other (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	0	0
Recommended Strategies							
Dumas contractual supplies	N/A	0	16	25	29	30	33
Total	**N/A**	**0**	**16**	**25**	**29**	**30**	**33**

5D.14.5 Moore County Manufacturing

The manufacturing needs in Moore County range from 792 acre-feet per year by 2030 to 4,190 acre-feet per year by 2080. Some of these needs are associated with needs for the City of Cactus, which will be met through the City of Cactus' water management strategies. Due to MAG limitations in Moore County Manufacturing is shown to have a need in 2050-2080 after strategies.

The potential water management strategies for Moore County Manufacturing include:

- Purchase water from Cactus (see **Section 5C.4**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that six new wells will be drilled near the location of need. There is limited groundwater available from the Ogallala aquifer in the later decades in Moore County. There is some available water from the Dockum aquifer. It is assumed that some of the new water for Manufacturing will be from the Ogallala and some from the Dockum. Since Manufacturing is an aggregated water user group, the number of wells and locations are difficult to assess. For purposes of this plan, the strategy has no transmission and minimal well field piping.

Time Intended to Complete

This strategy will likely be phased beginning in 2030 for both the Ogallala wells and Dockum wells. The costs and quantities are developed in one phase for each aquifer.

Quantity, Reliability and Cost

The quantity of water from these wells should be able to produce maximum combined total of about 1,500 acre-feet per year with average well capacities of 450 gpm. Reliability of Ogallala supplies is low to moderate since availability depends on other water users. It is assumed that that this strategy develops about 770 acre-feet per year from the Ogallala aquifer and about 730 acre-feet per year from the Dockum aquifer. The capital cost for the additional groundwater wells is approximately $2.2 million for the Ogallala wells and $2.7 million for the Dockum wells.

Environmental Issues

No significant environmental impact is expected for this strategy. There is no transmission system included in this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on groundwater will continue to deplete the storage in the aquifers. Competition for water in Moore County may impact other strategies. The MAG values were respected in developing these strategies, which should mitigate impacts.

Impact on Agriculture and Natural Resources

At the level of additional water development, no significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

Table 5D-47: Recommended Water Strategies for Moore County Manufacturing (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		792	1,495	2,182	2,853	3,522	4,190
Recommended Strategies							
Purchase from Cactus	N/A	0	358	658	656	498	235
Drill Additional Groundwater Well(s) Ogallala	$2.2	394	637	767	643	466	220
Drill Additional Groundwater Well(s) Dockum	$2.7	398	500	589	661	706	731
Total	**$4.9**	**792**	**1,495**	**2,014**	**1,960**	**1,670**	**1,186**

5D.14.6 Moore County Irrigation

The irrigation needs in Moore County range from 66,665 acre-feet per year in 2030 to 55,444 acre-feet per year in 2080. These needs cannot be fully met through irrigation conservation. A summary of the projected water needs and strategies for Moore County Irrigation is shown in **Table 5D-47**. The irrigation conservation strategy is discussed in **Section 5B.2**.

Table 5D-48: Recommended Water Strategies for Moore County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		66,665	72,883	68,994	64,716	59,954	55,444
Recommended Strategies							
Irrigation Conservation	$11.58	9,064	21,846	28,070	34,239	38,762	42,940
Total	**$11.58**	**9,064**	**21,846**	**28,070**	**34,239**	**38,762**	**42,940**

5D.14.7 Moore County Livestock

The livestock needs in Moore County range from 8,302 acre-feet per year in 2030 to 9,803 acre-feet per year in 2080. It is assumed that some of these demands will be self-supplied through additional groundwater development. Due to MAG limitations in Moore County Livestock is shown to have a need in 2050-2080 after strategies.

The potential water management strategies for Moore County Livestock include:

- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that eleven new wells will be drilled near the location of need. There is limited groundwater available from the Ogallala aquifer in the later decades in Moore County. There is some available water from the Dockum aquifer. It is assumed that some of the new water for Livestock will be from the Ogallala and some from the Dockum. Since Livestock is an aggregated water user group, the number of wells and locations are difficult to assess. For purposes of this plan, the strategy has no transmission and minimal well field piping.

Time Intended to Complete

This strategy will likely be phased beginning in 2030, but the costs and quantities are developed in one phase.

Quantity, Reliability and Cost

The quantity of water from these wells should be able to produce a maximum combined total of about 9,600 acre-feet per year with average well capacities of 600 gpm. Reliability of Ogallala supplies is moderate since availability depends on other water users. It is assumed that this strategy develops about 5,400 acre-feet per year from the Ogallala aquifer and about 4,200 acre-feet per year from the Dockum aquifer. The capital cost for the additional groundwater wells is approximately $9.1 million for the Ogallala wells and $4.0 million for the Dockum wells.

Environmental Issues

No significant environmental impact is expected for this strategy. There is no transmission system included in this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on groundwater will continue to deplete the storage in the aquifers. Competition for water in Moore County may impact other strategies. The MAG values were respected in developing these strategies, which should mitigate impacts.

Impact on Agriculture and Natural Resources

At the level of additional water development, no significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

Table 5D-49: Recommended Water Strategies for Moore County Livestock (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		8,302	9,557	9,616	9,677	9,739	9,803
Recommended Strategies							
Drill Additional Groundwater Well(s) Ogallala	$9.1	4,131	5,353	5,137	3,565	2,195	899
Drill Additional Groundwater Well(s) Dockum	$4.0	4,171	4,204	3,941	3,663	3,322	2,981
Total	**$13.1**	***8,302***	***9,557***	***9,078***	***7,228***	***5,517***	***3,880***

5D.14.8 Moore County Summary

The preferred source of water for Moore County is the Ogallala aquifer. This source is heavily used by current users and many strategies are limited due to MAG availability. There is not enough water supply to fully meet the county's projected needs. While the Ogallala MAG in Moore County is limited in the later decades **Table 5D-52** shows the available unallocated water in 2030 and 2040 that could be available for use in later decades. Conservation provides a means to balance the water supplies among users. Irrigation conservation can save over 129,000 acre-feet per year of Ogallala water by 2080 in Moore County. Collectively, the municipal water user (Cactus) is expected to develop approximately 1,800 acre-feet per year of new supplies from the Ogallala in Moore County.

The water plan for Moore County is shown in **Table 5D-49**.

Table 5D-50: Moore County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Cactus	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)
County-Other	Ogallala aquifer and purchased supplies from Dumas	No	Municipal conservation (See **Chapter 5B**), Purchase from Dumas
Dumas	Ogallala, Rita Blanca aquifers, and Reuse	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)
Fritch	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)
Irrigation	Ogallala and Dockum aquifers, Canadian River water rights	Yes	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala aquifer and local supply (stock ponds)	Yes	Drill additional groundwater well(s) in Ogallala and Dockum aquifers

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Manufacturing	Ogallala aquifer, direct reuse, and purchased supplies from Cactus	Yes	Purchase from Cactus, Drill additional groundwater well(s) in Ogallala and Dockum aquifers
Mining	Ogallala aquifer	No	None
Steam Electric	None	-	-
Sunray	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)

Table 5D-51: Unmet Water Needs in Moore County (ac-ft/yr)

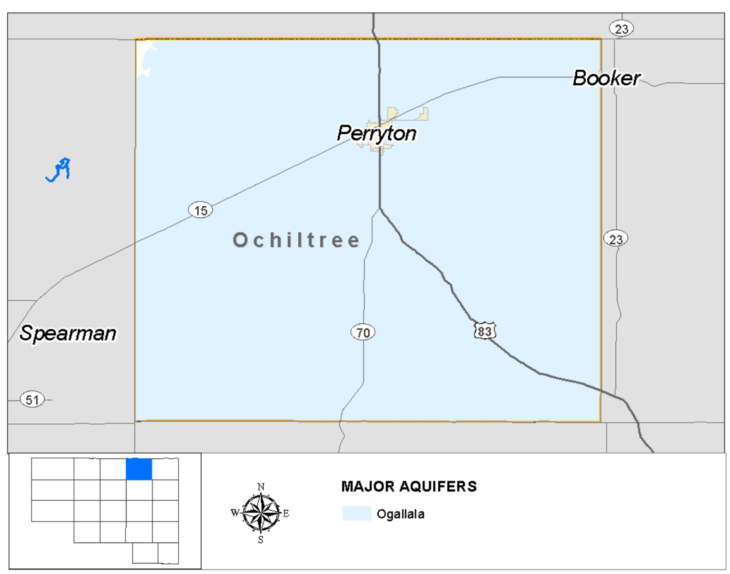
Water User Group	2030	2040	2050	2060	2070	2080
Cactus Municipal Water System	0	0	0	(105)	(211)	(322)
Manufacturing	0	0	(168)	(893)	(1,852)	(3,004)
Livestock	0	0	(538)	(2,449)	(4,222)	(5,923)
Irrigation	(57,601)	(51,037)	(40,924)	(30,477)	(21,192)	(12,504)

Table 5D-52: MAG Availabilty after WMS (ac-ft/yr)

Aquifer	County	2030	2040	2050	2060	2070	2080
Ogallala Aquifer	Moore	4,836	2,158	0	0	0	0

5D.15 Ochiltree County

Ochiltree County is located on the Texas-Oklahoma border in the northern part of the PWPA. The largest city in the county is Perryton, with a 2020 population of 8,210 and a projected total demand of 2,452 acre-feet per year in 2030 increasing to 2,879 acre-feet per year in 2080.



The primary source of water in Ochiltree County is the Ogallala aquifer. Only about 40 percent of the current available supply in the county has been developed.

Perryton Municipal Water System is shown to have a need starting in 2060 due to declining production of its well field, and City of Booker is shown to have a need starting in 2030. Note that Booker's strategies are summarized with Lipscomb County in **Section 5D.13**.

5D.15.1 Perryton Municipal Water System

Perryton Municipal Water System currently obtains its water from the Ogallala aquifer in Ochiltree County. Perryton is showing a need of 48 acre-feet per year by 2060. Some of this need may be able to be met through conservation, but Perryton will need to develop additional groundwater supplies. Perryton is developing additional supplies from the Ogallala aquifer to help meet the growing water demands and replace production losses of the existing well field. The potential water management strategies for Perryton include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that three new wells would be drilled to provide approximately 575 acre-feet per year, and the wells are assumed to produce water from approximately 530 feet below the surface. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. It is assumed that the new wells will be drilled near the city's existing wells in Ochiltree County, but the exact location is uncertain or if the city has sufficient water rights to expand its existing well field. For this plan, it is assumed that a new well field will be developed within ten miles of Perryton's existing infrastructure. The strategy includes a five-mile 12-inch pipeline to transport the water to the city.

Time Intended to Complete

This project will likely be implemented in phases, with new wells coming on-line as needed. For this plan, the strategy is shown in one phase with an online date of 2060.

Quantity, Reliability and Cost

The quantity of water from these strategies should be able to produce 575 acre-feet per year with average well capacities of 490 gpm. The reliability of Ogallala supplies is high. The capital cost for the additional groundwater well is approximately $10.5 million.

Environmental Issues

No significant environmental impact is expected for this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. There is sufficient undeveloped water in the Ogallala aquifer in Ochiltree County.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies. If additional water rights are needed, this strategy may reduce the irrigated acreage for farming. It is assumed that any purchase of water rights would be on a willing buyer-willing seller basis.

Other Relevant Factors

There are no other identified relevant factors.

Table 5D-53: Recommended Water Strategies for Perryton (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	48	320	575
Recommended Strategies							
Municipal Conservation	N/A	26	28	29	29	30	31
Drill Additional Groundwater Well(s)	$10.5	0	0	0	575	575	575
Total	**$10.5**	**26**	**28**	**29**	**604**	**605**	**606**

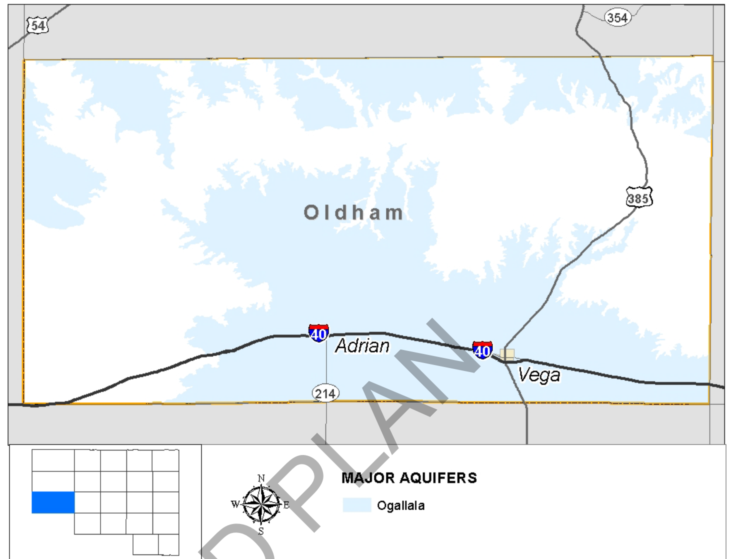
5D.15.2 Ochiltree County Summary

Ochiltree County has plenty of undeveloped water in the Ogallala aquifer. The needs identified for the City of Perryton are associated with expected declines in production of existing wells and increases in demands. With further development of water from the Ogallala aquifer, Ochiltree County can fully meet its projected water needs. While irrigation does not have a need over the planning period, it is recommended that conservation measures identified in **Chapter 5B** be implemented to preserve the groundwater supplies for future use. Conservation is not recommended for County-Other because there is no specific sponsor. **Table 5D-52** shows the recommended water plan for Ochiltree County.

Table 5D-54: Ochiltree County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Booker	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s) (See **Section 5D.13**)
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer	No	None
Mining	Ogallala aquifer	No	None
Perryton	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)
Steam Electric	None	-	-

5D.16 Oldham County



Oldham County is located in the far southwestern part of the region. The county borders New Mexico to the west and the Llano Estacado Region to the south. A geologic break in the Ogallala aquifer occurs in Oldham County, resulting in large non-productive areas in the county. The largest city in Oldham County is the City of Vega, with a 2020 population of less than 850, and a projected total demand of 224 acre-feet per year in 2030 and 200 acre-feet per year in 2080.

Most of the water supply in Oldham County is obtained from the Ogallala and Dockum aquifers. The county has sufficient supplies to meet the projected demands through the planning period. Conservation is recommended for the City of Vega and irrigation use. Water saved through these measures can be used for future needs. Conservation measures are discussed in **Chapter 5B**. **Table 5D-54** shows the recommended water plan for Oldham County.

5D.16.1 Oldham County Irrigation

The irrigation needs in Oldham County range from 319 acre-feet per year in 2030 to 592 acre-feet per year in 2080. These needs can be fully met through irrigation conservation after 2030 throughout the planning period. A summary of the projected water needs and strategies for Oldham County Irrigation is shown in **Table 5D-53**. The irrigation conservation strategy is discussed in **Section 5B.2**.

Table 5D-55: Recommended Water Strategies for Oldham County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		*319*	*319*	*319*	*319*	*319*	*592*
Recommended Strategies							
Irrigation Conservation	$0.29	191	464	592	719	810	891
Total	**$0.29**	**191**	**464**	**592**	**719**	**810**	**891**

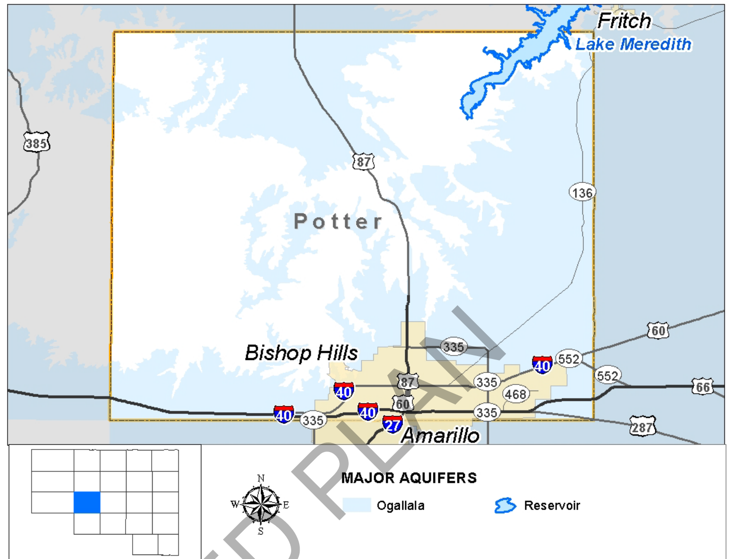
Table 5D-56: Oldham County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Ogallala and Dockum aquifers	No	Municipal conservation (See **Chapter 5B**)
Irrigation	Ogallala and Dockum aquifers	Yes	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala and Dockum aquifers and local supply (stock ponds)	No	None
Manufacturing	None	-	-
Mining	Ogallala aquifers	No	None
Steam Electric	None	-	-
Vega	Ogallala aquifer	No	Municipal conservation , Water audit & leak repair (See **Chapter 5B**)

Table 5D-57: Unmet Water Needs in Oldham County (ac-ft/yr)

Water User Group	2030	2040	2050	2060	2070	2080
Irrigation	(128)	-	-	-	-	-

5D.17 Potter County



Potter County is located along the southern boundary of the Canadian River Basin. The Canadian River runs through Potter County and flows into Lake Meredith to the northeast. A geologic break in the Ogallala aquifer occurs in Potter County, resulting in large non-productive areas in the county. Amarillo is the largest city in Potter County with a 2020 population of nearly 200,000, of which slightly less than half is located in Potter County. The remaining population is in Randall County. The City of Amarillo has a projected total demand of 46,830 acre-feet per year in 2030 (of which 13,829 is based out of Potter County), increasing to 56,866 acre-feet per year in 2080 (of which 11,467 is based out of Potter County).

Most of the demands in Potter County are associated with the City of Amarillo and Steam Electric Power. Amarillo obtains much of its water supplies from outside of the county through CRMWA and multiple well fields in Carson, Potter, Randall and Deaf Smith Counties. All of the Steam Electric Power demands are met from reuse from Amarillo. The remaining in-county water users obtain water from the Ogallala and Dockum aquifers. There is some additional reuse and local supplies used for irrigated agriculture, livestock use, and manufacturing. Potter County has a projected need of 13,250 acre-feet per year by 2080, most of which is associated with the City of Amarillo.

5D.17.1 Amarillo

The City of Amarillo is a water user group and a Major Water Provider in the PWPA, which are discussed in **Section 5C**. The current sources of water include well fields in the Ogallala aquifer, Dockum aquifer, reuse, and purchasing surface water and groundwater from the Canadian River Municipal Water Authority (CRMWA). The recommended strategies for the City of Amarillo include water conservation, AMI, Water Audit & Leak Repair, the development of Phase 2 of the Potter/ Carson County well field, developing reuse supplies, developing the Roberts County well field, and utilizing aquifer storage and recovery to more efficiently utilize their water sources. Additional information regarding Amarillo's recommended strategies is found in **Section 5C.2**.

5D.17.2 Potter County Manufacturing

The current supplies for manufacturing in Potter County include self-supplied Ogallala water, Dockum water, Ogallala and Edwards-Trinity-High Plains, direct reuse, and water purchased from Amarillo. Much of the water for manufacturing is currently supplied by the City of Amarillo via contracts to Tyson and ASARCO, Inc. The projected needs for Potter County Manufacturing are 535 acre-feet per year in 2030, increasing to 5,007 acre-feet per year in 2080. Amarillo is expected to meet the needs through strategies.

Table 5D-58: Recommended Water Strategies for Potter County Manufacturing (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		535	1,671	2,591	3,669	4,332	5,007
Recommended Strategies							
Amarillo's existing contracts	N/A	876	2,012	2,932	4,010	4,673	5,348
Total	**N/A**	**876**	**2,012**	**2,932**	**4,010**	**4,673**	**5,348**

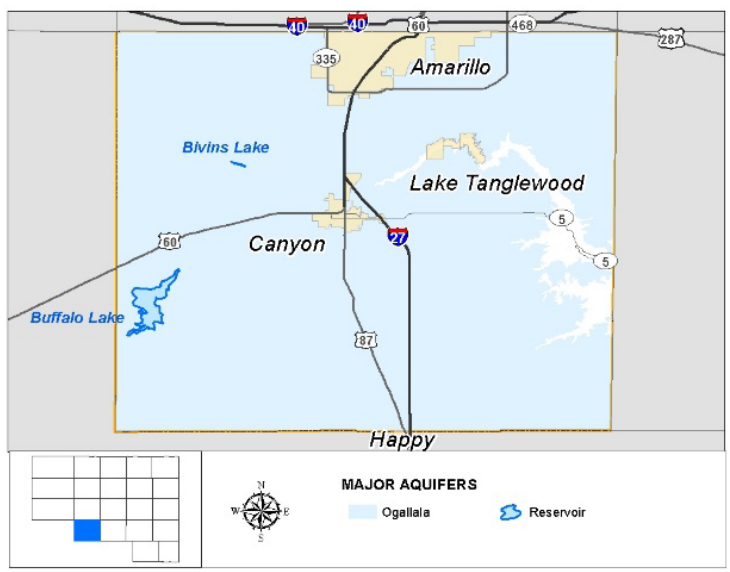
5D.17.3 Potter County Summary

Potter County has a projected need of 13,250 acre-feet per year by 2080. Most of this need is associated with the City of Amarillo and will be met through their strategies which are discussed in **Section 5C.2**. The remainder of the need will be met by municipal conservation and contractual supplies from CRMWA. Manufacturing needs will be met with purchases from Amarillo for potable and reuse supplies. While irrigation does not have a projected need, conservation is recommended. The recommended water plan for Potter County is shown in **Table 5D-57**.

Table 5D-59: Potter County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Amarillo	Ogallala, Dockum, Ogallala and Edwards-Trinity-High Plans aquifer, direct reuse and CRMWA system	Yes	Roberts and Potter/Carson Counties well fields, ASR, reuse, municipal conservation, AMI, Water Audit and Leak Repair (See **Chapter 5B**), and contracted supplies from CRMWA
County-Other	Ogallala and Dockum aquifers	No	Municipal conservation (See **Chapter 5B**)
Irrigation	Ogallala aquifer, Dockum aquifer and reuse	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala and Dockum aquifers and local supply (stock ponds)	No	None
Manufacturing	Ogallala, Dockum, Ogallala and Edwards-Trinity-High Plans aquifers, reuse, and CRMWA system	Yes	Obtain contracted supplies from Amarillo
Mining	Ogallala aquifer	No	None
Steam Electric	Reuse	No	None

5D.18 Randall County



Randall County is located in the southern portion of the PWPA. Amarillo is a major population center for the County. Slightly more than half of Amarillo's nearly 200,000 people reside in Randall County. The remaining portion of the population live in Potter County. Amarillo has a projected total demand of 46,830 acre-feet per year in 2030 (of which 23,923 is based out of Randall County), increasing to 56,866 acre-feet per year in 2080 (of which 37,871 is based out of Randall County). Other towns in Randall County include Canyon, Siesta Estates, and Lake Tanglewood. A small portion of the City of Happy falls in Randall County but it is being planned for by the Llano Estacado Region, where it is primarily located.

Current sources of water include the Ogallala aquifer, Dockum aquifer, Ogallala and Edwards-Trinity-High Plains aquifer, local supplies, run-of-river, reuse, and supplies from CRMWA's system.

Several water users show needs over the planning period due to increasing demands and declining water levels over time within the user's existing well fields. Needs are projected for Amarillo, Canyon, and Randall County Manufacturing and Irrigation.

5D.18.1 Amarillo

The City of Amarillo is a water user group and a Major Water Provider in Region A. The current sources of water include well fields in the Ogallala, Dockum, and Ogallala and Edwards-Trinity-High Plains aquifer, reuse, and purchasing surface water and groundwater from CRMWA. The recommended strategies for the City of Amarillo include water conservation, AMI, Water Audit and Leak Repair Savings, reuse, the development of the Potter County Phase II well field, expansion of Carson County well field, development of the Roberts County well field, and additional supplies from CRMWA. Additional information regarding Amarillo's recommended strategies is found in **Section 5C.2**.

5D.18.2 Canyon

Canyon currently buys water from the City of Amarillo, as well as using groundwater from its own wells in the Ogallala and Dockum aquifers. Canyon is shown to have needs beginning in 2040 with a projected need of 2,991 acre-feet per year by 2080. The potential water management strategies for Canyon include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)
- Contractual supplies from Amarillo

Drill Additional Groundwater Well(s)

The City is in the process of expanding their existing Kim Road Well Field and developing the Rockwell Road Well Field at the writing of this plan. These wells will produce from the Dockum aquifer. It is estimated that seven wells will be drilled in the Dockum and Ogallala aquifers by 2030 to provide an estimated 3,000 acre-feet per year of additional water supply. This cost includes connection piping and a storage tank. The City, also, is currently actively pursuing additional groundwater rights.

Time Intended to Complete

The City is currently in the process of developing and constructing a significant portion of this supply now. For planning purposes, the strategy cost and supplies are developed in two phases, with the first phase online by 2030. However, the city may choose to drill the wells in multiple phases.

Quantity, Reliability, and Cost

The total quantity of water from this strategy is 3,000 acre-feet per year, which would be implemented in two equal phases and should be sufficient to meet the City's needs. The reliability of the additional supply from groundwater is moderate. There is competition for groundwater in Randall County which can impact the long-term reliability of this source. The capital cost for additional infrastructure is estimated at $8.3 million for the Ogallala wells and $7.1 million for the Dockum wells.

Environmental Issues

No significant environmental impacts are expected as a result of drilling the additional wells.

Impact on Water Resources and Other Management Strategies

Long-term water quality of the Ogallala and Dockum aquifer in Randall County is unknown. Throughout much of the aquifer, groundwater withdrawals exceed the amount of recharge, and water levels have declined consistently through time. This strategy will place additional demands on these sources, which will continue to deplete available storage. The strategy is not expected to have significant impacts on other management strategies.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other relevant factors associated with these strategies.

Table 5D-60: Recommended Water Strategies for Canyon (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	511	1,171	1,812	2,408	2,991
Recommended Strategies							
Municipal Conservation	N/A	51	57	92	99	107	115
Contractual supplies from Amarillo	N/A	87	193	269	352	396	434
Drill Additional Groundwater Well(s) Ogallala	$8.3	1,500	1,500	1,500	1,500	1,500	1,500
Drill Additional Groundwater Well(s) Dockum	$7.1	1,500	1,500	1,500	1,500	1,500	1,500
Total	**$15.4**	**3,138**	**3,250**	**3,361**	**3,451**	**3,503**	**3,549**

5D.18.3 Randall County Irrigation

The irrigation needs in Randall County range from 317 acre-feet per year in 2030 to 9,353 acre-feet per year in 2080. These needs can be fully met through irrigation conservation throughout the planning period. A summary of the projected water needs and strategies for Randall County Irrigation is shown in **Table 5D-59**. The irrigation conservation strategy is discussed in **Section 5B.2**.

Table 5D-61: Recommended Water Strategies for Randall County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		317	2,299	4,380	6,103	7,845	9,353
Recommended Strategies							
Irrigation Conservation	$1.11	752	1,841	2,336	2,828	3,170	3,482
Total	**$1.11**	**752**	**1,841**	**2,336**	**2,828**	**3,170**	**3,482**

5D.18.4 Randall County Manufacturing

Randall County manufacturers currently get water supply from the Ogallala aquifer in Randall County and from the City of Amarillo's supplies. Randall County manufacturing users have needs ranging from 107 to 641 acre-feet per year beginning in 2030 due to increasing demands and limited supplies from Amarillo. Through existing contracts, Amarillo is expected to meet this need.

- Contractual supplies from Amarillo

Table 5D-62: Recommended Water Strategies for Randall County Manufacturing (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		107	245	356	485	563	641
Recommended Strategies							
Contractual supplies from Amarillo	N/A	107	245	356	485	563	641
Total	**N/A**	**107**	**245**	**356**	**485**	**563**	**641**

5D.18.5 Randall County Summary

Randall County has a projected need of over 29,000 acre-feet per year by 2080. Most of this need is associated with the City of Amarillo and will be met through their strategies which are discussed in **Section 5C.2**. The remainder of the need will be met by municipal conservation and drilling of additional wells in the Ogallala aquifer in Randall County. Irrigation conservation is recommended to reduce the demands on the limited resource in Randall County. The recommended water plan for Randall County is shown in **Table 5D-61**.

Table 5D-63: Randall County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Amarillo	Ogallala, Dockum, and Ogallala and Edwards-Trinity-High Plains aquifer and CRMWA system	Yes	Roberts and Carson/Potter Counties well fields, ASR, reuse, municipal conservation, AMI, Water Audit and leak Repair (See **Chapter 5B**), and contracted supplies from CRMWA

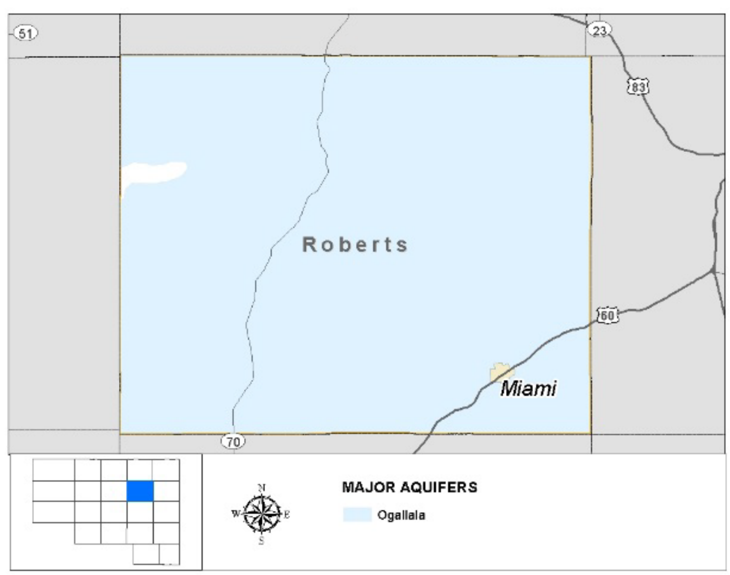
Water User Group	Current Supplies	Need	Proposed Water Management Strategies
Canyon	Ogallala and Dockum aquifers, and Amarillo supplies	Yes	Drill additional groundwater well(s), Municipal conservation (See **Chapter 5B**), and additional supplies from Amarillo
County-Other	Ogallala and Dockum aquifer and CRMWA system	No	Additional supplies from Amarillo
Irrigation	Ogallala and Dockum aquifers, Red River water rights, and reuse	Yes	Irrigation conservation (See **Chapter 5B**)
Lake Tanglewood	Ogallala and Dockum aquifers	No	Municipal conservation (See **Chapter 5B**)
Livestock	Ogallala and Dockum aquifers, and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer & CRMWA system	Yes	Contractual supplies from Amarillo
Mining	None	-	-
Steam Electric	None	-	-

Table 5D-64: Unmet Water Needs in Randall County (ac-ft/yr)

Water User Group	2030	2040	2050	2060	2070	2080
Irrigation	-	(458)	(2,044)	(3,275)	(4,675)	(5,871)

5D.19 Roberts County

Roberts County is located in the northeastern portion of the PWPA.The largest city in the county is Miami, with a 2020 population of 534 and a projected total demand of 180 acre-feet per year in 2030 and 162 acre-feet per year in 2080.



Nearly all of Roberts County's water supply is derived from the Ogallala aquifer. Small amounts of surface water are used from the Canadian Run-of-River for irrigation as well as small amounts from livestock local supplies for ranching operations.

Roberts County is water rich and has plenty of water in storage in the Ogallala aquifer to meet the County's water demands. In addition to demands stemming from within the county, groundwater from Roberts County is also used to supply customers of CRMWA including Amarillo. CRMWA holds a large quantity of water rights in Roberts County and plans to expand their existing well field. The City of Amarillo also holds unused water rights in Roberts County with the intention to develop these rights by 2065. Additional information on the Major Water Provider strategies in Roberts County can be found in **Sections 5C.1.1** and **5C.2.2**.

Roberts County has ample supply to support all current and future projected demands. The strategies recommended for Roberts County are municipal and irrigation conservation and drill additional groundwater wells.

5D.19.1 Miami

The City of Miami is located in Roberts County and is the most populated city in the county. Currently, Miami obtains its water supply from its own wells in the Ogallala aquifer in Roberts County. Miami is expected to need additional water to meet its demand starting in 2050. By 2080, the projected needs for Miami are 44 acre-feet per year. Miami is expected to meet the demands with groundwater.

The potential water management strategies for Miami include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that one new well would be drilled to provide about 45 acre-feet per year and is assumed to produce water from approximately 600 feet below the surface. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. The new well will be drilled near the City's existing wells in Roberts County. Well field piping will be installed to connect to the current collection system. The existing pipeline should have sufficient capacity to transport the water to the city.

Time Intended to Complete

The additional well will be completed by 2030. This project will likely be implemented in a single phase. For this plan, the strategy is shown in one phase.

Quantity, Reliability and Cost

The quantity of water from these strategies should be able to produce 45 acre-feet per year with a projected well capacity of 310 gpm. Reliability of Ogallala supplies is moderate since availability depends on competition with other water users. For cost purposes, it is assumed that the new well would be located within the existing well field. The capital cost for the additional groundwater well is approximately $1.4 million.

Environmental Issues

No significant environmental impact is expected for this strategy. The City already owns the water rights, and no transmission system is included in this strategy.

Impact on Water Resources and Other Management Strategies

Long-term water quality of the Ogallala aquifer in Roberts County is unknown. Throughout much of the aquifer, groundwater withdrawals exceed the amount of recharge, and water levels have declined consistently through time. This strategy will place additional demands on these sources, which will continue to deplete available storage. The strategy is not expected to have significant impacts on other management strategies.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

Table 5D-65: Recommended Water Strategies for Miami (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	6	19	33	44
Recommended Strategies							
Municipal Conservation	2	1	1	1	1	1	1
Drill Additional Groundwater Well(s)	$1.4	45	45	45	45	45	45
Total	**$1.4**	**47**	**46**	**46**	**46**	**46**	**46**

Table 5D-66: Roberts County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer and Canadian River water rights	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	None	-	-
Miami	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)
Mining	Ogallala aquifer	No	None
Steam Electric	None	-	-

5D.20 Sherman County

Sherman County is located in the northwestern part of the PWPA. Stratford is the largest city in Sherman County with a 2020 population of approximately 1,812, which accounts for about two thirds of the County's total population. Stratford has a projected total demand of 567 acre-feet per year in 2030, decreasing to 472 acre-feet per year in 2080.

Sherman County is one of the larger irrigation water users in the region. The primary source of water in the county is the Ogallala aquifer. Smaller quantities from the Dockum aquifer, local Canadian Run-of-River and local livestock supply are also used in the county.

There is plenty of water available from the Ogallala aquifer in Sherman County, but the use is concentrated in the heavily irrigated areas, which may result in great competition and some water declines over time. Sherman County is projected to have needs of up to 59,193 acre-feet per year over the planning period, all attributed to Sherman County Irrigation and the City of Stratford. Irrigation and municipal conservation is recommended as a way to preserve water for future use.

5D.20.1 Stratford

The City of Stratford is located in Sherman County and is the most populated city in the county. Currently, Stratford obtains its water supply from its own wells in the Ogallala aquifer in Sherman County. Stratford is expected to need additional water to meet its demand throughout the planning period (2030-2080). By 2080, the projected needs for Stratford are 326 acre-feet per year, and is expected to meet the demands with groundwater.

The potential water management strategies for Stratford include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that one new well would be drilled to provide more than 326 acre-feet per year and is assumed to produce water from approximately 450 feet below the surface. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. The new well will be drilled near the City's existing wells in Sherman County. Well field piping will be installed to connect to the current collection system. The existing pipeline should have sufficient capacity to transport the water to the city.

Time Intended to Complete

The additional well will be completed by 2030. This project will likely be implemented in a single phase. For this plan, the strategy is shown in one phase.

Quantity, Reliability and Cost

The quantity of water from these strategies should be able to produce 326 acre-feet per year with a projected well capacity of 550 gpm. Reliability of Ogallala supplies is moderate to moderate-low since availability depends on other water users and the well field is located in heavily irrigated area. For cost purposes, it is assumed that the new well would be located within the existing well field. The capital cost for the additional groundwater well is approximately $1.6 million.

Environmental Issues

No significant environmental impact is expected for this strategy. The City already owns the water rights, and no transmission system is included in this strategy.

Impact on Water Resources and Other Management Strategies

The increased demands on the Ogallala will continue to deplete the storage in the aquifer. There is sufficient water available in Sherman County in the later decades, however a reduction in irrigation water use associated with irrigation conservation may be needed in the future. This strategy is not expected to have significant impacts on other management strategies.

Impact on Agriculture and Natural Resources

This strategy may have a low impact on agricultural use due to competition for water in the later decades. No significant impact on natural resources is expected for the recommended strategy. If additional water rights are needed, this strategy may reduce the irrigated acreage for farming. It is assumed that any purchase of water rights would be on a willing buyer-willing seller basis.

Other Relevant Factors

There are no other identified relevant factors.

Table 5D-67: Recommended Water Strategies for Stratford (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		133	120	104	149	272	326
Recommended Strategies							
Municipal Conservation	N/A	5	5	5	5	5	4
Drill Additional Groundwater Well(s)	$1.6	326	326	326	326	326	326
Total	**$1.6**	**326**	**326**	**326**	**326**	**326**	**326**

5D.20.2 Sherman County Irrigation

The irrigation needs in Sherman County range from 34,490 acre-feet per year in 2030 to 43,115 acre-feet per year in 2080. A summary of the projected water needs and strategies for Sherman

County Irrigation is shown in **Table 5D-66**. The irrigation conservation strategy is discussed in **Section 5B.2**.

Table 5D-68: Recommended Water Strategies for Sherman County Irrigation (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		34,490	59,073	53,887	49,819	45,778	43,115
Recommended Strategies							
Irrigation Conservation	$14.70	15,578	37,721	48,351	58,887	66,532	73,626
Total	**$14.70**	**15,578**	**37,721**	**48,351**	**58,887**	**66,532**	**73,626**

5D.20.3 Sherman County Summary

Sherman County has a projected need of over 43,000 acre-feet in 2080, all associated with Sherman County Irrigation and the City of Straford. A summary of the water plan for Sherman County is shown in **Table 5D-67**.

