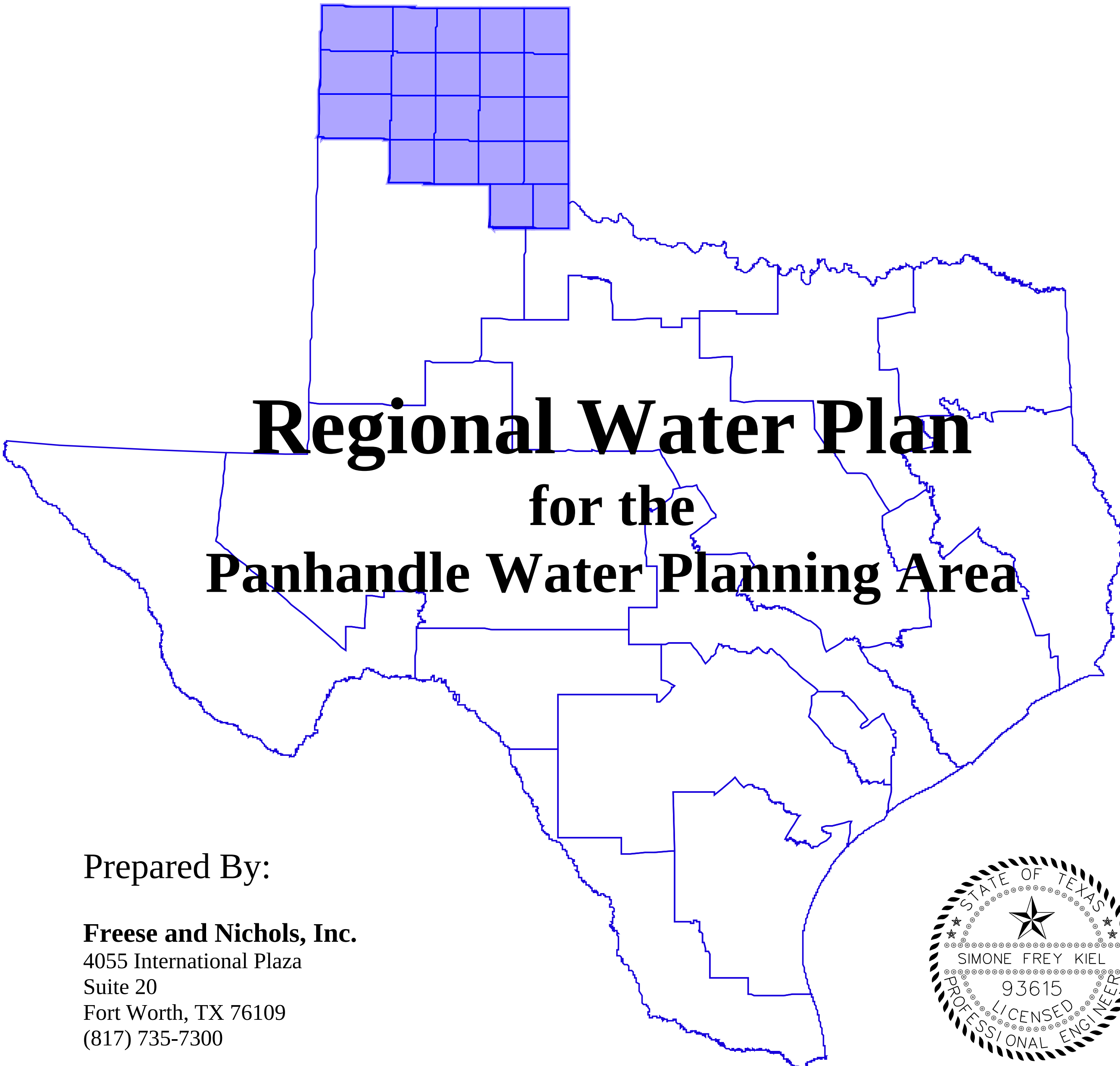
Prepared for:

Panhandle Water Planning Group

September 2010



Regional Water Plan
for the
Panhandle Water Planning Area

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To the readers:

This water plan represents the culmination of four years of working together with varied interest groups and technical consultants to map out a path forward to meet the projected water needs of our region. This regional water 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.

As you read this water plan, the Panhandle Water Planning Group would like you to keep in mind the following points:

- The plan does not predict or forecast future water disasters. Water is generally available to meet all municipal and industrial water needs. Conservation has the potential to meet most of the projected agricultural shortages.
- The large shortages shown for some counties are primarily due to the geographical constraints associated with local supplies for irrigated agriculture. New data collected for the Ogallala groundwater model indicate that there may be more water in some of the highly irrigated areas than assumed in this plan. This will be evaluated in more detail in the next plan update.
- The Ogallala aquifer, which is the predominant water source for the region, is a finite resource. At some point in the future (beyond this plan's timeframe) this resource will have limited supplies to meet the projected demands.
- The Panhandle Water Planning Group 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 or local groundwater district.
- 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 *Panhandle Water Planning Area Regional Water Plan* presents a comprehensive overview of the water supply issues in the region. It will take a concerted effort to continue to conserve and preserve our valuable water resources for the future. We appreciate your contributions to these efforts as we work together in making the Panhandle area a desirable place to work and live.

Sincerely,

C.E. Williams, Chairman, Panhandle Water Planning Group

PRPC
AUG 1 8 2010

2010 Board Members of the Panhandle Water Planning Group (PWPG), Region A and Their Respective Interest Group

C.E. Williams, Water Districts
PWPG Chairman

David Landis, Municipalities
PWPG Secretary

John Williams, Water Districts
PWPG Executive Committee

Emmett Autry, Municipalities

Denise Jett, Industrial

Kendall Harris, Agricultural

Joe Baumgardner, Agricultural

Cole Camp, Environmental

Gale Henslee, Electric Utilities

Steve Walthour, Water Districts

Charles Cooke, Water Utilities

Honorable Vernon Cook, Counties
PWPG Vice-Chairman

Dr. Nolan Clark, P.E., Environmental
PWPG Executive Committee

Janet Guthrie, General Public

Bill Hallerberg, Industrial

Ben Weinheimer, Agricultural

Janet Tregellas, Agricultural

Grady Skaggs, Environmental

Rusty Gilmore, Small Business

Jim Derington, River Authorities

Tom Baliff, Water Districts

Dr. John Sweeten, Higher Education

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List of Acronyms

Acronym	Name	Meaning
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	Managed Available Groundwater	The MAG is the amount of groundwater that can be permitted by a GCD on an annual basis. It 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.
PDRA	Palo Duro River Authority	River authority that operates Palo Duro Reservoir in Hansford County.
PWPA	Panhandle Water Planning Area	The 21-county area in the Texas Panhandle that comprises the regional water planning area for this plan. Also referrd 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.
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

List of Acronyms

Acronym	Name	Meaning
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 1,000 ac-ft/yr or more of wholesale water.

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 enter 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 Region A, the Panhandle Water Planning Area (PWPA). Since the initiation of this process, the PWPG has overseen the development of two regional water plans. This plan is the third regional water plan, which is an update of the 2006 Regional Water Plan for the PWPA.

This water plan is developed in accordance with the Planning Guidelines set forth in 31 Texas Administrative Code § 357.7 and all applicable rules. As required by rule, the plan is organized into ten chapters:

1. Planning Area Description;
2. Review and Revision of Population and Water Demand Projections;
3. Water Supply Analysis;
4. Identification, Evaluation and Selection of Water Management Strategies Based on Needs;
5. Impacts of Selected Water Management Strategies on Key Parameters of Water Quality and Impacts of Moving Water from Rural and Agricultural Areas;
6. Water conservation and drought management recommendations;
7. Description of how the regional water plan is consistent with long-term protection of the State's water resources, agricultural resources, and natural resources;
8. Unique Stream Segments/Reservoir Sites/Legislative Recommendations;
9. Report to Legislature on Water Infrastructure Funding Recommendations; and
10. Adoption of Plan.

In addition to these ten basic tasks, three special studies were conducted. One study was conducted by the Bureau of Economic Geology on the potential recharge to the Ogallala aquifer in Roberts and Hemphill Counties. This study was published in 2009 and a summary is included in Appendix E. Two other studies were conducted as part of this plan update: Update to the Northern Ogallala Groundwater Availability Model and the Evaluation of Reduced Inflows in Lake Meredith Watershed. The reports for both of these studies are included as appendices to this plan.

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. The PWPA has designated seven Wholesale Water Providers (1,000 acre-feet per year or more of wholesale water):

- Canadian River Municipal Water Authority (CRMWA)
- City of Amarillo
- City of Borger
- City of Cactus
- Mesa Water, Inc.
- Greenbelt Municipal and Industrial Water Authority
- Palo Duro River Authority (PDRA)

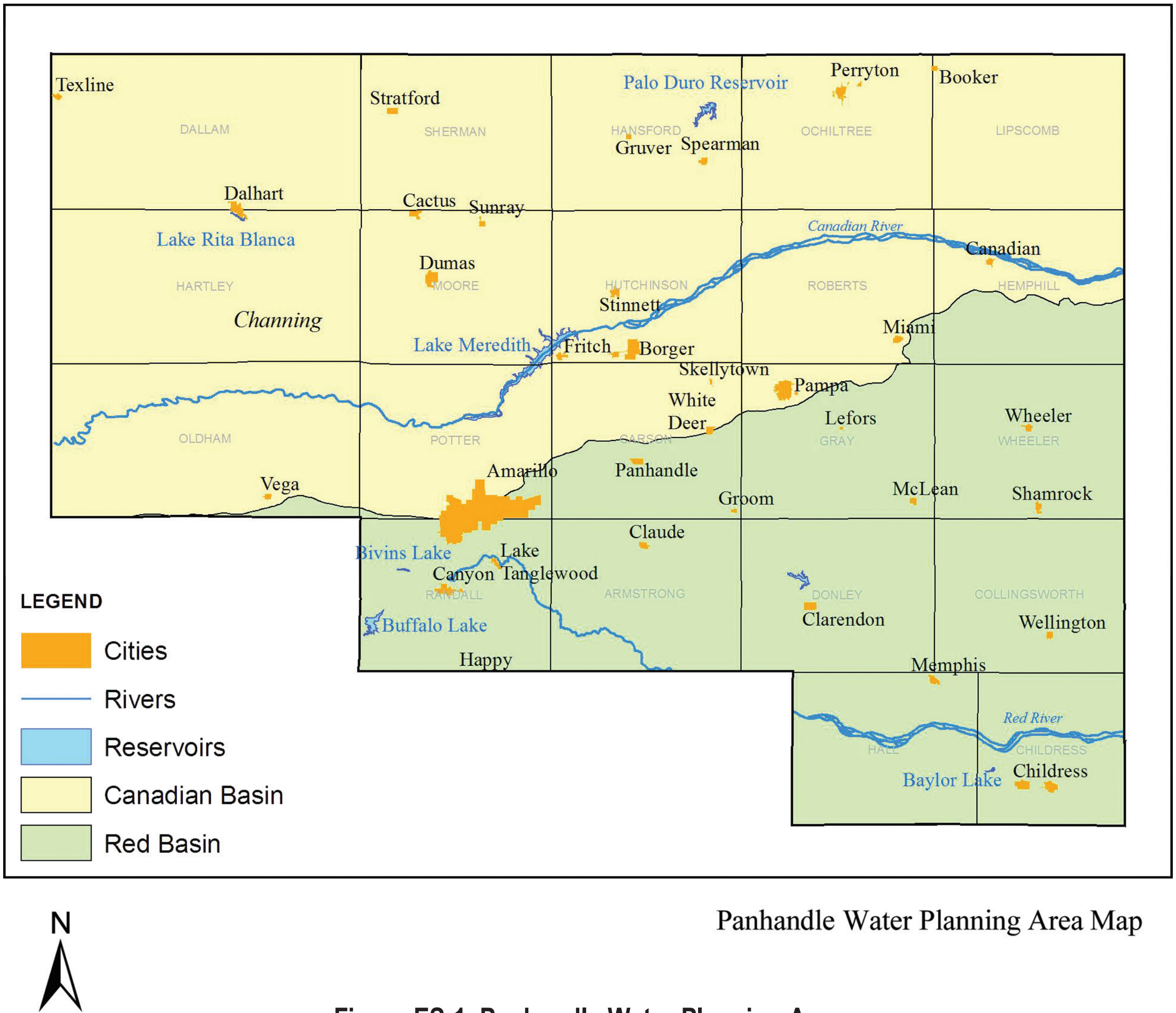


Figure ES-1: Panhandle Water Planning Area

Review and Revision of Population and Water Demand Projections

In 2006, the region accounted for 1.6 percent of the State's total population and about 13 percent of the State's annual water demand. Projections show total water use for the region will decline over the 2010-2060 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, implementation of new crop types, and the use of more efficient irrigation technology.

Regional population is expected to grow from 355,832 in 2000 to 423,830 in 2020 and 541,035 in 2060. Much of this growth is located in larger cities and surrounding rural areas. Projections for water demand indicate that total water usage in the PWPA will decrease from 1,628,344 acre-feet in 2010 to 1,199,644 acre-feet in 2060. Hartley County has the highest projected water use of 301,252 acre-feet in 2010 decreasing to 212,405 acre-feet by 2060. Only Randall and Potter Counties have 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 19 counties are projected to have decreases in projected water demand during the planning period, which is mostly attributed to declining irrigation demands.

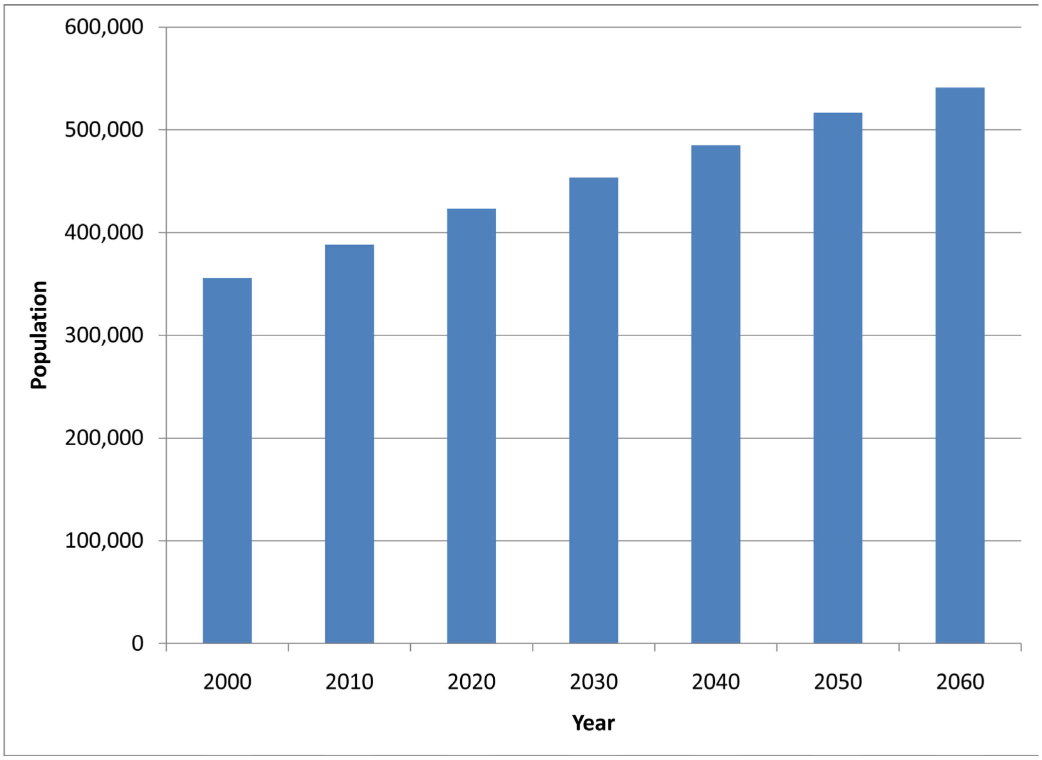


Figure ES-2: PWPA Population

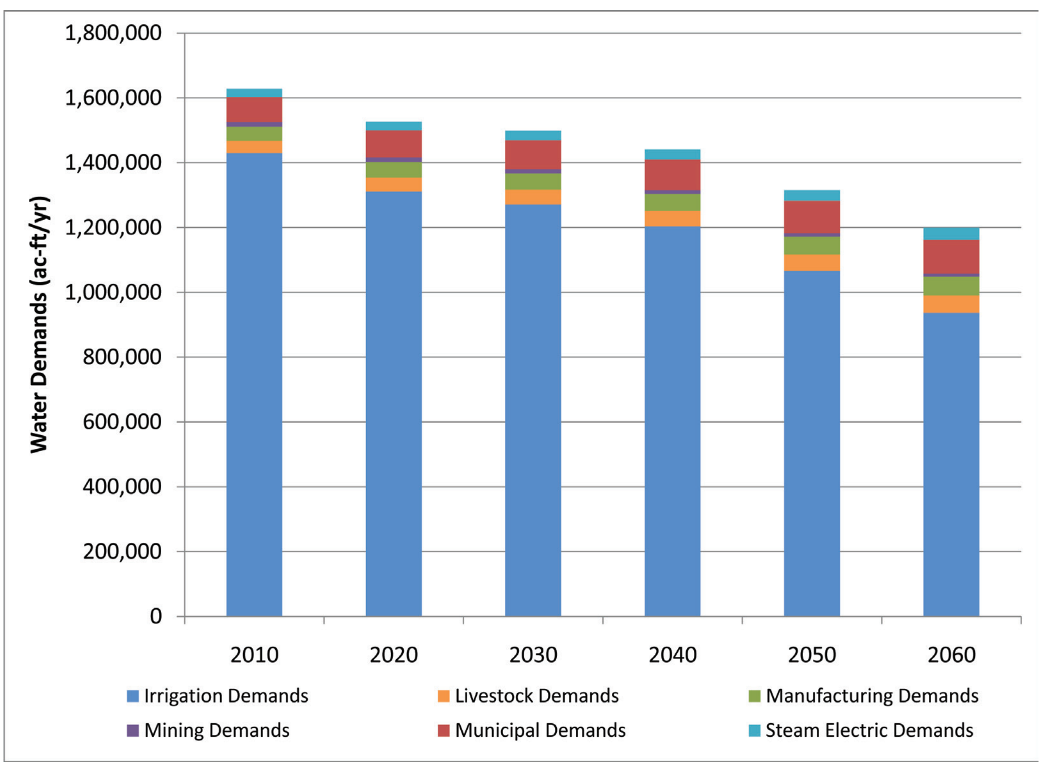


Figure ES-3: Projected Demands in the PWPA
Year 2010 – Year 2060

Water Supply Analysis

The PWPA is located within portions of the Canadian River Basin and Red River Basin. In 2006, only two 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.

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. The Whitehorse, not identified by the TWDB as a minor aquifer, was not included in the analysis during this round of planning due to the lack of data specifically tied to this aquifer.

Water availability within the region was determined by surface (WAM) and groundwater (GAM) models, unless more site specific information was available. The GAM program, whose development was overseen by the TWDB, completed several groundwater models for both the northern and southern Ogallala aquifer models. Refinements to the Northern Ogallala Aquifer were developed as part of this planning effort. Results from both the TWDB-adopted Northern Ogallala GAM (referred to as the 2004 Dutton GAM) and the Northern Ogallala GAM that was updated as part of this plan (referred to as the 2010 Intera GAM) are reported in this plan. Due to time constraints of the accelerated schedule, the 2004 Dutton GAM was used to assess groundwater availability for the Northern Ogallala aquifer. These supply values are the basis

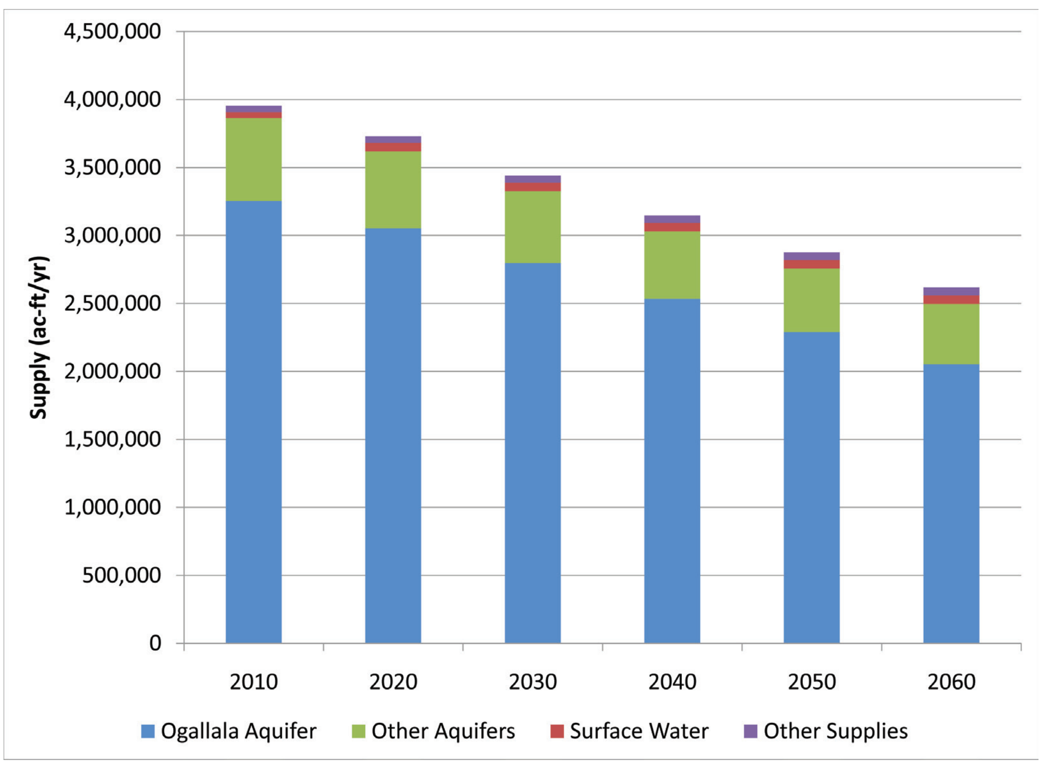


Figure ES-4: Total Available Supplies in the PWPA[1]

[1] The total available supply is the reliable firm 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-1: Available Water Supplies in PWPA

Source	2010	2020	2030	2040	2050	2060
Lake Meredith [1]	30,000	50,000	50,000	50,000	50,000	50,000
Greenbelt Lake [1]	6,864	6,728	6,592	6,456	6,320	6,181
Palo Duro Reservoir	3,958	3,917	3,875	3,833	3,792	3,750
Canadian River Run-of-River	296	296	296	296	296	296
Red River Run-of-River	2,168	2,168	2,168	2,168	2,168	2,168
Total Surface Water	**43,286**	**63,109**	**62,931**	**62,753**	**62,576**	**62,395**
Ogallala/ Rita Blanca Aquifer	3,254,347	3,052,069	2,797,538	2,534,069	2,289,502	2,053,260
Seymour Aquifer	41,525	40,525	38,650	38,650	38,650	38,650
Blaine Aquifer	230,000	228,750	228,750	228,750	228,750	228,750
Dockum Aquifer	338,000	295,900	259,400	227,500	199,500	174,800
Other Aquifer	676	676	673	671	671	671
Total Groundwater	**3,864,548**	**3,617,920**	**3,325,011**	**3,029,640**	**2,757,073**	**2,496,131**
Local Supply	21,017	21,017	21,017	21,017	21,017	21,017
Direct Reuse	24,883	28,682	30,374	32,282	34,352	37,331
Total Other Supplies	**45,900**	**49,699**	**51,391**	**53,299**	**55,369**	**58,348**
Total Supply in PWPA	**3,953,734**	**3,730,728**	**3,439,333**	**3,145,692**	**2,875,018**	**2,616,874**

[1] Reliable supply is shown for Lake Meredith and the safe yield is reported for Greenbelt Reservoir. These supply values were used for planning purposes.

for the needs analyses for the 2011 PWPA Regional Water Plan. The findings using the 2010 Intera GAM are summarized in Section 3.1.2 and Appendix F. In addition to the updated Ogallala GAM analyses, GAM analyses developed for the 2006 water plan were used for the Seymour and Blaine aquifers. The Dockum aquifer GAM was still under review by the TWDB and availabilities for this source are taken from a 2003 TWDB report.

Surface water supplies in the region were determined through the WAMs of the Red and Canadian Basins which included evaluations of critical drought, water right diversions, and sedimentation rates. As required by regional water planning rules, firm yields were determined for each reservoir. For planning purposes, a more conservative estimate of reliable supply from Lake Meredith and Greenbelt Reservoir were used for available supplies (as reported on Table ES-1). The firm yield for Lake Meredith is 69,750 acre-feet per year while the long-term reliable supply is estimated by CRMWA to be 50,000 acre-feet per year, assuming that the reservoir partially recovers from the current drought. The firm yield of Greenbelt Reservoir is approximately 8,300 acre-feet per year. The safe yield of the reservoir, which assumes that a one-year supply of water remains in storage at all times, is about 80 percent of the firm yield. The firm yield of Palo Duro Reservoir is slightly less than 4,000 acre-feet per year.

Groundwater availabilities used for regional water planning follow the PWPG guidelines. For the Ogallala and Rita Blanca aquifers, availabilities were calculated by county such that there was 40 percent of the aquifer storage remaining in 50 years for the four western counties (Dallam, Hartley, Sherman and Moore Counties), 80 percent of the storage remaining in Hemphill County, and 50 percent of the storage remaining in the other counties in GMA 1. For the other aquifers in the PWPA a 1.25 percent annual withdrawal was used as the basis for groundwater availability. All supplies listed as "avail-

Figure ES-5: Shortages in Region A for Planning Period Year 2010 – Year 2060

able" or "availability" in regards to groundwater refer to these assumptions. This has resulted in immediate shortages in the region, primarily for irrigated agriculture in counties with heavy irrigation demands.

To assess the water supplies needs in the PWPA the water supplies were allocated to the water users considering geographical availabilities, infrastructure constraints and contractual limits, as appropriate. With these considerations, the projected demands exceed the currently developed supplies on a regional basis by nearly 430,000 acre-feet per year in 2010. This shortage decreases to about 300,000 acre-feet per year by 2030 before increasing to 400,000 acre-feet per year in 2060. There are 10 counties with 27 water user groups with projected water shortages during the planning period. Collectively, the maximum projected shortage is just over 500,000 acre-feet per year in 2040. The largest shortages are associated with irrigation use, followed by municipal and manufacturing.

Most of the shortages are attributed to large irrigation demands that cannot be met with available groundwater sources. Other shortages are due to limitations of contractual agreements, infrastructure, and/or growth. There are supplies in the region that are not fully utilized, including untapped groundwater, which could possibly be used for some of the identified shortages. Conservation and demand management are important strategies to meet the irrigation shortages and offset dependence on expanding supply development. The PWPA considered conservation a priority and in maintaining future supplies.

Water management strategies were developed to meet the water shortages greater than 10 acre-feet per year for municipal, manufacturing, and steam electric power. Since the irrigation shortages may not be met by developing additional supplies, the water management strategies for irrigation needs are directed toward reducing demands. All potentially feasible strategies for each individual water use 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; and
- Other factors including, regulatory requirements, political and local issues, implementation time, recreational impacts and socioeconomic benefits or impacts.

In addition, each water shortage considered conservation as a first strategy to offset the water need for that user. Water quality impacts from implementation of the strategy were also considered.

The comparison of current water supplies to demands identified 27 different water user groups and three wholesale water providers with shortages greater than or equal to 10 acre-feet per year. The larger shortages are associated with irrigation in four counties: Dallam, Hartley, Moore and Sherman Counties. Most of the municipal and manufacturing shortages are associated with the wholesale water providers: Amarillo, Borger and Cactus. CRMWA does not show a shortage after 2010, assuming that Lake Meredith recovers and declining production in Roberts County is replaced with new wells in areas that CRMWA already holds water rights. If the storage in Lake Meredith continues to decline, then CRMWA may need to develop additional water management strategies.

Strategies were developed for water user groups in the context of their current supply sources, previous supply studies and available supply within the PWPA. Most of the water supply in the PWPA is from groundwater, and for many of the identified shortages, potentially feasible strategies include development of new groundwater supplies or further developing an existing well field. Conservation strategies were the only strategies considered for the irrigation shortages.

In addition to the identified shortages, the region conducted a cursory review of the available Ogallala supplies using the 2010 Intera GAM. While the results from this updated model generally show more water over much of the region than predicted with the 2004 Dutton GAM, there were areas with lower availabilities. As a result, four additional shortages were identified and strategies were developed for these water users.

Impacts of Selected Water Management Strategies on Key Parameters of Water Quality and Impacts of Moving Water from Rural and Agricultural Areas

Water quality plays an important role in determining the availability of water supplies to meet current and future water needs in the region. In addition, regional planning guidelines require that water management strategy evaluations consider the impacts to water quality.

All groundwater contains minerals carried in solution and their concentration is rarely uniform throughout the extent of an aquifer. The degree and type of mineralization of groundwater determines its suitability for municipal, industrial, irrigation and other uses. Groundwater resources in the PWPA 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 total dissolved solids. Sources of elevated nitrate include cultivation of soils and domestic and animal sources. Elevated concentrations of chloride are due to dissolution of evaporite minerals and upwelling from underlying, more brackish groundwater formations. Elevated concentrations of total dissolved solids are primarily the result of the lack of sufficient recharge and restricted circulation. Heavy pumping of the aquifers can increase total dissolved solids levels in groundwater. The water management strategies limited groundwater production to not exceed the PWPG's recommended availability amounts. This should limit potential impacts to water quality in the aquifers.

Water Conservation and Drought Management 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. Conservation is a significant water saving strategy for irrigated agriculture and municipal water users. For municipal water shortages the region recommended that municipal water users reduce consumption by 3 percent in 2020, and then 5 percent for subsequent decades through conservation. The regional median per capita water use is 191 gallons for cities, which is above the Water Conservation Task Force recommended state average of 140 gallons per person per day. The PWPG supports reducing the per capita water use by 1 percent per year until the region reaches an average per capita use of 140 gallons. With concentrated effort, this goal could be reached during the 2040 decade.

Eight conservation strategies were evaluated to reduce irrigation demands in the PWPA. Collectively, these strategies comprise the recommended irrigation conservation savings. The strategy that yields the largest water savings in the PWPA is the adoption of drought resistant varieties of corn, cotton and soybeans which are being developed with the aid of biotechnology. This strategy is estimated to have the potential to save 10.6 million ac-ft (cumulative savings), which equates to 14.7 percent of the total projected irrigation water pumped over the 50-year planning horizon. The next significant water saving strategy includes the application of on-farm irrigation water conservation practices. Precipitation enhancement shows great potential in increased water savings for irrigated agriculture, but it is currently practiced in counties within the Panhandle Groundwater Conservation District.

The total amount of potential water savings from recommended water conservation strategies in the PWPA is 314,283 acre-feet per year in 2020 and increasing to 572,120 acre-feet per year by 2060. Most of these savings are associated with recommendations for irrigated agriculture and may not be fully realized when combinations of strategies are implemented.

Long-Term Protection of the State's Water Resources, Agricultural Resources, and Natural Resources

The PWPG balanced meeting water shortages with good stewardship of the water, agricultural, and natural resources within the region. The PWPG considered water conservation to meet projected shortages. The PWPG also recommended conservation for irrigation water users to preserve future water supplies. During the strategy selection process, environmental impacts and impacts to State's water, agricultural and natural resources were considered. The groundwater availability assumptions are aimed at meeting the long-term protection of the regional water, agricultural, and natural resources of the PWPA.

In this plan, existing in-basin or region supplies were fully utilized before recommendations for new water supply projects or interbasin transfers were considered. Wastewater reuse is a water supply to meet long-term power generation water needs as alternatives to the development of new supplies.

The PWPG believes that local groundwater conservation districts are best-suited to manage groundwater resources in which the individual GCDs have the responsibility to regulate. The newly formed GMAs provide additional guidance to managing groundwater resources. This plan recommends following policies adopted by the GMA 1 for the Ogallala aquifer. For the aquifers where no desired future conditions were adopted by December 2009, this plan recommends using not more than 1.25 percent of annual saturated thickness within the aquifer as a management option. The PWPG believes these policies are appropriate for the long-term sustainable management of the aquifers within the PWPA to meet local demands.

Unique Stream Segments/Reservoir Sites/Legislative Recommendations

The PWPG considered unique stream segments and reservoir sites but did not make any recommendations for designation. The PWPG did identify several areas of importance to the region, including continued funding and support for groundwater data collection and modeling, conservation, agricultural programs that encourage water savings, funding for water management strategies and others. A complete listing of the legislative recommendations is included in Chapter 8.

Key Findings and Recommendations

- Groundwater supplies were allocated to water users such that the regional water planning goal was met both spatially and in time. This results in immediate shortages for some users that have geographical constraints for using groundwater. The actual distribution of water supplies over time may differ from these assumptions.
- Significant irrigation shortages are concentrated in four counties: Dallam, Hartley, Moore, and Sherman. Most of these shortages are due to the spatial constraints for supply for irrigated agriculture. The recommended strategies are conservation.
- Three wholesale water providers are projected to have shortages over the planning period. The recommended strategies for each provider are to develop additional groundwater.
- The recharge study in Roberts and Hemphill Counties found that recharge rates are relatively low and similar to values estimated in previous studies. The study noted that different site conditions result in different recharge rates. No changes to recharge were made to the 2010 Intera GAM model.
- The 2010 Intera GAM shows additional supplies in 12 counties and reduced supplies in five counties. These differences are primarily due to improved red bed data and changes in aquifer thickness.
- The Lake Meredith Study found increasing hydrologic loss over time in the Meredith watershed. There was no one clear contributing factor. It is likely a combination of factors, including increases in salt cedar, reduced groundwater levels in the Dockum aquifer, and increasing recurrence intervals between large storm events.
- Economic and political factors can affect near-term irrigation and agricultural demands. There is an estimated 1.2 million acres of land in the High Plains that will come out of the Conservation Reserve Program between 2008 and 2010. This could have a significant impact on agricultural demands and should be carefully studied in the next round.
- County-Other and rural water supply information should be improved to assist these entities for securing future supplies.

County Summary Pages

Detailed descriptions of water resource planning issues for each county within the PWPA follow this summary.

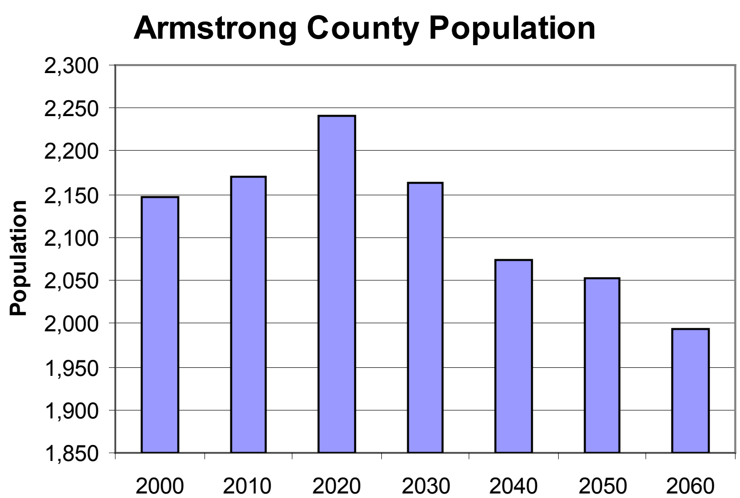
Who are my representatives?

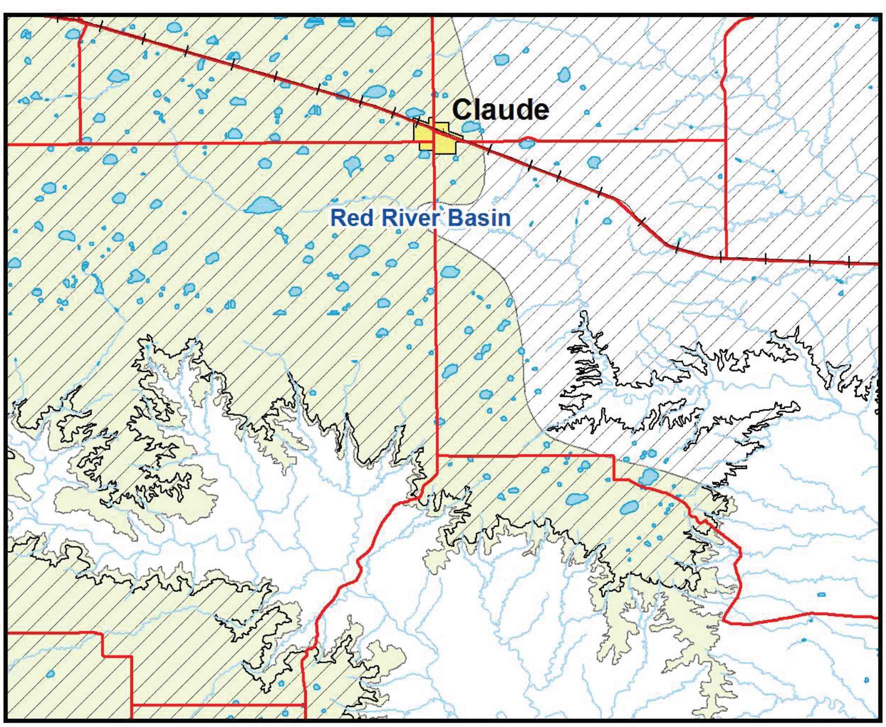
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
C.E. Williams - Panhandle GCD

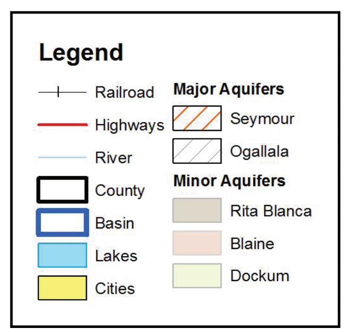
County Seat: City of Claude

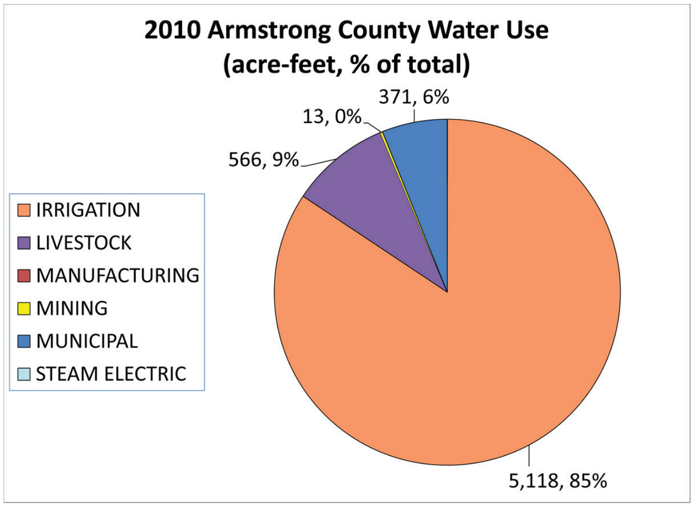
Economy: Agribusiness, tourism

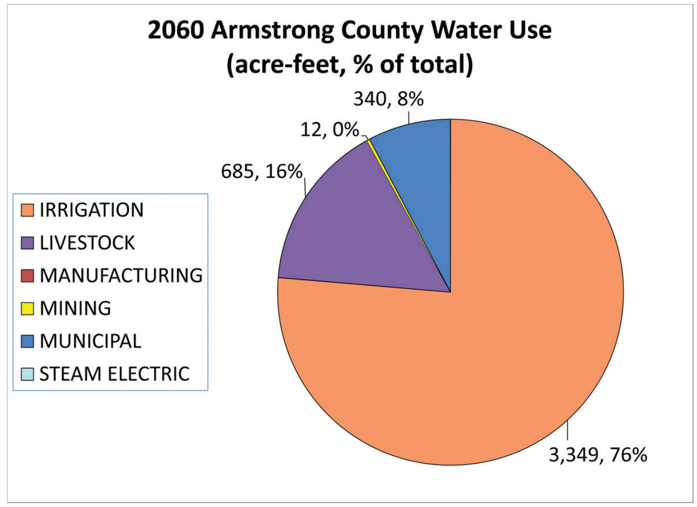
What is the source of my water? Ogallalla, Dockum Aquifers

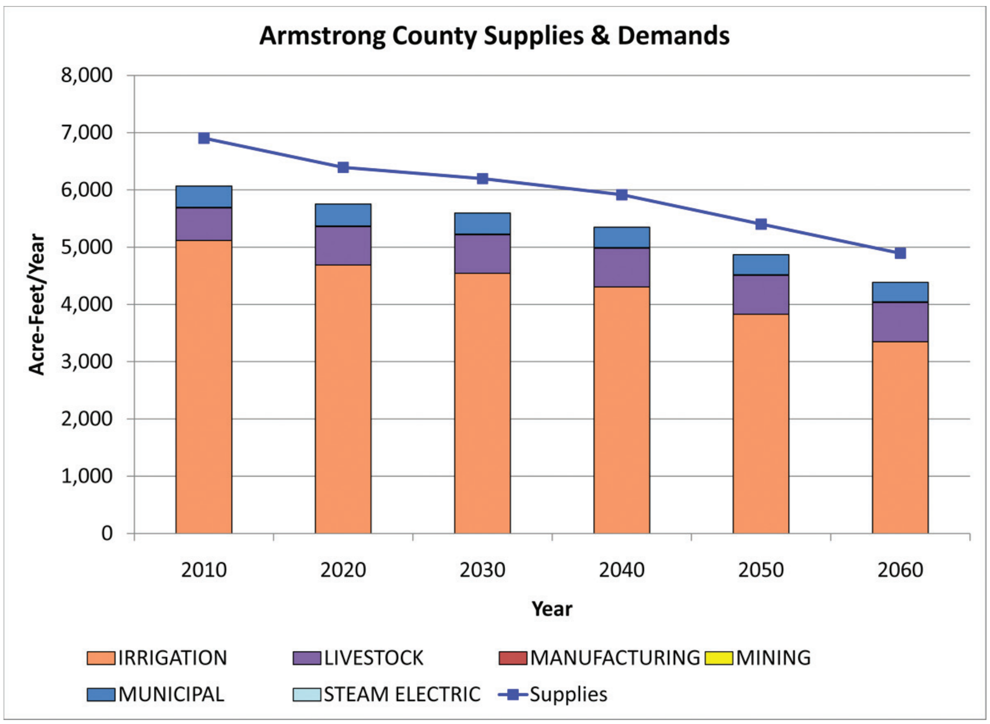












Water User Group	Strategy
Claude	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

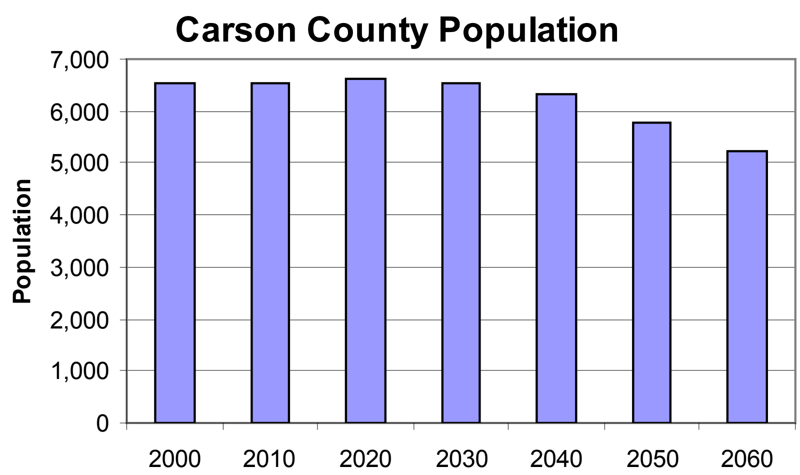
CARSON COUNTY

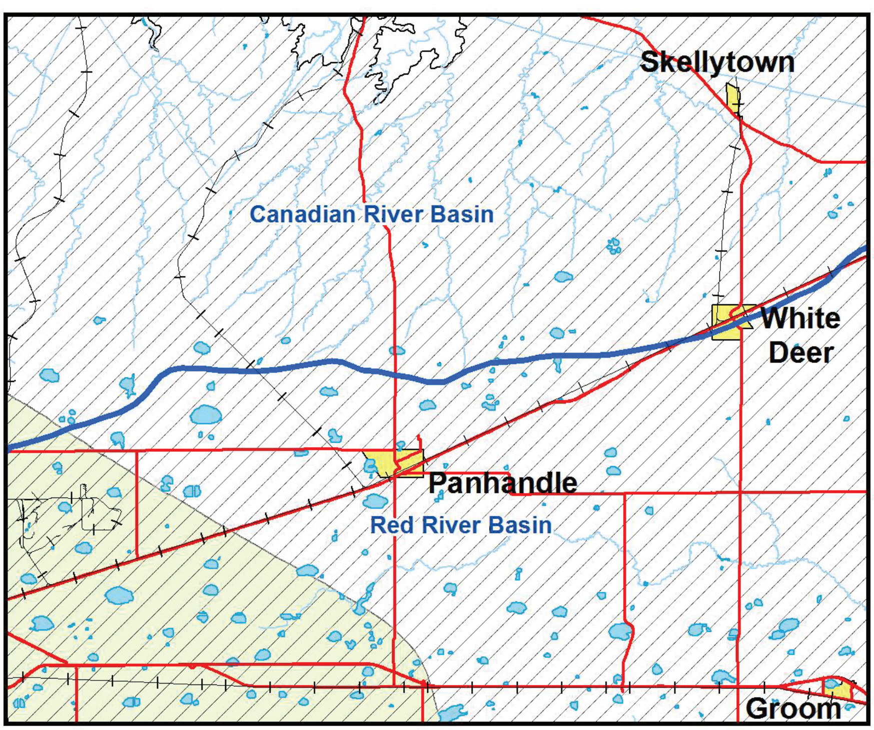
Who are my representatives?
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
C.E. Williams - Panhandle GCD
Gale Henslee - Xcel Energy

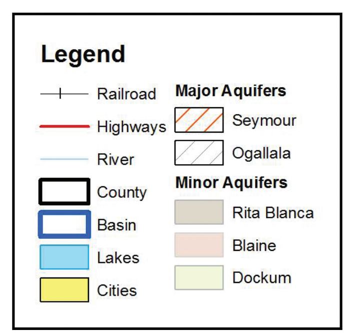
County Seat: City of Panhandle

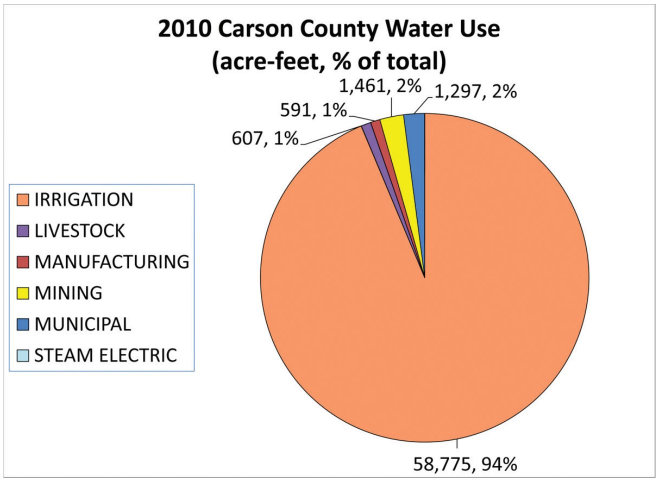
Economy: Agribusiness, Petroleum

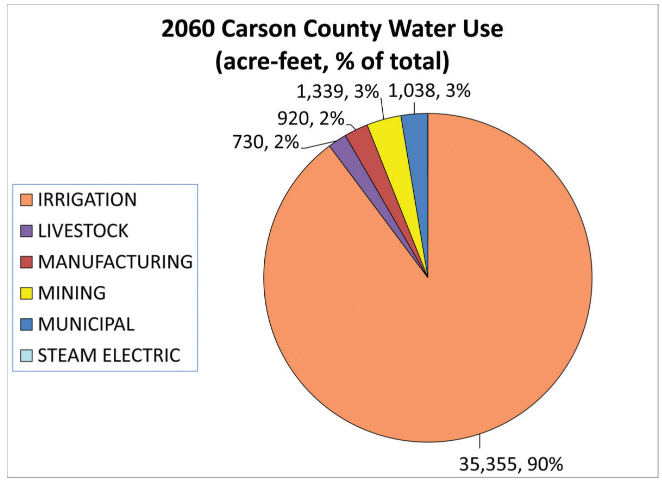
What is the source of my water? Ogallalla, Dockum Aquifers

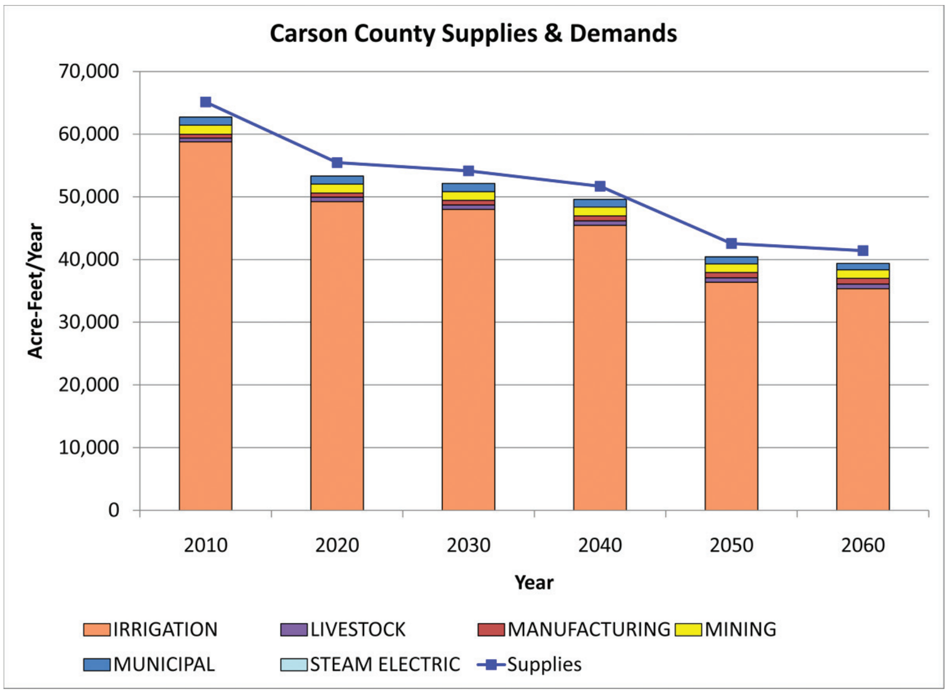












Water User Group	Strategy
Groom	No Water Shortage Identified
Hi Texas Water	No Water Shortage Identified
Panhandle	Conservation, New Wells
Skellytown	No Water Shortage Identified
White Deer	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Water Shortage Identified
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

CHILDRESS COUNTY

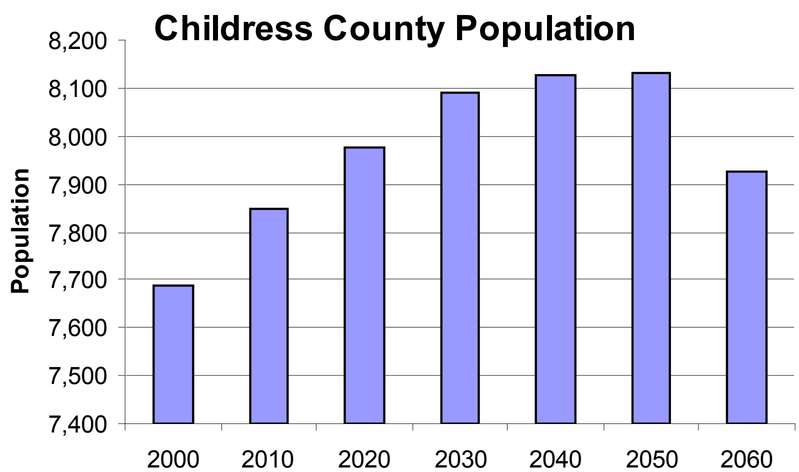
Who are my representatives?

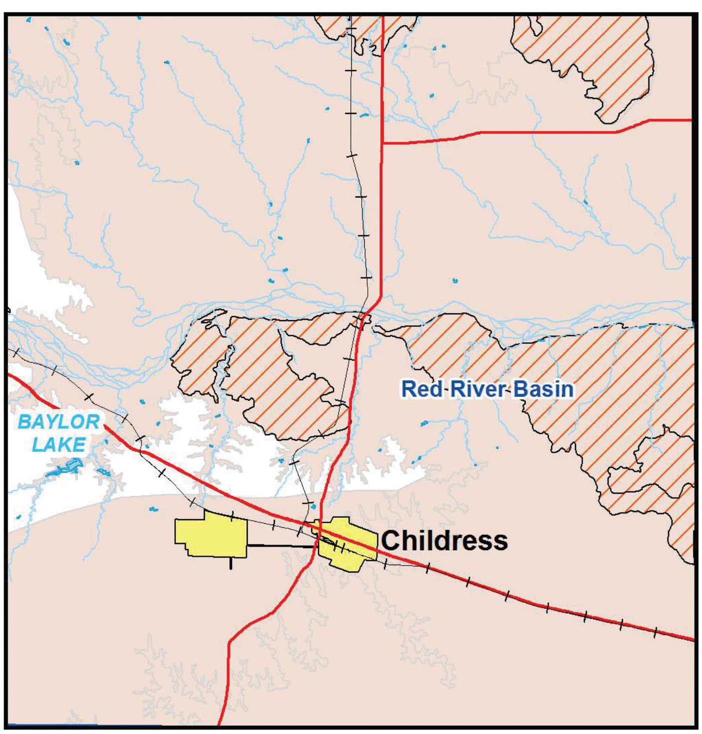
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
Tom Baliff - Greenbelt M&I Water Authority

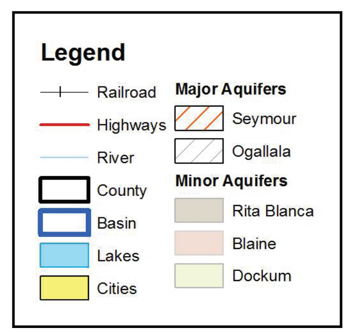
County Seat: City of Childress

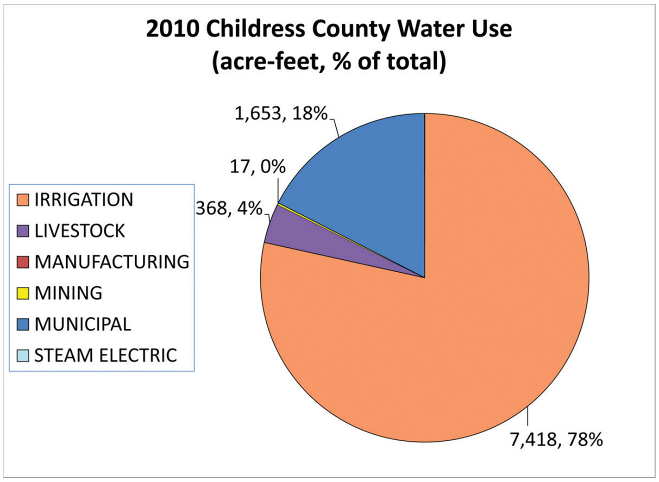
Economy: Agribusiness, Tourism

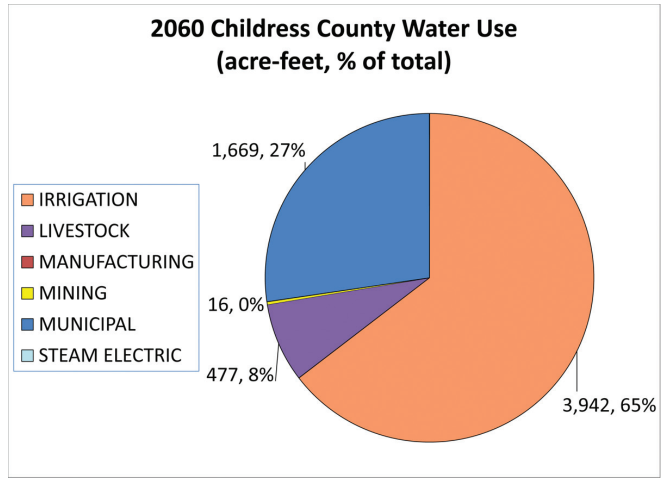
What is the source of my water? Seymour, Blaine Aquifers, Greenbelt Reservoir

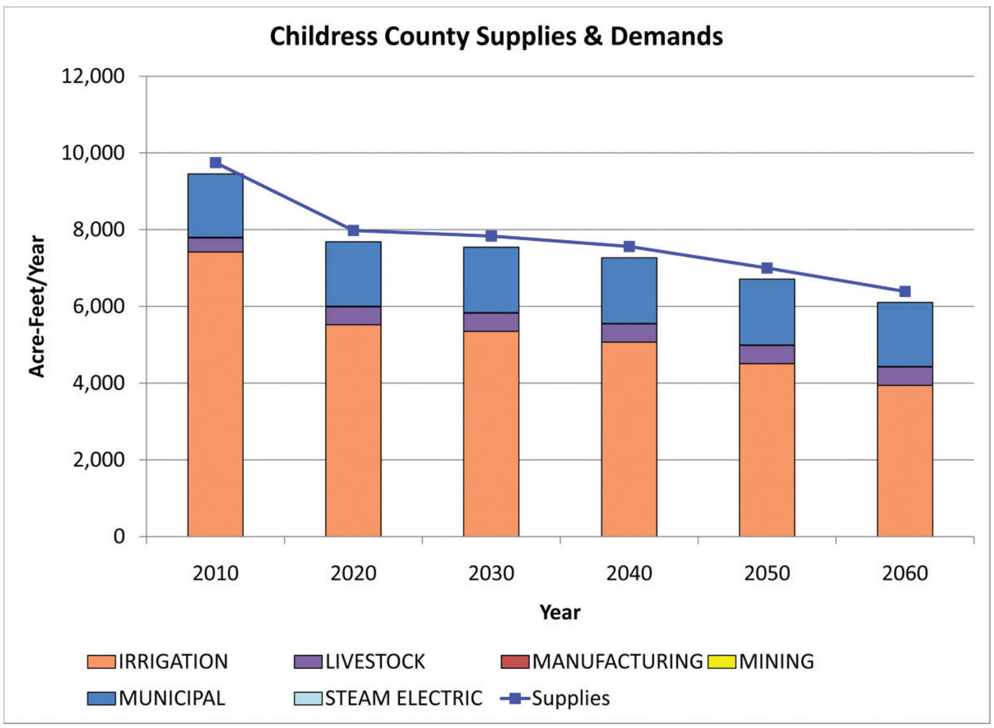












Water User Group	Strategy
Childress	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

COLLINGSWORTH COUNTY

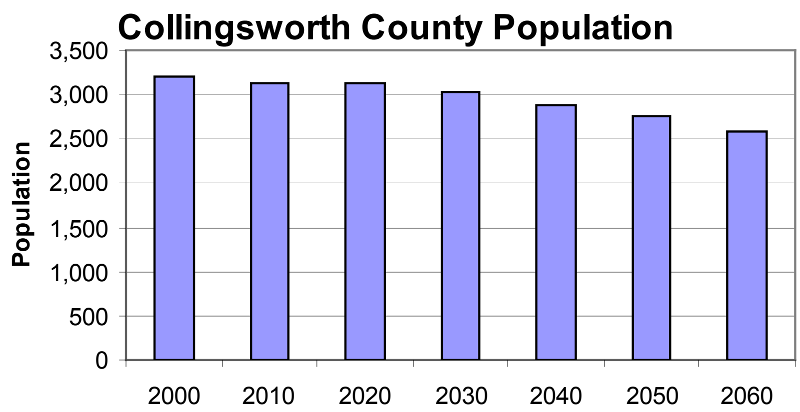
Who are my representatives?

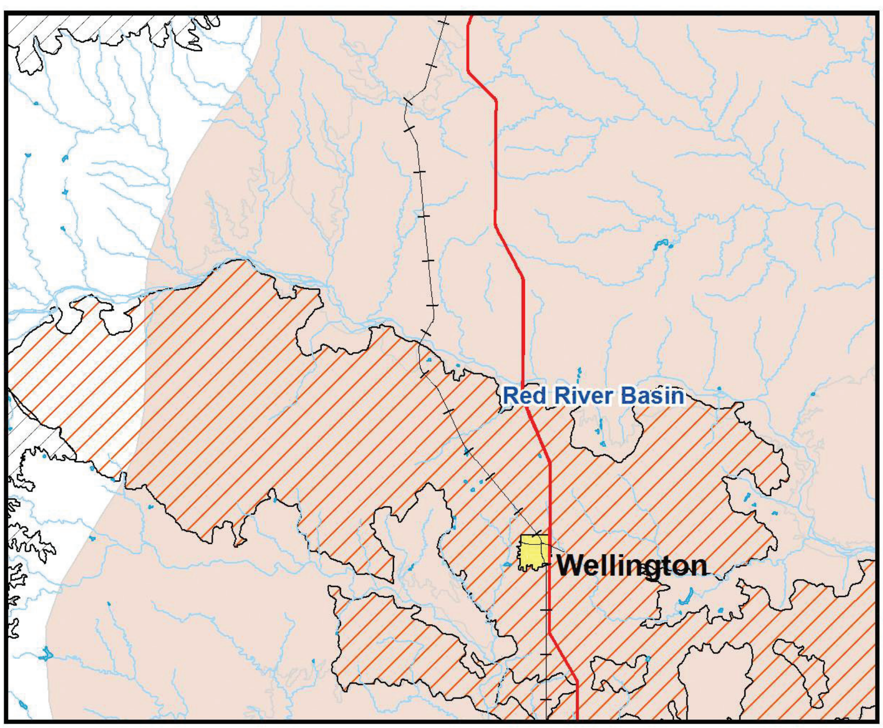
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
Joe Baumgardner - Farmer
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
Tom Baliff - Greenbelt M&I Water Authority

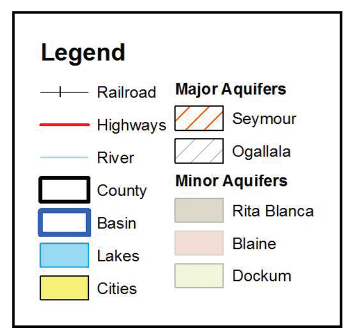
County Seat: City of Wellington

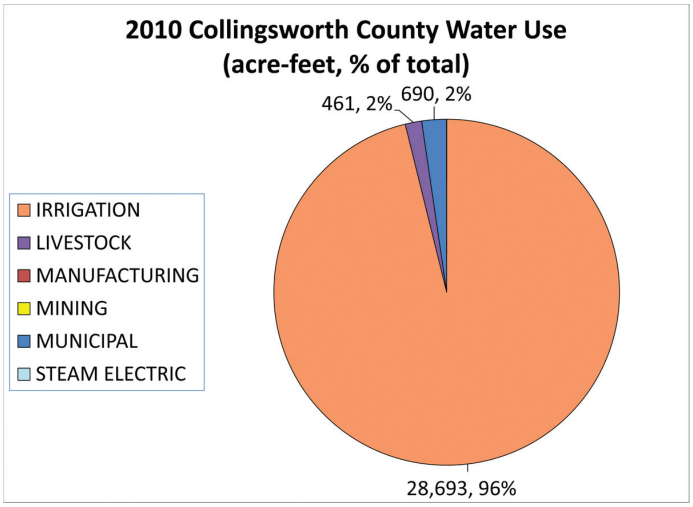
Economy: Agribusiness

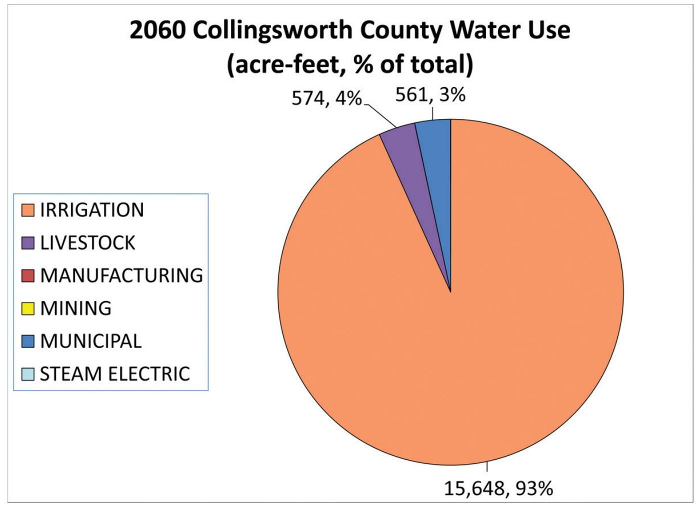
What is the source of my water? Seymour, Blaine Aquifers

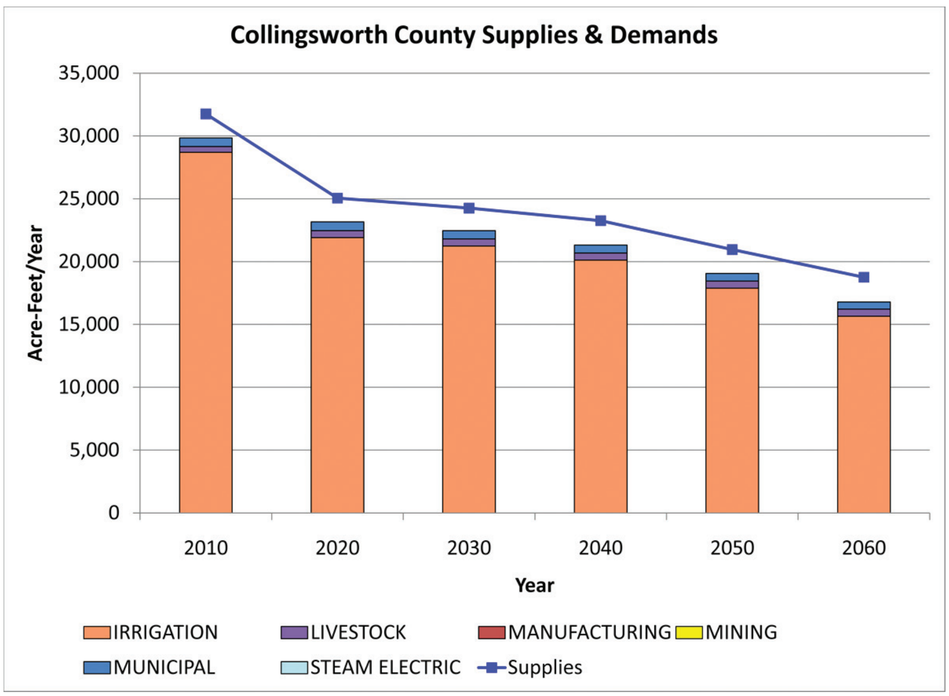












Water User Group	Strategy
Wellington	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Demands In This Category
Steam Electric Power	No Demands In This Category

DALLAM COUNTY

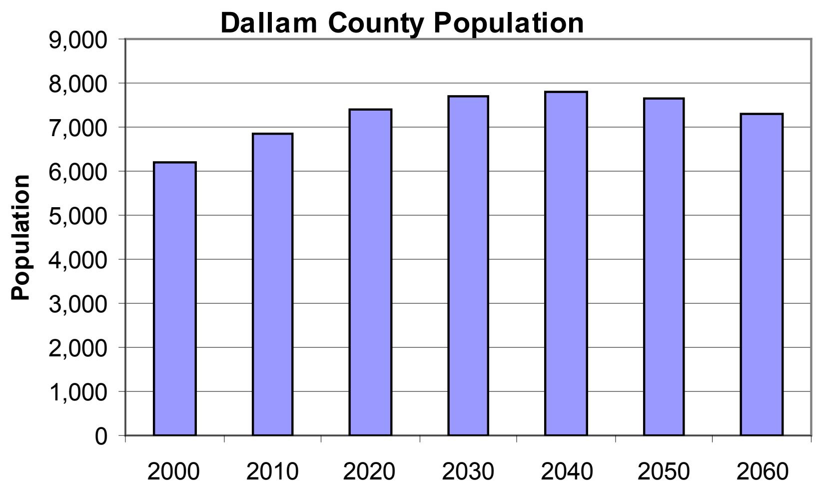
Who are my representatives?