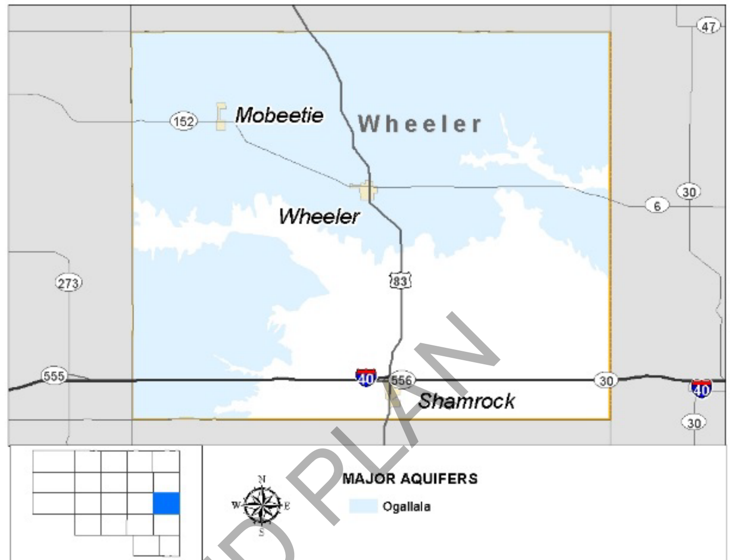
Table 5D-69: Sherman County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala and Dockum aquifers, and Canadian River water rights	Yes	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala aquifer and local supply (irrigation and stock ponds)	No	None
Manufacturing	Ogallala aquifer	No	None
Mining	Ogallala aquifer	No	None
Steam Electric	None	-	-
Stratford	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)
Texhoma	Ogallala aquifer	No	Municipal conservation (See **Chapter 5B**)

Table 5D-70: Unmet Water Needs in Sherman County (ac-ft/yr)

Water User Group	2030	2040	2050	2060	2070	2080
Irrigation	(18,912)	(21,352)	(5,536)	-	-	-

5D.21 Wheeler County



Wheeler County is located on the eastern edge of the PWPA. Shamrock is the largest city in Wheeler County, with a 2020 population of 1,673 people and a projected total demand of 282 acre-feet per year in 2030 and 250 acre-feet per year in 2080.

Most of the water supplies for Wheeler County are from the Ogallala aquifer. However, other undefined aquifers, also contribute to the water supply. Irrigation demands in Wheeler County use Red River supplies and Livestock demands use local supplies.

The next largest city is Wheeler, with a 2020 population of 1,472 people. Both Shamrock and Wheeler show a need in the county. No needs are shown for non-municipal water use.

5D.21.1 Wheeler

The City of Wheeler is shown to have a water need beginning in 2030 and reaching a peak need of 292 acre-feet per year by 2080. This need is due to declining water levels in the City's current well field. The City of Wheeler is evaluating a groundwater source in the Ogallala aquifer to back up its current supplies.

The potential strategies for Wheeler are:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

City of Wheeler is to develop additional groundwater from the Ogallala aquifer with a new well and associated transmission. For planning purposes, it is assumed that one new well and two miles of pipeline will be necessary to meet the City's water needs. This new well will provide more than 290 acre-feet per year and will produce water approximately 150 feet below the surface. Minimal treatment such as chlorine disinfection will be required.

Time Intended to Complete

This strategy would be completed by 2030. The strategy costs and supplies are developed for one phase.

Quantity, Reliability, and Cost

The quantity and reliability of water from this source is expected to be approximately 400 gpm and provide at least 290 acre-feet per year. Reliability of Ogallala supplies is high to moderate. There is plenty of supply in Wheeler County, but there may be potential competing demands. The capital cost for the additional groundwater wells and collection piping is $4.2 million.

Environmental Issues

Groundwater development from this source is expected to cause minimal environmental impacts.

Impact on Water Resources and Other Management Strategies

This strategy is assumed to have a minimal impact on the Ogallala aquifer and other surrounding water resources.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategy.

Other Relevant Factors

There are no other identified relevant factors.

Table 5D-71: Recommended Water Strategies for Wheeler (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		37	118	191	248	279	292
Recommended Strategies							
Municipal Conservation	N/A	4	4	4	4	4	4
Drill Additional Groundwater Well(s)	$4.2	290	290	290	290	290	290
Total	**$4.2**	**294**	**294**	**294**	**294**	**294**	**294**

5D.21.2 Shamrock

The City of Shamrock is located in Wheeler County and is the most populated city in the county. Currently, Shamrock obtains its water supply from its own wells in the Ogallala aquifer in Wheeler County. Shamrock is expected to need additional water to meet its demand by 2070. By 2080, the projected needs for Shamrock are 127 acre-feet per year, and is expected to meet the demands with groundwater.

The potential water management strategies for Shamrock include:

- Municipal Conservation (see **Section 5B.1**)
- Drill Additional Groundwater Well(s)

Drill Additional Groundwater Well(s)

This strategy assumes that one new well would be drilled to provide more than 127 acre-feet per year and is assumed to produce water from approximately 150 feet below the surface. Treatment associated with this strategy is minimal and most likely includes chlorine disinfection. The new well will be drilled near the City's existing wells in Wheeler County. Well field piping will be installed to connect to the current collection system. The existing pipeline should have sufficient capacity to transport the water to the city.

Time Intended to Complete

The additional well will be completed by 2070. This project will likely be implemented in a single phase. For this plan, the strategy is shown in one phase.

Quantity, Reliability and Cost

The quantity of water from these strategies should be able to produce 127 acre-feet per year with a projected well capacity of 250 gpm. Reliability of Ogallala supplies is moderate since availability depends on competition with other water users. For cost purposes, it is assumed that the new well would be located within the existing well field. The capital cost for the additional groundwater well is approximately $1.0 million.

Environmental Issues

No significant environmental impact is expected for this strategy. The City already owns the water rights, and no transmission system is included in this strategy.

Impact on Water Resources and Other Management Strategies

Long-term water quality of the Ogallala aquifer in Wheeler County is unknown. Throughout much of the aquifer, groundwater withdrawals exceed the amount of recharge, and water levels have declined consistently through time. This strategy will place additional demands on these sources, which will continue to deplete available storage. The strategy is not expected to have significant impacts on other management strategies.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

Table 5D-72: Recommended Water Strategies for Shamrock (ac-ft/yr)

	Capital Cost ($ Millions)	2030	2040	2050	2060	2070	2080
Need		0	0	0	0	45	127
Recommended Strategies							
Municipal Conservation	N/A	5	5	5	5	5	4
Water Audit and Leak Repair	$22.3	27	26	25	24	24	24
Drill Additional Groundwater Well(s)	$1.0	0	0	0	0	127	127
Total	**$23.3**	**32**	**31**	**30**	**29**	**156**	**155**

5D.21.3 Wheeler County Summary

Wheeler County has a total projected water need of 419 acre-feet per year by 2080, all of which is associated with the City of Wheeler and City of Shamrock. The county's primary source of water, Ogallala aquifer has over 100,000 acre-feet per year of water that is not currently developed and could be used to meet water needs. With development of additional Ogallala supplies, there are no needs after strategies.

Table 5D-73: Wheeler County Water Management Plan

Water User Group	Current Supplies	Need	Proposed Water Management Strategies
County-Other	Ogallala and Other aquifers	No	None
Irrigation	Ogallala and Red River water rights	No	Irrigation conservation (See **Chapter 5B**)
Livestock	Ogallala and Other aquifers, and local supply (stock ponds)	No	None
Manufacturing	None	-	-
Mining	Ogallala aquifer	No	None
Shamrock	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)
Steam Electric	None	-	-
Wheeler	Ogallala aquifer	Yes	Municipal conservation (See **Chapter 5B**), Drill additional groundwater well(s)

5D.22 Regional Water Management Strategies

Several regional water management strategies were considered by the PWPG for potential supply to the region. These include brush control, precipitation enhancement, groundwater recharge through playa lakes, and interstate water. Brush control is a recommended strategy for CRMWA and is discussed in **Chapter 5C**. Precipitation enhancement is a recommended strategy for the Panhandle GCD to enhance supplies for irrigation. This strategy is discussed in **Chapter 5B** under irrigation conservation strategies. Groundwater recharge through playa lakes and interstate water transfers are discussed in this section.

5D.22.1 Groundwater Recharge through Playa Lakes

Playa lakes perform a valuable ecological function in the Panhandle. They provide water to wildlife, flood storage and localized recharge. The TPWD has been working together with local non-profits to evaluate the potential benefits of playa lakes for water supply. Previous studies on the potential recharge to the Ogallala aquifer indicate recharge can vary from nearly 0 to over 4 inches per year. The higher recharge occurs beneath impoundments, including playa lakes. The variability in recharge rates is due in part to the near surface soil properties, land cover (vegetation) and available water (through irrigation or overlying impoundments). A study conducted for the PWPG in 2010 found the regional recharge rate in the PWPA was 0.26 inches per year.

The impact to water supply depends on the playa volume, recharge rate, depth to the aquifer, and location of playas relative to water supply wells. Across Texas water volumes captured in the playa lakes have ranged between very low to nearly 800,000 acre-feet, depending upon rainfall (see **Figure 5D- 1**). Of this amount, only about 36 percent of the impounded water infiltrates through deeper soils. The rest is lost to evaporation and evapotranspiration. In the PWPA, the evaporation loss is likely higher.

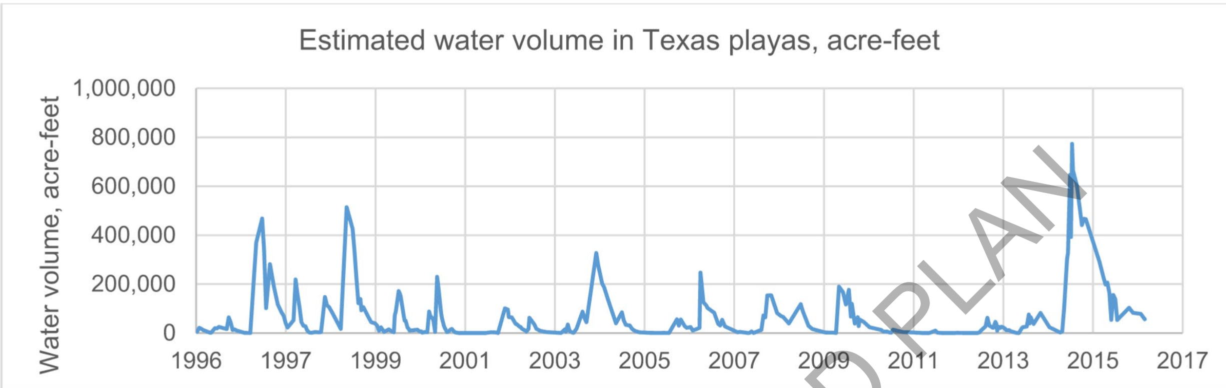


Figure 3-1. Estimated water volume in Texas playas, 1996 to 2017.

Figure 5D- 1: Estimated Water Volume in Texas Playas

The estimated net water volume captured by playa lakes and infiltrated as recharge represents a very small fraction of groundwater usage in the region. In the PWPA, current groundwater pumping from the Ogallala aquifer is estimated at 1.7 million acre-feet per year. Given the comparatively small volume of water captured in playas, more intensive utilization of playas for groundwater recharge cannot offset the regional drawdown of the Ogallala aquifer in response to current demands. At a local scale, playa lakes may be a viable source of recharge for some small-volume, high-value applications; such applications would require a detailed engineering analysis.

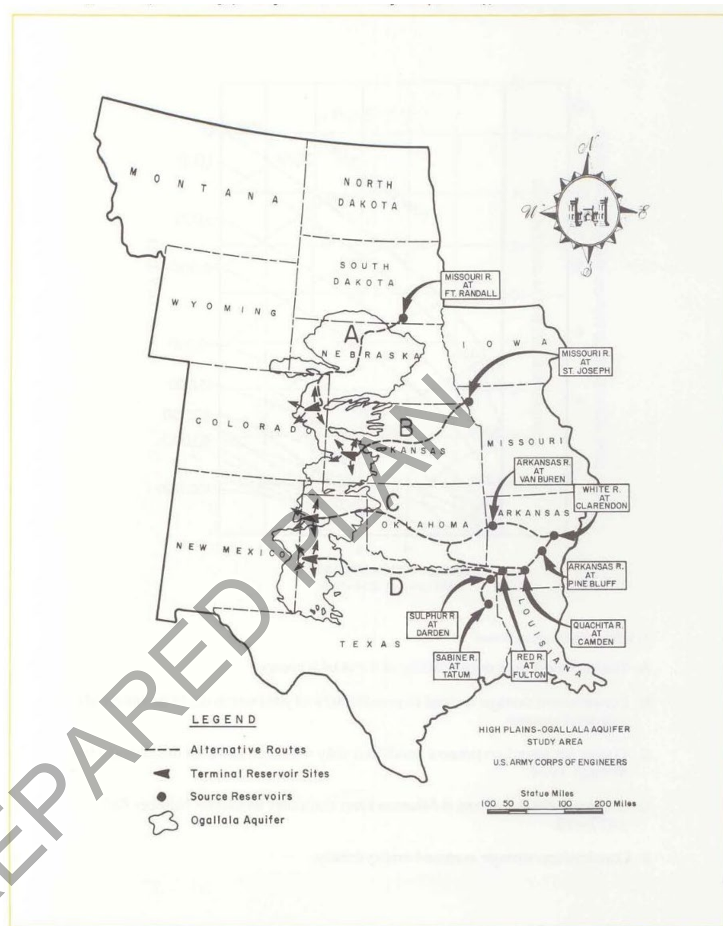
Some WUGs in the PWPA currently pump down playa lakes for flood control. If a sponsor were identified, it is conceptualized that this pumped water could be used to offset potable/non-potable supplies in the region. The amount of water is small and would not be available during drought.

Supplementing groundwater recharge or offsetting potable/non-potable supplies through playa lakes is not a recommended strategy in the PWPA.

5D.22.2 Interstate Water Transfer

The Water Resources Development Act of 1976 authorized the Six-State High Plains-Ogallala aquifer Regional Resources Study (the study) to address concerns regarding the depletion of the Ogallala Aquifer in Colorado, Kansas, Nebraska, New Mexico, Oklahoma, and Texas. The study considered agricultural, economic, environmental, social, and regulatory aspects of transferring water from adjacent areas to the High Plains. The study assessed multiple alternatives for increasing/ conserving water in the High Plains.

One alternative considered in the study was interstate importation of water supplies for the enhancement or expansion of irrigated acreages in the High Plains. The study developed four routes for further study. Routes C and D would provide water to the Panhandle region of Texas (Region A). Both routes would transfer water from the White River, Arkansas River, Ouachita River, and Red River in Arkansas, as well as water from the Sulphur River and Sabine River in Texas. Water would be routed either to terminal storage on the Canadian River near Canadian, Texas (Route C), or to terminal storage at Blanco Canyon near Crosbyton, Texas (Route D). The study did not assess the amount of water that could potentially be available for interstate importation, but instead developed high level designs and cost estimates for a range of supply amounts. The study developed cost curves for these routes, each totaling in the billions of dollars in 1977 dollars. The assumed supply for Route C ranged between 1.26 and 7.51 million acre-feet per year with respective capital costs ranging from $5.7 billion to $22.7 billion in 1977 dollars (assuming a 10-year construction period). The assumed supply for Route D ranged between 1.55 and 8.68 million acre-feet per year with respective capital costs ranging from $4.7 billion to $16.2 billion in 1977 dollars (assuming a 10-year construction period).



Source: Six State High Plains Ogallala Aquifer Regional Resource Study, Figure VI-5

Within the study, the U.S. Army Corps of Engineers made “no recommendation for further consideration of any of the water transfer routes” and the study did not determine that the water that was assumed as a “surplus” in the source basin was available in the present or future[1]. The study recommended a federal and state authorized and funded federal-state planning commission to complete a planning and feasibility study for the proposed interstate importation alternatives. This planning commission was never formed. However, in 2015 several agencies in Kansas worked together on an update to the 1976 study to look specifically at the proposed route to transfer water to Kansas. That high level study also found that many topics would need further study, including the cost of transferring the water, water right issues, ensuring the assumed water available could legally be transferred, and economic impacts.

[1] (Council & United States Army Corps of Engineers, 1982)

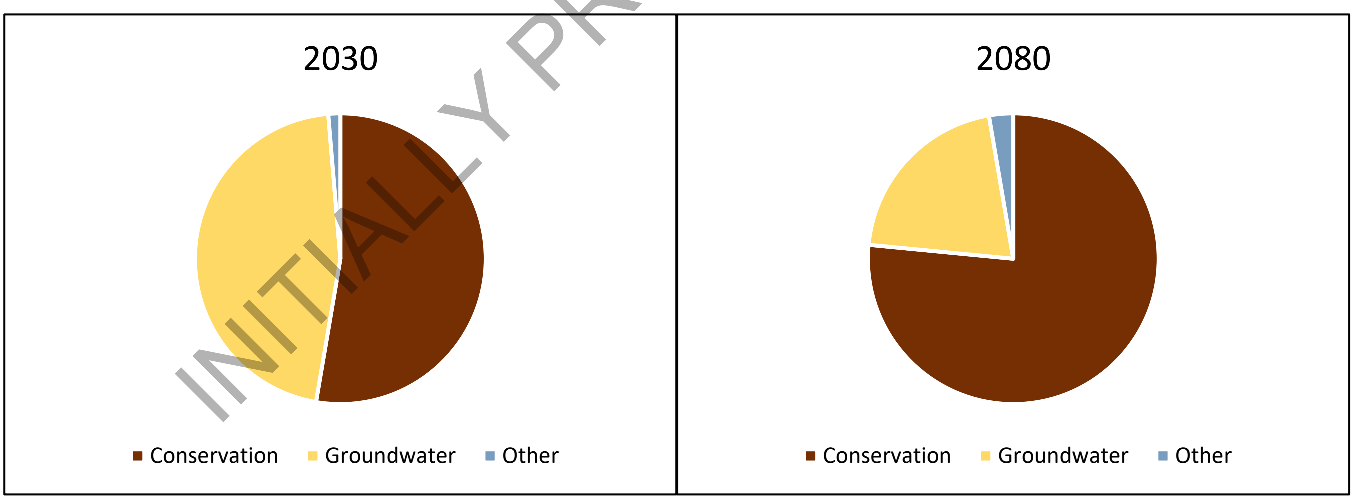
While the study assesses importing water from adjacent regions to the Texas panhandle, several assumptions were made that make the reality of this transfer improbable. None of the water that was assumed to be transferred was identified as a surplus to the needs in the basin of origin, no cost of water was included in the capital cost calculations, there are major environmental impacts (including altered flows at the source streams), large pumping costs, impacts to endangered species, and impacts to wildlife habitats. In addition, there are complex legal and permitting issues, including obtaining the water rights and agreements across multiple states necessary to complete this project. The implementation of this alternative would involve many stakeholders at the federal, state, and local levels and an owner of the project would also need to be identified.

Interstate Water Transfer is not a recommended strategy for the PWPA.

5D.23 PWPA Water Management Strategies Summary

Conservation (both irrigation and municipal) is a crucial component to the viability of the PWPA. Water conservation is recommended for all municipal water users (except County-Other users without a need) and irrigation water users, whether the user has a defined need or not, and it is encouraged for all other users. In total, conservation accounts for nearly 99,000 acre-feet per year of water savings in 2030, growing to about 442,000 acre-feet per year of water savings in 2080.

Groundwater development strategies represent an important part of the portfolio of PWPA strategies, with significant developments proposed by the major water providers and smaller expansions of groundwater use by water user groups. Other strategies recommended for implementation include Aquifer Storage and Recovery, Reuse, Brush Control, and Water Treatment.



The recommended strategies will meet the projected needs for all water users except for irrigation in five counties. The total cost of projects associated with water management strategies in Region A throughout the planning period is $3,118,654,365. The projected unmet needs for the PWPA is shown on **Table 5D-72**.

Table 5D-74: Unmet Water Needs in PWPA

County	WUG	2030	2040	2050	2060	2070	2080
Armstrong	Irrigation	0	0	0	0	(148)	(551)
Collingsworth	Irrigation	(14,416)	(14,749)	(13,561)	(12,119)	(11,471)	(11,423)
Dallam	Irrigation	(105,103)	(117,658)	(98,377)	(79,760)	(64,692)	(52,286)
Hall	Irrigation	(14,536)	(9,756)	(9,194)	(8,631)	(8,112)	(7,475)
Hartley	Irrigation	(154,700)	(186,470)	(160,847)	(136,832)	(116,977)	(99,439)
Moore	Cactus Municipal Water System	0	0	0	(105)	(211)	(322)
Moore	Manufacturing	0	0	(168)	(893)	(1,852)	(3,004)
Moore	Livestock	0	0	(538)	(2,449)	(4,222)	(5,923)
Moore	Irrigation	(57,601)	(51,037)	(40,924)	(30,477)	(21,192)	(12,504)
Oldham	Irrigation	(128)	0	0	0	0	0
Randall	Irrigation	0	(458)	(2,044)	(3,275)	(4,675)	(5,871)
Sherman	Irrigation	(18,912)	(21,352)	(5,536)	0	0	0
	Total	(365,396)	(401,480)	(331,189)	(274,541)	(233,552)	(198,798)

5D.23.1 Potential for Flood Mitigation

Most of the strategies recommended for the PWPA are for infrastructure improvements, new groundwater development and conservation. None of these strategies provide flood mitigation. The only strategy that may provide some flood mitigation is the direct reuse project for Amarillo. Currently, all of Amarillo's wastewater effluent is contracted to Excel Energy for steam electric power, but only a fraction of the contracted amount is being used. Unused wastewater effluent is discharged to East Amarillo Creek and Prairie Dog Fork of the Red River in Lake Tanglewood. Full use of the treated wastewater effluent would significantly reduce discharges to both East Amarillo Creek and Prairie Dog Fork of the Red River and could provide some flood mitigation during high flow events.

5D.23.2 Status and Implementation Schedule of Major Strategies

The regional water plans must report the implementation status for specific strategies recommended in the water plan. These strategies include:

1. All new major reservoirs
2. All seawater desalination strategies
3. Direct potable reuse strategies that provide more than 5,000 acre-feet per year
4. Brackish groundwater strategies that provide more than 10,000 acre-feet per year
5. Aquifer storage and recovery strategies that provide more than 10,000 acre-feet per year
6. All water transfers from out-of-state

The Panhandle Water Plan does not recommend any strategy that meets the requirements for this analysis. The City of Amarillo has a direct potable reuse project for 3,500 acre-feet per year, which is less than the trigger quantity of 5,000 acre-feet per year. Amarillo also has an aquifer storage and recovery project for 10,000 acre-feet per year. The criterion is for more than 10,000 acre-feet per year. There are no recommended new major reservoirs, seawater desalination, large brackish groundwater or out-of-state water strategies.

ATTACHMENT 5-1

WATER MANAGEMENT STRATEGIES CONSIDERED AND EVALUATED

MEMORANDUM

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TO: Panhandle Water Planning Group

CC: File

FROM: Simone Kiel

SUBJECT: Methodology to Identify Potentially Feasible Water Management Strategies

DATE: 10/9/2023

PROJECT: PPC21833

The Regional Water Planning rules requires each region to develop and document the process to identify potentially feasible water management strategies (PFWMS). This process is in addition to the process set forth by the TWDB to evaluate each PFWMS. This memorandum presents the proposed process to be used by the Panhandle Water Planning Group (PWPG).

For the Panhandle Water Planning Area (PWPA), the identification process for PFWMS will follow the sequence below:

1. Identify entities with needs
2. Review recommended strategies in previous Regional Water Plan (RWP)
3. Review new studies/ reports
4. Determine if new or changed strategies are needed
5. Review strategy types appropriate for the PWPA
6. Contact entity for input
7. Contact PWPG representative for county-wide WUGs
8. Verify recommendations

Section 2.5.1 of the *First Amended General Guidelines for Development of the 2026 Regional Water Plans* provides guidance on potentially feasible WMSs by listing 24 types of WMSs that the regional water planning groups (RWPGs) should consider for all identified water needs.

While the TWDB list is comprehensive, not each strategy type is appropriate for every need, and some strategy types may not be appropriate for PWPA water users. To determine whether a strategy is potentially feasible, the first considerations are:

- A strategy must use proven technology and must be technically feasible.
- A strategy should have an identifiable sponsor.
- A strategy must consider end use. This includes water quality, economics, geographic constraints, etc. For example, long transmission systems to move water for agricultural use is not economically feasible.
- A strategy must meet existing regulations.

The second consideration is whether a strategy would provide sufficient water to meet a projected need or a sizeable portion of the need. Considerations at this juncture include:

- Is there available existing supply that is not already allocated to another user?
- Can new water be developed? If yes, identify the potential sources.
- Does the water quality meet the end use requirements? If not, can it be treated?
- Are there any technical considerations that would preclude the feasibility of the strategy type? For example, are there suitable geologic formations for aquifer storage and recovery?

Strategy types that will be reviewed for consideration as potentially feasible for the PWPA include:

- Water conservation
    - Review for applicability and consider for all WUGs with a need
    - Consider water conservation for all municipal WUGs
    - Consider water conservation for all irrigation WUGs
- Reuse
    - Consider for WUGs with needs that generate a waste stream. This includes municipal, manufacturing and mining WUGs.
- Management of existing water supplies/System optimization
    - Consider for WUGs/WWPs that operate multiple water supply sources
- Conjunctive use
    - Consider for WUGs/WWPs that use or will use both surface water and groundwater sources
- Acquisition of available existing water supplies
    - Includes purchase of surface water and groundwater rights
- Developing regional water supply facilities or providing regional management of water supply facilities
- Developing large-scale desalination facilities for brackish groundwater that serve local or regional brackish groundwater production zones identified and designated under TWC §16.060(b)(5)
    - Consider for WUGs/WWPs that intend to develop large scale brackish groundwater for municipal use
- Voluntary transfer of water within the region using, but not limited to, contracts, water marketing, regional water banks, sales, leases, options, subordination agreements, and financing agreements
- Emergency transfer of water under TWC §11.139
- Enhancements of yields.
    - This may be considered with other strategies, such as Brush Control and Precipitation Enhancement
- Improvements to water quality
- New groundwater supply
- Interbasin transfers of surface water
    - This would likely be considered as part of a voluntary transfer of water strategy
- Brush control
- Precipitation enhancement
    - Consider for areas with an existing precipitation enhancement program
- Aquifer storage and recovery

There are several strategy types that likely are not appropriate for PWPA water users. However, they may be considered if a project sponsor requests a specific strategy.

- <u>Drought management.</u> Drought management is an emergency measure and is generally not recommended for long-term supply.
- <u>New surface water supply.</u> There are limited opportunities to develop new surface water supplies in the PWPA.

- Reallocation of reservoir storage to new uses. There are limited opportunities for reservoir storage reallocation in the PWPA.

Three strategy types identified by the TWDB are not appropriate for the PWPA. These include:

- Developing large-scale desalination facilities for marine seawater that serve local or regional entities. The PWPA does not have access to seawater.
- Cancellation of water rights. The run-of-river water rights in the Canadian River Basin and upper Red River Basin have little supply. Cancellation of water rights in the PWPA would not provide additional water.
- Rainwater harvesting. The average rainfall over the PWPA from west to east ranges from 14 to 24 inches per year. During drought there is very little rainfall. This is not a reliable strategy for the PWPA.

2026 Panhandle Water Plan DRAFT List of Potentially Feasible Water Management Strategies

Entity Name	Potentially Feasible WMSs
AMARILLO	MUNICIPAL CONSERVATION
AMARILLO	ADVANCED METERING INFRASTRUCTURE
AMARILLO	WATER AUDIT & LEAK REPAIR
AMARILLO	POTTER/CARSON COUNTY WELL FIELD - PHASE 2
AMARILLO	ROBERTS COUNTY WELL FIELD - WITHOUT CRMWA
AMARILLO	AQUIFER STORAGE AND RECOVERY
AMARILLO	VOLUNTARY TRANSFER FROM OTHER USERS (CRMWA)
AMARILLO	DIRECT POTABLE REUSE
BOOKER	DRILL ADDITIONAL GROUNDWATER WELL
BOOKER	MUNICIPAL CONSERVATION
BORGER	DRILL ADDITIONAL GROUNDWATER WELL
BORGER	VOLUNTARY TRANSFER FROM OTHER USERS (CRMWA)
BORGER	MUNICIPAL CONSERVATION
BORGER	ACQUISITION OF TCW WELL FIELD AND SYSTEM
CACTUS	DRILL ADDITIONAL GROUNDWATER WELL
CACTUS	MUNICIPAL CONSERVATION
CANADIAN	MUNICIPAL CONSERVATION
CANADIAN	DRILL ADDITIONAL GROUNDWATER WELL
CANADIAN RIVER MUNICIPAL WATER AUTHORITY	EXPANSION OF ROBERTS COUNTY WELL FIELD
CANADIAN RIVER MUNICIPAL WATER AUTHORITY	CONSTRUCTION OF CRMWA II PIPELINE (WITHOUT AMARILLO)
CANADIAN RIVER MUNICIPAL WATER AUTHORITY	REPLACE WELL CAPACITY
CANADIAN RIVER MUNICIPAL WATER AUTHORITY	DESALINATION OF SURFACE WATER
CANADIAN RIVER MUNICIPAL WATER AUTHORITY	CONJUNCTIVE USE
CANADIAN RIVER MUNICIPAL WATER AUTHORITY	LINEAR WELL FIELD SYSTEM
CANADIAN RIVER MUNICIPAL WATER AUTHORITY	BRUSH CONTROL
CANYON	DRILL ADDITIONAL GROUNDWATER WELL
CANYON	MUNICIPAL CONSERVATION
CANYON	PURCHASE FROM AMARILLO
CHILDRESS	MUNICIPAL CONSERVATION
CLARENDON	MUNICIPAL CONSERVATION
CLAUDE	MUNICIPAL CONSERVATION
COUNTY-OTHER (MOORE)	PURCHASE FROM DUMAS
COUNTY-OTHER (OLDHAM)	MUNICIPAL CONSERVATION
COUNTY-OTHER (POTTER)	MUNICIPAL CONSERVATION
COUNTY-OTHER (RANDALL)	PURCHASE FROM AMARILLO
DALHART	MUNICIPAL CONSERVATION
DARROUZETT	MUNICIPAL CONSERVATION
DARROUZETT	WATER AUDIT & LEAK REPAIR
DUMAS	DRILL ADDITIONAL GROUNDWATER WELL
DUMAS	MUNICIPAL CONSERVATION
FOLLETT	MUNICIPAL CONSERVATION
FRITCH	DRILL ADDITIONAL GROUNDWATER WELL

2026 Panhandle Water Plan DRAFT List of Potentially Feasible Water Management Strategies	
Entity Name	**Potentially Feasible WMSs**
FRITCH	MUNICIPAL CONSERVATION
GREENBELT MUNICIPAL & INDUSTRIAL WATER AUTHORITY	DRILL ADDITIONAL GROUNDWATER WELL (DONLEY COUNTY)
GROOM MUNICIPAL WATER SYSTEM	MUNICIPAL CONSERVATION
GRUVER	DRILL ADDITIONAL GROUNDWATER WELL
GRUVER	MUNICIPAL CONSERVATION
HARTLEY WSC	MUNICIPAL CONSERVATION
HIGGINS MUNICIPAL WATER SYSTEM	MUNICIPAL CONSERVATION
HIGGINS MUNICIPAL WATER SYSTEM	WATER AUDIT & LEAK REPAIR
IRRIGATION (ALL COUNTIES)	IRRIGATION CONSERVATION
LAKE TANGLEWOOD	MUNICIPAL CONSERVATION
LIVESTOCK (HARTLEY)	DRILL ADDITIONAL GROUNDWATER WELL
LIVESTOCK (MOORE)	DRILL ADDITIONAL GROUNDWATER WELL
MANUFACTURING (HUTCHINSON)	VOLUNTARY TRANSFER FROM OTHER USERS (BORGER)
MANUFACTURING (LIPSCOMB)	VOLUNTARY TRANSFER FROM OTHER USERS (BOOKER)
MANUFACTURING (MOORE)	VOLUNTARY TRANSFER FROM OTHER USERS (CACTUS)
MANUFACTURING (MOORE)	DRILL ADDITIONAL GROUNDWATER WELL
MANUFACTURING (POTTER)	VOLUNTARY TRANSFER FROM OTHER USERS (AMARILLO)
MANUFACTURING (RANDALL)	VOLUNTARY TRANSFER FROM OTHER USERS (AMARILLO)
MCLEAN	MUNICIPAL CONSERVATION
MEMPHIS	MUNICIPAL CONSERVATION
MIAMI	MUNICIPAL CONSERVATION
MIAMI	DRILL ADDITIONAL GROUNDWATER WELL
PAMPA	AQUIFER STORAGE AND RECOVERY
PAMPA	MUNICIPAL CONSERVATION
PAMPA	WATER AUDIT & LEAK REPAIR
PAMPA	VOLUNTARY TRANSFER FROM OTHER USERS (CRMWA)
PANHANDLE	MUNICIPAL CONSERVATION
PANHANDLE	WATER AUDIT & LEAK REPAIR
PANHANDLE	DRILL ADDITIONAL GROUNDWATER WELL
PERRYTON	DRILL ADDITIONAL GROUNDWATER WELL
PERRYTON	MUNICIPAL CONSERVATION
RED RIVER AUTHORITY OF TEXAS	MUNICIPAL CONSERVATION
SHAMROCK	MUNICIPAL CONSERVATION
SHAMROCK	WATER AUDIT & LEAK REPAIR
SHAMROCK	DRILL ADDITIONAL GROUNDWATER WELL
SIESTA ESTATES	MUNICIPAL CONSERVATION
SPEARMAN	MUNICIPAL CONSERVATION
STINNETT	DRILL ADDITIONAL GROUNDWATER WELL
STINNETT	MUNICIPAL CONSERVATION
STRATFORD	MUNICIPAL CONSERVATION
STRATFORD	DRILL ADDITIONAL GROUNDWATER WELL
SUNRAY	MUNICIPAL CONSERVATION
TCW SUPPLY INC	MUNICIPAL CONSERVATION
TEXLINE	MUNICIPAL CONSERVATION
TURKEY MUNICIPAL WATER SYSTEM	MUNICIPAL CONSERVATION
VEGA	MUNICIPAL CONSERVATION
VEGA	WATER AUDIT & LEAK REPAIR
WELLINGTON	ADVANCED TREATMENT

2026 Panhandle Water Plan DRAFT List of Potentially Feasible Water Management Strategies	
Entity Name	**Potentially Feasible WMSs**
WELLINGTON	MUNICIPAL CONSERVATION
WHEELER	DRILL ADDITIONAL GROUNDWATER WELL
WHEELER	MUNICIPAL CONSERVATION
WHITE DEER	MUNICIPAL CONSERVATION
PWPA WUGs	OUT OF STATE WATER
PWPA WUGs WITH IMPAIRED GROUNDWATER	GROUNDWATER DESALINATION

Water Management Strategies Considered and Evaluated

County	Identified WUG Need: WUG	Identified WUG Need: Maximum Need 2030-2080 (ac-ft/yr)	WMSs Considered: Conservation	Water Audit & Leak Repair	Reuse	Reallocation of storage	Voluntary Transfers	Conjunctive Use	Expansion of Existing Supplies	New Supplies	Regional Water Supply	Improvement of Water Quality	System Optimization, Subordination, Enhancement	Brush Control	Precipitation Enhancement	Desalination	Aquifer Storage and Recovery
Lipscomb, Ochiltree	Booker	361	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Moore	Cactus	2,168	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Hemphill	Canadian	0	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Randall	Canyon	2,991	●	○	○	○	●	○	○	●	○	○	○	○	○	○	○
Childress	Childress	0	●	○	○	○	●	○	○	○	○	○	○	○	○	○	○
Armstrong	Claude	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Donley	Clarendon	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Moore	County-Other (Moore)	0	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○
Hall	County-Other (Oldham)	0	●	○	○	○	○	○	●	○	○	●	○	○	○	○	○
Potter	County-Other (Potter)	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Randall	County-Other (Randall)	0	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○
Dallam, Hartley	Dalhart	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Lipscomb	Darrouzett	0	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○
Moore	Dumas	1,902	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Lispcomb	Follett	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Carson, Hutchinson, Moore	Fritch	90	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Carson	Groom Municipal Water System	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hansford	Gruver	107	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Randall	Happy	0	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hartley	Hartley WSC	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Lipscomb	Higgins Municipal Water System	0	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○
Armstrong	Armstrong County Irrigation	1,855	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Carson	Carson County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Childress	Childress County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Collingsworth	Collingsworth County Irrigation	19,069	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Dallam	Dallam County Irrigation	156,912	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Water Management Strategies Considered and Evaluated

County	Identified WUG Need		WMSs Required To be Considered														
County	WUG	Maximum Need 2030-2080 (ac-ft/yr)	Conservation	Water Audit & Leak Repair	Reuse	Reallocation of storage	Voluntary Transfers	Conjunctive Use	Expansion of Existing Supplie	New Supplies	Regional Water Supply	Improvement of Water Quality	System Optimization, Subordination, Enhancement	Brush Control	Precipitation Enhancement	Desalination	Aquifer Storage and Recovery
Donley	Donley County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Gray	Gray County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hall	Hall County Irrigation	15,780	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hansford	Hansford County Irrigation	46,748	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hartley	Hartley County Irrigation	229,447	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hemphill	Hemphill County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hutchinson	Hutchinson County Irrigation	1,980	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Lipscomb	Lipscomb County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Moore	Moore County Irrigation	72,883	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Ochiltree	Ochiltree County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Oldham	Oldham County Irrigation	592	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Potter	Potter County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Randall	Randall County Irrigation	9,353	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Roberts	Roberts County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Sherman	Sherman County Irrigation	59,073	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Wheeler	Wheeler County Irrigation	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Randall	Lake Tanglewood	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hartley	Hartley County Livestock	2,319	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Moore	Moore County Livestock	9,803	○	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Hutchinson	Hutchinson County Manufacturing	1,805	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○
Lipscomb	Lipscomb County Manufacturing	247	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○
Moore	Moore County Manufacturing	4,190	○	○	○	○	●	○	○	●	○	○	○	○	○	○	○
Potter	Potter County Manufacturing	5,007	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○
Randall	Randall County Manufacturing	641	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○
Gray	McLean Municipal Water System	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hall	Memphis	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Randall	Miami	44	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○

Water Management Strategies Considered and Evaluated

County	Identified WUG Need: WUG	Identified WUG Need: Maximum Need 2030-2080 (ac-ft/yr)	Conservation	Water Audit & Leak Repair	Reuse	Reallocation of storage	Voluntary Transfers	Conjunctive Use	Expansion of Existing Supplie	New Supplies	Regional Water Supply	Improvement of Water Quality	System Optimization, Subordination, Enhancement	Brush Control	Precipitation Enhancement	Desalination	Aquifer Storage and Recovery
Gray	Pampa Municipal Water System	1,092	●	●	○	○	●	○	○	○	○	○	○	○	○	○	●
Carson	Panhandle Municipal Water System	0	●	●	○	○	○	○	○	●	○	○	○	○	○	○	○
Ochiltree	Perryton Municipal Water System	575	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Childress	Red River Authority of Texas	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Wheeler	Shamrock Municipal Water System	127	●	●	○	○	○	○	○	●	○	○	○	○	○	○	○
Randall	Siesta Estates	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hansford	Spearman Municipal Water System	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hutchinson	Stinnett	50	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Sherman	Stratford	326	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Moore	Sunray	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hutchinson	TCW Supply	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Sherman	Texhoma	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Dallam	Texline	0	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Hall	Turkey	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Oldham	Vega	0	●	●	○	○	○	○	○	○	○	○	○	○	○	○	○
Collingsworth	Wellington Municipal Water System	174	●	○	○	○	○	○	○	○	○	●	○	○	○	○	○
Wheeler	Wheeler	292	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○
Carson	White Deer	0	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Major Water Providers:																
Potter, Randall	Amarillo	31,112	●	●	●	○	●	○	●	●	○	○	○	○	○	○	●
Hutchinson	Borger	4,863	●	○	○	○	●	○	○	●	○	○	●	○	○	○	○
Multiple	CRMWA	64,858	●	○	○	○	●	○	●	●	○	●	○	●	○	○	●
Multiple	Greenbelt MIWA	0	●	○	○	○	○	○	○	●	○	○	○	○	○	○	○

For purposes of this table, voluntary transfer also represents supplies developed by wholesale water providers to existing customers.

ATTACHMENT 5-2

STRATEGY EVALUATION MATRIX AND QUANTIFIED ENVIRONMENTAL IMPACT MATRIX

INTRODUCTION

In accordance with TWDB rules and guidelines, the Panhandle Water Planning Group has adopted a standard procedure for ranking potential water management strategies. This procedure classifies the strategies using the TWDB's standard categories developed for regional water planning.

The strategies are ranked based upon the following categories;

- Quantity
- Reliability
- Cost
- Environmental Factors
- Agricultural Resources/Rural Areas
- Other Natural Resources
- Key Water Quality Parameters

Each category is quantitatively assessed and assigned a ranking from 1 to 5. With the exception of the Environmental Factors category, **Table 1** shows the correlation between the category and the ranking. The Environmental Factors score is taken directly from the Environmental Matrix and are discussed later in this document.

Table 1: Evaluation Matrix Category Ranking Correlation

Rank	Quantity	Cost per Ac Ft	Reliability	Remaining Strategy Impacts
1	Meets 0-25% Shortage	>$3,000	Low	High
2	Meets 25-50% Shortage	$2,000-$3,000	Low to Medium	Medium
3	Meets 50-75% of Shortage	$1,000-$2,000	Medium	Low
4	Meets 75-100% of Shortage	$500-$1,000	Medium to High	None
5	Exceeds Shortage	<$500	High	Positive Impact

Environmental Factors

The evaluation of Environmental Factors considers multiple aspects of the potential impacts of the project as it relates to habitats, stream flow, water quality, threatened and endangered species and cultural resources. Each of these contributing factors are assessed through the Environmental Matrix and the resultant score is recorded on the Evaluation Matrix. Details of these evaluations are discussed under the Environmental Matrix.

Agricultural Resources

Impacts to Agricultural Resources are quantified based on the permanent impacts to water supplies to irrigation users or direct impacts to irrigated acreage. Projects with only temporary impacts, such as pipeline projects, would be classified as low impacts. Specific assumptions include:

- If the location of the strategy is known and data is available, actual impacts to agricultural lands will be used.
- If a strategy is located in a rural area of a county with significant irrigation use (>50,000 ac-ft/yr), it is assumed that the strategy could potentially impact agricultural lands. Since most projects will avoid direct impacts to agricultural lands, the quantity of impacts is estimated to be no more than 10% of the total area for the strategy.
- If a strategy permanently impacts more than 2,000 acres of agricultural land, the impacts are classified as "high". If a strategy impacts no more than 50 acres of agricultural lands, the impacts are classified as "low".
- If a strategy will reduce the available water to an irrigation user (by county) by the greater of 10% current irrigation use or 5,000 ac-ft/yr, the strategy is determined to have "high" impacts. If a strategy will reduce the available water to an irrigation user (by county) by 1% of current irrigation use or 500 ac-ft/yr, the strategy is determined to have "low" impacts.
- If the entity already holds water rights for the strategy, the impacts would be "none".
- If the strategy does not impact any agricultural or rural user, "none" is selected.
- For strategies that provide water to agricultural and rural users, the strategy is rated as "positive impacts."

The quantified impacts are recorded in the Environmental Matrix table.

Other Natural Resources

Other Natural Resources include parks and public lands, energy and mining reserves, and other water resources not directly affected by the proposed strategy. This evaluation is qualitatively assessed and scored as shown on **Table 1**.

Key Water Quality Parameters

Impacts to key water quality parameters are discussed by strategy type in **Chapter 6**. These parameters may vary by project type. This parameter is qualitatively assessed and scored as shown on **Table 1**.

Environmental Matrix
The Environmental Matrix is used to determine the score of the 'Environmental Factors' category on the Evaluation Matrix.

The Environmental Matrix takes into consideration the following categories;

- Total Acres Impacted
- Total Wetland Acres Impacted
- Environmental Water Needs
- Habitat
- Threatened and Endangered Species
- Cultural Resources
- Bays & Estuaries
- Environmental Water Quality

Each category is quantitatively assessed and assigned a ranking from 1 to 5. The Overall Environmental Impacts column averages all of the rankings assigned to the strategy. This value is also illustrated in the Evaluation Matrix as the Environmental Factors rank. **Table 2** shows the correlation between the rank assigned within each category.

Table 2: Environmental Matrix Category Ranking Correlation

Rank	Acres Impacted	Threatened and Endangered Species	All Remaining Categories
1	Greater than 5000 Acres and/or 500 Ac Wetlands	Greater than 50	High Impact
2	1000-5000 Acres and/or 100-500 Ac Wetlands	Between 30-50	Medium Impact
3	50-1000 Acres and/or 5-100 Ac Wetlands	Between 10-30 or 'varies'	Low Impact
4	0-50 Acres	Between 0-10	No Impact or n/a
5	None	None or n/a	Positive

Acres Impacted
Acres Impacted refers to the total amount of area that will be impacted due to the implementation of a strategy.

The following conservative assumptions were made (unless more detailed information was available);

- Each well will impact approximately 1 acre of land
- The acres impacted for pipelines is equivalent to the right of way easements required
- Reservoirs will impact an area equal to their surface area
- A conventional water treatment plant will impact 5 acres
- Conservation, Precipitation Enhancement and Subordination strategies will have no impact on acres

Wetland Acres

Wetland Acres refers to how many acres that are classified as wetlands are impacted by implementation of the strategy. No strategies in the PWPA are expected to have an impact on wetlands. The total acreage was determined using the National Wetlands Inventory located at http://www.fws.gov/wetlands/Data/Mapper.html .

Environmental Water Needs

Environmental Water Needs refers to how the strategy will impact the area's overall environmental water needs. Water is vital to the environmental health of a region, and so it is important to take into account how strategies will impact the amount of water that will be available to the environment.

The following conservative assumptions were made (unless more detailed information was available);

- The majority of the strategies are associated with new groundwater development and will have a low impact on environmental water needs
- Reuse will also have a medium impact if the effluent was previously used for irrigation or discharged back into the water system. This will decrease the overall amount of water that is available to the environment by diverting the effluent and using it for another purpose
- Precipitation Enhancement, Brush Control, and all Conservation related strategies will have a positive impact because both of these strategies increase the amount of water available to the environment.

Habitat

Habitat refers to how the strategy will impact the habitat of the local area. The more area that is impacted due to the implementation of the strategy, the more the area's habitat will be disrupted.

The following conservative assumptions were made (unless more detailed information was available);

- Strategies with less than 100 acres impacted will have a low impact
- Strategies above 100 acres impacted will have a medium impact

Threatened and Endangered Species

Threatened and endangered species refers to how the strategy will impact those species in the area once implemented.

The following conservative assumptions were made (unless more detailed information was available);

- Only applicable to strategies implementing infrastructure
- AMI is assumed to be a replacement of existing infrastructure with no new threat
- Rankings were based on the amount of State and federally threatened and endangered species located within the county. This amount was found using the Texas Parks and Wildlife Database located at http://tpwd.texas.gov/gis/rtest/ and the U.S. Fish and Wildlife Service Database located at http://www.fws.gov/endangered/ .

- This ranking only includes threatened and endangered species as defined in the TWDB guidelines and does not include species without official protection such as those proposed for listing or species that are considered rare or otherwise of special concern.

Cultural Resources
Cultural Resources refers to how the strategy will impact cultural resources located within the area. Cultural resources are defined as the collective evidence of the past activities and accomplishments of people. Locations, buildings and features with scientific, cultural or historic value are considered to be cultural resources.

The following conservative assumptions were made (unless more detailed information was available);

- Only applicable to strategies implementing infrastructure
- All groundwater and transmission strategies will have a low impact on cultural resources because of the ability to avoid areas with high probably of cultural resources.

Bays and Estuaries
The PWPA is located too far away from and bays or estuaries to have a quantifiable impact. Therefore this category was assumed to be non-applicable for every strategy.

Environmental Water Quality
Environmental Water Quality refers to the impact that the implementation of the strategy will have on the area's applicable water quality. These ranks were assumed to be equivalent to those assigned previously to each strategy in the Evaluation Matrix.

Water Management Strategy Evaluation Matrix

Entity	County Used	Basin Used	Strategy	Quantity (Ac Ft/Yr)	Maximum Need	Percentage of Max Need Met	Quantity Score	Reliability	Annual Cost ($/Ac Ft)	Cost Score	Environmental Factors	Impacts of Strategy on: Agricultural Resources/ Rural Areas	Impacts of Strategy on: Other Natural Resources	Key Water Quality Parameters	Overall Score (5-40)
Claude	Armstrong	Red	Conservation	3	0	N/A	5	3	$1,938	3	5	4	5	5	30
Irrigation	Armstrong	Red	Conservation	1,304	1,855	70%	3	3	$87	5	5	5	5	5	31
Groom	Carson	Red	Conservation	2	0	N/A	5	3	$2,863	2	5	4	5	5	29
Irrigation	Carson	Canadian and Red	Conservation	24,851	0	N/A	5	3	$87	5	5	5	5	5	33
Panhandle	Carson	Red	Conservation	7	0	N/A	5	3	$1,462	3	5	4	5	5	30
			Water Audit & Leak Repair	22		N/A	5	3	$1,517	3	5	4	5	5	30
			New Well(s) (Ogallala Carson)	600		>100%	5	4	$495	5	4	4	4	4	30
White Deer	Carson	Canadian and Red	Conservation	2	0	N/A	5	3	$3,843	1	5	4	5	5	28
Fritch	Carson, Hutchinson and Moore	Canadian	Conservation	12	90	13%	1	3	$1,384	3	5	4	5	5	26
			New Well(s) (Ogallala Carson)	100		111%	5	3	$1,140	3	4	4	4	4	27
Childress	Childress	Red	Conservation	16	0	N/A	5	3	$1,240	3	5	4	5	5	30
Red River Authority of Texas	Childress, Collingsworth, Donley and Hall	Red	Conservation	8	0	N/A	5	3	$1,454	3	5	4	5	5	30
Irrigation	Childress	Red	Conservation	2,486	0	N/A	5	3	$87	5	5	5	5	5	33
Wellington	Collingsworth	Red	Conservation	5	174	3%	1	3	$1,779	3	5	4	5	5	26
			Nitrate Treatment	174		100%	4	4	$3,431	1	4	4	5	3	25
Irrigation	Collingsworth	Red	Conservation	7,646	18,928	40%	2	3	$87	5	5	5	5	5	30
Dalhart	Dallam and Hartley	Canadian	Conservation	35	0	N/A	5	3	$659	4	5	4	5	5	31
Texline	Dallam	Canadian	Conservation	2	0	N/A	5	3	$3,221	1	5	4	5	5	28
Irrigation	Dallam	Canadian	Conservation	75,556	156,912	48%	2	3	$87	5	5	5	5	5	30
Clarendon	Donley	Red	Conservation	5	0	N/A	5	3	$1,768	3	5	4	5	5	30
Irrigation	Donley	Red	Conservation	5,244	0	N/A	5	3	$87	5	5	5	5	5	33
McLean	Gray	Red	Conservation	2	0	N/A	5	3	$2,805	2	5	4	5	5	29
Pampa	Gray	Canadian	Conservation	53	1,092	5%	1	3	$362	5	5	4	5	5	28
			Water Audit & Leak Repair	176		16%	1	3	$1,150	3	5	4	5	5	26
			CRMWA Strategies	1,242		>100%	5	3	$0	5	4	4	4	4	29
			Aquifer Storage and Recovery	500		46%	2	3	$580	4	4	4	4	4	25
Irrigation	Gray	Red and Canadian	Conservation	7,835	0	>100%	5	3	$87	5	5	5	5	5	33
Memphis	Hall	Red	Conservation	6	0	N/A	5	3	$1,756	3	5	4	5	5	30
Irrigation	Hall	Red	Conservation	5,469	15,780	35%	2	3	$87	5	5	5	5	5	30
County-Other, Hall (Brice-Lesley)	Hall	Red	Advanced Metering Infrastructure	2	0	N/A	5	3	$2,613	2	5	4	5	5	29
	Hall	Red	Water Audit & Leak Repair	3	0	N/A	5	3	$2,932	2	5	4	5	5	29
Gruver	Hansford	Canadian	Conservation	4	107	4%	1	3	$1,866	3	5	4	5	5	26
			New Well(s) (Ogallala Hansford)	110		>100%	5	4	$773	4	4	4	4	4	29
Spearman	Hansford	Canadian	Conservation	10	0	N/A	5	3	$1,346	3	5	4	5	5	30
Irrigation	Hansford	Canadian	Conservation	46,748	0	N/A	5	3	$87	5	5	5	5	5	33
Hartley WSC	Hartley	Canadian	Conservation	1	0	N/A	5	3	$3,327	1	5	4	5	5	28
Irrigation	Hartley	Canadian	Conservation	84,521	229,447	37%	2	3	$87	5	5	5	5	5	30
Livestock	Hartley	Canadian	New Well(s) (Dockum Hartley)	1,200	2,319	52%	3	3	$632	4	4	4	4	4	26
			New Well(s) (Ogallala and Rita Blanca Hartley)	1,200		52%	3	3	$196	5	4	4	4	4	27
Canadian	Hemphill	Canadian	Conservation	7	0	N/A	5	3	$1,490	3	5	4	5	5	30
			New Well(s) (Ogallala Hemphill)	725	0	N/A	5	3	$637	4	4	4	4	4	28
Irrigation	Hemphill	Canadian and Red	Conservation	701	0	N/A	5	3	$87	5	5	5	5	5	33
Stinnett	Hutchinson	Canadian	Conservation	5	50	10%	1	3	$2,011	2	5	4	5	5	25
			New Well(s) (Ogallala Hutchinson)	50		>100%	5	2	$2,620	2	4	4	4	4	25
TCW Supply	Hutchinson	Canadian	Conservation	4	0	N/A	5	3	$2,179	2	5	4	5	5	29
Irrigation	Hutchinson	Canadian	Conservation	16,099	1,980	>100%	5	3	$87	5	5	5	5	5	33
Manufacturing	Hutchinson	Candian	Additional Supplies from Borger	3,951	1,805	>100%	5	3	$0	5	5	4	4	4	30
Booker	Lipscomb and Ochiltree	Canadian	Conservation	4	114	4%	1	3	$2,092	2	5	4	5	5	25
			New Well(s) (Ogallala Lipscomb)	111		>100%	5	5	$350	5	4	4	4	4	31

Water Management Strategy Evaluation Matrix

Entity	County Used	Basin Used	Strategy	Quantity (Ac Ft/Yr)	Maximum Need	Percentage of Max Need Met	Quantity Score	Reliability	Annual Cost ($/Ac Ft)	Cost Score	Environmental Factors	Impacts of Strategy on: Agricultural Resources/ Rural Areas	Other Natural Resources	Key Water Quality Parameters	Overall Score (5-40)
Darrouzett	Lipscomb	Canadian	Conservation	1	0	N/A	5	3	$5,582	1	5	4	5	5	28
			Water Audit & Leak Repair	4		N/A	5	3	$2,577	2	5	4	5	5	29
Follett	Lipscomb	Canadian	Conservation	1	0	N/A	5	3	$5,764	1	5	4	5	5	28
Higgins	Lipscomb	Canadian	Conservation	1	0	N/A	5	3	$5,626	1	5	4	5	5	28
			Water Audit & Leak Repair	6		N/A	5	3	$1,925	3	5	4	5	5	30
Irrigation	Lipscomb	Canadian	Conservation	6,482	0	N/A	5	3	$87	5	5	5	5	5	33
Manufacturing	Lipscomb	Canadian	Additional Supplies from Booker	247	247	100%	4	3	$0	5	5	4	4	4	29
Cactus	Moore	Canadian	Conservation	9	380	2%	1	3	$1,379	3	5	4	5	5	26
			New Well(s) (Ogallala Moore)	320		>100%	5	4	$253	5	4	4	4	4	30
Dumas	Moore	Canadian	Conservation	46	1,869	2%	1	3	$424	5	5	4	5	5	28
			New Well(s) (Ogallala Hartley)	1,827		98%	4	4	$268	5	4	4	4	4	29
Sunray	Moore	Canadian	Conservation	5	0	N/A	5	3	$1,713	3	5	4	5	5	30
County-Other	Moore	Canadian	Additional Supplies from Dumas	33	0	N/A	5	3	$0	5	5	4	5	5	32
Irrigation	Moore	Canadian	Conservation	42,940	72,883	59%	3	3	$87	5	5	5	5	5	31
Livestock	Moore	Canadian	New Well(s) (Ogallala Moore)	8,302	9,803	85%	4	3	$202	5	4	4	4	4	28
Manufacturing	Moore	Canadian	New Well(s) (Ogallala Moore)	2,000	4,190	48%	2	3	$283	5	4	4	3	4	25
			New Well(s) (Dockum Moore)	563		13%	1	3	$347	5	4	4	4	4	25
			Additional Supplies from Cactus	1,454		35%	2	3	$0	5	5	4	4	4	27
Perryton	Ochiltree	Canadian	Conservation	31	575	5%	1	3	$680	4	5	4	5	5	27
			New Well(s) (Ogallala Ochiltree)	575		100%	4	5	$1,520	3	4	3	4	4	27
Irrigation	Ochiltree	Canadian	Conservation	21,969	0	N/A	5	3	$87	5	5	5	5	5	33
Vega	Oldham	Canadian	Conservation	2	0	N/A	5	3	$2,349	2	5	4	5	5	29
			Water Audit & Leak Repair	7		N/A	5	3	$2,127	2	5	4	5	5	29
Irrigation	Oldham	Canadian and Red	Conservation	1,284	0	N/A	5	3	$87	5	5	5	5	5	33
County-Other	Oldham	Canadian and Red	Conservation	1	0	N/A	5	3	$95,536	1	5	4	5	5	28
Irrigation	Potter	Canadian and Red	Conservation	468	0	N/A	5	3	$87	5	5	5	5	5	33
Manufacturing	Potter	Canadian and Red	Contractual Supplies from Amarillo	5,348	5,007	>100%	5	2	$0	5	5	4	4	4	29
County-Other	Potter	Canadian and Red	Conservation	30	0		1	3	$611	4	5	4	5	5	27
Canyon	Randall	Red	Conservation	115	2,991	4%	1	3	$803	4	5	4	5	5	27
			New Well(s) (Ogallala Randall)	1,500		50%	3	3	$466	5	4	4	4	4	27
			New Well(s) (Dockum Randall)	1,500		50%	3	3	$413	5	4	4	4	4	27
			Additional Supplies from Amarillo	434		15%	1	3	$0	5	5	4	4	4	26
Lake Tanglewood	Randall	Red	Conservation	2	0	N/A	5	3	$5,961	1	5	4	5	5	28
Irrigation	Randall	Red	Conservation	3,482	9,353	37%	2	3	$87	5	5	5	5	5	30
Manufacturing	Randall	Red	Contractual Supplies from Amarillo	641	641	100%	4	3	$0	5	4	4	4	4	28
County-Other	Randall	Red	Additional Supplies from Amarillo	10	0		1	3	$0	5	5	4	4	4	26
Miami	Roberts	Canadian	Conservation	2	44	5%	1	3	$3,143	1	5	4	5	5	24
			New Well(s) (Ogallala Roberts)	45		>100%	5	3	$2,511	2	4	4	4	4	26
Irrigation	Roberts	Canadian and Red	Conservation	2,162	0	N/A	5	3	$87	5	5	5	5	5	33
Stratford	Sherman	Canadian	Conservation	5	326	2%	1	3	$1,688	3	5	4	5	5	26
			New Well(s) (Ogallala Sherman)	326		100%	4	3	$423	5	4	4	4	4	28
Texhoma	Sherman	Canadian	Conservation	1	0	N/A	5	3	$6,092	1	5	4	5	5	28
Irrigation	Sherman	Canadian	Conservation	73,626	59,073	>100%	5	3	$87	5	5	5	5	5	33
Shamrock	Wheeler	Red	Conservation	5	127	4%	1	3	$1,689	3	5	4	5	5	26
			New Well(s) (Ogallala Wheeler)	127		100%	4	5	$638	4	4	4	4	4	29
Wheeler	Wheeler	Red	Conservation	4	292	1%	1	3	$1,813	3	5	4	5	5	26
			New Well(s) (Ogallala Wheeler)	290		>100%	5	5	$1,193	3	4	4	4	4	29
Irrigation	Wheeler	Red	Conservation	2,788	0	N/A	5	3	$87	5	5	5	5	5	33
Major Water Providers:															
			Advanced Metering Infrastructure	1,437		6%	1	3	$1,688	3	4	4	5	5	25
			Conservation	1,157		5%	1	3	$497	5	5	4	5	5	28
			Water Audit & Leak Repair	2,466		10%	1	3	$1,827	3	5	4	5	5	26

Water Management Strategy Evaluation Matrix

Entity	County Used	Basin Used	Strategy	Quantity (Ac Ft/Yr)	Maximum Need	Percentage of Max Need Met	Quantity Score	Reliability	Annual Cost ($/Ac Ft)	Cost Score	Environmental Factors	Impacts of Strategy on: Agricultural Resources/ Rural Areas	Other Natural Resources	Key Water Quality Parameters	Overall Score (5-40)
Amarillo	Potter and Randall	Red and Canadian	Potter/Carson Co. Well Field	5,560	24,679	23%	1	4	$608	5	4	3	3	4	24
			Roberts Co. Well Field (shared CRMWA II capacity)	5,032		20%	1	5	$3,921	1	4	4	4	4	23
			Aquifer Storage and Recovery	6,500		N/A	3	3	$286	5	4	4	4	4	27
			Direct Potable Reuse	2,787		11%	1	5	$5,197	1	4	4	2	4	21
			CRMWA Strategies	9,477		38%	2	3	$0	5	4	4	4	4	26
Borger	Hutchinson	Canadian	Conservation	38	912	4%	1	3	$404	5	5	4	5	5	28
			New Well(s) (Ogallala Hutchinson)	572		63%	3	2	$173	5	4	4	4	4	26
			CRMWA Strategies	307		34%	2	3	$0	5	4	4	4	4	26
CRMWA			Replace Well Capacity for CRMWA I and II	24,691	64,858	38%	2	5	$110	5	4	4	4	4	28
			Expand Groundwater and Delivery Capacity (CRMWA II)	65,000		>100%	5	5	$1,054	3	4	4	4	4	29
			Brush Control	2,500		4%	1	2	$40	5	4	3	4	4	23
			Aquifer Storage and Recovery	17,000		N/A	5	3	$398	5	4	4	4	4	29
			Desalination of Lake Meredith Water	9,500		N/A	5	5	$3,325	1	4	3	4	4	26
			Linear Well Field Along Existing Transmission System	2,700		4%	1	3	$536	4	0	0	4	4	16
Greenbelt MIWA			Donley Co. Well Field	2,692	0	>100%	5	3	$1,262	3	4	3	4	4	26

Quantified Environmental Impact Matrix

											Quantity (Ac Ft/Yr)									Agricultural Impacts	
Entity	County	Basin	Strategy	Acres Impacted	Wetland Acres	Acres Impacted Score	Envir Water Needs	Envir Water Needs Score	Habitat	Habitat Score	Threat and Endanger Species	Threat and Endanger Species Score	Cultural Resources	Cultural Resources Score	Bays & Estuaries	Bays & Estuaries Score	Envir Water Quality	Overall Environmental Impacts	Temporary	Permanent	Score
Claude	Armstrong	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Armstrong	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Groom	Carson	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Carson	Canadian and Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Panhandle	Carson	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			Water Audit & Leak Repair	0	N/A	5	Positive		None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Carson)	1	N/A	4	Low	3	None	4	9	4	Low	3	N/A	5	4	4	0	0	4
White Deer	Carson	Canadian and Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Fritch	Carson, Hutchinson and Moore	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Carson)	3	N/A	4	Low	3	None	4	9	4	Low	3	N/A	5	4	4	0	0	4
Childress	Childress	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Red River Authority of Tex	Childress, Collingsworth, Donley and Hall	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Childress	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Wellington	Collingsworth	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			Nitrate Treatment	2	N/A	4	Low	3	None	4	8	4	Low	3	N/A	5	3	4	0	0	4
Irrigation	Collingsworth	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Dalhart	Dallam and Hartley	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Texline	Dallam	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Dallam	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Clarendon	Donley	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Donley	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
McLean	Gray	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Pampa	Gray	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			Water Audit & Leak Repair	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			CRMWA Strategies	0	N/A	5	Low	3	None	4	N/A	5	N/A	5	N/A	5	4	4	0	0	4
			Aquifer Storage and Recovery	1	N/A	4	Low	3	Low	3	9	4	Low	3	N/A	5	4	4	0	0	4
Irrigation	Gray	Red and Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Memphis	Hall	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Hall	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
County-Other, Hall (Brice-Lesley)	Hall	Red	Advanced Metering Infrastructure	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
	Hall	Red	Water Audit & Leak Repair	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Gruver	Hansford	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Hansford)	3	N/A	4	Low	3	None	4	7	4	Low	3	N/A	5	4	4	0	0	4
Spearman	Hansford	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Hansford	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Hartley WSC	Hartley	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Hartley	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Livestock	Hartley	Canadian	New Well(s) (Dockum Hartley)	30	N/A	4	Low	3	None	4	8	4	Low	3	N/A	5	4	4	0	3	4
			New Well(s) (Ogallala and Rita Blanca Hartley)	4	N/A	4	Low	3	None	4	8	4	Low	3	N/A	5	4	4	0	0	4
Canadian	Hemphill	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Hemphill)	0	N/A	5	Low	3	None	4	10	4	N/A	5	N/A	5	4	4	0		4
Irrigation	Hemphill	Canadian and Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Stinnett	Hutchinson	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Hutchinson)	3	N/A	4	Low	3	None	4	10	4	Low	3	N/A	5	4	4	0	0	4
TCW Supply	Hutchinson	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Hutchinson	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Manufacturing	Hutchinson	Canadian	Additional Supplies from Borger	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	4	5	0	0	4
Booker	Lipscomb and Ochiltree	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Lipscomb)	3	N/A	4	Low	3	None	4	8	4	Low	3	N/A	5	4	4	0	0	4
Darrouzett	Lipscomb	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			Water Audit & Leak Repair	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4

Quantified Environmental Impact Matrix

Entity	County	Basin	Strategy	Acres Impacted	Wetland Acres	Acres Impacted Score	Envir Water Needs	Envir Water Needs Score	Habitat	Habitat Score	Threat and Endanger Species	Threat and Endanger Species Score	Cultural Resources	Cultural Resources Score	Bays & Estuaries	Bays & Estuaries Score	Envir Water Quality	Overall Environmental Impacts	Agricultural Impacts: Temporary	Agricultural Impacts: Permanent	Agricultural Impacts: Score
											Quantity (Ac Ft/Yr)										
Follett	Lipscomb	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Higgins	Lipscomb	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			Water Audit & Leak Repair	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Lipscomb	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Manufacturing	Lipscomb	Canadian	Additional Supplies from Booker	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	4	5	0	0	4
Cactus	Moore	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Moore)	3	N/A	4	Low	3	None	4	7	4	Low	3	N/A	5	4	4	0	0	4
Dumas	Moore	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Hartley)	7	N/A	4	Low	3	None	4	8	4	Low	3	N/A	5	4	4	0	1	4
Sunray	Moore	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
County-Other	Moore	Canadian	Additional Supplies from Dumas	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Moore	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Livestock	Moore	Canadian	New Well(s) (Ogallala Moore)	14	N/A	4	Low	3	None	4	7	4	Low	3	N/A	5	4	4	0	1	4
Manufacturing	Moore	Canadian	New Well(s) (Ogallala Moore)	9	N/A	4	Low	3	None	4	7	4	Low	3	N/A	5	4	4	0	1	4
			New Well(s) (Dockum Moore)	5	N/A	4	Low	3	None	4	7	4	Low	3	N/A	5	4	4	0	1	4
			Additional Supplies from Cactus	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	4	5	0	0	4
Perryton	Ochiltree	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Ochiltree)	68	N/A	3	Low	3	Low	3	8	4	Low	3	N/A	5	4	4	0	7	3
Irrigation	Ochiltree	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Vega	Oldham	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			Water Audit & Leak Repair	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Oldham	Canadian and Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
County-Other	Oldham	Canadian and Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Potter	Canadian and Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Manufacturing	Potter	Canadian and Red	Contractual Supplies from Amarillo	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	4	5	0	0	4
County-Other	Potter	Canadian and Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Canyon	Randall	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Randall)	4	N/A	4	Low	3	None	4	4	4	Low	3	N/A	5	4	4	0	0	4
			New Well(s) (Dockum Randall)	4	N/A	4	Low	3	None	4	4	4	Low	3	N/A	5	4	4	0	0	4
			Additional Supplies from Amarillo	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	4	5	0	0	4
Lake Tanglewood	Randall	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Randall	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Manufacturing	Randall	Red	Contractual Supplies from Amarillo	0	N/A	5	Low	3	None	4	N/A	5	N/A	5	N/A	5	4	4	0	0	4
County-Other	Randall	Red	Additional Supplies from Amarillo	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	4	5	0	0	4
Miami	Roberts	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Roberts)	3	N/A	4	Low	3	None	4	10	4	Low	3	N/A	5	4	4	0	0	4
Irrigation	Roberts	Canadian and Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Stratford	Sherman	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Sherman)	3	N/A	4	Low	3	None	4	5	4	Low	3	N/A	5	4	4	0	0	4
Texhoma	Sherman	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
Irrigation	Sherman	Canadian	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Shamrock	Wheeler	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Wheeler)	3	N/A	4	Low	3	None	4	8	4	Low	3	N/A	5	4	4	0	0	4
Wheeler	Wheeler	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			New Well(s) (Ogallala Wheeler)	20	N/A	4	Low	3	None	4	8	4	Low	3	N/A	5	4	4	0	0	4
Irrigation	Wheeler	Red	Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	5
Amarillo	Potter and Randall	Red and Canadian	Advanced Metering Infrastructure	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	0	4	0	0	4
			Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			Water Audit & Leak Repair	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4
			Potter/Carson Co. Well Field	132	N/A	3	None	4	Low	3	8	4	Low	3	N/A	5	4	4	0	13	3
			Roberts Co. Well Field (shared	495	N/A	3	None	4	Low	3	10	4	Low	3	N/A	5	4	4	0	0	4
			Aquifer Storage and Recovery	37	N/A	4	None	4	None	4	4	4	Low	3	N/A	5	4	4	0	4	4
			Direct Potable Reuse	44	N/A	4	Low	3	None	4	4	4	Low	3	N/A	5	4	4	0	4	4
			CRMWA Strategies	0	N/A	5	Low	3	None	4	N/A	5	N/A	5	N/A	5	4	4	0	0	4
			Conservation	0	N/A	5	Positive	5	None	4	N/A	5	N/A	5	N/A	5	5	5	0	0	4

Quantified Environmental Impact Matrix

Entity	County	Basin	Strategy	Acres Impacted	Wetland Acres	Acres Impacted Score	Envir Water Needs	Envir Water Needs Score	Habitat	Habitat Score	Quantity (Ac Ft/Yr) Threat and Endanger Species	Threat and Endanger Species Score	Cultural Resources	Cultural Resources Score	Bays & Estuaries	Bays & Estuaries Score	Envir Water Quality	Overall Environmental Impacts	Agricultural Impacts Temporary	Permanent	Score
Borger	Hutchinson	Canadian	New Well(s) (Ogallala Hutchinson)	22	N/A	4	Low	3	Low	3	10	4	Low	3	N/A	5	4	4	0	2	4
			CRMWA Strategies	0	N/A	5	Low	3	None	4	N/A	5	N/A	5	N/A	5	4	4	0	0	4
CRMWA			Replace Well Capacity for CRMWA I and II	15	N/A	4	Low	3	None	4	10	4	Low	3	N/A	5	4	4	0	0	4
			Expand Groundwater and Delivery Capacity (CRMWA II)	548	N/A	3	Low	3	Low	3	10	4	Low	3	N/A	5	4	4	0	0	4
			Brush Control	500	N/A	3	Positive	5	Low	3	Varies	3	Low	3	N/A	5	4	4	0	50	3
			Aquifer Storage and Recovery	89	N/A	3	Low	3	Low	3	10	4	Low	3	N/A	5	4	4	0	0	4
			Desalination of Lake Meredith Water	22	N/A	4	Low	3	None	4	10	4	Low	3	N/A	5	4	4	0	2	4
			Linear Well Field Along Existing Transmission System	53	N/A	3	Low	3	Low	3	52	1	Low	3	N/A	5	4	3	0	5	3
Greenbelt MIWA			Donley Co. Well Field	168	N/A	3	Low	3	Low	3	8	4	Low	3	N/A	5	4	4	0	17	3

ATTACHMENT 5-3

PER CAPITA WATER USE GOALS

Gallons per Capita per Day (GPCD) Goals

WUG	2030	2040	2050	2060	2070	2080
Amarillo	179	178	178	178	178	178
Booker	248	247	247	247	247	247
Borger	254	254	254	254	254	254
Cactus Municipal Water System	253	252	252	252	252	252
Canadian	226	225	225	225	225	225
Canyon	212	212	211	211	211	211
Childress	223	223	223	223	223	223
Clarendon	154	154	154	154	154	154
Claude Municipal Water System	259	258	259	259	259	259
Dalhart	264	263	263	263	263	263
Darrouzett	251	250	252	251	250	250
Dumas	181	180	180	180	180	180
Follett	262	261	262	263	263	261
Fritch	236	235	235	235	235	235
Groom Municipal Water System	271	271	271	270	270	270
Gruver	295	294	294	294	294	294
Hartley WSC	339	336	337	338	338	337
Higgins Municipal Water System	237	239	235	235	239	236
Lake Tanglewood	395	393	394	393	395	392
McLean Municipal Water Supply	236	236	235	236	236	236
Memphis	140	140	139	139	139	140
Miami	319	318	320	318	320	319
Oldham County-Other	257	257	259	255	262	265
Pampa Municipal Water System	164	163	163	163	163	163
Pandhandle Municipal Water System	198	198	198	198	198	198
Perryton Municipal Water System	253	252	252	252	252	252
Potter County-Other	152	152	152	152	152	152
Red River Authority of Texas	212	212	212	212	212	212
Shamrock Municipal Water System	151	151	151	151	151	151
Siesta Estates	309	309	310	309	309	310
Spearman Municipal Water System	247	246	246	246	246	246
Stinnett	198	197	197	197	197	197

Gallons per Capita per Day (GPCD) Goals

WUG	2030	2040	2050	2060	2070	2080
Stratford	288	287	287	287	287	287
Sunray	197	196	196	196	196	196
TCW Supply	636	635	636	635	635	636
Texhoma	336	334	334	333	336	336
Texline	340	337	339	337	337	338
Turkey Municipal Water System	313	315	315	312	312	315
Vega	245	245	245	245	245	245
Wellington Municipal Water System	195	195	194	195	195	195
Wheeler	268	268	268	268	268	268
White Deer	237	236	236	236	236	236

6 IMPACTS OF THE REGIONAL WATER PLAN

The purpose of this chapter is to describe the overall potential impacts of the recommended 2026 Panhandle Water Plan and document how the Water Plan is consistent with the long-term protection of the state's water resources, agricultural resources, and natural resources. This requirement is found in 31 TAC Chapter 357.41, which states:

"RWPGs shall describe how RWPs are consistent with the long-term protection of the state's water resources, agricultural resources, and natural resources as embodied in the guidance principles in §358.3(4) and (8) of this title (relating to Guidance Principles)."

More specifics of this evaluation is outlined in 31 TAC Chapter 357.40, which requires each regional water plan to include a description of how the water plan impacts the state's agricultural and rural areas, natural resources, other water resources, assessing the socio-economic impacts of not meeting the water needs and impacts on navigation. The water plan should also identify key parameters of water quality and describe how implementing the water plan could affect these parameters.

This chapter addresses each of these requirements for both recommended and alternative water management strategies. Additionally, the chapter will specifically address consistency of the 2026 Panhandle Water Plan with the state's water planning requirements. To demonstrate compliance with the state's requirements, a matrix has been developed and is included in **Appendix E**.

6.1 Potential Impacts of Water Management Strategies on Key Water Quality Parameters

Water quality plays an important role in determining the availability of water supplies to meet current and future water needs in the region. Evaluations of the potential impacts to water quality by each potential water management strategy are discussed in **Chapter 5**. This chapter describes the key water quality parameters for the surface water and groundwater sources in the region, identifies specific water quality concerns or issues, and discusses potential impacts on water quality associated with the recommended and alternative water management strategies.

The key water quality parameters to be evaluated are dependent on the type of water management strategy. Strategies recommended for municipal use must meet drinking water standards, while water used for non-municipal purposes may not. Source water quality for strategies can have an impact on key water quality parameters of the region's water sources depending on potential use and/or discharge of the water.

Surface water sources in the PWPA include Greenbelt Reservoir and Lake Meredith. Water quality in Greenbelt Reservoir is generally good but can contain elevated total dissolved solids (TDS) when lake levels are low (including chlorides and sulphates). The water quality in Lake Meredith has declined over the past decade due to extreme drought and low inflows. CRMWA is supplementing the water from Lake Meredith with groundwater from Roberts County to improve the quality of the water delivered from the lake. Lake Meredith is also included on the State of Texas Clean Water Act

Section 303(d) list for mercury in fish. Elevated salt contents, expressed in TDS, is also prevalent in many of the local rivers and streams in the PWPA.

Groundwater resources in the Panhandle region are generally potable, although region-wide up to approximately thirteen percent of the groundwater may be brackish. Groundwater quality issues in the region are generally related to elevated concentrations of nitrate, chloride, and TDS. Sources of elevated nitrate include cultivation of soils and domestic and animal sources. Higher concentrations of nitrate are typically found near agricultural areas and outcrop areas of the aquifer. Elevated concentrations of chloride are due to dissolution of evaporite minerals and upwelling from underlying, more brackish groundwater formations. Elevated concentrations of TDS are primarily the result of the lack of sufficient recharge and restricted circulation. Together, these limit the flushing action of fresh water moving through the aquifers.

Groundwater sources with known elevated concentrations of nitrates include the Seymour aquifer in the southeastern part of the region and parts of the Ogallala and Dockum aquifers, specifically in the heavily irrigated counties. High TDS levels occur throughout the Blaine and Dockum aquifers. Also, much of the Whitehorse formation and Other aquifers have elevated TDS levels, which limits their use.

Table 6-1 summarizes the most pertinent water quality parameters in the PWPA for the types of strategies proposed in this plan.

Table 6-1: Key Water Quality Parameters by Water Management Strategy Type[1]

Water Quality Parameter	Water Conservation	Reuse	Voluntary Transfer	New or Expanded Groundwater	Brush Control	Conjunctive Use	Advanced Treatment
Total dissolved solids (TDS)	+	+ / -	+ / -		+ / -	+	-
Alkalinity	+					+	
Hardness	+					+	
Dissolved Oxygen (DO)	+	+ / -	+ / -		+ / -	+	
Nitrogen	+	+ / -	+ / -		+ / -	+	-
Phosphorus	+	+ / -	+ / -		+ / -	+	
Radionuclides				-			
Metals[2]		+	-[2]	-[2]			-[2]

[1] A positive sign (+) indicates a potential positive impact. A negative sign (-) indicates a potential negative impact. If both signs are shown, the strategy could have either a positive or negative impact. Water management strategies with no potential impacts to water quality are not shown in this table.
[2] Only for specific metals where there are significant discharges of the metal.