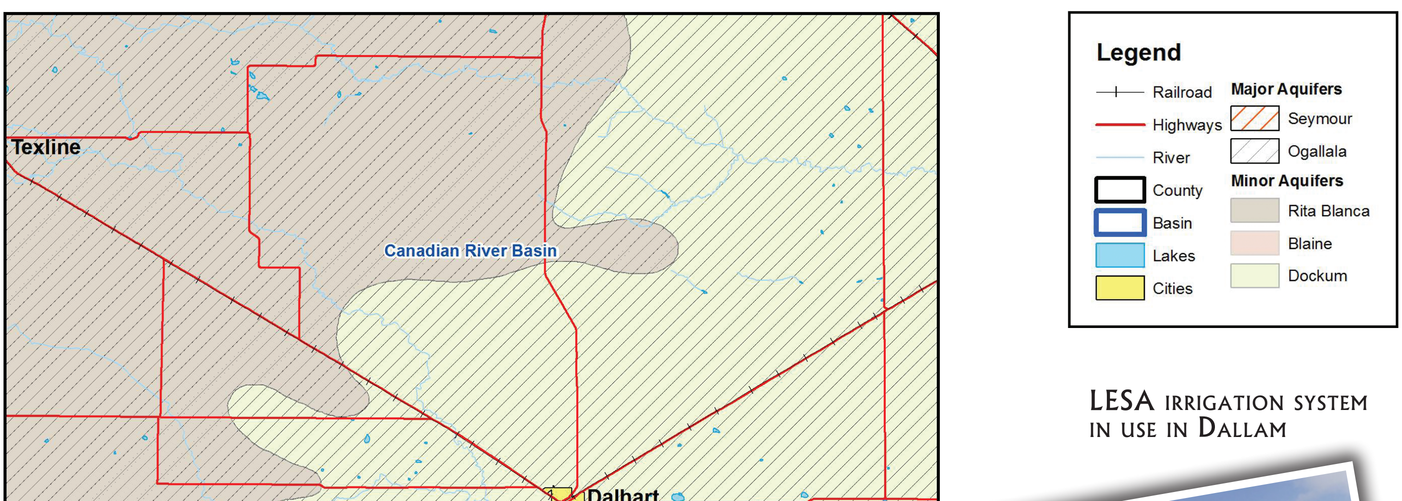
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
Rusty Gilmore - Water Well Driller
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
Steve Walthour - North Plains GCD

County Seat: City of Dalhart

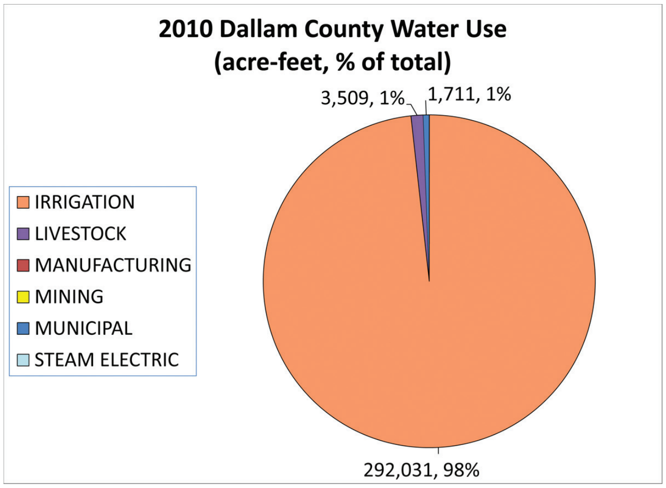
Economy: Agribusiness, Manufacturing, Tourism

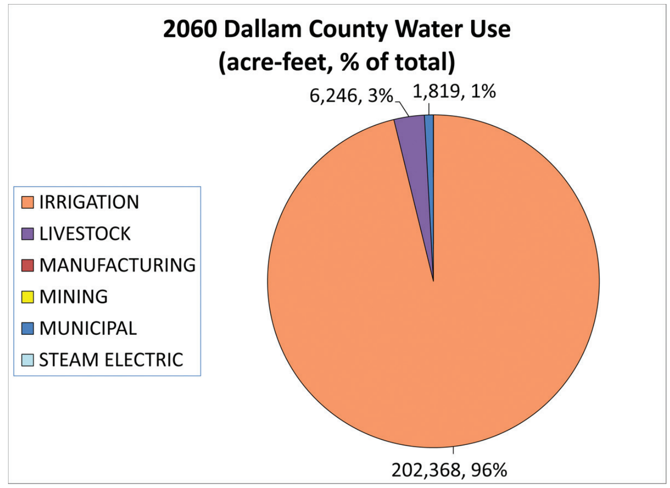
What is the source of my water? Ogallala, Dockum, Rita Blanca Aquifers

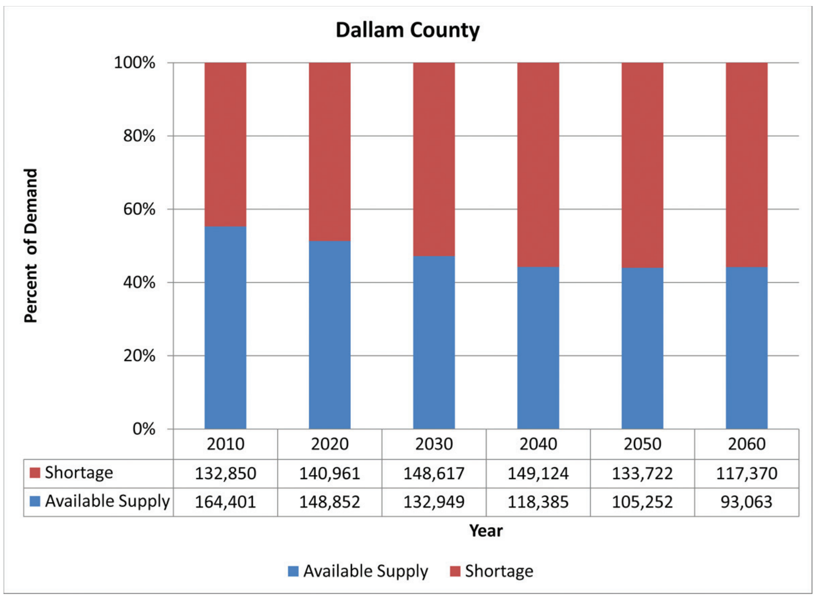




LESA IRRIGATION SYSTEM IN USE IN DALLAM

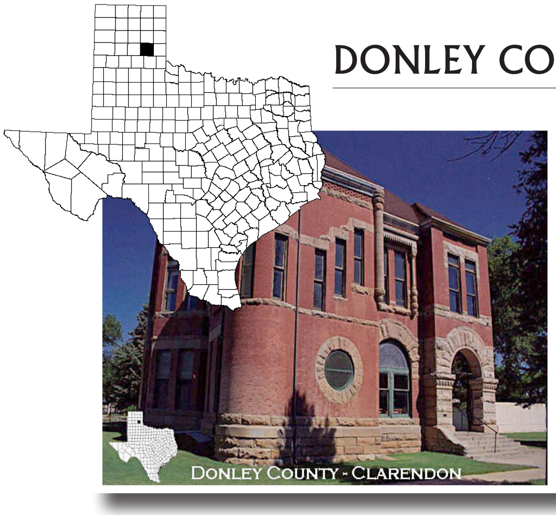






	2010	2020	2030	2040	2050	2060
Shortage	132,850	140,961	148,617	149,124	133,722	117,370
Available Supply	164,401	148,852	132,949	118,385	105,252	93,063

Water User Group	Strategy
Dalhart	No Water Shortage Identified
Texline	Conservation, New Wells
County-Other	No Water Shortage Identified
Irrigation	Change in Crop Type, Change in Crop Variety, Conservation Tillage, Convert to Dryland, Irrigation Equipment, NPET Network, Biotechnology Adoption. Alternative: Precipitation Enhancement
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Demands In This Category
Steam Electric Power	No Demands In This Category



DONLEY COUNTY

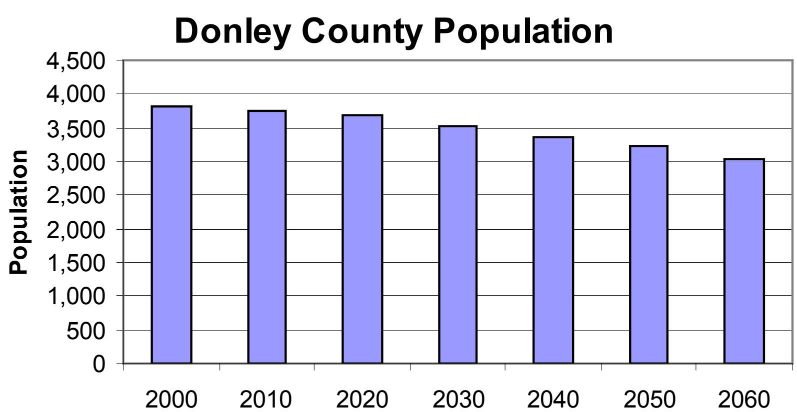
Who are my representatives?

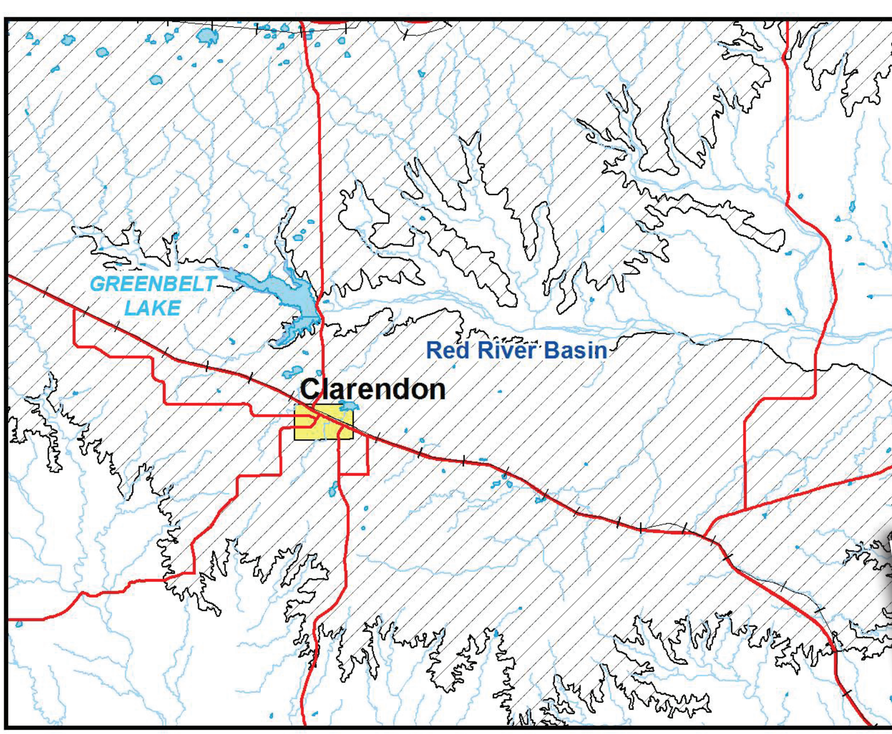
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
Tom Baliff - Greenbelt M&I Water Authority
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
C.E. Williams - Panhandle GCD

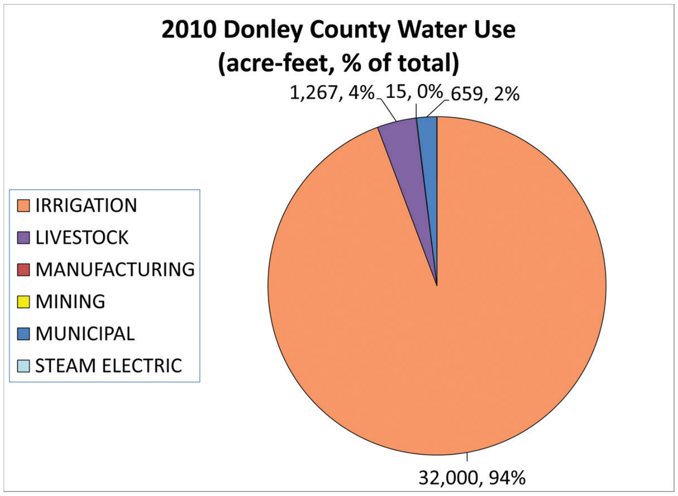
County Seat: City of Clarendon

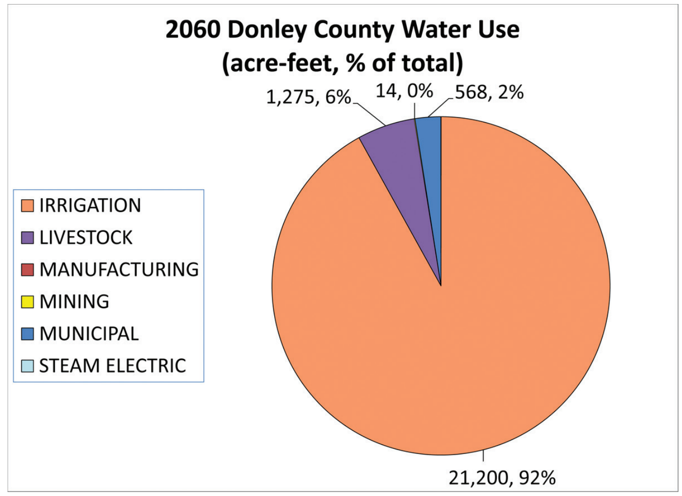
Economy: Agribusiness, Tourism

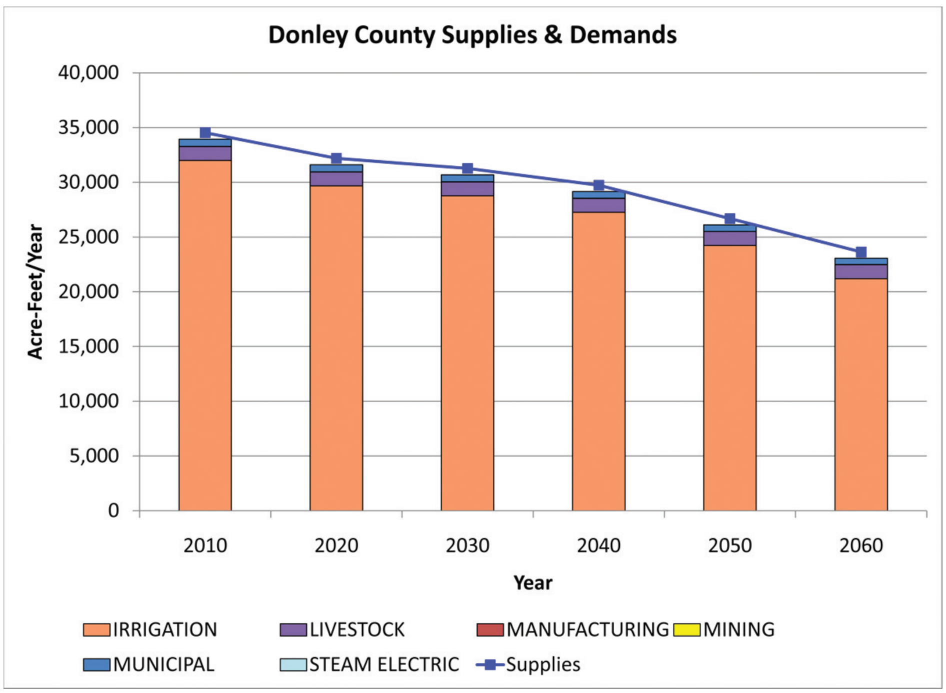
What is the source of my water? Ogallala Aquifer, Greenbelt Reservoir



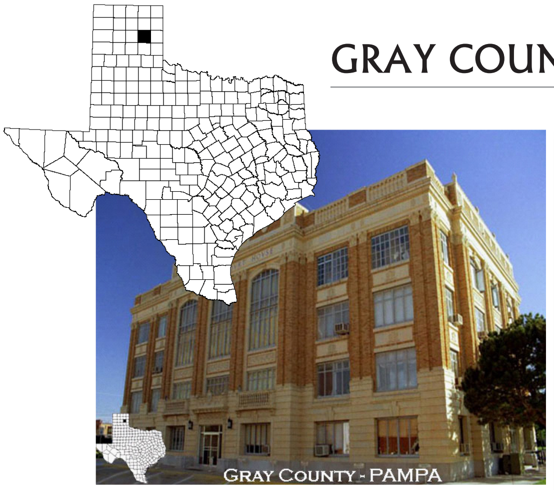








Water User Group	Strategy
Clarendon	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category



GRAY COUNTY

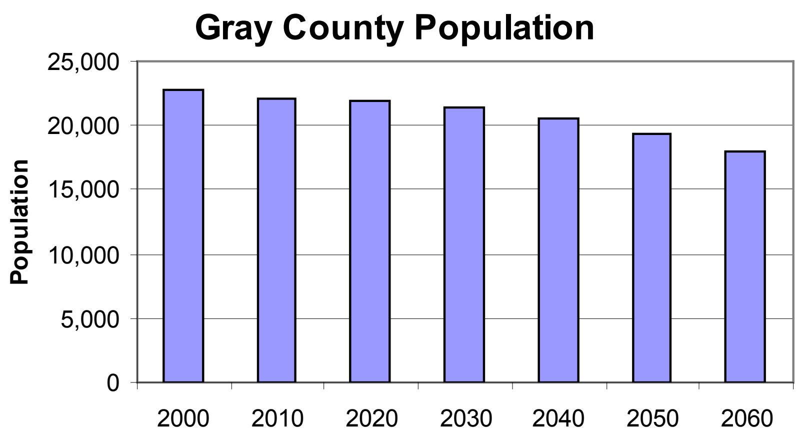
Who are my representatives?

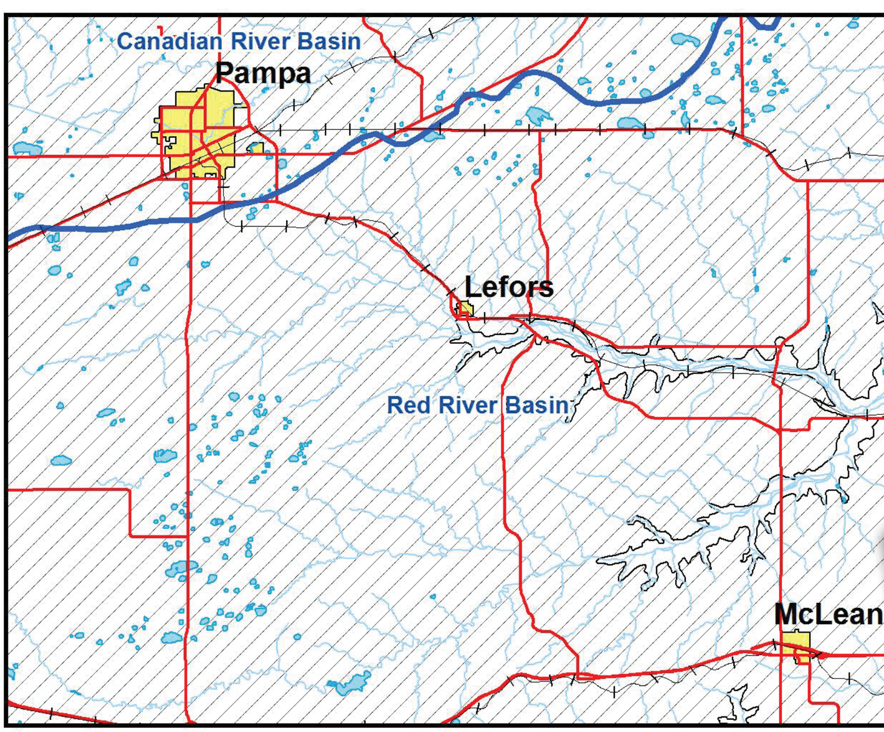
Dr. Nolan Clark	- USDA-ARS
Ben Weinheimer	- Texas Cattle Feeders Association
Bill Hallerberg	- Industry
John Sweeten	- Higher Education
Gale Henslee	- Xcel Energy
C.E. Williams	- Panhandle GCD
John Williams	- CRMWA

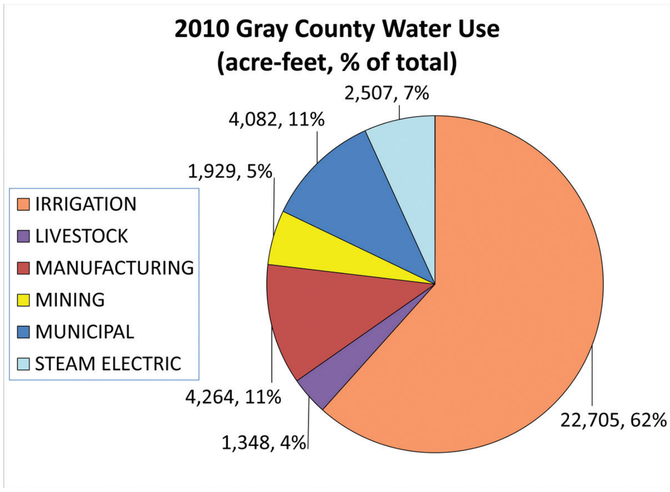
County Seat: City of Pampa

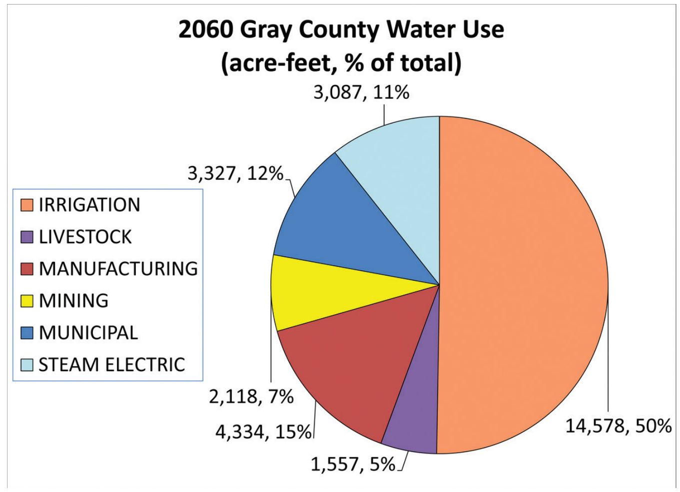
Economy: Agribusiness, Manufacturing, Tourism

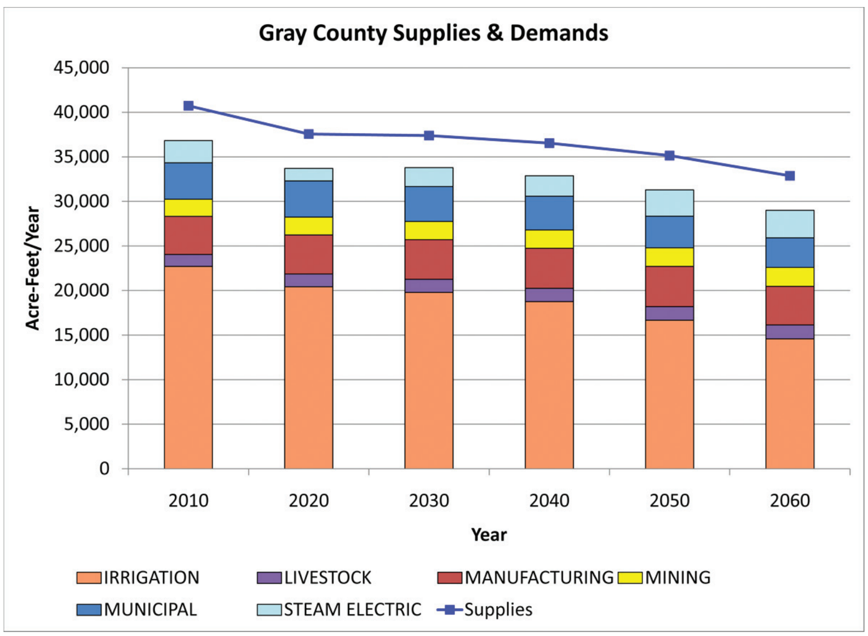
What is the source of my water? Ogallala Aquifer, Lake Meredith











WATER USER GROUP	STRATEGY
Lefors	Conservation, New Groundwater Wells
Mclean	No Water Shortage Identified
Pampa	New Groundwater Wells
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Water Shortage Identified
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Water Shortage Identified

HALL COUNTY

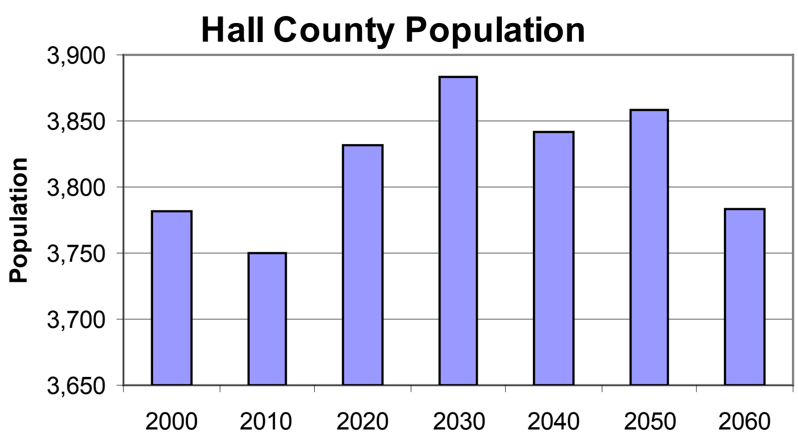
Who are my representatives?

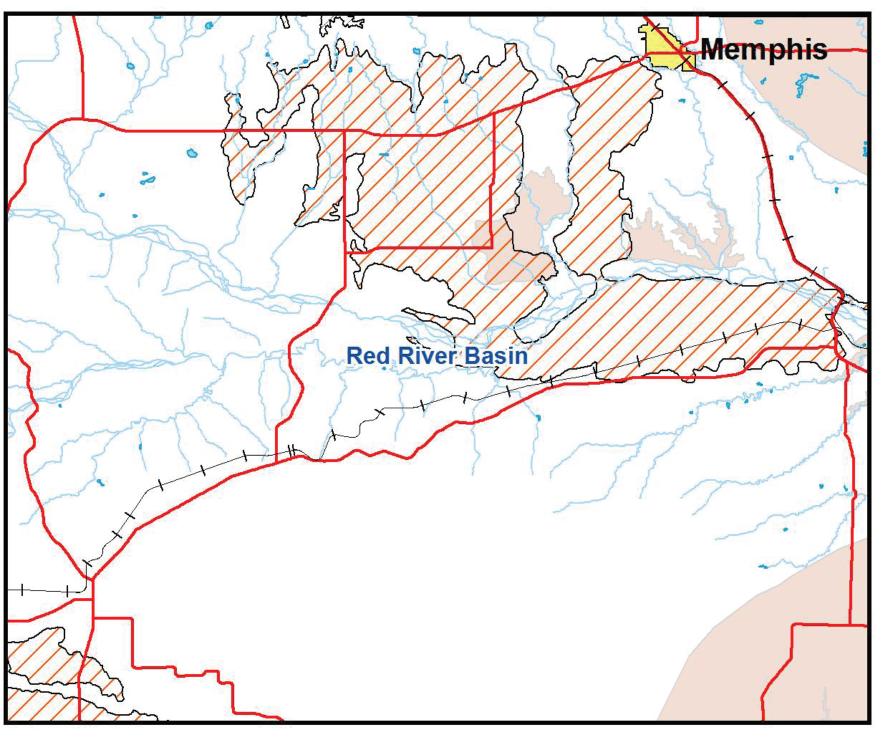
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
Tom Baliff - Greenbelt M&I Water Authority

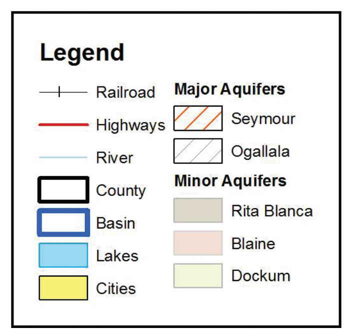
County Seat: City of Memphis

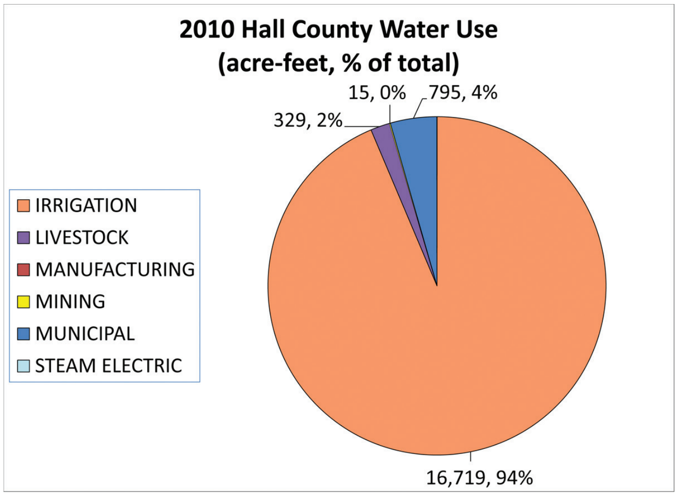
Economy: Agribusiness

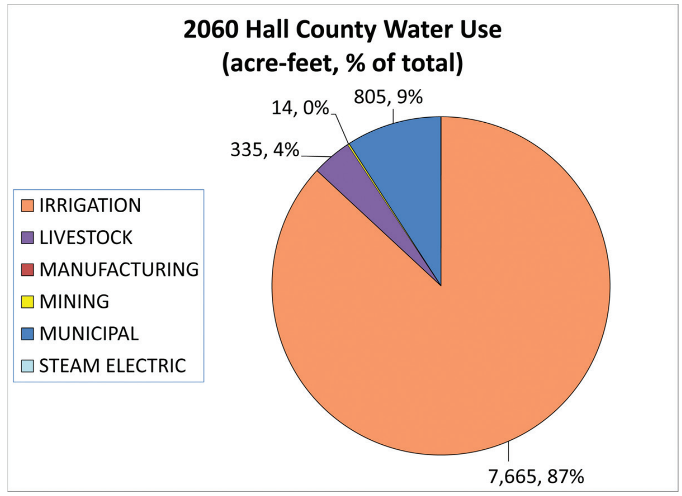
What is the source of my water? Seymour, Blaine Aquifers, Greenbelt Reservoir

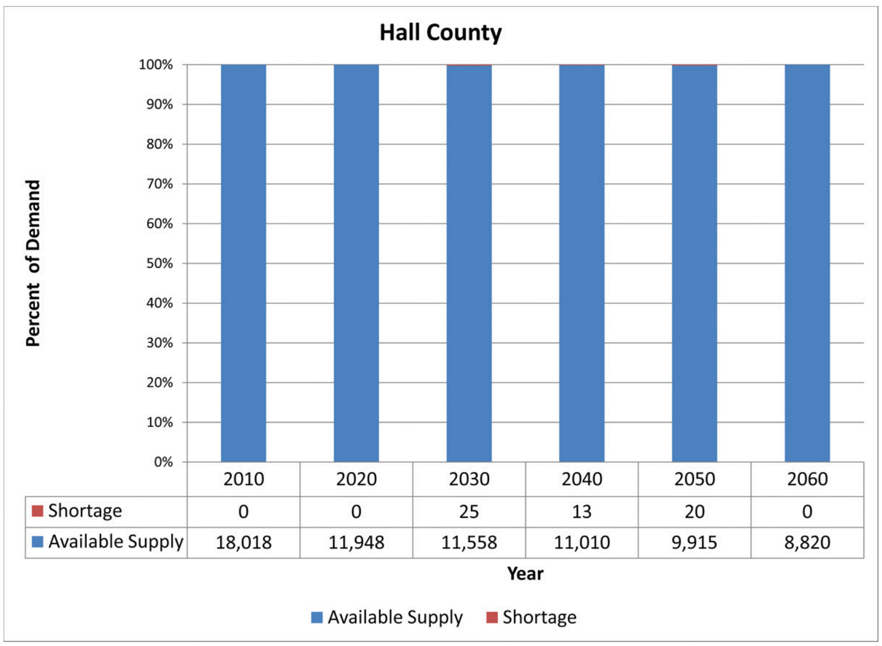












	2010	2020	2030	2040	2050	2060
Shortage	0	0	25	13	20	0
Available Supply	18,018	11,948	11,558	11,010	9,915	8,820

Water User Group	Strategy
Memphis	Conservation, New Groundwater Wells, Purchase Supply from Greenbelt MWA
County-Other	Water Quality, New Groundwater Wells
Irrigation	No Water Shortage Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

HANSFORD COUNTY

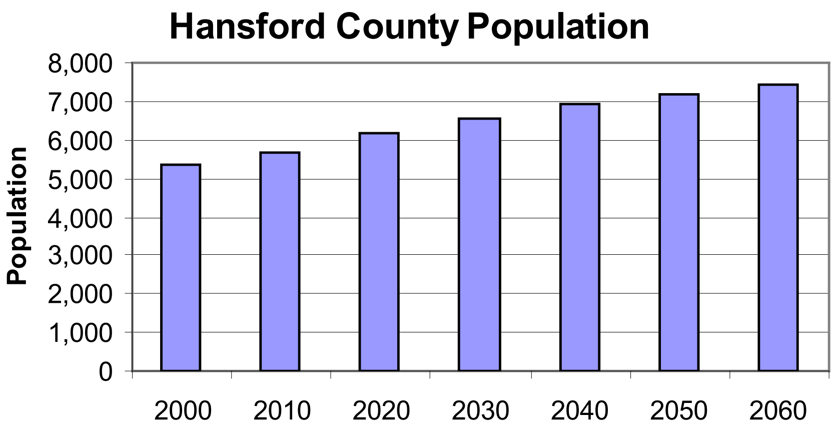
Who are my representatives?

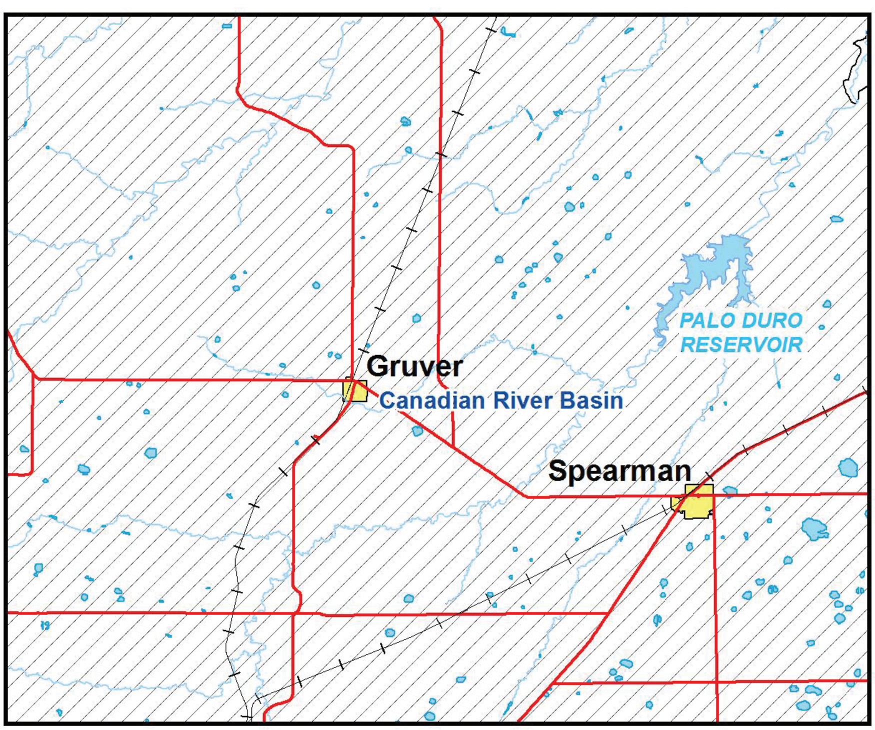
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
Steve Walthour - North Plains GCD
Jim Derington - Palo Duro River Authority

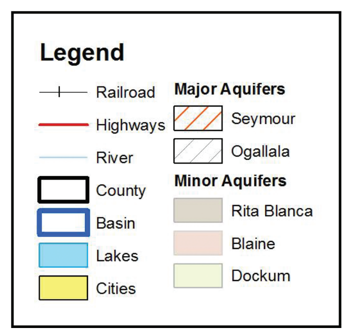
County Seat: City of Spearman

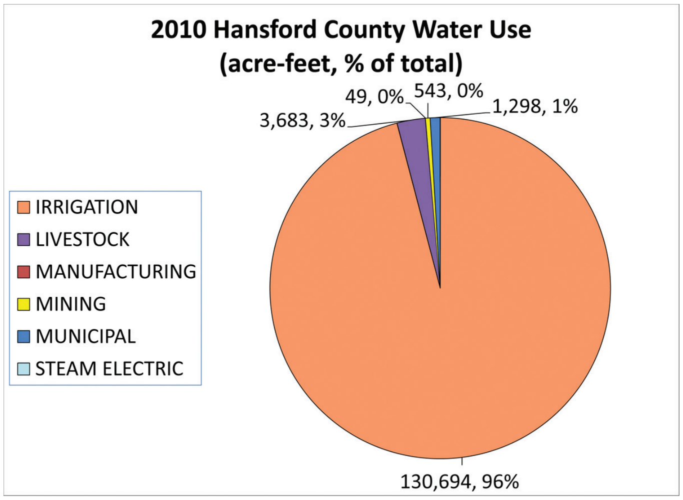
Economy: Agribusiness, Petroleum

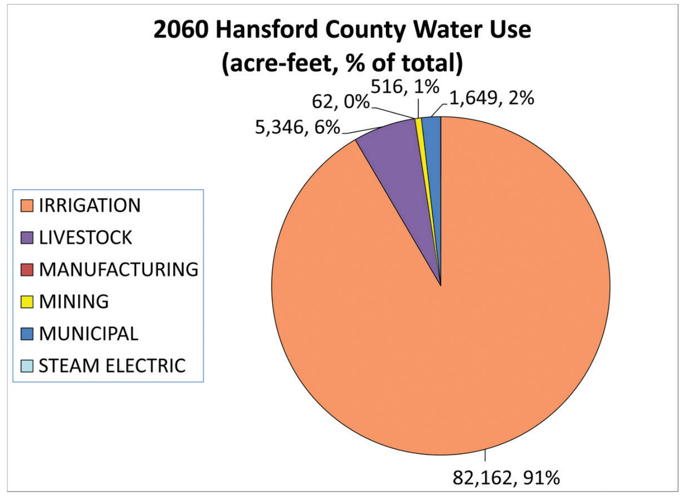
What is the source of my water? Ogallala Aquifer

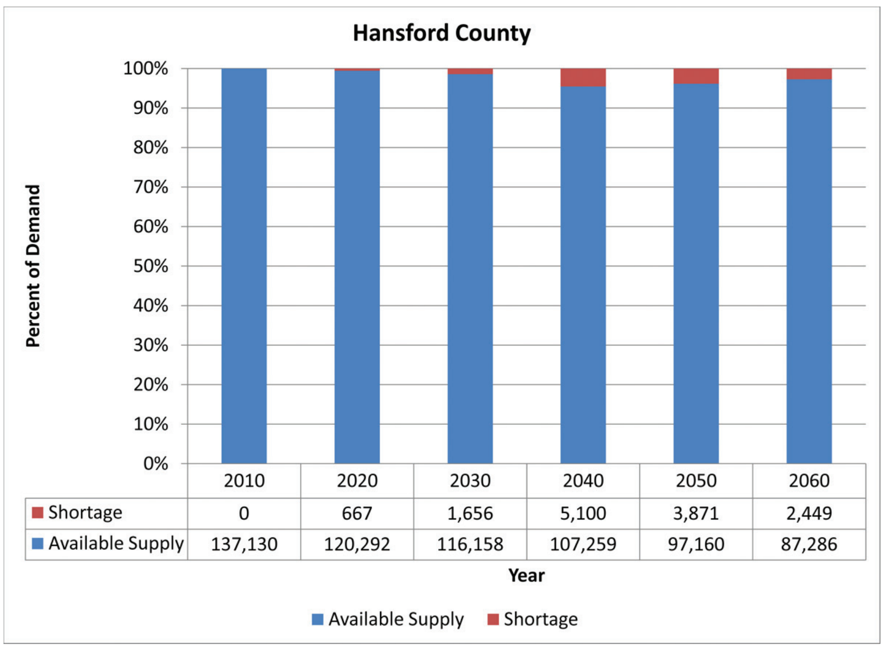












Water User Group	Strategy
Gruver	Conservation, New Groundwater Wells
Spearman	Conservation, New Groundwater Wells
County-Other	No Water Shortage Identified
Irrigation	Change in Crop Type, Change in Crop Variety, Conservation Tillage, Convert to Dryland, Irrigation Equipment, NPET Network, Biotechnology Adoption. Alternative: Precipitation Enhancement
Manufacturing	No Water Shortage Identified
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

HARTLEY COUNTY

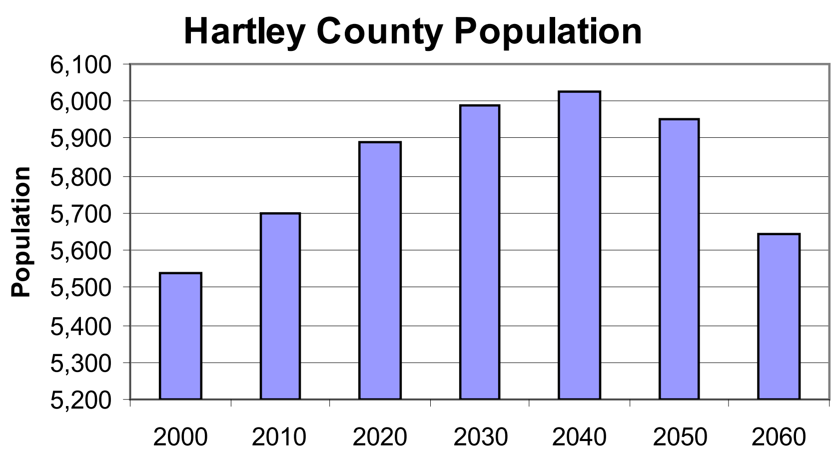
Who are my representatives?

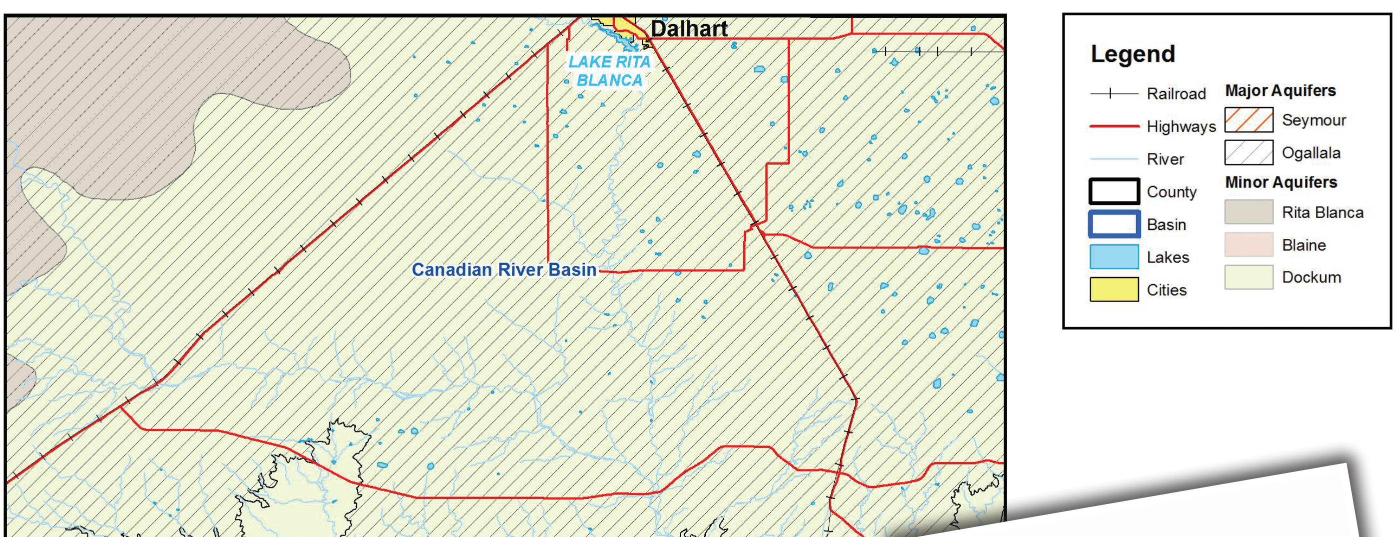
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
Steve Walthour - North Plains GCD

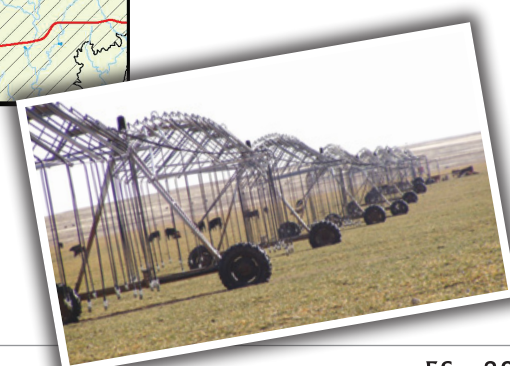
County Seat: City of Channing

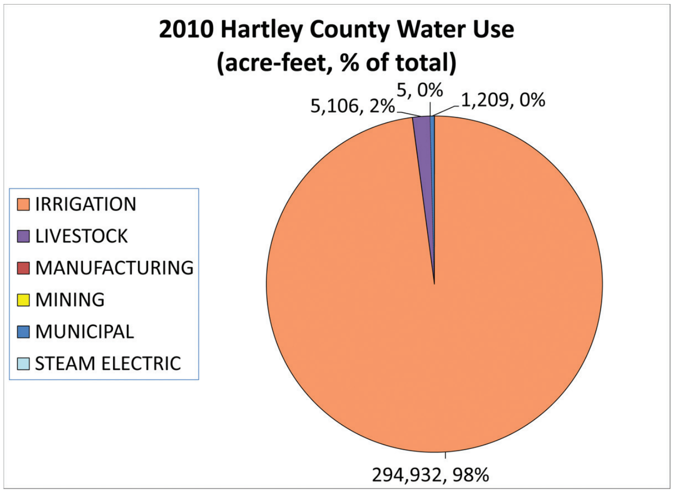
Economy: Agribusiness, Manufacturing, Petroleum

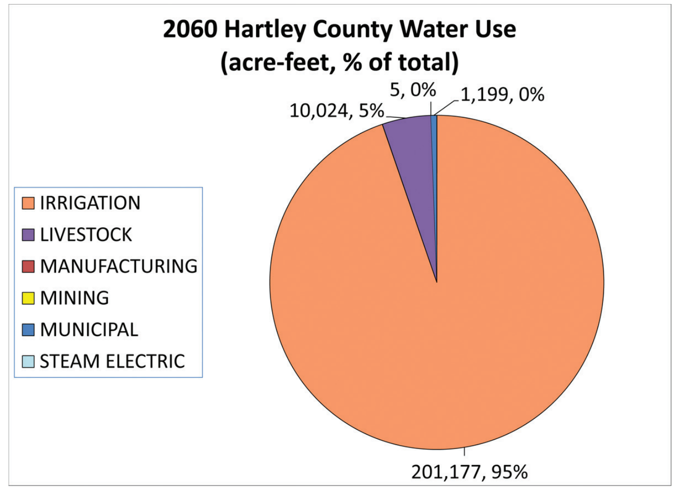
What is the source of my water? Ogallala, Dockum, Rita Blanca Aquifers

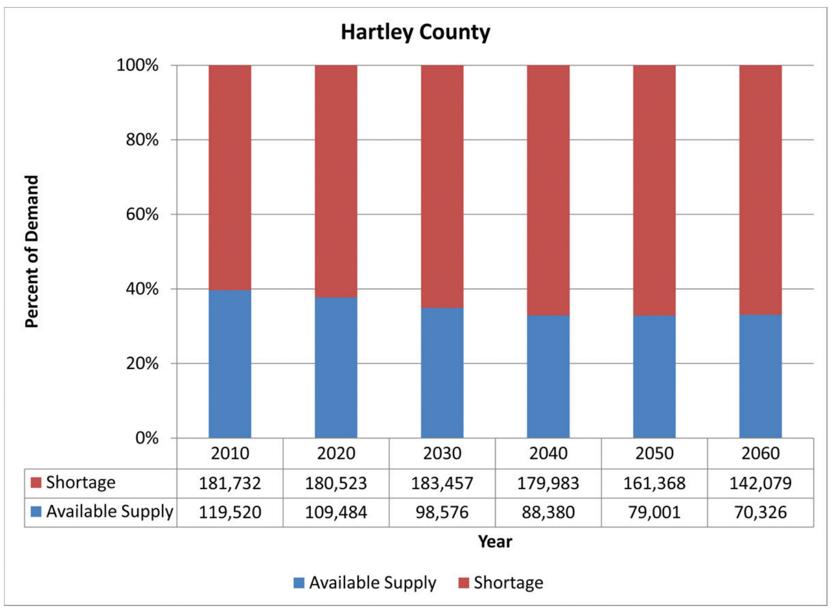








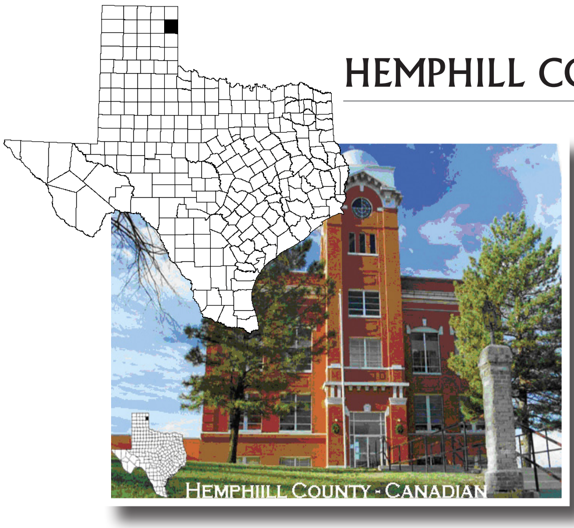




	2010	2020	2030	2040	2050	2060
Shortage	181,732	180,523	183,457	179,983	161,368	142,079
Available Supply	119,520	109,484	98,576	88,380	79,001	70,326

Water User Group	Strategy
Dalhart	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	Change in Crop Type, Change in Crop Variety, Conservation Tillage, Convert to Dryland, Irrigation Equipment, NPET Network, Biotechnology Adoption. Alternative: Precipitation Enhancement
Manufacturing	No Water Shortage Identified
Livestock	No Water Shortage Identified
Mining	No Demands In This Category
Steam Electric Power	No Demands In This Category

HEMPHILL COUNTY



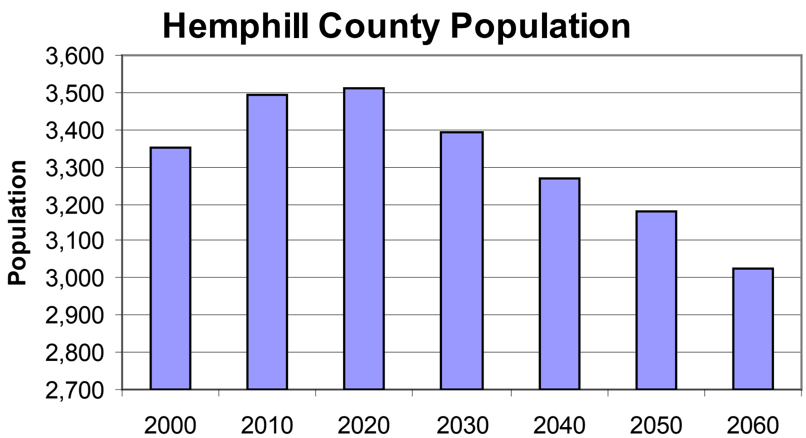
Who are my representatives?

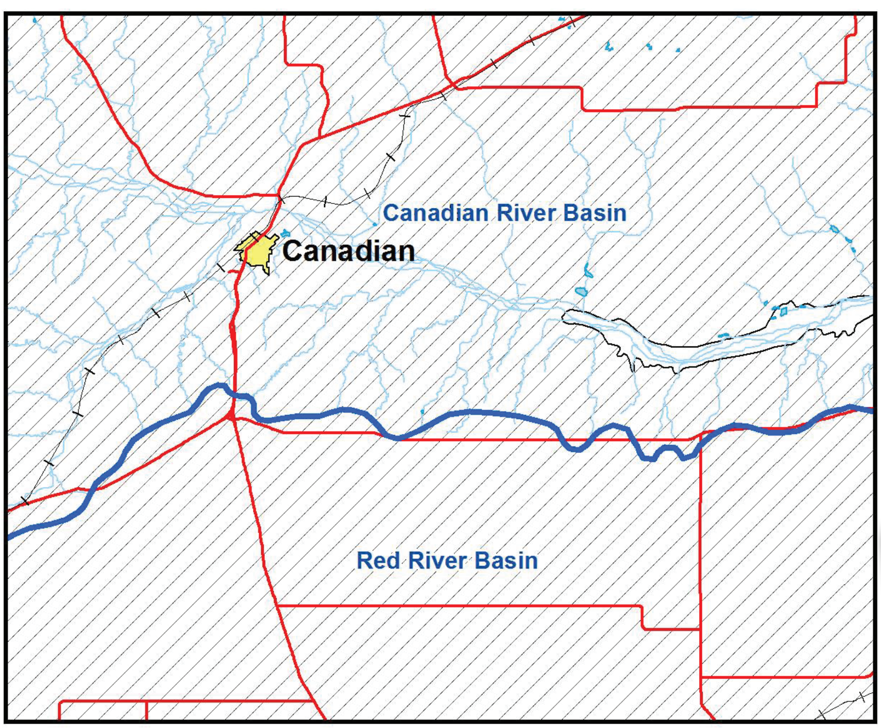
Dr. Nolan Clark	- USDA-ARS
Ben Weinheimer	- Texas Cattle Feeders Association
Janet Guthrie	- Public
John Sweeten	- Higher Education
Gale Henslee	- Xcel Energy

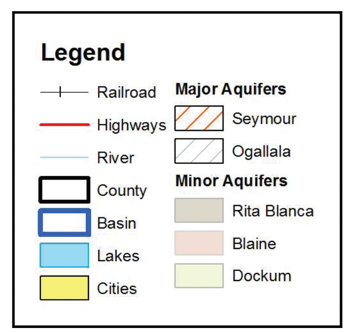
County Seat: City of Canadian

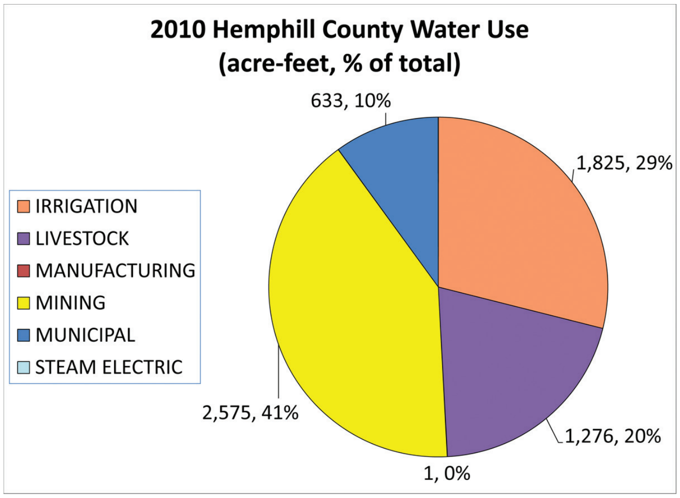
Economy: Agribusiness, Petroleum

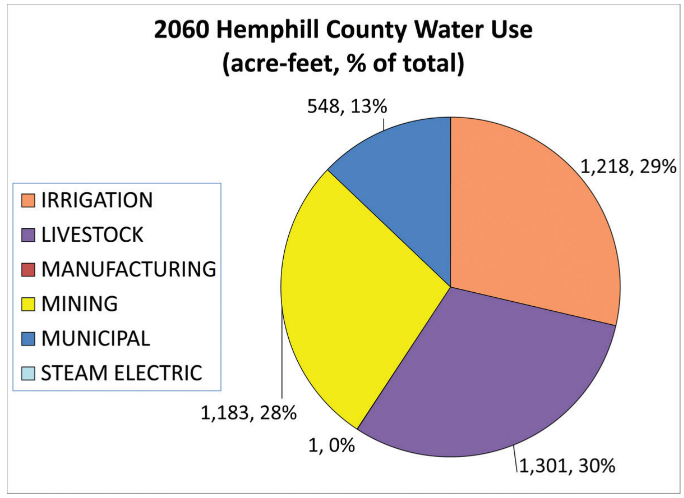
What is the source of my water? Ogallala Aquifer

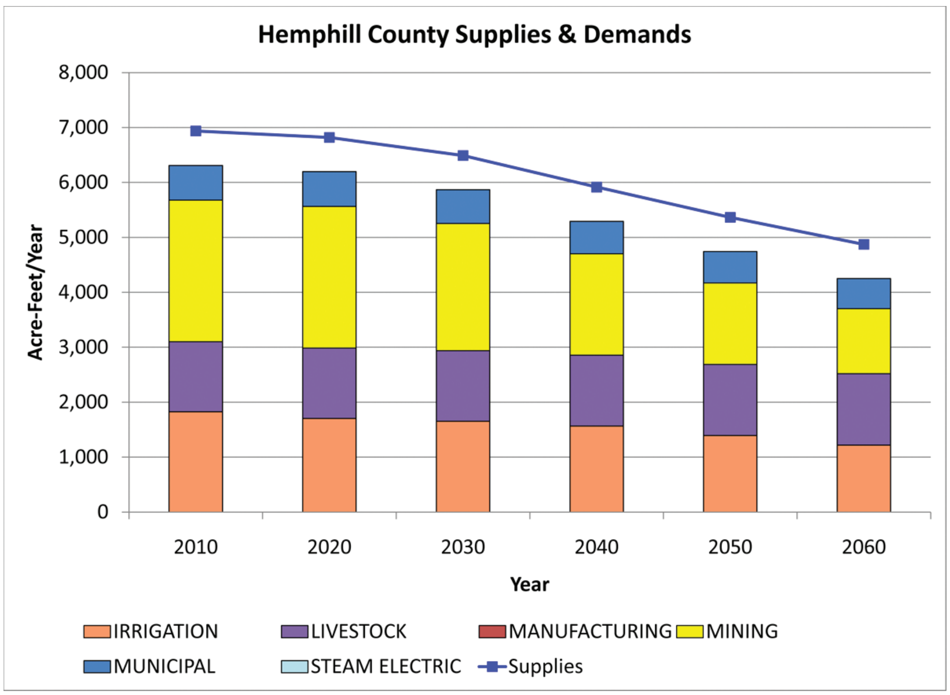












Water User Group	Strategy
Canadian	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Water Shortage Identified
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

HUTCHINSON COUNTY

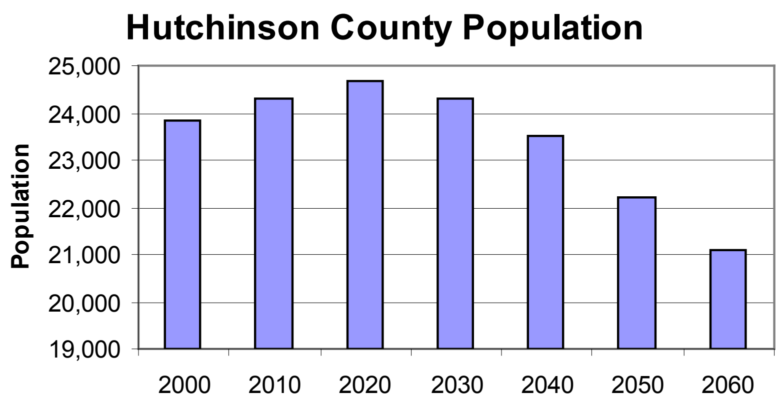
Who are my representatives?

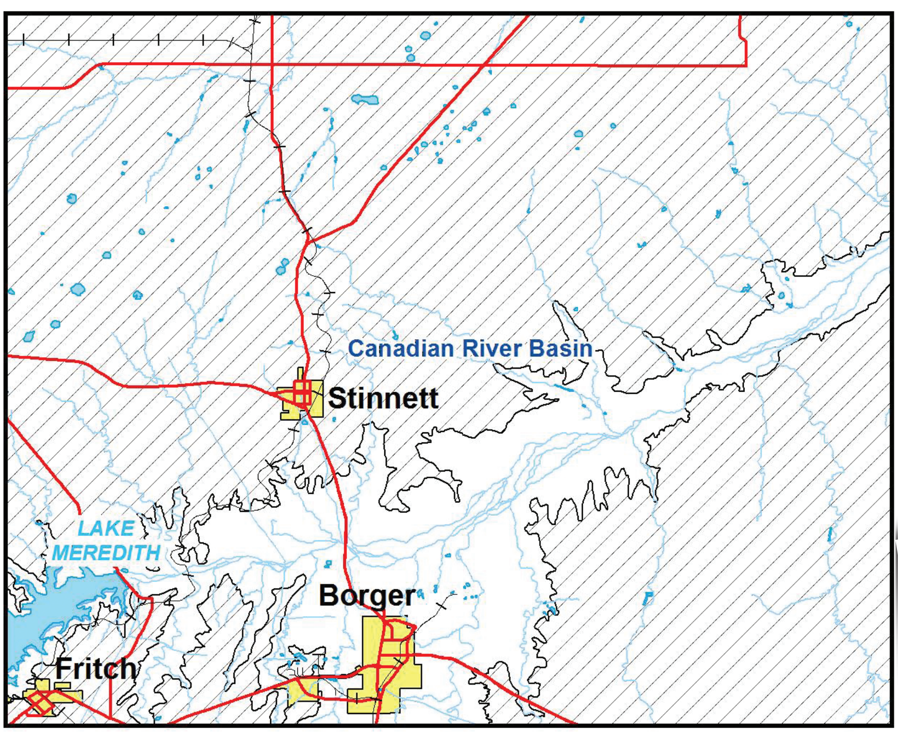
Dr. Nolan Clark	- USDA-ARS
Ben Weinheimer	- Texas Cattle Feeders Association
Denise Jett	- Conoco Phillips
John C. Williams	- Canadian River MWA
Gale Henslee	- Xcel Energy
Steve Walthour	- North Plains GCD
Jim Derington	- Palo Duro River Authority
Charles Cooke	- TCW Supply

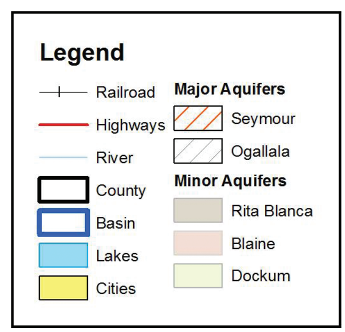
County Seat: City of Stinnett

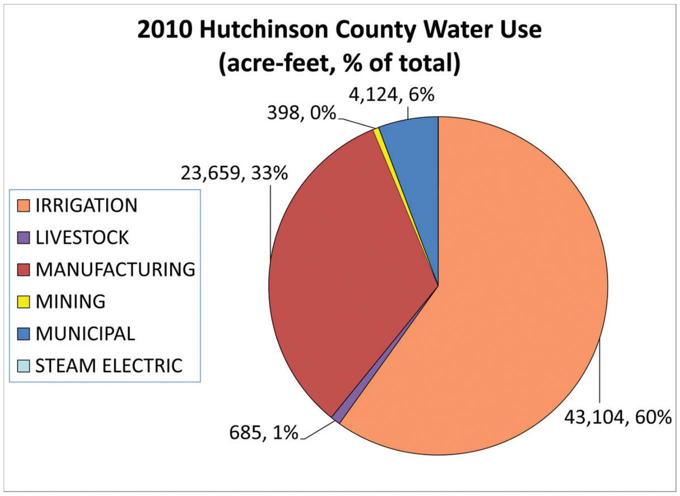
Economy: Agribusiness, Manufacturing, Petroleum, Tourism

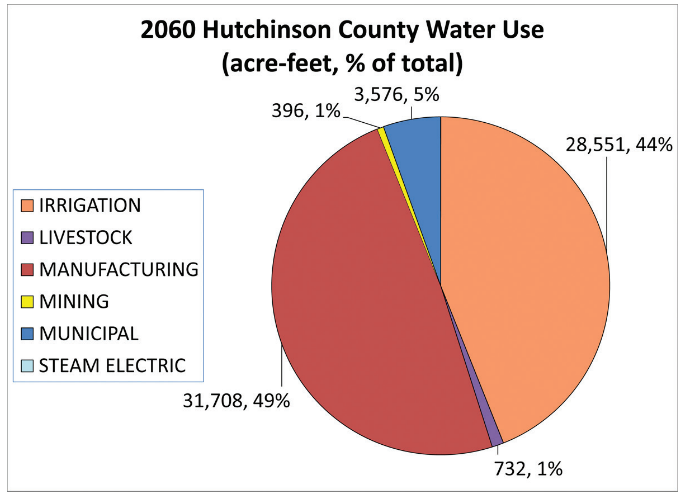
What is the source of my water? Ogallala Aquifer, Lake Meredith

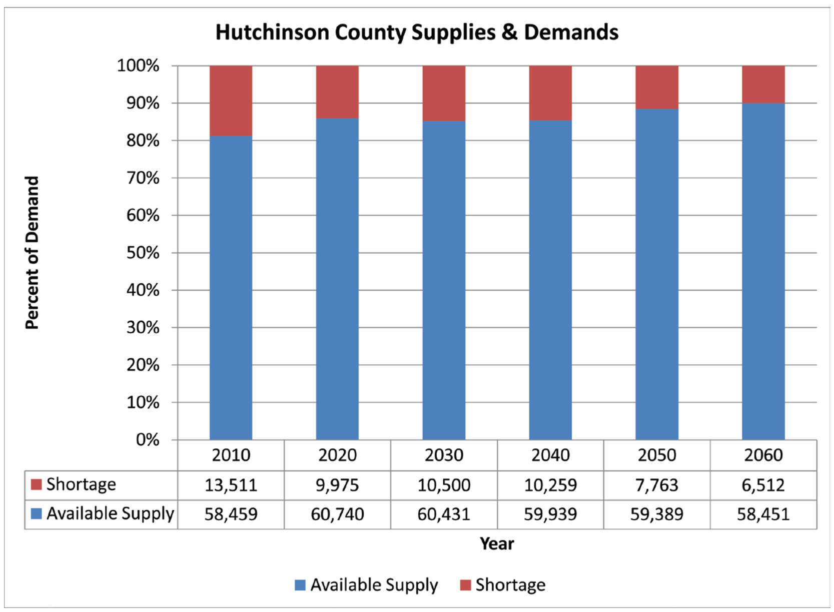












Water User Group	Strategy
Borger	Conservation, New Groundwater Wells
Fritch	No Water Shortage Identified, New Groundwater Wells
Hi Texas Water Company	No Water Shortage Identified
Stinett	No Water Shortage Identified
TCW Water Supply Inc.	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	Change in Crop Type, Change in Crop Variety, Conservation Tillage, Convert to Dryland, Irrigation Equipment, NPET Network, Biotechnology Adoption, Precipitation Enhancement
Manufacturing	Purchase Water From Borger
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

LIPSCOMB COUNTY

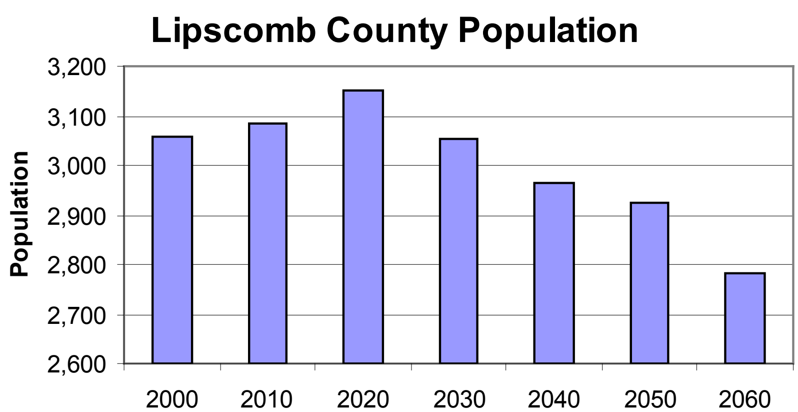
Who are my representatives?