The implementation of specific strategies can potentially impact both the physical and chemical characteristics of water resources in the region. The following is an assessment of the characteristics of each strategy type that may affect water quality and an identification of the specific water quality parameters that could be affected based on those characteristics. This assessment found that the implementation of water management strategies recommended in **Chapter 5** of the Panhandle Water Plan is not expected to have negative impact on native water quality and may actually improve water quality through conservation.

6.1.1 Water Conservation

Water conservation is a recommended strategy for irrigation and municipal water use in the PWPA. Recommended irrigation conservation measures include improvements in the efficiency of irrigation equipment, irrigation scheduling, change in crop type, advances in plant breeding, and enhanced education. These recommended strategies are not expected to affect water quality adversely. The results should be beneficial because the demand on surface and groundwater resources will be decreased. Municipal conservation should have similar beneficial effects, but at a smaller scale.

6.1.2 Reuse

In general, there are three possible water quality effects associated with the reuse of treated wastewaters:

- There can be a reduction in instream flow if treated wastewaters are not returned to the stream that could reduce stream flows and affect parameters associated with lower flows, such as temperature, DO and TDS.
- Conversely, in some cases, reducing the volume of treated wastewater discharged to a stream could have a positive effect and improve levels of TDS, nutrients, DO, and possibly metals in the receiving stream.
- Reusing water multiple times and then discharging it can significantly increase the TDS concentration in the effluent and possibly the receiving stream.

These impacts will vary depending on the quality and quantity of treated wastewater that has historically been discharged to the stream and the existing quality and quantity of the receiving stream.

In the PWPA, only Amarillo has a reuse strategy. Currently Amarillo's treated effluent is sold to Xcel Energy for power generation and little, if any, wastewater is discharged to a stream.

6.1.3 Voluntary Transfers

Voluntary transfers are defined as new sales of water from one provider to another. The Panhandle Water Plan recommends new sales or increased contract amounts for Manufacturing in three counties and County Other in Hartley County. Sales to users under existing contracts are discussed with the respective project type.

Sales to others occur when a provider has sufficient supplies to meet these sales or contract increases. Impacts on key water quality parameters are expected to be low. Any increase in wastewater effluent associated with these sales would be negligible.

6.1.4 New and/or Expanded Use of Groundwater Resources

Increased use of groundwater can decrease instream flows if the base flow is supported by spring flow. This is not expected to be a concern for the recommended water management strategies in the PWPA. Most new groundwater development is from relatively deep portions of aquifers that most likely do not have significant impact on surface flows, such as Roberts County. A previous study conducted by the Bureau of Economic Geology concluded that no identifiable relationship can be found at this time relating increased pumping of the Ogallala to the deterioration of water quality (Freese and Nichols, Inc., 2006).

Increased use of groundwater has the potential to increase TDS concentrations in area streams if the groundwater sources have higher concentrations of TDS or hardness than local surface water and are discharged as treated effluent. This is not the case in most areas in PWPA since all but two municipal strategies propose to use water from the Ogallala aquifer which has low to moderate levels of TDS. The City of Canyon is developing additional groundwater from the Ogallala and Dockum aquifers. Canyon is in the Red River Basin, where naturally occurring salt seeps and high TDS waters are common, and discharges of slightly elevated TDS water will not impact these streams. In general, the discharges of wastewater from groundwater sources are not expected to impact streams in the PWPA.

6.1.5 Brush Control

Brush control is a recommended strategy for the Lake Meredith watershed. Impacts to the water quality of area streams will depend upon the methods employed to control the brush. It is assumed that chemical spraying will not be used near water sources. Mechanical removal, prescribed burns and use of the salt cedar beetle are the preferred methods near water sources. With these assumptions, chemical contamination of the water source is very low. Increases in stream flow due to reduced evapotranspiration associated with the removed brush should improve water quality in the Lake Meredith watershed.

6.1.6 Conjunctive Use

Conjunctive use is not a recommended strategy but is actively employed in the PWPA. Both CRMWA and Greenbelt MIWA conjunctively use surface water and groundwater. As more groundwater supplies are developed, this would allow the water providers to operate their lakes in a manner that minimizes impacts on key water quality parameters while still being able to provide sufficient supplies to its customers from groundwater.

6.1.7 Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) is a recommended strategy for CRMWA, Amarillo, and Pampa. This strategy proposes to treat surface water, reuse, and/or groundwater to comparable aquifer quality and then store the water for future use. The water is typically stored during low use periods and later recovered from the aquifer for use during periods of high demand. This allows for optimal sizing of transmission systems and reduces evaporative losses associated with reservoir storage, preserving water resources for future use. ASR, as part of a conjunctive use operation, may allow a reservoir operator to minimize impacts to key water quality parameters while still providing users with sufficient supplies from stored groundwater. It also may reduce long-term demands on groundwater sources, which can reduce deterioration of water quality in the aquifer. ASR is expected to have minimal impacts on key water quality parameters of water in the receiving aquifer because the water being pumped into the aquifer will not degrade the existing quality of the aquifer.

6.1.8 Advanced Treatment

Advanced treatment is recommended for City of Wellington for nitrate removal and CRMWA for desalination of Lake Meredith water. The waste stream from the advanced treatment from the Wellington facility would likely be discharged to a tributary of the Salt Fork of the Red River. For the CRMWA desalination strategy, the brine waste would be discharged back to Lake Meredith. TCEQ would need to issue a discharge permit that would protect the water quality of the receiving stream. The small amount of proposed discharge from the Wellington facility is not expected to have significant impact to key water quality parameters. The CRMWA desalination plant waste could increase the salinity in Lake Meredith near the discharge. If needed, the discharge could be routed downstream of the dam. Further study is needed to confirm the location of the treatment plant and discharge location.

6.2 Impacts of Moving Water from Agricultural and Rural Areas

The implementation of water management strategies recommended in **Chapter 5** of this regional plan is not expected to impact water supplies that are currently in use for agricultural purposes. The Ogallala water for agricultural purposes is estimated using the GAM based on current irrigated acreages. The water plan does not recommend taking any existing supplies from agricultural use for other uses. However, if such transfers occurred, they would be predicated on a willing buyer, willing seller basis. Most of the recommended water management strategies for municipal water users rely on developing existing water rights. The methodology for assessing the available supply from groundwater for this regional water plan respects current water use, which provides some protection to current agricultural and rural users.

6.3 Socio-Economic Impacts of Not Meeting Water Needs

The TWDB will provide a report on the socio-economic impacts of not meeting water needs. This report will be included in the final plan.

6.4 Other Potential Impacts

In accordance with Section 10 of the Rivers and Harbors Act of 1899, navigable waters are those waters that are subject to the ebb and flow of the tide and/or are presently being used or have been used in the past for use to transport interstate or foreign commerce. In the PWPA, the major rivers include the Canadian and Red Rivers. Neither of these rivers are considered navigable within the PWPA. Therefore, the Panhandle Water Plan does not have an impact on navigation.

The Panhandle Water Plan protects existing water contracts and option agreements by reserving the contracted amount included in those agreements where those amounts were known. In some cases, there were insufficient supplies to meet existing contracts. In those cases, the supply amount was reduced proportionately for each contract holder. For entities with needs, water management strategies were recommended to meet deficits in contractual obligations.

6.5 Consistency with the Protection of Water Resources

Water resources in the PWPA include surface water from the Canadian and Red River Basins and groundwater from two major and three minor aquifers. The primary water resource in the region is the Ogallala aquifer. Over 90 percent of the current water used in the region is from the Ogallala aquifer. Of the recommended strategies, 75 percent of the new water supply in 2080 is associated with conservation with irrigation conservation accounting for the majority. The remaining 25 percent is from additional development of the PWPA groundwater resources, surface water desalination, brush control, and reuse.

The protections of water resources were considered through the supply allocation process and development of water management strategies. For surface water, the distribution of supplies does not exceed the safe yield of the reservoir. This provides some water in the lakes through the drought of record and provides some protection from future droughts. For groundwater, the desired future conditions (DFCs) adopted by the Groundwater Management Areas (GMAs) were honored for both currently developed supplies and potential future strategies.

To be consistent with the long-term protection of water resources, the plan must recommend strategies that minimize threats to the region's sources of water over the planning period. The water management strategies identified in **Chapter 5** were evaluated for threats to water resources. The recommended strategies represent a comprehensive plan for meeting the needs of the region while effectively minimizing threats to water resources. **Section 6.5.1** to **Section 6.5.9** describe the major strategies and the ways in which they minimize threats.

6.5.1 Water Conservation

Strategies for water conservation have been recommended that will reduce the demand for water, thereby reducing the impact on the region's groundwater and surface water sources. Water conservation practices are expected to save approximately 97,000 acre-feet of water annually by 2030, reducing impacts on both groundwater and surface water resources. By 2080, the recommended conservation strategies savings total about 439,000 acre-feet per year. These savings are in addition to the water savings assumed in the demands.

6.5.2 Wastewater Reuse

This strategy, developed by Amarillo, will provide high quality treated wastewater effluent to meet water needs in the region. This strategy will decrease the future demands on surface and groundwater sources and will not have a major impact on water resources.

6.5.3 New or Expanded Use of Groundwater

This strategy is recommended for entities with limited alternative sources and available groundwater supplies to meet needs. Groundwater supplies do not exceed the MAG values that were determined to meet the desired future conditions of the groundwater source. These future conditions are considered protective of the water resource. Large transfers of groundwater may have potential impacts to local surface water and springs. Such impacts were considered during the evaluation of the strategies. Where possible, strategies were selected that minimized impacts to surface water.

6.5.4 Brush Control

Brush control is recommended for the Lake Meredith watershed. This strategy will support the surface water supplies for Lake Meredith by reducing losses associated with evapotranspiration of invasive brush.

6.5.5 Aquifer Storage and Recovery

Aquifer Storage and Recovery represents an important operational solution for managing supplies and minimizing evaporation. CRMWA, Amarillo, and Pampa are planning to use ASR to store surplus supplies during low demand periods for use during periods of high demands. This will provide operational flexibility for CRMWA and its customers by fully using the capacity in the pipeline from Roberts County and water treatment facilities. It also provides Amarillo increased usability of its Randall County well field. The ASR strategy is not expected to threaten water resources of the State, but rather to preserve surface water resources for future use and allow the use of groundwater in a more economical manner.

6.5.6 Advanced Treatment

Both the City of Wellington and CRMWA have recommended long-term strategies for advanced treatment of its water sources for municipal purposes. Advanced treatment allows both Wellington and CRMWA to use more of their existing sources rather than develop additional new sources of fresh water. In doing this, there is less use of other water resources.

6.6 Consistency with Protection of Agricultural Resources

Agricultural resources are an important component of the Panhandle economy and way of life. According to the 2022 Census of Agriculture, the PWPA has approximately 12.5 million acres devoted to agricultural production with 8.7 million acres in permanent pasture and the remaining 3.8 million acres utilized as cropland. Five counties (Dallam, Hansford, Hartley, Moore, and

Sherman) accounted for approximately 76 percent of the total irrigation water applied in 2021 (TWDB, 2024).

The greatest needs identified in the PWPA are associated with irrigated agriculture. The plan assumes a level of demand reduction over time due to reduced groundwater availability. Water management strategies for irrigated agriculture include a suite of strategies to conserve irrigation water. These strategies will reduce the projected deficit in the heavily irrigated counties and preserve water supplies for future use in the counties with no identified needs. The Panhandle Water Plan also considered the development of new groundwater for irrigation, but there are limited supplies in areas with needs. Also, since groundwater generally is not transported for irrigation purposes, farms would need to be located in areas with groundwater supplies and there is great uncertainty if these areas can support farming. The transfer of agricultural water for other purposes would only occur on a willing buyer, willing seller basis.

6.7 Consistency with Protection of Natural Resources

The PWPA contains many natural resources and the water management strategies recommended in this plan are intended to protect those resources while still meeting the projected water needs of the region. The impacts of recommended strategies on specific resources are discussed below.

6.7.1 Threatened and Endangered Species

The abundance and diversity of wildlife in the PWPA is influenced by vegetation and topography, with areas of greater habitat diversity having the potential for more wildlife species.

The presence or potential occurrence of threatened or endangered species is an important consideration in planning and implementing any water resource project or water management strategy. Both the state and federal governments have identified species that need protection. Species listed by the U.S. Fish and Wildlife Service (USFWS) are afforded the most legal protection, but the Texas Parks and Wildlife Department (TPWD) also has regulations governing state-listed species. As detailed in **Chapter 1**, there are 15 state or federally protected species which have the potential to occur within the PWPA. This does not include species that are currently in recovery or species that are considered rare or otherwise of special concern.

The proposed infrastructure strategies in the Panhandle Water Plan can be designed to avoid and/or minimize impacts to threatened and endangered species. Most of the recommended strategies include the development or expansion of groundwater, which has flexibility in the placement of wells and pipelines. The recommended conservation strategies in the Panhandle Water Plan will continue to preserve water for wildlife. Brush control activities could potentially impact habitat for wildlife, including threatened and endangered species. However, the proposed methods can be implemented to minimize impacts. Also, the expected increase in stream flow from brush removal will provide water for these species.

6.7.2 Parks and Public Lands

The PWPA contains over 103,000 acres of protected parks and public lands. The PWPA is home to Palo Duro Canyon State Park, approximately 20,000 acres located in Armstrong and Randall Counties. Lake Meredith National Recreation Area, which encompasses the area surrounding Lake Meredith, is part of the National Park Service and offers recreational and ecological benefits to the region. The Alibates Flint Quarries National Monument located adjacent to the Lake Meredith Recreation Area is the only national monument in the State of Texas. Buffalo Lake National Wildlife Refuge is also located in the Region and is a valuable wintering area for migratory waterfowl. In addition to these lands, the PWPA contains three National Grasslands. These include Black Kettle National Grassland in Hemphill County, McClellan Creek National Grassland in Gray County and Rita Blanca National Grassland in Dallam County. No recommended strategies require water supply projects located within these areas. The implementation of water management strategies should not directly impact these lands.

6.7.3 Energy Reserves

The oil and gas industry represents an important economic base for the region with significant activities in the PWPA. There was renewed interest in the Granite Wash shale formation (Anadarko Basin) in the northeastern Panhandle, but this activity has declined. The projected water demands reflect the increased water needs for production of local energy reserves. The Panhandle Water Plan identifies sufficient water to meet these needs. None of the recommended water management strategies is expected to impact oil or gas production in the region.

6.8 Consistency with Protection of Public Health and Safety

Consistent with the guiding principles for regional water planning, the Panhandle Water Plan protects the public health and safety of current and future residents in the PWPA through the identification of water management strategies. The City of Cactus has limited supplies to serve future municipal needs in 2060-2080 without exceeding the MAG. This plan is unable to show the full supply amount expected from future groundwater development strategies for this entity because of this limitation. As a result, Cactus shows an unmet municipal need in this plan. Moore County as a whole is MAG limited in the later decades of the 2026 planning cycle, however, there does exist a surplus in the MAG in 2030 and 2040. It is feasible that this water not used in the early decades during non-drought years may be available for municipal use through subsequent joint planning efforts in later decades, avoiding impact on public health and safety. Cactus could also purchase water supplies from non-municipal users on a willing buyer/willing seller basis.

The PWPG is unaware of any plans to amend the plan to address the unmet municipal needs. However, conditions may change and cause an entity to request such a change, or the entity may choose to wait to incorporate any new information (such as modification of the MAGs) in the 2031 Regional Water Plans.

Conservation was considered and recommended as a strategy to help reduce the unmet needs and protect the human health and safety. Drought management was also considered but was not considered feasible for meeting long-term growth in demands. Instead, it is intended and encouraged to be used as means to reduce water usage during drought emergencies through the implementation of the entity's Drought Contingency Plan.

There are some unmet needs in the non-municipal categories, including livestock, manufacturing and irrigation. These needs may have socio-economic impacts but should not impact public health and safety.

6.9 Consistency with State Water Planning Guidelines

To be considered consistent with long-term protection of the State's water, agricultural, and natural resources, the PWPA water plan must also be in compliance with the following regulations:

- 31 TAC Chapter 357.35
- 31 TAC Chapter 357.40
- 31 TAC Chapter 357.41
- 31 TAC Chapter 358.3

The information, data, evaluation, and recommendations included in the 2026 Panhandle Water Plan collectively demonstrate compliance with these regulations. **Appendix E** presents a summary of the major components of the plan and references the regulations. The content of the 2026 Plan has been evaluated against the regulatory matrix in **Appendix E**.

6.10 Summary of Protections of State's Resources

The PWPG balanced meeting water needs with good stewardship of the water, agricultural, and natural resources within the region. During the strategy selection process, long-term protection of the State's resources was considered through the assessment of environmental impacts, impacts to agricultural and rural areas and impacts to natural resources.

In this plan, existing in-basin or region supplies were utilized as feasible before recommendations for new water supply projects. Wastewater reuse is an active water source to meet long-term power generation and future municipal water needs in the PWPA. The incorporation of aquifer storage and recovery further utilizes existing infrastructure and resources to meet projected water needs. The proposed conservation measures for the PWPA will continue to protect and conserve the State's resources for future water use.

Despite the best efforts to conserve and use the State's resources efficiently, the PWPA has unmet needs for irrigation throughout the PWPA and multiple uses in Moore County. Most of the irrigation unmet needs occur early in the planning cycle and decline as more water is saved through conservation. The other needs in Moore County (municipal, manufacturing, and livestock) occur after 2050 and increase as available supplies in the Ogallala decrease. The total amount of unmet water need for PWPA is shown in **Table 6-2**.

Table 6-2: PWPA Unmet Needs

County	WUG	2030	2040	2050	2060	2070	2080
Armstrong	Irrigation	0	0	0	0	(148)	(551)
Collingsworth	Irrigation	(14,416)	(14,749)	(13,561)	(12,119)	(11,471)	(11,423)
Dallam	Irrigation	(105,103)	(117,658)	(98,377)	(79,760)	(64,692)	(52,286)
Hall	Irrigation	(14,536)	(9,756)	(9,194)	(8,631)	(8,112)	(7,475)
Hartley	Irrigation	(154,700)	(186,470)	(160,847)	(136,832)	(116,977)	(99,439)
Moore	Cactus Municipal Water System	0	0	0	(105)	(211)	(322)
Moore	Manufacturing	0	0	(168)	(893)	(1,852)	(3,004)
Moore	Livestock	0	0	(538)	(2,449)	(4,222)	(5,923)
Moore	Irrigation	(57,601)	(51,037)	(40,924)	(30,477)	(21,192)	(12,504)
Oldham	Irrigation	(128)	0	0	0	0	0
Randall	Irrigation	0	(458)	(2,044)	(3,275)	(4,675)	(5,871)
Sherman	Irrigation	(18,912)	(21,352)	(5,536)	0	0	0
	Total	**(365,396)**	**(401,480)**	**(331,189)**	**(274,541)**	**(233,552)**	**(198,798)**

7 DROUGHT RESPONSE INFORMATION, ACTIVITIES, AND RECOMMENDATIONS

7.1 Drought Conditions and Droughts of Record

Numerous definitions of drought have been developed to describe drought conditions based on various factors and potential consequences. In the simplest of terms, drought can be defined as "a prolonged period of below-normal rainfall." However, the *State Drought Preparedness Plan* [1] provides more specific and detailed definitions:

- *Meteorological Drought*. A period of substantially diminished precipitation duration and/or intensity that persists long enough to produce a significant hydrologic imbalance.
- *Agricultural Drought*. Inadequate precipitation and/or soil moisture to sustain crop or forage production systems. The water deficit results in serious damage and economic loss to plant and animal agriculture. Agricultural drought usually begins after meteorological drought but before hydrological drought and can also affect livestock and other agricultural operations.
- *Hydrological Drought*. Refers to deficiencies in surface and subsurface water supplies. It is measured as stream flow, and as lake, reservoir, and groundwater levels. There is usually a lack of rain or snow and less measurable water in streams, lakes, and reservoirs, making hydrological measurements not the earliest indicators of drought.
- *Socioeconomic Drought*. Occurs when physical water needs start to affect the health, well-being, and quality of life of the people, or when the drought starts to affect the supply and demand of an economic product.

These definitions are not mutually exclusive and provide valuable insight into the complexity of droughts and their impacts. They also help to identify factors to be considered in the development of appropriate and effective drought preparation and contingency measures.

Definitions

Drought of Record: The worst drought to occur in a region during the entire period of hydrologic and/or meteorological record keeping.

Drought Contingency Plan: State-mandated plan that identifies different stages of drought and specific triggers and response for each stage. In addition, the plan must specify quantifiable targets for water use reductions for each stage, and a means and method for enforcement.

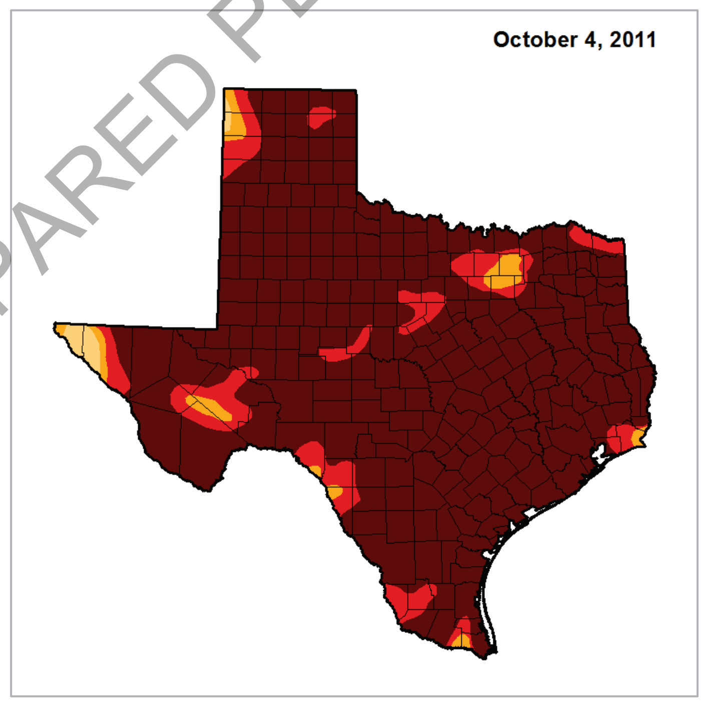
Run-of-River Supply: "Water right permit that allows the permit holder to divert water directly out of a stream or river." 2012 State Water Plan

Droughts have often been described as "insidious by nature." This is mainly due to several factors:

- Droughts cannot be accurately characterized by well-defined beginning or end points.
- Severity of drought-related impacts is dependent on antecedent conditions, as well as ambient conditions such as temperature, wind, and cloud cover.
- Droughts, depending on their severity, may have significant impacts on human activities; and human activities during periods of drought may exacerbate the drought conditions through increased water usage and demand.

Furthermore, the impact of a drought may extend well past the time when normal or above-normal precipitation returns.

Various indices have been developed in an attempt to quantify drought severity for assessment and comparative purposes. One numerical measure of drought severity that is frequently used by many federal and state government agencies is the Palmer Drought Severity Index (PDSI). It is an estimate of soil moisture that is calculated based on precipitation and temperature. Another is the Drought Monitor that incorporates measurements of climatic, hydrologic and soil conditions as well as site-specific observations and reports. The Drought Monitor is distributed weekly and is often the tool used to convey drought conditions to the public and water users. In 2011, most, if not all, of the counties in the PWPA experienced at least some periods of severe or extreme drought. Conditions have improved since 2011 with significant rainfalls in recent years, but some areas in the PWPA are still experiencing hydrological drought conditions. **Figure 7-1** shows the historical storage of PWPA reservoirs.



Drought Monitor, October 2011

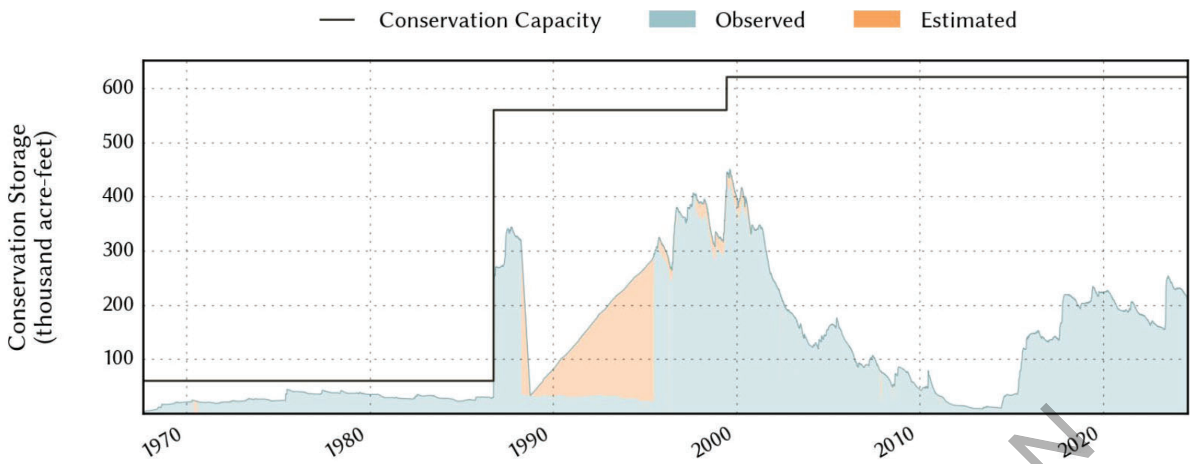


Figure 7-1: Combined Reservoir Storage in the PWPA

Source: Water Data For Texas: https://www.waterdatafortexas.org/reservoirs/region/panhandle

7.1.1 Drought of Record in the Panhandle Water Planning Area

The drought of record is commonly defined as the worst drought to occur in a region during the entire period of hydrologic and/or meteorological record keeping. Historically, for much of Texas the drought of record occurred from 1950 to 1957. During the 1950s drought, many wells, springs, streams, and rivers went dry, and some cities had to rely on water trucked in from other areas to meet drinking water demands. By the end of 1956, 244 of the 254 Texas counties were classified as disaster areas due to the drought.

For most of the PWPA, the current drought has eclipsed the drought of the 1950s. This drought has had a substantial impact on surface water supplies within the PWPA. All three major reservoirs in the PWPA are currently in the critical drought period. In 2011, Lake Meredith recorded the lowest historical inflow at approximately 6,300 acre-feet. Both Lake Meredith and Palo Duro Reservoir, which are in the Canadian River Basin, were at less than 10 percent until 2015. As of May 2024, Lake Meredith has improved to approximately 43 percent (**Figure 7-2**), and Palo Duro Reservoir remains at less than 10 percent (**Figure 7-3**). Greenbelt Reservoir, located in the Red River Basin, is approximately 9 percent full. (**Figure 7-4**).

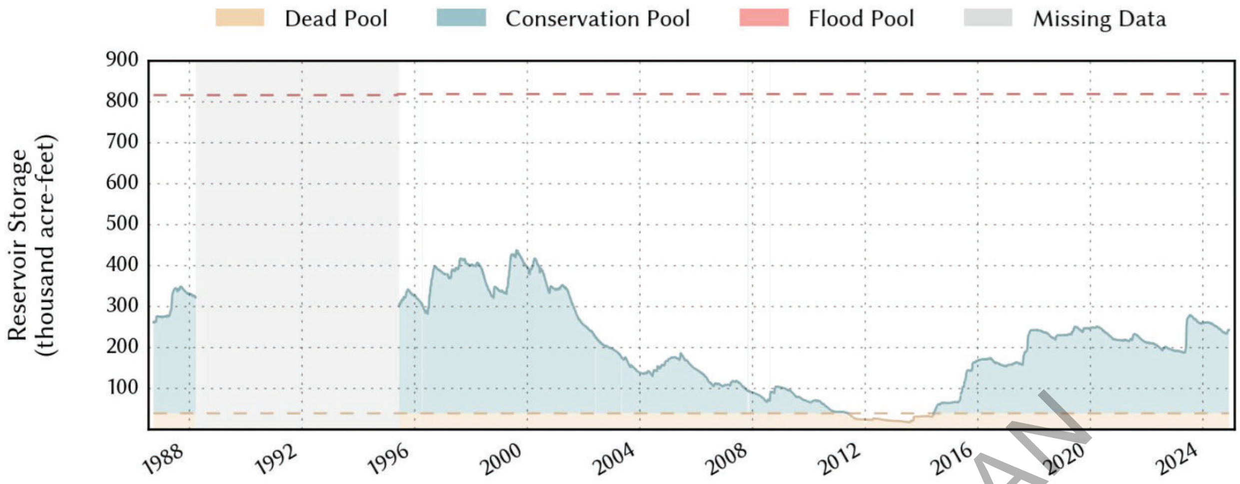


Figure 7-2: Historic Storage in Lake Meredith

Source: Water Data For Texas: https://www.waterdatafortexas.org/reservoirs/individual/meredith

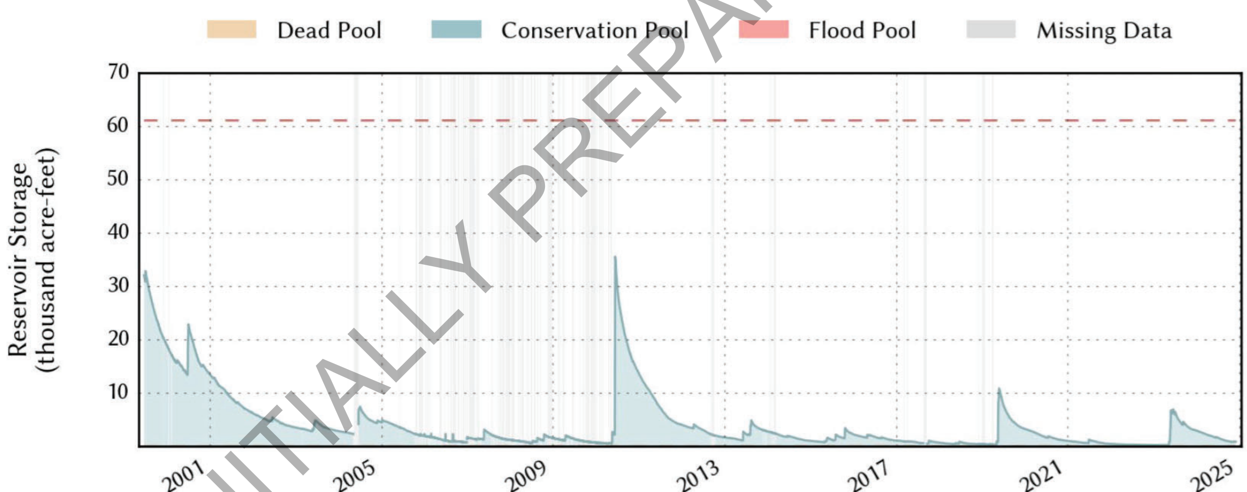


Figure 7-3: Historic Storage in Palo Duro Reservoir

Source: Water Data For Texas: https://www.waterdatafortexas.org/reservoirs/individual/palo-duro

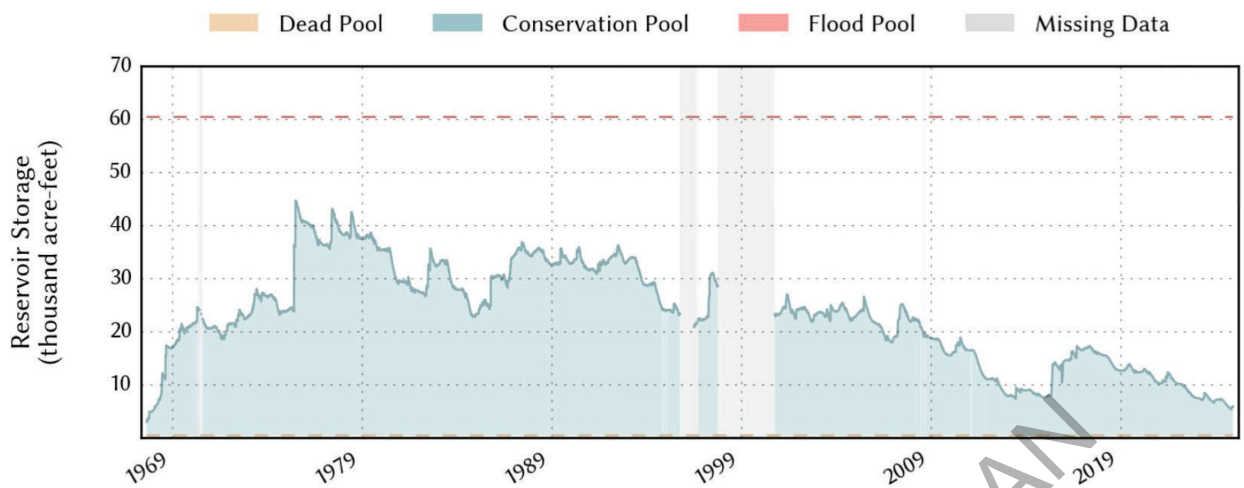


Figure 7-4: Historic Storage in Greenbelt Reservoir

Source: Water Data For Texas: https://www.waterdatafortexas.org/reservoirs/individual/greenbelt

For reservoirs, the drought of record is defined as the period of record that includes the minimum content of the reservoir. The period is recorded from the last time the reservoir spills before reaching its minimum content to the next time the reservoir spills. If a reservoir has reached its minimum content but has not yet filled enough to spill, then it is considered to be still in drought of record conditions. Based on the water availability modeling, the droughts of record for the reservoirs in the PWPA are shown in **Table 7-1**.

Table 7-1: Droughts of Record for PWPA Reservoirs

Reservoir	Date last full[1]	Date of minimum content	Drought of Record
Meredith	April 2000	May 2014[2]	2000 - Current
Palo Duro	May 1973	March 2022[3]	1973 - Current
Greenbelt	June 1962	December 2014[2]	1962 - Current

[1] None of the PWPA lakes have ever filled. The Date Last Full is based on the firm yield analyses. (Note: Firm yield analyses assume the reservoir is full at the beginning of the simulation.)
[2] Hydrology for Lake Meredith and Greenbelt Reservoir ends in 2017.
[3] Hydrology for Palo Duro Reservoir ends in 2022.

For groundwater supplies, meteorological and agricultural conditions were considered for defining the drought of record in the PWPA. The National Atmospheric and Oceanic Administration (NOAA) maintains data on the historical meteorological conditions and drought indices across the country. **Figure 7-5** shows the historical precipitation in the High Plains Region of Texas.

Based on this graph, the annual precipitation across the region averages 18.44 inches from 1895 to 2023. The years with the lowest historical precipitation occurred in 1956 and 2011 with 9.57 inches recorded in 1956 and 7.39 inches recorded in 2011. Both years occur during extreme drought.

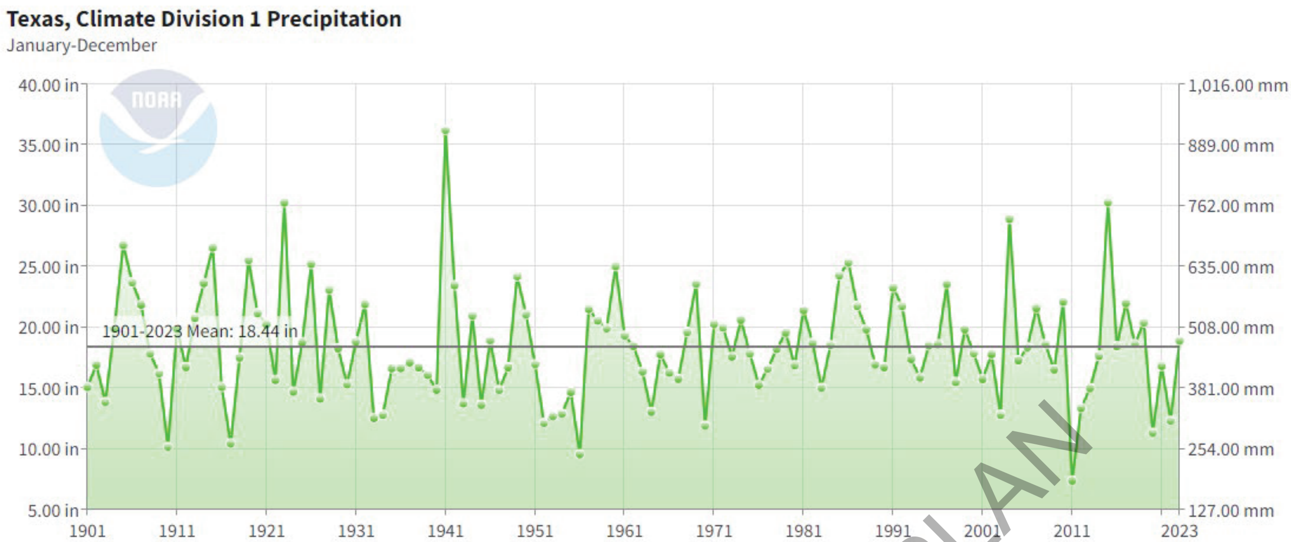


Figure 7-5: Historical Annual Precipitation for the High Plains of Texas

Source: NOAA website (http://www.ncdc.noaa.gov/cag/time-series/us)

Drought of record conditions for run-of-river supplies are typically evaluated based on minimum annual stream flows. **Figure 7-6** shows the historical stream flows for selected gages in the PWPA for both the Canadian and Red River Basins. Based on these gages, 2011 was the year with the lowest annual stream flow in the Canadian River Basin. It also was an extreme drought year in the Red River Basin, but there were other years with lower annual flows on the Salt Fork (2013) and North Fork (1996) of the Red River. Considering the overall basin drought, 2011 is the drought of record for the run-of-river supplies in the PWPA.

Drought of Record in PWPA

Reservoir Drought of Record: For reservoirs, the drought of record is defined as the period from the last time the reservoir spills before reaching its minimum content to the next time the reservoir spills. All major reservoirs in PWPA are currently in the Drought of Record.

Run-of-River Drought of Record: Based on minimum annual stream flows. For both the Canadian River Basin and the Red River Basin, the Drought of Record is considered to be the year 2011.

Groundwater Drought of Record: Generally defined by meteorological and agricultural conditions. In the PWPA, the years with the lowest recorded precipitation were 1956 and 2011.