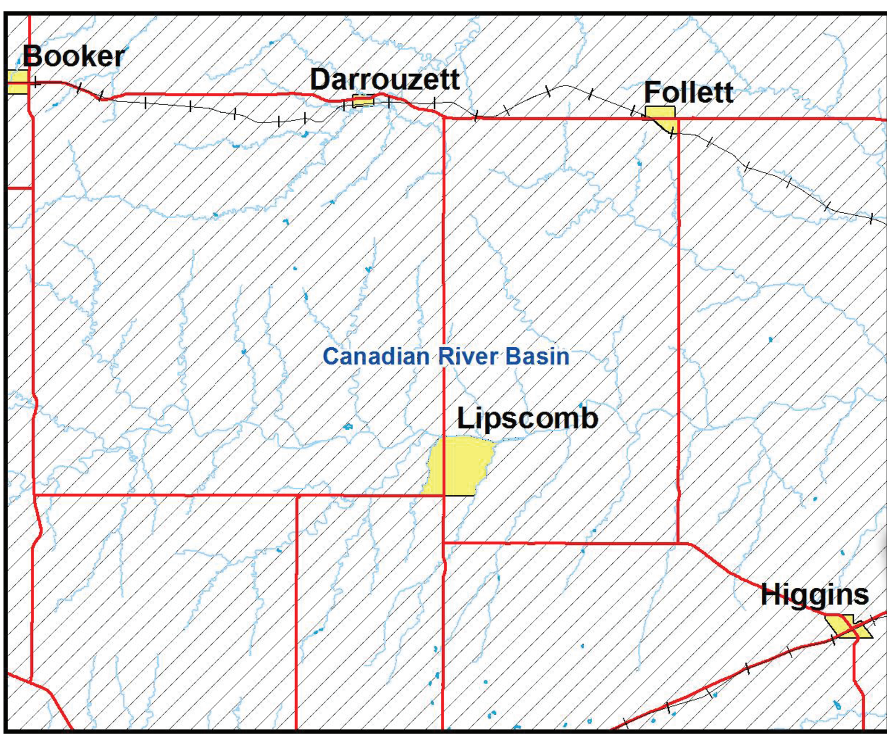
Dr. Nolan Clark	- USDA-ARS
Ben Weinheimer	- Texas Cattle Feeders Association
Janet Tregellas	- Farmer/Rancher
John Sweeten	- Higher Education
Gale Henslee	- Xcel Energy
Steve Walthour	- North Plains GCD

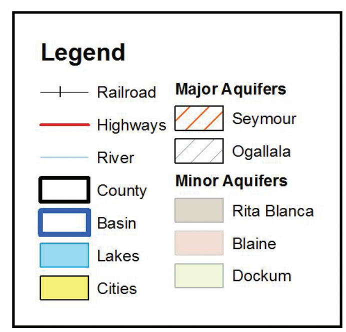
County Seat: City of Lipscomb

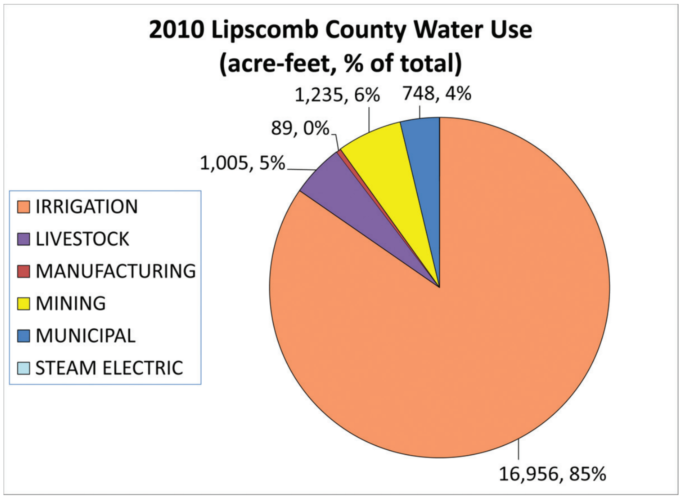
Economy: Agribusiness, Petroleum

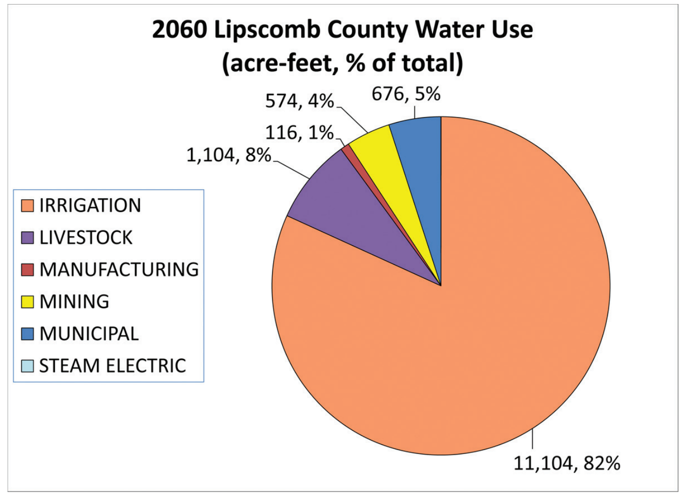
What is the source of my water? Ogallala Aquifer

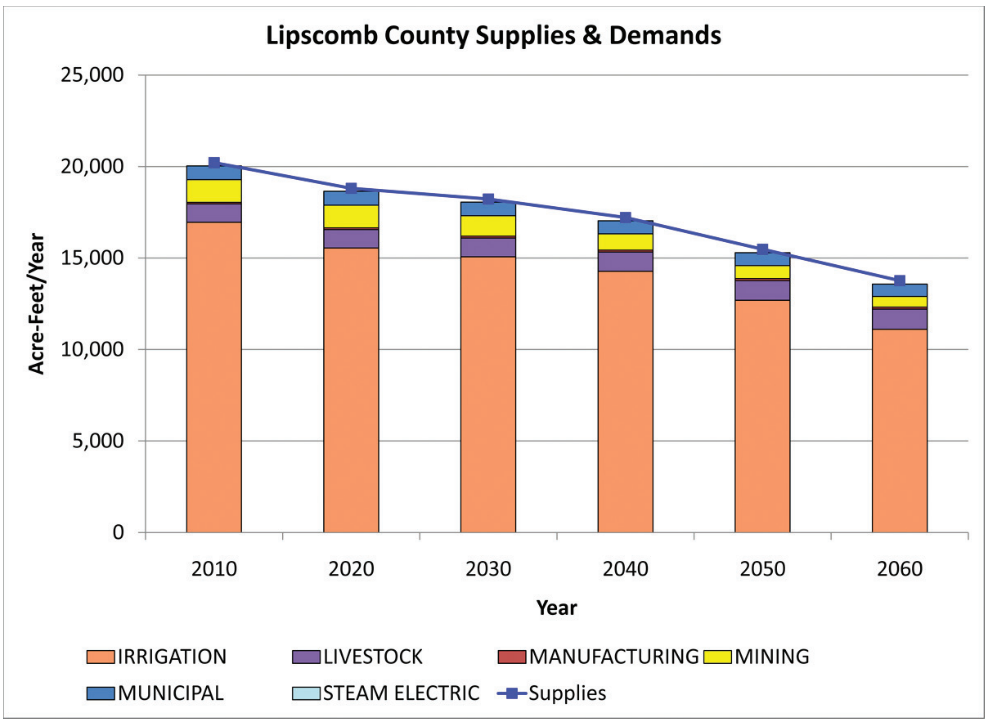












Water User Group	Strategy
Booker	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Water Shortage Identified
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

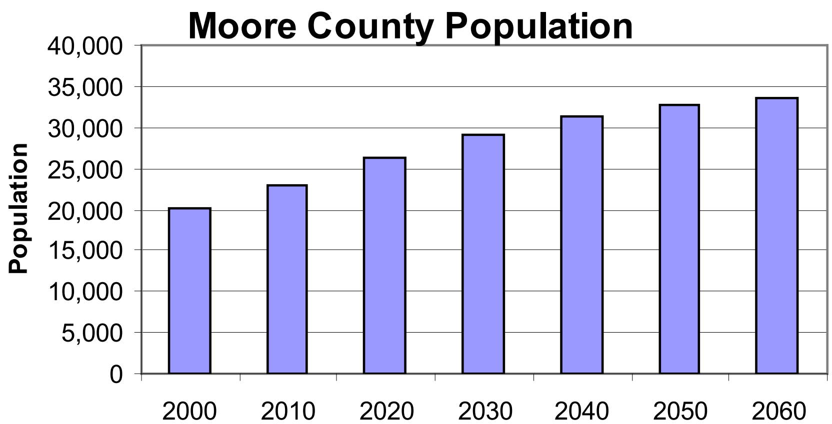
Who are my representatives?

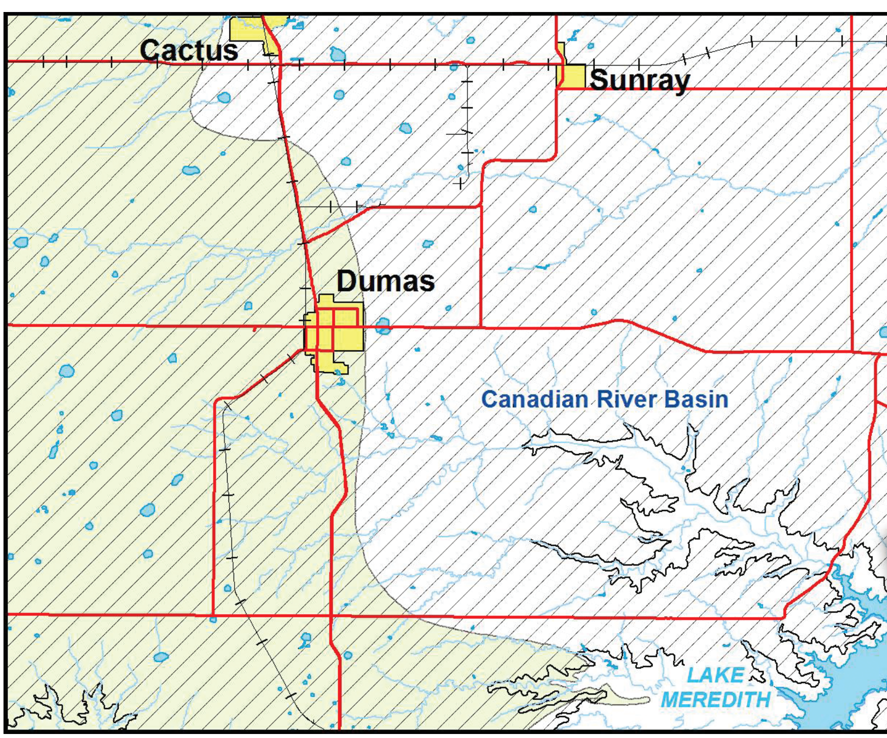
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
Steve Walthour - North Plains GCD
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
Jim Derington - Palo Duro River Authority
Kendall Harris - Mesquite Groundwater Conservation District

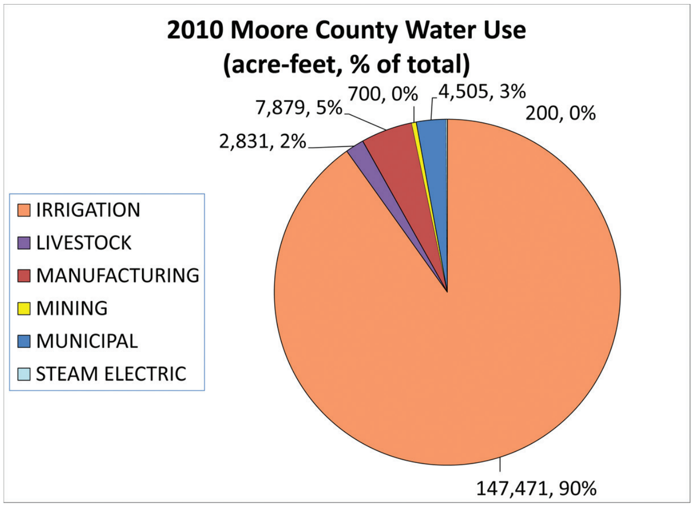
County Seat: City of Dumas

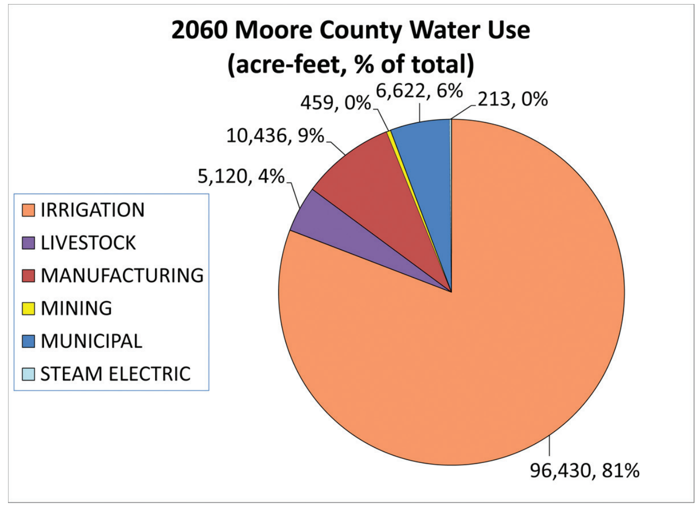
Economy: Agribusiness, Petroleum

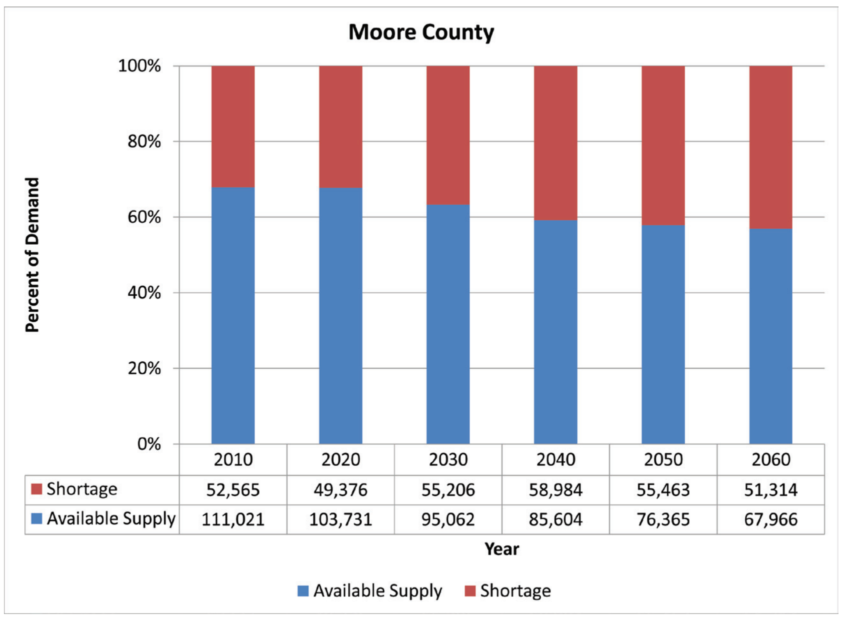
What is the source of my water? Ogallala, Dockum Aquifers











Water User Group	Strategy
Cactus	Conservation, New Groundwater Wells
Dumas	Conservation, New Groundwater Wells
Fritch	No Water Shortage Identified
Sunray	Conservation, New Groundwater Wells
County-Other	Conservation, New Groundwater Wells
Irrigation	Change in Crop Type, Change in Crop Variety, Conservation Tillage, Convert to Dryland, Irrigation Equipment, NPET Network, Biotechnology Adoption. Alternative: Precipitation Enhancement
Manufacturing	Purchase Water From Cactus
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	New Groundwater Wells

OCHILTREE COUNTY

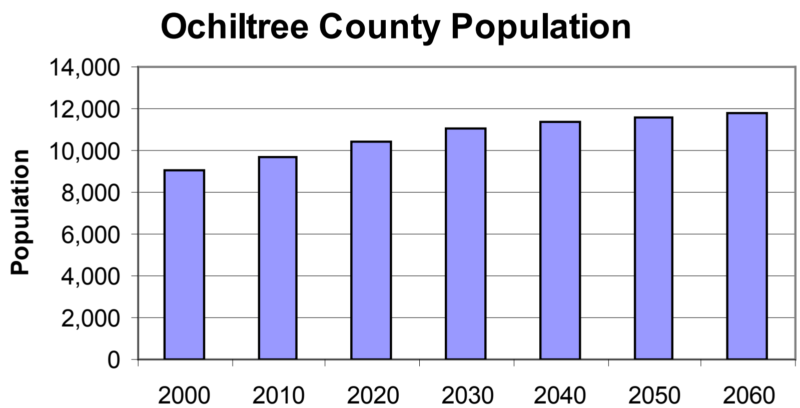
Who are my representatives?

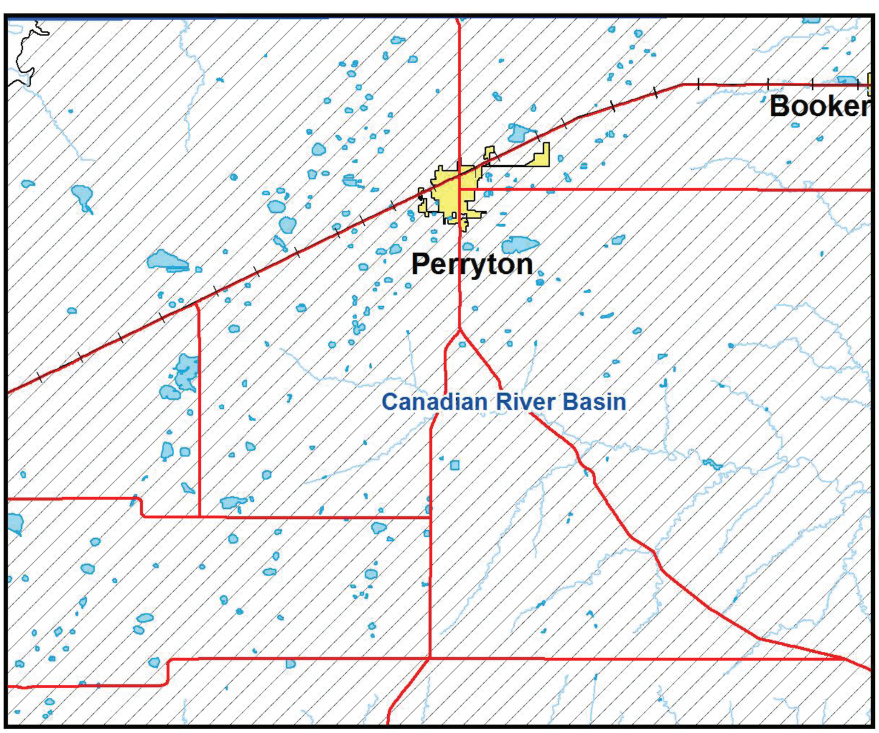
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
David Landis - City of Perryton
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
Steve Walthour - North Plains GCD

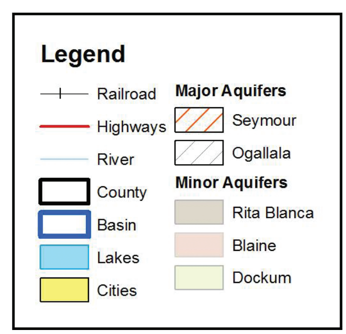
County Seat: City of Perryton

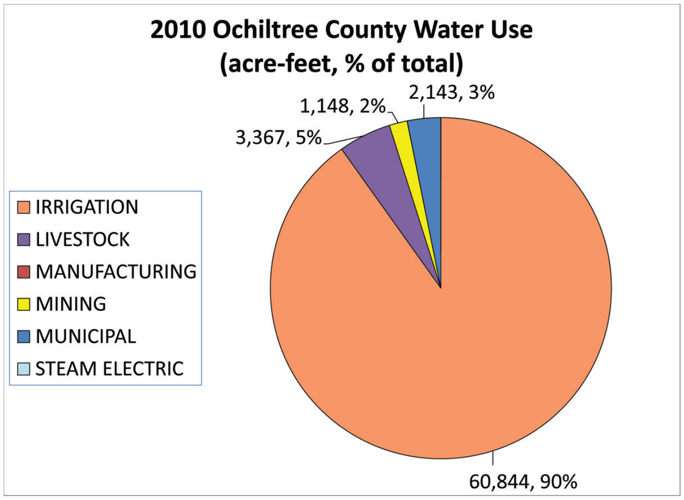
Economy: Agribusiness, Petroleum

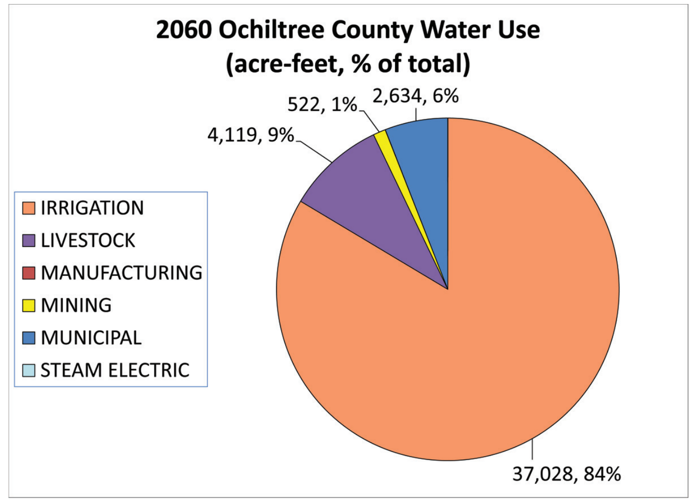
What is the source of my water? Ogallala Aquifers

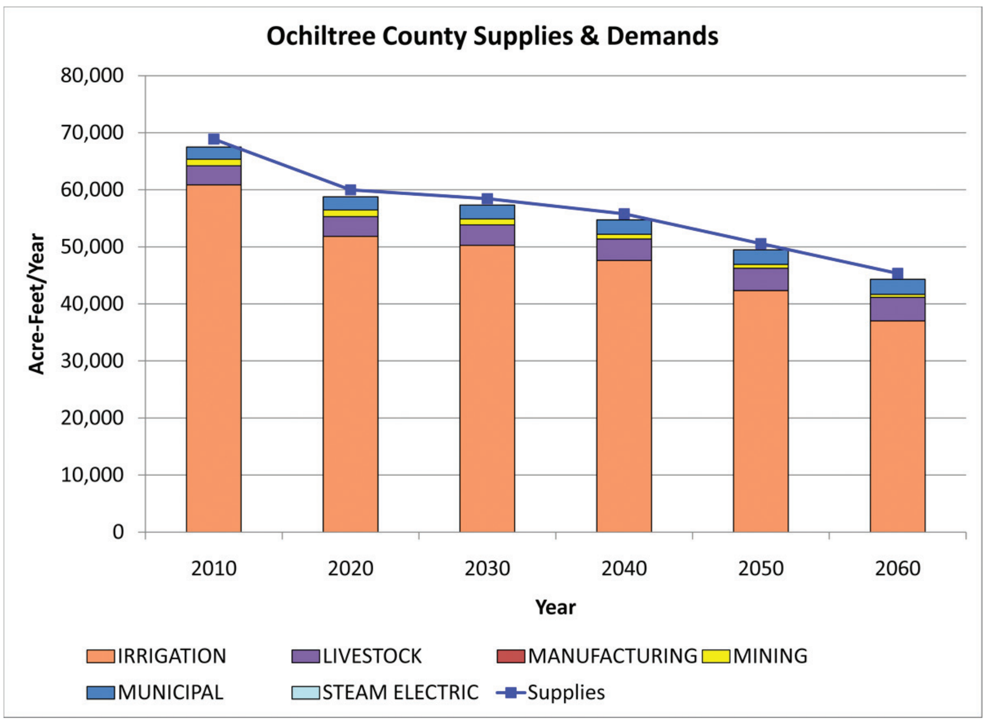












Water User Group	Strategy
Perryton	Conservation, New Wells
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

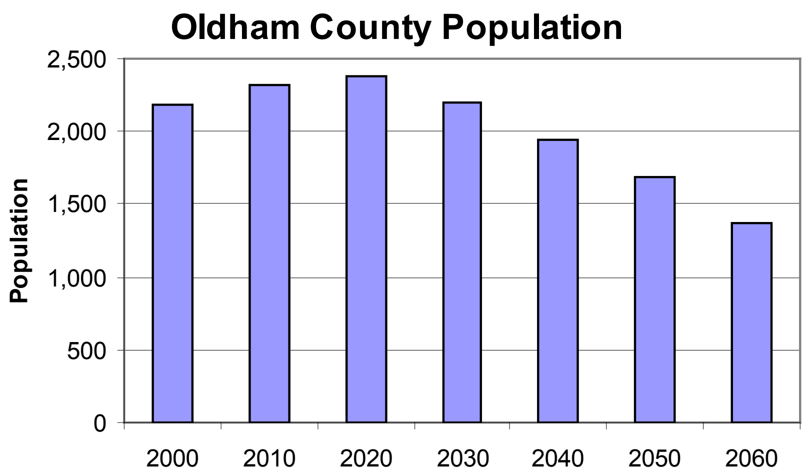
OLDHAM COUNTY

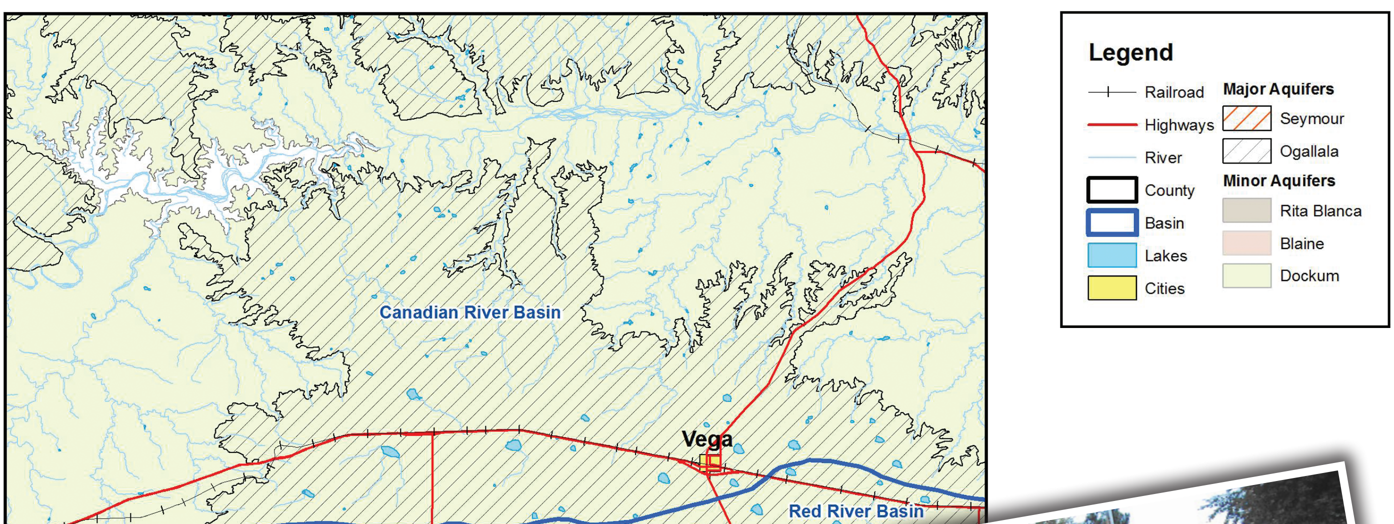
Who are my representatives?
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
Grady Skaggs - Farmer
John Sweeten - Higher Education
Gale Henslee - Xcel Energy

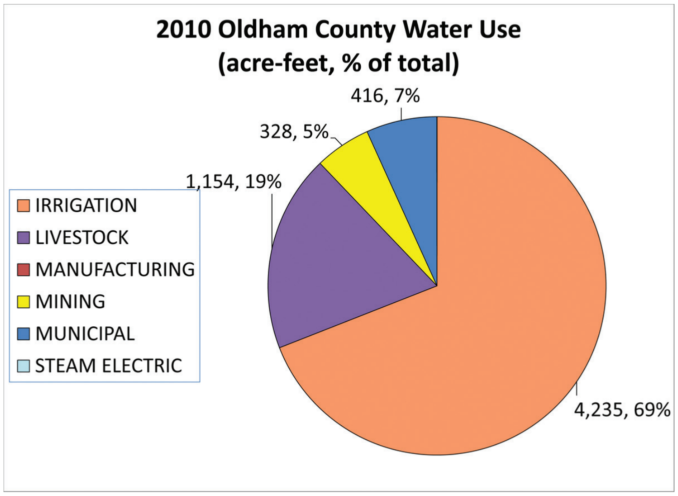
County Seat: City of Vega

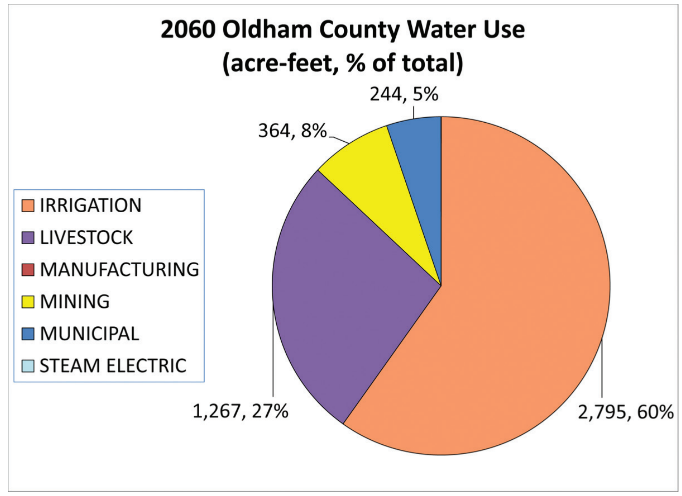
Economy: Agribusiness

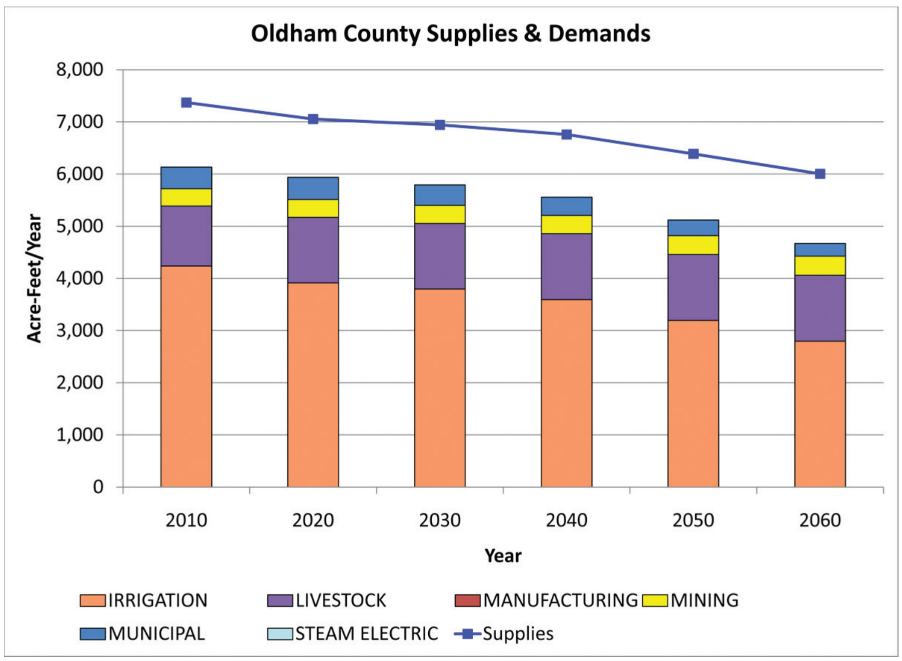
What is the source of my water? Ogallala, Dockum Aquifers





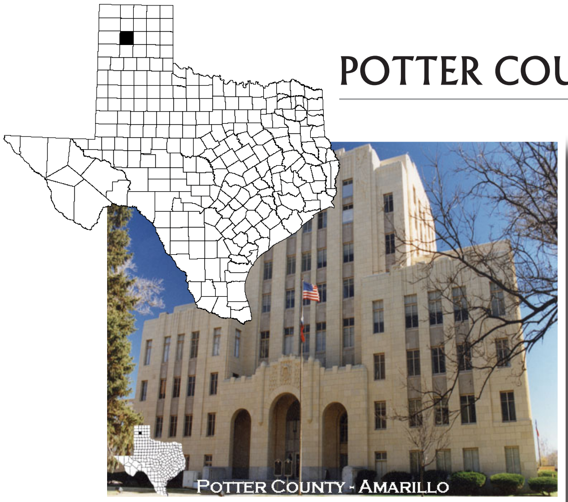






Water User Group	Strategy
Vega	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

POTTER COUNTY



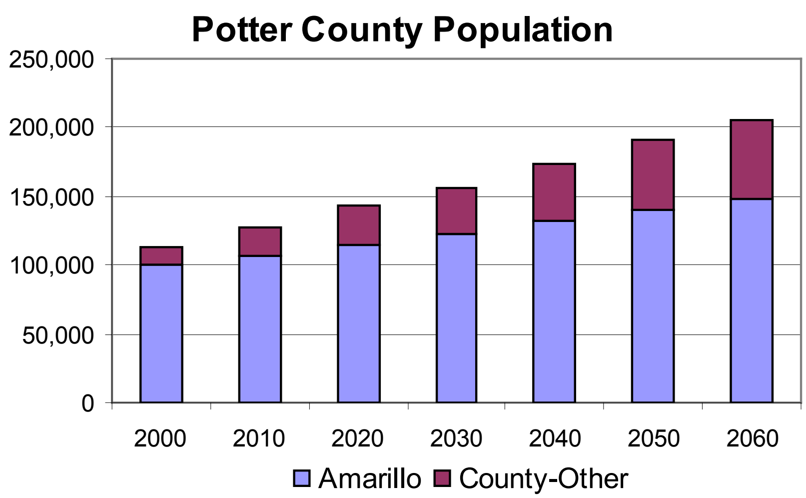
Who are my representatives?

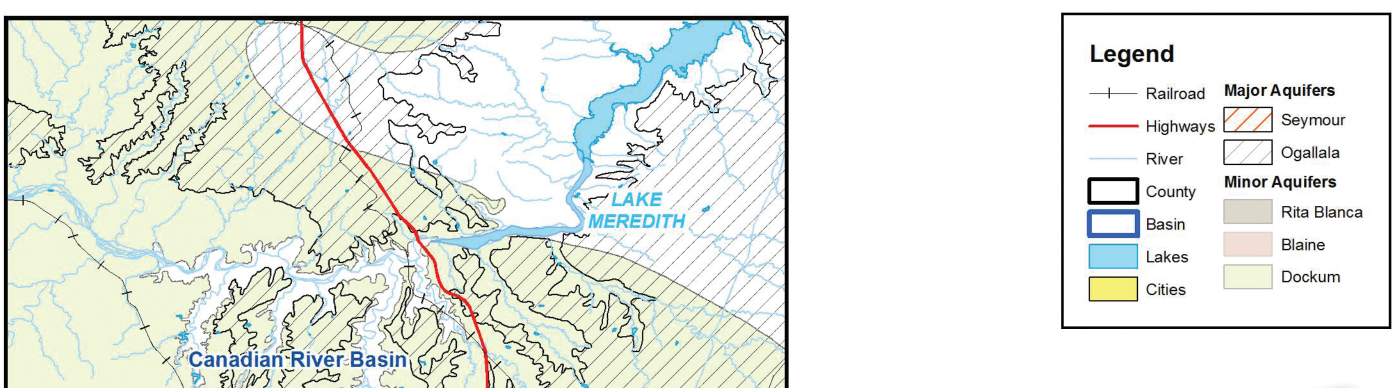
Emmett Autrey - City of Amarillo
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
Gale Henslee - Xcel Energy
C.E. Williams - Panhandle GCD
John Williams - CRMWA
John Sweeten - Higher Education
Bill Hallerberg - Industry
Cole Camp - Environmental

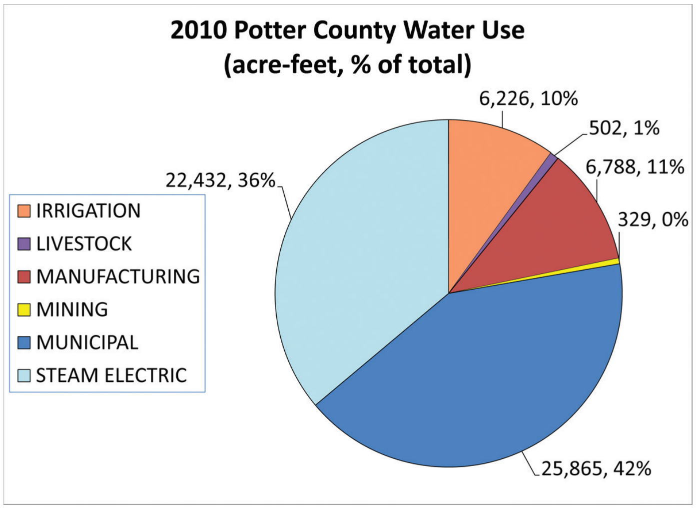
County Seat: City of Amarillo

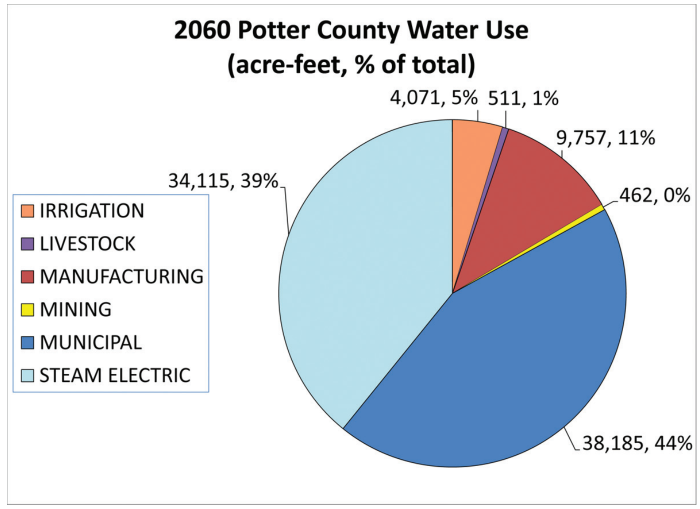
Economy: Agribusiness, Manufacturing, Petroleum, Tourism

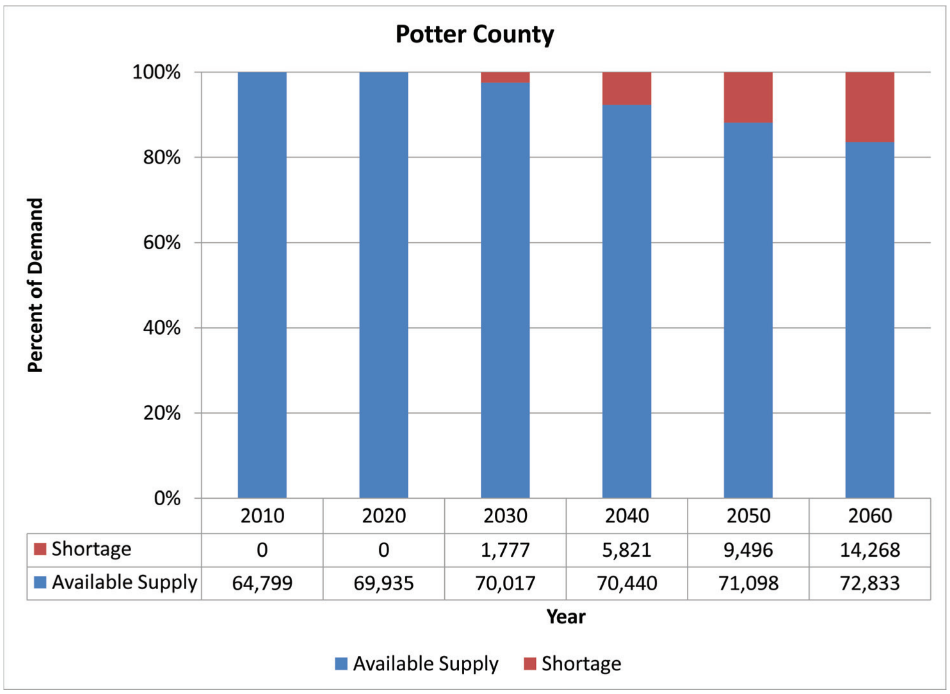
What is the source of my water? Ogallala, Dockum Aquifers; Lake Meredith











Water User Group	Water Management Strategy
Amarillo	Conservation, Potter County Well Field, Roberts County Well Field
County-Other	Conservation, New Groundwater Wells
Irrigation	No Water Shortage Identified
Manufacturing	Purchase Water From Amarillo
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Water Shortage Identified

RANDALL COUNTY

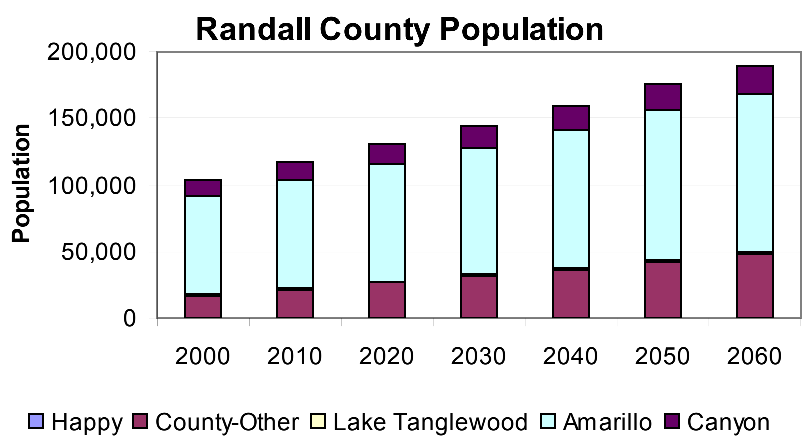
Who are my representatives?

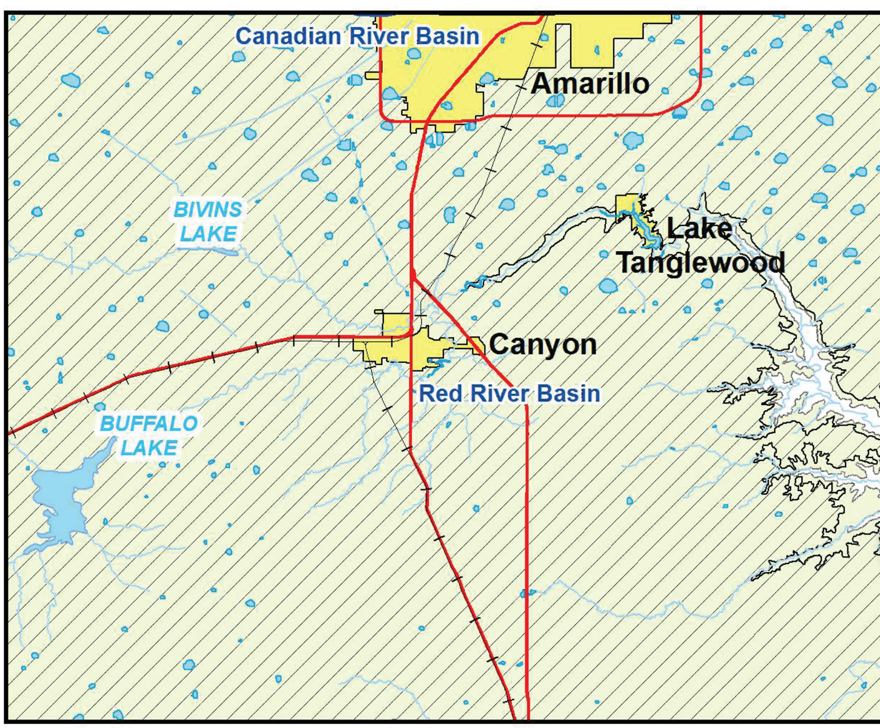
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
Emmett Autrey - City of Amarillo
Gale Henslee - Xcel Energy
John Williams - CRMWA

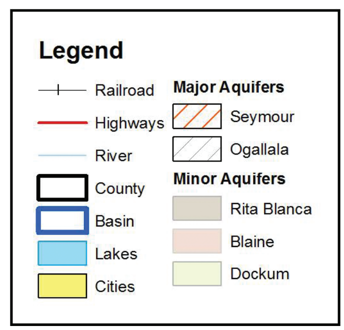
County Seat: City of Canyon

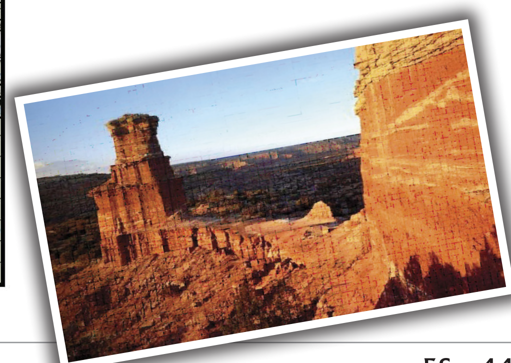
Economy: Agribusiness, Manufacturing, Tourism

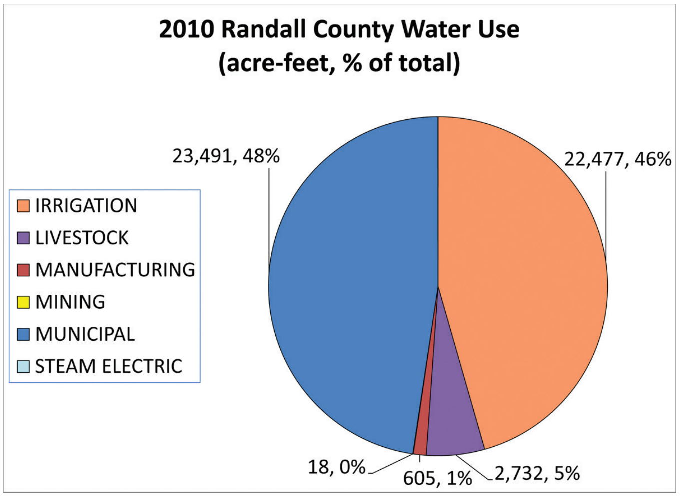
What is the source of my water? Ogallala, Dockum Aquifers, Lake Meredith

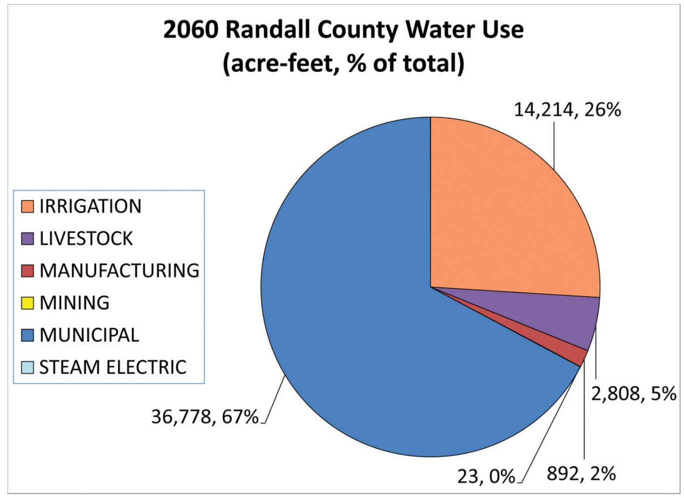


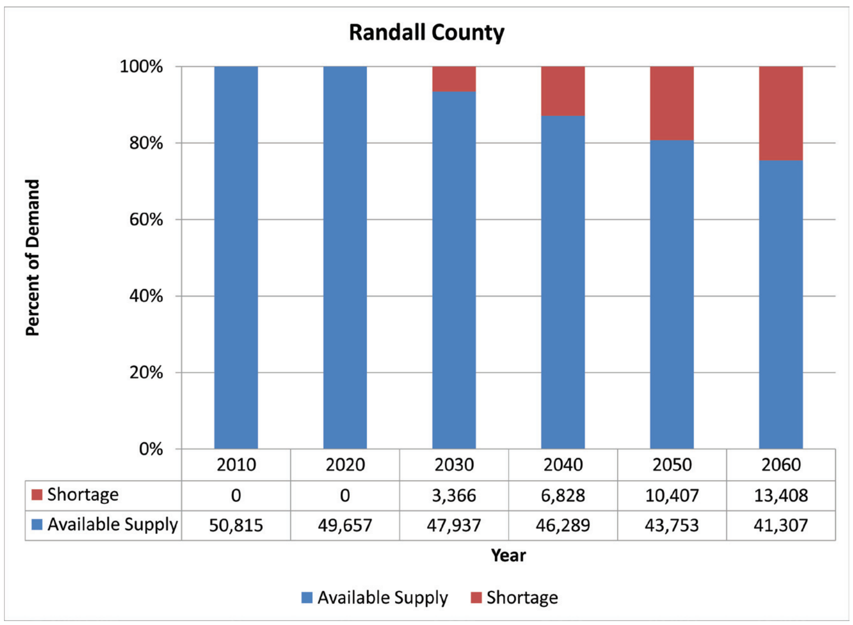




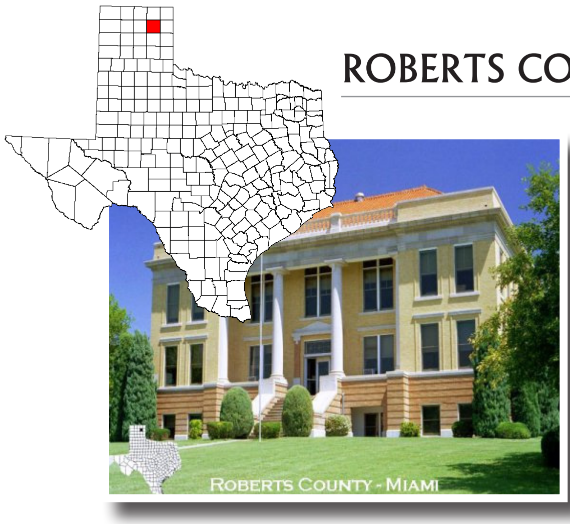








Water User Group	Strategy
Amarillo	Conservation, Potter County Well Field, Roberts County Well Field
Canyon	Conservation, New Groundwater Wells
Happy	No Water Shortage Identified
Lake Tanglewood	No Water Shortage Identified
County-Other	Conservation, Additional Groundwater
Irrigation	No Water Shortage Identified
Manufacturing	No Water Shortage Identified
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category



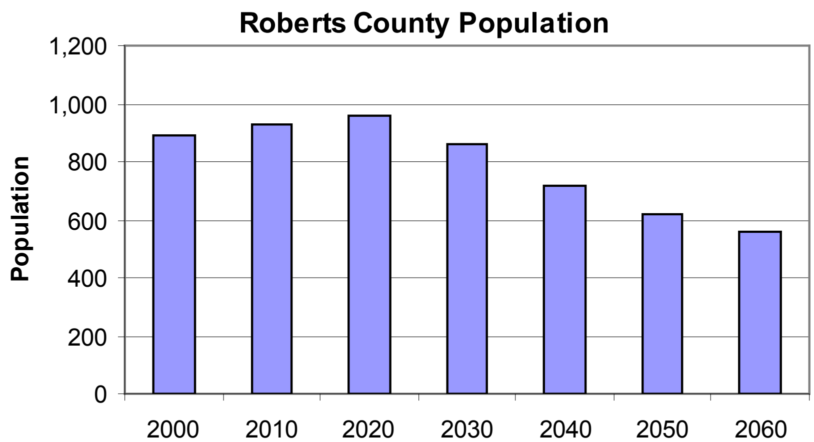
Who are my representatives?

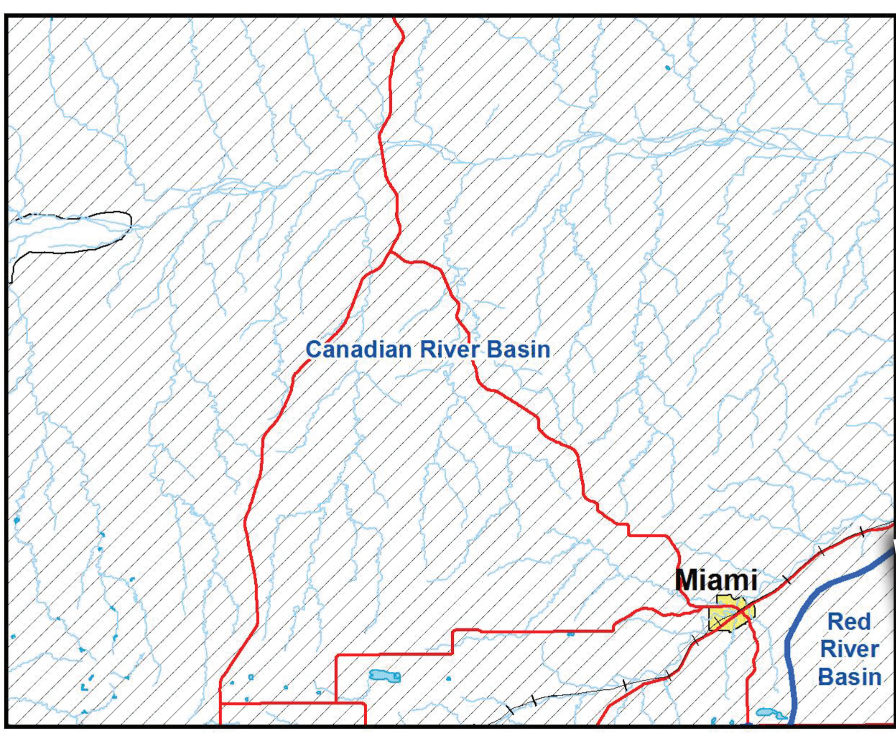
Dr. Nolan Clark	- USDA-ARS
Ben Weinheimer	- Texas Cattle Feeders Association
Judge Vernon Cook	- Roberts County
John Sweeten	- Higher Education
Gale Henslee	- Xcel Energy
C.E. Williams	- Panhandle GCD
John Williams	- CRMWA

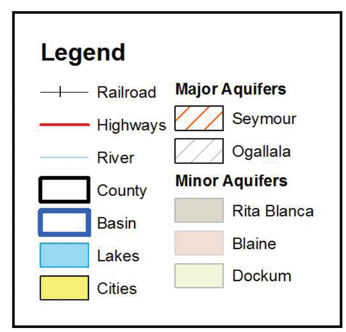
County Seat: City of Miami

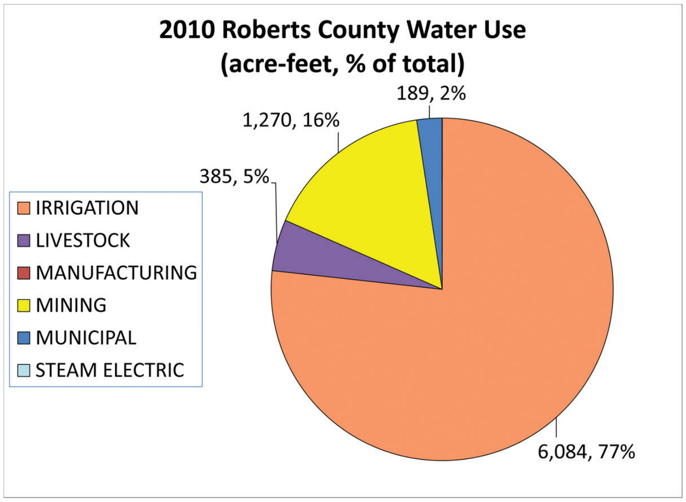
Economy: Agribusiness, Petroleum

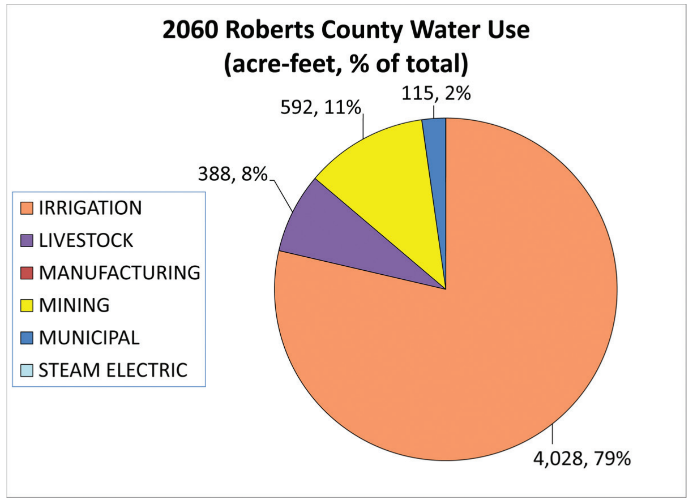
What is the source of my water? Ogallala Aquifer

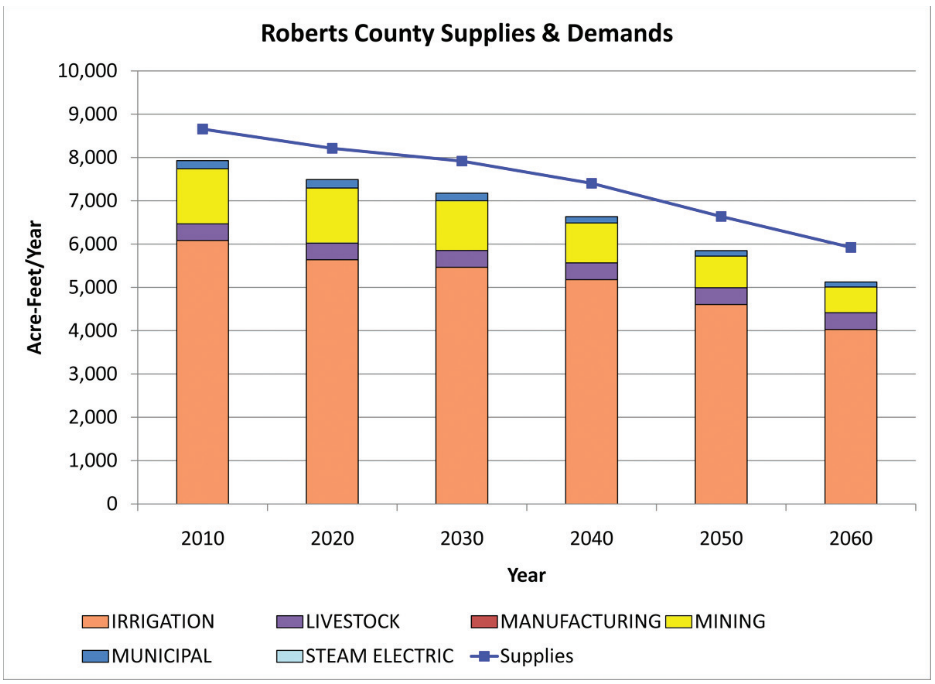












Water User Group	Strategy
Miami	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

SHERMAN COUNTY

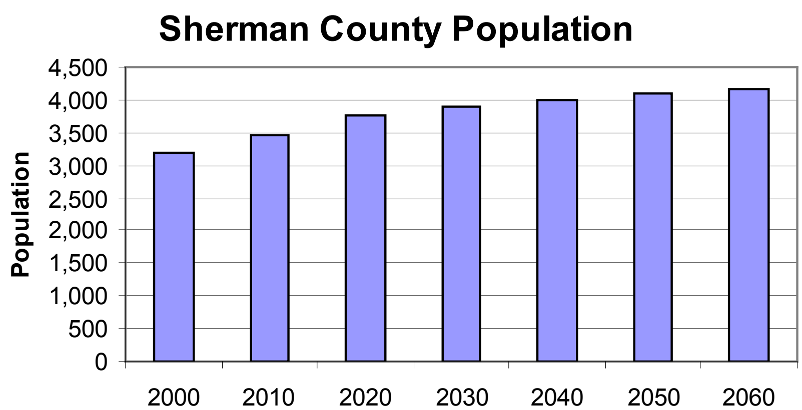
Who are my representatives?

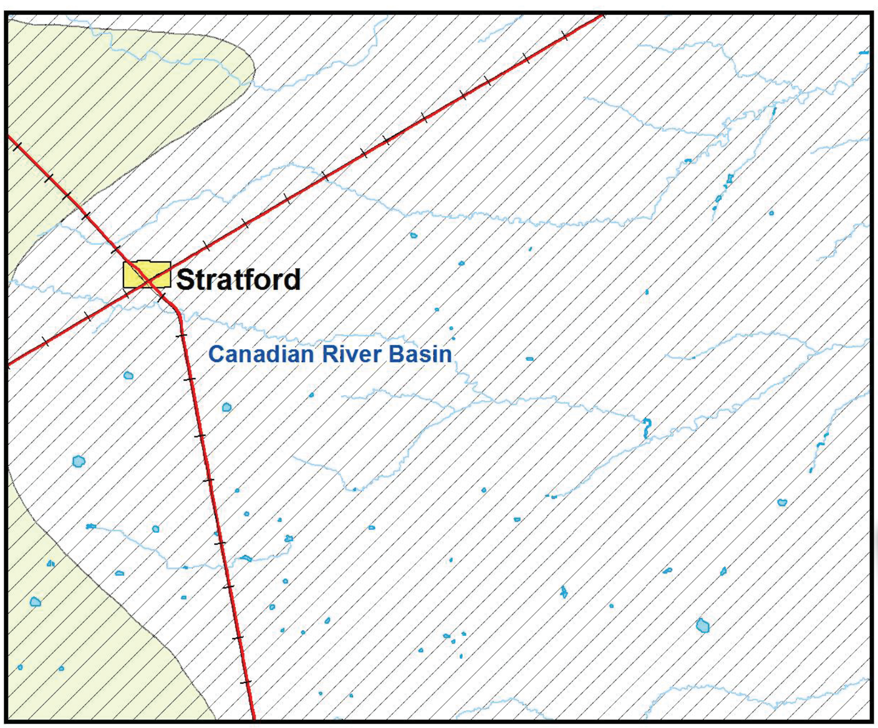
Dr. Nolan Clark	- USDA-ARS
Ben Weinheimer	- Texas Cattle Feeders Association
John Sweeten	- Higher Education
Gale Henslee	- Xcel Energy
Steve Walthour	- North Plains GCD

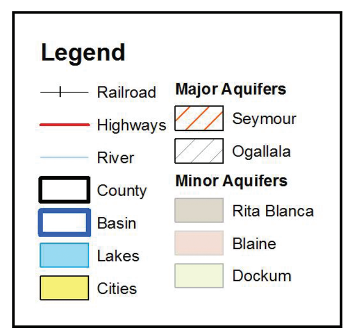
County Seat: City of Stratford

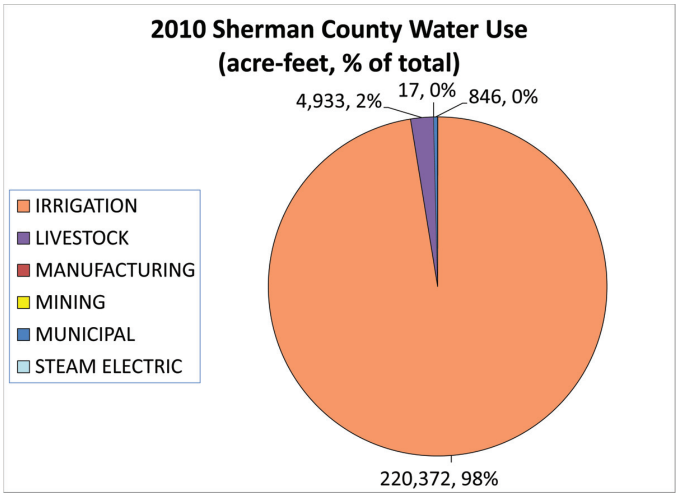
Economy: Agribusiness, Petroleum

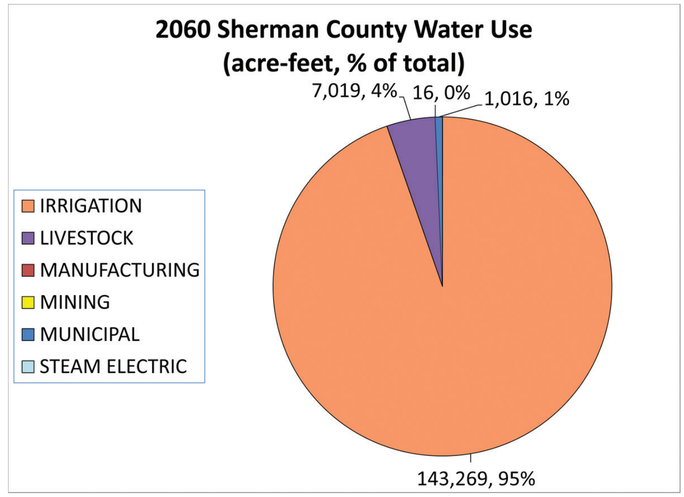
What is the source of my water? Ogallala, Dockum Aquifers

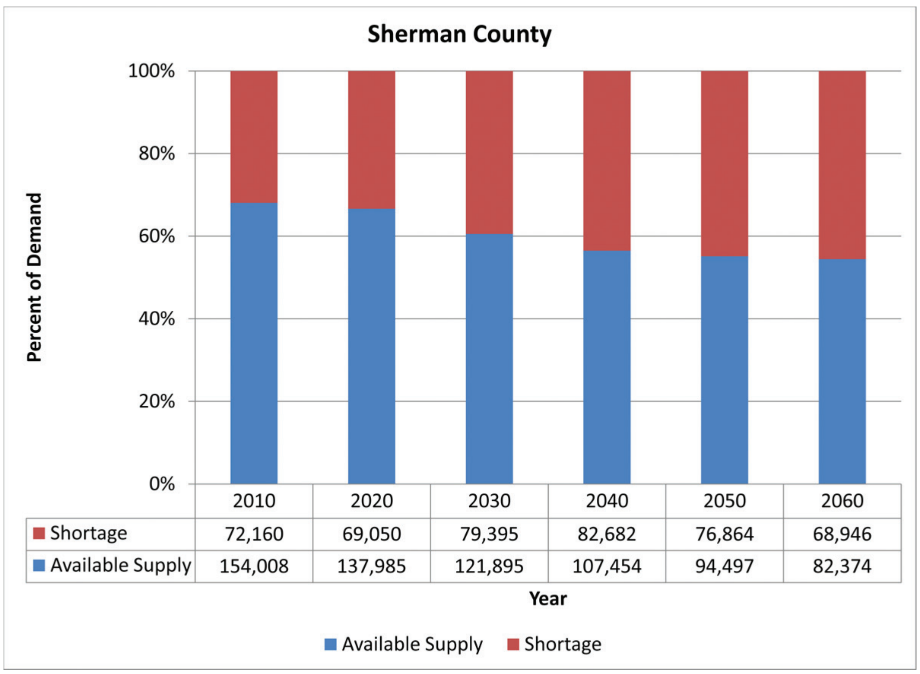












	2010	2020	2030	2040	2050	2060
Shortage	72,160	69,050	79,395	82,682	76,864	68,946
Available Supply	154,008	137,985	121,895	107,454	94,497	82,374

Water User Group	Strategy
Stratford	No Water Shortage Identified
County-Other	No Water Shortage Identified
Irrigation	Change in Crop Type, Change in Crop Variety, Conservation Tillage, Convert to Dryland, Irrigation Equipment, NPET Network, Biotechnology Adoption. Alternative: Precipitation Enhancement
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

WHEELER COUNTY

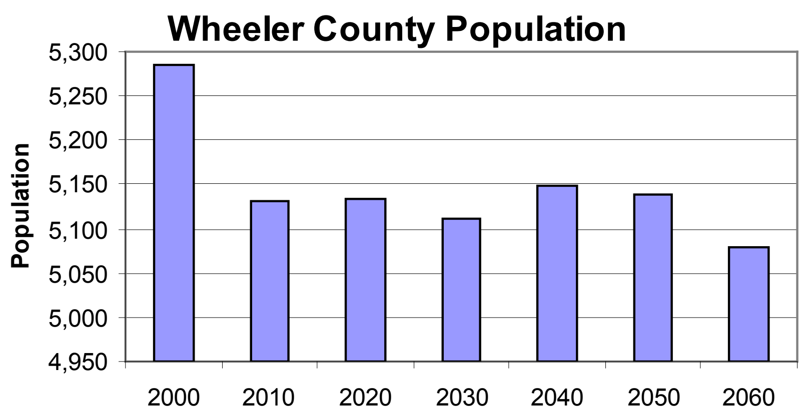
Who are my representatives?

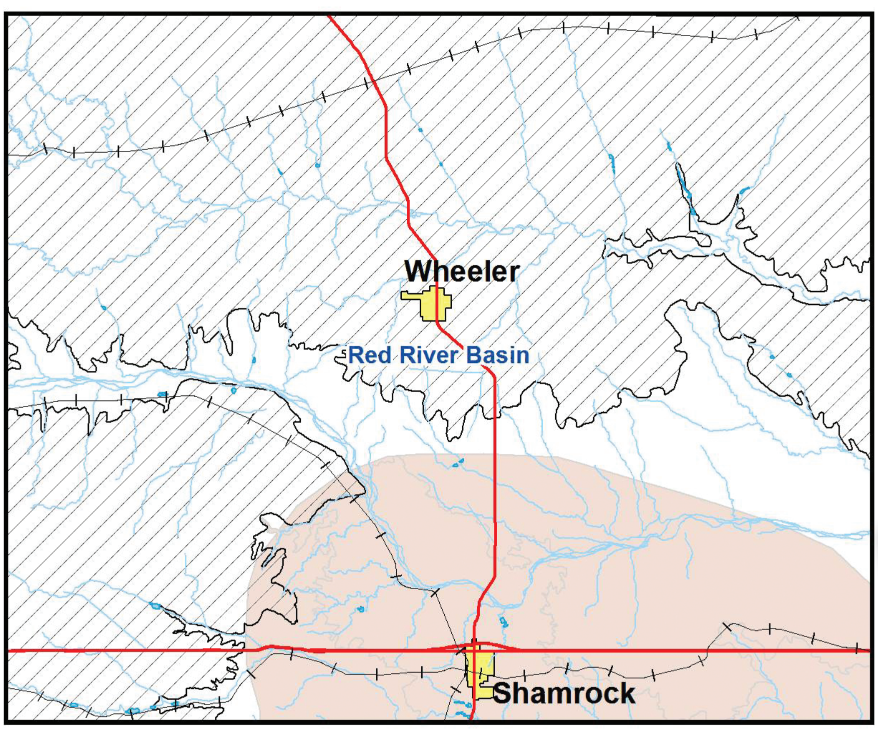
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Association
John Sweeten - Higher Education
Gale Henslee - Xcel Energy
C.E. Williams - Panhandle GCD

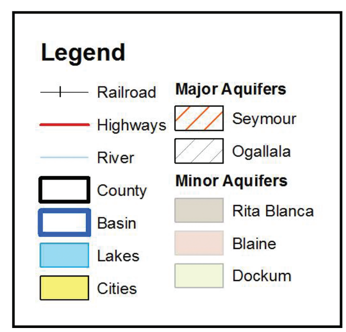
County Seat: City of Wheeler

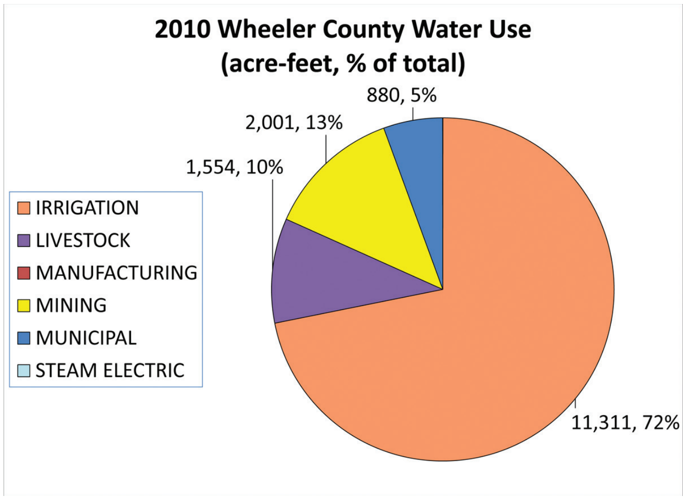
Economy: Agribusiness, Petroleum, Tourism

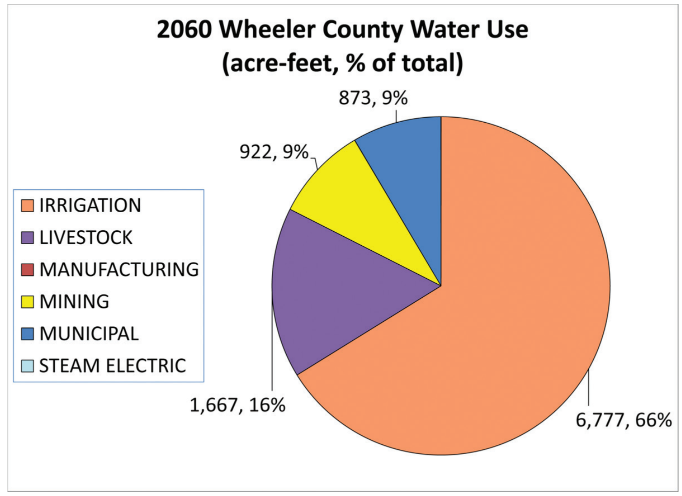
What is the source of my water? Seymour, Ogallala, Blaine Aquifers

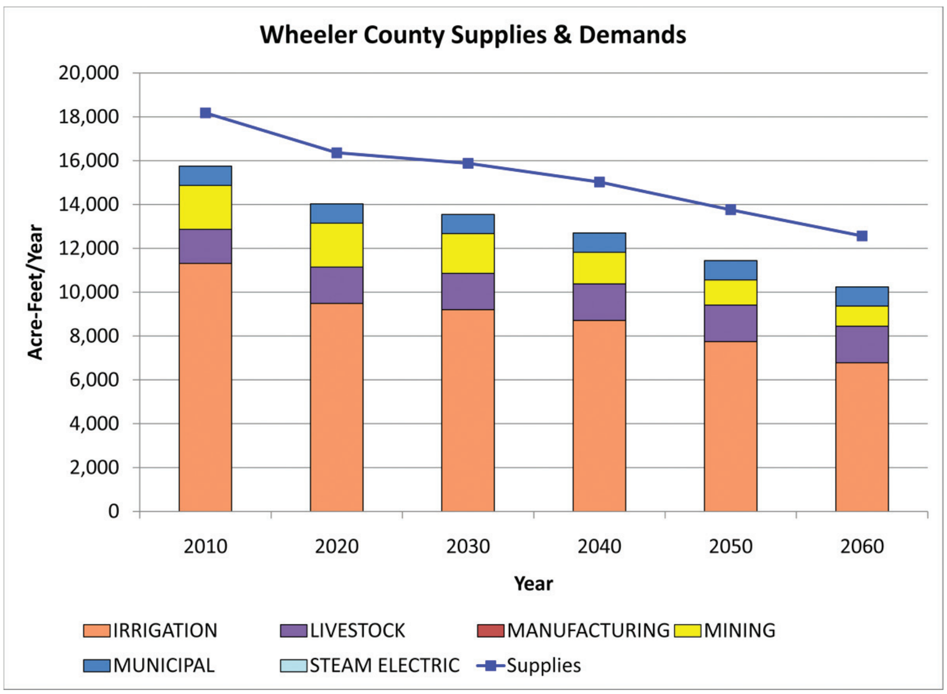








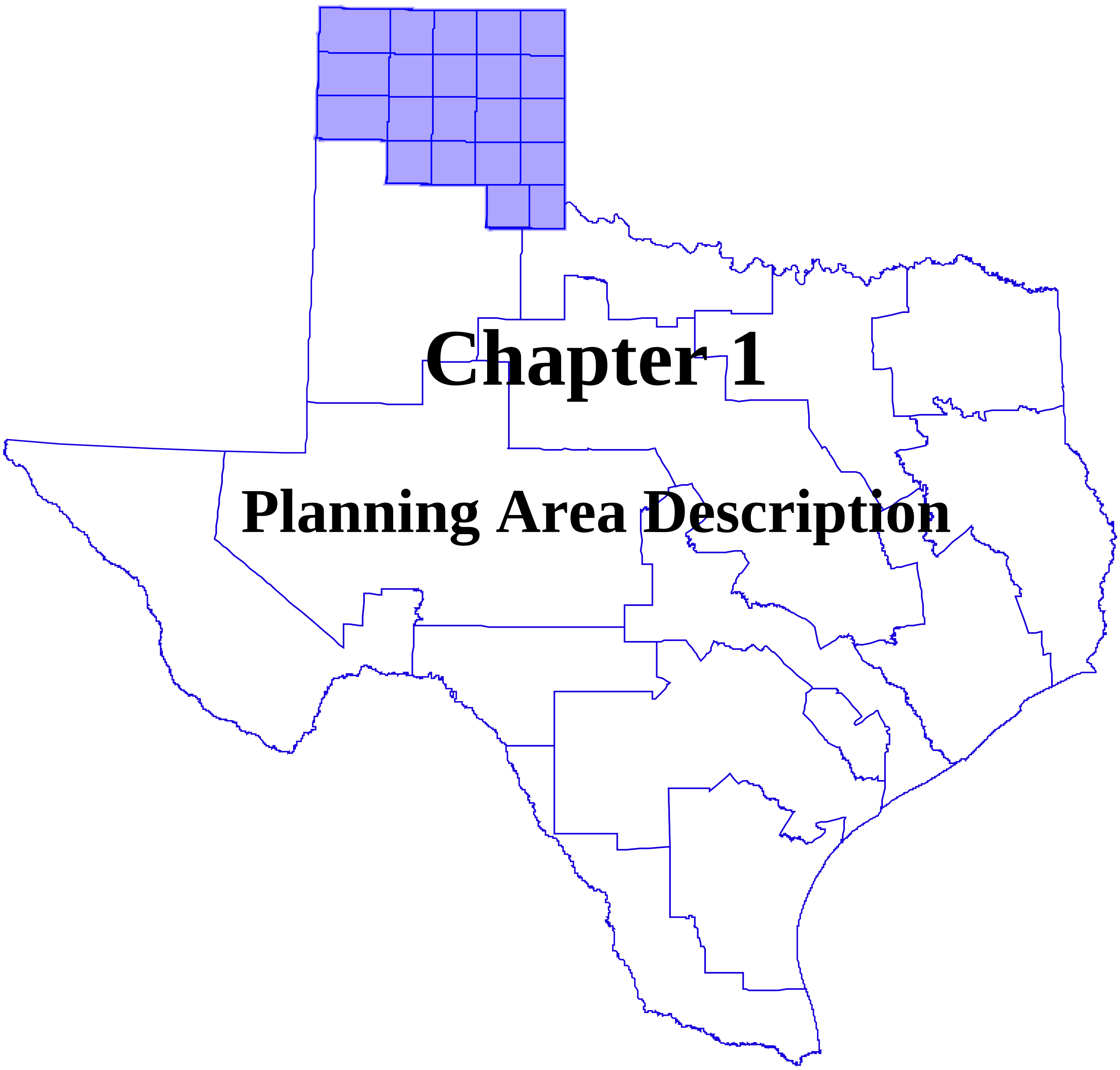




Water User Group	Strategy
Shamrock	No Water Shortage Identified
Wheeler	Conservation, New Wells
County-Other	No Water Shortage Identified
Irrigation	No Water Shortage Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortage Identified
Mining	No Water Shortage Identified
Steam Electric Power	No Demands In This Category

Chapter 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 shortages 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 across the state and established guidelines and rules governing regional planning efforts.

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 11 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 Agrilife Research and Extension Center at Amarillo, and Intera, Inc. The Panhandle Regional Planning Commission (PRPC) serves as the political subdivision and contractor.

The TWDB planning guidelines require each regional water plan to include ten chapters, which are addressed in the following sections of this report. The chapters are:

1. Planning Area Description;
2. Review and Revision of Population and Water Demand Projections;
3. Water Supply Analysis;
4. Identification, Evaluation and Selection of Water Management Strategies Based on Needs;
5. Impacts of Selected Water Management Strategies on Key Parameters of Water Quality and Impacts of Moving Water from Rural and Agricultural Areas;
6. Water Conservation and Drought Management Recommendations;
7. Description of How the Regional Water Plan is Consistent with Long-term Protection of the State's Water Resources, Agricultural Resources, and Natural Resources;
8. Unique Stream Segments/Reservoir Sites/Legislative Recommendations;
9. Report to Legislature on Water Infrastructure Funding Recommendations; and
10. Adoption of Plan.

The Panhandle Water Planning Area (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 third regional water supply plan that has been developed for the PWPA since the passage and implementation of SB1.

This updated plan contains new and/or changed information for the following items:

- Water demand projections for Agriculture, Mining and Steam Electric Power

- Northern Ogallala Aquifer Groundwater Availability Model (GAM) and recharge study for Ogallala aquifer
- Lake Meredith Watershed Study
- Allocation of water supplies to users and reassessment of water needs
- Evaluation of water management strategies, including designation of alternate strategies
- Recommendations on sources of funding for water infrastructure needs
- Legislative and other recommendations
- Water loss and water audit

1.2 Senate Bill 1 and Senate Bill 2

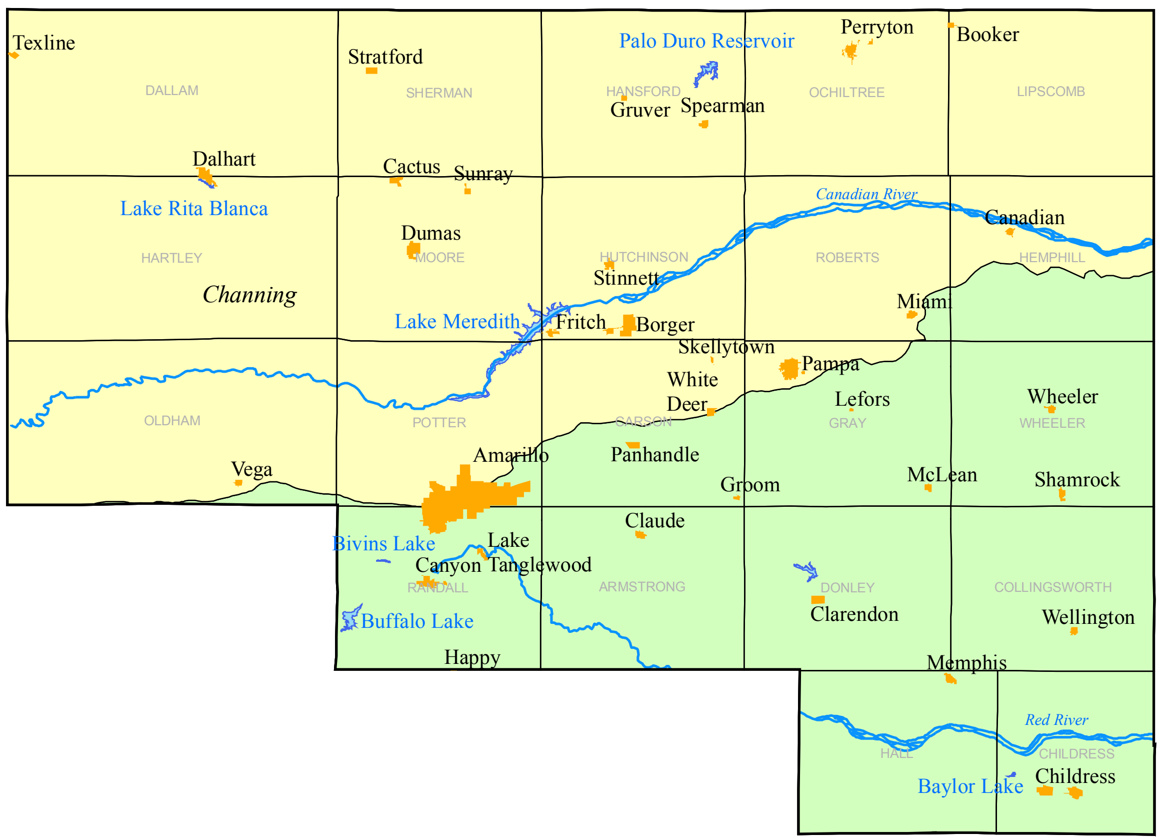
SB1 was a result of increased awareness of the vulnerability of Texas to drought and to the limits of existing water supplies to meet increasing demands as population grows. According to the 2007 State Water Plan, Texas' population is expected to exceed its 2000 level of nearly 21 million, growing to more than 45 million by 2060. Many areas of the state continue to be impacted by water shortages.

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 as Texas enters the 21st Century.

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 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
- Provide recommendations on the financing of water infrastructure needs.

The third round of planning, which culminates with the 2011 Regional Water Plans focused on special studies with updates based on changed conditions. No new population projections were developed for cities and counties in the PWPA. Municipal and manufacturing water demands are unchanged from the 2006 PWPA water plan. Demands were updated for agricultural and steam electric power use. Also with the increase of natural gas exploration, mining demands were updated for several eastern counties including Hemphill, Lipscomb, Ochiltree, Roberts and Wheeler. One special study was conducted focusing on the Recharge of the Ogallala Aquifer in the Eastern Panhandle, Texas. A synopsis of this study is included in Appendix E.



LEGEND

- Cities
- Rivers
- Reservoirs
- Canadian Basin
- Red Basin

0 7.625 15.25 30.5 Miles	PANHANDLE WATER PLANNING AREA	Location Map	FIGURE 1-1
DATE: SEPTEMBER 2009	OVERVIEW MAP		
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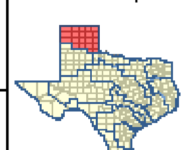

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The 16 regional water plans must be completed by January 5, 2011 and the TWDB must then approve and incorporate these plans into an all-inclusive state plan that is due in January 2012. The plans will continue to be updated every five years.

1.3 Regional Water Planning Area

The PWPA is among the largest water-consuming regions in the State, with over 90 percent of water used for agricultural purposes. In 2006, the region accounted for 1.6 percent of the State's total population and about 13 percent of the State's annual water demand. The TWDB projects that total water use for the region will decline over the 2010-2060 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, implementation of new crop types, and the use of more efficient irrigation technology.

The PWPG is composed of 22 members (Table 1-1), who collectively represent the interest of the public, industry, agriculture, environment, river authorities, counties, municipalities, water districts, small business, electrical generation, higher education water utilities, small business and electric generation. An additional six non-voting members serve as federal and state agency and neighboring regional water planning region liaisons. The PRPC serves as the political subdivision and contracting agency for the PWPA.

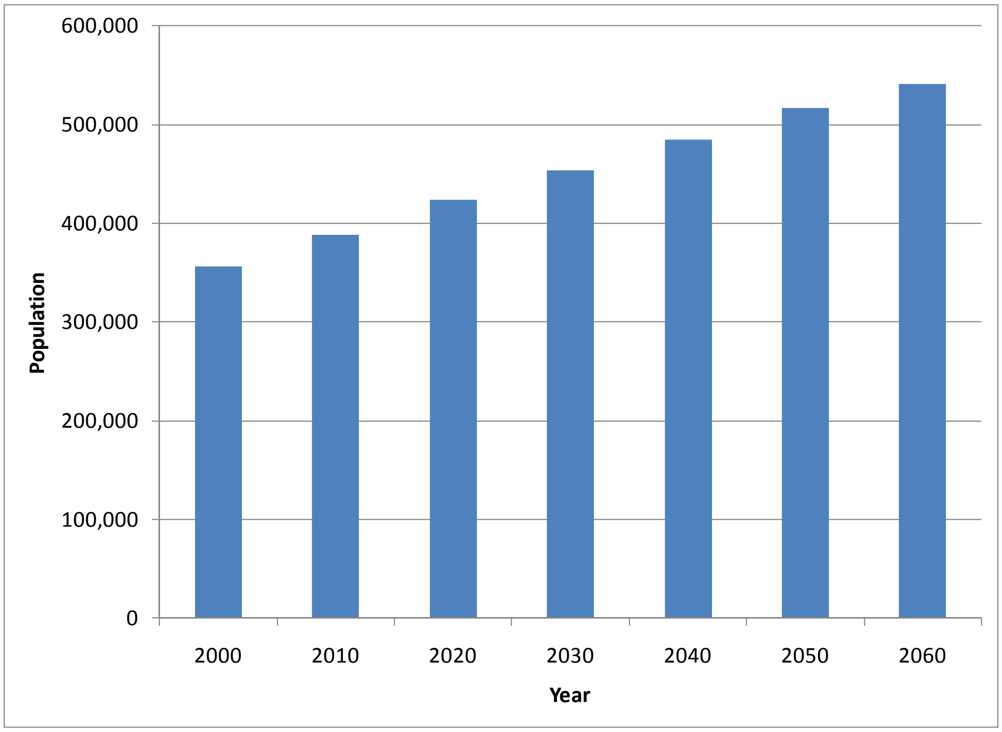
1.3.1 Population

According to the 2000 Census, the Texas state population was approximately 20.8 million people. The PWPA accounted for 1.7 percent of the total state population in 2000. Projected populations in counties located in the PWPA are seen in Figure 1-2. These estimates, developed in 2003 by the PWPG, are divided by city and smaller populated areas and totaled by county. Regional population is expected to grow from 355,832 in 2000 to 423,830 in 2020 and 541,035 in 2060.

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

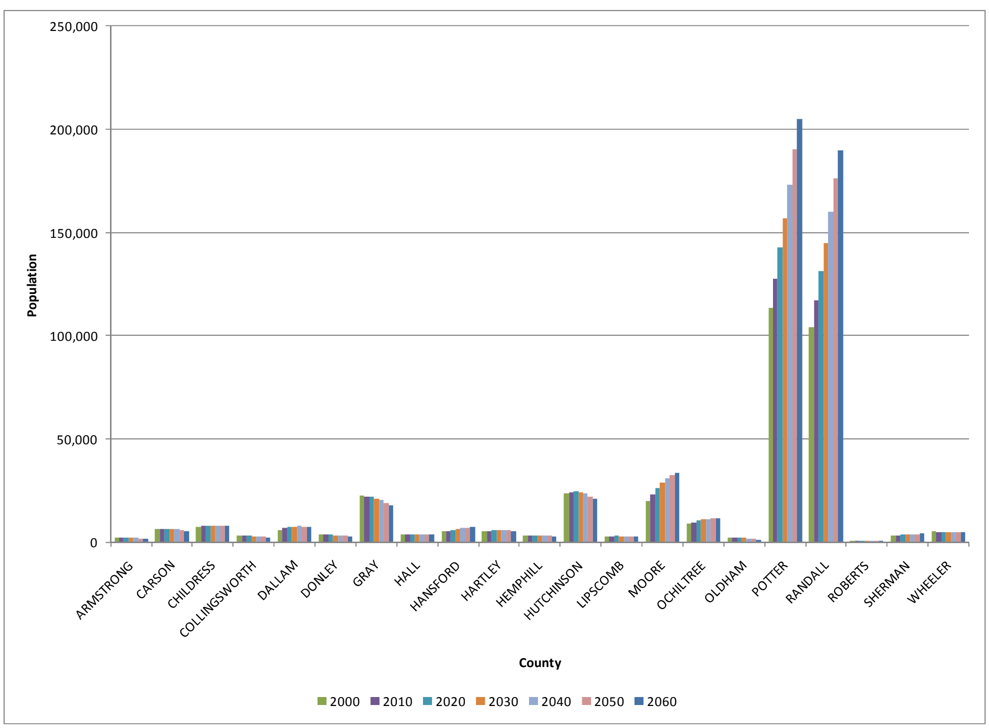
Interest	Name	Entity	County (Location of Interest)
Public	Janet Guthrie	City of Canadian/Hemphill County	Hemphill
Counties	Judge Vernon Cook	Roberts County	Roberts
Municipalities	Emmett Autry	City of Amarillo	Potter and Randall
	David Landis	City of Perryton	Ochiltree
Industries	Bill Hallerberg	Retired	Potter
	Denise Jett	ConocoPhillips	Hutchinson
Agricultural	Ben Weinheimer	Texas Cattle Feeders Association	Serves entire region
	Joe Baumgardner	Farmer	Collingsworth
	Janet Tregellas	Farm/Ranch	Lipscomb
	Kendall Harris	Mesquite Groundwater Conservation District	Collingsworth
Environmental	Nolan Clark	USDA-ARS	Potter
	Grady Skaggs	Farmer	Oldham County
	Cole Camp	Pika International	Potter
Small Businesses	Rusty Gilmore	Water Well Driller (Rita Blanca Well Service)	Dallam
Elec. Generation Utilities	Gale Henslee	Xcel Energy	Serves Entire Region
River Authorities	Jim Derington	Palo Duro RA	Hansford, Moore and Hutchinson
Water Districts	Steve Walthour	North Plains GCD	Moore and 7 other counties in the region
	Tom Baliff	Greenbelt M&I Water Authority	Donley and 3 other counties in the region
	C.E. Williams	Panhandle Groundwater Conservation Dist. No. 3	Carson and 8 other counties in the region
	John C. Williams	Canadian River Municipal Water Authority	Hutchinson and 3 member cities in the region
Water Utilities	Charles Cooke	TCW Supply	Hutchinson
Higher Education	John Sweeten	Texas AgriLife Research and Extension Center at Amarillo	Entire Region

Figure 1-2: Panhandle Population Projections



Source: TWDB, 2002.

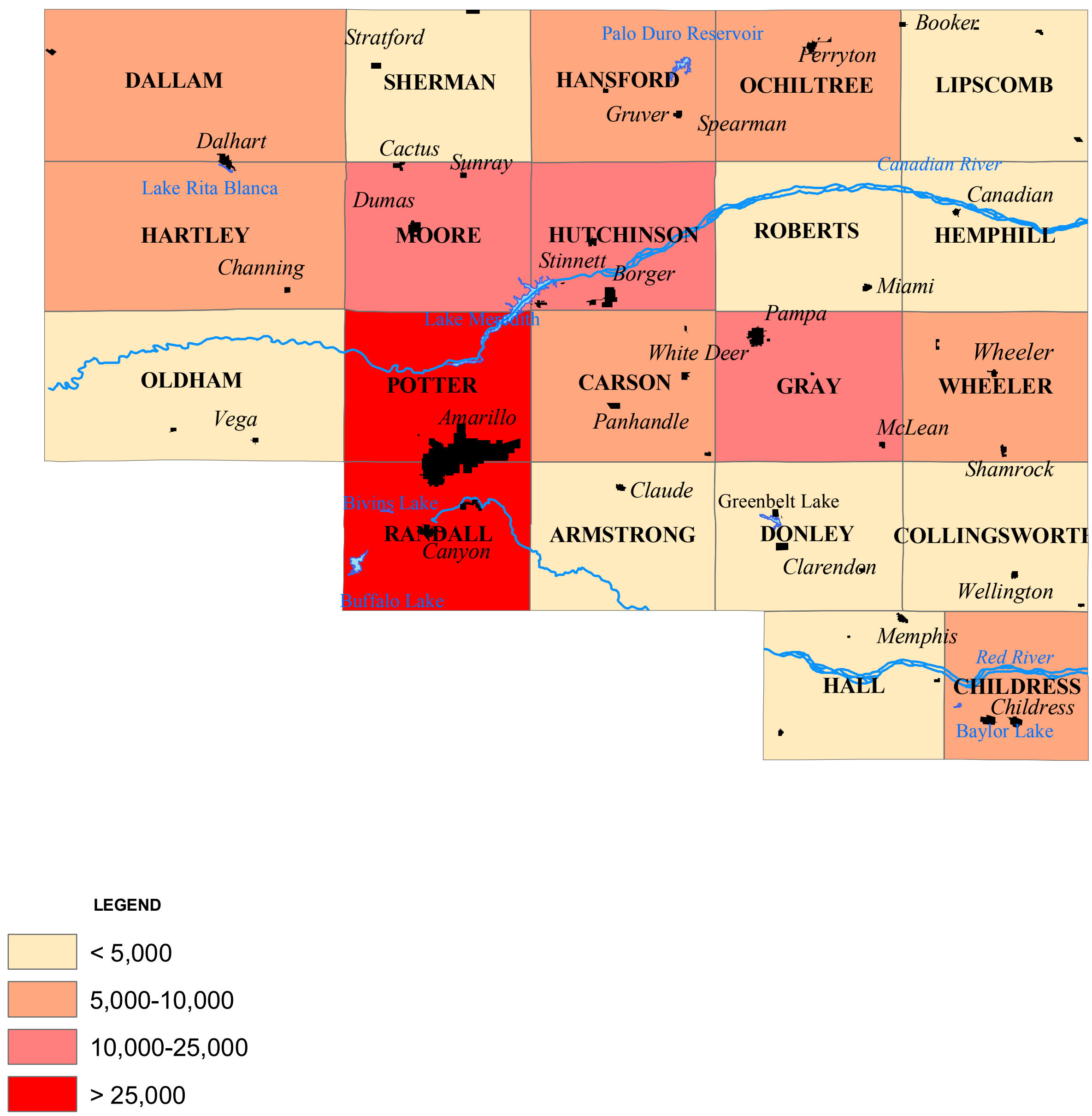
Figure 1-3: Panhandle Population Projections by County



Source: TWDB, 2002.

Table 1-2: Cities and Unincorporated Areas in PWPA

County	Populated Areas
Armstrong	Claude, Goodnight, Washburn, Wayside and other incorporated areas
Carson	Conway, Groom, Panhandle, Skellytown, White Deer and other incorporated areas
Childress	Childress, Kirkland, Tell and other incorporated areas
Collingsworth	Dodson, Quail, Samnorwood, Wellington and other incorporated areas
Dallam	Dalhart, Texline and other incorporated areas
Donley	Clarendon, Hedley and other incorporated areas
Gray	Alanreed, Lefors, McLean, Pampa and other incorporated areas
Hall	Estelline, Lakeview, Memphis, Turkey and other incorporated areas
Hansford	Gruver, Morse, Spearman and other incorporated areas
Hartley	Dalhart, Hartley and other incorporated areas
Hemphill	Canadian, Glazier and other incorporated areas
Hutchinson	Borger, Fritch, Plemons, Sanford, Stinnett and other incorporated areas
Lipscomb	Booker, Darrouzett, Follett, Higgins and other incorporated areas
Moore	Cactus, Dumas, Masterson, Sunray and other incorporated areas
Ochiltree	Booker, Farnsworth, Perryton and other incorporated areas
Oldham	Adrian, Boys Ranch, Vega, Wildorado, and other incorporated areas
Potter	Amarillo, Bushland and other incorporated areas
Randall	Amarillo, Canyon, Happy, Lake Tanglewood, Umbarger and other incorporated areas
Roberts	Codman, Miami, Wayside, and other incorporated areas
Sherman	Stratford, Texhoma and other incorporated areas
Wheeler	Mobeetie, Shamrock, Wheeler and other incorporated areas



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PANHANDLE WATER PLANNING AREA

2000 COUNTY POPULATION

Location Map

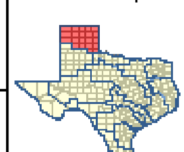
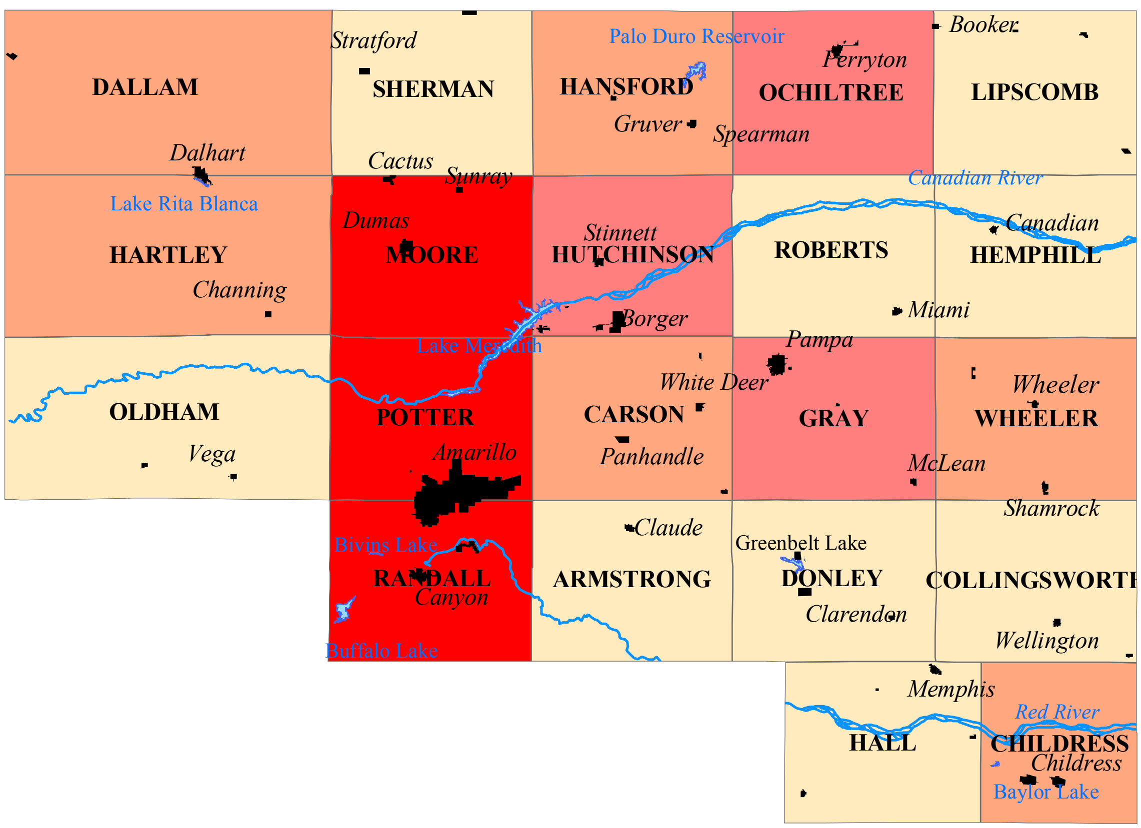


FIGURE 1-4



LEGEND

- < 5,000
- 5,000-10,000
- 10,000-25,000
- > 25,000

0 7.625 15.25 30.5 Miles

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PANHANDLE WATER PLANNING AREA

2060 COUNTY POPULATION

Location Map

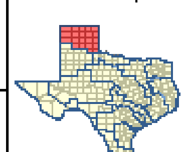


FIGURE 1-5

1.3.2 Economic Activities

The economy of the PWPA can be summarized in the following categories: agribusiness, manufacturing, petroleum, and tourism. Major water-using activities include irrigation, agricultural production, petroleum refining, food processing and kindred, chemical and allied products, and electric power generation. Total retail sales per county for 2002 are listed in Table 1-3 (most recent year for which data are available). In comparison to 1997 economic census data, 2002 retail sales values have increased slightly. Retail sales have increased 9 percent from $3,236,345,000 in 1997 to $3,518,693,000 in 2002. In the ten year period from 1989 to 1999, per capita income has also increased. The average per capita income for counties in the PWPA has increased 42 percent from $11,641 in 1989 to $16,552 in 1999. Payroll data, which is available for 2007, show the total payroll in the PWPA to exceed $4 billion, with nearly half of the payroll reported in Potter County.

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 ¾ of the region's total rainfall occurring between April to September. Heavy snowfall of 10 inches or more occurs approximately every five years (NWS, 2010). According to the National Climatic Data Center, the average yearly temperature and precipitation measured at the City of Amarillo are 57 degrees Fahrenheit and 19.71 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.

Table 1-3: Economic Activities of Counties in the PWPA

	Retail Sales (dollars)		Total Payroll (dollars)	Per capita income (dollars)		Major Economic Activities			
County	**1997**	**2002**	**2007**	**1998***	**2008**	**Agribusiness**	**Manufacturing**	**Petroleum**	**Tourism**
Armstrong	2,940,000	5,015,000	4,044,000	29,836	39,111	X			X
Carson	25,239,000	24,189,000	273,425,000	33,801	36,599	X		X	
Childress	43,683,000	48,945,000	32,095,000	19,504	19,723	X			X
Collingsworth	17,396,000	19,419,000	14,029,000	24,619	26,662	X			
Dallam	65,337,000	57,152,000	42,320,000	36,010	34,793	X	X		X
Donley	23,567,000	26,904,000	8,177,000	26,275	30,590	X	X		X
Gray	169,059,000	(D)	257,217,000	31,084	39,013	X	X	X	
Hall	43,135,000	13,648,000	10,341,000	19,412	22,900	X			
Hansford	38,965,000	40,108,000	31,409,000	41,853	38,676	X		X	
Hartley	14,370,000	17,240,000	24,252,000	37,807	38,290	X	X	X	
Hemphill	19,687,000	20,575,000	49,865,000	42,081	61,169	X		X	X
Hutchinson	150,983,000	144,197,000	273,545,000	28,927	38,547	X	X	X	X
Lipscomb	10,612,000	11,772,000	34,447,000	33,339	39,547	X		X	
Moore	127,459,000	145,760,000	247,195,000	27,767	30,392	X		X	
Ochiltree	63,322,000	73,463,000	130,903,000	33,995	39,728	X		X	
Oldham	8,040,000	9,202,000	12,214,000	34,121	29,986	X			
Potter	1,531,297,000	1,742,876,000	1,946,319,000	27,589	31,608	X	X	X	X
Randall	838,250,000	1,072,296,000	723,477,000	33,336	37,856	X	X		X
Roberts	1,749,000	(D)	1,640,000	28,695	39,902	X		X	
Sherman	8,108,000	10,248,000	6,396,000	47,055	42,860	X			X
Wheeler	33,147,000	35,684,000	36,560,000	36,160	43,312	X		X	X
Total	3,236,345,000	3,518,693,000	4,159,870,000	673,266	761,264				
Average	154,111,667	185,194,368	198,089,048	32,060	36,251				

***Adjusted for inflation to 2008 dollars**

1.4 Wholesale Water Providers

The term Wholesale Water Provider (WWP) was created within SB2 in order to include major providers of water for municipal and manufacturing use in the regional planning process. WWPs are defined as follows:

"Any person or entity, including river authorities and irrigation districts, that has contracts to sell more than 1,000 acre-feet of water wholesale in any one year during the five years immediately preceding the adoption of the last regional water plan. The regional water planning groups shall include as wholesale water providers other persons and entities that enter or that the regional water planning group expects or recommends to enter contracts to sell more than 1,000 acre-feet of water wholesale during the period covered by the plan."

The PWPA has designated seven WWPs.

- Canadian River Municipal Water Authority
- City of Amarillo
- City of Borger
- City of Cactus
- Mesa Water, Inc.
- Greenbelt Municipal and Industrial Water Authority
- Palo Duro River Authority

1.4.1 Canadian River Municipal Water Authority (CRMWA)

The 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 the Authority 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 more than 460,000 urban residents and provides water to Borger and Pampa in the Canadian Basin; and Amarillo in the Canadian and Red River basins. The CRMWA is currently involved in a salinity control project for the protection of water quality in Lake Meredith. CRMWA has a well field in Roberts which is used to supplement supplies from Lake Meredith.

1.4.2 City of Amarillo

The City of Amarillo currently operates with an average production of 42 million gallons per day to approximately 186,000 people. The City gets its water from several active well fields, reuse, 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. The City plans to expand their groundwater supply capacity through developing existing water rights in Potter and Roberts County.

1.4.3 City of Borger

The City of Borger currently services over 5,785 active water accounts. The source of supply for Borger is groundwater wells, reuse, and an allocation of water from CRMWA that is composed of a blend of Roberts County groundwater and surface water from Lake Meredith. Borger supplies wholesale water to TCW Supply (through a trade agreement with Conoco Phillips), County other, and manufacturing needs.

1.4.4 City of Cactus

The City of Cactus currently services over 924 active water accounts. The source of supply for Cactus is groundwater pumping from the Ogallala. Cactus supplies wholesale water to County other and manufacturing needs. Cactus plans to continue to supply these needs through groundwater from the Ogallala aquifer.

1.4.5 Mesa Water, Inc.

Mesa Water, Inc. owns and controls 210,000 acres of water rights in the PWPA. Mesa Water, Inc. currently does not provide water to any customer, but plans to provide wholesale water during the planning period. Mesa has been granted initial production permits, which are valid for five years.

1.4.6 Greenbelt Municipal and Industrial Water Authority (Greenbelt M&IWA)

The Greenbelt M&IWA provides water from Greenbelt Reservoir on the Salt Fork of the Red River. The Greenbelt M&IWA 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 M&IWA.

1.4.7 Palo Duro River Authority (PDRA)

The Palo Duro River Authority owns and operates Palo Duro reservoir. The Palo Duro Reservoir is located on Palo Duro River in Hansford County. The lake was completed in 1991. The Authority was authorized to serve Hansford and Moore Counties and the City of Stinnett. PDRA currently does not provide water to any member city and expects to begin construction on a transmission line from the reservoir to meet member city shortages by 2030.

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 1-4). 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 entering wells on and beneath their property.

Table 1-4: Summary of Policies Affecting Water Quality and Quantity in Texas

	General Policy Affecting:	
Type of Water	**Water Quantity**	**Water Quality**
Diffuse	Landowner control	Nonpoint source protection agencies: 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 (where applicable)	Groundwater Management Areas Groundwater District Rules State (TCEQ) Regulations

Source: TCEQ, 2002

1.5.1 Groundwater Regulation

SB1 altered several provisions of surface and groundwater law. One of the key provisions requires TCEQ to determine areas that warrant special consideration and for those areas to encourage the formation of a new groundwater conservation district or the incorporation of these areas into existing districts. Each groundwater conservation district is required to submit a water management plan to the TWDB for certification.

SB2 designated that the TWDB develop groundwater management areas (GMA) for the entire state. After numerous state-wide public input opportunities and meetings, the agency designated 16 management areas that generally follow major aquifer boundaries, groundwater district boundaries, and planning regions. The region 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. As required by HB 1763, the GMAs are tasked with identifying the desired future conditions for aquifers within their geographical area. The desired future conditions will be used to determine Managed Available Groundwater (MAG) values, which will be the basis for future regional water planning (2016 regional water plans).

Groundwater conservation districts (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 presented in Table 1-5 and shown in Figure 1-6. The county of Oldham and portions of Randall, Dallam, Hutchinson, Moore, and Hartley counties are not included in a groundwater district. The TCEQ has designated a portion of Dallam County as a Priority Groundwater Management Area (PGMA), which identifies critical groundwater areas in need of a GCD. Some of these counties, including the Dallam County PGMA, are considering joining a local groundwater conservation district. The GCDs work together within the framework of the GMAs in protecting groundwater in the region. The GCDs must set goals and objectives consistent with the desired future conditions 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.

Table 1-5: Ground Water Districts in PWPA

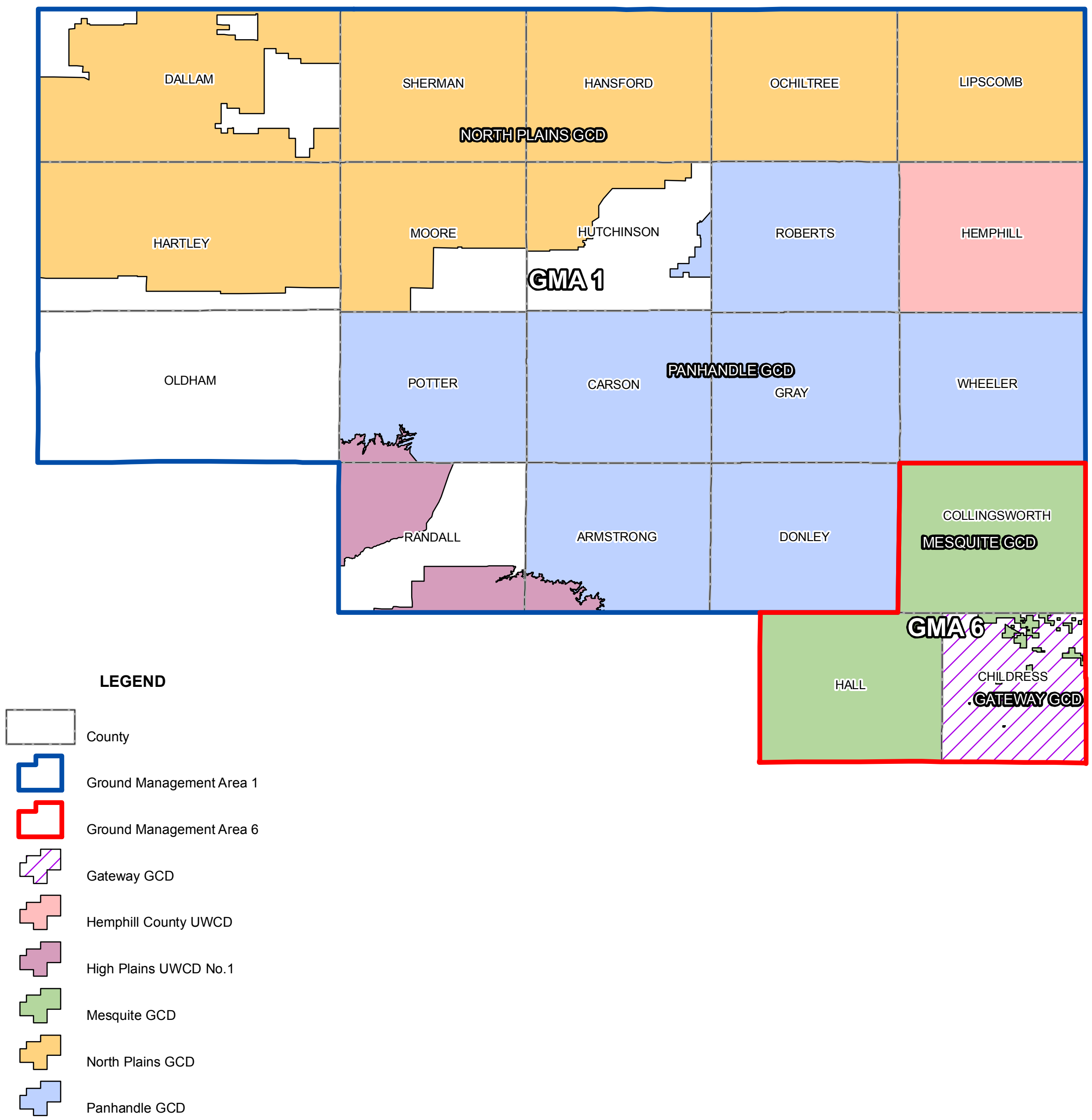
Groundwater District	Counties Served in PWPA	Aquifers
North Plains Groundwater Conservation District	Moore, Hutchinson, Sherman, Hartley, Dallam, Hansford, Ochiltree, Lipscomb	Ogallala Rita Blanca Dockum
Panhandle Groundwater Conservation District	Carson, Roberts, Gray, Donley, Armstrong, Potter, Hutchinson,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

1.5.2 Aquifers

There are two major aquifers in the PWPA, the Ogallala and Seymour aquifers (Figure 1-7), and three minor aquifers, Blaine, Rita Blanca, and Dockum (Figure 1-8). The Whitehorse Formation is recognized by local residents as a regional supply source but cannot be independently quantified and is therefore not included as a distinct supply source in this plan. All serve as water sources for various uses in the PWPA

1.5.2.1 <u>Ogallala Aquifer</u>

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, approximately 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 approximately parallel 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.



0 7.625 15.25 30.5 Miles

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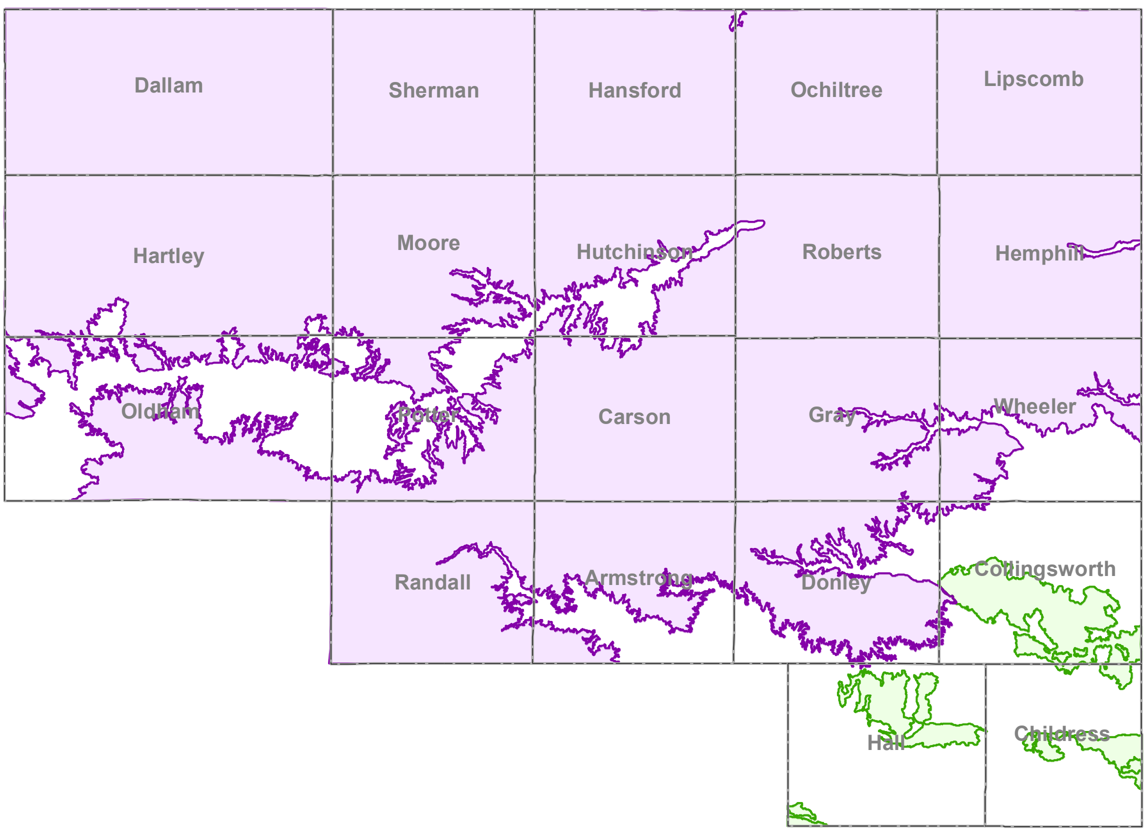
N W E S

PANHANDLE WATER PLANNING AREA

Groundwater Conservation Districts & Groundwater Managment Areas

Location Map

FIGURE 1-6



Legend

County

Major Aquifer

OGALLALA

SEYMOUR

0 7.5625 15.125 30.25 Miles

DATE: JANUARY 2010

SCALE: 1:1,916,640

DATUM & COORDINATE SYSTEM: GCS NORTH AMERICAN 1983

PREPARED BY: DLB

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N W E S

PANHANDLE WATER PLANNING AREA

MAJOR AQUIFERS IN PWPA

Location Map

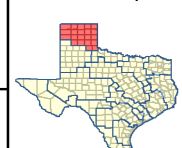
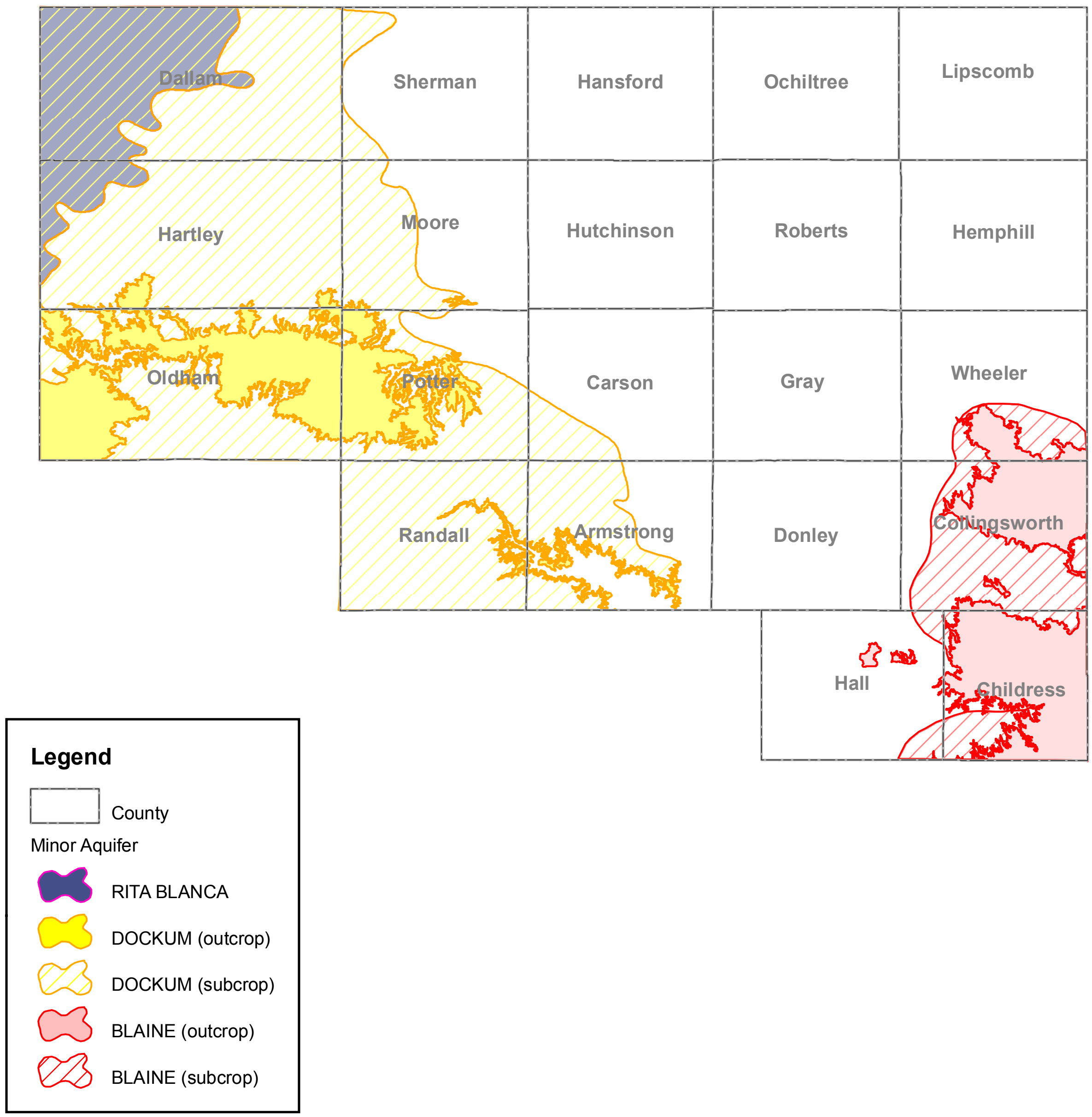


FIGURE 1-7



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DATUM & COORDINATE SYSTEM	GCS NORTH AMERICAN 1983
PREPARED BY:	DLB
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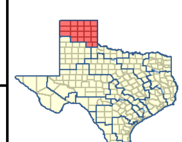
PANHANDLE WATER PLANNING AREA

MINOR AQUIFERS IN PWPA

Location Map



FIGURE

1-8

The Ogallala is composed primarily of sand, gravel, clay, and silt deposited during the Tertiary Period. Groundwater, under water-table conditions, moves 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. Previous estimates indicate that the long term average annual recharge rate is less than 3 inches per year. 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 100 feet from predevelopment to 2000 and continue to drop into the future. Conservation efforts, implementation of efficiency technologies, crop research, reduced commodity prices and increased power costs have resulted in a reduction in the rate of water level declines.

Based on the storage amounts in 2000 and 2010 using the Northern Ogallala Groundwater Availability Model (2004 Dutton GAM) and the Southern Ogallala GAM groundwater depletion in the Ogallala aquifer in the 18 counties underlain by this aquifer in PWPA was expected to average a total of 6.6 percent for the period between 2000 and 2010. The estimated water in storage in the Ogallala aquifer in the PWPA in 2000 was about 246 million acre feet, and was projected to decline to 229 million acre feet in 2010 as shown in Table 1-6. Refinements to this GAM made as part of this regional water plan update (2010 Intera GAM) show greater water in storage for some counties and less for others. This will impact the rate of depletion shown on Table 1-6, but for most counties, these depletion rates provide realistic indications of the decadal rates of use within the PWPA.

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 (see 2006 PWPA Plan, Appendix X). 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.

Table 1-6: Estimated Groundwater Storage Volume (million ac-ft) of the Ogallala Aquifer in the PWPA

County	1990 (1) Storage	2000 (2) GAM Storage	2010 (3) GAM Storage	Percent Depletion 2000-2010
Armstrong	3.64	4.05	4.01	0.99%
Carson	13.19	15.28	14.07	7.92%
Childress	NA	NA	NA	NA
Collingsworth	NA	NA	NA	NA
Dallam	29.97	17.6	14.42	18.07%
Donley	8.09	6.25	5.73	8.32%
Gray	12.96	13.65	13.13	3.81%
Hall	NA	NA	NA	NA
Hansford	23.27	21.69	20.41	5.90%
Hartley	27.82	24.93	21.75	12.76%
Hemphill	16.57	15.64	15.47	1.09%
Hutchinson	10.54	11.11	10.55	5.04%
Lipscomb	20.82	18.64	18.46	0.97%
Moore	13.2	10.66	9.07	14.92%
Ochiltree	18.57	19.8	19.10	3.54%
Oldham	1.14	2.52	2.47	1.98%
Potter	3.07	3.05	2.92	4.26%
Randall	4.51	6.26	6.02	3.77%
Roberts	27.62	27.49	27.08	1.49%
Sherman	21.88	19.5	17.29	11.33%
Wheeler	8.45	7.49	7.42	0.93%
Total Storage	265.31	245.61	229.37	
Estimated Average 10-year Total Depletion				6.6%

Source: (1) Wyatt, 1996; (2) Dutton, 2004; and (3) Baseline Simulation, 2004 Dutton GAM, Intera, 2010
Data include results from both the Northern Ogallala and Southern Ogallala aquifers GAMs
NA = data not available or the Ogallala aquifer does not occur in these counties.

1.5.2.2 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 these scattered alluvial aquifers is estimated to be 3.18 million ac-ft based on 75 percent of the total storage. Annual effective recharge to the aquifer is approximately 215,200 ac-ft, or 5 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 gal/min and range from less than 100 gal/min to as much as 1,300 gal/min.

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)

1.5.2.3 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).

According to a report published by the TWDB in 2003, the base of the Dockum Group aquifer is mudstones at elevations ranging from 1,200 ft. MSL in the south (Crockett County) to 3,200 ft. MSL in Oldham County, and to 3,400 ft. MSL in Dallam County. Saturated thicknesses range from 100 ft. to 2,000 ft. The water table ranges from approximately 3,800-4,000 ft. MSL in Oldham, Hartley, and Dallam counties to 3,200 ft. MSL or less in Potter, Carson, Armstrong, Moore and Sherman counties. 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. (Recharge reported in the 2001 plan is assumed for this update.) Estimates of the total volumes of water in storage are reported in Table 1-7.

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).

Table 1-7: Dockum Aquifer Storage and Recharge

	Storage (ac-ft)	Annual Recharge (ac-ft)
County *		
Armstrong	1,948,600	
Carson	566,700	
Dallam	6,561,800	
Hartley	6,374,300	
Moore	1,588,300	
Oldham	6,544,400	2,800
Potter	3,051,500	300
Randall	3,974,800	
TOTAL	30,610,400	3,100

Source: TWDB 2003
*The Dockum is absent or nearly so under the remaining counties in the PWPA.

1.5.2.4 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.

1.5.2.5 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 (TWDB, 1995).

1.5.2.6 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, was not specifically included in the supply analysis during this round of planning due to lack of reliable information to include in the Groundwater Availability Model.

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 across 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 1-9 provide surface water for municipal, agricultural, and industrial users in the area. This plan and its implementation are not expected to have any impact to navigable waters or navigation within the state.

1.5.4.1 Surface Water Management and Classification

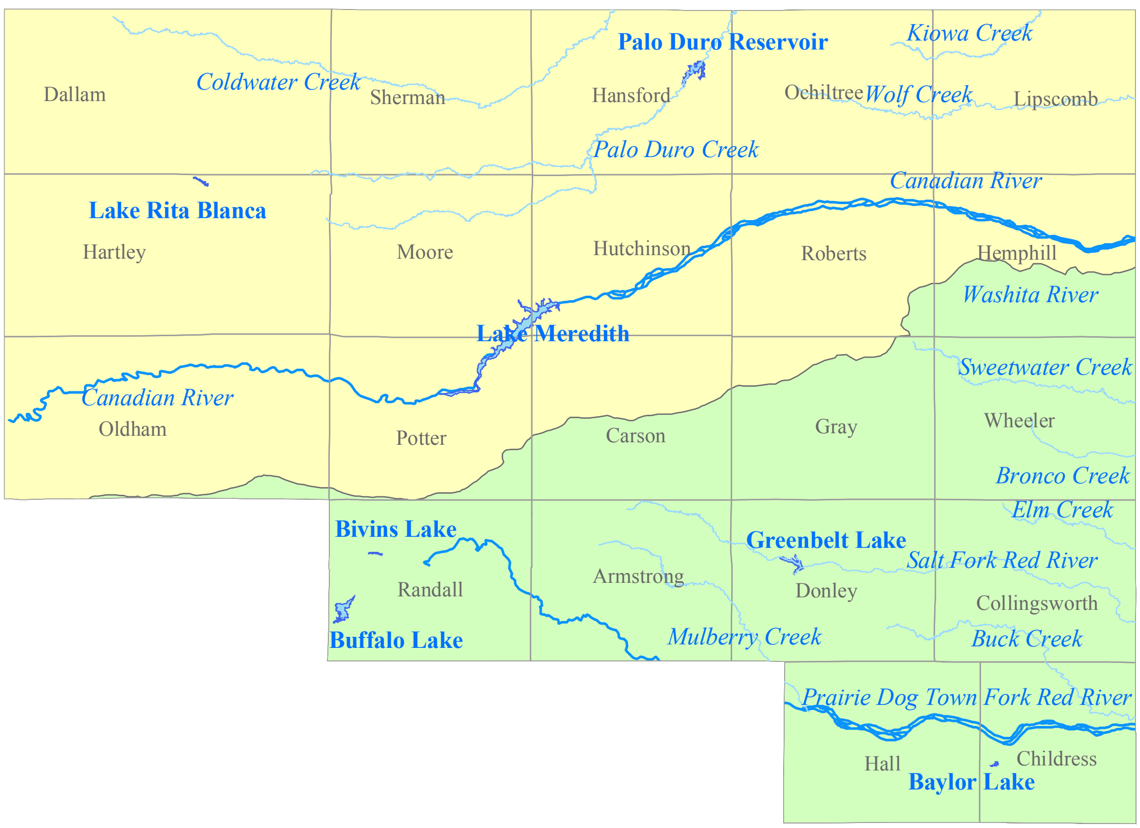
The TCEQ is the agency charged with the management of surface water quality and quantity. Water quantity for the state is managed by a permitting system administered by the Office of Water of TCEQ. Individual surface water rights greater than 1,000 acre-feet per year for both the Canadian River Basin and the Red River Basin and actual use are shown in Table 1-8. The data show that permitted water rights total 177,690 acre-feet per year and reported use ranging from 74,926 acre-feet per year to 46,259 acre-feet per year from 1995 to 2006.

Table 1-8: Individual Water Rights in the PWPA: Permitted and Actual Use (Greater Than or Equal to 1,000 ac-ft)

County	Water Right Holder	Water Source	Reservoir Firm Yield (4)	Use (1)	Use in 1995 (2)	Use in 2000	Use in 2006	Permitted Amount(3)
Canadian River Basin								
Hutchinson	CRMWA	Lake Meredith	69,750	1	70,688	45,000	39,353	100,000
				2	0	28,000	2,482	51,200
Hansford	Palo Duro River Authority	Palo Duro Reservoir	3,958	1	0	0		10,460
Red River Basin								
Donley	Greenbelt M&I WA	Greenbelt Reservoir	8,297	1	4,238	4,528	4,424	14,530
				2	0	0	0	500
				3	0	0	0	250
				4	0	0	0	750
Totals					74,926	77,528	46,259	177,690

Source: TCEQ, 2009

Notes:
1) Use Types: 1=Municipal; 2=Industrial; 3=Irrigation; 4=Mining; 7=Recreation; 8=Other
2) A "0" means that zero acre-feet of water was reported as used. A blank means that no report was submitted.
3) A blank permitted amount can represent an undivided water right, such as more than one water right owner or one amount of water authorized for several uses. In the case of Recreational use, the reservoir is on-channel and no diversion to fill is authorized.
(4) Lake Meredith and Palo Duro Reservoir are experiencing new droughts of record. The yields are based on a WAM analysis conducted in 2005 but are uncertain until reservoir refills.
N/A - Not Available
Inter-regional water transfers:
Approximately 50% of permitted amount of total water is authorized for use in Llano Estacado Planning Area from PWPA (Lake Meredith)
Additionally, there are 99 water rights of <1,000 AF each in the region totaling 7,989 AF of permitted water.