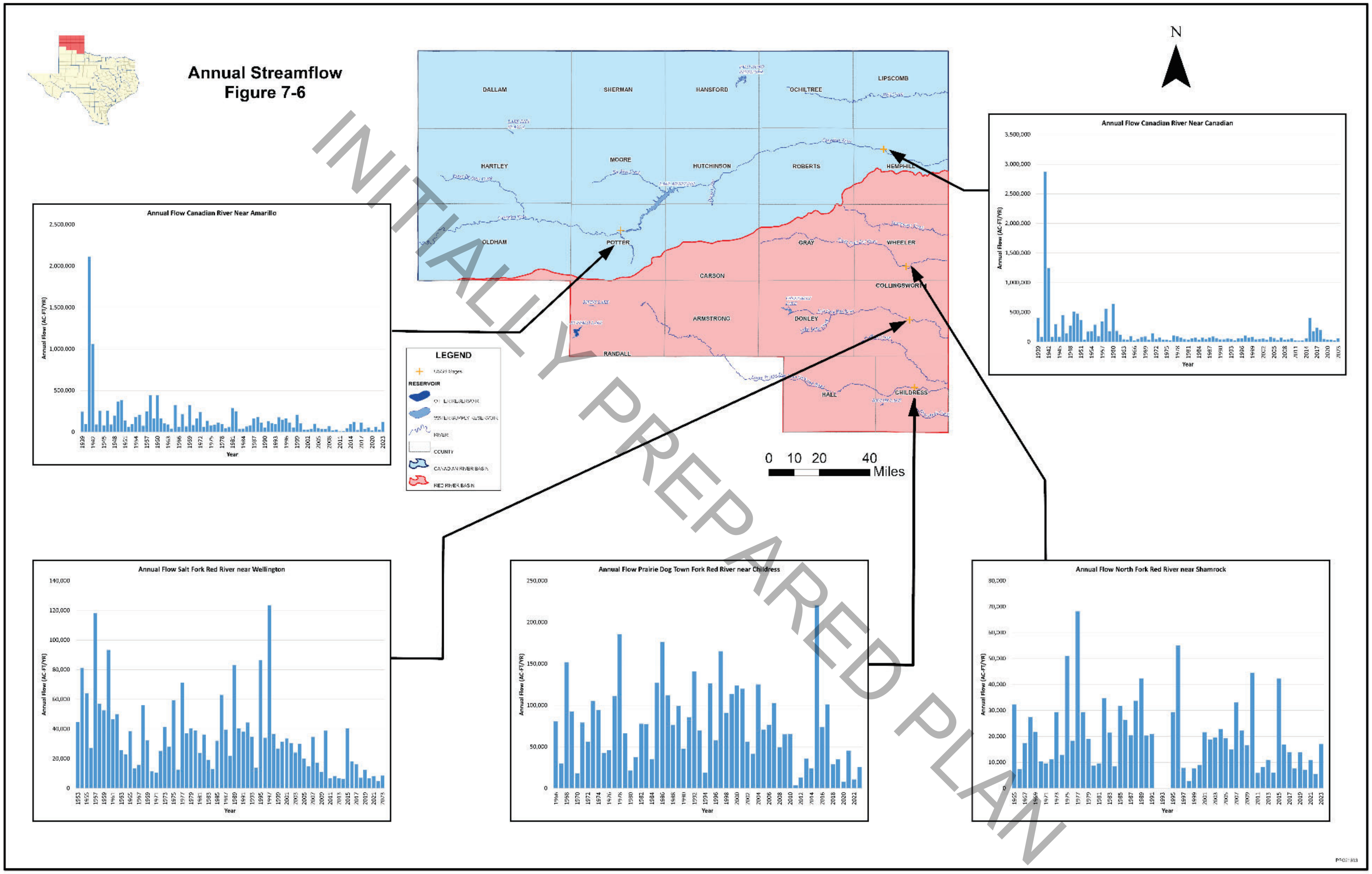


Figure 7-6: Historical Streamflows in the Canadian and Red River Basins

Looking at the PDSI over the same time period, **Figure 7-7** clearly shows the drought impacts during the 1950s and again since 2011. The PDSI provides a measurement of long-term drought based on the intensity of drought during the current month plus the cumulative patterns of previous months. It considers antecedent soil moisture and precipitation. For the PWPA, these considerations are important in assessing the potential impacts to groundwater sources during drought from increases in water demands and agricultural water needs.

Considering both the annual precipitation and PDSI in the region, the drought of record for groundwater sources is the drought from 2011 through 2015. Since 2020 the region has entered another very dry period. It is uncertain whether this period will surpass the 2011-2015 drought.

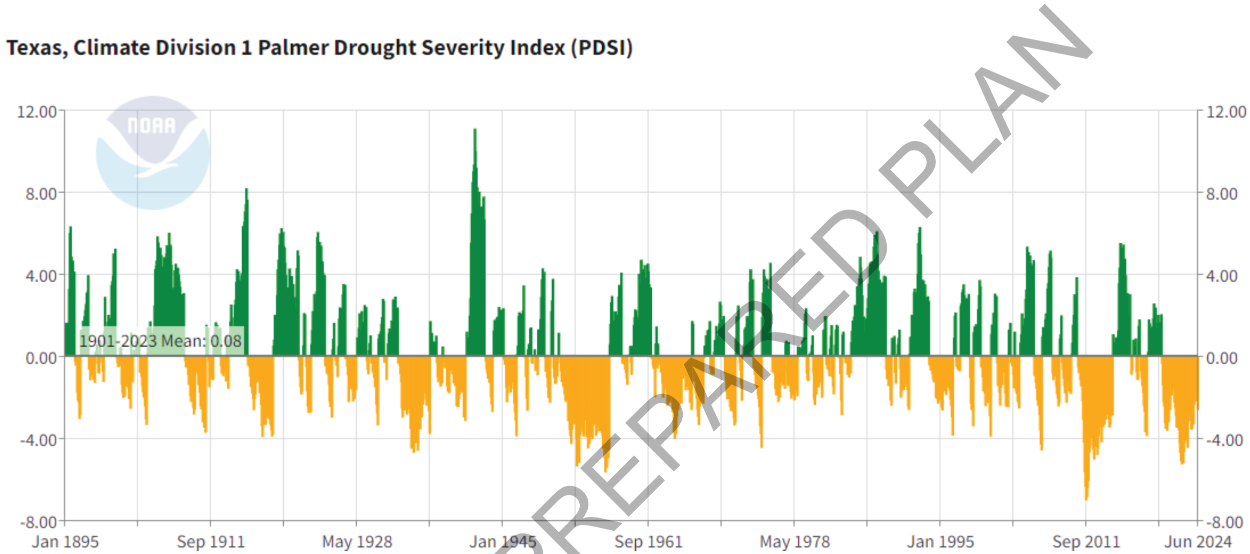


Figure 7-7: Palmer Drought Severity Indices for the High Plains of Texas

Source: NOAA website (http://www.ncdc.noaa.gov/cag/time-series/us)

7.1.2 Impact of Drought on Water Supplies

Drought is a major threat to surface water supplies in the PWPA and groundwater supplies that rely heavily on recharge (such as the Seymour aquifer). The Ogallala aquifer, which provides most of the water supplies in the PWPA, is less impacted by reduced recharge associated with meteorological droughts. However, the Ogallala aquifer is greatly impacted by agricultural droughts (which typically follow meteorological droughts) because the demands on the water source can increase significantly. Over time, the lack of recharge combined with increased demands can impact the amount of storage in the aquifer for future use.

For surface water supplies, hydrological drought is significant because it impacts the yield of water source. Typically, multi-year droughts have the greatest impact on a reservoir yield. As previously discussed, the Lake Meredith watershed experienced its lowest inflows during the 2011-2015 drought and the flows have not fully recovered since then. This impacts water supplies to users in both the PWPA and Llano Estacado Region. To better understand some of the factors contributing to the decline in inflows, a special study on the Lake Meredith watershed was conducted as part of the 2011 regional water plan (Salazar and Schnier, 2010). A concurrent study on drought in the entire Canadian River watershed above Lake Meredith was conducted by the Bureau of Reclamation in conjunction with others (Brauer et al, 2011).

Both studies concluded that it appears there is no one factor or event that appears to be the major contributor to the decline of inflows to Lake Meredith. Annual precipitation, evaporation, and changes in irrigation practices do not appear to be contributing factors. The Salazar and Schnier study hypothesized that the combination of factors, including reduced rainfall intensities, increasing shrubland and declining groundwater levels, have resulted in decreased runoff below Ute Reservoir. The Brauer study did not attribute the impacts of increased shrubland to the declining runoff. This conclusion was supported by the continued low stream flows in the watershed following extensive brush control and removal. The Brauer study noted that the entire Canadian River watershed was experiencing drought conditions and reduced reservoir storage. Both studies acknowledged that the activities in the watershed above the Logan gage (Ute Reservoir) may be a significant factor with respect to the total amount of inflow to Lake Meredith. **Figure 7-8** shows the historical gage flow at Logan (just below Ute Reservoir) and the historic water levels in Lake Meredith. Most of the flows at the Logan gage are releases from Ute Reservoir.

These studies show that drought can have a significant impact on a water source's reliable supply, but if drought is combined with other factors the results can be catastrophic.

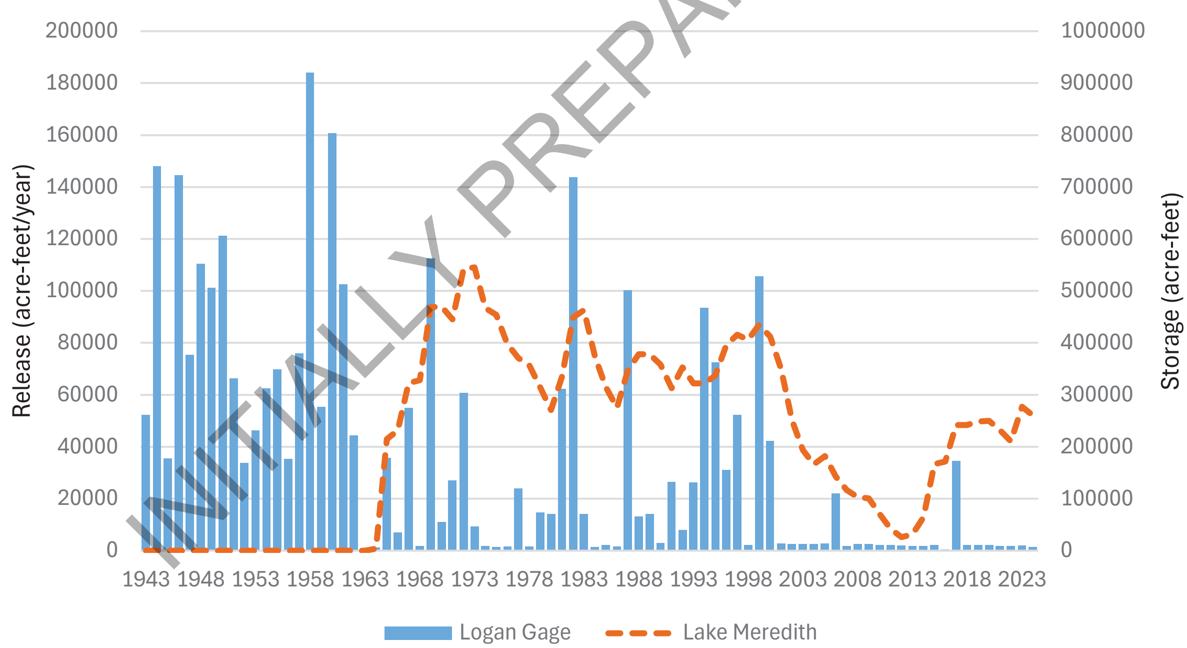


Figure 7-8: Comparison of Lake Meredith Lake Levels to Flows at Logan Gage

7.2 Current Drought Preparations and Response

In 1997, the Texas Legislature directed the TCEQ to adopt rules establishing common drought plan requirements for water suppliers in response to drought conditions throughout the state. Since 1997, the TCEQ has required all wholesale public water suppliers, retail public water suppliers serving 3,300 connections or more, and irrigation districts to submit drought contingency plans (DCP). TCEQ now also requires all retail public water suppliers serving less than 3,300 connections to prepare and adopt DCPs by no later than May 1, 2009. All DCPs shall be updated every five years and be available for inspection upon request. The most recent updates were to be submitted to the TCEQ by May 1, 2024.

All wholesale water providers and most municipalities in the PWPA have taken steps to prepare for and respond to drought through efforts including the preparation of individual DCPs and readiness to implement the DCPs as necessary. These drought plans include specific water savings goals and measures associated with multiple drought stages. In addition to these plans, many water providers have a Management Supply Factor (or safety factor) greater than 1.0 for demands that are essential to public health and safety.

DCPs typically identify different stages of drought and specific triggers and response for each stage. In addition, the plan must specify quantifiable targets for water use reductions for each stage, and a means and method for enforcement.

7.2.1 Drought Preparedness

In general, water suppliers in PWPA identify the onset of drought (drought triggers) based on either their current level of supply or their current level of demand. Often the triggers for surface water reservoirs are based on the current capacity of the reservoir as a percentage of the total reservoir capacity. In the PWPA, the reservoir operators use a combination of reservoir storage (elevation triggers) and/or demand levels. Triggers for groundwater supplies are commonly determined based on water well elevations or demand. Suppliers set these triggers as needed based on the individual parameters of their system. Customers of a wholesale water provider are subject to the triggers and measures of the providers' DCPs.

One DCP was submitted to the PWPG during this round of planning. Other plans were submitted during the previous planning cycles and are considered in this plan. Most of the submitted plans use trigger conditions based on the demands placed on the water distribution system. Of the plans reviewed, three based trigger actions on well levels, eight based actions on storage reservoir levels, and nine based actions on demands/consumption. **Table 7-2** summarizes the basis of the drought triggers by provider. **Attachment 7-1** summarizes the triggers and actions by water provider for initiation and response to drought. **Attachment 7-2** summarizes the DCPs submitted to the PWPG. There were no response actions that were considered unnecessary or counterproductive.

Table 7-2: Type of Trigger Condition for Entities with Drought Contingency Plans

Entity	Type of Trigger Condition		Implemented since 2020
	Demand	Supply	
Amarillo	X	X	Yes
Borger	X	X	No
Canyon		X	No
Childress	X		No
Claude	X		No
CRMWA		X	No
Dalhart	X		No
Dumas	X		No
Greenbelt MIWA		X	No
Gruver	X		No
Higgins	X	X	No
McLean	X	X	No
Palo Duro RA		X	No
Pampa		X	No
Perryton	X		No
Red River Authority		X	No
Shamrock	X		No
Turkey		X	No
Wellington	X		No
White Deer	X		No

While the DCPs triggers and responses are unique to each entity, they are clear and specific to the entity. Differences between entities should not confuse the public or otherwise impede drought response efforts due to the geographic separation of the entities in the PWPA. Drought responses for Major Water Providers, such as CRMWA, are clearly conveyed to all customers. Only Amarillo has implemented their DCP in the last five years to recommend a voluntary watering schedule in 2022. No entity reported having less than 180 days of supply over this period. The last time an entity reported having less than 180 days of supply was in 2011 for the City of Wellington. **Figure 7-9** displays the level of concern that has been designated for systems reporting some form of implementation of their Drought Contingency Plan.

Figure 7-10 shows the number of systems under some form of outdoor watering restrictions since 2010. The greatest number of systems under watering restrictions occurred in 2011 with three systems implementing a mandatory watering schedule and six others implementing voluntary measures. Since 2013, there have been very few instances of outdoor watering restrictions.

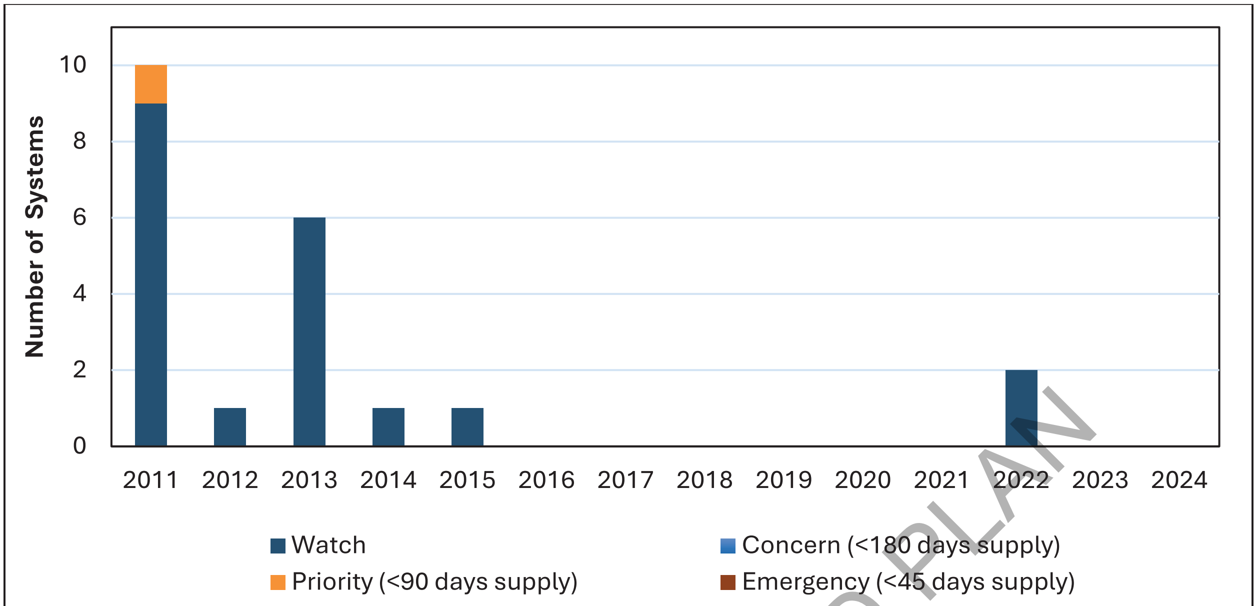


Figure 7-9: Level of Concern in System Implementation

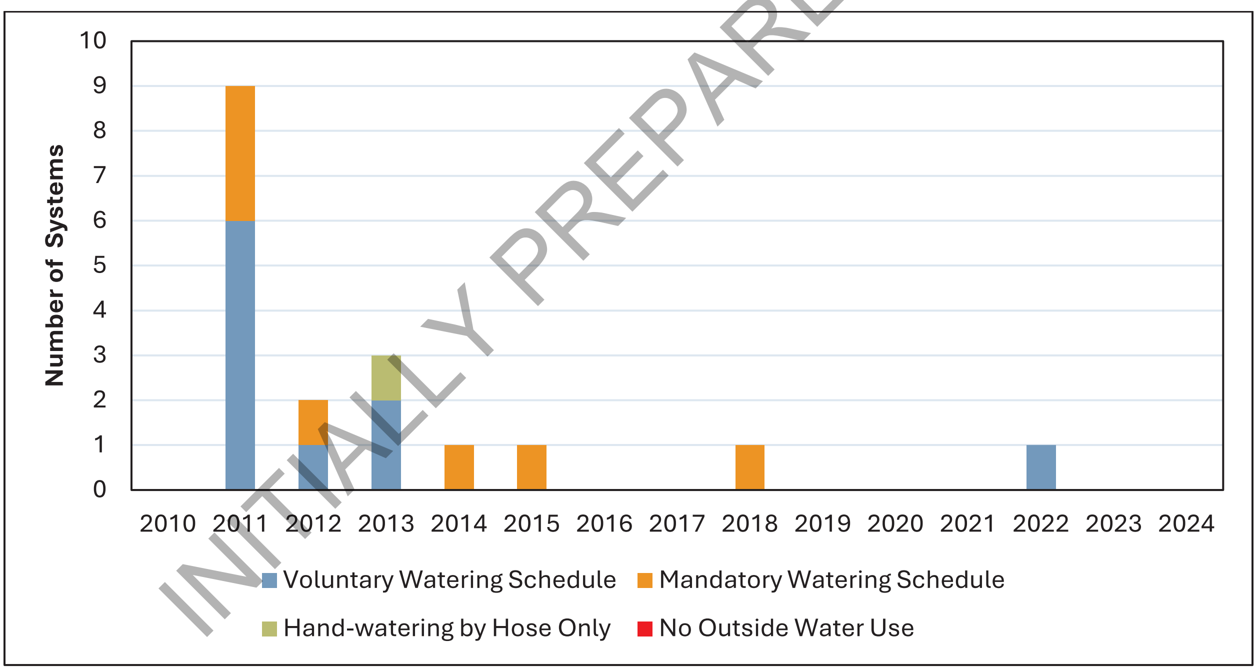


Figure 7-10: System Implementation of Outdoor Watering Restrictions

Challenges to the drought preparedness in the PWPA include the resources available to smaller cities to adequately prepare for drought and respond in a timely manner. For some cities the drought of 2011 tested the entity's drought plan and triggers. Several water providers found that the triggers were not set at the appropriate level to initiate different stages of the drought plan. The 2011 drought came quickly and was very intense with little time to adjust. Since 2011, several water providers have expanded their well fields to better protect against future droughts.

Water providers of surface water sources have proactively developed supplemental groundwater sources, providing additional protection during drought. Many groundwater users expanded groundwater production in response to drought. Groundwater in the PWPA provides a more drought-resilient water source, but it needs to be managed to assure future supplies.

7.3 Planning for Uncertainty

The PWPA has experienced a wide range of changing conditions that can affect water supplies and needs. While new records are being set with regularity across the state: population growth, soaring temperatures, record rainfall events, and new droughts of record, the PWPA continues to see declining surface water and groundwater and high agricultural water use. Changes in the economic sector that affect agricultural production add further uncertainty to water demands and supplies.

Record low water levels were recorded in all three PWPA major reservoirs during the 2011-2015 drought. Each reservoir continues to be in drought-of-record conditions. This results in continued declining reliable supply in the region. New analyses show that Palo Duro Reservoir has no reliable water supply.

To address uncertainty, the PWPG enlists several tools to plan for new droughts of record. The region strategically does not recommend drought management to meet long-term projected water needs. Drought management is reserved to address emergencies and potential droughts worse than the drought of record.

Water supplies and management strategies are based on sustainable supplies as defined through the Joint Planning and Regional Water Planning Processes. The PWPG considers droughts worse than the drought of record through using safe yield (rather than firm yield) for all surface water reservoirs. Supply from Lake Meredith is further reduced to account for water quality concerns. Groundwater supplies from the Ogallala consider groundwater availability in both space and time. No overdrafting of groundwater is considered. Other uncertainties are addressed through identifying and recommending strategies that provide supplies above the need, which provides a safety factor to address uncertainty.

The MWPs in the PWPA operate multiple water sources. System operation of these sources may provide increased resiliency to drought that is not specifically quantified in the plan. Emergency interconnects and/or interim emergency purchases with other providers are other options that can provide water during a drought worse than the Drought of Record.

7.4 Existing and Potential Emergency Interconnects

According to Texas Statute §357.42(d),(e) [(2)] regional water planning groups are to collect information on existing major water infrastructure facilities that may be used in the event of an emergency need of water. Pertinent information includes identifying the potential user(s) of the interconnect, the potential supplier(s), the estimated potential volume of supply that could be provided, and a general description of the facility. Texas Water Code §16.053(c) requires information regarding facility locations to remain confidential.

This section provides general information regarding existing and potential emergency interconnects among water user groups within the PWPA.

7.4.1 Existing Emergency Interconnects

Major water infrastructure facilities within the PWPA were identified to evaluate existing and potentially feasible emergency interconnects. Several water suppliers with existing emergency interconnections are Philips, Tri-City Water Company, and the Greenbelt MIWA. **Table 7-3** presents the survey results for the existing emergency interconnects among water users and neighboring systems.

Table 7-3: Existing Emergency Interconnects to Major Water Facilities in the PWPA

Entity *Providing* Supply	Entity *Receiving* Supply
Phillips County Wellfield	TCW Supply
Greenbelt Water Authority	City of Memphis
Tri-City Water Company	City of Stinnett
Phillips County Wellfield	City of Stinnett
Phillips Borger Plant	City of Borger

7.4.2 Potential Emergency Interconnects

Potential emergency interconnects for various WUGs in the PWPA were assessed based on proximity to nearby systems and past survey responses. **Table 7-4** presents a list of cities for those receiving and those supplying the potential emergency interconnects.

It was determined that additional emergency interconnects to the CRMWA system are feasible. However, it is assumed that the interconnects are probably limited to those facilities either currently within the CRMWA structure or near existing distribution lines. One of the most limiting factors for developing practical interconnects in the PWPA is the large distance that separates many cities and small towns.

In addition, an assessment was conducted to identify cities within a fifteen-mile radius to existing CRMWA distribution lines. Fifteen miles was assumed to be the farthest distance any system would find feasible for an alternative water supply during an emergency water need. Cities that meet the fifteen-mile radius requirement include: Stinnett, Fritch, TCW Supply Inc., Sanford, and Lake Tanglewood (**Table 7-4**). (Note: Borger is expected to acquire TCW Supply, Inc. and Borger's supplies will serve as an emergency connection. Borger also is a customer of CRMWA.)

Within the PWPA, Greenbelt MIWA serves customers in the counties of Donley, Collingsworth, Hall and Childress. The city of Memphis has a contract for emergency supplies. Only one other small community, Lakeview, was identified that potentially could interconnect to the Greenbelt MIWA system during an emergency water need. Several other rural communities in the PWPA are already served by this provider.

Emergency interconnects were found to be not practical for many of the entities that were evaluated for potential emergency water supplies due to the long distance of transmission and size of facilities. The type of infrastructure required between entities to provide or receive water during an emergency need was deemed impractical due to long transmission distances. Furthermore, it was deemed impractical during an emergency situation, to complete the required construction time in a reasonable timeframe.

Table 7-4: Potential Emergency Interconnects to Major Water Facilities in the PWPA

Entity *Providing* Supply	Entity *Receiving* Supply
CRMWA	Stinnett
	Fritch
	TCW Supply Inc.
	Sanford
	Lake Tanglewood
Greenbelt MIWA	Lakeview
WRB Refining (Borger)	Borger
Amarillo	Borger
Borger	Sanford
	Stinnett

7.5 Emergency Responses to Local Drought Conditions or Loss of Municipal Supply

Texas Statute §357.42(g) [(3)] requires regional water planning groups to evaluate potential temporary emergency water supplies for all County-Other WUGs and municipalities with existing populations less than 7,500 that rely on a sole source of water. The purpose of this evaluation is to identify potential alternative water sources that may be considered for temporary emergency use in the event that the existing water supply sources become temporarily unavailable due to extreme hydrologic conditions such as emergency water right curtailment, unanticipated loss of reservoir conservation storage, or other localized drought impacts.

This section provides potential solutions that should act as a guide for municipal water users that are most vulnerable in the event of a loss of supply. This review was limited and does not require technical analyses or evaluations required for water management strategies.

7.5.1 Emergency Responses to Local Drought Conditions

A review was conducted to identify and evaluate the municipal water users that are most vulnerable in the event of an emergency water need. The analysis included all 'county-other' WUGs and rural cities with a population less than 7,500 and on a sole source of water that were within 5 miles of another water system.

Figure 7-11 presents a PWPA map delineating municipalities that meet the analysis requirements. Three main reservoirs (Greenbelt, Lake Meredith and Palo Duro) were included on the map, along with the major water infrastructure facilities (CRMWA and Greenbelt) discussed in Section 7.3. The map illustrates a general proximity to potential alternative water sources that may be considered for temporary emergency use.

Table 7-5 presents temporary responses that may or may not require permanent infrastructure. It was assumed in the analysis that the entities listed would have approximately 180 days or less of remaining water supply.

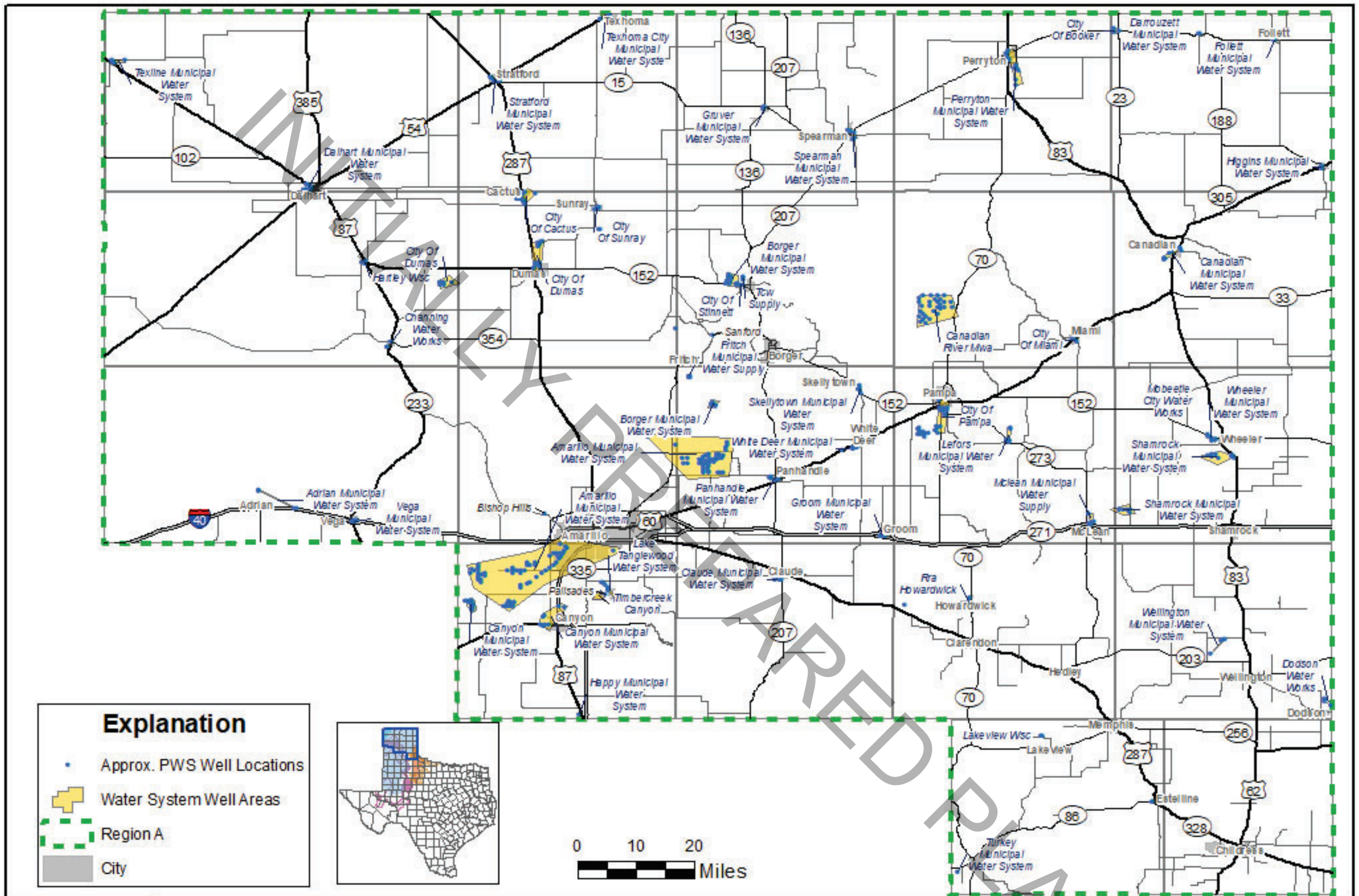


Figure 7-11: Entities Considered for Emergency Supplies

Table 7-5: Emergency Responses to Local Drought Conditions in the PWPA

Entity				Potential Emergency Water Supply Source(s)							Implementation Requirements		
Water User Group Name	County	2020 Population	2020 Demand (ac ft/yr)	Drill additional groundwater wells	Brackish groundwater limit treatment	Brackish groundwater desalination	Emergency interconnect	Other named local supply	Trucked - in water	Voluntary transfer from irrigation	Type of infrastructure required	Entity providing supply	Emergency agreements already in place
Booker	Lipscomb	1,740	496										
	Ochiltree	22	6										
Cactus	Moore	3,179	985										
Canadian	Hemphill	2,775	823										
Claude	Armstrong	1,202	360										
Fritch	Hutchinson	2,968	592									CRMWA	
	Moore	14	3										
Groom	Carson	568	177										
Gruver	Hansford	1,353	350										
Happy	Randall	678	10										
Lake Tanglewood	Randall	1,096	438									CRMWA	
McLean	Gray	800	210										
Miami	Roberts	600	225										
Panhandle	Carson	2,470	576										
Shamrock	Wheeler	1,910	350										
Spearman	Hansford	3,364	670										
Stinnett	Hutchinson	1,917	454									Phillips; Tri-City Water Company	Stinn ett

Entity				Potential Emergency Water Supply Source(s)							Implementation Requirements		
Water User Group Name	County	2020 Population	2020 Demand (ac ft/yr)	Drill additional groundwater wells	Brackish groundwater limit treatment	Brackish groundwater desalination	Emergency interconnect	Other named local supply	Trucked - in water	Voluntary transfer from irrigation	Type of infrastructure required	Entity providing supply	Emergency agreements already in place
Stratford	Sherman	2,134	496										
Sunray	Moore	1,945	450										
TCW Supply Inc.	Hutchinson	1,955	690									Phillips	
Texline	Dallam	512	219										
Vega	Oldham	1,036	272										
Wellington	Collingsworth	2,189	524										
Wheeler	Wheeler	1,547	493										
White Deer	Carson	1,068	113								Pump Station & Treatment	Groom	
County-Other Entities													
Skellyton	Carson	619											
Adrian	Oldham	166											
Bishop Hills	Potter	193											
Channing	Hartley	363											
Darrouzett	Lipscomb	350											
Dodson	Collingsworth	109											

Entity				Potential Emergency Water Supply Source(s)							Implementation Requirements		
Water User Group Name	County	2010 Population	2020 Demand (ac ft/yr)	Drill additional groundwater wells	Brackish groundwater limited treatment	Brackish groundwater desalination	Emergency interconnect	Other named local supply	Trucked - in water	Voluntary transfer from irrigation	Type of infrastructure required	Entity providing supply	Emergency agreements already in place
Follett	Lipscomb	459											
Hartley	Hartley	540											
Higgins	Lipscomb	397											
Howardwick	Donley	402											
Lakeview	Hall	199										Greenbelt	
Mobeetie	Wheeler	101									Piping from well to treatment plant	Wheeler	
Palisades	Randall	325											
Sanford	Hutchinson	164										CRMWA; Borger	
Texhoma	Sherman	346											
Timbercreek Canyon	Randall	418											
Turkey	Hall	421											
Lefors	Gray	540											
Grandview	Gray										Pump Station & Treatment	Groom	

[1] The analysis included all 'county-other' WUGs and rural cities with a population less than 7,500 and on a sole source of water that were within 5 miles of a potential water system. **Figure 7-9** illustrates a general proximity (within 5 miles) to potential alternative water sources that may be considered for temporary emergency use.

7.5.2 Voluntary Transfer of Irrigation Rights

An additional evaluation was conducted which considered voluntary transfer of irrigation rights as an emergency response to local drought conditions. Voluntary transfer of irrigation rights is the payment for temporary transfer of local irrigation supplies for other uses. Voluntary transfer or "irrigation suspension" programs have been implemented successfully by the Edwards Aquifer Authority. The plan is that WUGs would be willing and able to pay for temporary suspension and transfer of irrigation water from local wells to avoid trying to develop more distant sources that may prove impractical. By tapping local sources, WUGs could minimize construction cost and time required to develop infrastructure required for the emergency solution. Challenges with this strategy are that 1) it is uncertain whether a simple suspension of irrigation pumpage would result in sufficient recovery of the municipal wells, and 2) a direct transfer of groundwater from irrigation wells may need an exception from the TCEQ due to well completion requirements for public water systems. **Table 7-5** identifies the entities in the PWPA where voluntary transfer of irrigation rights might be feasible, given their proximity to currently used irrigated areas. Of the 42 entities listed, 31 communities were found to be located in applicable areas, making voluntary transfer of irrigation rights a potential drought management response.

7.5.3 Releases from Upstream Reservoirs and Curtailment of Rights

Releases from upstream reservoirs and the curtailment of upstream/downstream water rights were considered but were not identified as appropriate responses for the rural communities in the PWPA.

7.5.4 Brackish Groundwater

Brackish groundwater was evaluated as a temporary source during an emergency water need. Some brackish groundwater is found in certain places in the Ogallala, but other brackish groundwater supplies can be obtained from the Dockum, Rita Blanca, Seymour, Blaine, and other formations which underlie the shallow aquifers found in the PWPA.

Required infrastructure would include additional groundwater wells, potential treatment facilities and conveyance facilities. Brackish groundwater at lower TDS concentrations may require only limited treatment. Eighteen of the 43 entities listed in **Table 7-5** will be able to potentially use brackish groundwater as a feasible solution to an emergency local drought condition.

7.5.5 Drill Additional Local Groundwater Wells and Trucking in Water

In the event that the existing water supply sources become temporarily unavailable, drilling additional groundwater wells and trucking in water are optimal solutions. **Table 7-5** presents these options as viable for all 43 entities listed.

7.6 Region-Specific Drought Response Recommendations and Model Drought Contingency Plans

As required by the TWDB, the PWPG shall develop drought recommendations regarding the management of existing groundwater and surface water sources. These recommendations must include factors specific to each source as to when to initiate drought response and actions to be taken as part of the drought response. These actions should be specified for the manager of a water source and entities relying on the water source. The PWPG has defined the manager of water sources as the entity that controls the water production and distribution of the water supply from the source. For purposes of this assessment, a manager must also meet the TCEQ requirements for development of DCP. Entities that rely on the water sources include customers of the water source manager and direct users of the water sources, such as irrigators. A list of each surface water and groundwater source in the PWPA and the associated managers and users of the source is included in **Attachment 7-1**.

7.6.1 Drought Trigger Conditions for Surface Water Supply

Drought trigger conditions for surface water supply are customarily related to reservoir levels. The PWPG acknowledges that the DCPs for the suppliers who have surface water supplies are the best management tool for these water supplies. The PWPG recommends that the drought triggers and associated actions developed by the regional operator of the reservoirs are the PWPA regional triggers for these sources. A summary of these triggers and actions by reservoir as effective October 1, 2024, follows. The region also recognizes any modification to these drought triggers that are adopted by the regional operator.

Lake Meredith (Canadian River Municipal Water Authority)

CRMWA adopted a DCP on July 14, 1999, and the same was revised on January 12, 2011 and last reviewed on April 10, 2019. Since CRMWA has multiple sources of water (Lake Meredith and Roberts County groundwater), the drought triggers are based on the Authority's total water supply. Lake Meredith has been in drought conditions for over a decade, with water levels generally declining since 2000. Recent rains have increased the water levels, but the lake is still in drought of record conditions. The triggers and actions for CRMWA are shown in the following table (**Table 7-6**). These triggers can be implemented at the time of any review of the supply by the CRMWA Board of Directors.

Table 7-6: Lake Meredith Drought Triggers and Actions

Drought Stage	Trigger (No. of Member Cities with Needs):	Action[1]
Mild	1 to 2	Public awareness; Promote conservation; Technical assistance to users; Cities to initiate appropriate stage of DCP
Moderate	3 to 5	Above
Severe	> 5	Above

[1] At any stage, CRMWA may restrict deliveries based on pro rata shares in accordance with State law, if needed.

Greenbelt Reservoir (Greenbelt Municipal and Industrial Water Authority)
The Board of Directors for Greenbelt Municipal and Industrial Water Authority passed a resolution adopting a DCP on August 19, 1999. The DCP was updated in 2020. Triggering criteria are based on water storage levels in the Greenbelt Reservoir and are described as follows:

Table 7-7: Greenbelt Reservoir Drought Triggers and Actions

Drought Stage	Trigger	Action [1]
Mild	Water level = 2,634 feet mean sea level (msl)	Voluntary measures to achieve 10% use reduction
Moderate	Water level = 2,631 feet msl	20% use reduction; reduce customer storage to 75% capacity; initiate customer's Stage 2 of DCP
Severe	Water level = 2,628 feet msl	30% use reduction; reduce customer storage to 50% capacity; initiate customer's Stage 3 of DCP
Emergency	Water level = 2,625 feet msl; Equipment failure; Water quality impairment	Actions as appropriate

[1] All stages include communications with customers and media.