LEGEND

- Reservoirs
- Rivers
- Canadian Basin
- Red Basin

0 7.625 15.25 30.5 Miles

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N W E S

PANHANDLE WATER PLANNING AREA

SURFACE WATER FEATURES

Location Map

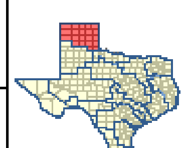


FIGURE 1-9

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 2008 State of Texas Water Quality Inventory (TCEQ, 2008), 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. 11 segments in the PWPA were identified on the final 2008 303(d) list and are shown in Table 1-9. All 11 segments are classified by TCEQ as low priority and may be scheduled for Total Maximum Daily Load (TMDL) development.

Table 1-9: 2008 303d Listed Segments in the PWPA

		Constituents of Concern						
Water Body	**Segment Number**	**bacteria**	**pH**	**mercury in walleye**	**dissolved oxygen**	**total dissolved solids**	**Chloride**	**Sulfate**
Canadian River Basin								
Dixon Creek	0101A	X			X			
Rock Creek	0101B	X						
Lake Meredith	102			X		X	X	X
Canadian River abv Lake Meredith	103						X	
Rita Blanca Lake	105		X			X		
Palo Duro Reservoir	0199A				X			
Red River Basin								
Buck Creek	0207A	X						
Upper Prairie Dog Town Fork of Red River	229		X					
Sweetwater Creek	0299A	X						

Source: TCEQ 2008

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.

1.5.4.2 Surface Water Bodies

Canadian River Basin

Basin Description: 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. See Figure 1-9.

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 measured near Canadian, Texas, approximately 22 miles upstream of the Texas-Oklahoma state line, averages 89 cubic feet per second (CFS), or 64,700 acre-feet per annum.

Water Use: In 2006, total water use in the Canadian River Basin portion of the PWPA continues to be from groundwater sources, with less than two percent contributed by surface water sources. The greatest surface water contribution to total water use by county was Potter (30 percent from surface water). The remaining counties in the PWPA in the Canadian River Basin utilize surface waters for less than 10 percent of their total water use (TWDB, 2009).

Future Water Supplies: Due to the scarcity of locally-developable surface water supplies, any additional water needed for the basin will likely come from reuse of present supplies, development of additional well fields in the Ogallala aquifer, and possible new development in minor aquifers present in the basin. It is estimated that by 2060 over 37,000 ac-ft per year of the basin needs will be supplied by reuse. A recent example of additional well field development is the Canadian River Municipal Water Authority's well fields in Roberts County which supplements and improves the quality of Lake Meredith's surface water. The Authority is planning to use approximately 69,000 ac-ft of groundwater per year from these wells. Since the 2006 PWPA plan was completed, the region has experienced record low inflows to Lake

Meredith and Palo Duro Reservoir and numerous water providers are considering groundwater options for future supplies.

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

Basin Description: 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 body used within the PWPA of the Red River Basin.

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.

Water Use: According to the TWDB estimates of water use during 2006, about 5 percent of the total water used in the Red River Basin portion of the PWPA was surface water. Of this amount approximately 8,000 acre-feet was from imported water from the Canadian River Basin (Lake Meredith). Most of the remaining surface water use is associated with municipal use from Greenbelt Reservoir and local supplies for livestock use.(TWDB, 2009).

1.6 Current Water Users 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. In 2006, agricultural water use accounts for 92 percent of total water use and includes both irrigation and livestock watering. Irrigated crop use accounts for 88 percent of the total water use, while livestock production accounts for 4 percent of the total and is forecast to nearly double during the planning period.

1.6.1 Municipal Use

The amount of water used for municipal purposes is closely tied to population centers. The TWDB estimates that during 2006, the total municipal water use in the PWPA was 81,399 ac-ft

(Table 1-10), which is almost 5 percent of total water use. Potter and Randall Counties, which contain the City of Amarillo, comprised 67 percent of the municipal water use in the PWPA, while five counties (Armstrong, Donley, Hemphill, Roberts, and Sherman) each comprise less than one percent.

Table 1-10: Historical and Projected Municipal Water Use for the PWPA, (ac-ft/yr)

County	2000	2006	2010	2020	2030	2040	2050	2060
Armstrong	414	437	371	382	369	354	350	340
Carson	1,422	1,150	1,297	1,308	1,300	1,257	1,143	1,038
Childress	1,847	1,935	1,653	1,680	1,704	1,712	1,713	1,669
Collingsworth	707	685	690	691	666	631	605	561
Dallam	1,964	1,519	1,711	1,844	1,928	1,949	1,908	1,819
Donley	516	651	659	650	631	611	594	568
Gray	4,204	3,950	4,082	4,048	3,936	3,782	3,551	3,327
Hall	805	686	795	820	835	822	827	805
Hansford	1,304	1,260	1,298	1,391	1,469	1,555	1,605	1,649
Hartley	1,405	1,095	1,209	1,251	1,271	1,279	1,263	1,199
Hemphill	607	591	633	636	614	592	575	548
Hutchinson	4,174	3,505	4,124	4,180	4,122	3,988	3,766	3,576
Lipscomb	899	605	748	764	741	720	709	676
Moore	4,979	4,675	4,505	5,151	5,724	6,179	6,455	6,622
Ochiltree	2,231	2,039	2,143	2,318	2,448	2,536	2,579	2,634
Oldham	392	622	416	425	394	348	302	244
Potter	29,780	30,230	25,865	28,273	30,525	33,091	35,890	38,185
Randall	25,645	24,209	23,491	26,084	28,510	31,271	34,283	36,778
Roberts	180	159	189	194	175	146	127	115
Sherman	776	561	846	919	948	977	1,003	1,016
Wheeler	942	775	880	881	878	883	882	873
TOTAL	**85,193**	**81,339**	**77,605**	**83,890**	**89,188**	**94,683**	**100,130**	**104,242**

Source: TWDB, 2009

The CRMWA provides surface water from Lake Meredith 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 the year 2006, approximately 43 percent of the water used by the CRMWA member cities was groundwater. The remaining 57 percent was surface water. Water usage by CRMWA member cities in 2006 is summarized in Table 1-11.

Table 1-11: Water Used by CRMWA Member Cities in the PWPA during 2006

	Municipal Water Supplied by CRMWA, ac-ft/yr		
City	Wells Groundwater	Surface Water CRMWA	Total
Amarillo	16,388	17,439	33,826
Borger	2,167	1,224	3,391
Pampa	923	1,448	2,371
Total	19,478	20,110	39,588

TWDB projections for municipal water use by decade for 2000 through 2060 are located in Table 1-10. TWDB projected total municipal water use ranges from 77,605 acre-feet per year in 2010 to 104,242 acre-feet per year in 2060. Potter and Randall Counties make up the largest portion of projected municipal water use in the PWPA with approximately 71 percent of the total municipal water use by 2060. Armstrong, Collingsworth, Donley, Hall, Hartley, Hemphill, Lipscomb, Roberts, Sherman, and Wheeler Counties are projected to each use less than one percent of the total.

The amount of water from Lake Meredith available to the three member cities by the CRMWA is based on the available supply in the lake. According to CRMWA, the City of Amarillo is entitled to approximately 37 percent, Borger to 5 percent, and Pampa to 7 percent of the reservoir estimated yield. Just over 50 percent of the yield of Lake Meredith is contracted to cities in Region O.

Greenbelt M&IWA provides surface water from Greenbelt Reservoir for municipal, industrial, mining and irrigation uses. In 2006, Greenbelt M&IWA supplied just over 2,300 acre-feet of water to the cities of Childress, Clarendon, Hedley, Memphis, and to the Red River Authority for use in the PWPA. Over 1,200 acre-feet were provided to entities for use in Region B. (TWDB, 2009)

1.6.2 Industrial Use

Industrial use includes mining, manufacturing, and power generation, and accounted for approximately 52,800 ac-ft in 2006. Table 1-12 contains the historical and projected industrial water use for counties in the PWPA.

1.6.2.1 Mining

Based on TWDB data, mining water use totaled approximately 1,010 acre-feet for the entire region in 2006, approximately 2 percent of the total industrial water used. Hansford County had the highest use with 402 acre-feet (TWDB, 2009). 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.

1.6.2.2 Manufacturing

According to the TWDB, manufacturing water use totaled approximately 45,789 acre-feet for the entire region in 2006, approximately 87 percent of the total industrial water used. Hutchinson County had the highest use with 26,515 acre-feet.

1.6.2.3 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 and Moore are the only counties to have reported water use for power generation activities in 2006. Water use of nearly 6,000 acre-feet accounts for approximately 11 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 in 2010 will be 16,834 acre-feet per year for their facilities. With the proposed new power plant in Gray County, power demand in 2010 could increase to 19,300 acre-feet per year, or approximately 23 percent of the total projected industrial use in the PWPA. Xcel obtains municipal effluent (City of Amarillo). If needed, additional supplies from the City of Amarillo can supplement its wastewater reuse. Xcel currently uses most of the wastewater from Amarillo for cooling and is considering investigation into 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.

The TWDB projections for industrial water use in the PWPA are located in Table 1-12. Hutchinson and Potter Counties are projected to use the most water for industrial purposes, while Armstrong, Childress, Donley, Hall, Hartley and Sherman are projected to use less than 20 acre-feet per year. The TWDB does not have any industrial use projections for Collingsworth or Dallam Counties.

Table 1-12: TWDB Historical and Projected Industrial Water Use for the PWPA (ac-ft/yr)

County	2000	2006	2010	2020	2030	2040	2050	2060
Armstrong	19	0	13	12	12	12	12	12
Carson	2,201	352	2,052	2,081	2,128	2,173	2,209	2,259
Childress	20	27	17	16	16	16	16	16
Collingsworth	0	0	0	0	0	0	0	0
Dallam	0	9	0	0	0	0	0	0
Donley	22	0	15	14	14	14	14	14
Gray	5,822	3,694	8,700	7,791	8,591	8,852	9,550	9,539
Hall	22	0	15	14	14	14	14	14
Hansford	630	437	592	585	583	581	579	578
Hartley	5	0	5	5	5	5	5	5
Hemphill	1	2	2,576	2,576	2,315	1,845	1,480	1,184
Hutchinson	20,575	26,834	24,057	25,875	27,363	28,794	30,036	32,104
Lipscomb	82	102	1,324	1,330	1,214	991	821	690
Moore	8,687	8,614	8,779	9,350	9,744	10,138	10,483	11,108
Ochiltree	164	49	1,148	1,148	1,027	818	661	522
Oldham	292	2	328	341	347	352	357	364
Potter	24,104	12,100	29,549	33,222	35,239	37,429	39,543	44,334
Randall	504	534	623	689	746	799	843	915
Roberts	9	0	1,270	1,270	1,148	922	731	592
Sherman	20	2	17	16	16	16	16	16
Wheeler	113	0	2,001	2,001	1,810	1,444	1,148	922
TOTAL	**63,292**	**52,758**	**83,081**	**88,336**	**92,332**	**95,215**	**98,518**	**105,188**

Source: TWDB, 2009

1.6.3 Agricultural Use

1.6.3.1 Land Use

Agricultural land use in the PWPA includes irrigated cropland, dryland cropland, and pastureland. Major crops include corn, cotton, hay, peanuts, sorghum, sunflower, soybeans, and wheat. According to 2007 Census of Agriculture estimates presented in Table 1-13, the number of farms has decreased over the last 20 years between 1987 through 2007, but the acres of harvested cropland have increased appreciably. By 2007, total harvested cropland in the PWPA approximated 2,640,293 acres and was distributed between 2,952 farms. In 2007, approximately 65 percent of the harvested cropland was contained in seven counties (Carson, Dallam, Hansford, Hartley, Moore, Ochiltree, and Sherman) on 1,269 farms.

Table 1-13 Number of Farms and Acres of Harvested Cropland.

	1987		1992		1997		2002		2007	
County Name	Farms	Acres	Farms	Acres	Farms	Acres	Farms	Acres	Farms	Acres
Armstrong	173	81,576	148	74,910	125	67,217	118	(D)	126	79,703
Carson	266	154,361	242	172,506	227	174,821	151	105,259	196	181,185
Childress	199	66,295	179	86,806	166	96,967	119	63,879	142	77,509
Collings-worth	248	78,250	258	83,752	290	90,387	215	89,709	171	98,829
Dallam	293	203,239	272	230,710	263	299,352	213	250,350	218	317,249
Donley	190	32,035	160	30,073	176	41,188	151	37,271	124	31,922
Gray	193	77,615	164	92,719	162	95,724	118	58,177	115	82,596
Hall	216	78,598	200	86,363	177	90,783	126	99,041	160	105,536
Hansford	259	169,195	221	203,150	189	212,647	147	127,477	155	249,487
Hartley	178	115,245	159	140,626	142	153,346	140	159,433	152	241,558
Hemphill	125	33,748	105	29,505	106	26,971	71	16,331	81	23,043
Hutchinson	87	55,412	94	74,740	68	87,885	61	(D)	68	97,920
Lipscomb	206	74,940*	177	75,212	142	67,255	111	(D)	101	60,283
Moore	224	133,869	203	162,528	160	177,769	139	147,854	162	219,086
Ochiltree	334	214,199	301	233,663	240	239,796	179	(D)	230	263,068
Oldham	94	57,818	82	60,996	75	47,391	40	14,541	67	55,996
Potter	68	25,900*	50	21,925	53	23,109	40	(D)	61	27,884
Randall	364	130,238	315	120,833	278	131,938	194	71,410	259	106,682
Roberts	58	23,399	47	25,999	40	24,832	22	15,535	34	28,223
Sherman	241	168,821	194	181,527	155	186,873	183	220,226	156	240,804
Wheeler	291	65,477	265	62,249	237	57,366	224	47,346	174	51,730
Totals	4,307	1,939,390	3,836	2,250,792	3,471	2,393,617	2,762	1,523,839	2,952	2,640,293

Source: 1987-1992 Data, USDOC, 1998; 1997-2002 Data, National Agricultural Statistics Service, Table 9, 2002 Census of Agriculture available at, http://www.nass.usda.gov/census/, 2007 Texas Census of Agriculture http://www.agcensus.usda.gov/Publications/2007/index.asp
* estimated county average
(D) Withheld to avoid disclosing data for individual farms

1.6.3.2 Irrigation

As part of this study, the Texas Agrilife Research and Extension Service in Amarillo (Texas AgriLife) developed updated irrigated agriculture water demands in the PWPA. The 2010 demands shown in Table 1-14 best represent current irrigation water use. Irrigation for crop production represents the most significant use of water and accounts for approximately 90 percent of crop receipts within the PWPA. According to TWDB data, use of irrigation water totaled approximately 1,530,422 acre-feet in 2006. Five counties, Dallam, Hansford, Hartley, Moore, and Sherman, accounted for approximately 73 percent of the total irrigation water applied in 2006 (TWDB, 2006).

Table 1-14: Historical and Projected Irrigation Water Use for the PWPA (ac- ft/yr)

County	2000	2006	2010	2020	2030	2040	2050	2060
Armstrong	10,544	6,583	5,118	4,688	4,544	4,305	3,827	3,349
Carson	97,345	64,707	58,775	49,230	47,982	45,457	36,368	35,355
Childress	10,304	9,910	7,418	5,519	5,350	5,068	4,505	3,942
Collingsworth	25,607	51,185	28,693	21,907	21,236	20,118	17,883	15,648
Dallam	320,475	346,605	292,031	283,315	274,642	260,187	231,278	202,368
Donley	21,019	26,347	32,000	29,676	28,771	27,257	24,228	21,200
Gray	25,499	27,181	22,705	20,410	19,785	18,744	16,661	14,578
Hall	20,789	22,909	16,719	10,731	10,403	9,855	8,760	7,665
Hansford	138,389	108,000	130,694	115,027	111,506	105,637	93,899	82,162
Hartley	289,008	307,260	294,932	281,648	273,026	258,657	229,917	201,177
Hemphill	3,779	7,187	1,825	1,705	1,653	1,566	1,392	1,218
Hutchinson	63,208	41,194	43,104	39,971	38,748	36,708	32,630	28,551
Lipscomb	14,789	28,020	16,956	15,546	15,070	14,277	12,690	11,104
Moore	180,594	147,000	147,471	135,001	130,869	123,981	110,205	96,430
Ochiltree	104,220	66,539	60,844	51,839	50,252	47,607	42,317	37,028
Oldham	5,223	7,267	4,235	3,914	3,794	3,594	3,195	2,795
Potter	8,009	4,205	6,226	5,697	5,525	5,234	4,652	4,071
Randall	30,302	23,156	22,477	19,900	19,291	18,275	16,245	14,214
Roberts	22,890	14,639	6,084	5,639	5,466	5,179	4,603	4,028
Sherman	294,703	207,000	220,372	200,521	194,437	182,913	163,736	143,269
Wheeler	8,335	13,528	11,311	9,488	9,198	8,713	7,745	6,777
TOTAL	**1,695,031**	**1,530,422**	**1,429,990**	**1,311,372**	**1,271,548**	**1,203,332**	**1,066,736**	**936,929**

Source: Texas AgriLife 2009

The five counties of highest irrigation water use (Dallam, Hansford, Hartley, Moore, and Sherman) are projected to utilize approximately 77 percent of the total irrigation water use in the PWPA. Due to new technologies, economic considerations, and changing crop acreages the irrigation water use projections for future decades in the planning period will need to be reviewed and possibly revised with each plan update to accurately reflect changes in the farming community.

1.6.3.3 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 other agricultural uses in the region.

Estimating livestock water consumption consists of estimating water consumption for a livestock unit and the total number of livestock. The Texas Agricultural Statistics service provides current and historical numbers of livestock by livestock type and county. Texas AgriLife, working together with representatives of the livestock industry, developed updated data on 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 livestock 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 kinds of livestock considered for the PWPA livestock demands include beef cattle (cows, feedlot cattle, dairy cattle, and stockers on pasture winter or summer) and calves, poultry, sheep and lambs, and hogs and pigs.

Total livestock water use for the PWPA in 2006 was estimated at 66,081 acre-feet. Table 1-15 contains TWDB estimates of livestock water use by county supplied by surface and groundwater sources. Dallam County and Hartley County accounted for the most livestock water use in the region with Dallam using 9,868 acre-feet and Hartley using 8,872 acre-feet. Approximately 80 percent of the total livestock water use was supplied from groundwater sources.

Table 1-15: Estimates of Livestock Water Use in the PWPA during 2006 (ac-ft)

County	Surface Water	Groundwater	Total
Armstrong	102	916	1,018
Carson	112	1,007	1,119
Childress	34	304	338
Collingsworth	24	780	804
Dallam	1,974	7,895	9,869
Donley	215	862	1,077
Gray	666	1,998	2,664
Hall	67	268	335
Hansford	2,181	5,088	7,269
Hartley	2,661	6,210	8,871
Hemphill	351	1,991	2,342
Hutchinson	189	567	756
Lipscomb	72	647	719
Moore	833	4,719	5,552
Ochiltree	351	3,158	3,509
Oldham	695	1,042	1,737
Potter	95	539	634
Randall	1,093	4,374	5,467
Roberts	62	350	412
Sherman	877	7,896	8,773
Wheeler	704	2,112	2,816
TOTAL	**13,358**	**52,723**	**66,081**

Source: TWDB, 2009

The majority of current livestock water used in the PWPA is accounted for by feedlot cattle and swine production. The largest cattle feeding operations are in Hansford and Hartley counties. Other counties with more than 100,000 head feedlot capacity are: Dallam, Moore, Ochiltree, Randall and Sherman.

Swine production is concentrated generally in counties along the northern portion of the PWPA. It is estimated that production in this area will experience zero growth (Appendix C).

Methods used to develop TWDB livestock water use projections were also evaluated in the PWPG agricultural water use study and new projections were developed (Table 1-16). Seven counties, Dallam, Hansford, Hartley, Moore, Ochiltree, Randall, and Sherman, are projected to use approximately 69 percent of the total livestock water use in the PWPA in 2010, and more than 76 percent by 2060.

Expected expansions to the dairy industry will make it the second largest water user by 2060

Table 1-16: Projections for Livestock Water Use in the PWPA (ac-ft/yr)

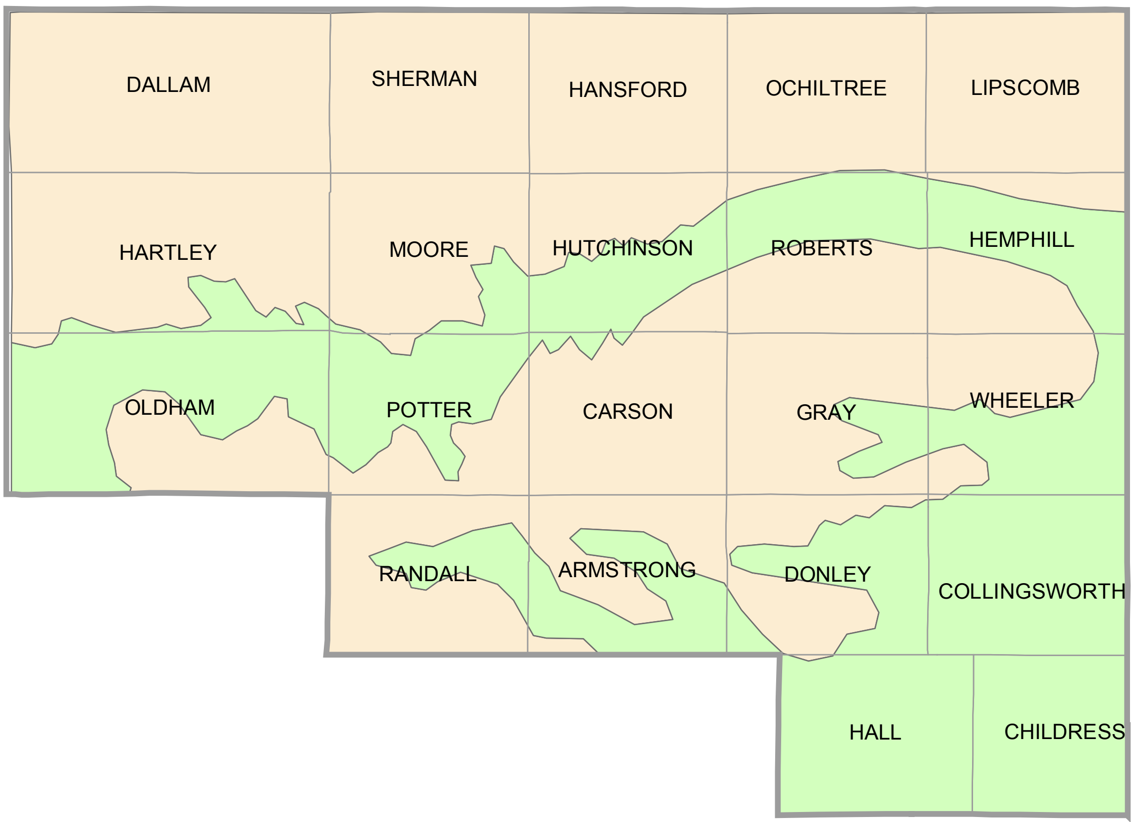
County	2010	2020	2030	2040	2050	2060
Armstrong	566	670	673	677	681	685
Carson	607	711	716	720	725	730
Childress	368	470	472	473	475	477
Collingsworth	461	564	566	569	571	574
Dallam	3,509	4,654	4,996	5,373	5,788	6,246
Donley	1,267	1,268	1,270	1,271	1,273	1,275
Gray	1,348	1,451	1,474	1,499	1,527	1,557
Hall	329	330	331	332	334	335
Hansford	3,683	3,956	4,256	4,586	4,948	5,346
Hartley	5,106	7,103	7,731	8,422	9,184	10,024
Hemphill	1,276	1,281	1,285	1,290	1,296	1,301
Hutchinson	685	689	698	708	720	732
Lipscomb	1,005	1,007	1,028	1,051	1,076	1,104
Moore	2,831	3,605	3,931	4,290	4,685	5,120
Ochiltree	3,367	3,463	3,605	3,761	3,932	4,119
Oldham	1,154	1,257	1,259	1,262	1,265	1,267
Potter	502	504	505	507	509	511
Randall	2,732	2,741	2,756	2,772	2,789	2,808
Roberts	385	385	386	387	388	388
Sherman	4,933	5,579	5,889	6,230	6,606	7,019
Wheeler	1,554	1,657	1,660	1,662	1,664	1,667
TOTAL	**37,668**	**43,345**	**45,487**	**47,842**	**50,436**	**53,285**

Source: (Appendix C) Texas AgriLife, 2009

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 1-10). The Rolling Plains is the largest 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.



LEGEND

REGIONS

- High Plains
- Rolling Plains

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N W E S

PANHANDLE WATER PLANNING AREA

NATURAL REGIONS

Location Map

FIGURE 1-10

1.7.2 Regional Vegetation

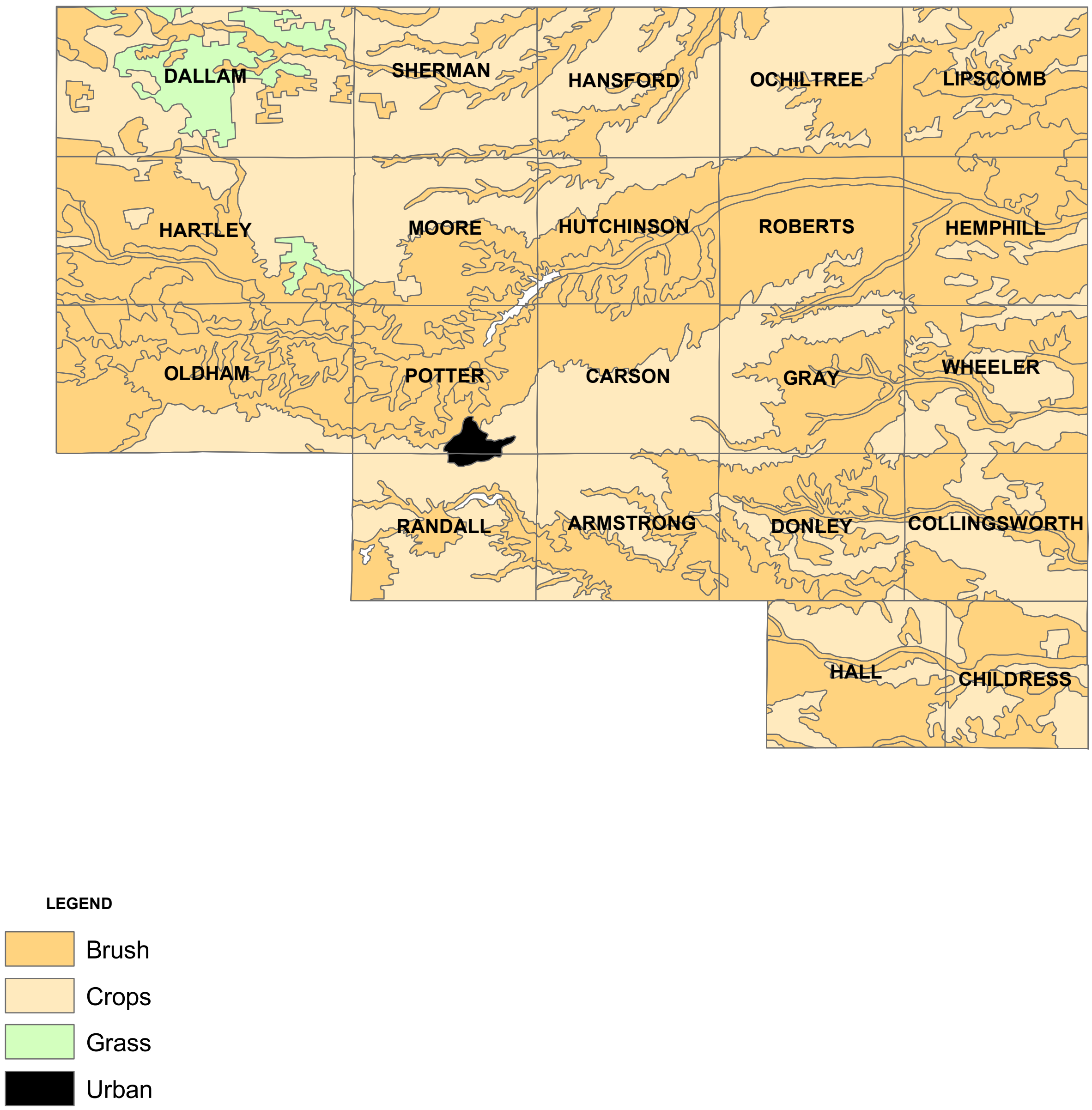
The PWPA is located in two vegetation regions which generally correspond to the natural regions described in the previous section – the High Plains and Rolling Plains. Figure 1-11 illustrates the types of vegetation characteristic of the PWPA.

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).

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.

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 2001, 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. Approximately 0.067 acre-feet water per acre per year additional water is estimated to be available with a continuing brush control program. (Bretz, et. al., 2000) The CRMWA, in partnership with local landowners, TSSWCB and the NRCS have targeted thousands of acres for removal of brush. Between 2005 and 2009, over $3 million has been spent on controlling invasive brush through herbicidal spraying. In addition, pilot studies for biological control of brush are on-going in the PWPA. These activities are an important component in the management of the watershed for water supplies.



0 7.625 15.25 30.5 Miles

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N W E S

PANHANDLE WATER PLANNING AREA

REGIONAL VEGETATION

Location Map

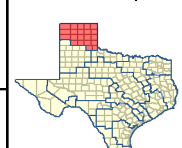


FIGURE 1-11

1.7.3 Regional Geology

The geology of 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 1-12) 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.

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).

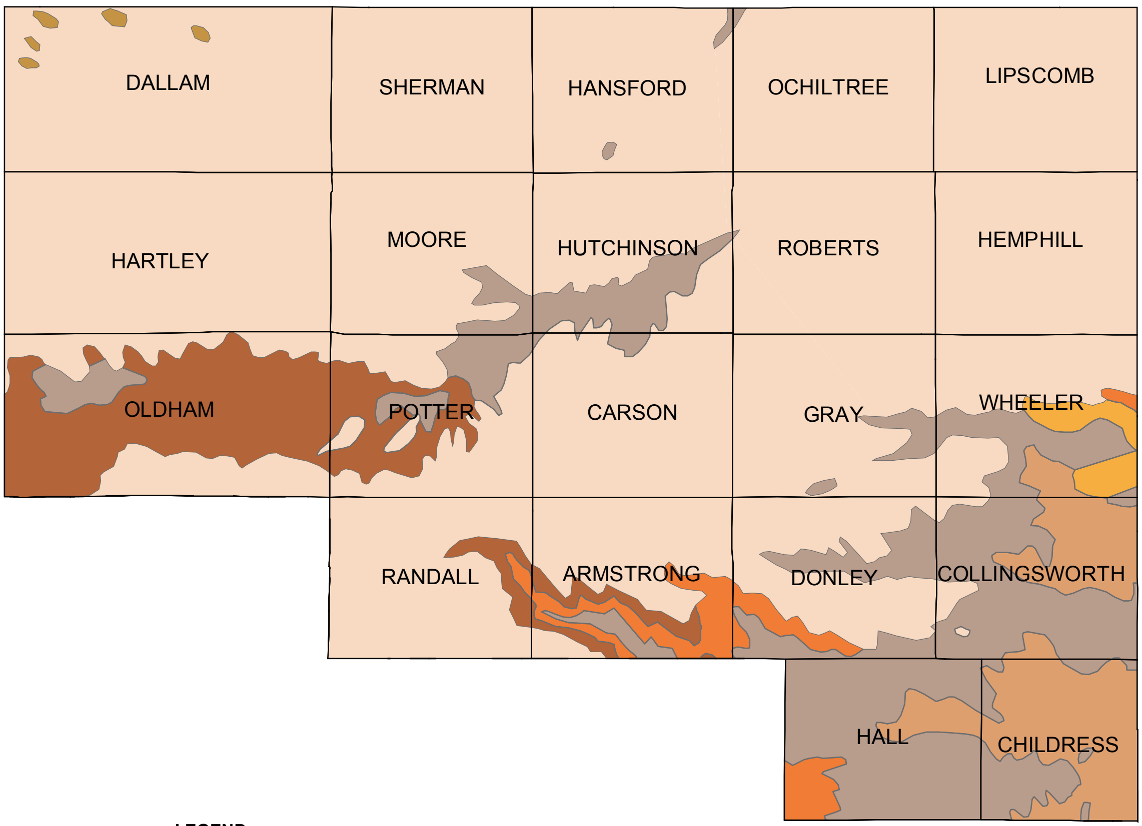
1.7.4 Mined Resources

Natural resources that are mined in the PWPA (Table 1-17) are primarily oil and natural gas. Non-petroleum products include sand, gravel, caliche, stone, and helium. Three counties, Dallam, Hall, and Randall, reportedly do not have any significant mining production.

Table 1-17: 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	
Hemphill					X	X	
Hutchinson	X	X			X	X	
Lipscomb					X	X	
Moore					X	X	X
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



LEGEND

- Lower part of Guadalupian Series
- Ochoan Series
- Pliocene continental
- Quaternary
- Triassic
- Upper part of Guadalupian Series
- Woodbine and Tuscaloosa groups

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N W E S

PANHANDLE WATER PLANNING AREA

REGIONAL GEOLOGY

Location Map

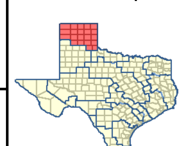


FIGURE 1-12

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 1-13). Most of the nearly level soils in the PWPA have loamy surfaces and clayey subsoils. The major associations involving these nearly level soils are:

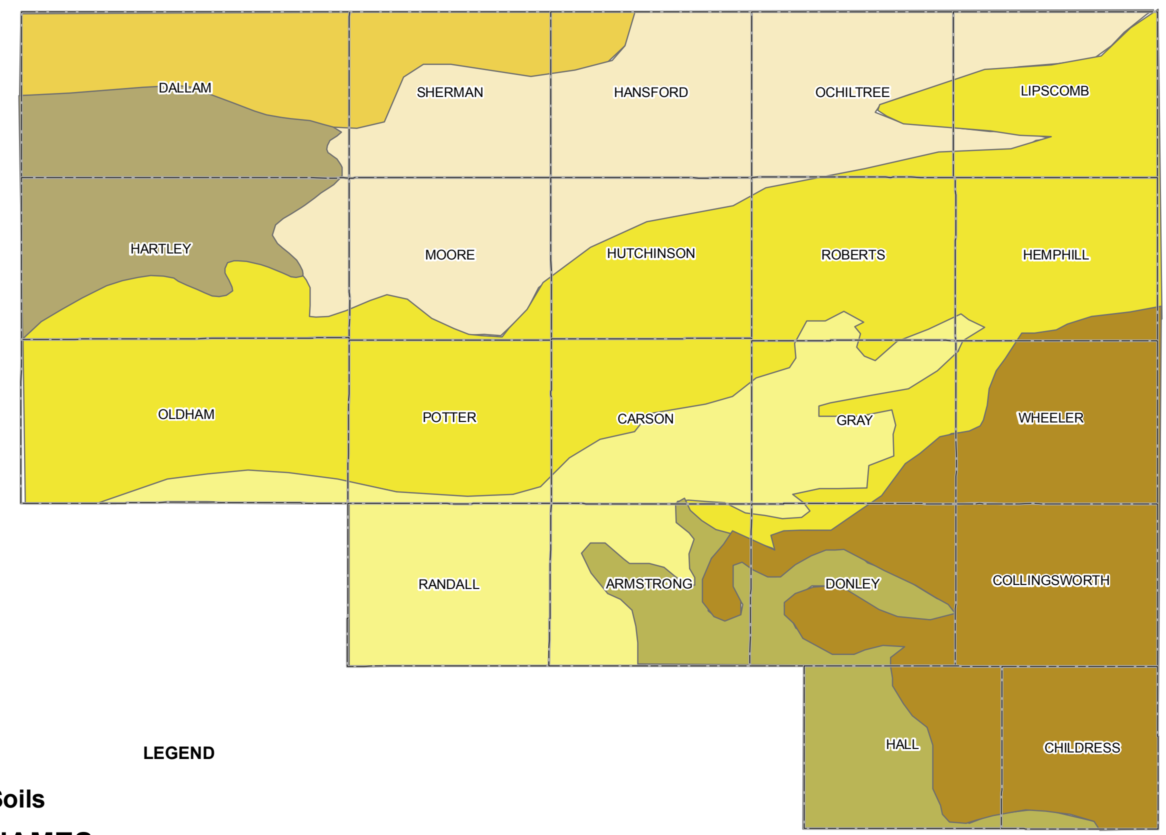
- Pullman-Olton-Mansker;
- Sherm-Gruver-Sunray;
- Dallam-Sunray-Dumas; and
- Sunray-Conlen-Gruver.

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; and
- 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.



LEGEND

Soils

NAMES

- Dallam-Sunray-Dumas
- Mansker-Berda-Potter
- Miles-Springer-Woodward
- Pullman-Olton-Mansker
- Sherm-Gruver-Sunray
- Sunray-Conlen-Gruver
- Woodward-Quinlan-Vernon

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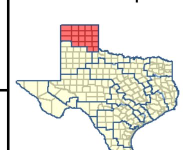
N W E S

PANHANDLE WATER PLANNING AREA

Soil Associations

Location Map



FIGURE

1-13

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 wetlands 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 1-18).

Table 1-18: Physical characteristics of playas within 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	751	15,541	2.65%	356	0.13	0.56
Carson	595	18,198	3.08%	404	0.04	0.68
Childress	7	98	0.02%	24	7.48	0.61
Collingsworth	0	0	0.00%	0	0.00	0.00
Dallam	262	4,245	0.44%	201	0.00	0.54
Donley	109	1,846	0.31%	181	1.27	0.54
Gray	792	12,958	2.18%	388	0.31	0.53
Hall	0	0	0.00%	0	0.00	0.00
Hansford	381	7,047	1.20%	392	0.13	0.54
Hartley	222	4,055	0.43%	131	0.06	0.53
Hemphill	9	100	0.02%	34	0.93	0.47
Hutchinson	191	3,360	0.59%	141	0.02	0.55
Lipscomb	19	233	0.04%	36	0.05	0.53
Moore	214	4,694	0.81%	170	0.37	0.59
Ochiltree	693	16,560	2.82%	843	0.04	0.62
Oldham	173	4,252	0.44%	443	0.00	0.59
Potter	118	3,332	0.56%	292	0.21	0.62
Randall	594	16,802	2.84%	243	0.25	0.68
Roberts	109	1,069	0.18%	185	0.00	0.41
Sherman	218	4,515	0.76%	212	0.62	0.62
Wheeler	0	0	0.00%	0	0.00	0.00
REGION TOTAL	**5,457**	**118,907**	**1.03%**	**843**	**<1**	**0.49**

Source: NRCS, 2009

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 much 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.

1.7.7.1 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 Regional Water Planning Group 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.

The Texas Parks and Wildlife Department (TPWD) has developed a draft list of Texas streams and rivers satisfying at least one of the criteria defined in SB1 for ecologically unique river and stream segments. The PWPG is not currently recommending any segments in the PWPA for designation. The list developed by the TPWD for the PWPA is included in Chapter 8 for informational purposes.

1.7.7.2 Special Water Resources

Special water resources are designated by the TWDB and include surface water resources that are located in one region and used in whole or in part in another region. In the PWPA, the TWDB has designated Lake Meredith and Greenbelt Reservoir as special water resources. Both of these lakes provide water to users outside of the PWPA. Descriptions of these resources and allocations of water are discussed in Chapter 3 of this plan.

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 1-19 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.

Table 1-19: 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																								
American Peregrine Falcon	*Falco peregrinus anatum*		T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Bald Eagle	*Haliaeetus leucocephalus*		T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Interior Least Tern	*Sterna antilarrum athalossas*	E	E	S		B	F		F	F	B			B	B	S	S		S	S	B	B		F
Peregrine Falcon	*Falco peregrinus*		T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Piping Plover	*Charadrius melodus*		T							S														
Whooping Crane	*Grus americana*	E	E	B	B	B	B	S	B	B	B	S	S	B	S	B	S	S	B	B	B	S	S	B
Fish																								
Arkansas River Shiner	*Notropis girardi*	T	T											B	B				B	B		B		
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*		T			S																		
Mammal																								
Black Bear	*Ursus americanus*		T		S			S					S				S		S	S	S		S	
Gray Wolf	*Canis lupus*		E	S	S	S	S	S	S	S		S	S	S	S	S	S	S	S	S	S	S	S	S
Palo Duro Mouse	*Peromyscus truei comanche*		T	S																	S			
Texas Kangaroo Rat	*Dipodomys elator*		T			S																		
Reptile																								
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

Key:

F - Federal listings only (US Fish and Wildlife Service. 2009. Ecological Services. Endangered Species List. http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm)

S - State listings only (Texas parks and Wildlife Department. 2009. Annotated County Lists of Rare Species. http://gis.tpwd.state.tx.us/TpwEndangeredSpecies/DesktopDefault.aspx)

B - both Federal and State listings

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; and drought related shortages 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.

Most water used in the PWPA is supplied from aquifers such as the Ogallala, making aquifer depletion a potentially major constraint on water sources 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 recent efforts to revisit 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 this regional water plan. The findings of this study are presented in Appendix G and summarized in Chapter 3. A concurrent study on drought in the Canadian River Basin is being conducted by the Bureau of Reclamation, in conjunction with others. This study was not available for review for the Initially Prepared Plan.

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, such as Lake Meredith, for certain uses.

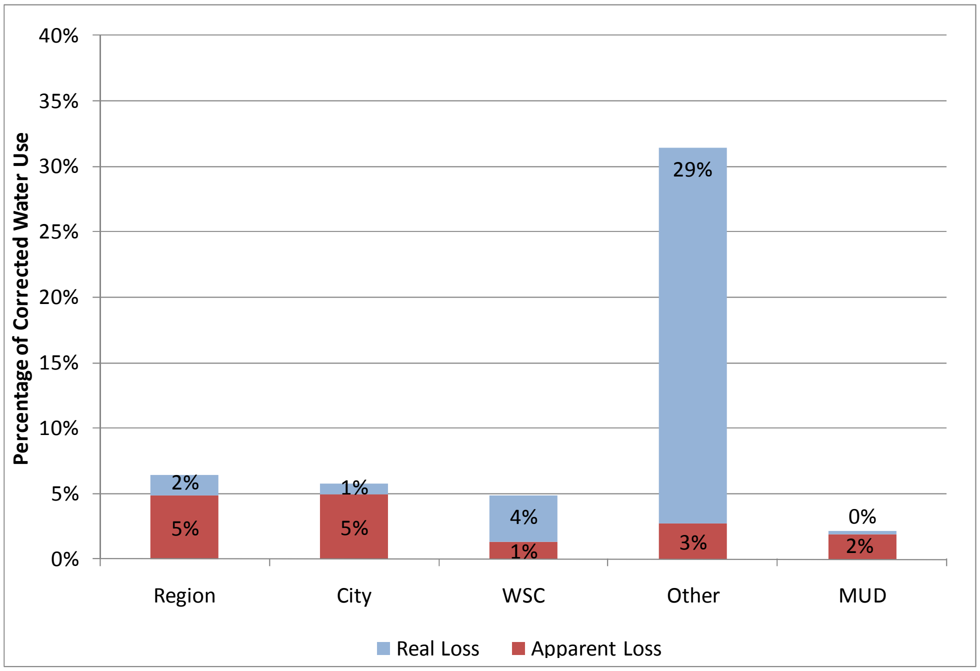
1.8.1 Water Loss and Water Audit

Since the previous round of regional planning retail public water utilities are now required to complete and submit a water loss audit form to the TWDB every five years. The first water loss audit reports were submitted to the TWDB by March 31, 2006. The data from these reports were compiled by Alan Plummer Associates Inc. through a research and planning fund grant from TWDB (Alan Plummer Associates, 2007). 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, 45 public water suppliers submitted a water loss audit to TWDB. The breakdown of the public water suppliers are 20 cities, nine water supply corporations, 15 other water suppliers and one municipal utility district. The total percentage water loss was calculated for each water supplier using a corrected input volume. (The corrected input volume is water delivered divided by master meter accuracy, this represents the actual amount of water that was delivered to the utility.) Figure 1-14 shows the percentage of total water loss for the region, cities, water supply corporations, municipal utility districts and other utilities.

Figure 1-14: Water Loss in the PWPA



On a regional basis, the percentage of total water loss for the PWPA is seven 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 twelve percent). The amount of total water loss as a percent of corrected input volume for the "Other" suppliers is much higher. One explanation for this is the low density of service connections per mile of main line for other suppliers. Table 1-20 shows the ratio of the number of connections per mile of main line by category.

Table 1-20: Service Connections per Mile of Main Line

Category	Service Connections/Mile
Region	23.76
City	38.04
WSC	21.17
Other	6.73
MUD	16.67

The amount of real losses in the PWPA from the 45 public water suppliers totaled 347 million gallons in 2006. This represents 1.4 percent of the total estimated municipal water demand for the region. Based on these findings, the region is adequately addressing municipal water loss.

1.8.2 Drought Contingency

Drought contingency plans are required by the TCEQ for wholesale water suppliers, irrigation districts and retail water suppliers. To aid in the preparation of the water plans, workshops sponsored by the Texas Rural Water Association (TRWA), Texas Water Utilities Association (TWUA), TCEQ and TWDB have been provided for those required to submit plans.

Surface water right holders that supply 1,000 acre-feet or more per year for non-irrigation use and 10,000 acre-feet per year for irrigation use are required to prepare a water conservation plan and submit it to TCEQ. In 2007, legislation was passed that requires all public water suppliers with greater than 3,300 connections to submit a conservation plan to the TWDB by May 1, 2009. According to this legislation entities required to submit a plan are the CRMWA, Greenbelt M & IWA, PDRA, City of Amarillo, City of Borger, City of Canyon, City of Dumas, and the City of Pampa.

Drought contingency plans have been prepared by different stakeholders in the planning area. CRMWA, Greenbelt M&IWA, City of Amarillo, and the City of Borger are the wholesale water suppliers with available drought contingency plans within the PWPA.

As discussed in Chapter 3, all of the major reservoirs in the PWPA are currently still in their critical period, the time frame typically used to identify the drought of record. Using that definition, the PWPA is in a drought of record.

Drought trigger conditions for the reservoirs are detailed in each of the respective reservoir operators' drought contingency plans and discussed in Chapter 6. Drought triggers for all groundwater sources will be based on local atmospheric conditions using the currently available PET stations.

Generally, precipitation at less than 50 percent of the 30-year average for the month and 55 percent of the 30-year average for the preceding twelve months triggers the Alert Stage of drought response. Precipitation at less than 25 percent of the 30-year average for the month and 45 percent of the 30-year average for the preceding twelve months triggers the Warning Stage of drought response.

The PWPA is divided into geographical areas based on location of existing PET stations for drought trigger and response purposes. The current locations of PET stations are Dalhart, Etter, Morse, Perryton, Bushland, White Deer, and Wellington.

Table 1-21 shows the breakdown of drought trigger and response zones in the PWPA.

Table 1-21 Drought Trigger Station Locations and Response Zones

Station	Counties
Dalhart	Dallam and Hartley
Etter	Sherman and Moore
Morse	Hutchinson and Hansford
Perryton	Ochiltree, Lipscomb, Roberts and Hemphill
Bushland	Oldham, Potter, and Randall
White Deer	Carson, Armstrong, and Gray
Wellington	Wheeler, Collingsworth, Childress, Donley and Hall

1.8.3 Drought Response

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.

For example: when the Alert Stage Drought Conditions have been triggered as described above, the respective reservoir operators and groundwater districts will notify all affected entities in the relevant geographical area. Those entities exercise their authority to implement their own drought contingency plans as they deem necessary.

When the Warning Stage Drought Conditions have been triggered as described above, the respective reservoir operators and groundwater districts will notify all affected entities in the relevant geographical area. These entities exercise their authority to implement their own drought contingency plans as they deem necessary.

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/management goals.

1.9 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 salt water 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 fresh water 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.

1.10 Existing Programs and Goals

1.10.1 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; and
- Healthy upland and wetland habitats to maximize waterfowl production and winter survival.

Food, Conservation and Energy Act of 2008 - The 2008 Farm Bill, governing federal farm programs for the next 5 years, was signed into law in June 2008. Its provisions continue many of the programs introduced in previous legislation to support the production of a reliable, safe, and affordable supply of food and fiber; promote stewardship of agricultural land and water resources; facilitate access to American farm products at home and abroad; encourage continued economic and infrastructure development in rural America; and ensure continued research to maintain an efficient and innovative agricultural and food sector. The Act introduces provisions for permanent disaster assistance and support of organic farming through increased funding and research. Conservation programs continue to be supported with a new Conservation Stewardship Program. Restoration and land retirement programs continue but at reduced funding. One provision in the 2008 Farm Bill reduces the cap on the acreage enrolled in the Conservation Reserve Program. As a result of this provision, approximately 1.2 million acres in the High Plains will be leaving the program between 2008 and October 2010. This has a potential significant impact on agricultural production and water use in the region. Also, the Energy Title of the 2008 Farm Bill encourages the production, use and development of bio-based and renewable energy sources. The Bill provides a temporary tax credit for cellulosic biofuels, but reduces the credit for ethanol after the Renewable Fuel Standard is attained.

Bio-Terrorism Preparedness and Response Act - Following the events of September 11th, Congress passed the Bio-Terrorism Preparedness and Response Act. Drinking water utilities serving more than 3,300 people were required and have completed vulnerability preparedness assessments and response plans for their water, wastewater, and stormwater facilities. The U.S. Environmental Protection Agency (EPA) funded the development of three voluntary guidance documents, which provide practical advice on improving security in new and existing facilities of all sizes. The documents include:

- Interim Voluntary Security Guidance for Water Utilities
  www.awwa.org
- Interim Voluntary Security Guidance for Wastewater/Stormwater Utilities
  www.wef.org
- Interim Voluntary Guidelines for Designing an Online Contaminant Monitoring System
  www.asce.org

1.10.2 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. The two reaches pertinent to the states of Oklahoma and Texas are Reach I and Reach II. Reach I is defined as the Red River and its tributaries from the New Mexico-Texas state boundary to Denison Dam. Reach II is defined as the Red River from Denison Dam to the point where it crosses the Arkansas-Louisiana state boundary and all tributaries which contribute to the flow of the River with in this Reach.

In Reach I, four subbasins are defined and the annual flow within these subbasins is apportioned as follows: 60 percent to Texas and 40 percent to Oklahoma in subbasin 1; Oklahoma has free and unrestricted use of water in subbasin 2; Texas has free and unrestricted use of water in subbasin 3; and equal quantities to both states of the annual flows and storage capacity of Lake Texoma in subbasin 4. In Reach II, annual flow in subbasin 1 is apportioned wholly to Oklahoma, while annual flow in subbasin 2 is apportioned wholly to Texas.

1.10.3 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).

Surface Water Rights – Surface water rights are administered by the TCEQ under Section 11 of the Texas Water Code. The TCEQ has the authority to revise existing water rights and grant new water rights if unappropriated water is available in the source of supply. The issuance of new water rights permits by the TCEQ is based on the following criteria to determine the availability of supply:

- Non municipal use at least 75 percent of the water can be expected to be available at least 75 percent of the time.
- For municipalities with no backup supply, 100 percent of the water can be expected to be available 100 percent of the time.
- For municipalities with a backup supply, a permit may be issued to use water that can be expected to be available less than 100 percent of the time.

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 waste 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; and
- 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.

Water for Texas (2007) - The Water for Texas Plan was adopted by the TWDB in November 2006. 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 16 Regional Water Planning Groups (Planning Groups) identified more than 1,198 water user groups that will need additional water supplies sometime during the next 50 years and recommended feasible water management strategies to meet most of those needs. Solutions proposed by the Planning Groups include strategies such as the use of currently developed surface water and groundwater sources, conservation, reuse, new interbasin transfers, and development of additional groundwater and surface water resources. 14 major and two minor new reservoirs were recommended by the Planning Groups to meet identified needs of the water user groups. The Planning Groups evaluated the environmental impacts of these water management strategies, with the goal of providing adequate water to maintain instream flows and freshwater inflows to bays and estuaries. The Planning Groups estimated total capital costs over the next 50 years to meet needs for additional water supplies at $30.7 billion, including $4.91 billion to implement strategies involving new reservoirs. Meeting these costs will require a long-term financial commitment from local political subdivisions, regional authorities, and the State of Texas. Meeting the State's future water needs will require a full range of management tools and strategies.

The 2007 State Water Plan was a culmination of a 4-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 2007 State Water Plan, 14 public meetings were held across the state during the month of September 2006 and one public hearing was held in October 2006 in Austin.

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, 2009):

- TCEQ, Office of Water – water planning, water quality and water supply
- TCEQ, Office of Permitting and Registration. – permitting and registration

- TCEQ, Office of Compliance and Enforcement-remediation, field operation, support, enforcement.
- 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, Groundwater Resources Division
- TWDB, Water Resources Planning

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

1) 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.

2) 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.

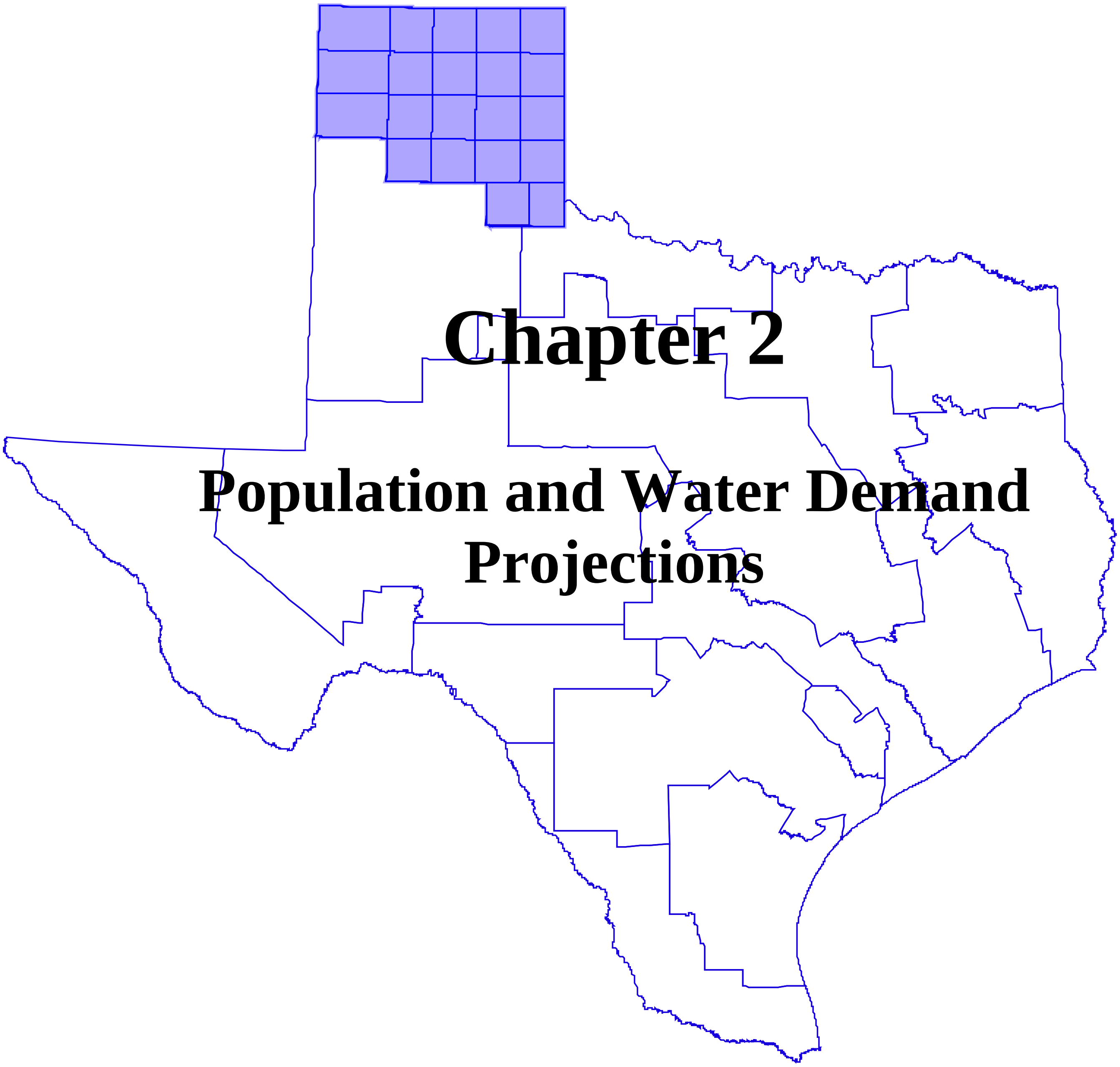
1.10.4 Local Programs

Canadian River Municipal Water Authority – In 1993, the CRMWA completed a regional water supply study under a Regional Water Supply Planning Grant, TWDB Contract No. 92-483-314. This study determined that there were several sources of supplemental groundwater which could be used for conjunctive use with Lake Meredith water. The study also determined that the current yield of Lake Meredith is on the order of 76,000 acre-feet per year, and that additional supplies of 30,000 to 65,000 acre-feet per year were needed to meet the current demands, bringing delivered water up to State or Federal standards, and provide for some future expansion of demand. Since this study was completed the reliable supply from Lake Meredith has continued to decline. CRMWA has implemented the recommendations of the study with the development of wells in Roberts County from which up to 69,000 acre-feet per year can be produced. A 36-mile long aqueduct of 54-inch pipe has been constructed to bring the well water to intersect the Authority's existing aqueduct. Water from the two sources (groundwater and Lake Meredith water) is mixed to produce a blend meeting the State drinking water quality standards. In June 2005, CRMWA completed and submitted a Management Plan for the Arkansas River Shiner. CRMWA and its partners in this endeavor consider a flexible, adaptive, and proactive management approach to be an appropriate and effective means of achieving continued conservation of the Arkansas River Shiner while contributing to national recovery efforts. CRMWA is also currently expanding the Roberts County Well Field, and reviewing the need for additional aqueduct capacity in future plans.

1.11 Special Studies Conducted During First Biennium

There were four special studies conducted for the PWPA during the first biennium of this planning cycle. Studies 1 through 3 centered on the evaluation of recharge to the Ogallala aquifer in the Eastern Panhandle area. These studies included field data collection, calculation of recharge rates under different land use conditions, numerical modeling of groundwater recharge and geochemical studies. One collective report was prepared for these three studies and a synopsis is presented in Appendix E. The findings of the recharge study were considered in the 2011 plan during the update of the Northern Ogallala GAM model, which is discussed in detail in Appendix F.

The fourth study was funding for interregional coordination with the Llano Estacado Region (Region O). The PWPA and Region O share interests in water supplies. The CRMWA provides water to member cities in both the PWPA and Region O. This study focused on coordinating the changing water supplies with CRMWA and the distribution to customers in both the PWPA and Region O. This coordination effort was documented in a summary report submitted to the TWDB. On-going coordination continued during the second biennium activities and the results of the supply coordination are incorporated into the regional water plans.



Chapter 2

Population and Water Demand Projections

2.1 Current and Projected Population and Water Demand for the Region

In November 2003[1], the Texas Water Development Board (TWDB) approved population and water demand projections for the Panhandle Water Planning Area (PWPA) for use in the 2006 regional water plan. As part of this regional water planning update, these projections were reviewed by the region and revised as needed. Due to the substantial changes in the agricultural sector in the region, a detailed study of the current and projected agricultural water use was conducted for this plan update. Also, revisions were made to mining and steam electric power water demands. There were no revisions to population or municipal and manufacturing water use.

The TWDB distributes its population and demand projections by Water User Groups. A Water User Group is defined as one of the following:

- Cities with population of 500 or more,
- Individual utilities providing more than 0.25 million gallons per day (MGD) for municipal use,
- Rural/unincorporated areas of municipal water use, known as County Other,
- 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), or
- Livestock (aggregated on a county/basin basis).

Each Water User Group has an associated water demand. Only municipal Water User Groups have population projections.

To simplify the presentation of these data all projections in this chapter are aggregated by county where the water is used. Projections divided by Water User Group, county and basin may be found in the tables at the end of this chapter. The projections were developed by decade and cover the period from 2010 to 2060.

Projected demands on water sources are addressed in Chapter 3. Specifically, expected demands on the Ogallala aquifer by county are included in Table 3-19. Demands on other sources are accounted for through the allocation of water supplies to users and recommended water management strategies.

This chapter documents historical and projected estimates of population and water demands of cities and counties in the PWPA, as well as the demands on designated wholesale water providers. Revisions to population and water demand projections discussed in this chapter have been approved by the TWDB.

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[1] Texas Water Development Board: *Final Projected Water Use Data for Region A*, approved by the Board of the TWDB on August 20, 2009.

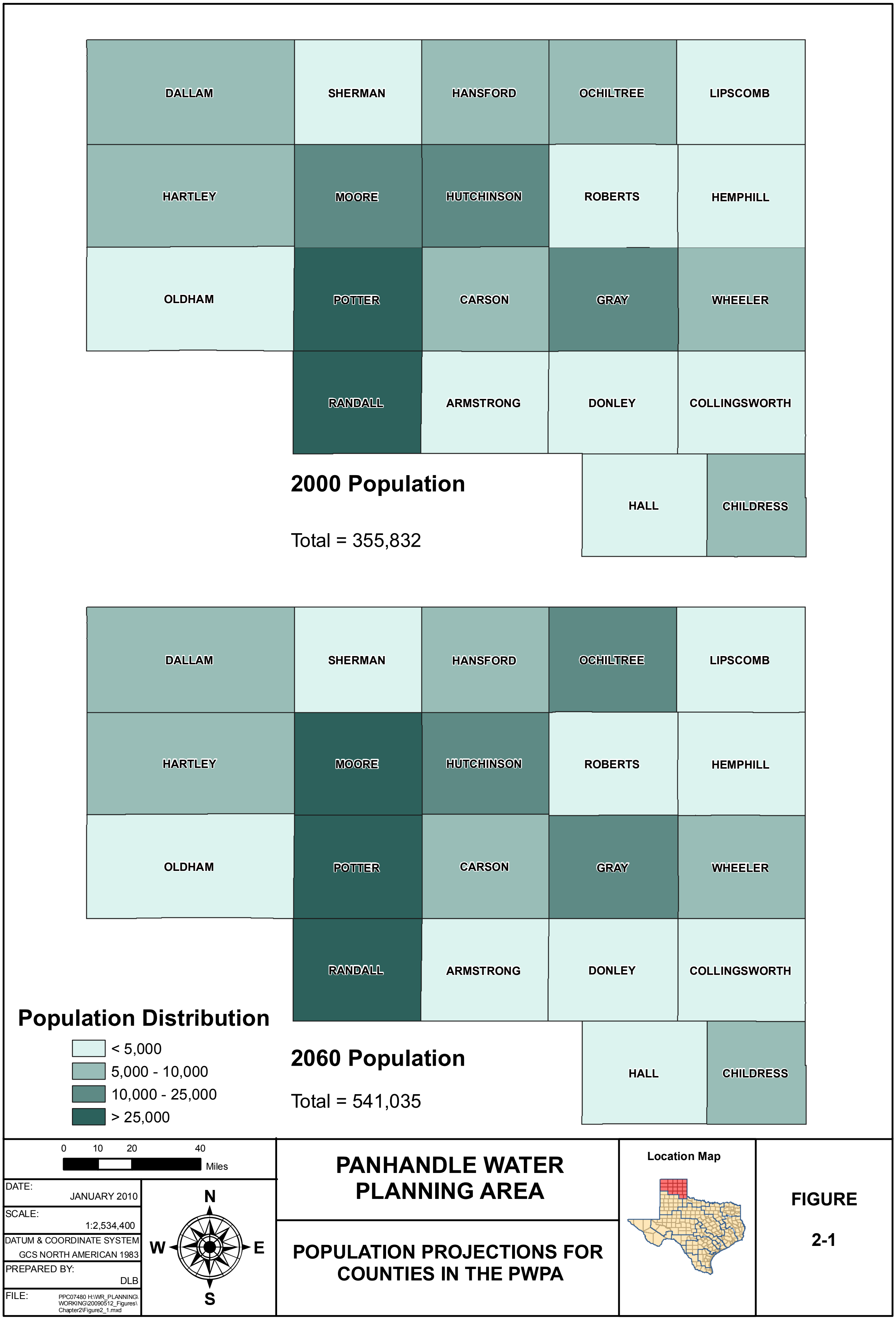
2.1.1 Population

In 2000, the population of the State of Texas was approximately 20,000,000. The population of the PWPA in 2000 was estimated to be 355,832. This represents approximately 1.7 percent of the state's population. Most of the region's population is located in Potter and Randall Counties, which contains Amarillo and surrounding areas. The remaining population in the PWPA is distributed among the other 19 counties, ranging from populations of 887 in Roberts County to 23,857 in Hutchinson County.

Population projections for the PWPA are based on the 2000 U.S. Census. The projections use a standard methodology known as the *cohort-component method*. This method is based upon historical birth and survival rates of the region's population. The population for the PWPA is projected to increase from the 355,832 in 2000 to 541,035 in 2060, or an average annual growth rate of 0.7 percent. As shown on Table 2-1, approximately 61 percent of the region's growth is expected to occur in Randall and Potter Counties, with much of this growth occurring outside of the city limits of Amarillo. Other counties showing increases in population include Childress, Hansford, Moore, Ochiltree and Sherman counties. The 2000 population and 2060 population projections by county are shown in Figure 2-1.