Palo Duro Reservoir (Palo Duro Water District)
Palo Duro River Authority (now Palo Duro Water District) adopted a conservation plan for Palo Duro Reservoir in May of 1987. Triggering criteria are based on water storage levels in Palo Duro Reservoir and are described as follows:

Table 7-8: Palo Duro Reservoir Drought Triggers and Actions

Drought Stage	Trigger	Action
Mild	Water level = 2,876 feet msl	Communication, voluntary outdoor water schedule
Moderate	2,864 feet msl < Water level < 2,876 feet msl	10% reduction in deliveries, request mandatory limits in outdoor water use
Severe	Water level < 2,864 feet msl	Curtail deliveries as needed, request no outdoor water use, consider alternative supplies
Emergency	Equipment failure	Above

7.6.2 Drought Trigger Conditions for Run-of-River and Groundwater Supply

Both run-of-river and groundwater supplies are more regional than reservoirs and typically there are many users of these sources. As noted in Section 7.2.1, some water providers will have developed DCPs that are specific to their water supplies. Other water users, such as agricultural or industrial users, may not have DCPs. To convey drought conditions to all users of these resources in the PWPA, the PWPG proposes to use the Drought Monitor. This information is easily accessible and updated regularly. It does not require a specific entity to monitor well water levels or stream gages. It is also geographically specific so that drought triggers can be identified on a sub-county level that is consistent with the location of use. The PWPG adopted the same nomenclature for the

Drought Monitor for corresponding PWPA drought triggers. **Table 7-9** shows the categories adopted by the U.S. Drought Monitor and the associated PDSI.

Table 7-9: Drought Severity Classification

Category	Description	Possible Impacts	Palmer Drought Severity Index
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered	-1.0 to -1.9
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water needs developing or imminent; voluntary water-use restrictions requested	-2.0 to -2.9
D2	Severe Drought	Crop or pasture losses likely; water needs common; water restrictions imposed	-3.0 to -3.9
D3	Extreme Drought	Major crop/pasture losses; widespread water needs or restrictions	-4.0 to 4.9
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; needs of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less

Source: U.S. Drought Monitor: http://droughtmonitor.unl.edu/AboutUs/ClassificationScheme.aspx

For groundwater and run-of-river supplies, the PWPG recognizes that the initiation of drought response is the decision of the manager of the source and/or user of the source. The PWPG recommends the following actions based on each of the drought classifications listed above:

- Abnormally Dry – Entities should begin to review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage is necessary.
- Moderate Drought – Entities should review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage is necessary.
- Severe Drought – Entities should review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage or changing to a more stringent stage is necessary. At this point if the review indicates current supplies may not be sufficient to meet reduced demands, the entity should begin considering alternative supplies.
- Extreme Drought – Entities should review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage or changing to a more stringent stage is necessary. At this point if the review indicates current supplies may not be

sufficient to meet reduced demands, the entity should consider alternative supplies.

- Exceptional Drought – Entities should review their DCP, status of current supplies and current demands to determine if implementation of a DCP stage or changing to a more stringent stage is necessary. At this point if the review indicates current supplies are not sufficient to meet reduced demands, the entity should implement alternative supplies.

7.6.3 Model Drought Contingency Plans

Model DCPs were developed for the PWPG and are available online through the PWPG website (http://www.panhandlewater.org/). Each plan identifies four drought stages: mild, moderate, severe and emergency. Some plans also include a critical drought stage. The recommended responses range from notification of drought conditions and voluntary reductions in the "mild" stage to mandatory restrictions during an "emergency" stage. Each entity will select the trigger conditions for the different stages and the appropriate response. Entities should use the TAC 228 rules mandated by the TCEQ as the guideline in developing these plans.

7.7 Drought Management Strategies

Drought management is a temporary strategy to conserve available water supplies during times of drought or emergencies. This strategy is not recommended to meet long-term growth in demands, but rather acts as means to minimize the adverse impacts of water supply needs during drought. The TCEQ requires drought contingency plans for wholesale and retail public water suppliers and irrigation districts. A drought contingency plan may also be required for entities seeking State funding for water projects. The PWPG does not recommend specific drought management strategies. The PWPG recommends the implementation of DCPs by suppliers when appropriate to reduce demand during drought and prolong current supplies. The PWPG also recommends the implementation of conservation measures for all users to conserve water resources for the future.

7.8 Other Drought-Related Considerations

7.8.1 Texas Drought Preparedness Council and Drought Preparedness Plan

In accordance with TWDB rules, all relevant recommendations from the Drought Preparedness Council were considered in the writing of this Chapter. The Texas Drought Preparedness Council is composed of representatives from multiple State agencies and plays an important role in monitoring drought conditions, advising the governor and other groups on significant drought conditions, and facilitating coordination among local, State, and federal agencies in drought-response planning. The Council meets regularly to discuss drought indicators and conditions across the state and releases Situation Reports summarizing their findings.

Additionally, the Council has developed the State Drought Preparedness Plan, which sets forth a framework for approaching drought in an integrated manner in order to minimize impacts to people and resources. The PWPG supports the ongoing efforts of the Texas Drought Preparedness Council and recommends that water providers and other interested parties regularly review the Situation

Reports as part of their drought monitoring procedures. The Council provided three recommendations to all RWPGs which are addressed in this chapter:

1. The regional water plans and state water plan shall serve as water supply plans under drought of record conditions. The DPC encourages regional water planning groups to consider planning for drought conditions worse than the drought of record, including scenarios that reflect greater rainfall deficits and/or higher surface temperatures.

2. The Drought Preparedness Council encourages regional water planning groups to incorporate projected future reservoir evaporation rates in their assessments of future surface water availability.

3. The Drought Preparedness Council encourages regional water planning groups to identify in their plans utilities within their boundaries that reported having less than 180 days of available water supply to the Texas Commission on Environmental Quality during the current or preceding planning cycle. For systems that appeared on the 180-day list, RWPGs should perform the evaluation required by Texas Administrative Code Section 357.42(g), if it has not already been completed for that system.

Under the TWDB rules and guidance, all RWPs are developed using dry-year demands and drought of record conditions. The effects of hotter and drier climates are not directly addressed in the Panhandle Water Plan through changes to the water availability models. The PWPG considers droughts worse than the drought of record through using safe yield (rather than firm yield) for all surface water reservoirs. Previous studies showed reduced inflows have basically eliminated Palo Duro Reservoir as a reliable water supply and significantly reduced the yields of the other two major reservoirs in the region. The higher evaporation rates affect both the available water supply and the water quality. The supply from Lake Meredith considers diminished water quality due to higher evaporative losses and lower inflows. Further discussion on planning for uncertainty in the PWPA is discussed in Section 7.3. Utilities with less than 180 days of supply are discussed in Section 7.5.

The incorporation of future evaporation rates in the assessments of future surface water availability (Recommendation #2) would need to be developed by the TCEQ as part of the WAM updates. Regional water planning rules require the TCEQ-approved WAMs be used for surface water supplies.

7.8.2 Other Drought Recommendations

One of the challenges with drought in the PWPA is that the response to drought and associated impacts can vary depending upon the timing of the drought. Droughts that occur during the agricultural growing season can have a greater impact than if it occurs at other times. Since irrigated agriculture accounts for such a large percent of the water use in the region, the impacts of agricultural droughts on water supplies can be significant because it not only affects agricultural producers but also impacts other users that rely on those supplies.

To be better prepared for future droughts, the PWPG has the following recommendations:

- Municipal water users that rely on groundwater should consider protecting their water supplies from competition through the acquisition of additional water rights and/or expansion of current well fields. Municipalities should take advantage of such opportunities if they become available.

- To minimize potential catastrophic failure of an entity's water system, the entity should provide sufficient resources to maintain its infrastructure in good condition. The PWPG recognizes that water main breaks and system failures do occur, but with proper maintenance these may be able to be reduced.

- Water users should continue to use water efficiently to conserve limited resources.

List of References

(1) Texas Water Development Board: *Chapter 357, Regional Water Planning Guidelines*, Austin, August 12, 2012.

(2) Texas Water Development Board: *Chapter 357, Regional Water Planning Guidelines*, *Rule 357.42 Drought Response Information, Activities, and Recommendations,* Austin, August 12, 2012.

(3) Drought Preparedness Council. Letter to Region A Water Planning Group, February 8, 2024.

ATTACHMENT 7-1

SOURCES, SOURCE MANAGER, AND DROUGHT CONTINGENCY PLAN TRIGGERS

Sources, Source Manager, Drought Contingency Plan Triggers

Source	Manager[1]	PWPA User
Lake Meredith	CRMWA	Amarillo
		Borger
		Pampa
		Manufacturing (Potter County)
		Canyon
		County-Other (Randall County)
		Manufacturing (Randall County)
		Manufacturing (Hutchison County)
Greenbelt Lake	GMIWA	Childress County-Other
		Childress
		Donley County-Other
		Clarendon
		Hall County-Other
		Red River Authority (Childress County)
		Red River Authority (Collingsworth County)
		Red River Authority (Donley County)
		Red River Authority (Hall County)
		Memphis
Palo Duro Reservoir	PDRA	
Canadian River Run-of-River - Gray County		Irrigation (Gray County)
Canadian River Run-of-River - Hutchinson County		Irrigation (Hutchinson County)
Canadian River Run-of-River - Lipscomb County		Irrigation (Lipscomb County)
Canadian River Run-of-River - Moore County		Irrigation (Moore County)
Canadian River Run-of-River - Roberts County		Irrigation (Roberts County)
Canadian River Run-of-River - Hansford County		Irrigation (Hansford County)
Canadian River Run-of-River - Hutchinson County		Manufacturing (Hutchinson County)
Canadian River Run-of-River - Sherman County		Irrigation (Sherman County)
Red River Run-of-River - Carson County		Irrigation (Carson County)
Red River Run-of-River - Childress County		Irrigation (Childress County)
Red River Run-of-River - Collingsworth County		Irrigation (Collingsworth County)
Red River Run-of-River - Donley County		Irrigation (Donley County)
Red River Run-of-River - Gray County		Irrigation (Gray County)
Red River Run-of-River - Hall County		Irrigation (Hall County)
Red River Run-of-River - Randall County		Irrigation (Randall County)
Red River Run-of-River - Wheeler County		Irrigation (Wheeler County)
Blaine Aquifer - Hall County		Livestock (Hall County)
Blaine Aquifer - Collingsworth County		County-Other (Collingsworth County)
		Irrigation (Collingsworth County)
		Livestock (Collingsworth County)
Blaine Aquifer - Wheeler County		County-Other (Wheeler County)
		Irrigation (Wheeler County)
		Livestock (Wheeler County)
Blaine Aquifer - Childress County		Irrigation (Childress County)
		Livestock (Childress County)
Dockum Aquifer - Armstrong County		County-Other (Armstrong County)
		Irrigation (Armstrong County)
Dockum Aquifer - Dallam County		Irrigation (Dallam County)
Dockum Aquifer - Hartley County		Livestock (Hartley County)
		Irrigation (Hartley County)
Dockum Aquifer - Moore County		Irrigation (Moore County)
Dockum Aquifer - Sherman County		Irrigation (Sherman County)
Dockum Aquifer - Oldham County		County-Other (Oldham County)
		Irrigation (Oldham County)
		Livestock (Oldham County)
		Mining (Oldham County)
Dockum Aquifer - Potter County		County-Other (Potter County)
		Irrigation (Potter County)
		Manufacturing (Potter County)
		Livestock (Potter County)
Dockum Aquifer - Randall County	Happy	County-Other (Randall County)
		Canyon
		Lake Tanglewood
		Irrigation (Randall County)
		Livestock (Randall County)

Sources, Source Manager, Drought Contingency Plan Triggers

Source	Manager[1]	PWPA User
Ogallala Aquifer - Armstrong County	Claude	County-Other (Armstrong County)
		Irrigation (Armstrong County)
		Livestock (Armstrong County)
Ogallala Aquifer - Carson County	Amarillo	County-Other (Carson County)
	Groom	Irrigation (Carson County)
	Panhandle	Livestock (Carson County)
	Skellytown	Manufacturing (Carson County)
		Fritch
		Manufacturing (Hutchinson County)
	White Deer	Mining (Carson County)
Ogallala Aquifer - Dallam County	Dalhart	County-Other (Dallam County)
	Texline	Irrigation (Dallam County)
		Manufacturing (Dallam County)
		Livestock (Dallam County)
Ogallala Aquifer - Donley County		County-Other (Donley County)
		Red River Authority (Childress County)
		Red River Authority (Collingsworth County)
		Red River Authority (Donley County)
		Red River Authority (Hall County)
		Childress
		Clarendon
		Memphis
		Irrigation (Donley County)
		Livestock (Donley County)
Ogallala Aquifer - Gray County	Lefors	County-Other (Gray County)
	McLean	Irrigation (Gray County)
	Pampa	Mining (Gray County)
		Livestock (Gray County)
		Manufacturing (Gray County)
Ogallala Aquifer - Hansford County	Gruver	County-Other (Hansford County)
	Spearman	Irrigation (Hansford County)
		Livestock (Hansford County)
		Manufacturing (Hansford County)
		Mining (Hansford County)
Ogallala Aquifer - Hartley County		County-Other (Hartley County)
		Irrigation (Hartley County)
		Hartley WSC
		Mining (Hartley County)
		Dumas
		County-Other (Moore County)
		Livestock (Hartley County)
Ogallala Aquifer - Hemphill County	Canadian	County-Other (Hemphill County)
		Irrigation (Hemphill County)
		Livestock (Hemphill County)
		Manufacturing (Hemphill County)
		Mining (Hemphill County)
Ogallala Aquifer - Hutchinson County	Borger	County-Other (Hutchinson County)
		Irrigation (Hutchinson County)
	Stinnett	Livestock (Hutchinson County)
	TCW Supply Inc	Manufacturing (Hutchinson County)
		Mining (Hutchinson County)
Ogallala Aquifer - Lipscomb County	Booker	County-Other (Lipscomb County)
		Darrouzett
		Follett
		Higgins
		Irrigation (Lipscomb County)
		Livestock (Lipscomb County)
		Manufacturing (Lipscomb County)
		Mining (Lipscomb County)
Ogallala Aquifer - Moore County	Cactus	County-Other (Moore County)
	Dumas	Irrigation (Moore County)
	Fritch	Livestock (Moore County)
	Sunray	Manufacturing (Moore County)
		Mining (Moore County)

Sources, Source Manager, Drought Contingency Plan Triggers

Source	Manager[1]	PWPA User
Ogallala Aquifer - Ochiltree County	Booker	County-Other (Ochiltree County)
	Perryton	Irrigation (Ochiltree County)
		Livestock (Ochiltree County)
		Manufacturing (Ochiltree County)
		Mining (Ochiltree County)
Ogallala Aquifer - Oldham County	Vega	County-Other (Oldham County)
		Irrigation (Oldham County)
		Livestock (Oldham County)
Ogallala Aquifer - Potter County	Amarillo	County-Other (Potter County)
		Irrigation (Potter County)
		Livestock (Potter County)
		Mining (Potter County)
Ogallala Aquifer - Randall County	Amarillo	County-Other (Randall County)
	Canyon	Irrigation (Randall County)
	Lake Tanglewood	Livestock (Randall County)
		Manufacturing (Randall County)
Ogallala Aquifer - Roberts County	CRMWA	Amarillo
	Miami	Borger
		Pampa
		Canyon
		Manufacturing (Hutchinson County)
		Manufacturing (Potter County)
		Manufacturing (Randall County)
		County-Other (Roberts County)
		Irrigation (Roberts County)
		Livestock (Roberts County)
		Mining (Roberts County)
Ogallala Aquifer - Sherman County	Stratford	County-Other (Sherman County)
		Texhoma
		Manufacturing (Sherman County)
		Irrigation (Sherman County)
		Livestock (Sherman County)
		Mining (Sherman County)
Ogallala Aquifer - Wheeler County	Shamrock	County-Other (Wheeler County)
	Wheeler	Irrigation (Wheeler County)
		Livestock (Wheeler County)
		Mining (Wheeler County)
Other Aquifer - Armstrong County		Livestock (Armstrong County)
Other Aquifer - Childress County		Irrigation (Childress County)
		County-Other (Childress County)
Other Aquifer - Collingsworth County		Irrigation (Collingsworth County)
		Livestock (Collingsworth County)
Other Aquifer - Donley County		Livestock (Donley County)
Other Aquifer - Hall County		Livestock (Hall County)
		Irrigation (Hall County)
Other Aquifer - Wheeler County		County-Other (Wheeler County)
		Irrigation (Wheeler County)
		Livestock (Wheeler County)
Seymour Aquifer - Childress County		County-Other (Childress County)
		Irrigation (Childress County)
		Livestock (Childress County)
Seymour Aquifer - Collingsworth County	Wellington	County-Other (Collingsworth County)
		Irrigation (Collingsworth County)
		Livestock (Collingsworth County)
Seymour Aquifer - Hall County		County- Other (Hall County)
		Irrigation (Hall County)
		Turkey
		Red River Authority (Hall County)
		Livestock (Hall County)

1. Muncipalities that are shown as Manager of a source are also a User of the source.
CRMWA and Greenbelt MIWA are the only entities that are only Managers of a source.

Summary of Drought Triggers and Action Recommendations

Source Name	Type (sw/gw)	Factor considered	TRIGGERS: Source Manager Mild	TRIGGERS: Source Manager Severe	TRIGGERS: Source Manager Critical/ Emergency	TRIGGERS: Users Mild	TRIGGERS: Users Severe	TRIGGERS: Users Critical/ Emergency	ACTIONS: Source Manager Mild	ACTIONS: Source Manager Severe	ACTIONS: Source Manager Critical/ Emergency	ACTIONS: Users Mild	ACTIONS: Users Severe	ACTIONS: Users Critical/ Emergency
Lake Meredith	sw	Cities with shortages	1 to 2	> 5	> 5	Approaching shortage	shortage	shortage	Public awareness; Promote conservation; Technical assistance to affected customers			Implement appropriate stage of DCP		
Greenbelt Lake	sw	Water level	2634 msl	2628 msl	2625 msl	Same as Manager			Request users to reduce use by 10% (mild)	30% use reduction; customer storage reduced to 50%	Actions as appropriate	Voluntary reduction by 10%; review DCP	30% use reduction; Implement Stage 3 of DCP	Actions as appropriate
Palo Duro Reservoir	sw	Water level	2876 msl	< 2864 msl	equipment failure	NA	NA	NA	Voluntary outdoor water reductions	Limit deliveries; no outdoor water use	Limit deliveries; no outdoor water use	NA	NA	NA
Red River	sw	Drought Monitor	D1 (Moderate)	D2 (Severe)	D4 (Critical)	D1 (Moderate)	D2 (Severe)	D4 (Critical)	Review DCP; Initiate actions if appropriate	Review DCP; Initiate actions; consider additional supplies		Review DCP and implement ,if appropriate; consider voluntary demand reductions	Review DCP; Initiate actions; consider additional supplies	
Canadian River	sw	Drought Monitor	D1 (Moderate)	D2 (Severe)	D4 (Critical)	D1 (Moderate)	D2 (Severe)	D4 (Critical)	Review DCP; Initiate actions if appropriate	Review DCP; Initiate actions; consider additional supplies		Review DCP and implement ,if appropriate; consider voluntary demand reductions	Review DCP; Initiate actions; consider additional supplies	
Ogallala Aquifer	gw	Drought Monitor	D1 (Moderate)	D2 (Severe)	D4 (Critical)	D1 (Moderate)	D2 (Severe)	D4 (Critical)	Review DCP; Initiate actions if appropriate	Review DCP; Initiate actions; consider additional supplies		Review DCP and implement ,if appropriate; consider voluntary demand reductions	Review DCP; Initiate actions; consider additional supplies	
Seymour Aquifer	gw	Drought Monitor	D1 (Moderate)	D2 (Severe)	D4 (Critical)	D1 (Moderate)	D2 (Severe)	D4 (Critical)	Review DCP; Initiate actions if appropriate	Review DCP; Initiate actions; consider additional supplies		Review DCP and implement ,if appropriate; consider voluntary demand reductions	Review DCP; Initiate actions; consider additional supplies	
Blaine Aquifer	gw	Drought Monitor	D1 (Moderate)	D2 (Severe)	D4 (Critical)	D1 (Moderate)	D2 (Severe)	D4 (Critical)	Review DCP; Initiate actions if appropriate	Review DCP; Initiate actions; consider additional supplies		Review DCP and implement ,if appropriate; consider voluntary demand reductions	Review DCP; Initiate actions; consider additional supplies	
Dockum Aquifer	gw	Drought Monitor	D1 (Moderate)	D2 (Severe)	D4 (Critical)	D1 (Moderate)	D2 (Severe)	D4 (Critical)	Review DCP; Initiate actions if appropriate	Review DCP; Initiate actions; consider additional supplies		Review DCP and implement ,if appropriate; consider voluntary demand reductions	Review DCP; Initiate actions; consider additional supplies	
Other Aquifer	gw	Drought Monitor	D1 (Moderate)	D2 (Severe)	D4 (Critical)	D1 (Moderate)	D2 (Severe)	D4 (Critical)	Review DCP; Initiate actions if appropriate	Review DCP; Initiate actions; consider additional supplies		Review DCP and implement ,if appropriate; consider voluntary demand reductions	Review DCP; Initiate actions; consider additional supplies	

NA - Not Applicable. Currently there are no users of Palo Duro Reservoir

ATTACHMENT 7-2

SUMMARY OF DROUGHT CONTINGENCY PLANS IN PWPA

Summary of Current Drought Triggers and Responses in PWPA

		Onset of Drought							Severe Drought
Water Provider	**Water Sources**	**Stage 1 Trigger**	**Response**	**Stage 2 Trigger**	**Response**	**Stage 3 Trigger**	**Response**	**Stage 4 Trigger**	**Response**
Amarillo	Ogallala, CRMWA	Demand>70% production capacity for 5 consecutive days	Request voluntary Watering Schedules and encourage other Conservation measures	Demand>80% production capacity for 5 consecutive days	Require mandatory Watering Schedule and other Conservation Methods as ordered by the Director	Demand>85% production capacity for 5 consecutive days	Require mandatory Watering Schedule between 8PM and 6AM and may prohibit nonessential water use	Demand>90% production capacity for 5 consecutive days	All nonessential watering prohibited. All commercial, institutional, industrial, and wholesale users shall be notified to initiate appropriate stage. Washing of mobile equipment is permitted only to a commercial vehicle washing facility. Director shall begin preparations for implementation of pro rata curtailment.
Borger	Ogallala, CRMWA	Total supply<6,240 AF/Y and supplies from CRMWA < 3,600 AF/Y	Achieve a voluntary 10% reduction in total water use. Best management practices for supply management. Voluntary water use restrictions for retail customers. Voluntary water use restrictions for wholesale and industrial customers.	Total supply<6,420 AF/Y and supplies from CRMWA <3,080 AF/Y	Achieve a 20% reduction in total water use. Best management practices for supply management. Water use restrictions for retail customers. Water use restrictions for wholesale and industrial customers.	Total supply<6,356 AF/Y and supplies from CRMWA <2,524 AF/Y	Achieve a 30% reduction in total water use. Best management practices for supply management. Water use restrictions for retail customers. Water use restrictions for wholesale and industrial customers.	Total supply<6,471AF/Y and supplies from CRMWA <1,967AF/Y	Achieve a 35% reduction in total water use. Best management practices for supply management. Water use restrictions for retail customers. Water use restrictions for wholesale and industrial customers.
Canyon	Ogallala, Dockum, Amarillo	Supply=<72.5% full	Achieve voluntary 5% reduction in use of total contracted water from storage. Implementation of supply management and demand measurement measures.	Supply=< 64% full	Achieve 10% voluntary reduction in uses of total contracted water from storage. Implementation of supply management and demand measurement measures.	Supply =< 56% full	Achieve 15% voluntary reduction in use of total contracted water from storage. Implementation of supply management and demand measurement measures.	Mechanical or system failures. Natural or man-made contamination.	Assess severity of emergency. Inform the utility director of each wholesale water customer. Undertake necessary actions for cleanup.
Childress	Ogallala	Supply and demand (Non Specified)	Voluntary 10% reduction in use	Supply and demand (Non Specified)	20% reduction in demand	Supply and demand (Non Specified)	30% reduction in water use	Supply and demand (Non Specified)	Initiate emergency response procedures.
Claude	Ogallala	Dry weather conditions before and during then normal landscape growing season	Voluntary 15% reduction in use	Demand>0.55 MGD for 3 consecutive days	Voluntary 25% reduction in use	Demand>0.575 MGD for 3 consecutive days	Voluntary 35% reduction in use	Water supply emergency such as major water line breaks, pump system failures	Voluntary 15% reduction in use
CRMWA	Ogallala, Meredith	One or two members cities cannot meet actual or expected demand	CRMWA will issue a press release in the cities affected, describing the initiation of Stage 1 of the Drought Contingency Plan and the general condition of water supply. Work with affected city(s) to promote water conservation. Provide technical help for affected city(s)	Three to five members cities cannot meet actual or expected demand.	Continue Stage 1 Responses. Work with additional affected cities to promote water conservation to the public. Work with additional affected cities to provide technical and request cities to initiate appropriate stage of DCP.	More than five members cities cannot meet actual or expected demand	Continue Stage 1 & Stage 2 Responses. Work with additional affected cities to promote water conservation to the public. Work with additional affected cities to provide technical and request cities to initiate appropriate stage of DCP.	N/A	

Summary of Current Drought Triggers and Responses in PWPA

		Onset of Drought						Severe Drought	
Water Provider	**Water Sources**	**Stage 1 Trigger**	**Response**	**Stage 2 Trigger**	**Response**	**Stage 3 Trigger**	**Response**	**Stage 4 Trigger**	**Response**
Dalhart	Ogallala	Dry weather conditions before and during then normal landscape growing season	Achieve 10% voluntary reduction in water use.	Demand>5.7 MGD for 3 consecutive days or equals 6 MGD on a single day	Achieve 20% reduction in daily demand.	Demand>6 MGD for 3 consecutive days or equals 6.3 MGD on a single day	Achieve 30% reduction in daily water demand.	Water supply emergency such as major water line breaks, pump system failures	Initiate emergency response procedures.
Dumas	Ogallala	Demand>85% production capacity of 3 consecutive days	Achieve a voluntary 10% reduction in daily water demand. Voluntary limit irrigation of landscaped areas by street address. Request practice of water conservation and nonessential water use.	Demand>90% production capacity for 3 consecutive days	Achieve a 15% reduction in daily water demand. Irrigation to be limited to two days a week. Use of water to wash a moto vehicle is prohibited except on watering days at designated hours. Water will be served at restaurants only when requested.	Demand=100% production capacity for 3 consecutive days	Achieve a 20% reduction in daily water demand. All Stage 2 requirements except irrigation of landscapes is prohibited by hose-end sprinklers. The watering of golf courses is prohibited and use of water for construction purposes from designated fire hydrants under special permit is to be discontinued.	Demand>=100% production capacity for 3 consecutive days	Achieve a 25% reduction in daily water demand. Irrigation of landscapes is limited to designated watering days and prohibited by used of hose-end sprinklers or permanently installed automatic sprinkler systems. Use of water to wash any motor vehicle, motorbike, boat, trailer or other vehicle not occurring on the premises of a commercial car or truck wash and not in immediate interest of public health/welfare is prohibited
Greenbelt		Reservoir Elevation Level=2,634 msl	Achieve a voluntary 10% reduction in total water use.	Reservoir Elevation Level=2,631 msl	Achieve a 20% reduction in total water use. Water authority would lower the level in all storage tanks to no more than 75% of capacity. Implement demand management measures.	Reservoir Elevation Level=2,628 msl	Achieve a 30% reduction in total water use. Water authority would lower the level in all storage tanks to no more than 50% of capacity. Implement demand management measures.	Reservoir Elevation Level=2,625 msl. Event of major water line water or pump or system failures occur. Natural or man-made contamination of water supply	Assess severity of the emergency and identify actions needed and time required to solve the problem. Inform all necessary parties and notify parties for assistance.
Gruver	Ogallala	Consumption reached 65% total production capacity for 5 consecutive days	Public notification of Stage 1 condition and encouragement of voluntary water conservation measures	Consumption reached 75% total production capacity for 5 consecutive days	City may require even/odd watering days or other restrictions on non-essential water uses	Consumption reached 80% total production capacity for 5 consecutive days	Restrictions for non-essential water uses and may require odd/even water days	Consumption reached 90% total production capacity for 5 consecutive days	Restrictions for non-essential water uses and may require odd/even water days
Higgins	Ogallala	Supply<= 90% of wells capacity or Demand>0.3 MGD for 3 consecutive days	Request voluntary water restrictions	Supply>90% of original well capacity for 3 consecutive days	Comply with requirements and restrictions on certain non-essential water use	Supply>95% of original well capacity for 3 days	Comply with requirements for Stage 3 non-essential water usages	Water supply outage	Comply with requirements for Stage 4
McLean	Ogallala	Consumption reached 65% total production capacity for 5 consecutive days	Public notification of Stage 1 condition and encouragement of voluntary water conservation measures	Consumption reached 75% total production capacity for 5 consecutive days	City may require even/odd watering days or other restrictions on non-essential water uses	Consumption reached 80% total production capacity for 5 consecutive days	Restrictions for non-essential water uses and may require odd/even water days	Consumption reached 90% total production capacity for 5 consecutive days	Restrictions for non-essential water uses and may require odd/even water days
Pampa	Ogallala, CRMWA	CRMWA provides that all or part of the city supply has initiated Stage 1. CRMWA informs member cities that the Reservoir Operation Model projections shows a projected three year future supply in Lake Meredith. City wells, supply lines, pumps or storage where continuously falling water storage levels do not refill above 70%.	Reduce water use by 5%. May implement the following: notify major water users of the situation and request voluntary water use reductions, review Stage 1 cause, and intensify leak detection and repair efforts.	CRMWA provides that all or part of the city supply has initiated Stage 2. CRMWA informs member cities that the Reservoir Operation Model projections shows a projected two year future supply in Lake Meredith. City wells, supply lines, pumps or storage where continuously falling water storage levels do not refill above 50%.	Reduce water by 10%. May implement the following: irrigation utilizing sprinkler systems, notify major users of the situation and should reduce water usage, car wash shall use minimum practical water settings,etc.	CRMWA provides that all or part of the city supply has initiated Stage 3 .CRMWA informs member cities that the Reservoir Operation Model projections shows a projected 1.5 year future supply in Lake Meredith. City wells, supply lines, pumps or storage where continuously falling water storage levels do not refill above 40%.	Reduce water by 15%. Prohibited allowing irrigation water to run off into gutter, ditch, or drain, failure to repair a controllable leak, and washing sidewalks driveways, parking areas, tennis courts, or other paved areas, except to alleviate immediate fire or health hazards.	CRWS provides that all or part of the city supply has initiated Stage 4. CRMWA inform Pampa that a water line fails or pump or system failures occur which cause unprecedented loss of capability to provide water services or natural or man-made contamination of the water supply source occurs.	Reduce water by 30%. Outdoor irrigation of vegetation shall be allowed only between hours of 8PM to 2AM on designated days. Washing of automobiles, trucks, trailers, boats, airplane, etc. is prohibited unless on premises of commercial car washes and commercial service stations.
Panhandle	Ogallala	Demand =90% system capacity	Request voluntary Watering Schedules and encourage other Conservation measures	N/A	N/A	Demand reaches safe limit of 2.5 MGD system capacity for 15 consecutive days	Request voluntary Watering Schedules and encourage other Conservation measures	Demand reaches safe limit of 2.5 MGD system capacity for 10 consecutive days	Request voluntary Watering Schedules and encourage other Conservation measures
Perryton		Dry weather conditions before and during then normal landscape growing season	Achieve a voluntary 10% reduction in total water use. Request voluntary water conservation and prescribed restrictions on certain water uses.	Daily demand>= 4.9 MGD for 3 consecutive days	Achieve a 20% reduction in total water use. Comply with requirements and restrictions on certain non-essential water uses	Daily demand>= 5.25 MGD for 3 consecutive days	Achieve a 30% reduction in total water use. Comply with requirements and restrictions on certain non-essential water use for Stage 3	Water supply emergencies	Initiate emergency response procedures. Mandatory water use restrictions such as prohibited landscape irrigation and filling of swimming pools.
Red River Authority	Ogallala	System Water production capacity drops 20% and remains consistent for a period of at least 60 consecutive days.	Raise public awareness. Achieve up to 20% reduction in demand.	System water production capacity drops by 30% and remains consistent for a period of at least 30 consecutive days.	Increase public awareness. Achieve a 30% reduction in demand.	System water production capacity drops by 40% and remains consistent for a period of at least 20 consecutive days.	Inform public of critical situation. Reduce demand by 40%.	System water production capacity drops by 50% and remains consistent for a period of at least 10 consecutive days.	Inform public of critical and possible hazardous situation. Reduce demand to a level necessary to maintain public health and safety.

Summary of Current Drought Triggers and Responses in PWPA

		Onset of Drought							Severe Drought
Water Provider	**Water Sources**	**Stage 1 Trigger**	**Response**	**Stage 2 Trigger**	**Response**	**Stage 3 Trigger**	**Response**	**Stage 4 Trigger**	**Response**
Shamrock	Ogallala	Consumption reached 65% total production capacity for 5 consecutive days	Public notification of Stage 1 condition and encouragement of voluntary water conservation measures	Consumption reached 75% total production capacity for 5 consecutive days	City may require even/odd watering days or other restrictions on non-essential water uses	Consumption reached 80% total production capacity for 5 consecutive days	Restrictions for non-essential water uses and may require odd/even water days	Consumption reached 90% total production capacity for 5 consecutive days	Restrictions for non-essential water uses and may require odd/even water days
Turkey	Ogallala	Supply<= 75% capacity	Voluntary 25% reduction in use	Supply>= 50% capacity	50% reduction in water use	Supply>= 25% capacity	75% reduction in water use	Water supply emergency	Identify action needed, inform wholesale water supply customers, and if appropriate notify city/country emergency response officials
Wellington	Ogallala	Demand >=90% system capacity for 5 consecutive days	Voluntary 10% reduction in use	Demand >=95% system capacity for 3 consecutive days	15% reduction in demand	Demand >=100% system capacity for 3 consecutive days	20% reduction in water use	Water supply emergency	20% reduction in water use
White Deer	Ogallala	Dry weather conditions before and during then normal landscape growing season	Request voluntary water conservations	Demand>0.55 MGD for 3 consecutive days	Comply with requirements and restrictions on certain non-essential water use	Demand>0.575 MGD for 3 consecutive days	Comply with requirements and restrictions on certain non-essential water use	Water supply emergency such as major water line breaks, pump system failures	Comply with requirements for Stage 4

8 REGULATORY, ADMINISTRATIVE AND LEGISLATIVE RECOMMENDATIONS

Regional Water Planning Guidelines specified in the Texas Administrative Code call for the regional water planning groups to make recommendations regarding ecologically unique river and stream segments; unique sites for reservoir construction; and regulatory, administrative, or legislative actions that will facilitate the orderly development, management, and conservation of water resources. Recommendations of the PWPG are presented in this section.

PWPG Recommendations:

- No unique stream segments or unique reservoir sites are recommended.
- About 20 regulatory, legislative, and state water planning recommendations:
    - Reuse
    - Groundwater
    - Conservation
    - Brush Control
    - Data Collection and Updates
    - Funding

8.1 Unique Stream Segments

Under regional planning guidelines, each planning region may recommend specific river or stream segments to be considered by the Legislature for designation as ecologically unique. The Legislative designation of a river or stream segment would only mean that the State could not finance the construction of a reservoir that would impact the segment. The intent is to provide a means of protecting the segments from activities that may threaten their environmental integrity.

TPWD provided guidance for such designations and the following criteria shall be used when recommending a unique river or stream segment:

Biological Function: Segments which display significant overall habitat value including both quantity and quality considering the degree of biodiversity, age, and uniqueness observed and including terrestrial, wetland, aquatic, or estuarine habitats;

- *Hydrologic Function*: Segments which are fringed by habitats that perform valuable hydrologic functions relating to water quality, flood attenuation, flow stabilization, or groundwater recharge and discharge;
- *Riparian Conservation Areas*: Segments which are fringed by significant areas in public ownership including state and federal refuges, wildlife management areas, preserves, parks, mitigation areas, or other areas held by governmental organizations for conservation purposes under a governmentally approved conservation plan;
- *High Water Quality/Exceptional Aquatic Life/High Aesthetic Value*: Segments and spring resources that are significant due to unique or critical habitats and exceptional aquatic life uses dependent on or associated with high water quality; or
- *Threatened or Endangered Species/Unique Communities*: Sites along segments where water development projects would have significant detrimental effects on state or federally listed threatened and endangered species, and sites along segments that are significant due to the presence of unique, exemplary, or unusually extensive natural communities.

During the first round of planning (2001 Regional Water Plans), TPWD compiled a listing of potential ecologically significant stream segments located in the PWPA (see **Figure 8-1**). These stream segments were selected by TPWD because of the above-listed criteria.