Table 2-1: PWPA Population by County 2000-2060

County Name	2000	2010	2020	2030	2040	2050	2060
Armstrong	2,148	2,171	2,240	2,163	2,074	2,053	1,994
Carson	6,516	6,541	6,610	6,557	6,345	5,767	5,237
Childress	7,688	7,847	7,977	8,090	8,129	8,133	7,925
Collingsworth	3,206	3,134	3,139	3,029	2,880	2,767	2,578
Dallam	6,222	6,851	7,387	7,724	7,808	7,645	7,291
Donley	3,828	3,764	3,694	3,536	3,375	3,238	3,026
Gray	22,744	22,163	21,988	21,371	20,542	19,286	18,064
Hall	3,782	3,750	3,832	3,884	3,841	3,859	3,783
Hansford	5,369	5,699	6,148	6,532	6,948	7,191	7,406
Hartley	5,537	5,697	5,889	5,989	6,026	5,950	5,646
Hemphill	3,351	3,496	3,511	3,394	3,269	3,181	3,024
Hutchinson	23,857	24,320	24,655	24,311	23,513	22,209	21,087
Lipscomb	3,057	3,084	3,149	3,054	2,966	2,925	2,784
Moore	20,121	23,049	26,241	29,057	31,293	32,655	33,474
Ochiltree	9,006	9,685	10,440	11,001	11,380	11,566	11,803
Oldham	2,185	2,322	2,373	2,204	1,942	1,689	1,364
Potter	113,546	127,580	142,703	156,846	172,950	190,526	204,933
Randall	104,312	117,420	131,546	144,757	159,800	176,218	189,811
Roberts	887	930	955	857	719	622	561
Sherman	3,186	3,469	3,770	3,886	4,005	4,110	4,164
Wheeler	5,284	5,132	5,133	5,112	5,149	5,139	5,080
PWPA Total	**355,832**	**388,104**	**423,380**	**453,354**	**484,954**	**516,729**	**541,035**


DALLAM
SHERMAN
HANSFORD
OCHILTREE
LIPSCOMB
HARTLEY
MOORE
HUTCHINSON
ROBERTS
HEMPHILL
OLDHAM
POTTER
CARSON
GRAY
WHEELER
RANDALL
ARMSTRONG
DONLEY
COLLINGSWORTH
HALL
CHILDRESS
2000 Population
Total = 355,832
DALLAM
SHERMAN
HANSFORD
OCHILTREE
LIPSCOMB
HARTLEY
MOORE
HUTCHINSON
ROBERTS
HEMPHILL
OLDHAM
POTTER
CARSON
GRAY
WHEELER
RANDALL
ARMSTRONG
DONLEY
COLLINGSWORTH
HALL
CHILDRESS
2060 Population
Total = 541,035
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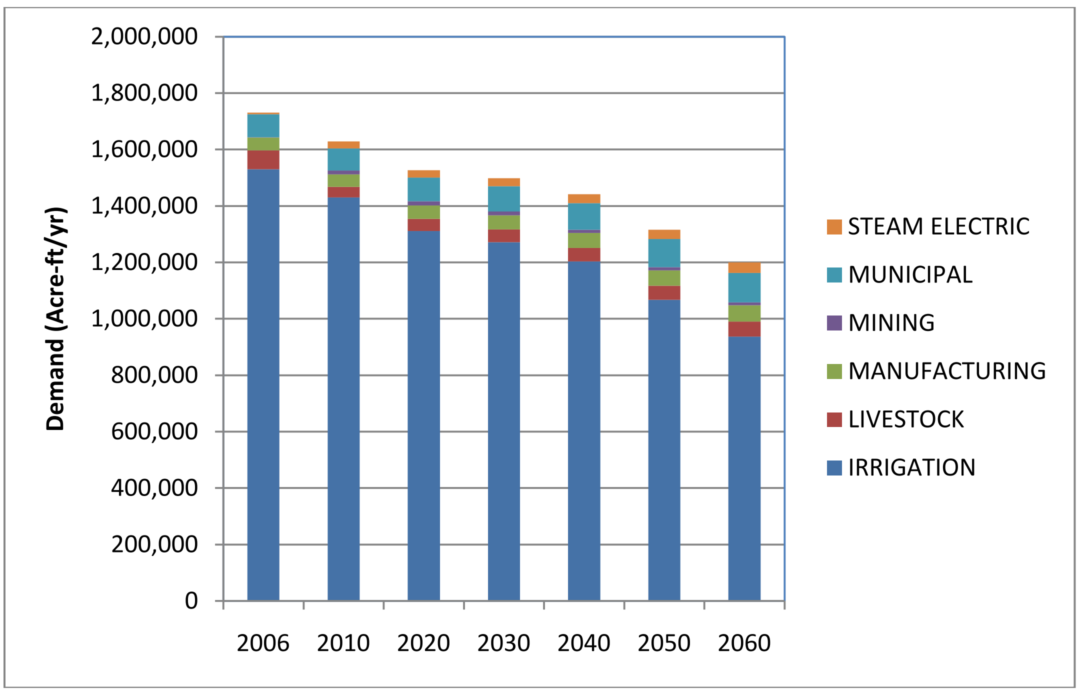
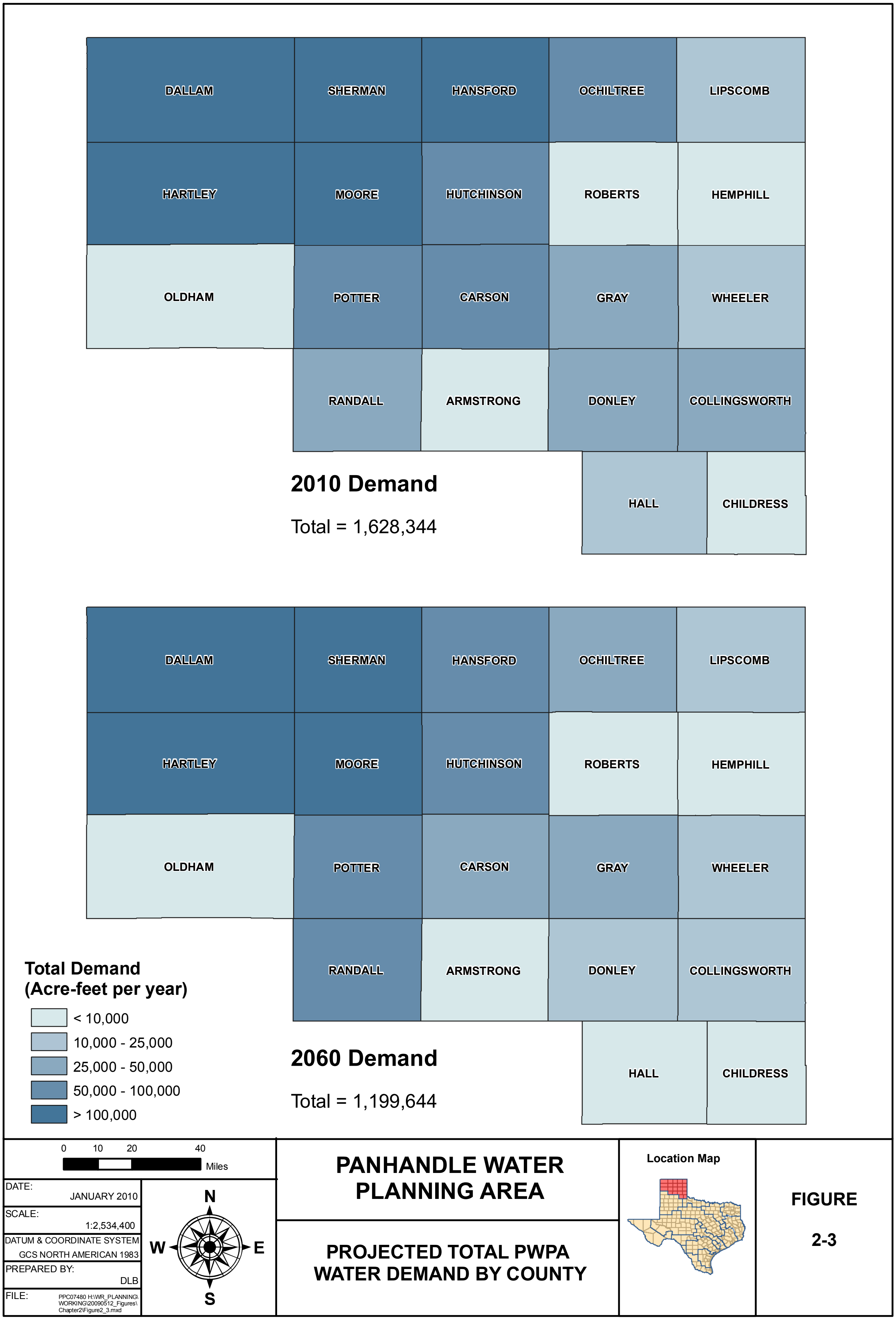
PANHANDLE WATER PLANNING AREA
POPULATION PROJECTIONS FOR COUNTIES IN THE PWPA
Location Map
FIGURE
2-1

2.2 Historical Water Use and Projected Water Demand

Water use in the PWPA during 2006 totaled over 1.7 million acre-feet, or approximately 13 percent of the state total. Three counties in the PWPA, Dallam, Hartley and Sherman, reported water use of over 200,000 acre-feet with a combined water use of more than 0.8 million acre-feet in 2006. Water use by these three counties represents approximately 52 percent of the total water use in the PWPA during 2006. Water use of the remaining 18 counties totaled nearly 840,000 acre-feet and ranged from 8,037 acre-feet in Armstrong County to 165,841 acre-feet in Moore County. Projections for water demand indicate that total water usage in the PWPA will decrease from 1,628,344 acre-feet in 2010 to 1,199,644 acre-feet in 2060. (Figure 2-2). Most of the water use will continue to be used in the three, above noted, counties. Figure 2-3 shows the distribution of total water demands by county.

Figure 2-2: Total Water Use for PWPA 2006-2060





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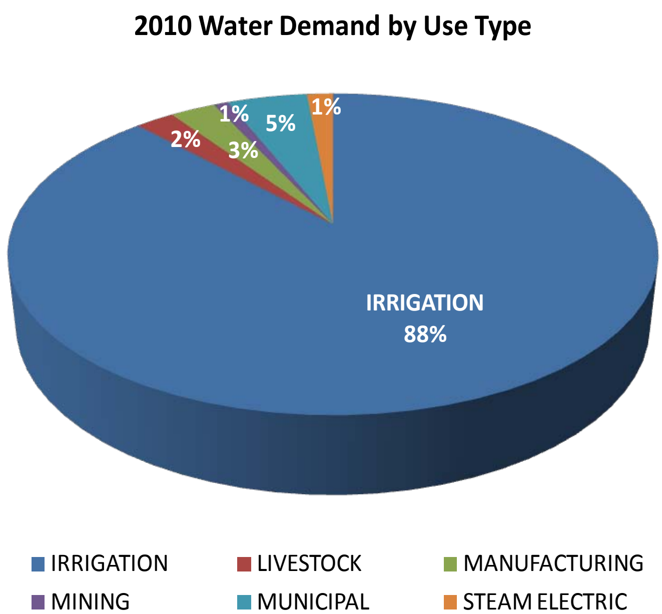
PANHANDLE WATER PLANNING AREA

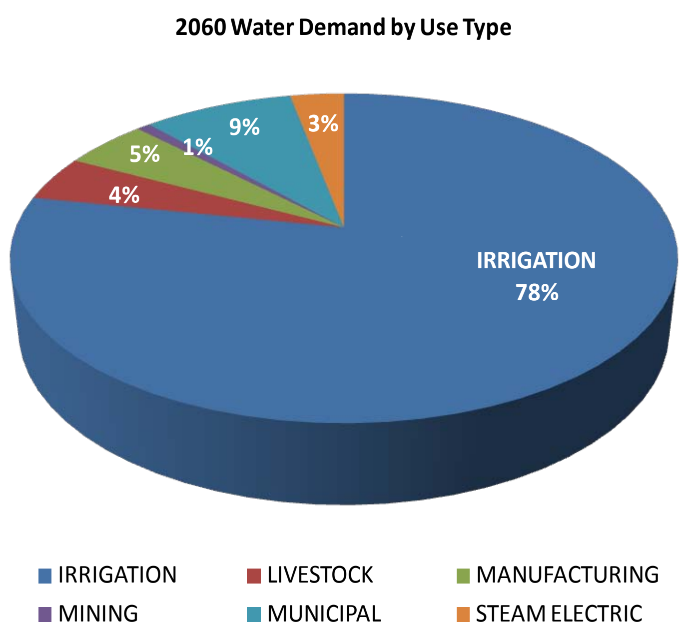
PROJECTED TOTAL PWPA WATER DEMAND BY COUNTY

FIGURE 2-3

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, agricultural, steam-electric, and industrial water users.

Figure 2-4 Water Demand by Use Type



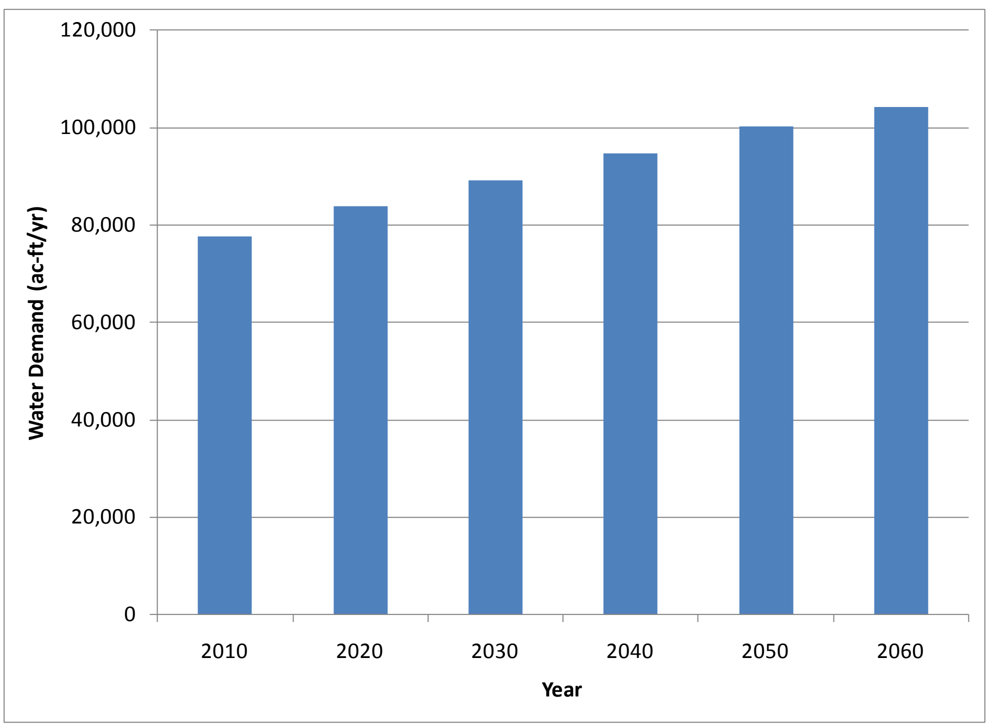


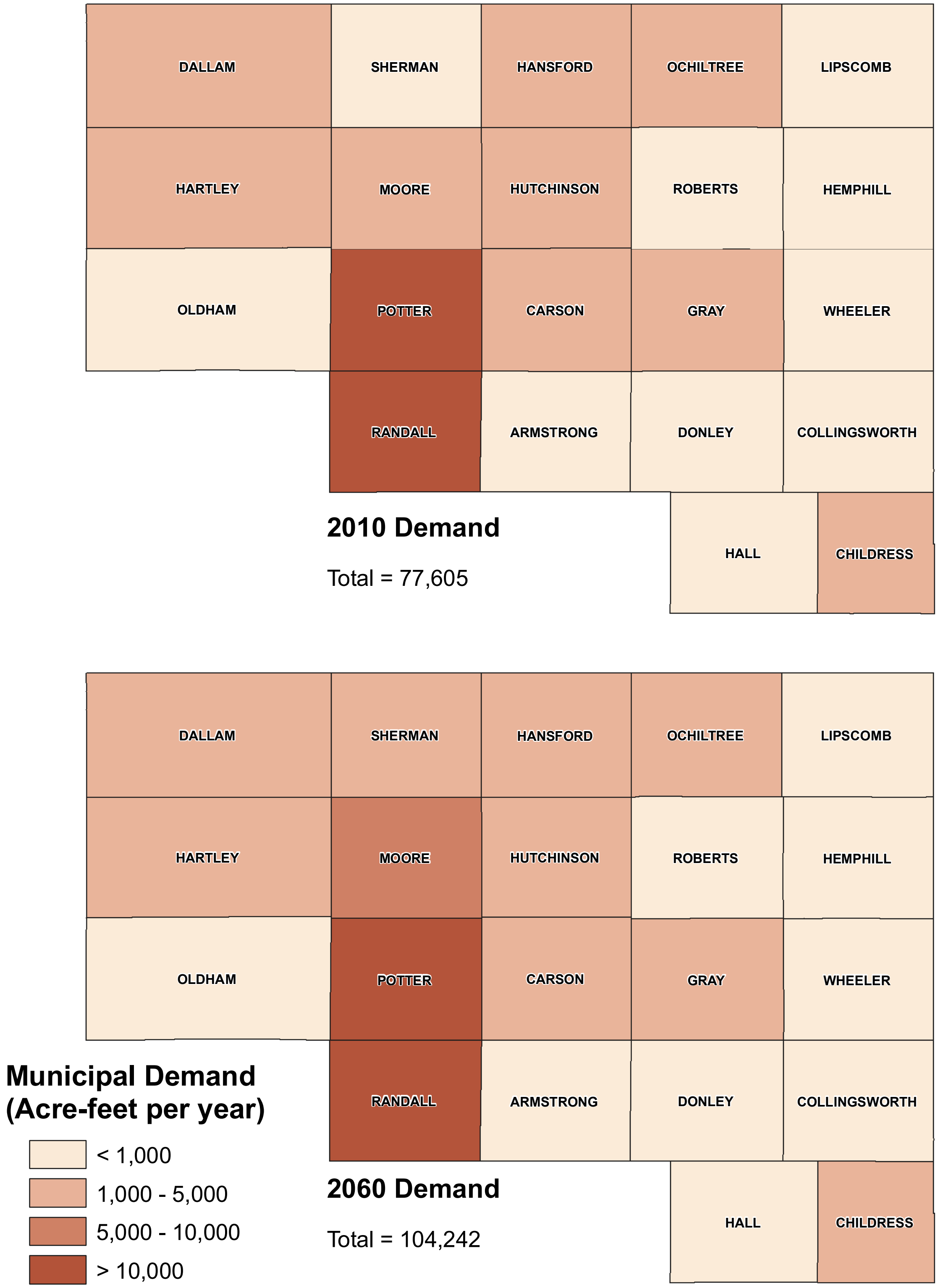
2.2.1 Municipal Water Demands

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. 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 conservation measures will be implemented and result in lower water use. These conservation savings will be further explored and discussed in the subsequent chapter highlighting conservation efforts in the region.

Municipal water use in the PWPA accounts for approximately 5 percent of total water use in the PWPA in 2010. With the projected population growth, the municipal water demand for the PWPA is projected to increase from 77,605 acre-feet in 2010 to 104,242 acre-feet in 2060. This is approximately a 34 percent increase in water demand. Potter and Randall Counties represent most of the municipal water use increase over the planning period. In these counties the populations and municipal water demands in the County-Other municipal water user group are growing at nearly twice the rate of the population within the city of Amarillo. Since most of these users are not supplied by municipal water supply systems but domestic wells, water user shortages in these areas are occurring now and need to be carefully considered. Figure 2-5 shows the increasing trend in projected municipal water demand for users in the PWPA through 2060. Figure 2-6 shows the municipal use by county.

Figure 2-5: Projected Municipal Water Demand for Counties in the PWPA





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PANHANDLE WATER PLANNING AREA

PROJECTED MUNICIPAL PWPA WATER DEMAND BY COUNTY

Location Map

FIGURE 2-6

2.2.2 Industrial Water Demands

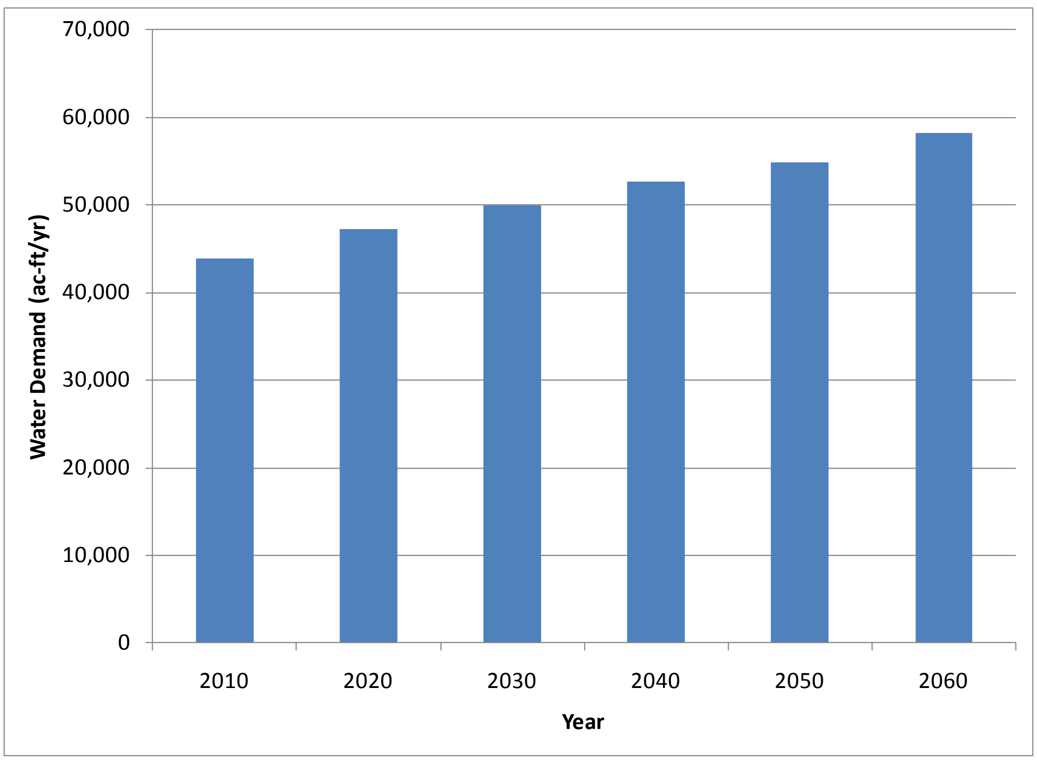
The TWDB defines industrial water use as water required in the production process of manufactured products, including water used by employees for drinking and sanitation purposes. The industrial use category includes manufacturing, steam power generation, and mining. Each of these categories is discussed below. Figure 2-7 shows the total industrial water demand in the PWPA by county for years 2010 and 2060.

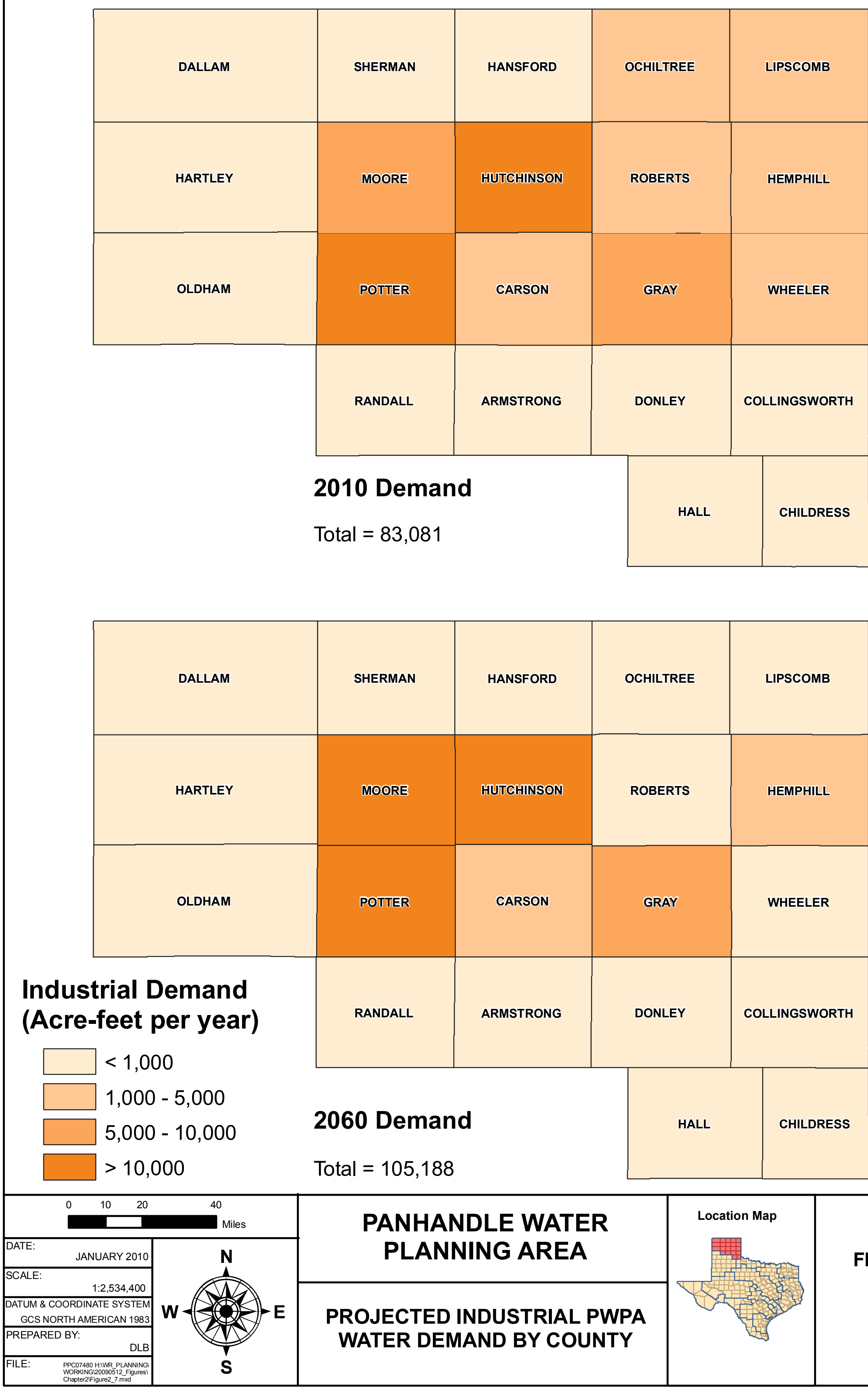
2.2.2.1 Manufacturing

Most of the manufacturing industries in the PWPA are associated with agribusiness or energy production (oil and gas). There are ten counties in the region with Manufacturing water use. The larger users are located in Hutchinson, Moore and Potter Counties.

Figure 2-8 shows the total projected water demand of manufacturing users in the PWPA through 2060. Total manufacturing water demand for the PWPA is projected to increase from 43,930 acre-feet in 2010 to 58,231 acre-feet by 2060. Manufacturing water use represents 3 to 5 percent of the total water use in the PWPA over the planning period.

Figure 2-8: Projected Manufacturing Water Use for Counties in the PWPA





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PANHANDLE WATER PLANNING AREA

PROJECTED INDUSTRIAL PWPA WATER DEMAND BY COUNTY

FIGURE 2-7

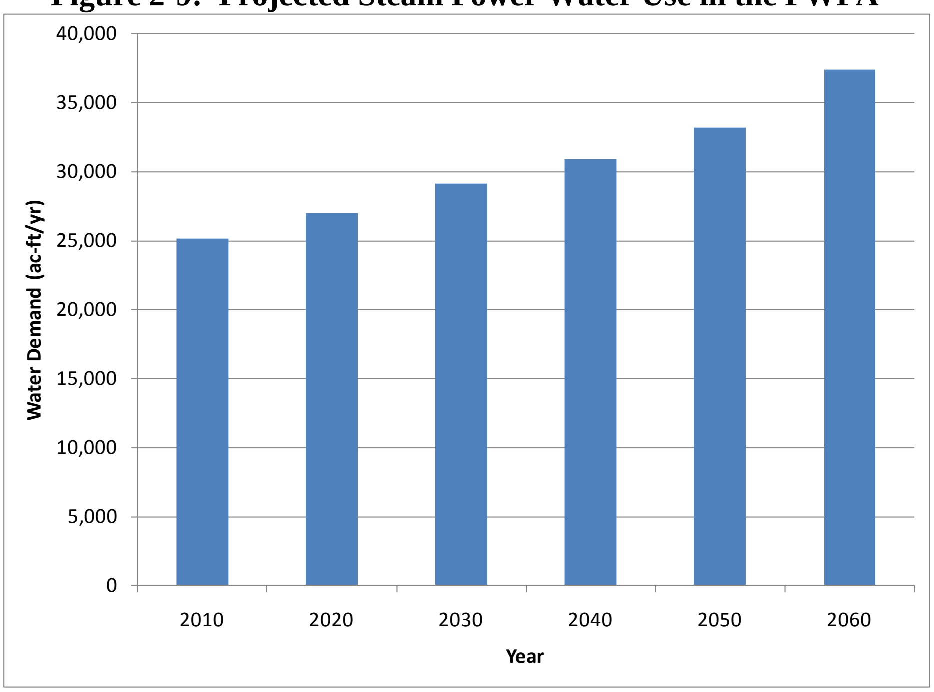
2.2.2.2 Steam Electric Power

Xcel Energy has power generation plants located in Moore and Potter counties that account for nearly all of the current water use by power generators in the PWPA. In conjunction with regional water planning efforts, Xcel performed a detailed analysis of steam electric generation and water use for their facilities in the PWPA. This analysis was the basis for the steam electric demands developed for the 2006 regional water plan. An updated analysis showed a slight reduction in projected water use by Xcel Energy. The reduced water use is partly attributed to water conservation measures that have been implemented and projected new generation from wind energy rather than gas turbines or combined cycle plants. However, these differences were not large enough to recommend revising the 2006 projections.

In addition to the Xcel Energy facilities there is a proposed new coal plant in Gray County that is planned to support wind generation in the Panhandle. Water demands for this facility were developed by the Bureau of Economic Geology (BEG) as part of a study contracted by the TWDB[2]. These demands are included in this planning update.

Considering existing and proposed facilities, water demand for power generation in the PWPA is projected to increase from 25,139 acre-feet in 2010 to 37,415 acre-feet by 2060. This represents between 1 to 3 percent of the total water use in the PWPA over the planning period. Figure 2-9 illustrates the projected water demands of steam power generators in the PWPA.

Figure 2-9: Projected Steam Power Water Use in the PWPA



[2] Bureau of Economic Geology, *Water Demand Projections for Power Generation in Texas*, prepared for the Texas Water Development Board, August 2008.

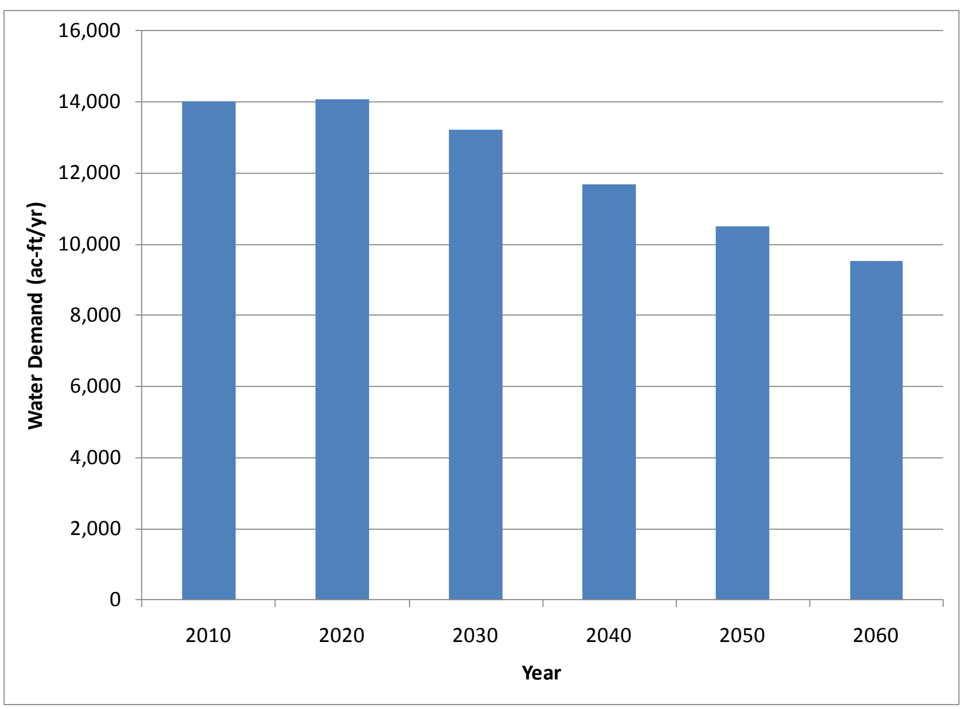
2.2.2.3 Mining

Mining activities in the PWPA consist primarily of oil and gas extraction and removal of industrial minerals such as sand, gravel, and gypsum. 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 next 10 to 20 years, and then decrease over time. Water use for other oil and gas activities has seen recent fluctuation with the volatility of the energy market. In response to these changes, the TWDB is sponsoring a study of long-term mining use associated with the oil and gas industry across the State. This study will be available for use in the 2016 regional water plan.

For this plan update, mining water use was reviewed and updated to reflect the increased oil and gas activities in five counties: Hemphill, Lipscomb, Ochiltree, Roberts and Wheeler. The mining water demand in Moore County was reduced to reflect current mining use in the county.

Mining water use is projected for 18 counties in the PWPA, totaling 14,012 acre-feet in 2010 and reducing to 9,542 acre-feet by 2060. Mining water use represents a small fraction of the total water use in the region (less than 1 percent). 2-10 shows the projected water demands for mining in the PWPA.

Figure 2-10 Projected Mining Water Use in the PWPA



2.2.3 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 nearly 90 percent of the total water demand in the PWPA. Figure 2-11 shows the agricultural water use by county in the region. The largest agricultural water users are in Dallam, Hartley, Moore and Sherman Counties.

2.2.3.1 Irrigation Water Demands

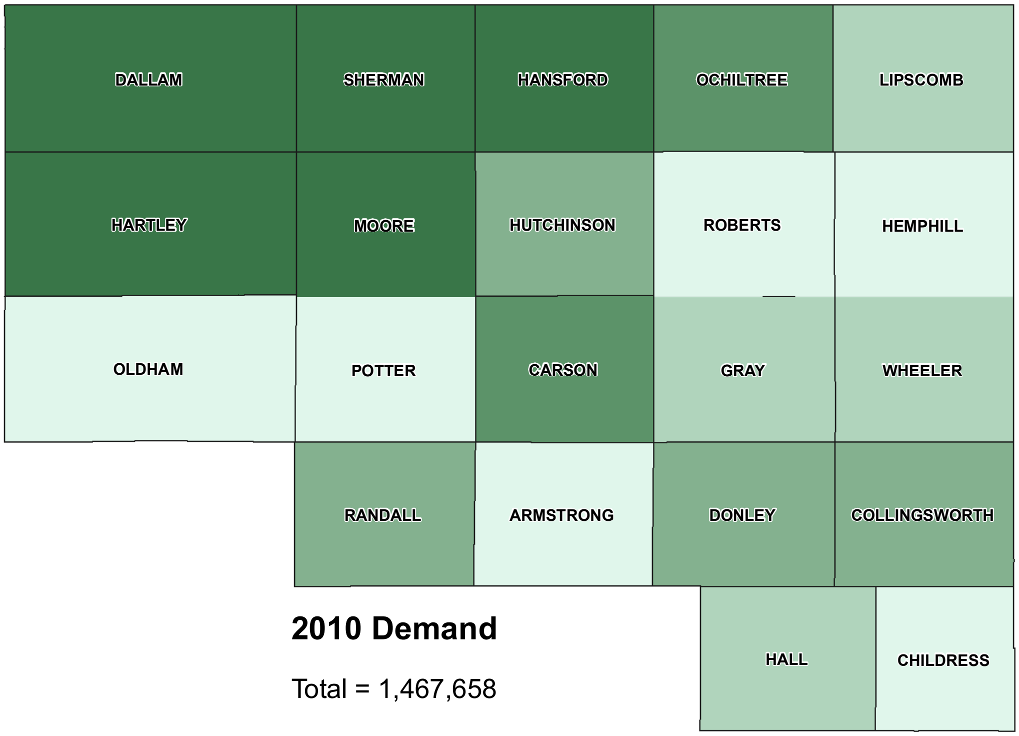
Irrigation water use accounts for the majority of the water used in the PWPA. Accurate estimates of current and projected water use can be difficult because historically most irrigation water is not metered. The methodology used to estimate irrigation water use is based on the number of irrigated acres, water use by crop type, effective rainfall received during the growing season, and seasonal usable soil moisture from the soil profile. Projections of annual future water use are made using planted irrigated acreage (pia) and the long-term averages for rainfall and potential evapotranspiration (PET) by county.

Changes to the crop mix and acreages can have a significant impact to projected irrigation water use. As part of the scope of work for the update to the Panhandle Regional Water Plan, facility at the Texas AgriLife Research and Extension Center in Amarillo (Texas AgriLife) conducted a review and update to the agricultural demands in the PWPA. The report is provided in Appendix C.

The updated study shows a reduction in agricultural demands across the region from the 2006 water plan, including both irrigation and livestock water demands. Much of the reduced irrigation water demands are due to fewer irrigated acres, of which most is associated with wheat. This difference may be in part due to an error in the irrigated acreages for wheat that was used for the 2006 regional water plan. Several counties also showed shifts in crop type, with significant acreage shifts in the counties of Hutchison, Moore, Ochiltree, Roberts and Sherman.

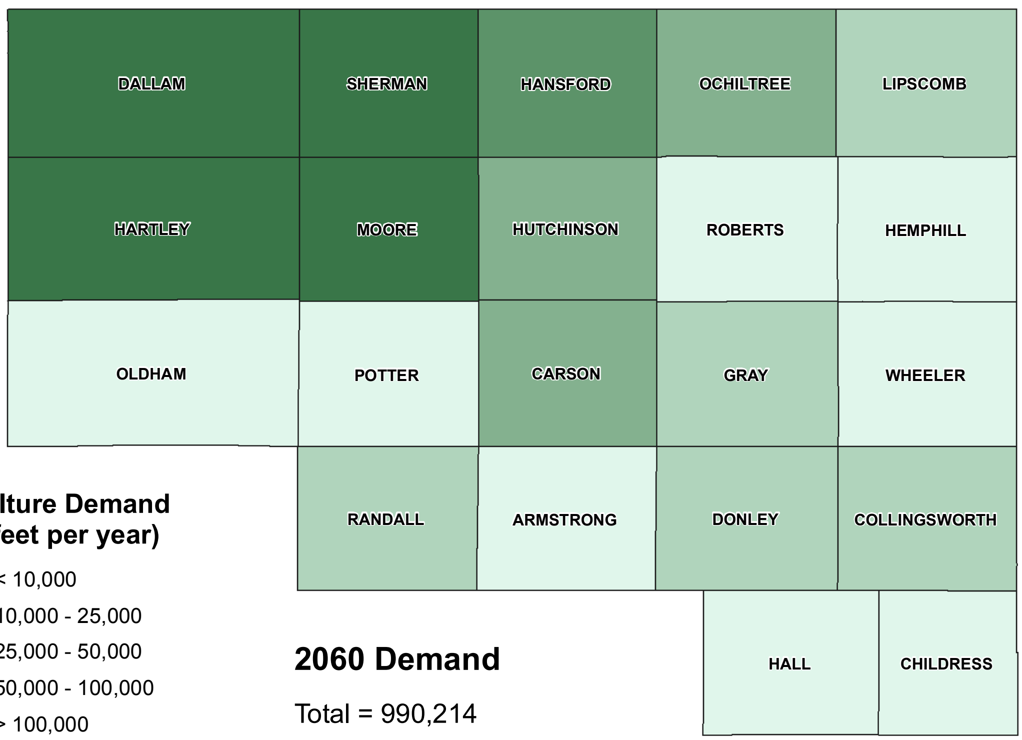
Considering the current irrigated acreages by crop type, irrigation equipment, energy prices for irrigation wells, and the shifts in crop demands, the irrigation water demands for 2010 in the PWPA are projected to be 1.43 million acre-feet per year. This is a reduction of about 222,000 acre-feet per year from the 2006 regional water plan. As with the 2006 plan, irrigated water needs are projected to decline over time due to increases in conservation and conversion of acreages to other uses. By 2060, the updated irrigation water demands are projected to be 937,000 acre-feet per year.

The results of the evaluation and modeling efforts represent water use based on best available current data. The irrigation water use projections should be verified during the next round of planning as more metered water data become available and to reflect changes in the farming community due to new technologies, economic considerations, or crop acreages. Figure 2-12 show the total projected irrigation water demand in the PWPA.



2010 Demand

Total = 1,467,658

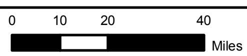


Agriculture Demand (Acre-feet per year)

- < 10,000
- 10,000 - 25,000
- 25,000 - 50,000
- 50,000 - 100,000
- > 100,000

2060 Demand

Total = 990,214



DATE: JANUARY 2010

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DATUM & COORDINATE SYSTEM: GCS NORTH AMERICAN 1983

PREPARED BY: DLB

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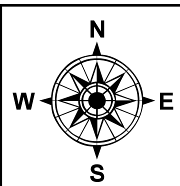


PANHANDLE WATER PLANNING AREA

PROJECTED AGRICULTURE PWPA WATER DEMAND BY COUNTY

Location Map

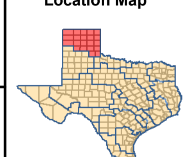
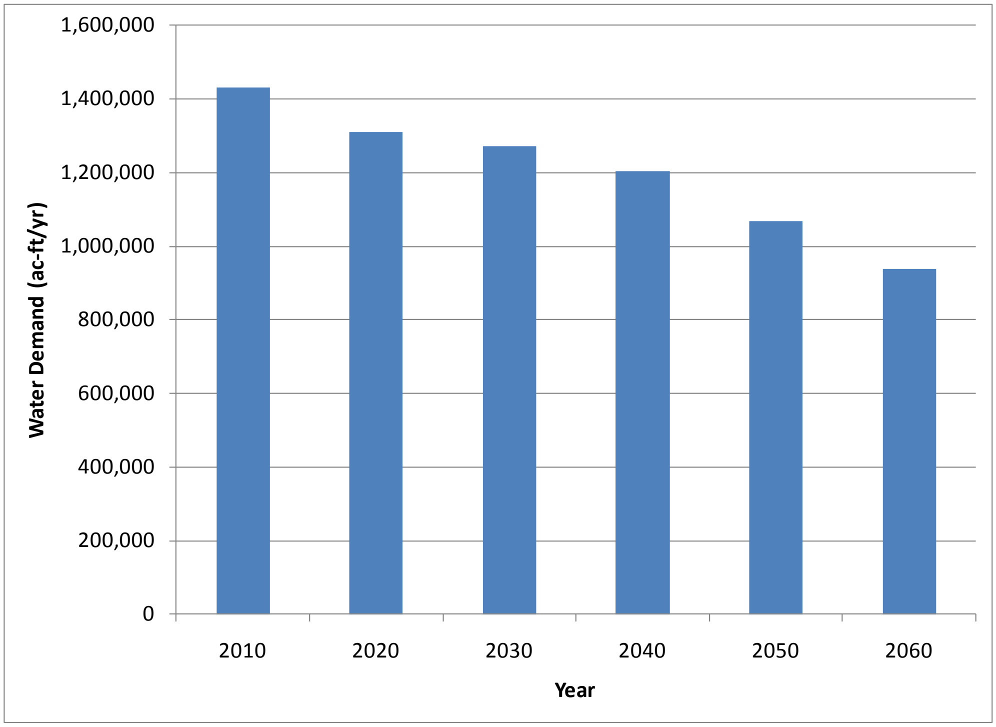


FIGURE 2-11

Figure 2-12: Projected Water Use for Irrigation in the PWPA



2.2.3.2 <u>Livestock Water Demands</u>

Livestock water use is part of the total agricultural demand in the PWPA. While comprising only about 2 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 AgriLife. The report is included in Appendix C.

New projections developed by Texas 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 three advisory committees consisting of industry experts and local stakeholders.

Inventories of current livestock production, along with estimates of water use by species, result in an estimated livestock use of 37,668 acre-feet in 2010 and increasing to 53,285 acre-feet per year by 2060. The updated livestock water use estimates are significantly less (70%) than projected in the 2006 regional water plan. This is mainly due to reductions in the previous swine projections and changes in water use by species. The largest livestock water use group is the fed cattle industry with an annual usage of about 26,000 acre-feet per year by 2060. The forecasted expansion of the dairy industry results in a water usage estimate by 2060 of just over 10,000 acre-feet per year. These two user groups account for 68 percent of projected livestock water use in 2060. The swine industry is the third largest water user group with a projected annual water use of nearly 6,000 acre-feet per year in 2060. Overall, water use in the PWPA livestock sector is predicted to increase 40 percent from 2000 to 2060.

Figure 2-13 shows the projected livestock demand in the PWPA. Figure 2-14 illustrates the water demand by major livestock category for the planning period. Detailed livestock population and water demand data is contained in the Texas AgriLife report in Appendix C.

Figure 2-13: Projected Livestock Water Demands for PWPA

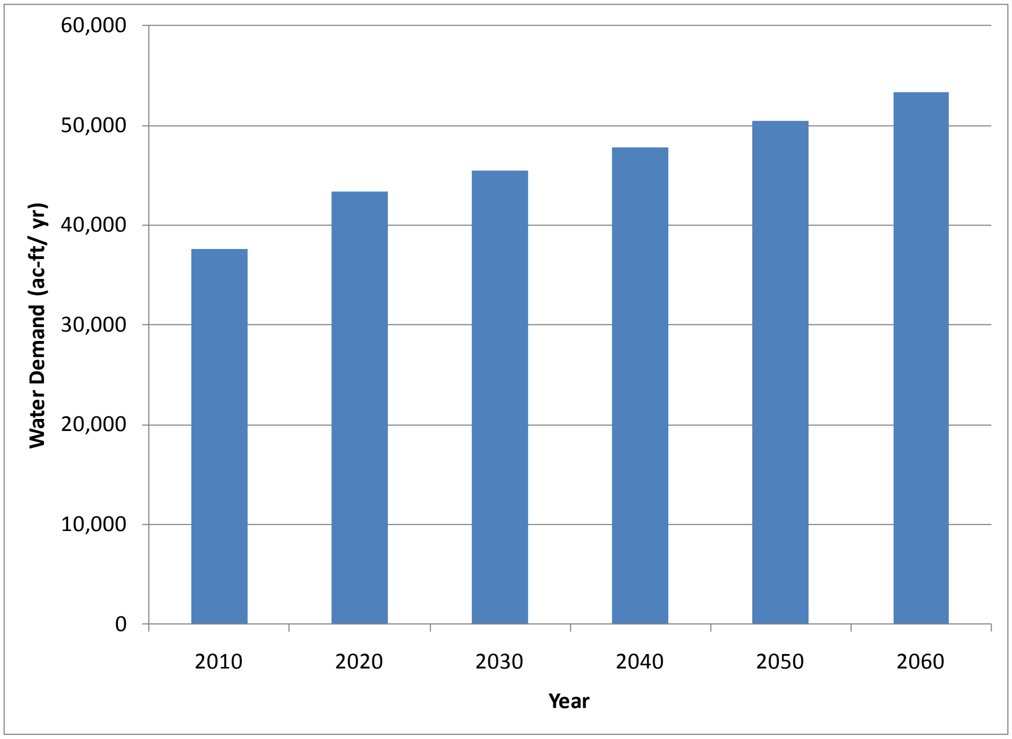
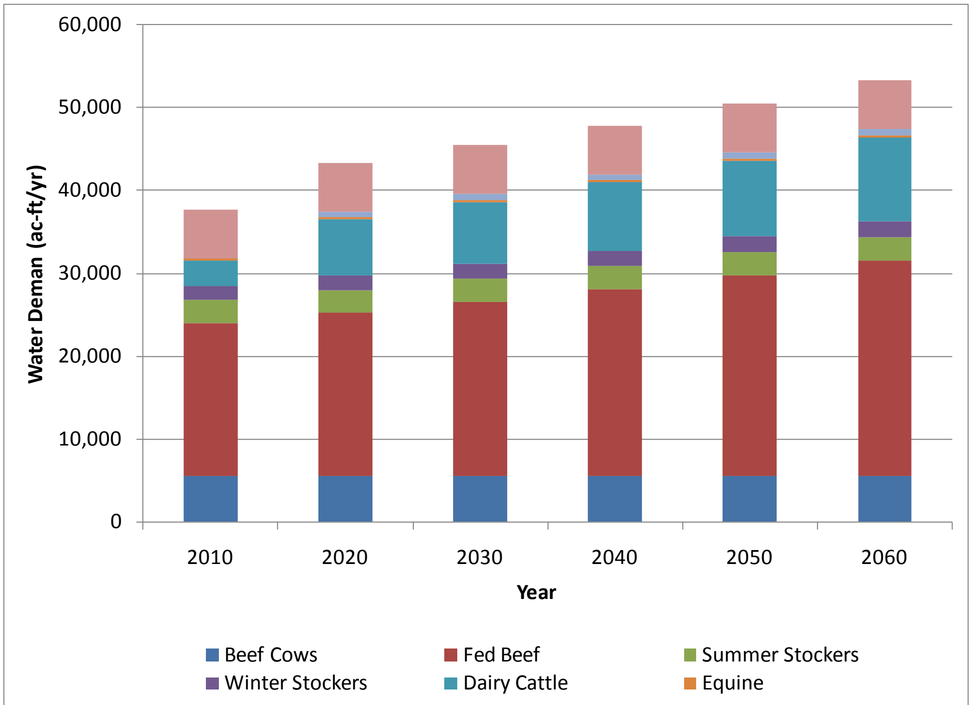


Figure 2-14: Projected Livestock Water Demands by Animal Category



2.2.3.3 <u>Uncertainty in Agricultural Demand Projections</u>

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. In just the last five years, the region has seen a significant shift from the expansion of the hog industry to the dairy industry. This not only affects the water use by that industry, but has significant impacts on the crop mix in the PWPA to support this shift. 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.

With the changing economic and political climate, governmental programs are also changing. The 2008 Farm Bill reduced the maximum number of acres that could be enrolled in the Conservation Reserve Program (this program pays landowners to take acreage out of agricultural production). As a result, over 1.2 million acres of farmland in the High Plains could potentially be coming out of the Conservation Reserve Program by October 2010. Not all of this acreage is located in the PWPA and some of the acreage will not be put back into production, but the potential exists to impact future agricultural water demands. Additional study will be needed for or prior to the 2016 regional water plan to assess the potential impacts of this additional acreage on water demands in the PWPA.

2.3 Wholesale Water Providers

The category of Wholesale Water Provider (WWP) was created to include major providers of water for municipal and industrial use in the regional planning process. The PWPG has designated seven WWPs in the region. These include the Canadian River Municipal Water Authority (CRMWA), cities of Amarillo, Borger, and Cactus, Mesa Water, Inc., Greenbelt Municipal and Industrial Water Authority (Greenbelt M&IWA) and Palo Duro River Authority (PDRA). Descriptions of each of these wholesale water providers are provided in Section 1.4 of this plan.

Of the seven wholesale water providers, Mesa Water Inc. and PDRA are not currently providing water to customers but each of these entities expect to provide wholesale water during the planning period. CRMWA and Greenbelt M&IWA 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 M&IWA provides water to customers in Region B.

Table 2-2 shows the total sales for each wholesale water provider that provided water in 2006 and 2007.

Table 2-2 Historical Sales for Wholesale Water Providers
(Values are in Acre-feet per year)

	2006 Total Water Sales	2007 Total Water Sales
City of Amarillo[1]	66,905	57,258
Greenbelt M & IWA	4,424	3,865
CRMWA	81,962	71,106
City of Borger	7,896	9,510
City of Cactus	2,417	3,317

1. Sales from Amarillo include sales of reuse water to Xcel Energy.

2.3.1 City of Amarillo

In 2010, the City of Amarillo is projected to provide 70,456 acre-feet of water for municipal use by the City of Amarillo, the City of Canyon, Texas Parks and Wildlife Department (Palo Duro State Park), and industrial use by ASARCO, IBP, Inc., and Xcel Energy. Most of the water from Amarillo to Xcel Energy in 2010 is treated wastewater, and after 2010 all of Xcel Energy's demands will be supplied through reuse. By 2060, Amarillo is expected to provide approximately 102,849 acre-feet per year to existing customers. Most of the increase in projected demand on Amarillo is associated with growth of the city and local manufacturing needs. As the surrounding County-Other in Potter and Randall Counties continue to grow, additional demands may be placed on Amarillo.

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

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Amarillo	42,329	45,817	49,079	52,794	56,848	60,188
Manufacturing - Potter County	6,516	7,169	7,721	8,260	8,726	9,367
City of Canyon	1,000	1,000	1,000	1,000	1,000	1,000
Manufacturing - Randall County	300	300	300	300	300	300
Palo Duro State Park	25	25	25	25	25	25
Steam Electric Power	20,286	23,241	24,658	26,262	27,865	31,969
Total Demand	**70,456**	**77,552**	**82,783**	**88,641**	**94,764**	**102,849**

2.3.2 Greenbelt Municipal and Industrial Water Authority (Greenbelt M&IWA)

Greenbelt M&IWA 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 60 percent of the current demand on Greenbelt M&IWA is to 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. Demand projections for Greenbelt M&IWA were developed based on each recipient's projected water demand and the percentage of the historical water demands that the Greenbelt M&IWA had supplied. The demand on Greenbelt M&IWA is expected to remain about the same through the planning period.

Table 2-4 Projected Water Demands for Greenbelt M&IWA

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Childress	1,457	1,481	1,502	1,509	1,510	1,471
City of Chillicothe	61	55	53	51	50	49
City of Clarendon	440	440	440	440	440	440
City of Crowell	332	317	302	289	280	269
City of Memphis	100	100	100	100	100	100
Childress County-Other	196	199	202	203	203	198
Donley County-Other	219	210	191	171	154	128
Foard County-Other	68	68	68	68	68	68
Hall County-Other	152	152	152	152	152	152
Hardeman County-Other	210	210	210	210	210	210
Hardeman County Manufacturing	449	478	509	542	576	576
City of Quanah	652	612	589	544	511	463
Wilbarger County-Other	6	6	6	6	6	6
Total	**4,342**	**4,328**	**4,324**	**4,285**	**4,260**	**4,130**

2.3.3 Canadian River Municipal Water Authority (CRMWA)

CRMWA is the largest wholesale water provider in the PWPA. In 2006 CRMWA supplied nearly 82,000 acre-feet of water to customers in the PWPA and Region O. CRMWA delivers water to Amarillo, Borger, and Pampa in the PWPA and to eight cities in Region O, including Lubbock. Projected water demands on CRMWA through the planning period are anticipated to hold steady at approximately 100,000 acre-feet per year.

Table 2-5 Projected Water Demands for CRMWA

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
PWPA:						
City of Pampa	3,300	3,273	3,182	3,058	2,871	2,689
City of Borger	4,000	5,510	5,510	5,510	5,510	5,510
City of Amarillo	42,987	42,987	42,987	42,987	42,987	42,987
Region O:						
City of Lamesa	2,528	2,528	2,528	2,528	2,328	2,328
City of O'Donnell	322	322	322	322	292	292
City of Plainview	4,281	4,281	4,281	4,281	3,881	3,881
City of Levelland	3,236	3,236	3,236	3,236	2,808	2,808
City of Lubbock	32,000	34,000	34,000	34,000	32,000	32,000
City of Slaton	1,369	1,369	1,369	1,369	1,369	1,369
City of Tahoka	534	534	534	534	460	460
City of Brownfield	2,549	2,549	2,549	2,549	2,549	2,549
Total	**97,106**	**100,589**	**100,498**	**100,374**	**97,055**	**96,873**

2.3.4 City of Borger

The City of Borger provides wholesale water to industrial customers in Hutchinson and Carson Counties and retail services to its city customers and Hutchinson County-Other. Currently, the industrial demands on Borger total about 6 MGD, which accounts for about 25 percent of the manufacturing demand in Hutchinson County (assuming a peaking factor of 1.25). It is expected that Borger will continue to provide water for 25 percent of the projected manufacturing demands. The City also provides water to a carbon plant in Carson County. Borger has a contract to supply water to TCW Supply. This contract is met through a complex agreement of trading water supplies with several of its industrial customers such that the net demand on the City of Borger is zero.

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

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Borger	2,352	2,384	2,351	2,274	2,148	2,039
Manufacturing - Hutchinson Co.	5,910	6,370	6,740	7,100	7,410	7,930
Manufacturing Carson Co.	450	450	450	450	450	450
Hutchinson County-Other	56	57	57	55	52	49
TCW Supply	0	0	0	0	0	0
Total Demand	**8,768**	**9,261**	**9,598**	**9,879**	**10,060**	**10,468**

2.3.5 City of Cactus

The City of Cactus provides wholesale water to manufacturers in Moore County and retail water to its municipal customers. The City has a contract for 3.2 MGD with a meat packing plant in Moore County and also provides water to the Etter Community outside the city limits. In 2007 the City supplied over 750 acre-feet of water for municipal purposes.

Table 2-7 Projected Water Demands for the City of Cactus

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Cactus	533	615	615	615	615	615
Moore County-Other	70	96	126	151	165	174
Moore County Manufacturing	2,758	2,958	3,120	3,280	3,421	3,587
Total Demand	**3,361**	**3,669**	**3,861**	**4,046**	**4,201**	**4,376**

ATTACHMENT 2-1

TWDB Population and Demand Projections

Texas Water Development Board
2011 Regional Water Plan Population Projections for 2000 - 2060
Region A Panhandle

WATER USER GROUP	COUNTY NAME	P2000 [1)]	P2010	P2020	P2030	P2040	P2050	P2060
CLAUDE	ARMSTRONG	1,313	1,327	1,369	1,322	1,268	1,255	1,219
COUNTY-OTHER	ARMSTRONG	835	844	871	841	806	798	775
	ARMSTRONG Total	**2,148**	**2,171**	**2,240**	**2,163**	**2,074**	**2,053**	**1,994**
COUNTY-OTHER	CARSON	1,178	1,182	1,195	1,186	1,147	1,043	947
GROOM	CARSON	587	589	595	591	572	520	472
HI TEXAS WATER COMPANY	CARSON	492	494	499	495	479	435	395
PANHANDLE	CARSON	2,589	2,599	2,626	2,605	2,521	2,291	2,081
SKELLYTOWN	CARSON	610	612	619	614	594	540	490
WHITE DEER	CARSON	1,060	1,065	1,076	1,066	1,032	938	852
	CARSON Total	**6,516**	**6,541**	**6,610**	**6,557**	**6,345**	**5,767**	**5,237**
CHILDRESS	CHILDRESS	6,778	6,918	7,033	7,132	7,167	7,170	6,987
COUNTY-OTHER	CHILDRESS	910	929	944	958	962	963	938
	CHILDRESS Total	**7,688**	**7,847**	**7,977**	**8,090**	**8,129**	**8,133**	**7,925**
COUNTY-OTHER	COLLINGSWORTH	931	895	898	842	766	709	613
WELLINGTON	COLLINGSWORTH	2,275	2,239	2,241	2,187	2,114	2,058	1,965
	COLLINGSWORTH Total	**3,206**	**3,134**	**3,139**	**3,029**	**2,880**	**2,767**	**2,578**
COUNTY-OTHER	DALLAM	1,063	1,170	1,262	1,320	1,334	1,306	1,245
DALHART	DALLAM	4,648	5,118	5,518	5,770	5,833	5,711	5,447
TEXLINE	DALLAM	511	563	607	634	641	628	599
	DALLAM Total	**6,222**	**6,851**	**7,387**	**7,724**	**7,808**	**7,645**	**7,291**
CLARENDON	DONLEY	1,974	1,974	1,974	1,974	1,974	1,974	1,974
COUNTY-OTHER	DONLEY	1,854	1,790	1,720	1,562	1,401	1,264	1,052
	DONLEY Total	**3,828**	**3,764**	**3,694**	**3,536**	**3,375**	**3,238**	**3,026**
COUNTY-OTHER	GRAY	3,468	3,379	3,354	3,259	3,132	2,941	2,755
LEFORS	GRAY	559	545	540	525	505	474	444
MCLEAN	GRAY	830	809	802	780	750	704	659
PAMPA	GRAY	17,887	17,430	17,292	16,807	16,155	15,167	14,206
	GRAY Total	**22,744**	**22,163**	**21,988**	**21,371**	**20,542**	**19,286**	**18,064**
COUNTY-OTHER	HALL	1,303	1,267	1,358	1,416	1,368	1,388	1,303
MEMPHIS	HALL	2,479	2,483	2,474	2,468	2,473	2,471	2,480
	HALL Total	**3,782**	**3,750**	**3,832**	**3,884**	**3,841**	**3,859**	**3,783**
COUNTY-OTHER	HANSFORD	1,186	1,388	1,663	1,898	2,152	2,301	2,433
GRUVER	HANSFORD	1,162	1,169	1,178	1,186	1,195	1,200	1,204
SPEARMAN	HANSFORD	3,021	3,142	3,307	3,448	3,601	3,690	3,769
	HANSFORD Total	**5,369**	**5,699**	**6,148**	**6,532**	**6,948**	**7,191**	**7,406**
COUNTY-OTHER	HARTLEY	2,948	3,033	3,135	3,189	3,208	3,168	3,006
DALHART	HARTLEY	2,589	2,664	2,754	2,800	2,818	2,782	2,640
	HARTLEY Total	**5,537**	**5,697**	**5,889**	**5,989**	**6,026**	**5,950**	**5,646**
CANADIAN	HEMPHILL	2,233	2,330	2,340	2,262	2,178	2,120	2,015
COUNTY-OTHER	HEMPHILL	1,118	1,166	1,171	1,132	1,091	1,061	1,009
	HEMPHILL Total	**3,351**	**3,496**	**3,511**	**3,394**	**3,269**	**3,181**	**3,024**
BORGER	HUTCHINSON	14,302	14,580	14,780	14,574	14,096	13,314	12,641
COUNTY-OTHER	HUTCHINSON	303	308	314	310	299	283	268
FRITCH	HUTCHINSON	2,226	2,269	2,300	2,268	2,194	2,072	1,968

Texas Water Development Board
2011 Regional Water Plan Population Projections for 2000 - 2060
Region A Panhandle

WATER USER GROUP	COUNTY NAME	P2000 [1)]	P2010	P2020	P2030	P2040	P2050	P2060
HI TEXAS WATER COMPANY	HUTCHINSON	3,020	3,079	3,121	3,077	2,976	2,811	2,669
STINNETT	HUTCHINSON	1,936	1,974	2,001	1,973	1,908	1,802	1,711
TCW SUPPLY INC	HUTCHINSON	2,070	2,110	2,139	2,109	2,040	1,927	1,830
	HUTCHINSON Total	**23,857**	**24,320**	**24,655**	**24,311**	**23,513**	**22,209**	**21,087**
BOOKER	LIPSCOMB	1,306	1,318	1,345	1,305	1,267	1,250	1,189
COUNTY-OTHER	LIPSCOMB	1,751	1,766	1,804	1,749	1,699	1,675	1,595
	LIPSCOMB Total	**3,057**	**3,084**	**3,149**	**3,054**	**2,966**	**2,925**	**2,784**
CACTUS	MOORE	2,538	2,600	3,000	3,000	3,000	3,000	3,000
COUNTY-OTHER	MOORE	1,877	3,307	4,534	5,970	7,110	7,805	8,223
DUMAS	MOORE	13,747	14,884	16,123	17,216	18,084	18,613	18,931
FRITCH	MOORE	9	21	34	45	54	59	62
SUNRAY	MOORE	1,950	2,237	2,550	2,826	3,045	3,178	3,258
	MOORE Total	**20,121**	**23,049**	**26,241**	**29,057**	**31,293**	**32,655**	**33,474**
BOOKER	OCHILTREE	9	9	9	9	9	9	9
COUNTY-OTHER	OCHILTREE	1,223	1,223	1,223	1,223	1,223	1,223	1,223
PERRYTON	OCHILTREE	7,774	8,453	9,208	9,769	10,148	10,334	10,571
	OCHILTREE Total	**9,006**	**9,685**	**10,440**	**11,001**	**11,380**	**11,566**	**11,803**
COUNTY-OTHER	OLDHAM	1,249	1,327	1,356	1,260	1,110	965	780
VEGA	OLDHAM	936	995	1,017	944	832	724	584
	OLDHAM Total	**2,185**	**2,322**	**2,373**	**2,204**	**1,942**	**1,689**	**1,364**
AMARILLO	POTTER	99,833	107,316	115,380	122,922	131,510	140,882	148,564
COUNTY-OTHER	POTTER	13,713	20,264	27,323	33,924	41,440	49,644	56,369
	POTTER Total	**113,546**	**127,580**	**142,703**	**156,846**	**172,950**	**190,526**	**204,933**
AMARILLO	RANDALL	73,794	80,688	88,117	95,065	102,976	111,611	118,760
CANYON	RANDALL	12,875	14,227	15,684	17,047	18,599	20,293	21,695
COUNTY-OTHER	RANDALL	16,783	21,446	26,471	31,169	36,520	42,359	47,194
HAPPY	RANDALL	35	66	100	132	168	207	239
LAKE TANGLEWOOD	RANDALL	825	993	1,174	1,344	1,537	1,748	1,923
	RANDALL Total	**104,312**	**117,420**	**131,546**	**144,757**	**159,800**	**176,218**	**189,811**
COUNTY-OTHER	ROBERTS	299	313	322	289	242	210	189
MIAMI	ROBERTS	588	617	633	568	477	412	372
	ROBERTS Total	**887**	**930**	**955**	**857**	**719**	**622**	**561**
COUNTY-OTHER	SHERMAN	1,195	1,297	1,405	1,447	1,490	1,528	1,547
STRATFORD	SHERMAN	1,991	2,172	2,365	2,439	2,515	2,582	2,617
	SHERMAN Total	**3,186**	**3,469**	**3,770**	**3,886**	**4,005**	**4,110**	**4,164**
COUNTY-OTHER	WHEELER	1,877	1,795	1,796	1,785	1,805	1,799	1,766
SHAMROCK	WHEELER	2,029	1,963	1,963	1,954	1,970	1,966	1,941
WHEELER	WHEELER	1,378	1,374	1,374	1,373	1,374	1,374	1,373
	WHEELER Total	**5,284**	**5,132**	**5,133**	**5,112**	**5,149**	**5,139**	**5,080**
	Region A Total	**355,832**	**388,104**	**423,380**	**453,354**	**484,954**	**516,729**	**541,035**

2011 Regional Water Plan
Municipal Water Demand Projections for 2010 - 2060 in acft
Region A

WATER USER GROUP	COUNTY NAME	D2010	D2020	D2030	D2040	D2050	D2060
CLAUDE	ARMSTRONG	262	270	261	250	247	240
COUNTY-OTHER	ARMSTRONG	109	112	108	104	103	100
	ARMSTRONG Total	**371**	**382**	**369**	**354**	**350**	**340**
COUNTY-OTHER	CARSON	256	259	258	249	227	206
GROOM	CARSON	142	143	142	138	125	114
HI TEXAS WATER COMPANY	CARSON	55	55	55	53	48	44
PANHANDLE	CARSON	574	579	575	556	506	459
SKELLYTOWN	CARSON	106	107	106	102	93	85
WHITE DEER	CARSON	164	165	164	159	144	130
	CARSON Total	**1,297**	**1,308**	**1,300**	**1,257**	**1,143**	**1,038**
CHILDRESS	CHILDRESS	1,457	1,481	1,502	1,509	1,510	1,471
COUNTY-OTHER	CHILDRESS	196	199	202	203	203	198
	CHILDRESS Total	**1,653**	**1,680**	**1,704**	**1,712**	**1,713**	**1,669**
COUNTY-OTHER	COLLINGSWORTH	234	234	220	200	185	160
WELLINGTON	COLLINGSWORTH	456	457	446	431	420	401
	COLLINGSWORTH Total	**690**	**691**	**666**	**631**	**605**	**561**
COUNTY-OTHER	DALLAM	181	195	204	206	202	192
DALHART	DALLAM	1,319	1,422	1,487	1,503	1,471	1,403
TEXLINE	DALLAM	211	227	237	240	235	224
	DALLAM Total	**1,711**	**1,844**	**1,928**	**1,949**	**1,908**	**1,819**
CLARENDON	DONLEY	440	440	440	440	440	440
COUNTY-OTHER	DONLEY	219	210	191	171	154	128
	DONLEY Total	**659**	**650**	**631**	**611**	**594**	**568**
COUNTY-OTHER	GRAY	511	507	493	473	444	417
LEFORS	GRAY	86	85	83	80	75	70
MCLEAN	GRAY	185	183	178	171	161	151
PAMPA	GRAY	3,300	3,273	3,182	3,058	2,871	2,689
	GRAY Total	**4,082**	**4,048**	**3,936**	**3,782**	**3,551**	**3,327**
COUNTY-OTHER	HALL	353	379	395	382	387	363
MEMPHIS	HALL	442	441	440	440	440	442
	HALL Total	**795**	**820**	**835**	**822**	**827**	**805**
COUNTY-OTHER	HANSFORD	266	319	364	412	441	466
GRUVER	HANSFORD	325	327	329	332	333	334
SPEARMAN	HANSFORD	707	745	776	811	831	849
	HANSFORD Total	**1,298**	**1,391**	**1,469**	**1,555**	**1,605**	**1,649**
COUNTY-OTHER	HARTLEY	523	541	550	553	546	519
DALHART	HARTLEY	686	710	721	726	717	680
	HARTLEY Total	**1,209**	**1,251**	**1,271**	**1,279**	**1,263**	**1,199**
CANADIAN	HEMPHILL	475	477	461	444	432	411
COUNTY-OTHER	HEMPHILL	158	159	153	148	143	137
	HEMPHILL Total	**633**	**636**	**614**	**592**	**575**	**548**
BORGER	HUTCHINSON	2,352	2,384	2,351	2,274	2,148	2,039
COUNTY-OTHER	HUTCHINSON	56	57	57	55	52	49
FRITCH	HUTCHINSON	407	412	406	393	371	353

2011 Regional Water Plan
Municipal Water Demand Projections for 2010 - 2060 in acft
Region A

WATER USER GROUP	COUNTY NAME	D2010	D2020	D2030	D2040	D2050	D2060
HI TEXAS WATER COMPANY	HUTCHINSON	341	346	341	330	312	296
STINNETT	HUTCHINSON	365	370	365	353	333	316
TCW SUPPLY INC	HUTCHINSON	603	611	602	583	550	523
	HUTCHINSON Total	**4,124**	**4,180**	**4,122**	**3,988**	**3,766**	**3,576**
BOOKER	LIPSCOMB	354	362	351	341	336	320
COUNTY-OTHER	LIPSCOMB	394	402	390	379	373	356
	LIPSCOMB Total	**748**	**764**	**741**	**720**	**709**	**676**
CACTUS	MOORE	533	615	615	615	615	615
COUNTY-OTHER	MOORE	700	960	1,264	1,505	1,652	1,741
DUMAS	MOORE	2,734	2,962	3,163	3,322	3,419	3,478
FRITCH	MOORE	4	6	8	10	11	11
SUNRAY	MOORE	534	608	674	727	758	777
	MOORE Total	**4,505**	**5,151**	**5,724**	**6,179**	**6,455**	**6,622**
BOOKER	OCHILTREE	2	2	2	2	2	2
COUNTY-OTHER	OCHILTREE	181	181	181	181	181	181
PERRYTON	OCHILTREE	1,960	2,135	2,265	2,353	2,396	2,451
	OCHILTREE Total	**2,143**	**2,318**	**2,448**	**2,536**	**2,579**	**2,634**
COUNTY-OTHER	OLDHAM	174	178	165	146	126	102
VEGA	OLDHAM	242	247	229	202	176	142
	OLDHAM Total	**416**	**425**	**394**	**348**	**302**	**244**
AMARILLO	POTTER	24,162	25,978	27,675	29,609	31,719	33,449
COUNTY-OTHER	POTTER	1,703	2,295	2,850	3,482	4,171	4,736
	POTTER Total	**25,865**	**28,273**	**30,525**	**33,091**	**35,890**	**38,185**
AMARILLO	RANDALL	18,167	19,839	21,404	23,185	25,129	26,739
CANYON	RANDALL	2,438	2,688	2,922	3,188	3,478	3,718
COUNTY-OTHER	RANDALL	2,715	3,351	3,945	4,623	5,361	5,973
HAPPY	RANDALL	11	17	22	27	33	38
LAKE TANGLEWOOD	RANDALL	160	189	217	248	282	310
	RANDALL Total	**23,491**	**26,084**	**28,510**	**31,271**	**34,283**	**36,778**
COUNTY-OTHER	ROBERTS	44	45	41	34	30	27
MIAMI	ROBERTS	145	149	134	112	97	88
	ROBERTS Total	**189**	**194**	**175**	**146**	**127**	**115**
COUNTY-OTHER	SHERMAN	218	236	243	250	257	260
STRATFORD	SHERMAN	628	683	705	727	746	756
	SHERMAN Total	**846**	**919**	**948**	**977**	**1,003**	**1,016**
COUNTY-OTHER	WHEELER	277	278	276	279	278	273
SHAMROCK	WHEELER	312	312	311	313	313	309
WHEELER	WHEELER	291	291	291	291	291	291
	WHEELER Total	**880**	**881**	**878**	**883**	**882**	**873**
	Region A Total	**77,605**	**83,890**	**89,188**	**94,683**	**100,130**	**104,242**

2011 Regional Water Plan
Irrigation Water Demand Projections for 2010 -2060 (in acft[1])
Region A

	2010	2020	2030	2040	2050	2060
ARMSTRONG	5,118	4,688	4,544	4,305	3,827	3,349
CARSON	58,775	49,230	47,982	45,457	36,368	35,355
CHILDRESS	7,418	5,519	5,350	5,068	4,505	3,942
COLLINGSWORTH	28,693	21,907	21,236	20,118	17,883	15,648
DALLAM	292,031	283,315	274,642	260,187	231,278	202,368
DONLEY	32,000	29,676	28,771	27,257	24,228	21,200
GRAY	22,705	20,410	19,785	18,744	16,661	14,578
HALL	16,719	10,731	10,403	9,855	8,760	7,665
HANSFORD	130,694	115,027	111,506	105,637	93,899	82,162
HARTLEY	294,932	281,648	273,026	258,657	229,917	201,177
HEMPHILL	1,825	1,705	1,653	1,566	1,392	1,218
HUTCHINSON	43,104	39,971	38,748	36,708	32,630	28,551
LIPSCOMB	16,956	15,546	15,070	14,277	12,690	11,104
MOORE	147,471	135,001	130,869	123,981	110,205	96,430
OCHILTREE	60,844	51,839	50,252	47,607	42,317	37,028
OLDHAM	4,235	3,914	3,794	3,594	3,195	2,795
POTTER	6,226	5,697	5,525	5,234	4,652	4,071
RANDALL	22,477	19,900	19,291	18,275	16,245	14,214
ROBERTS	6,084	5,639	5,466	5,179	4,603	4,028
SHERMAN	220,372	200,521	194,437	182,913	163,736	143,269
WHEELER	11,311	9,488	9,198	8,713	7,745	6,777
Region A Total	**1,429,990**	**1,311,372**	**1,271,548**	**1,203,332**	**1,066,736**	**936,929**

2011 Regional Water Plan
Livestock Water Demand Projections for 2010 -2060 (in acft[1])
Region A

	2010	2020	2030	2040	2050	2060
ARMSTRONG	566	670	673	677	681	685
CARSON	607	711	716	720	725	730
CHILDRESS	368	470	472	473	475	477
COLLINGSWORTH	461	564	566	569	571	574
DALLAM	3,509	4,654	4,996	5,373	5,788	6,246
DONLEY	1,267	1,268	1,270	1,271	1,273	1,275
GRAY	1,348	1,451	1,474	1,499	1,527	1,557
HALL	329	330	331	332	334	335
HANSFORD	3,683	3,956	4,256	4,586	4,948	5,346
HARTLEY	5,106	7,103	7,731	8,422	9,184	10,024
HEMPHILL	1,276	1,281	1,285	1,290	1,296	1,301
HUTCHINSON	685	689	698	708	720	732
LIPSCOMB	1,005	1,007	1,028	1,051	1,076	1,104
MOORE	2,831	3,605	3,931	4,290	4,685	5,120
OCHILTREE	3,367	3,463	3,605	3,761	3,932	4,119
OLDHAM	1,154	1,257	1,259	1,262	1,265	1,267
POTTER	502	504	505	507	509	511
RANDALL	2,732	2,741	2,756	2,772	2,789	2,808
ROBERTS	385	385	386	387	388	388
SHERMAN	4,933	5,579	5,889	6,230	6,606	7,019
WHEELER	1,554	1,657	1,660	1,662	1,664	1,667
Region A Total	**37,668**	**43,345**	**45,487**	**47,842**	**50,436**	**53,285**

2011 Regional Water Plan
Manufacturing Water Demand Projections for 2010 -2060 (in acft[1])
Region A

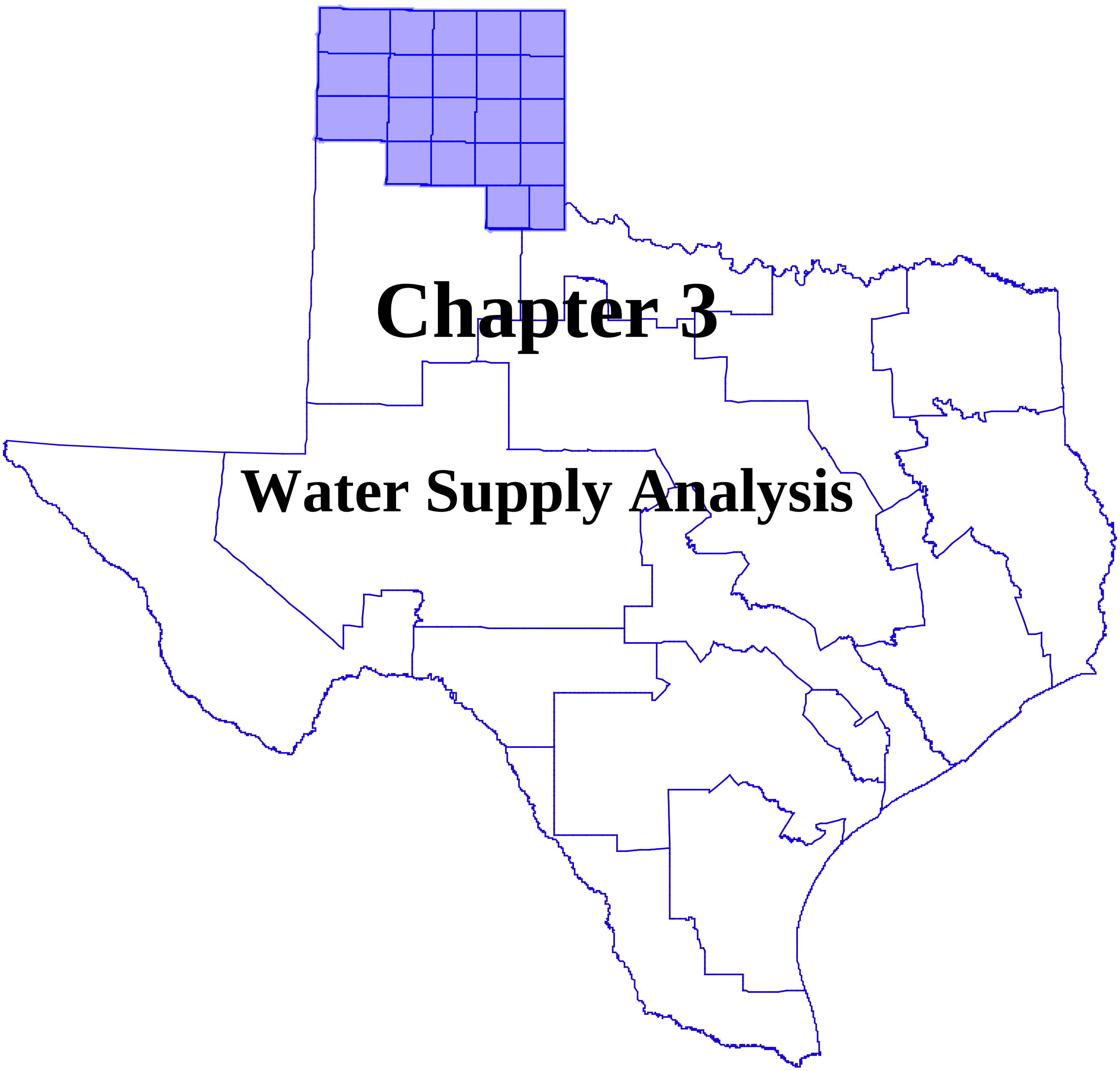
	2010	2020	2030	2040	2050	2060
ARMSTRONG	0	0	0	0	0	0
CARSON	591	669	735	797	849	920
CHILDRESS	0	0	0	0	0	0
COLLINGSWORTH	0	0	0	0	0	0
DALLAM	0	0	0	0	0	0
DONLEY	0	0	0	0	0	0
GRAY	4,264	4,383	4,451	4,497	4,515	4,334
HALL	0	0	0	0	0	0
HANSFORD	49	52	54	56	58	62
HARTLEY	5	5	5	5	5	5
HEMPHILL	1	1	1	1	1	1
HUTCHINSON	23,659	25,482	26,969	28,399	29,640	31,708
LIPSCOMB	89	95	100	104	108	116
MOORE	7,879	8,450	8,914	9,371	9,773	10,436
OCHILTREE	0	0	0	0	0	0
OLDHAM	0	0	0	0	0	0
POTTER	6,788	7,468	8,043	8,604	9,090	9,757
RANDALL	605	670	726	778	821	892
ROBERTS	0	0	0	0	0	0
SHERMAN	0	0	0	0	0	0
WHEELER	0	0	0	0	0	0
Region A Total	**43,930**	**47,275**	**49,998**	**52,612**	**54,860**	**58,231**

2011 Regional Water Plan
Mining Water Demand Projections for 2010 -2060 (in acft[1])
Region A

	2010	2020	2030	2040	2050	2060
ARMSTRONG	13	12	12	12	12	12
CARSON	1,461	1,412	1,393	1,376	1,360	1,339
CHILDRESS	17	16	16	16	16	16
COLLINGSWORTH	0	0	0	0	0	0
DALLAM	0	0	0	0	0	0
DONLEY	15	14	14	14	14	14
GRAY	1,929	1,999	2,028	2,056	2,083	2,118
HALL	15	14	14	14	14	14
HANSFORD	543	533	529	525	521	516
HARTLEY	0	0	0	0	0	0
HEMPHILL	2,575	2,575	2,314	1,844	1,479	1,183
HUTCHINSON	398	393	394	395	396	396
LIPSCOMB	1,235	1,235	1,114	887	713	574
MOORE	700	700	630	567	510	459
OCHILTREE	1,148	1,148	1,027	818	661	522
OLDHAM	328	341	347	352	357	364
POTTER	329	367	392	417	442	462
RANDALL	18	19	20	21	22	23
ROBERTS	1,270	1,270	1,148	922	731	592
SHERMAN	17	16	16	16	16	16
WHEELER	2,001	2,001	1,810	1,444	1,148	922
Region A Total	**14,012**	**14,065**	**13,218**	**11,696**	**10,495**	**9,542**

2011 Regional Water Plan
Steam Electric Water Demand Projections for 2010 -2060 (in acft[1])
Region A

	2010	2020	2030	2040	2050	2060
ARMSTRONG	0	0	0	0	0	0
CARSON	0	0	0	0	0	0
CHILDRESS	0	0	0	0	0	0
COLLINGSWORTH	0	0	0	0	0	0
DALLAM	0	0	0	0	0	0
DONLEY	0	0	0	0	0	0
GRAY	2,507	1,409	2,112	2,299	2,952	3,087
HALL	0	0	0	0	0	0
HANSFORD	0	0	0	0	0	0
HARTLEY	0	0	0	0	0	0
HEMPHILL	0	0	0	0	0	0
HUTCHINSON	0	0	0	0	0	0
LIPSCOMB	0	0	0	0	0	0
MOORE	200	200	200	200	200	213
OCHILTREE	0	0	0	0	0	0
OLDHAM	0	0	0	0	0	0
POTTER	22,432	25,387	26,804	28,408	30,011	34,115
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
Region A Total	**25,139**	**26,996**	**29,116**	**30,907**	**33,163**	**37,415**



Chapter 3

Water Supply Analysis

3.1 EVALUATION OF REGIONAL WATER SUPPLIES

This chapter of the regional water plan 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. This section focuses on the first component: availability by source. Section 3.2 discusses the availability of supplies to water user groups, and Section 3.3 provides a comparison of these supplies to the projected demands.

In the Panhandle Region water comes from groundwater, surface water sources such as reservoirs and river diversions, reuse of treated wastewater effluent, and local supplies such as stock ponds. Most of the region's water is obtained from groundwater. Groundwater sources which are identified in this chapter include two major (Ogallala and Seymour) and three minor aquifers (Blaine, Dockum, and Rita Blanca). The major surface water reservoirs include Lake Meredith, Palo Duro Reservoir and Greenbelt Reservoir.

Senate Bill 2 (SB2) and Texas Water Development Board (TWDB) guidelines require that Groundwater Availability Models (GAMs) are to be used to determine available groundwater supplies, unless more site specific information is available. The GAM program, whose development was overseen by the TWDB, has completed several groundwater models for major aquifers in Texas including both the northern and southern Ogallala aquifer models. In addition, GAMs have been developed for the Seymour, Blaine and Dockum aquifers. The TWDB is still reviewing the Dockum aquifer GAM and availabilities calculated for the Dockum in this plan are based on data reported in published reports.

In addition to the State's GAM program, Texas is currently utilizing a Joint Planning effort for groundwater. Under this new planning effort, the State has created 16 Groundwater Management Areas (GMAs), of which two GMAs (GMA 1 and GMA 6) are located within the PWPA. The GMAs are tasked with identifying the desired future conditions for aquifers within their geographical area. The desired future conditions are the basis for determining the Managed Available Groundwater (MAG) values. The Texas Water Code requires that by 2016 the regional water planning groups rely on the MAG values as the amount of available water by aquifer source. The GMAs have been diligently working toward the statutory deadline of September 2010 to adopt desired future conditions. Desired future conditions adopted after September 10, 2008 are not required to be utilized in the 2011 regional water plans. On July 7, 2009, GMA 1 adopted desired future conditions for the Ogallala and Rita Blanca aquifers. As of December 2009, the MAG values for the Ogallala/Rita Blanca aquifers had not been determined and the desired future conditions for the other aquifers in the PWPA had not been adopted. In light of the on-going nature of this process, the PWPG adopted approaches for determining available groundwater supplies, which will be used for this water plan. MAG estimates as determined by the TWDB and adopted by the GMAs will be incorporated in the 2016 regional water plans.

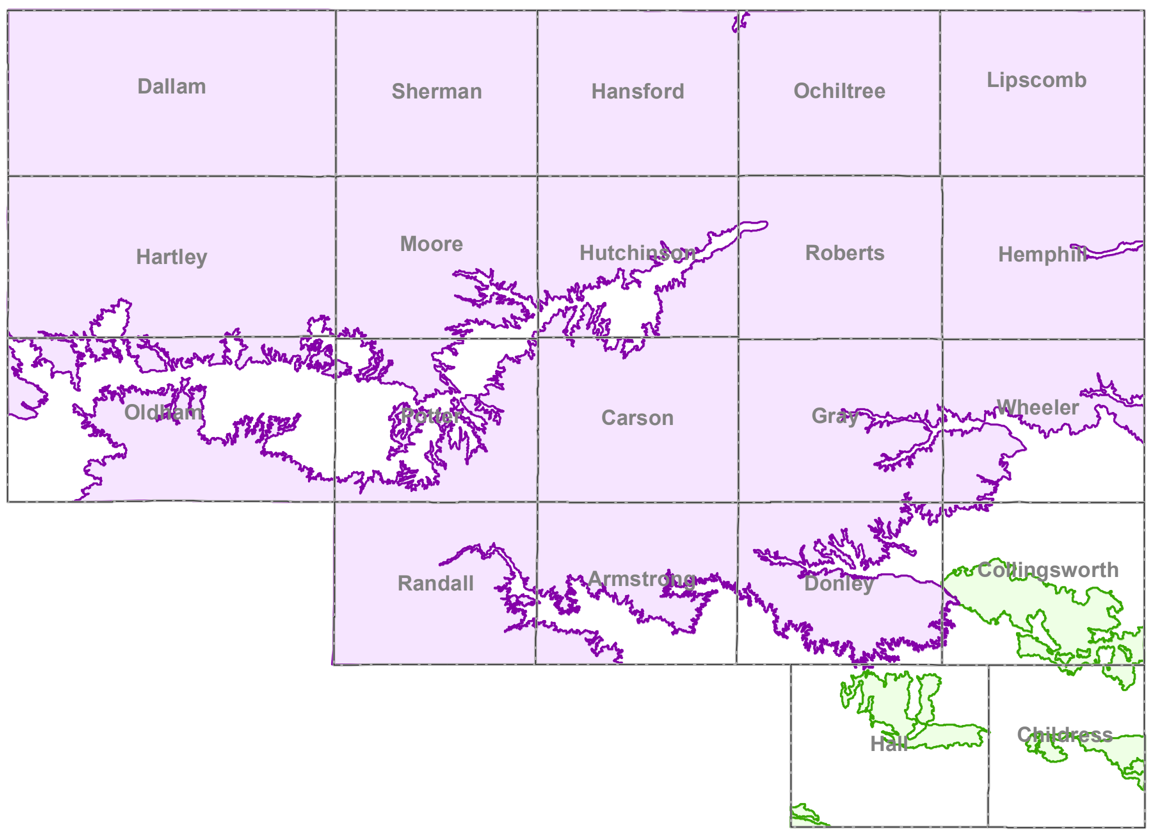
Available surface water supplies were determined using TCEQ-approved Water Availability Models (WAMs). WAMs have been developed for each of the river basins in Texas. Because the WAMs were developed for the purpose of reviewing and granting new surface water rights permits, the assumptions in the WAMs are based upon the legal interpretation of water rights and sometimes do not accurately reflect current hydrologic operation. WAM Run 3, which is the version required for planning, assumes full permitted diversions by all water rights and no return flows unless return flows are specifically included in the water right. Availabilities for each water right are analyzed in priority date order, with water rights with the earliest permit date diverting first. Run 3 also does not include agreements or operations that are not reflected in the water rights permits and does not account for reductions in reservoir storage capacities due to sediment accumulation. For planning purposes, adjustments were made to the WAMs to better reflect current and future surface water conditions in the region. Further discussion of surface water availability is in Section 3.1.3.

3.1.1 Groundwater Supplies

In the previous round of planning, the PWPG adopted an approach to define groundwater supplies for the aquifers within the region to no more than an annual 1.25% withdrawal of current saturated thickness of the aquifer with a 5-year recalculation of the saturated thickness remaining. Subsequent to the development of the 2006 regional water plan, the Groundwater Management Area #1 (GMA 1) adopted desired future conditions (DFCs) for the Ogallala/ Rita Blanca aquifer. The adopted DFCs include management goals to have 40 percent of the aquifer storage remaining in 50 years for the four western counties (Dallam, Hartley, Sherman and Moore Counties), 80 percent of the storage remaining in Hemphill County, and 50 percent of the storage remaining in the other counties in the GMA. After much consideration by the PWPG, the management policy adopted by GMA 1 is being utilized as the basis for the groundwater availability for the Ogallala and Rita Blanca aquifer for this plan. The 1.25% annual withdrawal is the basis for groundwater availability for the other aquifers in the Panhandle area.

Two major aquifers, the Ogallala and Seymour (Figure 3-1), and three minor aquifers, the Blaine, Dockum, and Rita Blanca (Figure 3-2) supply the majority of all water uses in the PWPA. The Ogallala aquifer supplies the predominant share of groundwater, with additional supplies obtained from the remaining aquifers.

The availability of water from the Northern Ogallala/Rita Blanca aquifer was determined using the Northern Ogallala Groundwater Availability Model (GAM) (Dutton, Reedy and Mace, 2001; Dutton 2004), henceforth referred to as the 2004 Dutton GAM (see Appendix D). Availability was calculated on a one-square mile basis, and pumping was adjusted annually to meet the target goals. The source availability was summed for each county/basin. For counties that are partially located in the Southern Ogallala GAM (Oldham, Potter, Randall and Armstrong Counties), the availabilities determined for the 2006 water plan from the Southern Ogallala GAM areas were used. Each of these counties fall under the goal of having 50 percent storage remaining, which is consistent with the annual 1.25 percent depletion that was used in the 2006 plan. The volumes of water available from the Seymour and Blaine aquifers were determined using the GAM analyses conducted for the 2006 plan. For the Seymour and Blaine aquifers, recharge was also considered in the availability calculations. Available supplies of water from the Dockum aquifer were determined using estimates of saturated thickness, specific yield, and recharge rates from historical studies and published reports.



Legend

County

Major Aquifer

OGALLALA

SEYMOUR

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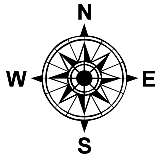

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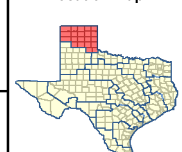
PANHANDLE WATER PLANNING AREA

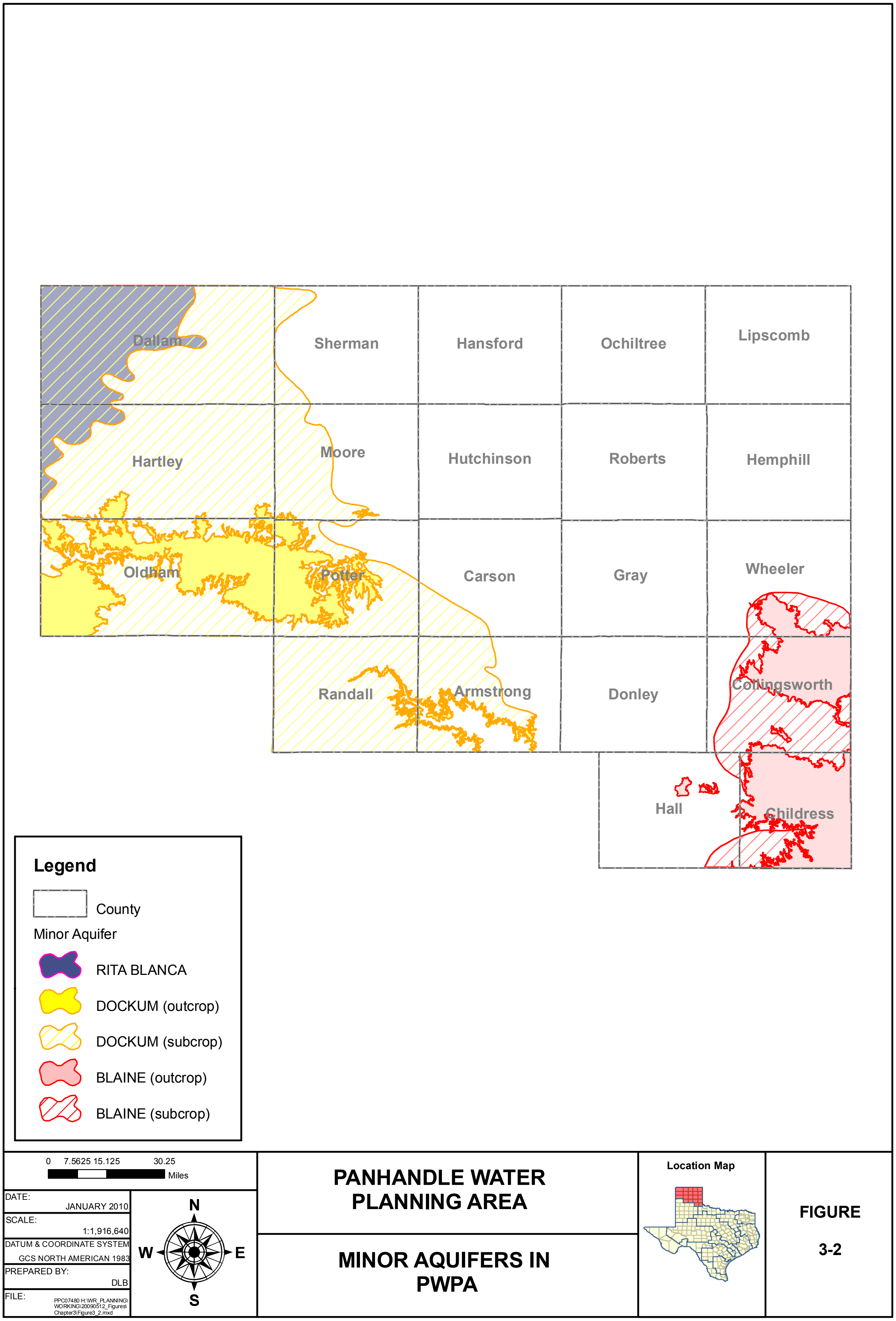
MAJOR AQUIFERS IN PWPA

Location Map



FIGURE

3-1



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PANHANDLE WATER PLANNING AREA

MINOR AQUIFERS IN PWPA

FIGURE 3-2

As part of this planning effort additional data was collected to refine the Northern Ogallala GAM. A special study by the Bureau of Economic Geology was conducted to assess the recharge values in Roberts and Hemphill Counties. (See Appendix E). The findings of this study were incorporated into the update of the Northern Ogallala GAM. Other data updates include, but are not limited to, refinements of the red bed data, pumping locations, and historical pumping quantities. Further discussion of the GAM update and potential impacts to available supplies is presented in Section 3.1.2.

<u>Ogallala Aquifer</u>

The Ogallala aquifer is present in all counties in the PWPA except for Childress and Hall counties and is the region's largest source of water. 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 and water generally does not move through the aquifer as freely as some other major aquifers in the state. Estimates of storage volumes in the Ogallala using the management assumptions adopted by the PWPG for this plan are presented in Table 3-1. Table 3-2 shows the estimates of theoretical annual availability based on the PWPG adopted approach. Figure 3-3 shows the available storage by county.

Table 3-1: Total Water in Storage in the Ogallala/Rita Blanca Aquifer

(Values in ac-ft)

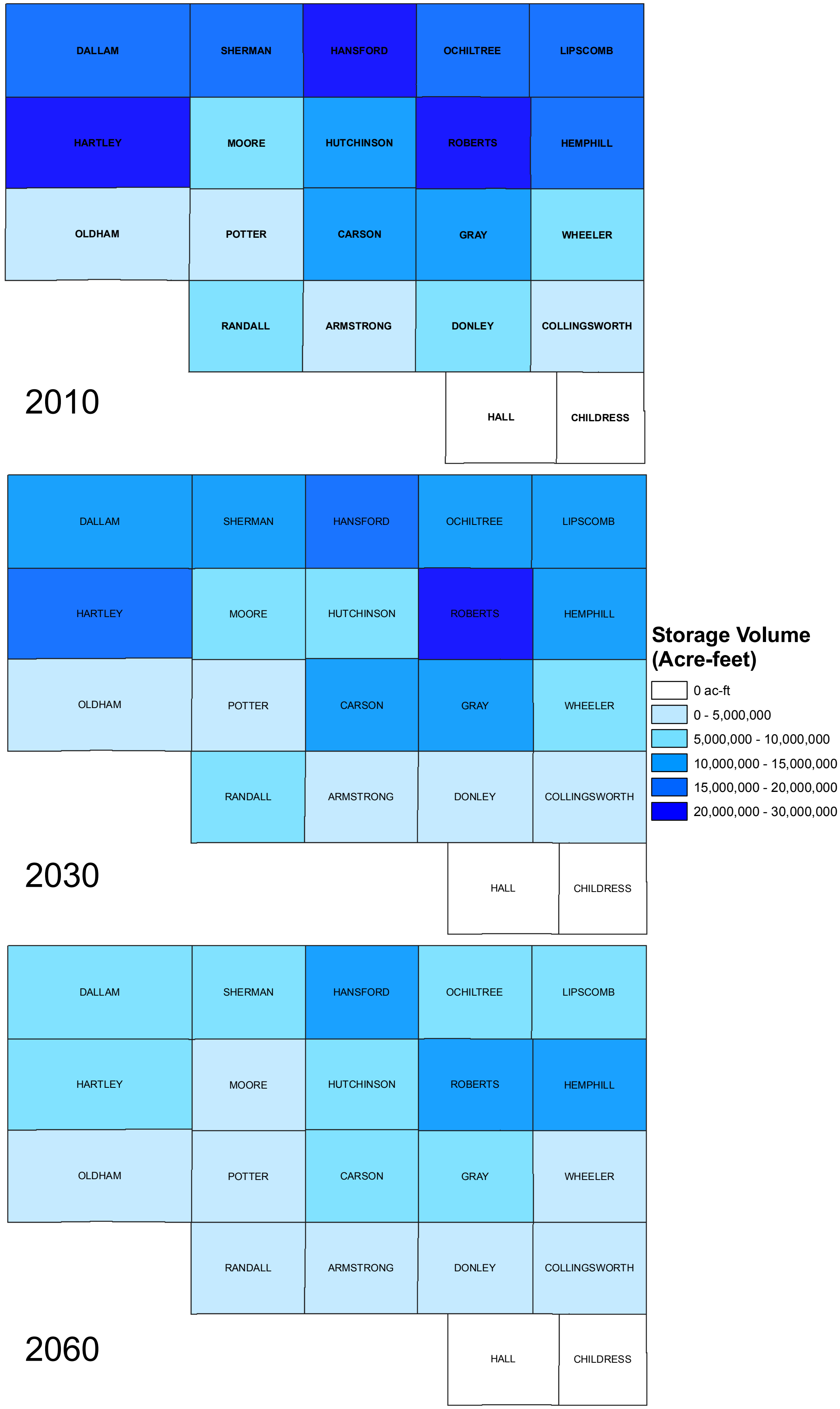
County	2010	2020	2030	2040	2050	2060
Armstrong	3,983,849	3,527,443	3,140,575	2,768,907	2,465,512	2,178,805
Carson	14,523,374	12,748,607	11,166,494	9,751,901	8,489,527	7,367,135
Collingsworth	85,792	85,703	85,608	85,514	85,420	85,329
Dallam	15,651,329	13,171,909	11,022,071	9,172,190	7,596,070	6,270,784
Donley	5,822,805	5,121,980	4,498,266	3,944,520	3,453,986	3,021,052
Gray	13,000,446	11,420,486	10,008,063	8,744,601	7,618,601	6,621,642
Hansford	20,769,174	18,218,902	15,883,250	13,768,737	11,879,677	10,213,135
Hartley	23,097,231	19,495,348	16,428,918	13,820,010	11,603,668	9,725,660
Hemphill	15,407,023	14,834,800	14,206,672	13,569,550	12,947,908	12,352,238
Hutchinson	10,542,798	9,248,736	8,078,744	7,025,960	6,087,234	5,257,916
Lipscomb	18,394,426	16,186,671	14,214,079	12,448,522	10,873,857	9,477,201
Moore	9,608,708	8,053,014	6,694,926	5,528,205	4,540,089	3,714,338
Ochiltree	19,066,318	16,739,260	14,648,686	12,768,510	11,083,298	9,580,902
Oldham	2,361,966	2,305,686	2,265,140	2,191,713	2,189,245	2,164,715
Potter	2,872,857	2,524,917	2,234,142	1,962,552	1,753,081	1,555,489
Randall	5,832,429	5,383,671	5,153,440	4,696,439	5,018,636	4,985,955
Roberts	26,852,172	23,590,451	20,655,707	18,018,243	15,657,191	13,557,937
Sherman	18,035,001	15,203,063	12,766,854	10,667,622	8,860,604	7,320,539
Wheeler	7,340,143	6,468,071	5,684,345	4,987,318	4,369,708	3,824,747
TOTAL	**233,247,839**	**204,328,717**	**178,835,981**	**155,921,014**	**136,573,311**	**119,275,520**

1. Storage values shown above include 2004 Dutton Northern GAM results developed by Intera, Inc. for this water plan (October 2009) and the Southern GAM results developed by TWDB for the 2006 water plan.
2. Storage remaining at the end of the 50-year planning period is within 0.1% of the volume goals for the 40/50/80 subareas. On a county basis, storage is within 3% of the PWPA volume goals.

Table 3-2
Available Water Supply from the Ogallala
(Values are in ac-ft /yr)

County	2010	2020	2030	2040	2050	2060
Armstrong	51,374	47,666	42,659	37,938	34,185	30,650
Carson	196,889	178,545	160,493	144,656	129,882	116,336
Collingsworth	1,072	1,071	1,070	1,069	1,068	1,067
Dallam	280,136	253,072	225,124	198,739	173,986	151,305
Donley	82,762	81,347	76,005	69,672	63,613	58,017
Gray	166,636	157,029	143,819	130,646	117,614	105,634
Hansford	276,277	258,780	238,529	217,640	195,835	174,892
Hartley	398,799	361,195	314,995	273,474	236,815	204,661
Hemphill	49,909	44,654	44,129	43,784	43,673	43,579
Hutchinson	135,941	129,548	119,798	108,985	98,239	87,979
Lipscomb	251,789	251,652	247,761	234,999	219,735	203,198
Moore	174,410	164,319	142,529	122,138	103,539	86,974
Ochiltree	257,903	236,618	215,489	195,506	176,566	159,017
Oldham	32,692	32,120	31,865	30,944	30,670	30,162
Potter	41,085	31,886	28,684	25,560	23,216	20,984
Randall	74,440	69,663	66,697	60,842	64,746	64,207
Roberts	345,057	339,518	322,909	301,420	277,509	251,933
Sherman	316,971	298,567	262,820	229,557	198,809	169,672
Wheeler	120,205	114,819	112,163	106,500	99,802	92,993
TOTAL	**3,254,347**	**3,052,069**	**2,797,538**	**2,534,069**	**2,289,502**	**2,053,260**

Source: 2004 Dutton GAM, developed by Intera, Inc. for this water plan (October 2009) and the Southern GAM results developed by TWDB for the 2006 water plan. (See Appendix D)



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N W E S

PANHANDLE WATER PLANNING AREA

TOTAL VOLUME IN STORAGE IN THE OGALLALA AQUIFER IN PWPA

Location Map

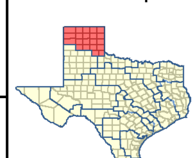

FIGURE 3-3

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).

Annual effective recharge to the Seymour aquifer in the PWPA is approximately 33,000 acre-feet or five percent of the average annual rainfall that falls on the outcrop area. No significant groundwater level declines have occurred in wells that pump from the Seymour.

As shown on Table 3-3, the Seymour GAM results indicated small declines to increases in storage volumes with the pumpage amounts used for the model. These pumpage amounts in the PWPA ranged from 41,000 acre-feet per year in 2000, decreasing to 26,800 acre-feet per year by 2060. Based on the GAM pumpage and volumes of water remaining in storage, the estimated annual availability from the Seymour aquifer is shown in Table 3-4.

Table 3-3
Total Water in Storage in the Seymour Aquifer (GAM 2005 Results in ac-ft)

County	2010	2020	2030	2040	2050	2060
Childress	130,000	130,000	140,000	140,000	140,000	140,000
Collingsworth	480,000	460,000	450,000	450,000	460,000	470,000
Hall	200,000	180,000	180,000	180,000	190,000	190,000
Total	**810,000**	**770,000**	**770,000**	**770,000**	**790,000**	**800,000**

Source: TWDB 2005

Table 3-4
Available Annual Water Supply from the Seymour Aquifer (in ac-ft/yr)

County	2010	2020	2030	2040	2050	2060
Childress	1,625	1,625	1,750	1,750	1,750	1,750
Collingsworth	19,400	18,900	17,900	17,900	17,900	17,900
Hall	20,500	20,000	19,000	19,000	19,000	19,000
Total	**41,525**	**40,525**	**38,650**	**38,650**	**38,650**	**38,650**

Source: TWDB 2005

Blaine Aquifer

The Blaine Formation 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 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). Total water in storage is shown on Table 3-5 and the annual availability is shown in Table 3-6. Based on the 1.25%, the annual availability of water from the Blaine aquifer is considered to be the greater than either effective recharge or pumpage rates in the PWPA.

Table 3-5
Total Water in Storage in the Blaine Aquifer (GAM 2005 Results in ac-ft)

County	2010	2020	2030	2040	2050	2060
Childress	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000	5,000,000
Collingsworth	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000
Hall	800,000	800,000	800,000	800,000	800,000	800,000
Wheeler	2,600,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000
Total	**18,400,000**	**18,300,000**	**18,300,000**	**18,300,000**	**18,300,000**	**18,300,000**

Source: TWDB 2005

Table 3-6
Available Annual Water Supply from the Blaine Aquifer
(1.25% Available Supplies in Storage in ac-ft/yr)

County	2010	2020	2030	2040	2050	2060
Childress	62,500	62,500	62,500	62,500	62,500	62,500
Collingsworth	125,000	125,000	125,000	125,000	125,000	125,000
Hall	10,000	10,000	10,000	10,000	10,000	10,000
Wheeler	32,500	31,250	31,250	31,250	31,250	31,250
Total	**230,000**	**228,750**	**228,750**	**228,750**	**228,750**	**228,750**

Source: TWDB 2005

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).

The estimated volume of water in storage in the Dockum aquifer is shown in Table 3.7 and the groundwater availability of the Dockum aquifer is presented in Table 3-8. The availability of water from the Dockum aquifer is estimated to be 1.25% of the total storage estimate plus effective annual recharge (TWDB, 2003).

Table 3-7
Total Water in Storage in the Dockum Aquifer (Values in ac-ft)

County	2010	2020	2030	2040	2050	2060
Armstrong	1,704,600	1,491,600	1,305,600	1,142,600	999,600	874,600
Carson	495,700	433,700	379,700	332,700	290,700	254,700
Dallam	5,741,800	5,023,800	4,395,800	3,846,800	3,365,800	2,944,800
Hartley	5,577,300	4,880,300	4,270,300	3,736,300	3,269,300	2,860,300
Moore	1,389,300	1,215,300	1,063,300	930,300	814,300	712,300
Oldham	5,726,400	5,010,400	4,384,400	3,836,400	3,356,400	2,936,400
Potter	2,670,600	2,336,600	2,044,600	1,788,600	1,564,600	1,368,600
Randall	3,477,800	3,042,800	2,662,800	2,329,800	2,038,800	1,783,800
TOTAL	**26,783,500**	**23,434,500**	**20,506,500**	**17,943,500**	**15,699,500**	**13,735,500**

Table 3-8
Available Annual Water Supply from the Dockum Aquifer
(1.25% Available Supplies in Storage in ac-ft/yr)

County	2010	2020	2030	2040	2050	2060
Armstrong	21,300	18,600	16,300	14,300	12,500	10,900
Carson	6,200	5,400	4,700	4,200	3,600	3,200
Dallam	71,800	62,800	54,900	48,100	42,100	36,800
Hartley	69,700	61,000	53,400	46,700	40,900	35,800
Moore	17,400	15,200	13,300	11,600	10,200	8,900
Oldham	74,400	65,400	57,600	50,800	44,800	39,500
Potter	33,700	29,500	25,900	22,700	19,900	17,400
Randall	43,500	38,000	33,300	29,100	25,500	22,300
Total	**338,000**	**295,900**	**259,400**	**227,500**	**199,500**	**174,800**

Source: TWDB Report 359, 2003

Rita Blanca Aquifer

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 the 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 leakage from the Ogallala. No estimates of recoverable storage, saturated thickness, or other water availability parameters for the aquifer were located for the Rita Blanca aquifer. Supplies from the Rita Blanca were modeled in the Ogallala GAM and these supplies are included in Ogallala availability numbers.

According to TWDB data, pumpage from the Rita Blanca averaged about 5,419 acre-feet per year from 1980 to 1997. Less than 500 acre-feet per year was pumped by the city of Texline for municipal/industrial supply over this time period. An average of 5,343 acre-feet per year was pumped for irrigation supply and an average of 77 acre-feet per year for municipal uses. All pumpage occurs in Dallam County, and no pumping of the Rita Blanca is reported for Hartley County. Municipal water well levels in the Rita Blanca aquifer have historically remained stable, whereas irrigation well water levels have declined steadily. This indicates that irrigation usage rates are currently mining the Rita Blanca supply. Insufficient data exist to quantify the rate.

3.1.2 Refinements to Northern Ogallala GAM

The 2004 Dutton GAM was revised and updated to support planning activities in the 2011 planning cycle. These revisions were needed to incorporate new hydrogeologic data relevant to the GAM and because additional data had been collected regarding projected groundwater use and in the region. The two most significant updates to the GAM in this planning cycle are the revised base aquifer picks (structure) and the updated historical and predictive pumping data sets. These are most significant because they are the two elements of the model most altered from the 2004 Dutton GAM and because they are two of the most important aspects of the model which determine aquifer storage. A third important component to future aquifer storage is specific yield which was not revised from 2004 Dutton GAM in this effort. To clarify between the model versions, the updated model will be referred to as the 2010 Intera GAM.

Revisions and updates to the groundwater pumping data included extending the historical dataset from 1997 (Dutton, 2004) through 2008 and developing projected groundwater demands from 2010 through 2060. Significant revisions to historical pumping include using an improved historical dataset for municipal pumping provided by the TWDB. All municipal pumping was uniquely matched to an owner and location. Staff from Texas AgriLife Research and Extension Services in Amarillo (Texas AgriLife) updated historic and projected irrigation and livestock pumping demands. Irrigation pumping was located to individual known metered irrigation well locations, where available, in the Panhandle and North Plains GCDs. In areas with no metered wells, the 2000 irrigated crop survey was used for spatial allocation. Livestock pumping was updated and centered around Confined Livestock Operations provided by Texas AgriLife.

Additional point estimates of hydraulic conductivity from aquifer tests were collected from the City of Amarillo, Mesa Water Inc., and Panhandle GCD resulting in twelve new estimates of hydraulic conductivity in Carson, Potter and Roberts Counties. These estimates were evaluated for consistency with the model hydraulic conductivity field (Dutton, 2004) and neighboring support data. These new data were incorporated into the revised model prior to recalibration.

In addition to new hydraulic conductivity data, a large dataset of new base aquifer picks were provided by North Plains, Panhandle, and Hemphill GCDs, CRMWA, the City of Amarillo, Mesa Water Inc. and Dr. Alan Dutton. Updates to structure in the 2004 Dutton GAM modified aquifer structure on model cell-by-cell basis and only if the new pick increased saturated thickness. In this revision, the new structure picks of the base of the Ogallala were incorporated into the model using a consistent methodology that smoothly interpolated the aquifer base using all the available data. The aquifer thickness was allowed to increase and decrease, pending the new data. New data show widespread increases in aquifer thickness in Dallam, Roberts, Lipscomb counties and reductions in Potter, Armstrong, Donley, and parts of Gray counties. Some of these reductions are associated with reclassifications of the aquifer. In Potter County areas that were previously classified as Ogallala are now considered Dockum formation. The distinction between Ogallala and Dockum is not always apparent from the well records and drilling logs.

The Bureau of Economic Geology, under funding from the PWPG and the TWDB, performed recharge studies in the region of the Northern Ogallala GAM (see Appendix E for synopsis of this special study). Many of their investigations are based upon the Chloride Mass Balance (CMB) recharge estimation method, which is based in part upon vadose zone or shallow saturated zone measurements of chloride. The studies provide a range of recharge estimates under a variety of land uses, many of which are not representative of predevelopment aquifer conditions. A review of the available data, including a draft recharge map based upon the CMB method applied to groundwater chloride data, provides a lower limit estimate of recharge for the region at approximately 0.22 in/year, which is considered by the investigators as being biased low. The Dutton (2004) calibrated model-wide average recharge rate is equal to 0.32 in/year. Given the uncertainty in a regional steady-state recharge rate, it is difficult to discriminate between these two recharge estimates. Because only the steady-state model is sensitive to natural recharge and because the model is calibrated with the Dutton and others (2001) and Dutton (2004) hydraulic conductivity field, the Dutton (2004) recharge distribution was maintained in this revised model. Consistent with the 2004 Dutton GAM, return flow is not applied because it was found to be immaterial to model predictions, given vadose zone transit times consistent with field estimates (less than 0.5 ft/yr).

The 2010 Intera GAM was calibrated to steady-state conditions (assumed to be prior to 1950) and to transient conditions from 1950 through 2008. The calibration was performed using a trial-and-error approach with the objective of decreasing residuals on a county-by-county basis. The primary parameter adjusted in calibration was hydraulic conductivity. However, it did not require significant modification from what is defined in the 2004 Dutton GAM. The root mean square error (RMSE) of the steady-state model was reduced from 32 to 29 feet model wide. The RMSE was reduced in most counties with the most significant reduction of 20 feet occurring in Dallam County. The TWDB GAM standards stipulate that the model-wide RMSE divided by the range be less than or equal to 10 percent. The model-wide RMSE divided by the range was reduced from 1.4 percent to 1.2 percent. The model-wide mean-absolute error (MAE) was reduced from 23 feet to 21.8 feet.

The transient calibration was also improved in most counties. Comparing model error in 1998, the revised model reduced the RMSE from 53 ft to 46 ft, an improvement of 7 feet. The model-wide RMSE divided by observed head target range improved slightly from 2.2 percent to 2.0 percent. The revised model simulates through 2008. The calibration model-wide improved from 1998 to 2007 with a RMSE of 36 feet and a RMSE divided by observed head target range of 1.6 percent. Overall, the 2010 Intera GAM appears to better represent aquifer conditions than the 2004 Dutton GAM model. As more data becomes available, continued refinements will improve its predictive capabilities.

To assess the impacts of the updates on water availability, the calibrated model was used in the forward mode to simulate predicted aquifer conditions from 2008 through 2060. These findings are discussed in Appendix F, and are consistent with previous analyses that show significant portions of the aquifer becoming depleted over time with the projected pumping. The areas most impacted include the westernmost counties of the PWPA and parts of Roberts County.

The 2010 Intera GAM was also used to assess groundwater availability based upon the criteria defined by the planning group. These availabilities were compared to the values determined using the 2004 Dutton GAM. Overall, the 2010 Intera GAM shows increases in availability in the PWPA. On a region-wide basis, the 2010 Intera GAM shows approximately 320,000 acre-feet per year of additional supply in 2010, reducing to 119,000 acre-feet per year by 2060. However, not every county shows increased water supplies. As shown on Figure 3-4, five counties show lower groundwater availabilities, two counties are about the same and the remainder of the region shows increases in availability. The biggest increases in availability occur in Dallam, Roberts, Moore, Lipscomb and Hartley counties. In Dallam County there is approximately 80,000 acre-feet per year on average more water than projected with the 2004 Dutton GAM. This represents a 37 percent increase in supply. Increases for the other counties generally ranged from less than 5 percent to 20 percent.

While these counties show additional supplies, there will continue to be shortages in the heavily irrigated counties. The additional supplies projected with the updated GAM may delay irrigation shortages in the four western counties, but will not eliminate shortages. For counties with relatively small irrigation shortages (Hansford), these shortages may be eliminated using the availabilities from the 2010 Intera GAM.

Further review is needed to assess the potential impacts for the five counties with lower groundwater availability. The groundwater may be available to meet the projected demands, but the source may be the Dockum aquifer rather than the Ogallala aquifer.

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N W E S

PANHANDLE WATER PLANNING AREA

CHANGE IN AVAILABLE GROUNDWATER

Location Map

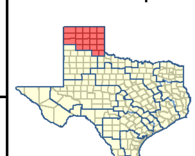


FIGURE 3-4

3.1.3 Water Supply Reservoirs

Major surface water supplies in the PWPA include Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir (see Figure 3-5). The supply available from these reservoirs is determined through the Water Availability Models (WAM) of the Red and Canadian Basins which include evaluations of critical drought, water right diversions, and sedimentation rates. 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 that time period 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 critical period. A definition of the critical period for each reservoir is essential to determine the yield, or estimate of available water supply. The 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.

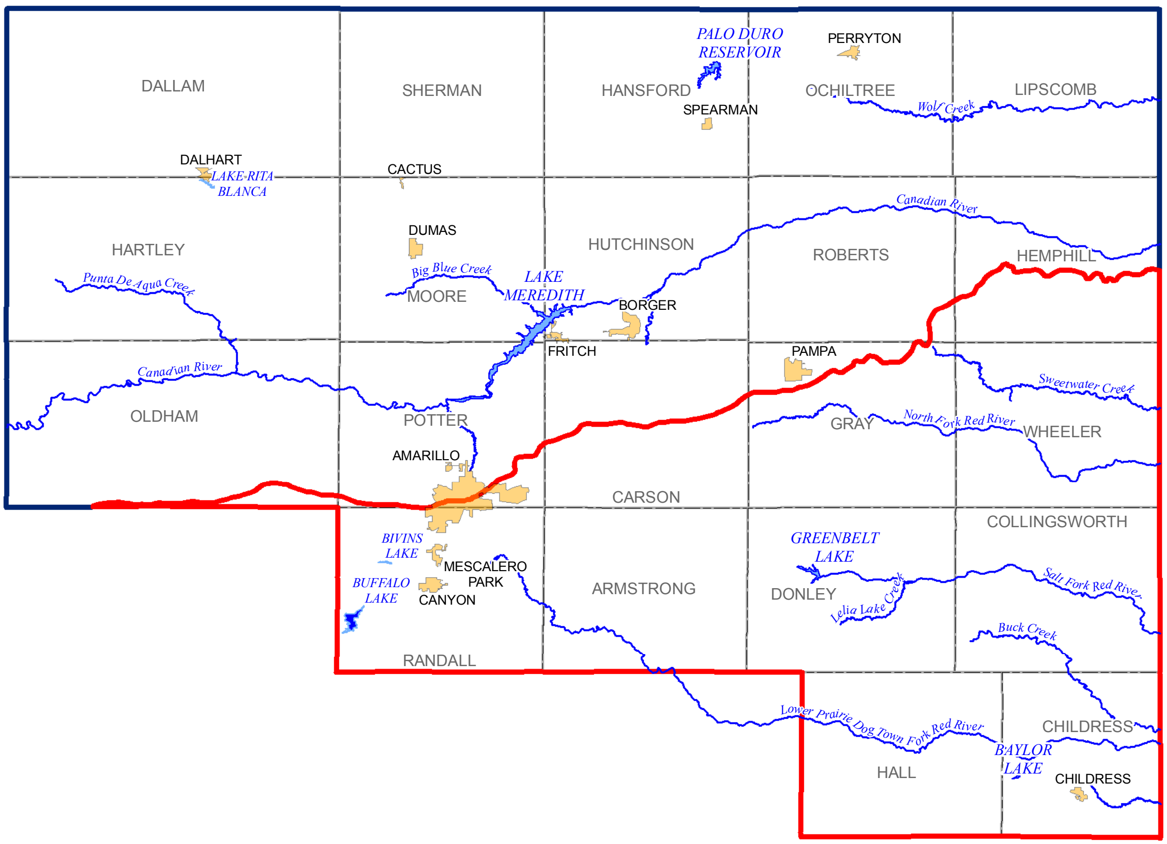
All three reservoirs appear to be in the critical drought period. In 2009, Lake Meredith recorded the lowest historical inflow at less than 26,000 acre-feet. Both Lake Meredith and Palo Duro Reservoir, which are located in the Canadian River Basin, are at less than 10 percent full as of July 2009. Greenbelt Reservoir, located in the Red River Basin, is approximately 30 percent full.

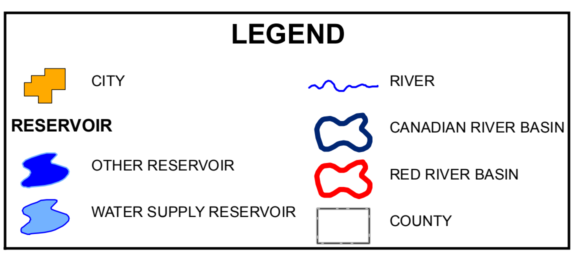
As part of the water supply analysis conducted for the 2006 regional water plan, the Canadian River WAM was updated to address the on-going drought and correct several hydrological assumptions. The major changes included extending the hydrology from 1998 through September 2004, adjusting flows from New Mexico to account for major new reservoirs in New Mexico, correcting channel loss calculations and other hydrological adjustments. The changes to the Canadian WAM are discussed in detail in the 2006 PWPA Regional Water Plan (Chapter 3.2 and Appendix V). Since completion of the 2006 regional water plan, the TCEQ has adopted the hydrological changes to the Canadian WAM.

Due to the on-going drought in the Canadian River Basin, the firm yields determined for the 2006 PWPA Regional Water Plan were retained for this plan. Until the reservoir fills, a firm yield cannot be reliably assessed. To account for the uncertainty of the on-going drought the available supply from Lake Meredith was reduced based on estimates from CRMWA. There are also plans to provide a firm supply of 24,000 acre-feet per year are being developed by the Eastern New Mexico Rural Water System. The initial proposed diversion is 16,450 acre-feet per year with the potential for expansion to the full project amount. This development could further reduce the yield of Lake Meredith and should be considered in future updates to the Canadian WAM.

The continuing decline of the available supply from Lake Meredith is of great concern to the CRMWA and the region. A special study was conducted to assess the possible contributing factors for the observed decreasing inflows. This study is summarized in Section 3.1.4 and the complete report is included in Appendix G.

Surface water supplies in the Red River Basin were estimated using the most recent Red River WAM..





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PREPARED BY: DLB

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N W E S

PANHANDLE WATER PLANNING AREA

SURFACE WATER SUPPLIES IN PWPA

Location Map

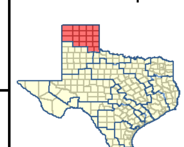


FIGURE 3-5

The firm yield of the three surface water supply reservoirs for the PWPA (Lake Meredith, Palo Duro Reservoir, and Greenbelt) will very likely be reduced if low flows continue. However, the firm yield for Palo Duro Reservoir will remain difficult to define using the available hydrologic records in the area. A brief description of each of the three major reservoirs is presented below in Table 3-9.

Table 3-9
Descriptive Information of Water Supply Reservoirs in the PWPA

	Palo Duro Reservoir	**Lake Meredith**	**Greenbelt Reservoir**
Owner/Operator	PDRA	CRMWA	GM&IWA
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	16,230 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 can be diverted directly from the lake, 4.030 ac-ft/yr diverted from Lelia Lake Creek, and 250 diverted directly from Salt Fork of the Red River.

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)

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). The study by HDR (1987) estimated that the firm yield was about 76,000 acre-feet per year and that development of New Mexico projects might further reduce the yield to 66,000 acre-feet per year. Another yield study in 1993 (Lee Wilson and Associates, 1993) estimated a firm yield of approximately 76,000 acre-feet based on 1991 area-capacity conditions and 1980 sedimentation rates. The yield study showed the reservoir reaching a minimum content of 59,700 acre-feet in May 1981. This content represents the lowest elevation from which the water intake structures can divert water. A TWDB survey of Lake Meredith in 1995 estimated conservation and sediment storage of 817,970 acre-feet (TWDB, 1995). The Canadian River Compact limits the conservation storage to 500,000 acre-feet. The analyses conducted for the 2006 Panhandle Water Plan using the Canadian Basin WAM with the hydrology ending in September 2004, shows that the firm yield of Lake Meredith is 69,750 acre-feet per year, assuming full use of Ute Reservoir in New Mexico. Safe yield for Lake Meredith is approximately 63,750 acre-feet per year. Since 2004, inflows to Lake Meredith continue to be low. Subsequent studies conducted by CRMWA, considering recent inflows, indicate that the long-term reliable yield of Lake Meredith may be approximately 50,000 ac-ft/yr. These estimates assume that the reservoir receives several years of average to above average inflows. If the very low inflows continue, the reliable supply will be less. For planning purposes, the CRMWA is planning on using less than 50,000 acre-feet from Lake Meredith in the near-term to allow the reservoir storage to refill. For this water plan, the reliable supply from Lake Meredith is estimated at 30,000 ac-ft/yr in 2010 and 50,000 ac-ft/yr for the following decades.

Projections of conservation storage, firm yield and safe yield for Lake Meredith during the planning period shown in Table 3-10 are based on the Canadian River WAM. Sedimentation is not anticipated to adversely affect the yield of Lake Meredith during the 50-year planning period.

Table 3-10: Projected Yield and Available Supply of Lake Meredith

	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Conservation Storage [1](ac-ft)	500,000	500,000	500,000	500,000	500,000	500,000
Firm Yield (ac-ft/yr)	69,750	69,750	69,750	69,750	69,750	69,750
Safe Yield (ac-ft/yr)	63,750	63,750	63,750	63,750	63,750	63,750
Available Supply[2] (ac-ft/yr)	30,000	50,000	50,000	50,000	50,000	50,000

[1] Limited by provisions of the Canadian River Compact.
[2] Available supply is the amount of water assumed available to users for regional water planning.

Palo Duro Reservoir

The Palo Duro River Authority owns and operates the Palo Duro Reservoir as a water supply for its six member cities of Cactus, Dumas, Sunray, Spearman, Gruver, and Stinnett. The reservoir is located on Palo Duro Creek in Hansford County, 12 miles north of Spearman. The dam began impounding water in January 1991 and was over 80% full (by depth) in 2000. However, due to continued drought and reduced inflows, the reservoir was less than 10% full in July 2009. Construction of transmission systems for delivering water to member cities is anticipated to be complete by 2030.

The original conservation storage capacity of the reservoir was estimated to be 60,897 acre-feet. A study by Freese and Nichols (1974) estimated the yield to be approximately 8,700 acre-feet per year. The most recent yield studies for the Palo Duro Reservoir show that it is currently in its critical period (Freese and Nichols, 1974, 1984, 1986) and that the yield is estimated to be 6,543 acre-feet per year. The firm yield with the Canadian River Basin WAM estimated the yield of 4,000 acre-feet year considering a hydrology through September 2004.

In all these studies inflows from January 1946 through September 1979 are based on flow measurement at the gage on Palo Duro Creek near Spearman. This gage was discontinued in September 1979, but was reactivated in June 1999 and currently is an active gage. The data of this gage is missing for most of the critical period of Palo Duro. Estimates of inflow have been made in several yield studies using correlation with other near gages or mass balance.

USGS gages in nearby watersheds are not well correlated with the Spearman gage, although they provide the best means of predicting reservoir inflows. The large scatter indicates a degree of uncertainty in estimated inflow to Palo Duro Reservoir during the critical period. Without a stronger correlation in inflows between the two gages, the yield for the reservoir is difficult to define.

Normally, a volumetric balance can be used to estimate inflows to existing reservoirs. However, the balance for Palo Duro shows large apparent losses from the reservoir. The apparent monthly net runoff (runoff less losses) is normally negative for the operation period from May 1991 to September 2004. The negative net runoff estimates mean that some outflow or losses have not been accounted for in the mass balance. There are some losses due to infiltration and leaking that are not being quantified. Large losses are not impossible when a reservoir is filling. To quantify these losses, an independent estimate of inflows is required.

Based on a linear interpolation of the most recent yield estimate, the projected firm yield of Palo Duro Reservoir is expected to decrease from 4,000 acre-feet in 2000 to 3,875 acre-feet in 2030 and down to 3,750 acre-feet by 2060. Table 3-11 shows the projected yield and available supply from Palo Duro Reservoir during the planning period. The available supply from Palo Duro Reservoir is limited during the beginning of the planning period by the lack of a delivery system.

Table 3-11
Projected Yield of Palo Duro Reservoir

	2010	2020	2030	2040	2050	2060
Conservation Capacity (ac-ft)	58,822	57,942	57,062	56,182	55,302	54,422
Firm Yield (ac-ft/yr)	3,958	3,917	3,875	3,833	3,792	3,750

<u>Greenbelt Reservoir</u>

Greenbelt Reservoir is owned and operated by the Greenbelt Municipal and Industrial Water Authority (Greenbelt M&IWA), and 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).

A firm yield analysis of Greenbelt Reservoir was performed using Run 3 of the state-adopted Water Availability Model (WAM) of the Red River Basin. This run assumes full permitted diversions by all water rights and no return flows unless return flows are included specifically in the water right. Results from this analysis show a firm yield of approximately 8,300 acre-ft per year in 2010, decreasing to 7,630 acre-feet per year in 2060. The safe yield of the reservoir is estimated to be nearly 6,900 acre-feet/yr (6.2 MGD). These findings are summarized in Table 3-12 below.

Table 3-12
Projected Yield and Available Supply of Greenbelt Reservoir

	2010	2020	2030	2040	2050	2060
Conservation Capacity (ac-ft)	50,651	48,628	46,606	44,584	42,562	40,540
Firm Yield (ac-ft/yr)	8,297	8,164	8,031	7,898	7,765	7,630
Safe Yield (ac-ft/yr)	6,864	6,728	6,592	6,456	6,320	6,181

3.1.4 Lake Meredith Study

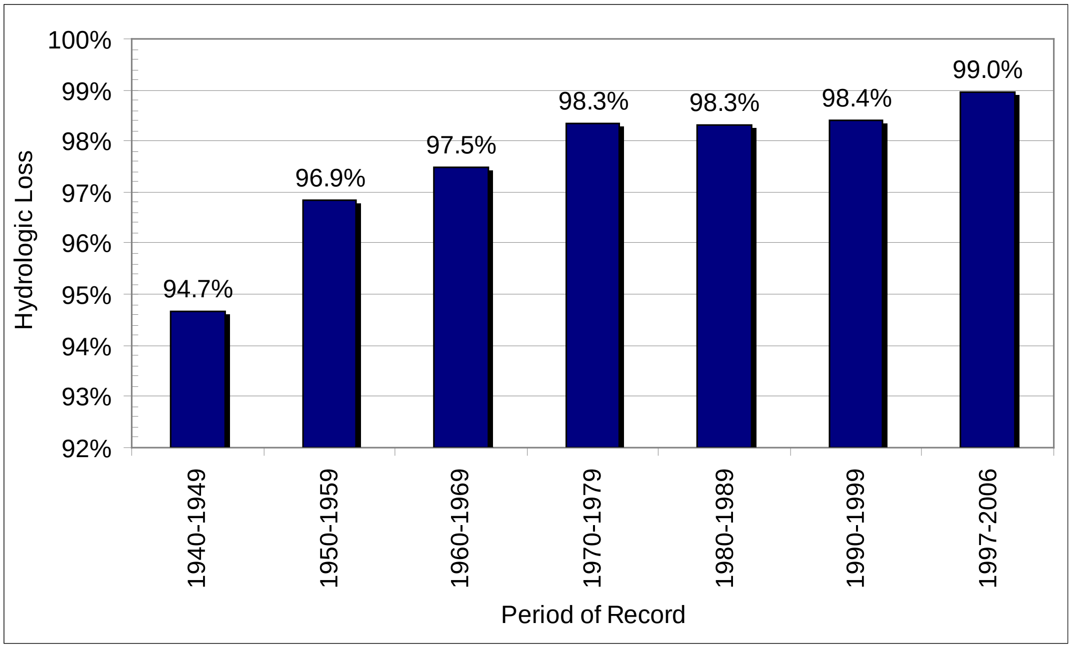
Sanford dam was built in 1965, impounding the Canadian River to form Lake Meredith, which has never reached its full capacity of around 860,000 acre-feet. Water levels in the lake have been consistently decreasing since 2000 due to decreased inflows from the Canadian River. The impact of the reduced supplies to the PWPA is great. Without renewable surface water, the region must rely on groundwater. This study was conducted to better understand the current decline in Lake Meredith water supplies. The study evaluated several potential causes of reduced inflows, including hydrologic loss, groundwater inflows and changes in land use. The complete study report is included in Appendix G.

3.1.4.1. Hydrologic loss. Historical changes in hydrologic loss in the Lake Meredith watershed between Logan and Amarillo gages were evaluated. This study area includes only the portion of the watershed that contributes to stream flows below the Logan gage, effectively eliminating the potential impacts due to operations of Ute Reservoir. Hydrologic loss is the percent of rainfall that does not turn into stream flow. Hydrologic loss occurs due to evaporation, transpiration, and infiltration and can also be used to estimate the watershed's ability to generate runoff from precipitation events.