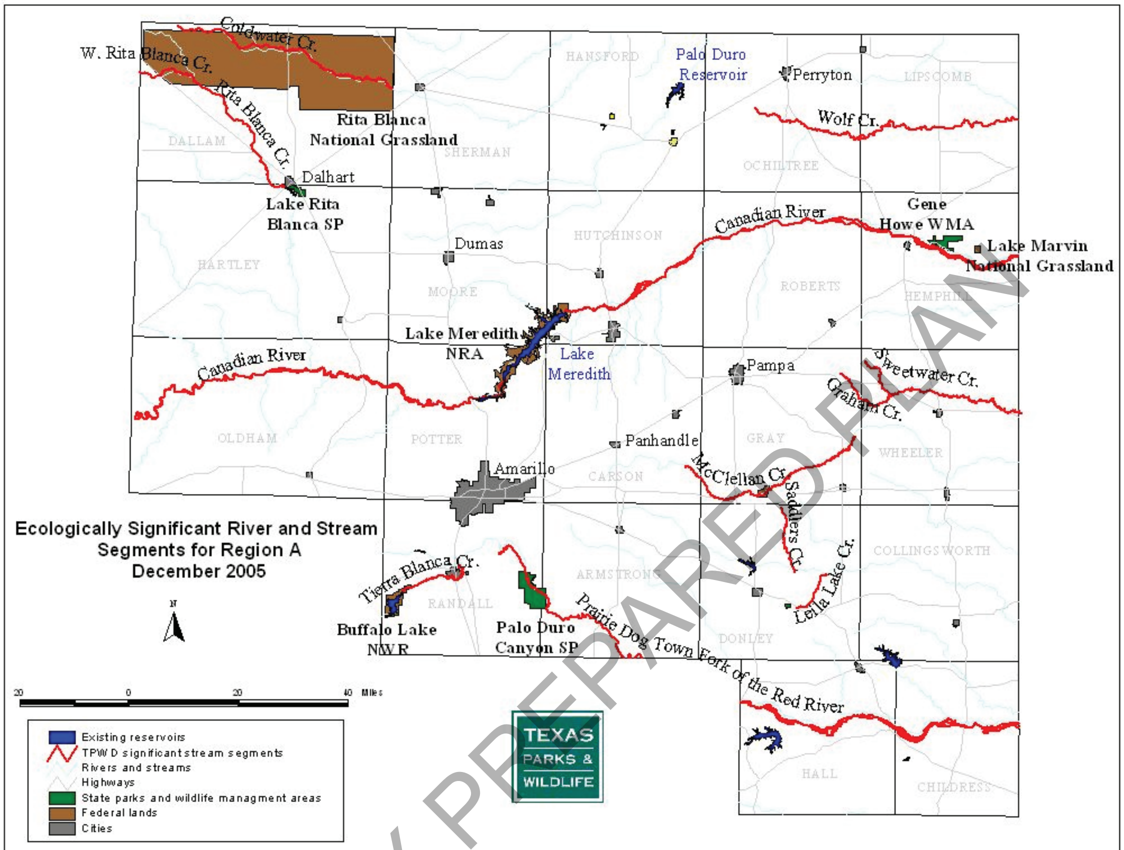


Figure 8-1: TPWD Identified Streams Segments for Consideration of Designation as Ecologically Significant in the PWPA

As part of the initial planning process, each of the TPWD-identified segments were evaluated by the PWPG for potential recommendation as unique stream segments. After careful consideration of the unknown consequences of recommendation, the PWPG made no recommendations for river and stream segments for designation as ecologically unique. The following stream segments were presented to the planning group by TPWD for consideration:

- Canadian River (TCEQ Segment 0101)
  From the Oklahoma State line in Hemphill County upstream to Sanford Dam in Hutchinson County
- Canadian River (TCEQ Segment 0103)
  From a point immediately upstream of the confluence of Camp Creek in Potter County to the New Mexico State line in Oldham County
- Coldwater Creek
  From the Dallam/Sherman County line upstream to the Texas/Oklahoma State line

- Graham Creek
  From the confluence with Sweetwater Creek east of Mobeetie in Wheeler County upstream to SH 152 in northeast Gray County
- Lelia Lake Creek
  From the confluence with the Salt Fork of the Red River in Donley County upstream to US 287 in Donley County
- McClellan Creek
  From the confluence with the North Fork of the Red River in east Gray County upstream to its headwaters in the southwestern part of Gray County
- Prairie Dog Town Fork Red River (TCEQ Segment 0229)
  From the Armstrong/Briscoe County line upstream to Lake Tanglewood in Randall County
- Prairie Dog Town Fork Red River (TCEQ Segment 0207)
  From the Childress/Hardeman County line upstream to the Hall/Briscoe County line
- Rita Blanca Creek
  From the headwaters of Lake Rita Blanca in Hartley County upstream to US 87 in Dallam County
- Saddlers Creek
  From the confluence with the Salt Fork of the Red River eight miles northeast of Clarendon in Donley County upstream to its headwaters located about two miles southeast of Evans in north Donley County
- Sweetwater Creek
  From the Oklahoma State line in Wheeler County upstream to its headwaters in northwest Wheeler County
- Tierra Blanca Creek
  From the confluence with Prairie Dog Town Fork of the Red River upstream to Buffalo Lake in Randall County
- West Fork of Rita Blanca Creek
  From the confluence with Rita Blanca Creek in Dallam County upstream to the New Mexico State line
- Wolf Creek (TCEQ Segment 0104)
  From the Oklahoma State line in Lipscomb County to a point 1.2 miles upstream of FM 3045 in Ochiltree County

During subsequent planning cycles, the PWPG considered each of these stream segments for designation as ecologically unique and did not designate any segments. As part of this update to the regional water plan, the PWPG again considered each of these stream segments. Portions of several segments are currently protected by other means, such as a designated wildlife management area; others have protections through existing regulations like the Threatened and Endangered Species Act. These local, state, and federal protections provide a mechanism to preserve the ecological value of these streams. By law, the designation of ecologically unique stream segment only prevents the state from funding a new reservoir project that impacts the segment, but the designation could be used to prevent other valid activities. Since there are no new reservoir sites currently being considered in the PWPA, the designation would add no additional protections. In light of these considerations, the PWPG chose not to designate any ecologically unique stream segments in the PWPA.

8.2 Sites of Unique Value for the Construction of Reservoirs

Planning groups may recommend sites of unique value for construction of reservoirs by including descriptions of the sites, reasons for the unique designation, and expected beneficiaries of the water supply to be developed at the site. The following criteria shall be used to determine if a site is unique for reservoir construction:

- Site-specific reservoir development is recommended as a specific water management strategy or in an alternative long-term scenario in an adopted plan; or
- The location, hydrologic, geologic, topographic, water availability, water quality, environmental, cultural, and current development characteristics, or other pertinent factors make the site uniquely suited for:
    - Reservoir development to provide water supply for the current planning period; or
    - Where it might reasonably be needed to meet needs beyond the 50-year planning period.

Local river and stream segments were evaluated by the PWPG for potential recommendation as unique reservoir sites. No sites were recommended by the planning group as sites of unique value for the construction of reservoirs.

8.3 Legislative Recommendations

As the PWPG has gone through the preparation of the regional water supply plan, several items have been identified which the PWPG recommends be considered before the next planning cycle. Title 31 of the Texas Administrative Code (TAC) §357.43 states that the regional water plans will include regulatory, administrative, legislative or "Any other recommendations that the regional water planning group believes are needed and desirable to achieve the stated goals of the state and regional water planning, including to facilitate the orderly development, management, and conservation of water resources and prepare for and respond to drought conditions." The rules also encourage the PWPG to consider recommendations that would facilitate more voluntary transfers in the PWPA.

Over previous planning cycles, the PWPG has developed a detailed list of regulatory and legislative recommendations. Some of these recommendations have been implemented. Others are currently being considered. In light of the continual changes in water management and development, the PWPG identified recommendations for the 2026 Panhandle Water Plan. The following sections discuss the PWPG recommendations and consider recommendations by the Interregional Planning Council.

8.3.1 Regulatory Issues

Continue to evaluate the rules governing reuse to encourage the use of wastewater effluent. The current regulatory environment provides a number of barriers to encourage the reuse of wastewater effluent. TCEQ should re-evaluate the current rules and change the rules to provide and quantify incentives for municipalities, industries and agriculture to reuse wastewater effluent

8.3.2 Legislative Issues

Manage groundwater resources through local groundwater conservation districts. There remain certain areas of the PWPA that are not within the boundaries of a groundwater district. Many of these areas do not have substantial quantities of groundwater or located in areas with no aquifers. However, areas with groundwater should be included in a local district contained within the regional planning area to create an equitable situation regarding groundwater management, provided that it is feasible and locally supported.

Develop additional tools for GCD's to enforce rules. For the areas that are within the boundaries of an existing groundwater conservation district, the planning group requests the Legislature authorize additional measures and resources to help enforce rules.

Create a water conservation reserve program for irrigated acreage management. A water conservation reserve program should be created to make it economically feasible for farmers to convert irrigated acreage to dryland.

Encourage the federal government to continue to support Conservation Reserve Program (CRP) participation. This program continues to help protect local groundwater resources. As properties currently in CRP are coming out, property owners may convert and reestablish the properties to irrigated agriculture and utilize higher volumes of groundwater.

Evaluate policy barriers to use playa lakes for conservation purposes. The State should evaluate the current legislative barriers to using playa lakes. The barriers should be removed or reduced to allow using the playas for aquifer recharge or other beneficial water supply purposes.

Maintain the functionality and viability of the Water Conservation Advisory Council. The group currently operates on a volunteer basis with no state or federal funding.

Continue to support and enhance funding for the entire regional water planning process. The public process requires considerable coordination and staff assistance to comply. The costs to administer the PWPA regional planning process are significant. The planning group acknowledges the current funding and requests continued support for all portions of the regional water planning process.

Provide funding for the GMA process. GCD's currently pay subconsultants for the GMA process. Often, various districts have different levels of funding available for the process. The planning group requests the GMA process be state funded to ensure a fair process for all GCD's within a given GMA.

Provide funding for educational events including demonstrations of irrigation conservation strategies to encourage adoption. Irrigation conservation relies on the adoption of measures by individual producers. Education is the first step to making long-term conservation efforts become a reality.

Provide funding for the Master Irrigator Program. The Master Irrigator Program is an established event hosted in Region A by the North Plains Groundwater Conservation District. The program is an irrigation management course and has had great success within the Region. The PWPG requests funding and support to expand this program to other areas in the region and state.

Provide funding for more information on agricultural water use to better inform the TWDB baseline estimates and irrigation conservation strategies. Considering that agricultural use accounts for more than 90 percent of total usage in the PWPA, a thorough understanding of agricultural water use is critical to the future of the region. Many of the agricultural conservation strategies are dependent on knowing the water use and acreage by crop.

Provide funding for the Water Supply Enhancement Program (WSEP). The WSEP provides funding to landowners and surface water suppliers to control invasive brush that threatens to reduce stream flows, shallow springs, and groundwater seeps. Currently this program is not funded by the Legislature. The PWPG recommends funding this program to promote land stewardship and conservation of water supplies.

Support CRMWA brush control efforts. CRMWA has an active salt cedar control program in the Lake Meredith watershed. The purpose of the program is to increase flow in the Canadian River, improve water quality and improve the habitat for the federally listed Arkansas River Shiner, which is known to inhabit this area.

8.4 Recommendations for Future State Water Plans

TWDB should establish and continue to promote clear guidelines for eligibility for funding and needs assessment for very small cities and unincorporated areas. Statements to the effect that "entities which fall under the planning limits retain eligibility for state funding assistance for water-related projects without having specific individual needs identified in the Regional Water Plan" would greatly enhance the ability of these small systems to provide their users with a safe and adequate supply of water.

TWDB should coordinate with other agencies on data and continue to improve the monitoring and quantification of small communities, county-other, manufacturing, and livestock operator water use to provide better information for planning purposes.

TCEQ should be made an ex-officio member of the RWPGs and attend RWPG meetings to provide input on known water quality/quantity problems.

Continue to support salinity and brush control projects for the Canadian River and/or Red River Basin. Although there have been salinity and brush control projects recently implemented in the Canadian and Red River Basins, future State Water Plans should continue to plan for future salinity and brush control projects and their funding to continue to improve water quality and quantity in the basins.

Support enhanced groundwater recharge. Groundwater accounts for a major source of water in the PWPA. Recharge rates are near zero for most of the area over the Ogallala aquifer with slopes around playas having the highest rates. Other regional aquifers, such as the Seymour Aquifer, may be more amenable to enhanced recharge. Means of enhanced recharge also include any man-made structure(s) that slow down or hold surface water to increase the probability of groundwater recharge. With current drought conditions, alternative sources of rechargeable water need to be identified and studies conducted to determine the feasibility of enhancing recharge with these water sources.

Updated analysis of groundwater supplies and availability. The PWPG supports continuing funding of the TWDB's groundwater availability models for the major and minor aquifers of Texas. The PWPG appreciates TWDB's leadership in this initiative and recognizes the importance of the data that comes from these models. Therefore, the PWPG stresses how imperative it is to continue funding this effort at an amount similar to or greater than the past.

9 IMPLEMENTATION AND COMPARISON TO PREVIOUS REGIONAL WATER PLAN

9.1 Introduction

The Regional and State Water Planning process administered by the TWDB operates on a five-year cycle. Inherently, this cycle enables continual refinements and changes to major components of the planning process, such as water demands, supplies, and recommended strategies. This chapter assesses the changes between cycles of Regional Water Plans. This chapter includes a discussion on the major differences between the 2026 Panhandle Water Plan and the previous Plan (2021 Panhandle Water Plan) and a description of strategies that have been implemented since the publication of the 2021 Plan.

9.2 Differences Between Previous and Current Regional Water Plans

The following sections specifically address changes between the 2021 and 2026 Plan in:

- Population projections,
- Water demand projections,
- Drought of record and hydrologic modeling and assumptions,
- Groundwater and surface water availability,
- Existing water supplies for water users,
- Identified water needs for WUGs and MWPs, and
- Recommended and alternate water management strategies.

9.2.1 Population Projections

Population projections for the 2026 Plan are based on the 2020 Census, while the 2021 Plan population projections were based on the 2010 Census. An additional change for this round of planning is the declining population for some water user groups. In the 2021 round of regional planning, if a water user group experienced a decline in population, the population was held constant throughout the entire planning period. In the 2026 round of regional planning, if a water user experienced a population decline between the 2010 and 2020 census, the population projection reflected the decline. This resulted in a lower population for some WUGs and the region as a whole (**Figure 9.1**).

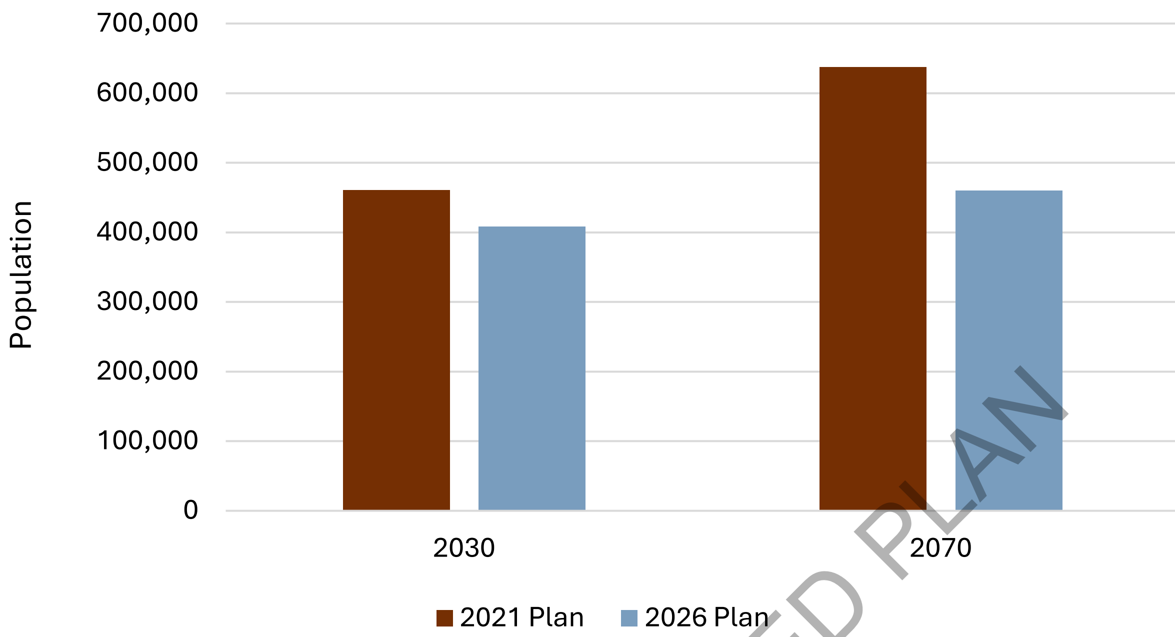


Figure 9.1: Comparison of PWPA Population

Region A added one new WUG in the 2026 Plan (Siesta Estates) and no municipal WUGs were removed. However, Cactus was removed as a Major Water Provider.

9.2.2 Water Demand Projections

Development of municipal and non-municipal water demands for the 2026 Plan was similar to the methodology used in the 2021 Plan. Water demands in the PWPA for the 2026 Plan increased in comparison to the 2021 Plan (**Figure 9.2**) by approximately 1 to 14 percent. Irrigation water demands are primarily driving these increases (**Table 9-2**) with a 241,754 ac-ft difference in 2070. Irrigation demands decline in at least one decade in four counties: Dallam, Hartley, Moore, and Randall between the 2026 and 2021 Plans. As shown on **Figure 9.3**, projected demands for irrigation are significantly higher in the 2026 Plan. Livestock demands also increased for the region as a whole in the 2026 Plan due to new dairy farms expected to arrive in Region A.

Manufacturing, mining, and steam-electric power demands all are relatively similar in the 2026 Plan compared to the 2021 Plan. Manufacturing decreases slightly in the 2026 Plans in the early decades, with a slight increase in 2070. Mining decreases slightly in the first decade, with a slight increase throughout the remainder of the planning cycle. Steam-electric power has a consistent 3,554 acre-feet per year decrease throughout the planning period.

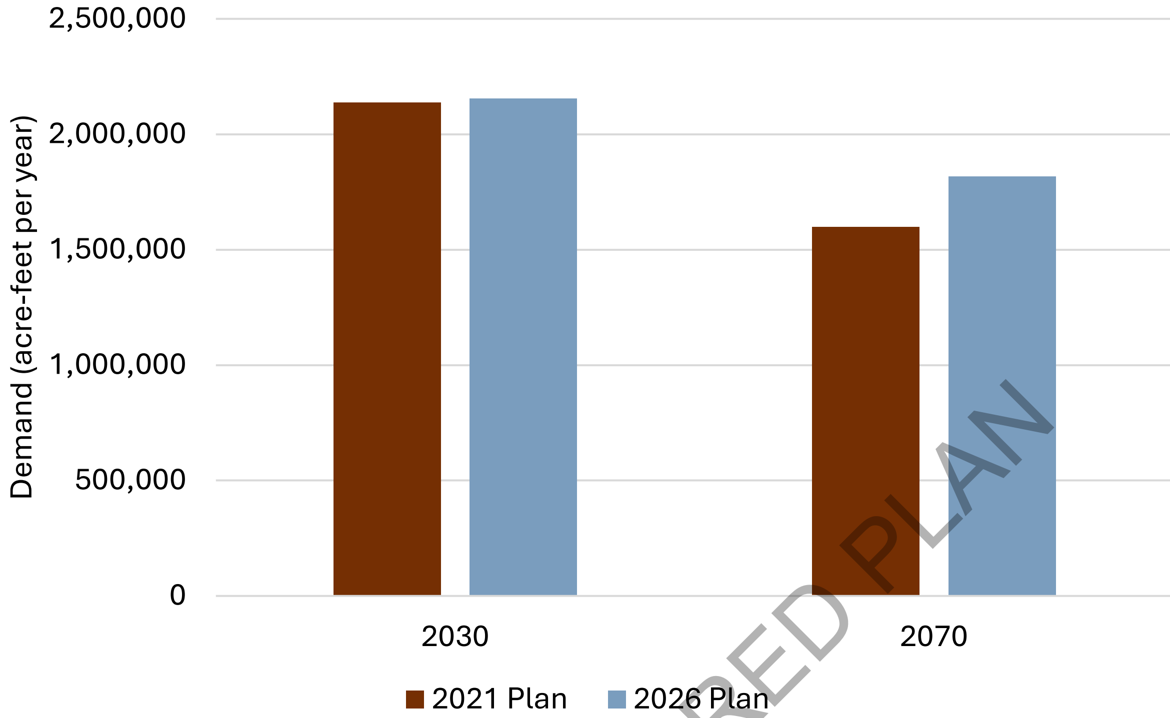


Figure 9.2: Comparison of PWPA Water Demand

Table 9-1: Changes in Projected Demands from the 2021 Plan to the 2026 Plan by Use Type

Use Type	Changes in Projected Water Demands (ac ft/yr) 2030	2070
Municipal	(10,067)	(34,635)
Irrigation	23,877	241,754
Livestock	12,329	6,811
Manufacturing	(6,337)	932
Mining	(232)	6,917
Steam Electric Power	(3,554)	(3,554)
Total	**16,016**	**218,225**

Note: Negative numbers indicate lower demand in the 2026 Plan and positive numbers show higher demand in the 2026 Plan.

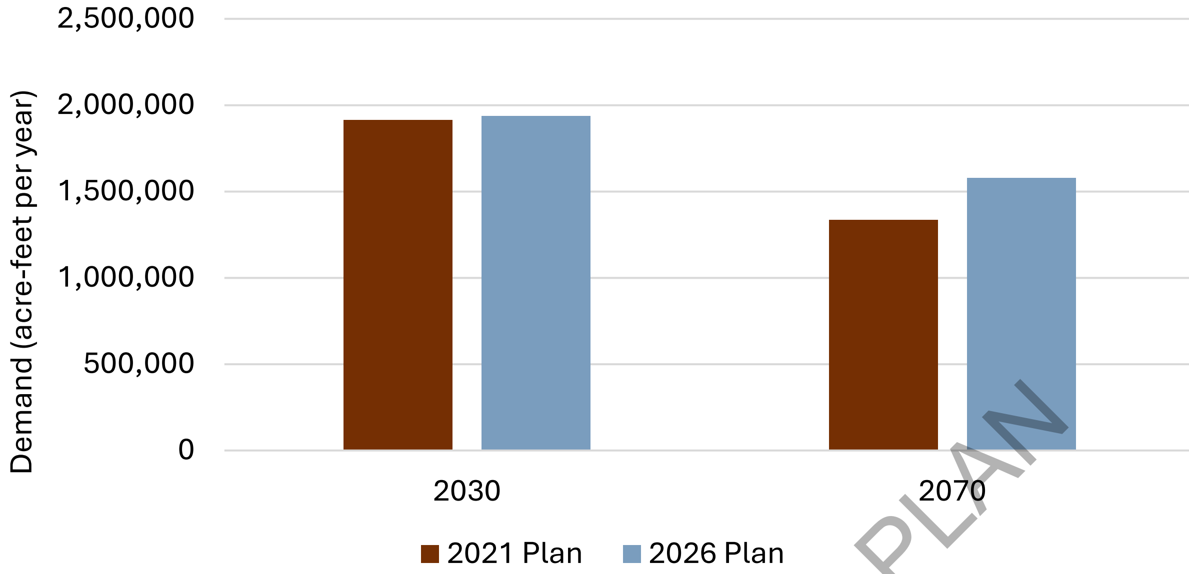


Figure 9.3: Comparison of PWPA Irrigation Water Demand

Table 9-2: Changes in Projected Irrigation Demands from the 2021 Plan to the 2026 Plan

County	Change in Projected Irrigation Demand (ac ft/yr)	
	2030	2070
Armstrong	80	80
Carson	10,644	10,644
Childress	829	829
Collingsworth	7,052	9,874
Dallam	(3,201)	71,810
Donley	1,530	1,530
Gray	4,663	4,663
Hall	1,533	6,812
Hansford	3,786	3,786
Hartley	(7,876)	65,143
Hemphill	198	198
Hutchinson	1,956	1,956
Lipscomb	2,479	2,479
Moore	(9,228)	33,900
Ochiltree	2,223	2,223
Oldham	319	319
Potter	296	296
Randall	(278)	(278)
Roberts	1,021	1,021
Sherman	5,162	23,780
Wheeler	689	689
Total	**23,877**	**241,754**

Negative numbers indicate lower demand in the 2026 Plan and positive numbers show higher demand in the 2026 Plan.

Figure 9.4 shows that the projected municipal water demands are lower for the 2026 Plan in comparison to the 2021 Plan. This is due to both the projected population and GPCD being lower in the 2026 Plan.

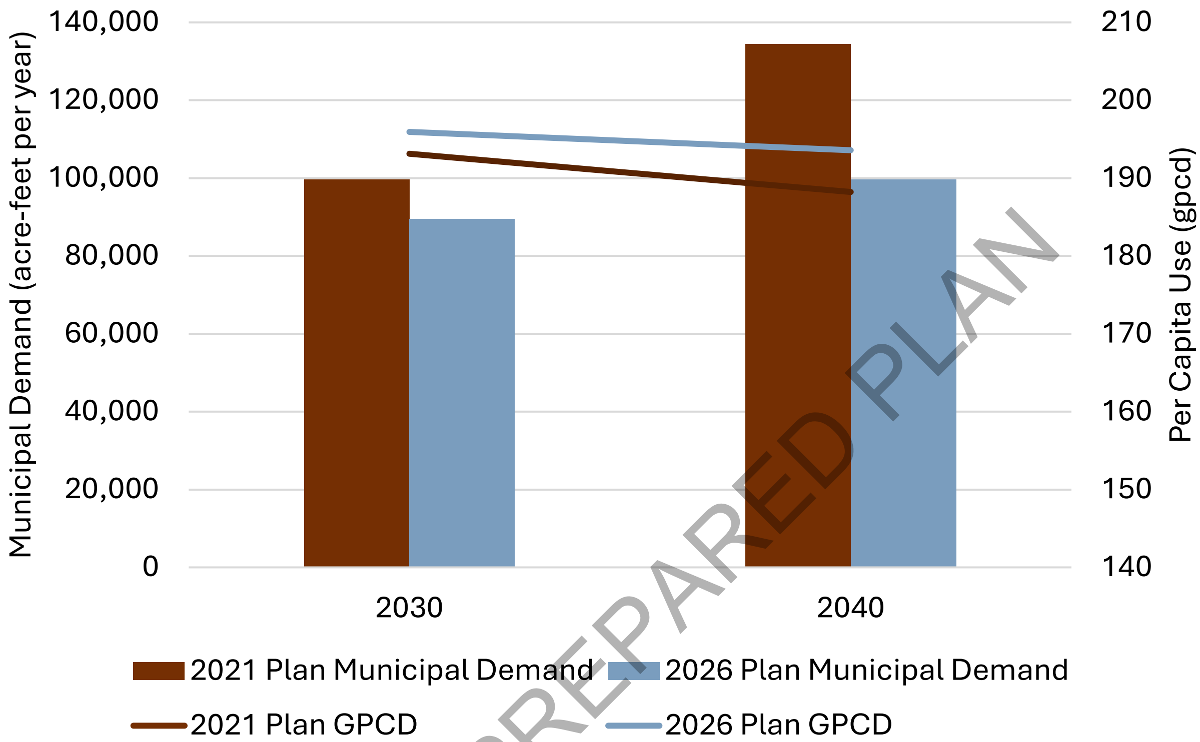


Figure 9.4: Comparison of Projected Per Capita Use and Municipal Demand

9.2.3 Drought of Record and Hydrologic Modeling Assumptions

In general, the drought of record is defined as the worst drought to occur in a region during the entire period of meteorological record keeping. For most of Texas, the drought of record occurred from 1950-1957. Surface water sources in the PWPA were in drought of record conditions for the 2011, 2016, 2021 Plan and continue to be in drought of record conditions for the 2026 Plan.

In the 2021 Plan, the estimated reliable supply from Lake Meredith was based on a firm and safe yield analysis using extended hydrology through December 2027. The safe yield for Lake Meredith was estimated at around 24,670 acre-feet per year. For the 2026 Plan, the safe yield was reduced to 24,600 acre-feet per year in all decades due to previous sedimentation estimates causing the yield to fluctuate throughout the planning cycle in the 2021 Plan. Furthermore, the diversions from Lake Meredith have averaged about 12,000 acre-feet per year since 2011 due to water quality concerns. Without significant inflows the water quality in the lake is expected to continue to deteriorate, further limiting its availability for water supply. Considering this, the reliable supply of Lake Meredith for the 2026 Plan is 12,000 acre-feet per year in 2030 reducing to 4,500 acre-feet per year by 2080. For Greenbelt Reservoir, the TCEQ approved Red River WAM was updated in 2021 and extended the period of record to 1948 through 2017. Resulting in a safe yield of 3,140 acre-feet per year in 2030 (compared to 3,112 acre-feet per year in 2020 in the 2021 Plan) and decreasing to 2,175 acre-feet per year by 2080.

For groundwater, hydrogeologic modeling assumptions change each planning cycle as GMAs adopt new Desired Future Conditions (DFCs) and new or updated groundwater models become available. In the 2021 Plan the GMA's 50-year planning cycle for model runs was 2012-2062. For the 2026 Plan the cycle extended from 2018-2080. The adopted DFCs for the Ogallala/Rita Blanca state that the aquifers shall have 40 percent of the aquifer storage remaining for each 50-year period between 2018 and 2080 for the four western counties (Dallam, Hartley, Sherman and Moore), 80 percent of the storage remaining in Hemphill County, and 50 percent of the storage remaining in the other counties in the GMA, except for Randall, and those portions of Armstrong and Potter Counties located within the High Plains UWCD. In these areas, the DFC is approximately 20 feet of total average drawdown for each 50-year period between 2012 and 2080. Other than the model run years, the adopted DFCs for the 2026 Plan were the same in the 2021 Plan.

For the Dockum aquifer the DFC was set as the average decline in water levels to be no more than 30 feet over the next 50 years for areas within the Panhandle GCD. For the Dockum that falls in the North Plains GCD (Dallam, Hartley, Moore and Sherman Counties), the DFC was set at 40 percent of storage remaining at the end of the simulation (2080). Greater drawdown (approximately 40 feet) was allowed in Randall County, and in the portions of Armstrong and Potter counites within the High Plains UWCD. This is consistent with the DFC used for the 2021 Plan.

The DFC for the portions of Seymour Pods 1, 2 and 3 that are within the Mesquite and Gateway GCDs in Childress, Collingsworth and Hall Counties (Mesquite GCD) require that no more than 33 feet of drawdown in Childress and Collingsworth Counties, and 15 feet in Hall County between 2010 and 2080. For the portion of Seymour Pod 4, located in the Gateway GCD in Childress County, the adopted DFC requires that total decline in water levels will not exceed one foot over the 2010 to 2080 period. This is consistent with the DFC used for the 2021 Plan.

The Blaine aquifer DFC for the part of Childress County north of the Red River, located in the Mesquite GCD, all of Collingsworth and Hall Counties, also located within the Mesquite GCD, and that part of Childress County north of the Red River located in the Gateway GCD is that the total decline in water levels will be no more than 9 feet during the period from 2010 to 2080. For the part of Childress County south of the Red River, located in the Mesquite & Gateway GCDs, the total decline in water levels should be no more than 2 feet during the period from 2010 to 2080. This is consistent with the DFC used for the 2021 Plan.

9.2.4 Groundwater Availability

In general, groundwater availability remained similar for the 2026 Plan. Groundwater availability decreased by a few ten thousand acre-feet in 2030 and 2070 (**Figure 9.5**) for the Region as a whole. **Figure 9.6** and **Table 9-5** show the differences between the 2026 plan and 2021 Plan by County. The Ogallala and Ogallala and Rita Blanca Aquifers saw the most significant changes in 2030 and 2070 (**Table 9-3**). Decreases in the Ogallala Aquifer is shown in 15 of 21 counties in the PWPA, resulting in a net decrease of about 147,000 acre-feet per year for the region by 2070 compared to the 2021 Plan. Hansford, Lipscomb, Ochiltree, and Roberts County show the largest decrease in 2070 (**Table 9-4**) compared to the 2021 Plan.

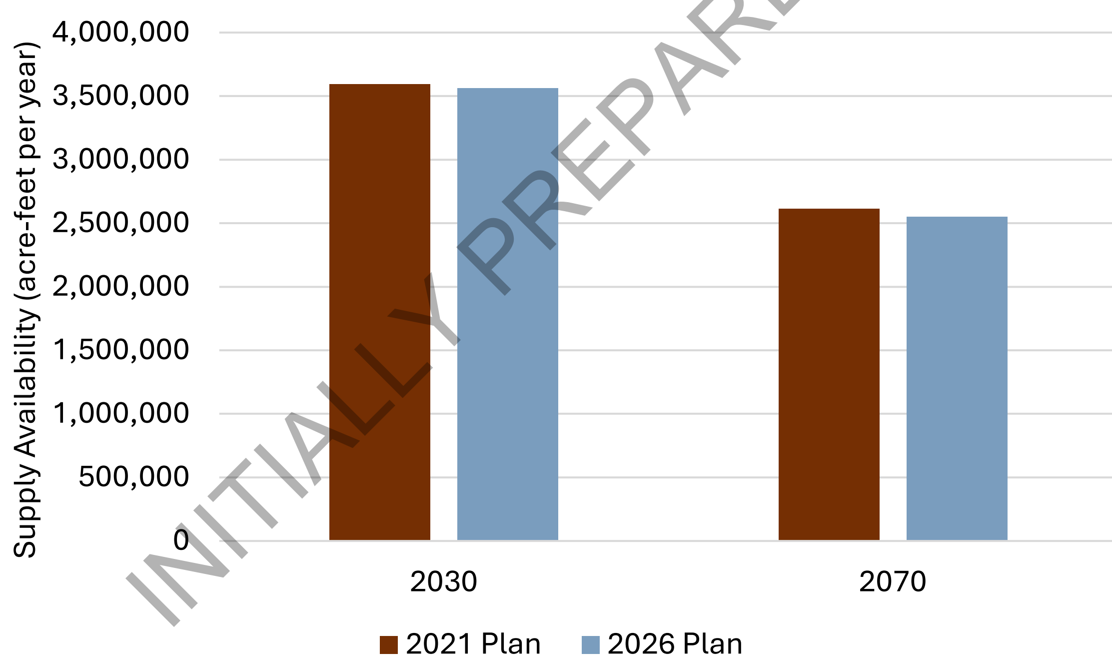


Figure 9.5: Comparison of Groundwater Availability from the 2021 and 2026 Plans

Table 9-3: Change in Groundwater Availability by Aquifer from the 2021 Plan to 2026 Plan

Source	Changes in Groundwater Availability (ac ft/yr) 2030	2070
Ogallala & Rita Blanca	(20,182)	59,085
Ogallala	(71,944)	(146,863)
Seymour	(1)	(1)
Blaine	(1,750)	(1,750)
Dockum	60,994	27,774
Other	0	0
Total	**(32,883)**	**(61,755)**

Table 9-4: Changes in Ogallala Aquifer Availability by County from the 2021 Plan to 2026 Plan

County	Changes in Groundwater Availability (ac ft/yr) 2030	2070
Armstrong	1,977	(7,817)
Carson	(18,239)	-2,850
Collingsworth	(50)	(50)
Dallam	(17,630)	31,496
Donley	1,978	(1,143)
Gray	6,381	(629)
Hansford	23,044	(39,789)
Hartley	(2,552)	27,589
Hemphill	(6,402)	6,921
Hutchinson	28,051	5,989
Lipscomb	4,109	(47,584)
Moore	(31,793)	16,191
Ochiltree	16,041	(44,758)
Oldham	(1,136)	1,803
Potter	8,738	8
Randall	8,619	(7,839)
Roberts	(45,829)	(32,930)
Sherman	(61,238)	18,123
Wheeler	(6,195)	(10,509)
Total	**(92,126)**	**(87,778)**

Table 9-5: Changes in Total Groundwater Availability by County from the 2021 Plan to 2026 Plan

County	Changes in Groundwater Availability (ac ft/yr)	
	2030	2070
Armstrong	890	(8,227)
Carson	(18,341)	(3,042)
Childress	(1)	(1)
Collingsworth	(50)	(50)
Dallam	(16,296)	30,207
Donley	1,978	(1,143)
Gray	6,381	(629)
Hall	-	-
Hansford	23,044	(39,789)
Hartley	7,004	24,960
Hemphill	(6,402)	6,921
Hutchinson	28,051	5,989
Lipscomb	4,109	(47,584)
Moore	(30,941)	16,521
Ochiltree	16,041	(44,758)
Oldham	23,822	14,959
Potter	9,981	4,933
Randall	32,570	5,851
Roberts	(45,829)	(32,930)
Sherman	(60,949)	18,316
Wheeler	(7,945)	(12,259)
Total	**(32,883)**	**(61,755)**

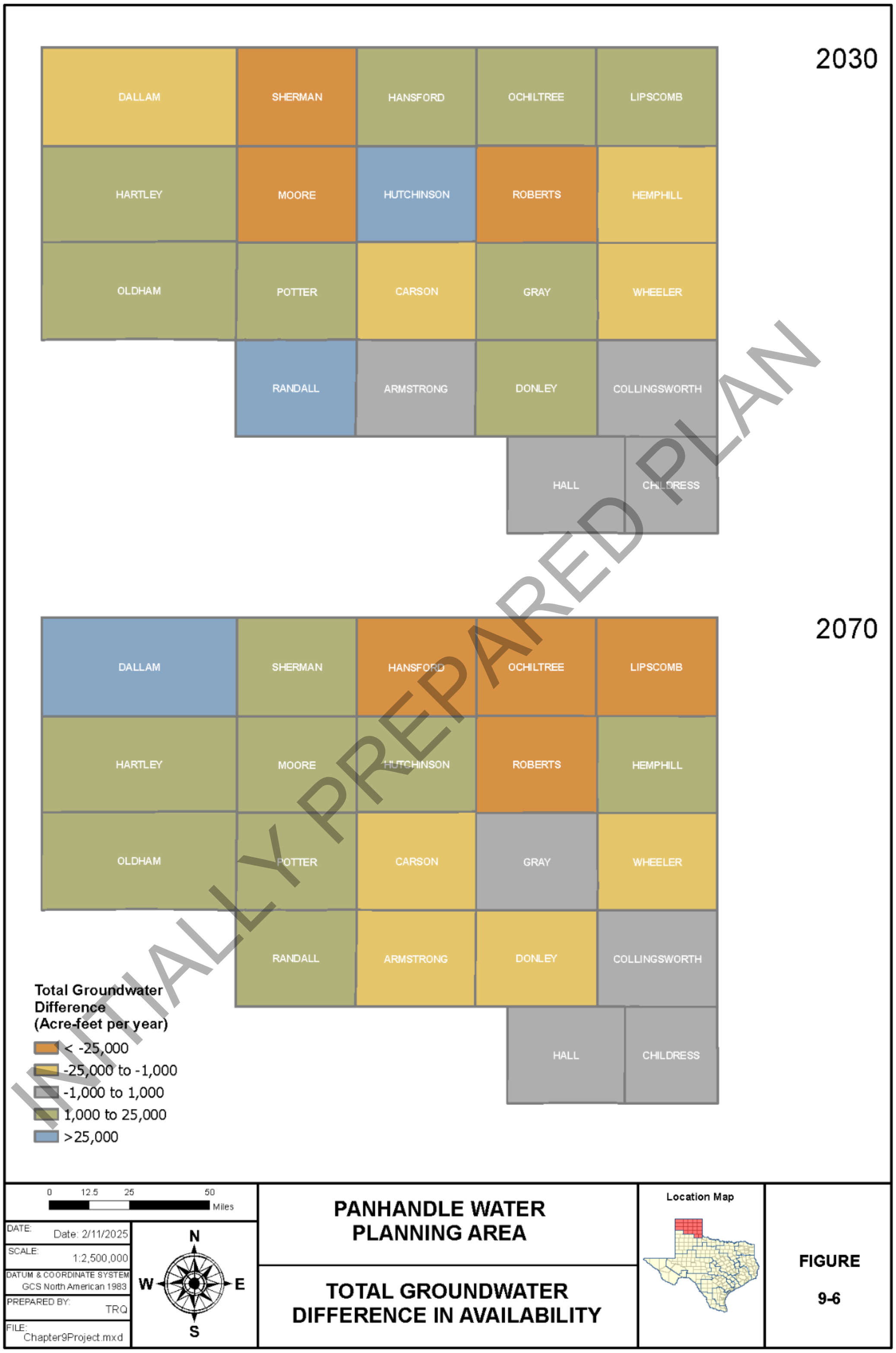


Figure 9.6: Total Groundwater Difference in Availability

9.2.5 Surface Water Availability

Surface water availability decreased by approximately 16 percent from the 2021 Plan to the 2026 Plan as shown in **Figure 9.7**. In 2015, the three major reservoirs (Lake Meredith, Greenbelt Reservoir and Palo Duro Reservoir) began capturing inflow after a long significant drought. Reservoir storage increased, but the reservoirs are still in drought of record conditions. The available supply from Greenbelt Reservoir is projected to be 6 percent less in 2070 than estimated for the 2021 Plan. Palo Duro Reservoir's large reduction (100 percent less compared to the 2021 plan) is due to adjustments for losses through infiltration and leakage, resulting in no supply under a safe yield analysis this round. While the Lake Meredith safe yield is comparable in the 2021 and 2026 plans, the reliable yield has been reduced to 12,000 acre-feet in 2030 decreasing to 4,500 acre-feet in 2080 in the 2026 plan due to concerns on water quality. Local supplies and run-of-river availability is projected to decrease by over 20 percent in 2070 in comparison to the 2021 Plan. (**Table 9-6**).

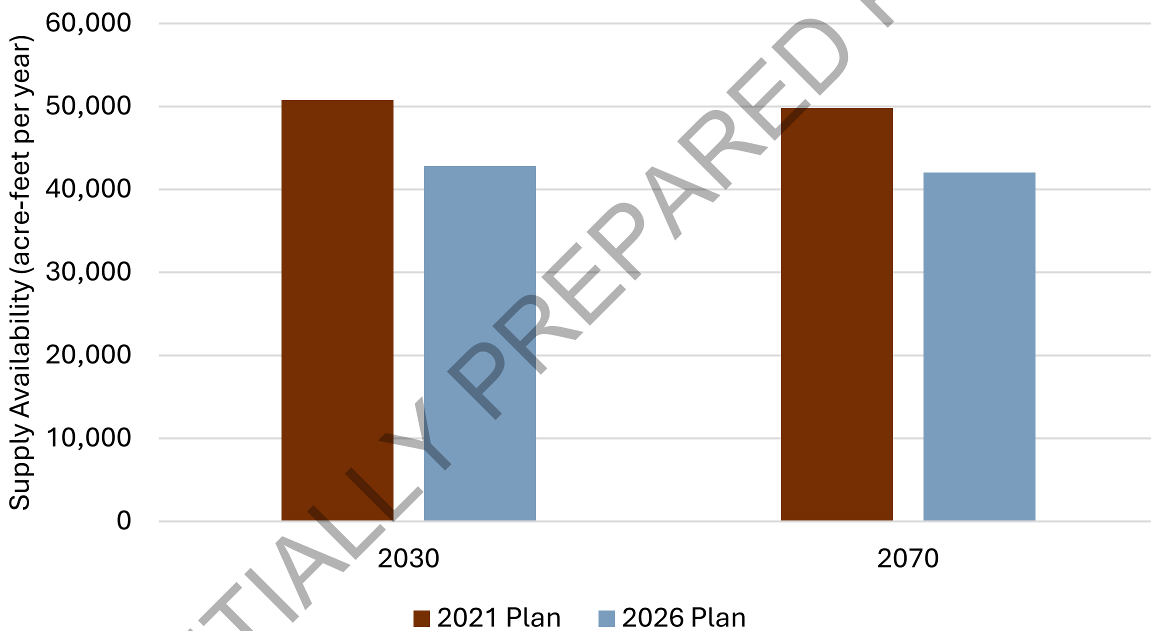


Figure 9.7: Comparison of Surface Water Availability in the 2021 and 2026 Plans

Table 9-6: Projected Change in Surface Water Supply from the 2021 to 2026 Plan in 2070

Supply	2021 Plan	2026 Plan	Percent Change
	(ac ft/yr)		
Lake Meredith[1]	24,501	6,000	-76%
Greenbelt Reservoir	2,256	2,383	6%
Palo Duro Reservoir	3,708	0	-100%
Local Supplies	16,783	13,192	-21%
Run-of-River	2,538	1,859	-27%
Total	**49,786**	**23,434**	**-53%**

[1]Reliable supply is shown for 2026 Plan. No change in safe yield.

9.2.6 Existing Water Supplies of Water Users

Existing supplies to users are based on the source availability and infrastructure developed to provide the water. Due to changes in source availability and demand, supplies to some users increased while others may have decreased. In general, existing water supplies of water users are similar in the 2026 Plan compared to the 2021 Plan.

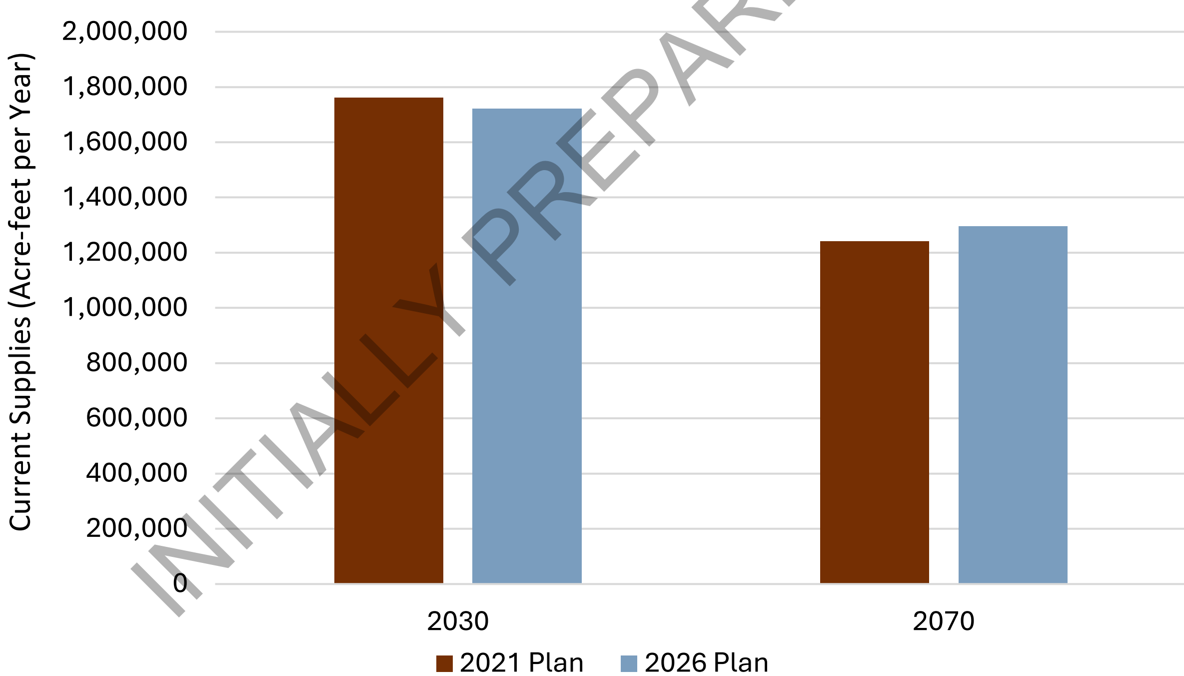


Figure 9.8: Comparison of Current Water Supplies for WUGs

9.2.7 Identified Water Needs

Water Use Type

As mentioned in **Section 9.2.2**, water demands in the PWPA for the 2026 Plan increased in comparison to the 2021 Plan (**Figure 9.2**) by approximately 1 to 14 percent. Irrigation water demands are primarily driving these increases. However, a pattern of overall decline continues to be projected throughout the 50-year analysis. Relative consumption of water by use type has remained fairly constant between the two plans with irrigation being the largest consumer followed by municipal, livestock, manufacturing, steam electric power and mining use. There were some absolute differences in demands by use type, with higher demands for irrigation, livestock, manufacturing, and mining use and lower demands for municipal and steam-electric use in 2070. Manufacturing and mining use show lower demands beginning in 2030 and then increase to higher demands by 2070.

Needs

The total needs for the 2026 Plan are more than the 2021 Plan in both 2030 and 2070 (**Figure 9.9**). Total demand, primarily driven by increased irrigation demand, is higher in the 2026 Plan compared to the 2021 Plan. As a result, the distribution of water needs by use type are different with municipal and manufacturing water use having lower needs in the 2026 Plan and irrigation and livestock having greater water needs (**Figure 9.10**). Mining and Steam Electric Power do not have a need in either plan. While Livestock has a need in the 2026 Plan and did not in the 2021 Plan.

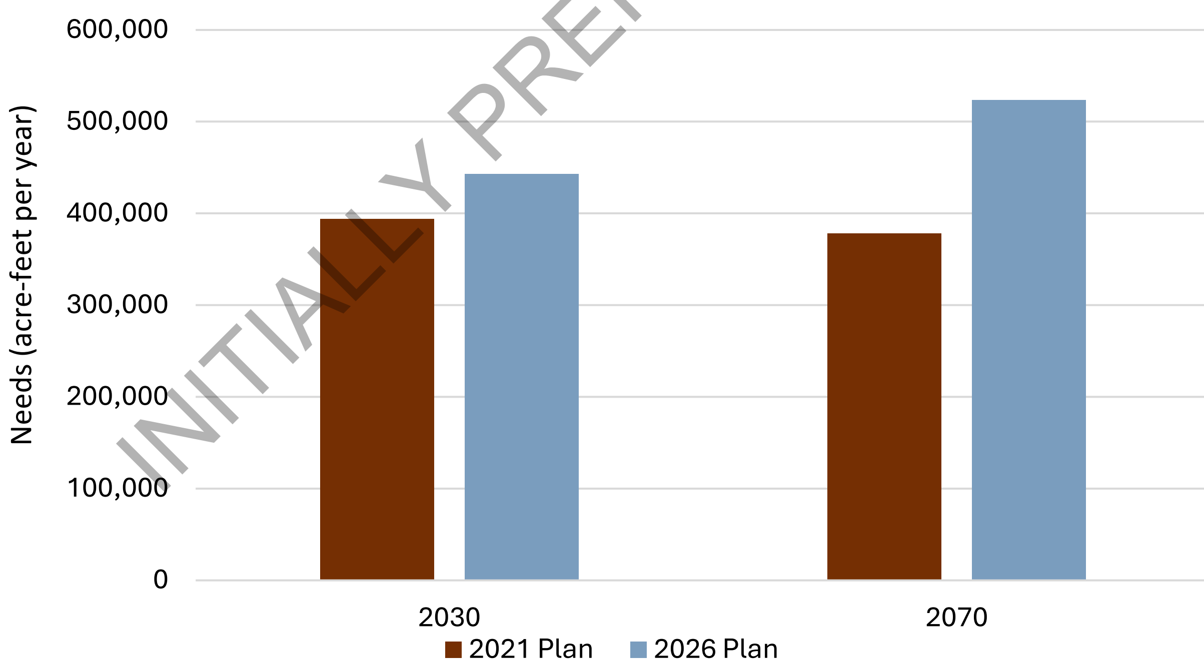


Figure 9.9: Projected Water Need for the 2021 and 2026 Plans

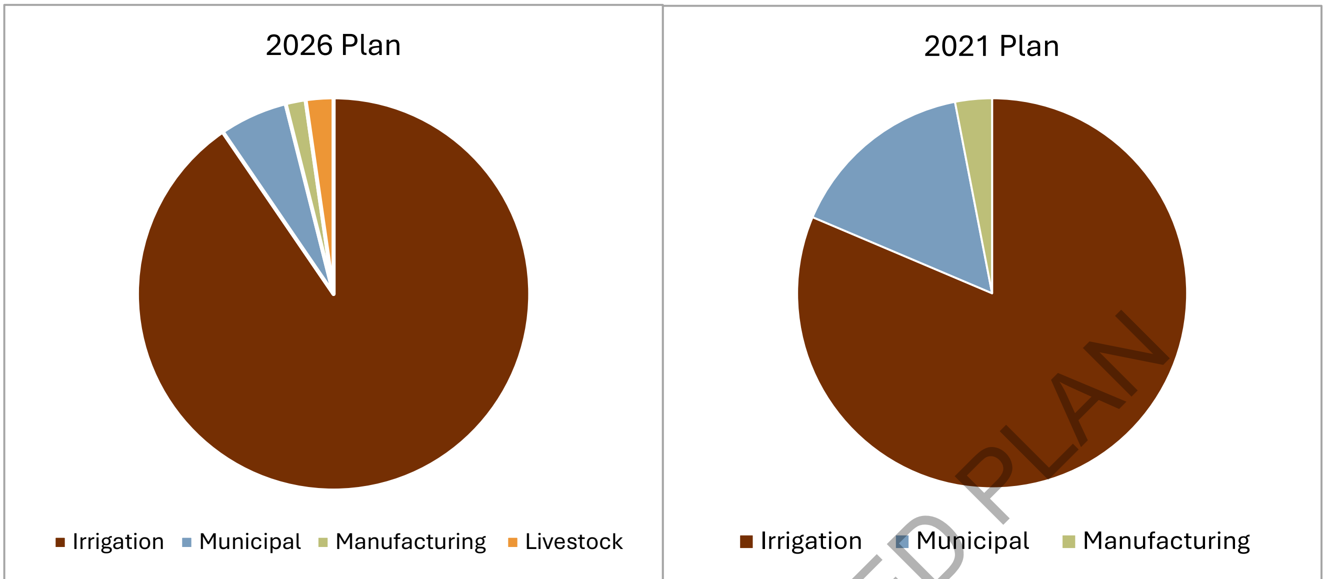


Figure 9.10: Projected Water Need in 2070 by Type

For the 2026 Plan, three of the four Major Water Providers are shown to have a need at some time during the planning period. In the 2021 Plan, all five of the Major Water Providers were shown to have a need. CRMWA's higher needs in the 2026 Plan can be attributed to the reduction in existing supplies from Lake Meredith due to water quality concerns. Both Amarillo and Borger are customers of CRMWA and receive less existing water from CRMWA in the 2026 Plan. The changes in projected water needs for the Major Water Providers are shown on **Figure 9.11**.

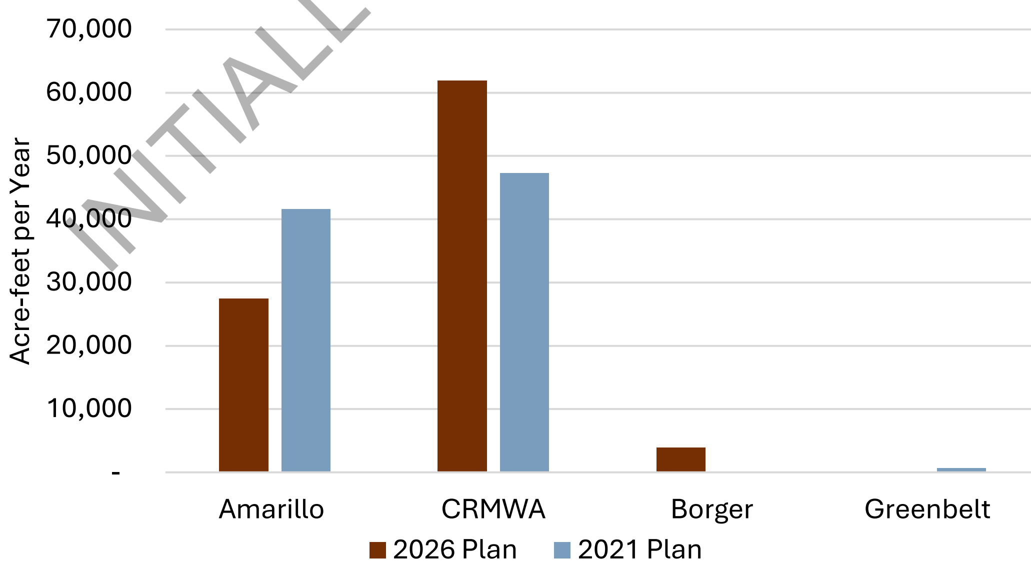


Figure 9.11: Comparison of 2070 Need by Major Water Provider

New Water Management Strategies

Due to changes in water needs, new strategies were developed for the 2026 Water Plan. **Table 9-7** lists the 2026 new recommended strategies for water user groups. There are no new alternate strategies for the 2026 Plan. Additional information on strategies can be found in **Chapter 5C** and **5D**.

Table 9-7: New Recommended Water Management Strategies in the 2026 Plan

Water User Group	New Recommended Water Management Strategy
Borger	Develop New Well Field (Ogallala Aquifer), Acquisition of TCW Well Field and System
Canadian	Develop New Well Field (Ogallala Aquifer)
CRMWA	Desalination of Lake Meredith, Linear Well Field
Fritch	Develop New Well Field (Ogallala Aquifer)
Livestock, Hartley	Develop New Well Field (Ogallala Aquifer), Develop New Well Field (Dockum Aquifer)
Livestock, Moore	Develop New Well Field (Dockum Aquifer)
Shamrock	Develop New Well Field (Ogallala Aquifer)
Stratford	Develop New Well Field (Ogallala Aquifer)
Miami	Develop New Well Field (Ogallala Aquifer)

9.2.8 Altered Water Management Strategies

Several strategies in the current plan were listed in the previous plan but have been altered in some way. This section focuses on strategies that were significantly changed from the last plan either due to major conceptual changes, better available data, or considerable changes in assumptions used to calculate the water available from the strategy. This section is meant to highlight the differences, not give a full description of the strategy. More information on these strategies can be found in **Chapter 5**.

Irrigation Conservation

The recommended combinations of irrigation conservation strategies remained similar to the 2021 Plan with the addition of Enhanced Education. The 2026 Plan suit of strategies includes Crop Type, Plant Breeding, Irrigation Equipment, Irrigation Scheduling, and Enhanced Education. Additional information on agricultural water conservation can be found in **Subchapter 5B.2**.

Major Water Provider Strategies

There were numerous changes to the concepts and details of the strategies for the major water providers. Most of these changes reflect additional information since the 2021 Plan. **Table 9-9** lists previous and new recommended water management strategies for the PWPA major water providers.

While several of the strategies in the 2026 Plan are the same as in the 2021 Plan, there are some modifications to some strategies. Specifically, CRMWA's Desalination of Lake Meredith Water is now conceptualized as adding usable supply to CRMWA's system (not just making the supply more reliable) due to concerns of Lake Meredith's quality and is a recommended (not alternate) strategy. Also, the former joint CRMWA and Amarillo CRMWA II pipeline will now be developed individually.

For Amarillo, Borger, and Greenbelt MIWA's strategies retained, the concepts remain similar to the 2021 Plan.

Table 9-8: Major Water Provider Strategies and Projects in the 2021 and 2026 Plan

Major Water Providers	2021 Plan	2026 Plan
CRMWA	CRMWA II pipeline with Amarillo	CRMWA II pipeline
	Replace well capacity	Replace well capacity
	Brush Control	Brush Control
	ASR (with operational efficiencies of CRMWA I and II pipelines)	ASR (with operational efficiencies of CRMWA I and II pipelines)
	---	Desalination of Lake Meredith Water
	---	Linear Well Field Along Existing Transmission System
Amarillo	Potter/Carson County Well Field (Phase II)	Potter/Carson County Well Field (Phase II)
	ASR (Randall County)	ASR (Randall County)
	Direct Potable Reuse (Recommended)	Direct Potable Reuse (Recommended)
	Roberts County Well Field	Roberts County Well Field
Borger	---	Drill Additional Groundwater Wells
	---	Acquisition of TCW Well Field and System
Greenbelt MIWA	Donley County Well Field	Donley County Well Field

9.2.9 No Longer Recommended or Considered Water Management Strategies

In addition to new and altered strategies, some strategies included in the 2021 Plan are no longer being considered for the entity for various reasons. Most of these strategies are no longer needed because the entity does not have a need in the 2026 Plan. These strategies are outlined in **Table 9-9**.

9.2.10 Unmet Water Needs

The PWPA has additional needs in the 2026 Plan compared to the 2021 Plan. In the 2021 Plan all unmet needs were associated with irrigation. In addition to unmet irrigation needs in the 2026 Plan, unmet needs remain in Moore County (Cactus, manufacturing, livestock, and irrigation) due to MAG limitations in later decades.

Table 9-9: Changes in Unmet Needs from the 2021 Plan to the 2026

Use Type	Changes in Unmet Needs (ac ft/yr)	
	2030	2070
Municipal	-	(211)
Manufacturing	-	(1,852)
Livestock	-	(4,222)
Irrigation	(129,568)	(185,236)
Total	**(129,568)**	**(191,521)**

Table 9-10: Strategies and Projects No Longer Considered in the 2026 Plan

Entity	Strategies No Longer Considered in the 2026 Plan
2021 Recommended Strategies	
Panhandle	Drill Additional Groundwater Well(s)
Wellington	Drill Additional Groundwater Well(s)
Dalhart	Drill Additional Groundwater Well(s)
Texline	Drill Additional Groundwater Well(s)
McLean	Drill Additional Groundwater Well(s)
Pampa	Drill Additional Groundwater Well(s)
Memphis	Drill Additional Groundwater Well(s)
Spearman	Drill Additional Groundwater Well(s)
TCW Supply	Drill Additional Groundwater Well(s)
Sunray	Drill Additional Groundwater Well(s)
Randall County Manufacturing	Drill Additional Groundwater Well(s)
Canyon	Water Audit and Leak Repairs
Dumas	Water Audit and Leak Repairs
Turkey	Water Audit and Leak Repairs, Drill Additional Groundwater Well(s)
2021 Alternate Strategies	
Hall County-Other (Lakeview)	Advanced Treatment
Palo Duro Water District	Develop PDWD Transmission System
Hall County-Other (Brice-Lesly)	Develop Seymour Aquifer Supplies
Hall County-Other (Estelline)	Develop Seymour Aquifer Supplies

1. These strategies and/or projects are not evaluated or discussed in the 2026 Plan.

9.3 Implementation of Previously Recommended Strategies

There are no known strategies that were recommended in the 2021 Plan that have been completely implemented since the plan was published. Amarillo has partially completed the implementation of its AMI program.

9.4 Assessment of Regionalization Across Region A

The PWPA providers continue to identify opportunities for regionalization as evidenced by **Table 9-10.** All four Major Water Providers in Region A have strategies in the 2026 Plan to move water to their customers in Region A, B, and O. Additionally, Booker, Cactus, and Dumas all include strategies in the 2026 plan benefiting multiple WUGs.

Table 9-11: Comparison of Recommended Water Management Strategies Serving More than one Water User Group (WUG) in the 2021 and 2026 Plans

2021 Regional Plan	2026 Regional Plan
Develop Potter/Carson County Well Field (Ogallala Aquifer) - Amarillo	Develop Potter/Carson County Well Field (Ogallala Aquifer) - Amarillo
Develop Roberts County Well Field (Ogallala Aquifer) - Amarillo	Develop Roberts County Well Field (Ogallala Aquifer) - Amarillo
Direct Potable Reuse - Amarillo	Direct Potable Reuse - Amarillo
---	Drill Additional Groundwater Wells - Borger
CRMWA ASR	CRMWA ASR
Expand Capacity CRMWA 2	Expand Capacity CRMWA 2
Replace Well Capacity	Replace Well Capacity
Brush Control - CRMWA	Brush Control - CRMWA
---	Desalination of Lake Meredith Water - CRMWA
Develop Ogallala Aquifer In Donley County - Greenbelt MIWA	Develop Ogallala Aquifer In Donley County - Greenbelt MIWA
Develop Ogallala Aquifer Supplies - Booker	Develop Ogalalla Aquifer Supplies - Booker
Develop New Well Field (Ogallala Aquifer) - Cactus	Develop New Well Field (Ogallala Aquifer) - Cactus
Develop Ogallala Aquifer Supplies - Dumas	Develop Ogallala Aquifer Supplies - Dumas
11 Recommended WMS Serving More than one WUG	**13 Recommended WMS Serving More than one WUG**

9.5 Conclusion

While there were several significant changes to supplies and demands in the PWPA for the 2026 Plan, the overall recommended strategies remain fairly consistent. Conservation remains a major strategy to meet irrigation and municipal water needs and preserve existing supplies. Groundwater is still the preferred source for new supply development. There is an increased concern with Lake Meredith's water quality, as evidenced by the reduction in reliable supply and CRMWA's desalination strategy. The region continues to show significant demands on groundwater resources and limited quantities available in future decades. The heavy demand on these resources results in some unmet water needs for irrigation and users in Moore County.

10 PLAN ADOPTION AND PUBLIC PARTICIPATION

This chapter describes the various public participation, information, outreach, and education activities conducted by the Panhandle Water Planning Group (PWPG). All activities and events discussed in this section were performed in direct support of the regional water planning effort and serve to support the PWPG's dedication and commitment to ensuring that the public is provided with timely, accurate information regarding the planning process and that opportunities to provide input to the planning process are available as often as possible.

The chapter also details the plan adoption process followed by the PWPG. The process explains the required hearing, receipt of comments, comment response, and final adoption of the PWPA's Regional Water Plan.

10.1 Panhandle Water Planning Group

The PWPG was created in accordance with and operates under the auspices of SB1 and updated under subsequent legislation. The enabling legislation and TWDB planning rules and guidelines established the basis for the creation and composition of the regional planning groups. The original statute listed eleven required interest groups that must be represented at all times on the planning groups. To these original eleven interest groups, the PWPG has elected to add an additional group to adequately ensure that the interests of the region are fully protected. In 2011, groundwater management areas were added as a required interest category. The following lists the thirteen interest groups represented by the 23 voting members of the PWPG:

- General Public
- Counties
- Municipalities
- Industrial
- Agricultural
- Environmental
- Small Business
- Electric Generating Utilities
- River Authorities
- Water Districts
- Water Utilities
- Groundwater Management Areas
- Higher Education (added interest)

Table 10-1 lists the voting members of the PWPG (as of January 2025), their respective interest groups, and their principal county of interest. **Table 10-1** also lists the three former members of the PWPG who also participated in the planning process for the 2026 PWPA Plan. The PWPG appreciates the contributions of these individuals and would like for their efforts to be recognized along with the current members.

Table 10-1: Panhandle Water Planning Group - Voting Members

Interest	Name	Entity	County (Location of Interest)
Public	Megan Eikner	Texas A&M AgriLife Research & Extension Center	Potter
Counties	Judge Vernon Cook	Retired (Roberts County)	Roberts
Municipalities	Floyd Hartman	City of Amarillo	Potter and Randall
	David Landis	City of Perryton	Ochiltree
Industries	Herman Berngen	Hilmar Cheese Company	Dallam
	Spencer Cave	Phillips 66	Hutchinson
Agricultural	Ben Weinheimer	Texas Cattle Feeders Association	Serves entire region
	Joe Baumgardner	Farmer	Collingsworth
	Janet Tregellas	Farm/Ranch	Lipscomb
Environmental	Jason Shubert	Talon/LPE	Randall
	Gary Marek	Conservation & Production Research Laboratory	Potter
	David Parker (former)	Texas A&M AgriLife Research & Extension Center	Randall
Small Businesses	Rusty Gilmore	Water Well Driller	Dallam
Electrical Generating Utilities	Glen Green	Xcel Energy	Potter (serve entire region)
River Authorities	Drew Satterwhite	Canadian River MWA	Multiple counties
Water Districts	Janet Guthrie Steve Walthour (former)	North Plains GCD	Moore and 7 other counties in the region
	Jason Coleman	High Plains Underground Water Conservation District	Donley
	Britney Britten	Panhandle Groundwater Conservation District	Carson
	Christa Perry Janet Guthrie (former)	Hemphill County UWCD	Hemphill
Water Utilities	Dean Cooke	TCW Supply	Hutchinson
Groundwater Management Areas	Danny Krienke	GMA#1	Ochiltree and 17 other counties
	Whitney Wiebe Lynn Smith (former)	Mesquite Groundwater Conservation District (GMA#6)	Collingsworth, Childress and Hall
Higher Education	Brent Auvermann	Texas A&M AgriLife Research and Extension Center	Serves entire region

Former – Retired during the planning cycle.

In addition to the 23 voting members, the PWPG has six key state resource agency stakeholder positions in accordance with the appropriate regulations governing the process. **Table 10-2** lists the six key stakeholder positions on the PWPG and their respective interests. Also listed are the liaisons from the PWPG to adjoining regions.

Table 10-2: Panhandle Water Planning Group - Other Key Stakeholders

PWPG Member	Position	Interest Group	Membership
Michele Foss	Texas Water Development Board (TWDB)	TWDB (Rules)	Non-Voting
Briann Schenk	Texas Department of Agriculture (TDA)	TDA (Rules)	Non-Voting
(Vacant)	Region B Liaison		
Drew Satterwhite	Region O Liaison	Water Districts	Voting
Troy Headings	USDA/NRCS	Agricultural	Non-Voting
Caleb Huber	Texas Parks & Wildlife Department	TPWD (Rules)	Non-Voting
Glenn W. Baker	Texas State and Soil Water Conservation Board	TSSWCB (Rules)	Non-Voting

10.2 Panhandle Water Planning Group Public Information and Education Commitment

The PWPG is firmly committed to ensuring the activities of the planning group are open and accessible to all interested parties. In addition, the PWPG has worked diligently to ensure that the public throughout the region is afforded every opportunity to participate in planning group activities and to receive timely information regarding the planning process. Participation in the regional water planning effort by local entities and the public was engaged throughout the process. Public participation opportunities were afforded to the region through the following broad categories. The PWPG met all requirements of the Public Information Act.

Media – Media throughout the region were provided notification of all Planning Group activities. Media outlets participated in various planning activities throughout the process, with PWPG representatives appearing at media events as well as routine press in regional newspapers. In addition, regional radio stations provided recaps of PWPG activities on occasion. PRPC (Panhandle Regional Planning Commission) Staff has conducted interviews with local television and newspaper outlets in conjunction with many regular meetings and public hearings for the PWPG.

Electronic Communication - Web Access to Planning Information The PWPG has developed and placed online a dedicated project website, www.panhandlewater.org. The site is updated on a regular basis and provides the general public with quick, reliable access to planning data at any time. Each meeting is posted on this site and/or provided to the County Clerk of each county in the PWPG ahead of the scheduled meetings and all presented meeting materials are made available on the site within 5 working days of each meeting's conclusion. Additionally, each full and committee meeting of the PWPG has been posted electronically with the Texas Secretary of State for easy public access to the notifications. Finally, the PWPG leverages the wider audience that views the TWDB's home page (www.twdb.texas.gov) to disseminate upcoming meeting notices, minutes of previous meetings, contact information, and prior Regional Water Plans.

Public Information Meetings The PWPG held all meetings in accordance with the Open Meetings Act and encouraged public attendance at the meetings.

Symposiums and Forums PWPG membership has provided technical expertise to several symposiums and forums during the planning process. Included among these are Water Conservation Symposium, the High Plains Irrigation Annual Conferences and the Agricultural Water Planning Summit and other public forums.

Required Public Meeting One public meeting was conducted to solicit input and comments on the scope of work for the development of the updated regional water plan. This meeting was held in Amarillo at the PRPC office on June 29, 2021.

Required Public Hearing The public hearing on the Initially Prepared Water Plan (IPP) will be held at the PRPC in Amarillo on April 22, 2025.

Panhandle Water Planning Group Meetings The PWPG conducted numerous public meetings over the past five years as necessary to develop the 2026 Panhandle Water Plan. In addition, subcommittee meetings were held on specific technical and planning topics. All meetings of the PWPG are conducted in accordance with the Texas Open Meetings Act.

10.3 Water Provider Input

Throughout the planning process, the PWPG conducted multiple surveys and reached out individually to specific water users with needs, major water providers and groundwater conservation districts. One survey was sent to all municipal water users, major water providers and county judges to solicit input on population and water demands, current water sources and drought planning. Other surveys collected information on the status of the proposed 2021 Plan water strategies, potential emergency interconnections, Water Conservation Plans and Drought Contingency Plans, and proposed 2026 Plan water strategies. Responses from the various surveys were used to develop the information in the 2026 Plan.

10.3.1 Rural Outreach

Most of the PWPA and its municipal water providers are considered rural. Many of these rural water providers are designated water user groups (WUGs) and are planned for directly in the 2026 Panhandle Water Plan. Each WUG was sent surveys as discussed above. For those with water needs that did not respond directly to the survey, follow-up emails and/or phone calls were made to confirm the preferred water management strategy.

Smaller municipal water suppliers that fall under the "County-Other" category or that were not reached out to as part of the standard planning process as a WUG were attempted to be contacted directly if the entity meet any of the four criteria outlined in **Appendix H**. There are 70 water providers in the PWPA identified by the TWDB as rural. Of these, surveys were sent to 48 providers as part of the regional outreach to water user groups. One provider identified by TWDB is based in Region O and was not contacted. The remaining 21 providers are included in the "County-Other" category for regional water planning. Of these, individual utilities were contacted if it met the criteria discussed above. All the County-Other providers have a very low to low level of uncertainty for potential water needs.

A list of the rural water providers and the PWPG outreach efforts is included in **Appendix H**.

10.4 Panhandle Water Planning Group Functions

Members of the PWPG have been quite active and very committed to the planning process. Through the course of the functions detailed below, Planning Group members have contributed many non-reimbursed hours of time. In addition, PWPG members have traveled thousands of miles. This level of participation by these Planning Group members speaks very highly of not only the commitment of the people of the region to the water planning process but also to the intense effort and dedication to the process. As mentioned previously, the PWPG has not reimbursed any members for the time they have committed to the process and none of the miles traveled have been reimbursed through use of local funds. This fact becomes quite important when the membership of the PWPG is analyzed. The majority of these members work in the public sector or are retired experts, so the donation of time and travel by these individuals with restricted budgets is of great value to the region.

10.5 Panhandle Water Planning Group Meetings

Through the Initially Prepared Plan planning process, the PWPG has conducted 29 Planning Group and Subcommittee meetings. Attendance at the meetings by the voting members of the PWPG has been excellent, with appropriate quorums in attendance at all meetings. PWPG meetings have been conducted in the central location of the planning area in Amarillo at the office of the political subdivision, the PRPC. The frequency of PWPG meetings has averaged almost one per quarter. Often subcommittee meetings were held the same day as full PWPG meetings.

10.6 Panhandle Water Planning Group Committee Activities

To further enhance the regional planning process, the PWPG has established a committee structure to assist in evaluating planning progress and to provide recommendations to the PWPG. The committees, as authorized, serve only in an advisory capacity. In addition, committee membership includes, where appropriate, PWPG members as well as nonmembers.

Historically, the PWPG has utilized up to five committees for a myriad of purposes. However, in recent cycles the PWPG has utilized only two committees with the Executive Committee serving multiple purposes previously handled in multiple Committee settings.

The Agriculture Committee met nine times in the sixth planning cycle to review multiple aspects of the planning process since agriculture demand constitutes such a large portion of water usage in the region. The first two meetings of the Agriculture Committee were Joint Interregional meetings with Region O, which focused on reviewing, revising, and recommending agriculture demand numbers for the TWDB to more accurately account for agriculture demand in the region. Subsequent Agriculture Committee meetings focused on the agricultural supplies, projected needs, and development of agriculture strategies for the 2026 Panhandle Regional Water Plan.

The Executive Committee of the PWPG has served multiple functions throughout the sixth planning cycle. The Executive Committee has continued to function in the role of conducting administrative reviews for member nominations and contractual requirements. The Executive Committee also acted in this cycle at the request of the voting membership of the PWPG in an oversight role for the Scope of Work development, financial review, and Public Participation activities. The Executive Committee met six times over the planning period.

10.7 Interregional Coordination

As part of the planning process, the PWPG determined that coordination with adjacent Region B and Llano-Estacado Region (Region O) water planning groups was necessary. The PWPG appointed a board member to be the liaison between each respective region and charged them with the assignment of attendance of their region's meetings. Coordination was made with the notice and exchange of meeting agendas and when necessary, attendance and participation in their meetings was provided by additional PWPG Board members and staff. At every regular meeting of the PWPG, the liaison reported to the Board the activity of their respective planning group's activity. Communication among the Board Chairmen and Board members was also utilized and allowed for a secondary line of exchange of information to take place.

In addition to the coordination at the regional planning group level, the consultants for each planning group coordinated on the supplies, demands and strategies for shared water users and Major Water Providers (MWP). There are two MWPs in the PWPA that provide water to users in adjoining regions: CRMWA provides water to customers in Region O and Greenbelt MIWA provides water to customers in Region B.

The PWPG Agricultural Committee also reached out to Region O during the development of the livestock water demands. A joint meeting of the two regions was held on May 18, 2022, along with livestock experts to review the methodology the TWDB used to develop livestock demands. Recommendations from a follow-up workshop on May 27, 2022, were the basis for changes to the livestock demands for both the PWPA and Region O.

10.8 Local Participation in the Regional Water Planning Process

Participation by local entities in the regional water planning process was quite commendable. Local funds were necessary to provide for the maintenance and operation of the PWPG, fiscal accountability, meeting costs, posting costs, etc. The PWPG estimated that $79,000 annually in local funds would be needed to cover these costs. Working through the previous public participation committee, the original formula from the first round of planning was updated in the fifth cycle (and retained in the sixth) and implemented to attempt to keep up with inflation and spread these costs equally throughout the region. Possible participants were divided into the following categories: municipalities, counties, water utilities, groundwater districts, surface water districts, and solicited contributions. Entities and organizations in each of these categories were contacted by mail requesting their pro-rata share of the local planning cost. Solicitations were made once, and these various entities and organizations provided approximately $365,000 for regional water planning over the 5-year planning cycle. Ninety-four percent of the funds solicited were received over the planning cycle. The PWPG believes this is a strong indicator of the local commitment to water resource planning throughout the region.

The PWPG would like to thank and recognize all those entities and organizations who contributed funds to the regional water planning effort.

In addition to the local funds received, the PWPG adopted a policy whereby all local water use groups are considered to have participated in the Regional Water Plan by virtue of their inclusion in and review of the Plan.

10.9 Plan Adoption Process

In accordance with Texas Administrative Code Chapter 357 and the relevant rules governing the water planning process, the PWPG conducted a formal process for the adoption of the Regional Water Plan. Activities under this section are primarily along two main lines. The first series of activities are directly related to the adoption of the Initially Prepared Plan, and the second series of activities are related to the final adoption of the completed Regional Water Plan.

10.9.1 Initially Prepared Plan Adoption

The PWPG conducted a formal Planning Group meeting on February 18, 2025, prior to the Public Hearing. Of the 23 voting members, 19 were present or represented. Four non-voting members were also present. The Initially Prepared Regional Plan was given unanimous approval for submission to the TWDB.

10.9.2 Public Hearing

The PWPG will conduct the required public hearing on April 22, 2025. All required notifications for the hearing will be posted prior to the 30-days before the hearing. Electronic or printed copies of the Initially Prepared Regional Plan will be placed in the County Clerk's office of each of the 21 counties in the region and also placed in the primary public library in each of the 21 counties. In addition, full posting requirements regarding County Clerks, Mayors, Judges, and all interested parties will be conducted at least 30 days prior to the hearing. Finally, the newspaper of general circulation in each county ran the Hearing Notice over 30 days prior to the hearing. Oral comments from the public were solicited at the hearing and written comments are to accepted for 60 days following the hearing.

10.9.3 State and Federal Agency Review

The adopted Initially Prepared Plan was provided to the TWDB by the March 3, 2025, deadline. Comments are due from the agencies in the summer of 2025.

10.9.4 Response to Comments

Comments received on the Initially Prepared Plan will be addressed and documented in **Appendix J**.

10.9.5 Final Regional Water Plan Adoption

The final 2026 Panhandle Water Plan will be adopted by the PWPG prior to the October 20, 2025, deadline.

10.10 Conclusion

The PWPG has maintained a high level of commitment to public participation throughout the planning process. The PWPG believes that public information and participation activities are at least as important to the success of regional planning initiatives as is the data accumulated and analyzed. A key recommendation of the PWPG is to continue to fund and encourage public information activities throughout all subsequent planning processes.