Changes in hydrologic loss can occur for a variety of reasons. Some of these reasons could include decreased precipitation, increased evapotranspiration, decreased spring flows, increased infiltration, changes in water use (e.g. increased diversions, or decreased return flows), changes in land use (e.g. changes in agricultural practices, or spread of salt cedar), increased surface water impoundments, and climatic variability. This study investigates historical trends in the rainfall to runoff ratio, rainfall intensities, annual and seasonal temperatures, groundwater levels, land cover and surface water impoundments.

As shown on Figure 3-6, hydrologic loss over the Lake Meredith watershed has increased over time. Trends in precipitation data show no decrease in the total precipitation amount over time, while losses have increased from 94.7 percent to 99 percent since 1940. The historical change in rainfall to runoff ratio indicates that the watershed is losing its ability to generate runoff.

Figure 3-6
Hydrologic Loss per Decade



While rainfall totals have remained relatively constant, rainfall events in recent years may lack the intensity and duration needed to generate significant run-off. An analysis of daily rainfall intensities shows increasing trends in the number of days of rainfall, while total rainfall is remaining about the same. This indicates that the intensities of these rainfall events are decreasing. Significant rain events (greater than 2 in/day) are also occurring less frequently over the period of record (as indicated by the number of days between events). This reduction in intensity may be contributing to the apparent reduction in runoff and stream flows.

Evaporation is an important avenue of hydrologic loss, and air temperature is a key factor in determining potential evapotranspiration. The annual maximum temperature has decreased throughout the entire watershed with the most rapid decreases occurring in the central-western portion. The annual minimum temperature has decreased in the northwestern and southwestern portions of the watershed and increased in the center and eastern portions of the watershed. With lower average temperatures we expect lower rates of evaporation.

The range between annual and seasonal maximum and minimum temperatures is converging. The difference between average maximum and minimum temperatures throughout the year has decreased by 1.8°C in the past 50 years. The largest decrease in temperature range occurs during the winter months (a decrease of 2.3°C over the past 50 years).

The historical change in annual and seasonal air temperatures indicates that the potential for evapotranspiration has decreased. This would mean that actual evaporation and transpiration has decreased unless surface water impoundments or the area covered by heavily-transpiring vegetation (e.g. salt cedar) has increased, which they have. In short, while potential evapotranspiration has decreased, an increase in actual evaporation and transpiration cannot be ruled out.

3.1.4.2 Groundwater Inflows. Spring flows can be affected by changes in groundwater levels. Of the counties pumping from the Ogallala aquifer, Moore County experienced the greatest decreases in groundwater levels since 1950 (up to a 200 ft decrease). Sherman, Dallam, Carson, Hartley, Hutchinson, and Hansford Counties experienced draw-downs of up to 120 ft. Spring flow in these counties could be decreasing due to increased pumping from the Ogallala aquifer, but in areas with known springs the draw downs have not been significant. Also the areas with the largest draw downs tend to coincide with the non-contributing portions of the watershed.

Changes in historical water levels in the Dockum aquifer could also be contributing to declining lake levels in Lake Meredith. The area of greatest drawdown in the Dockum occurs beneath Lake Meredith and the 30 miles of the Canadian River leading up to the reservoir. According to this analysis, groundwater levels have dropped by more than 250 ft in some areas of the watershed since the 1960s. The precipitous decline in inflows to Lake Meredith could be related to draw downs in Dockum water levels during same period of time.

3.1.4.3 Land Use. Changes in land use can have important implications for rates of infiltration and transpiration, which impacts the net runoff to local drainages. There have been some shifts in land use over time, with reductions in irrigated agricultural lands and grasslands and increases in shrubland and urban areas. These trends are consistent with natural succession. The biggest shift is the increase in shrubland, which is occurring primarily in the southwestern portion of the watershed. The increased shrubland increases transpiration and can inhibit rainfall from reaching the ground surface and impede runoff. This part of the watershed typically experiences between 14 and 17 inches of rainfall per year. While brush management strategies tend to be less effective in areas that experience less than 18 inches of rainfall per year, there appears to be a correlation of increased shrubland within the contributing areas of the watershed and reduced inflows.

Much of the irrigated agriculture is located in parts of the basin that do not contribute hydrologically to Lake Meredith and therefore, changes in irrigation practices and/or irrigated acreages should have minimal impacts. Urban areas account for only 1.5 percent of the watershed area. Increases in urban areas would typically result in increased runoff; however, due to the small percentage of the area in the basin, this change has minimal impacts.

According to the National Inventory of Dams, surface impoundments have increased by over 10,000 ac-ft since 1940. Impoundments not included in the National Inventory include stock ponds for livestock use and some SCS structures. No data were available on the historical development of these structures in the watershed. While there may be some impact on inflows from increases in surface impoundments it is likely that these changes are not causing the significant decreases being observed today.

3.1.4.4 Conclusions. The study confirmed that the Lake Meredith watershed is losing its ability to generate runoff and stream flow to the Canadian River. Based on the factors studied there is no one factor or event that appears to be the major contributor to the decline of inflows to Lake Meredith. Annual precipitation, potential evaporation, and changes in irrigation practices do not appear to be contributing factors. Changing trends in the potential contributing factors occur over decades with no significant increase in this last decade. It is likely that the combination of factors, including reduced rainfall intensities, increasing shrubland and declining groundwater levels, 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 cannot be ignored with respect to the total amount of inflow to Lake Meredith, this study confirms that changes in the watershed below Ute Reservoir have contributed to reduced stream flows.

3.1.5 Run of the River Supplies

According to the TCEQ water rights database there are 107 water rights permit holders in the PWPA representing a total of 185,992 acre-feet/yr. (TCEQ 2009). Three water rights permits are associated with water supply reservoirs, which are discussed in Section 3.1.3. These represent a total of 177,690 acre-feet/year, or approximately 96 percent of the total water rights allocated in the PWPA. The remaining 104 water rights represent the run of the river supplies, which are diversions directly from a stream or river. Table 3-13 summarizes these rights by county in the PWPA. The permitted diversions total 8,302 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 2,598 acre-feet per year.

Table 3-13
Total Run of the River Water Rights by County in the PWPA
(Values in ac-ft/yr)

County	Basin Name	Permitted Diversion	Reliable Supply
Carson	Red	445	300
Childress	Red	436	28
Collingsworth	Red	1,147	867
Dallam	Canadian	190	0
Donley	Red	664	195
Gray	Canadian	2	1
Gray	Red	259	33
Hall	Red	101	59
Hansford	Canadian	530	22
Hartley	Canadian	0	0
Hemphill	Canadian	0	0
Hemphill	Red	0	0
Hutchinson	Canadian	646	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	215
Roberts	Canadian	640	72
Sherman	Canadian	275	32
Wheeler	Red	1,048	603
Total		**8,302**	**2,598**

3.1.6 Other Potential Surface Water Sources

Ten 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, Club Lake, 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 3-14 summarizes descriptive information about each of the minor reservoirs.

Table 3-14: Descriptive Information of Minor Reservoirs in the PWPA

Reservoir	Stream	River Basin	Use	Water Rights *	Date of Impoundment	Capacity (acre-feet)
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	18,150
Lake Tanglewood	Palo Duro Creek	Red	recreation	n/a	1960s	n/a
Rita Blanca Lake	Rita Blanca Creek	Canadian	recreation	Dallam & Hartley Counties (recreational)	1941	12,100
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 acre-feet/yr	1949	9,220
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	n/a
Club Lake	n/a	Red	n/a	n/a	N/a	n/a
Bivins Lake	Palo Duro Creek	Red	ground water recharge	n/a	1926	5,120

Source: Breeding, 1999
*Permitted capacity (TCEQ, 2009)
n/a – data are not available

<u>Lake McClellan</u>
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).

<u>Buffalo Lake</u>
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.

In 1973-1975, a low water dam was built to increase habitat for ducks and geese. In 1978, the low water dam was washed out and the water was released. In 1982, the low water dam was rebuilt, and was reworked in 1992 to become a flood control structure (R.N. Clark, Personal Communication). Several species of waterfowl use the lake as a winter refuge (Breeding, 1999). Buffalo Lake has a water right for storage of 14,363 acre-feet, without a right for diversion.

<u>Lake Tanglewood</u>
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.

<u>Rita Blanca Lake</u>
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.

<u>Lake Marvin</u>
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).

<u>Baylor Lake</u>
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 earthfill 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).

<u>Lake Childress</u>
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).

<u>Lake Fryer</u>
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).

<u>Club Lake</u>
Brookhollow Country Club Lake, a private fishing lake with cabin sites, is six miles northeast of the city of Memphis in Hall County. The reservoir is in the Red River basin. No estimates of lake capacity are available.

<u>Bivens Lake</u>
Bivens Lake, also known as Amarillo City Lake, is an artificial 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 reservoir 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).

<u>Playa Lakes</u>
The most visible and abundant wetlands features within the PWPA are playa basins. These are ephemeral wetlands which are an important element of surface hydrology and ecological diversity. Most playas are seasonally flooded basins, receiving their water only from rainfall or snowmelt. Moisture loss occurs by evaporation and filtration through the soil to underlying aquifers. In some years there is little to water in area playa lakes.

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 5,457 playa lakes are located in the PWPA, covering approximately one percent of the surface area (NRCS, 2009). Playa basins 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, and are generally circular to oval in shape. Typically, the soil in the playas is the Randall Clay.

Playa basins also supply important habitat for resident wildlife. The basins 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. Table 3-15 shows the estimated acreage and water storage for playa lakes in the PWPA.

Table 3-15: Acreage and Estimated Maximum Storage of Playa Lakes in the PWPA

County	Estimated Area (acres)[1]	Estimated Maximum Storage[2] (acre-feet)
Armstrong	15,541	46,623
Carson	18,198	54,595
Childress	98	293
Collingsworth	0	0
Dallam	4,245	12,736
Donley	1,846	5,537
Gray	12,958	38,873
Hall	0	0
Hansford	7,047	21,142
Hartley	4,055	12,166
Hemphill	100.48	301
Hutchinson	3,360	10,081
Lipscomb	233.01	699
Moore	4,694	14,083
Ochiltree	16,560	49,680
Oldham	4,252	12,755
Potter	3,332	9,995
Randall	16,802	50,406
Roberts	1,069	3,207
Sherman	4,515	13,546
Wheeler	0	0
TOTAL	**118,907**	**356,720**

1. NRCS SSURGO Dataset
2.Source: Fish, et. al., 1997 *Based on average depth of 3 feet

A number of other small reservoirs are currently used for private storage and diversion purposes. In order to use any of the minor reservoirs for water supply purposes, water rights for diverting the water for a specific use may be needed. Other issues may be associated with diverting water from playa lakes. Therefore, these surface water sources have not been included as sources of available water supplies.

3.1.7 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 3-16.

Table 3-16 Direct Reuse in the PWPA
(Values are in ac-ft /yr)

County	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Carson	67	64	62	61	56	50
Childress	146	148	150	151	151	147
Collingsworth	50	50	50	50	50	50
Dallam	430	421	409	391	379	379
Gray	246	246	246	246	246	246
Hall	0	0	0	0	0	0
Hemphill	0	0	0	0	0	0
Hutchinson	1,045	1,045	1,045	1,045	1,045	1,045
Lipscomb	0	0	0	0	0	0
Moore	547	592	633	664	684	696
Potter	21,803	25,567	27,230	29,125	31,192	34,169
Randall	700	700	700	700	700	700
Roberts	0	0	0	0	0	0
Wheeler	95	95	95	95	95	95
Total	**25,129**	**28,928**	**30,620**	**32,528**	**34,598**	**37,577**

3.1.8 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 and self contained storage facilities (old gravel pits, etc.) for mining. The amounts of available supplies for these uses are based on data collected by the TWDB on historical water use. A summary of the local supplies by county is shown in Table 3-17.

Table 3-17
Summary of Local Supplies in the PWPA
(Values are in ac-ft /yr)

	2010	2020	2030	2040	2050	2060
LIVESTOCK LOCAL SUPPLY						
Armstrong	121	121	121	121	121	121
Carson	284	284	284	284	284	284
Childress	300	300	300	300	300	300
Collingsworth	750	750	750	750	750	750
Dallam	741	741	741	741	741	741
Donley	1,225	1,225	1,225	1,225	1,225	1,225
Gray	2,732	2,732	2,732	2,732	2,732	2,732
Hall	301	301	301	301	301	301
Hansford	2,464	2,464	2,464	2,464	2,464	2,464
Hartley	1,702	1,702	1,702	1,702	1,702	1,702
Hemphill	888	888	888	888	888	888
Hutchinson	493	493	493	493	493	493
Lipscomb	657	657	657	657	657	657
Moore	981	981	981	981	981	981
Ochiltree	2,506	2,506	2,506	2,506	2,506	2,506
Oldham	1,249	1,249	1,249	1,249	1,249	1,249
Potter	516	516	516	516	516	516
Randall	511	511	511	511	511	511
Roberts	515	515	515	515	515	515
Sherman	699	699	699	699	699	699
Wheeler	1,561	1,561	1,561	1,561	1,561	1,561
OTHER LOCAL SUPPLY						
Childress	21	21	21	21	21	21
Total Local Supply	**21,217**	**21,217**	**21,217**	**21,217**	**21,217**	**21,217**

3.1.9 Summary of Water Supplies in the PWPA

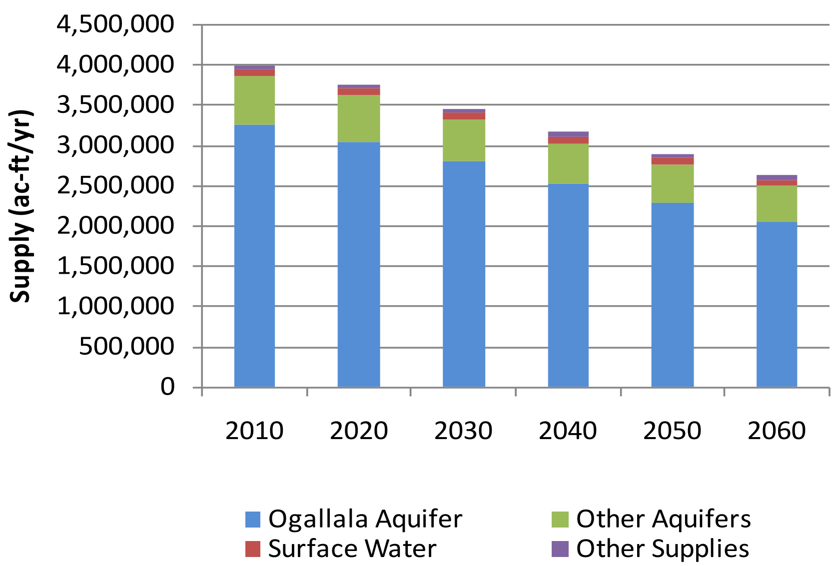
The available water supplies in the PWPA total over 4,100,000 acre-feet per year in 2010, decreasing to 2,600,000 acre-feet per year by 2060. Most of this supply is associated with groundwater, specifically the Ogallala aquifer. Surface water supplies are an important component of the available supply 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 3-18 and Figure 3-7 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 theoretical annual withdrawals that meet the PWPG adopted definitions for availability are shown. These values do not consider infrastructure constraints, contractual agreements, or the economic feasibility of developing these sources. Nor do they consider the ultimate location of use (e.g., exports to Regions O and B). These values are reported by its source location (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 based on the region's definition of 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 3-18
Summary of Available Water Supplies in the PWPA
(Values are in ac-ft /yr)

Source	2010	2020	2030	2040	2050	2060
Lake Meredith (available supply)	30,000	50,000	50,000	50,000	50,000	50,000
Greenbelt Lake (safe yield)	6,864	6,728	6,592	6,456	6,320	6,181
Palo Duro Reservoir	3,958	3,917	3,875	3,833	3,792	3,750
Canadian Run-of-River	296	296	296	296	296	296
Red Run-of-River	2,168	2,168	2,168	2,168	2,168	2,168
Total Surface Water	**43,286**	**63,109**	**62,931**	**62,753**	**62,576**	**62,395**
Ogallala Aquifer	3,254,347	3,052,069	2,797,538	2,534,069	2,289,502	2,053,260
Seymour Aquifer	41,525	40,525	38,650	38,650	38,650	38,650
Blaine Aquifer	230,000	228,750	228,750	228,750	228,750	228,750
Dockum Aquifer	338,000	295,900	259,400	227,500	199,500	174,800
Other Aquifers	679	678	675	672	672	672
Total Groundwater	**3,864,551**	**3,617,922**	**3,325,013**	**3,029,641**	**2,757,074**	**2,496,132**
Local Supply	21,217	21,217	21,217	21,217	21,217	21,217
Direct Reuse	25,129	28,928	30,620	32,528	34,598	37,577
Total Supply in PWPA	**3,954,183**	**3,731,176**	**3,439,781**	**3,146,139**	**2,875,465**	**2,617,321**

Figure 3-7
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. Figure 3-8 shows the locations of irrigable acres in the PWPA as reported in 2002 and underlying groundwater sources (TWDB, 2009). 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.

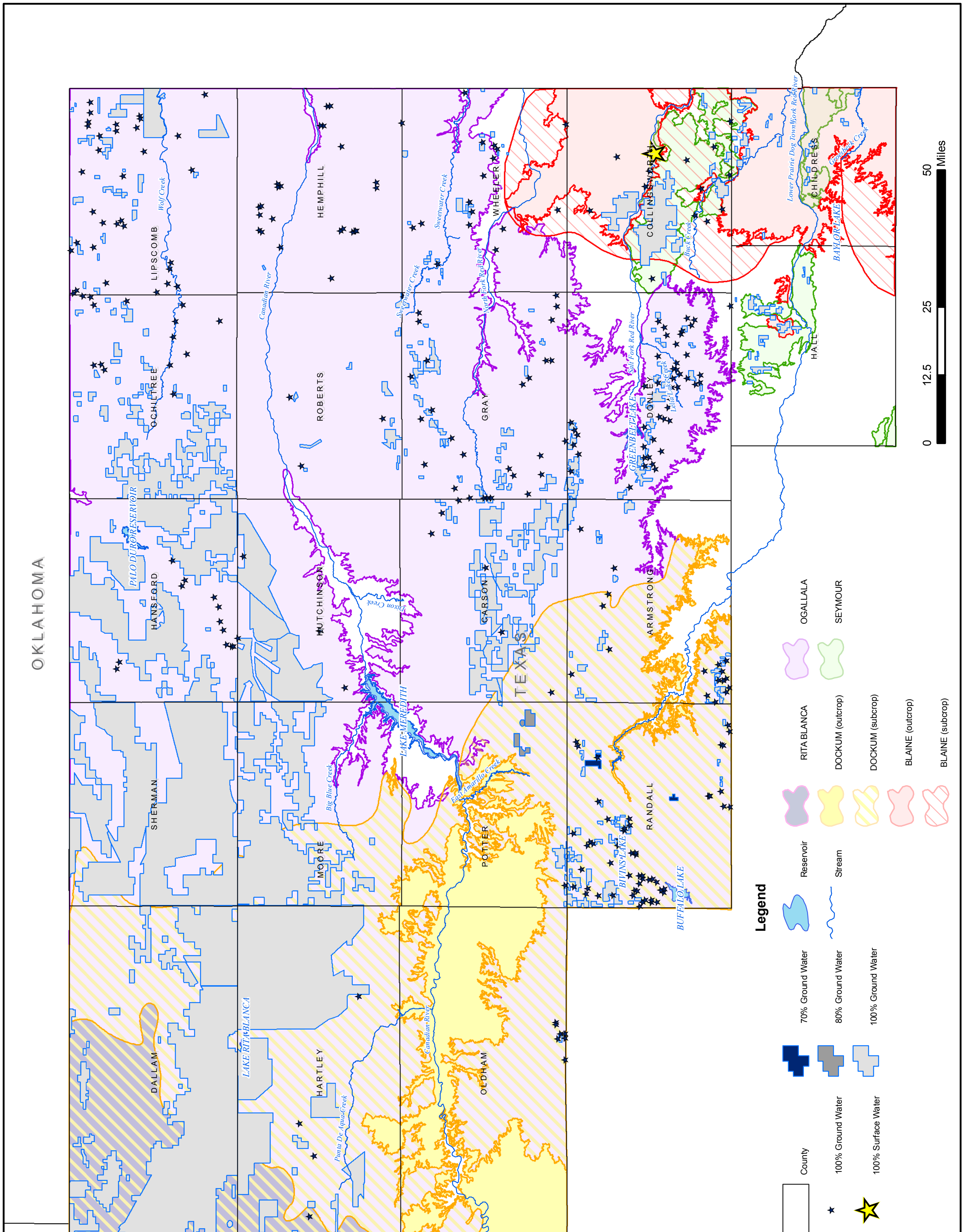
The allocation of water supplies also considers the source of water, the location of the water, and current imports and exports of water in the region. All water supplies from groundwater aquifers stated in this plan comply with the adopted PWPA definitions for groundwater availability as discussed in Section 3.1.1.

Voluntary transfers of water between water user groups were not considered during the allocation process, but will be considered as a strategy in Chapter 4. It should be noted that in some cases, local Groundwater Conservation District 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. Table 3-19 shows the projected demand on the Ogallala aquifer by county.

To better understand the capability of the aquifer to meet these demands with current infrastructure, a baseline analysis using the 2004 Dutton GAM was conducted. The simulation used the updated pumping demand distribution for the model from 2010 through 2060. Figure 3-9 shows the saturated thickness of the aquifer simulated by the GAM in the year 2010. By 2010 most of the aquifer Northern Ogallala GAM in Texas has a finite saturated thickness with the largest amount of depleted storage (inactive cells representing dry aquifer conditions and white in the figure) are in Dallam County. By 2060 Figure 3-10 shows significant portions of the aquifer in Dallam, Hartley, Moore and Sherman Counties have become inactive. These areas may not represent completely dry conditions, but rather there would likely be a thin saturated thickness in these portions of the aquifer in the future because pumping efficiency will decrease to such a degree that desaturation of the aquifer is not possible. However, these regions would not support irrigation rates of pumping. In the decade between 2050 and 2060 the annual



DATE: JANUARY 2010

SCALE: 1:1,584,000

DATUM & COORDINATE SYSTEM GCS NORTH AMERICAN 1983

PREPARED BY: DLB

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N W E S

PANHANDLE WATER PLANNING AREA

IRRIGATED AREAS IN PWPA

Location Map

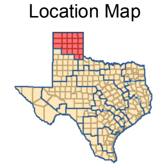


FIGURE 3-8

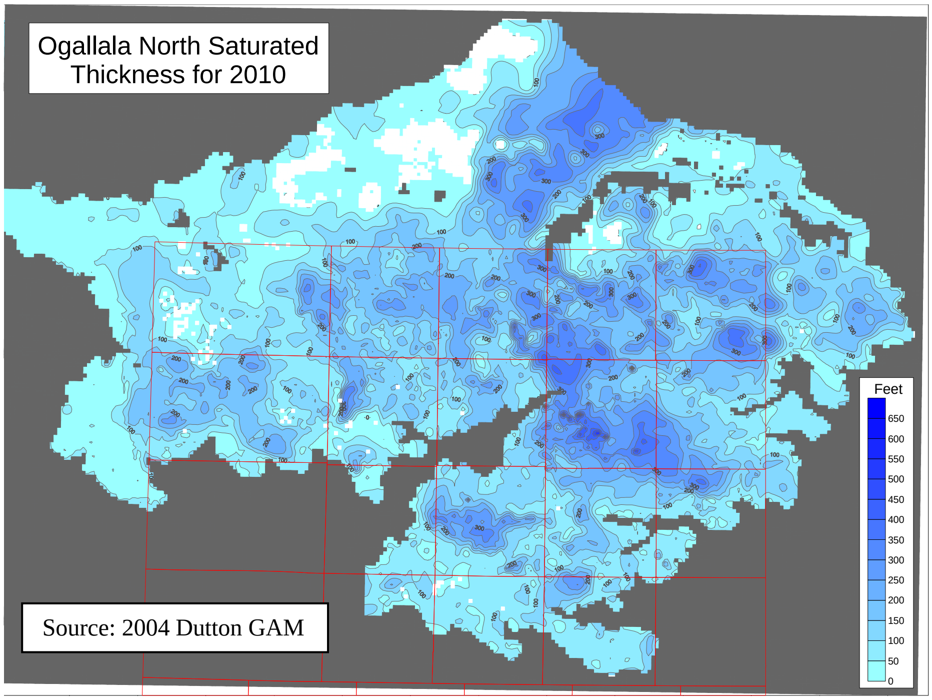


Figure 3-9 Saturated Thickness for Northern Ogallala Aquifer in 2010

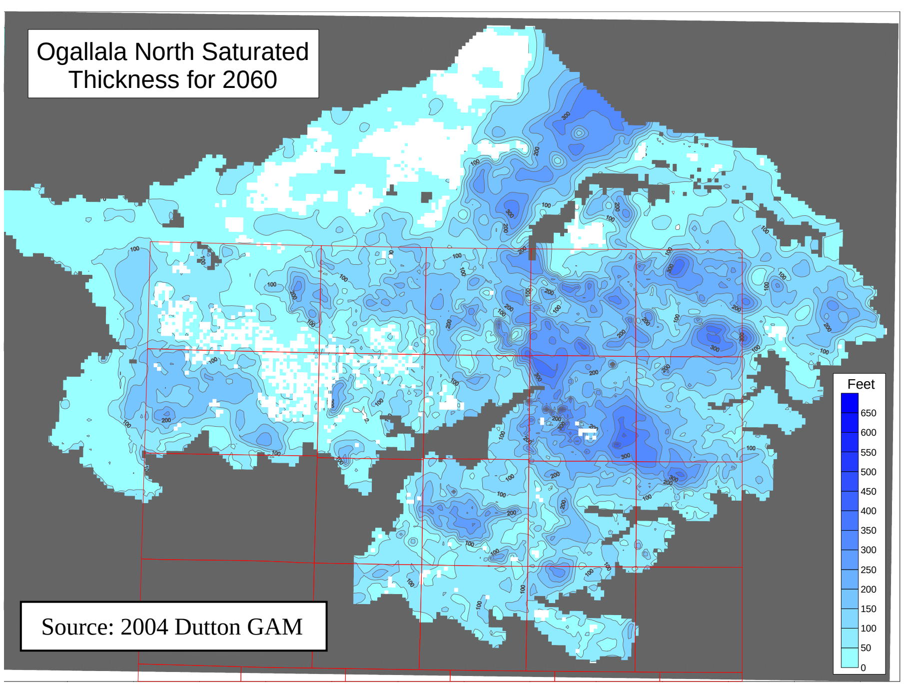


Figure 3-10 Projected Northern Ogallala Aquifer Saturated Thickness in 2060 with Unrestricted Projected Pumpage

average demand for the Ogallala is 1,517,667 acre-feet per year. However, the 2004 Dutton GAM predicts that users will only be able to pump an average annual amount of 521,150 acre-feet per year for that decade, a reduction of 45 percent of the desired demand.

The baseline analyses show that with unrestrained pumping there will be significant areas of the aquifer with depletions greater than the PWPG's criteria for regional water planning. Many of these areas occur in heavily irrigated areas. Irrigated water users have limited options for new water sources and are constrained by geographical location. Other users with known well field locations and potential constraints on existing supplies include cities and wholesale water providers.

Table 3-19
Projected Demand on Ogallala Aquifer in PWPA
(Values are in ac-ft /yr)

County	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Armstrong	5,845	5,528	5,373	5,122	4,643	4,158
Carson	73,133	63,056	60,415	56,619	46,358	44,467
Collingsworth	0	0	0	0	0	0
Dallam	284,653	277,232	268,998	254,961	226,434	197,867
Donley	32,381	30,046	29,121	27,587	24,541	21,489
Gray	31,251	28,063	28,481	27,718	26,332	24,196
Hansford	133,631	118,324	115,181	109,727	98,401	87,105
Hartley	299,526	288,409	279,949	266,074	237,789	209,762
Hemphill	5,422	5,310	4,979	4,405	3,855	3,363
Hutchinson	67,149	65,356	65,574	64,843	61,798	59,609
Lipscomb	19,278	17,892	17,298	16,284	14,541	12,819
Moore	146,124	135,446	133,839	130,026	118,945	107,785
Ochiltree	64,994	56,259	54,822	52,211	46,977	41,790
Oldham	4,131	3,823	3,684	3,454	3,026	2,590
Potter	4,485	15,281	16,385	17,558	23,789	21,563
Randall	29,581	26,766	26,786	26,515	25,231	23,729
Roberts	67,471	76,029	75,713	75,170	74,383	73,656
Sherman	225,437	206,304	200,559	189,405	170,630	150,589
Wheeler	13,264	11,491	11,010	10,166	8,904	7,704

Note: The demands on the Ogallala aquifer shown above represent the expected demands less supplies from other sources. This differs from the allocated supplies from the Ogallala aquifer. Allocated supplies may be greater in some counties and less in other counties, pending availability and infrastructure constraints.

To assist with the allocation of Ogallala water to irrigation and municipal users, the 2004 Dutton GAM was used. Model grid cells were assigned to a specific user group using data provided by the Groundwater Conservation Districts, TCEQ and TWDB. The availabilities were estimated based on the summation of the pumpage for the associated grid cells. The irrigation zones generally followed the irrigated areas shown on Figure 3-8. For irrigation water users, the lesser of the demands or the availabilities were assigned to the irrigation WUG. Six counties were shown to have irrigation demands greater than the estimated water availability. These include Dallam, Hartley, Hansford, Hutchinson, Moore and Sherman Counties.

The allocation of Ogallala water to municipal water users considered several factors, including the availabilities determined using the 2004 Dutton 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.

3.2.2 Imports and Exports

A small amount of water is imported to the PWPA from a well field owned by Amarillo in Deaf Smith 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 M&IWA. CRMWA provides water to eleven cities, of which eight are located in the Llano Estacado RWPA. Water from Lake Meredith and CRMWA's Roberts County well field are exported to CRMWA's member and customer cities in the Llano Estacado RWPA. The Greenbelt M&IWA owns and operates Greenbelt Reservoir. Water from this source is exported to three cities in Region B and the Red River Authority that provides water to county-other in Region B. Mesa Water has expressed an interest to export water from the PWPA to other regions, but at this time Mesa Water is not exporting water. Approximately 56,000 acre-feet per year of water may be exported from the PWPA. Table 3-20 shows the amount of water imported and exported from the region.

Table 3-20
Summary of Exports and Imports with other Regions
(Values are in ac-ft /yr)

Source	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Exports:						
Lake Meredith	15,607	20,512	20,512	20,512	19,196	19,196
Greenbelt Reservoir	1,778	1,746	1,737	1,710	1,701	1,641
Ogallala (Roberts County)	30,060	27,398	27,269	27,142	25,198	25,147
TOTAL	**47,445**	**49,656**	**49,518**	**49,364**	**46,095**	**45,984**
Imports:						
Ogallala (Deaf Smith County)	125	125	100	100	50	14
TOTAL	**125**	**125**	**100**	**100**	**50**	**14**

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 3-21 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 3-21
Summary of Groundwater Exports and Imports within the PWPA
(Values are in ac-ft /yr)

Export	Import	2010	2020	2030	2040	2050	2060
Carson	Hutchinson	987	945	906	882	858	819
	Moore	4	6	8	10	11	11
	Potter	6,278	5,854	5,012	4,268	3,632	3,158
	Randall	4,722	4,469	3,874	3,341	2,878	2,524
Dallam	Hartley	686	710	721	726	717	680
Donley	Hall	427	345	285	285	285	285
Hartley	Moore	1,823	1,975	1,500	1,300	1,000	900
Lipscomb	Ochlitree	2	2	2	2	2	2
Roberts	Gray	1,883	1,898	1,845	1,773	1,665	1,559
	Hutchinson	2,282	2,319	2,319	2,319	2,319	2,319
	Potter	15,922	15,110	14,843	14,595	14,381	14,193
	Randall	8,694	9,815	10,082	10,330	10,544	10,732

3.2.3 Summary of Developed Supplies to Water User Groups

The currently developed supply in the PWPA consists mainly of groundwater, 95 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 90 percent of the total supply in year 2010.

The total volume of the developed supply for water users in the PWPA in year 2010 is approximately 1,200,000 acre-feet per year and projected to decrease to 1,034,000 by the year 2030 and ultimately to 803,400 acre-feet per year in 2060. These supply volumes are shown in Table 3-22.

The developed supply is less than one third of the total available supply that could be developed (Table 3-18). 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 3-23 by source and shown by county on Figure 3-11.

Table 3-22
Developed Water Supplies to Water User Groups in PWPA
(Values are in ac-ft /yr)

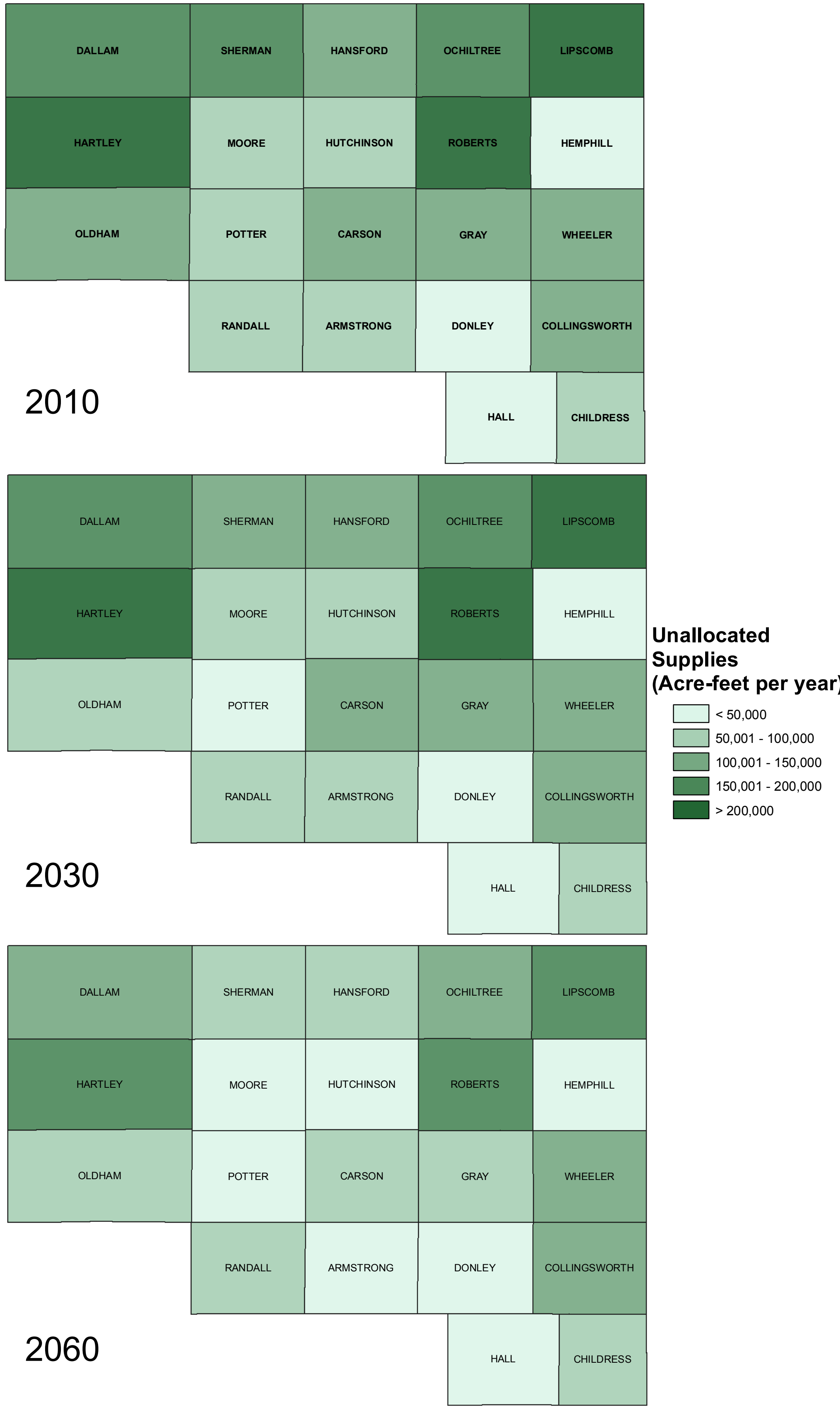
Source	2010	2020	2030	2040	2050	2060
Lake Meredith[1]	14,391	21,118	21,080	21,028	20,949	20,873
Greenbelt Lake[1]	2,564	2,582	2,587	2,575	2,559	2,489
Palo Duro Reservoir[2]	0	0	0	0	0	0
Canadian River Run-of-River	296	296	296	296	296	296
Red River Run-of-River	2,168	2,168	2,168	2,168	2,168	2,168
Total Surface Water	**19,419**	**26,164**	**26,131**	**26,067**	**25,972**	**25,826**
Ogallala Aquifer[1]	1,052,265	953,496	889,000	818,692	736,884	665,712
Seymour Aquifer	36,843	26,955	26,125	24,877	22,282	19,687
Blaine Aquifer	16,986	12,887	12,418	11,836	10,473	9,210
Dockum Aquifer	24,420	24,420	23,620	21,920	20,520	19,220
Rita Blanca Aquifer	Included with the Ogallala supplies					
Other Aquifer	636	636	636	636	636	636
Total Groundwater	**1,131,150**	**1,018,394**	**951,799**	**877,961**	**790,795**	**714,465**
Local Supply	21,217	21,217	21,217	21,217	21,217	21,217
Direct Reuse	25,129	28,928	30,620	32,528	34,598	37,577
Total Other Supplies	**46,346**	**50,145**	**51,837**	**53,745**	**55,815**	**58,794**
Total Supply	**1,196,915**	**1,094,703**	**1,029,767**	**957,773**	**872,582**	**799,085**

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 wholesale provider and are not reported in this table.
2. There is no currently available supply from Palo Duro Reservoir because there is no infrastructure.

Table 3-23
Unallocated Water Supplies in PWPA
(Values are in ac-ft /yr)

Source	2010	2020	2030	2040	2050	2060
Lake Meredith	0	6,977	6,886	6,811	8,035	8,060
Greenbelt Lake	2,522	2,400	2,268	2,171	2,060	2,051
Ogallala Aquifer	2,172,725	2,071,648	1,881,877	1,688,843	1,528,022	1,362,994
Seymour Aquifer	4,682	13,570	12,525	13,773	16,368	18,963
Blaine Aquifer	213,014	215,863	216,332	216,914	218,277	219,540
Dockum Aquifer	313,580	271,480	235,780	205,580	178,980	155,580
Other Aquifer	43	42	39	36	36	36
Total Groundwater	**2,704,044**	**2,572,603**	**2,346,553**	**2,125,146**	**1,941,683**	**1,757,113**
Other Supplies	**0**	**0**	**0**	**0**	**0**	**0**
Total Unallocated Supply	**2,706,566**	**2,581,980**	**2,355,707**	**2,134,128**	**1,951,778**	**1,767,224**

The amount shown for unallocated supplies accounts for water that is used outside of the PWPA.



0 12.5 25 50 Miles

DATE: MARCH 2010

SCALE: 1:3,168,000

DATUM & COORDINATE SYSTEM: GCS NORTH AMERICAN 1983

PREPARED BY: JJR

FILE: PPC07480 H:\WR_PLANNING\ WORKING\20090512_Figures\ Chapter3\Figure3_11.mxd

N W E S

PANHANDLE WATER PLANNING AREA

UNALLOCATED SUPPLIES IN PWPA

Location Map

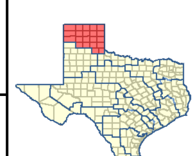


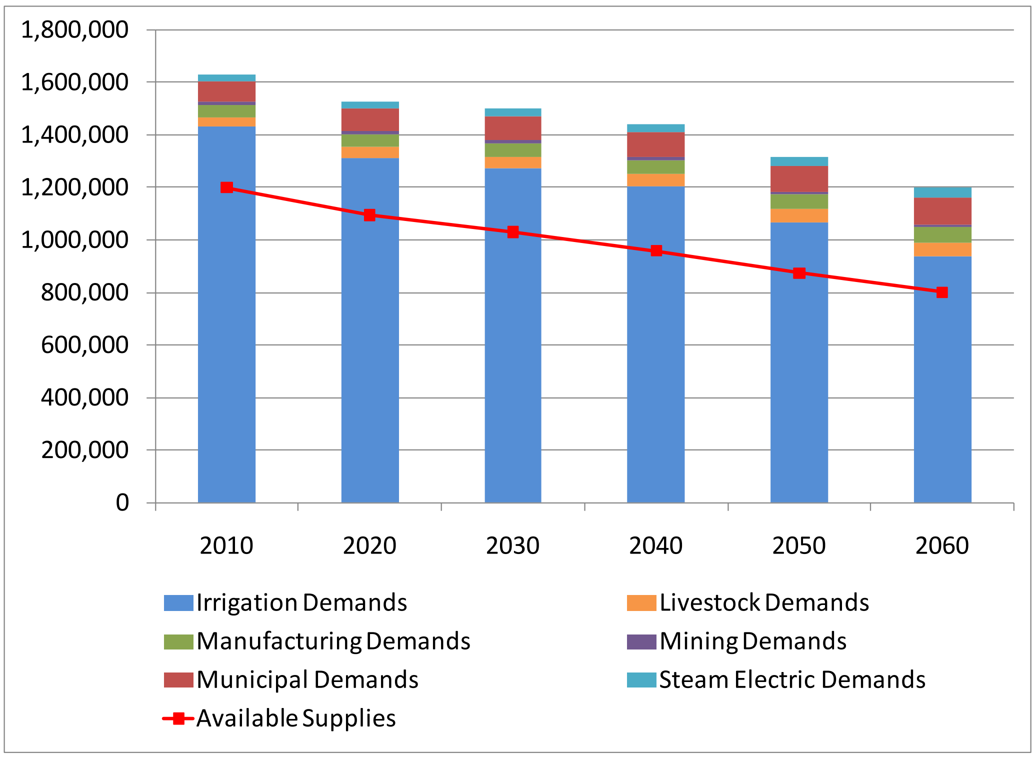
FIGURE 3-11

3.3 WATER SUPPLY AND DEMAND SUMMARY

This section discusses the comparison of the developed supply in the PWPA to the projected demands developed in Chapter 2. This comparison is made for the region, county, basin, wholesale water provider, and water user group. If the projected demands for an entity exceed the developed supplies, then a shortage 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 2060.

Considering only developed and connected supplies for the Panhandle, on a regional basis there is a projected regional shortage of over 428,000 acre-feet per year in 2010, increasing to a maximum shortage of 479,000 in 2040. This is shown graphically on Figure 3-12.

Figure 3-12: PWPA Supplies and Demands (ac-ft/yr)



On a county-basis, there are eight counties with shortages over the planning period. These include Dallam, Hansford, Hartley, Hutchinson, Moore, Potter, Randall and Sherman. Table 3-22 presents developed supply versus demand by county. Figure 3-13 shows the spatial distribution of shortages in the region for years 2010, 2030 and 2060. Typically the counties with the largest shortages are those with large irrigation demands. The shortages by category and county for years 2000, 2030 and 2060 are summarized in Tables 3-24, 3-25 and 3-26, respectively. Based on this analysis, there are significant irrigation shortages over the 50-year planning period. The municipal shortages shown are typically attributed to growth, allocation limitations in developed water rights, or infrastructure limitations. A brief discussion of these shortages is presented in the following section.

0 12.5 25 50 Miles

DATE: JANUARY 2010

SCALE: 1:3,168,000

DATUM & COORDINATE SYSTEM: GCS NORTH AMERICAN 1983

PREPARED BY: DLB

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N W E S

PANHANDLE WATER PLANNING AREA

SHORTAGES IN PWPA

Location Map

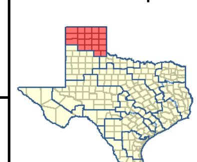


FIGURE 3-13

Table 3-24: Comparison of Developed Supply and Demand by County of Use
(Values are in ac-ft/yr)

		Year 2010		Year 2030		Year 2060	
County	**Basin**	**Developed Supply**	**Demand**	**Developed Supply**	**Demand**	**Developed Supply**	**Demand**
Armstrong	Red	6,902	6,068	6,197	5,598	4,893	4,386
Carson	Canadian	16,764	15,525	13,998	12,970	10,874	9,881
	Red	48,370	47,206	39,842	39,156	30,546	29,501
Childress	Red	9,948	9,456	7,735	7,542	6,589	6,104
Collingsworth	Red	31,254	29,844	24,254	22,468	18,754	16,783
Dallam	Canadian	164,401	297,251	139,942	281,566	93,063	210,433
Donley	Red	34,530	34,383	31,267	31,126	23,631	23,499
Gray	Canadian	18,370	16,353	17,469	15,314	16,800	14,351
	Red	22,612	20,482	20,777	18,472	16,324	14,650
Hall	Red	18,018	17,416	11,863	11,143	8,820	8,377
Hansford	Canadian	136,980	136,267	119,152	117,814	87,142	89,735
Hartley	Canadian	119,520	301,252	221,007	282,033	70,326	212,405
Hemphill	Canadian	4,419	4,131	6,120	3,845	3,109	2,822
	Red	2,517	2,179	2,358	2,022	1,764	1,429
Hutchinson	Canadian	58,459	71,970	73,180	70,931	58,451	64,963
Lipscomb	Canadian	20,211	20,033	19,371	18,053	13,763	13,574
Moore	Canadian	111,021	163,586	86,685	150,268	67,966	119,280
Ochiltree	Canadian	68,877	67,502	59,113	57,332	45,351	44,303
Oldham	Canadian	6,101	4,958	5,754	4,700	4,970	3,796
	Red	1,270	1,175	1,189	1,094	1,033	874
Potter	Canadian	44,197	42,240	48,615	49,248	54,112	60,675
	Red	20,602	19,902	22,492	22,546	18,721	26,426
Randall	Canadian	28	11	72	16	19	22
	Red	50,787	49,312	51,440	51,287	41,288	54,693
Roberts	Canadian	8,308	7,596	6,521	6,876	5,689	4,907
	Red	349	332	1,396	299	234	216
Sherman	Canadian	154,008	226,168	147,487	201,290	82,374	151,320
Wheeler	Red	18,092	15,746	15,921	13,546	12,479	10,239
TOTAL		**1,196,915**	**1,628,344**	**1,201,217**	**1,498,555**	**799,085**	**1,199,644**

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

Table 3-25: Year 2010 Shortages by County and Category

County	Irrigation			Manufacturing			Mining			Municipal			Steam Electric			Livestock			Total		
	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage
ARMSTRONG	5,118	5,118	0	0	0	0	82	13	69	932	371	561	0	0	0	770	566	204	6,902	6,068	834
CARSON	59,142	58,775	367	706	591	115	1,673	1,461	212	2,129	1,297	832	0	0	0	1,484	607	877	65,134	62,731	2,403
CHILDRESS	7,654	7,418	236	0	0	0	21	17	4	1,673	1,653	20	0	0	0	600	368	232	9,948	9,456	492
COLLINGSWORTH	29,648	28,693	955	0	0	0	0	0	0	747	690	57	0	0	0	859	461	398	31,254	29,844	1,410
DALLAM	159,142	292,031	-132,889	0	0	0	0	0	0	1,750	1,711	39	0	0	0	3,509	3,509	0	164,401	297,251	-132,850
DONLEY	32,195	32,000	195	0	0	0	50	15	35	839	659	180	0	0	0	1,446	1,267	179	34,530	33,941	589
GRAY	22,985	22,705	280	4,768	4,264	504	2,625	1,929	696	5,065	4,082	983	2,507	2,507	0	3,032	1,348	1,684	40,982	36,835	4,147
HALL	16,778	16,719	59	0	0	0	22	15	7	871	795	76	0	0	0	347	329	18	18,018	17,858	160
HANSFORD	130,544	130,694	-150	90	49	41	600	543	57	2,063	1,298	765	0	0	0	3,683	3,683	0	136,980	136,267	713
HARTLEY	113,200	294,932	-181,732	5	5	0	0	0	0	1,209	1,209	0	0	0	0	5,106	5,106	0	119,520	301,252	-181,732
HEMPHILL	1,825	1,825	0	1	1	0	2,575	2,575	0	697	633	64	0	0	0	1,838	1,276	562	6,936	6,310	626
HUTCHINSON	28,096	43,104	-15,008	23,659	23,659	0	593	398	195	5,426	4,124	1,302	0	0	0	685	685	0	58,459	71,970	-13,511
LIPSCOMB	17,022	16,956	66	120	89	31	1,235	1,235	0	829	748	81	0	0	0	1,005	1,005	0	20,211	20,033	178
MOORE	95,154	147,471	-52,317	7,706	7,879	-173	700	700	0	4,505	4,505	0	125	200	-75	2,831	2,831	0	111,021	163,586	-52,565
OCHILTREE	60,844	60,844	0	0	0	0	1,148	1,148	0	3,518	2,143	1,375	0	0	0	3,367	3,367	0	68,877	67,502	1,375
OLDHAM	4,235	4,235	0	0	0	0	518	328	190	1,119	416	703	0	0	0	1,499	1,154	345	7,371	6,133	1,238
POTTER	7,308	6,226	1,082	7,205	6,788	417	450	329	121	26,775	25,865	910	22,432	22,432	0	629	502	127	64,799	62,142	2,657
RANDALL	22,477	22,477	0	798	605	193	19	18	1	24,587	23,491	1,096	0	0	0	2,931	2,732	199	50,812	49,323	1,489
ROBERTS	6,156	6,084	72	0	0	0	1,270	1,270	0	606	189	417	0	0	0	625	385	240	8,657	7,928	729
SHERMAN	147,840	220,372	-72,532	0	0	0	17	17	0	1,218	846	372	0	0	0	4,933	4,933	0	154,008	226,168	-72,160
WHEELER	12,281	11,311	970	0	0	0	2,001	2,001	0	1,951	880	1,071	0	0	0	1,859	1,554	305	18,092	15,746	2,346
Grand Total	**979,644**	**1,429,990**	**-450,346**	**45,058**	**43,930**	**1,128**	**15,599**	**14,012**	**1,587**	**88,509**	**77,605**	**10,904**	**25,064**	**25,139**	**-75**	**43,038**	**37,668**	**5,370**	**1,196,912**	**1,628,344**	**-431,432**

Table 3-26: Year 2030 Shortage by County and Category

County	Irrigation			Manufacturing			Mining			Municipal			Steam Electric			Livestock			Total		
	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage
ARMSTRONG	4,544	4,544	0	0	0	0	52	12	40	831	369	462	0	0	0	770	673	97	6,197	5,598	599
CARSON	48,344	47,982	362	802	735	67	1,521	1,393	128	1,989	1,300	689	0	0	0	1,484	716	768	54,140	52,126	2,014
CHILDRESS	5,590	5,350	240	0	0	0	21	16	5	1,724	1,704	20	0	0	0	700	472	228	8,035	7,542	493
COLLINGSWORTH	22,648	21,236	1,412	0	0	0	0	0	0	747	666	81	0	0	0	859	566	293	24,254	22,468	1,786
DALLAM	126,012	274,642	-148,630	0	0	0	0	0	0	1,941	1,928	13	0	0	0	4,996	4,996	0	132,949	281,566	-148,617
DONLEY	28,966	28,771	195	0	0	0	44	14	30	811	631	180	0	0	0	1,446	1,270	176	31,267	30,686	581
GRAY	20,065	19,785	280	4,875	4,451	424	2,625	2,028	597	4,923	3,936	987	2,112	2,112	0	3,032	1,474	1,558	37,632	33,786	3,846
HALL	10,462	10,403	59	0	0	0	22	14	8	729	835	-106	0	0	0	345	331	14	11,558	11,583	-25
HANSFORD	110,022	111,506	-1,484	93	54	39	600	529	71	1,040	1,469	-429	0	0	0	4,256	4,256	0	116,011	117,814	-1,803
HARTLEY	89,569	273,026	-183,457	5	5	0	0	0	0	1,271	1,271	0	0	0	0	7,731	7,731	0	98,576	282,033	-183,457
HEMPHILL	1,653	1,653	0	1	1	0	2,314	2,314	0	683	614	69	0	0	0	1,838	1,285	553	6,489	5,867	622
HUTCHINSON	27,096	38,748	-11,652	26,905	26,969	-64	506	394	112	5,226	4,122	1,104	0	0	0	698	698	0	60,431	70,931	-10,500
LIPSCOMB	15,136	15,070	66	120	100	20	1,114	1,114	0	826	741	85	0	0	0	1,028	1,028	0	18,224	18,053	171
MOORE	78,444	130,869	-52,425	7,881	8,914	-1,033	630	630	0	4,093	5,724	-1,631	83	200	-117	3,931	3,931	0	95,062	150,268	-55,206
OCHILTREE	50,252	50,252	0	0	0	0	1,027	1,027	0	3,561	2,448	1,113	0	0	0	3,605	3,605	0	58,445	57,332	1,113
OLDHAM	3,794	3,794	0	0	0	0	532	347	185	1,118	394	724	0	0	0	1,499	1,259	240	6,943	5,794	1,149
POTTER	5,977	5,525	452	7,823	8,043	-220	450	392	58	27,962	30,525	-2,563	27,176	26,804	372	629	505	124	70,017	71,794	-1,777
RANDALL	19,291	19,291	0	750	726	24	20	20	0	24,918	28,510	-3,592	0	0	0	2,958	2,756	202	47,937	51,303	-3,366
ROBERTS	5,538	5,466	72	0	0	0	1,148	1,148	0	606	175	431	0	0	0	625	386	239	7,917	7,175	742
SHERMAN	114,747	194,437	-79,690	0	0	0	16	16	0	1,243	948	295	0	0	0	5,889	5,889	0	121,895	201,290	-79,395
WHEELER	10,168	9,198	970	0	0	0	1,810	1,810	0	1,951	878	1,073	0	0	0	1,859	1,660	199	15,788	13,546	2,242
Grand Total	**798,318**	**1,271,548**	**-473,230**	**49,255**	**49,998**	**-743**	**14,452**	**13,218**	**1,234**	**88,193**	**89,188**	**-995**	**29,371**	**29,116**	**255**	**50,178**	**45,487**	**4,691**	**1,029,767**	**1,498,555**	**-468,788**

Table 3-27: Year 2060 Shortages by County and Category

County	Irrigation			Manufacturing			Mining			Municipal			Steam Electric			Livestock			Total		
	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage	Supply	Demand	Shortage
ARMSTRONG	3,349	3,349	0	0	0	0	64	12	52	710	340	370	0	0	0	770	685	85	4,893	4,386	507
CARSON	35,705	35,355	350	1,024	920	104	1,501	1,339	162	1,706	1,038	668	0	0	0	1,484	730	754	41,420	39,382	2,038
CHILDRESS	4,179	3,942	237	0	0	0	21	16	5	1,689	1,669	20	0	0	0	700	477	223	6,589	6,104	485
COLLINGSWORTH	17,148	15,648	1,500	0	0	0	0	0	0	747	561	186	0	0	0	859	574	285	18,754	16,783	1,971
DALLAM	84,972	202,368	-117,396	0	0	0	0	0	0	1,845	1,819	26	0	0	0	6,246	6,246	0	93,063	210,433	-117,370
DONLEY	21,395	21,200	195	0	0	0	42	14	28	748	568	180	0	0	0	1,446	1,275	171	23,631	23,057	574
GRAY	14,858	14,578	280	5,532	4,334	1,198	2,625	2,118	507	3,990	3,327	663	3,087	3,087	0	3,032	1,557	1,475	33,124	29,001	4,123
HALL	7,724	7,665	59	0	0	0	22	14	8	729	805	-76	0	0	0	345	335	10	8,820	8,819	1
HANSFORD	80,522	82,162	-1,640	120	62	58	600	516	84	554	1,649	-1,095	0	0	0	5,346	5,346	0	87,142	89,735	-2,593
HARTLEY	59,098	201,177	-142,079	5	5	0	0	0	0	1,199	1,199	0	0	0	0	10,024	10,024	0	70,326	212,405	-142,079
HEMPHILL	1,218	1,218	0	1	1	0	1,183	1,183	0	633	548	85	0	0	0	1,838	1,301	537	4,873	4,251	622
HUTCHINSON	23,096	28,551	-5,455	30,438	31,708	-1,270	487	396	91	3,698	3,576	122	0	0	0	732	732	0	58,451	64,963	-6,512
LIPSCOMB	11,170	11,104	66	120	116	4	574	574	0	795	676	119	0	0	0	1,104	1,104	0	13,763	13,574	189
MOORE	51,010	96,430	-45,420	8,392	10,436	-2,044	459	459	0	2,926	6,622	-3,696	59	213	-154	5,120	5,120	0	67,966	119,280	-51,314
OCHILTREE	37,028	37,028	0	0	0	0	522	522	0	3,682	2,634	1,048	0	0	0	4,119	4,119	0	45,351	44,303	1,048
OLDHAM	2,795	2,795	0	0	0	0	592	364	228	1,117	244	873	0	0	0	1,499	1,267	232	6,003	4,670	1,333
POTTER	4,541	4,071	470	7,228	9,757	-2,529	465	462	3	25,855	38,185	-12,330	34,115	34,115	0	629	511	118	72,833	87,101	-14,268
RANDALL	14,214	14,214	0	892	892	0	23	23	0	23,163	36,778	-13,615	0	0	0	3,015	2,808	207	41,307	54,715	-13,408
ROBERTS	4,100	4,028	72	0	0	0	592	592	0	606	115	491	0	0	0	625	388	237	5,923	5,123	800
SHERMAN	74,079	143,269	-69,190	0	0	0	16	16	0	1,260	1,016	244	0	0	0	7,019	7,019	0	82,374	151,320	-68,946
WHEELER	7,747	6,777	970	0	0	0	922	922	0	1,951	873	1,078	0	0	0	1,859	1,667	192	12,479	10,239	2,240
Grand Total	**559,948**	**936,929**	**-376,981**	**53,752**	**58,231**	**-4,479**	**10,710**	**9,542**	**1,168**	**79,603**	**104,242**	**-24,639**	**37,261**	**37,415**	**-154**	**57,811**	**53,285**	**4,526**	**799,085**	**1,199,644**	**-400,559**

3.3.1 Identified Shortages for the PWPA

A shortage occurs when developed supplies are not sufficient to meet projected demands. In the PWPA there are 27 water user groups (accounting for basin and county designations) with identified shortages during the planning period. Of these, there are four cities and county other water users in three counties that are projected to experience a water shortage before 2060. The largest shortages are attributed to high irrigation use and comparably limited groundwater resources in Dallam, Hartley, Moore, and Sherman Counties.

Total shortages for all water user groups are projected to be approximately 454,726 acre feet per year in 2010, increasing to 484,176 acre feet per year in 2030 and nearly 415,317 acre-feet per year by the year 2060. Of this amount, irrigation represents approximately 99 percent in the 2010 projections and over 84 percent of the total shortage in 2060 with shortages ranging from 454,000 to 381,000 acre-feet per year. The shortages attributed to the other water use categories total approximately 34,000 acre-feet per year in 2060.

A summary of when the individual water user group shortages begin by county and demand type is presented in Table 3-28. To account for the level of accuracy of the data, a shortage is defined as a demand greater than the current supply by more than or equal to 10 acre-feet per year.

Table 3-28: Decade Shortage Begins by County and Category

County	Irrigation	Municipal	Manufacturing	Mining	Steam Electric Power	Livestock
Armstrong	-	-	-	-	-	-
Carson	-	-	-	-	-	-
Childress	-	-	-	-	-	-
Collingsworth	-	-	-	-	-	-
Dallam	2010	-	-	-	-	
Donley	-	-	-	-	-	-
Gray	-	-	-	-	-	-
Hall	-	2020	-	-	-	-
Hansford	2020	2030	-	-	-	-
Hartley	2010	-	-	-	-	
Hemphill	-	-	-	-	-	-
Hutchinson	2010	2040	2030	-	-	-
Lipscomb	-	-	-	-	-	-
Moore	2010	2020	2030		2010	-
Ochiltree	-	-	-	-	-	-
Oldham	-	-	-	-	-	-
Potter	-	2030	2040	-	-	-
Randall	-	2030	-	-	-	-
Roberts	-	-	-	-	-	-
Sherman	2010	-	-	-	-	
Wheeler	-	-	-	-	-	-

Irrigation

Irrigation shortages are identified for Dallam, Hansford, Hartley, Hutchinson, Moore, and Sherman Counties. All of these counties rely heavily on the Ogallala for irrigation supplies. Shortages are observed in five counties starting in 2010.

Table 3-29: Projected Irrigation Shortages in the PWPA
(Values are in ac-ft /yr)

COUNTY	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
DALLAM	132,889	140,984	148,630	149,134	133,737	117,396
HANSFORD	150	1,005	1,484	4,548	3,077	1,640
HARTLEY	181,732	180,523	183,457	179,983	161,368	142,079
HUTCHINSON	15,008	12,175	11,652	10,612	7,534	5,455
MOORE	52,317	48,090	52,425	54,994	50,321	45,420
SHERMAN	72,532	69,367	79,690	82,955	77,118	69,190
TOTAL	**454,628**	**452,144**	**477,338**	**482,226**	**433,155**	**381,180**

Municipal

Municipal supplies in the PWPA are typically groundwater while surface water is used in counties with limited groundwater and by river authorities and their member cities to supply their customers. For some cities, there is additional groundwater supply but it is not fully developed. A list of the municipalities indicating a shortage is presented in Table 3-30.

Table 3-30: Projected Municipal Shortages in the PWPA
(Values are in ac-ft /yr)

	2010	**2020**	**2030**	**2040**	**2050**	**2060**
AMARILLO	0	0	4,097	9,042	14,065	18,337
BORGER	0	0	0	0	0	196
CACTUS	0	0	204	262	309	354
CANYON	0	422	1,245	1,903	2,452	2,859
COUNTY-OTHER MOORE	0	0	264	505	652	741
COUNTY-OTHER POTTER	0	103	329	885	1,574	2,139
COUNTY-OTHER RANDALL	0	5	597	1,273	2,009	2,619
DUMAS	0	387	1,163	1,672	2,219	2,478
GRUVER	0	77	229	282	333	334
LEFORS	0	0	0	29	35	36
MEMPHIS	0	81	140	140	140	142
SPEARMAN	0	0	276	611	831	849
SUNRAY	0	0	0	27	108	127
TOTAL	**0**	**1,075**	**8,544**	**16,631**	**24,727**	**31,211**

Manufacturing

There are three counties with manufacturing shortages 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 shortage is associated with shortages associated with wholesale water providers. For Moore County, these shortages are the result of limited groundwater supplies for the city of Cactus. In Potter County, the shortages are associated with shortages identified with the city of Amarillo. In Hutchinson County the shortage is associated with the city of Borger.

Table 3.31: Projected Manufacturing Shortages in the PWPA
(Values are in ac-ft /yr)

	2010	**2020**	**2030**	**2040**	**2050**	**2060**
HUTCHINSON	0	0	64	469	784	1,270
MOORE	173	800	1,033	1,396	1,718	2,067
POTTER	0	0	220	980	1,710	2,529
TOTAL	**173**	**800**	**1,317**	**2,845**	**4,212**	**5,866**

Mining

There are no mining shortages in the PWPA.

Steam Electric Power

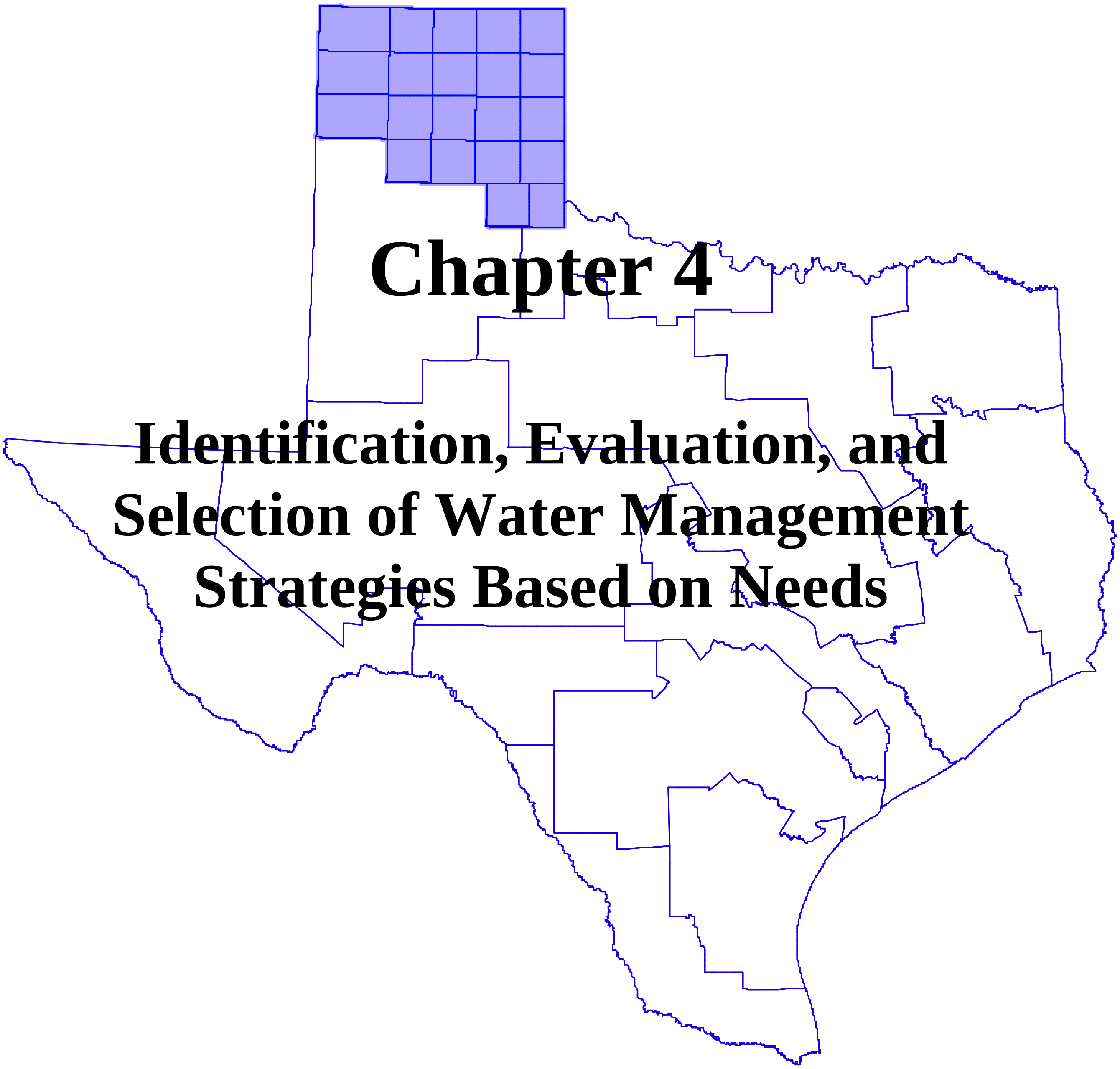
There is only one steam electric power shortage identified in the PWPA. A shortage of less than 100 acre-feet per year is projected in Moore County beginning in 2010; by 2060 this shortage is projected to be approximately 150 acre-feet per year. All of these shortages are expected to be met by increasing the supply coming from groundwater.

Livestock

There are no identified livestock shortages in the Panhandle Planning Area. This is because it was assumed if there was sufficient supply available within the county, this supply would be developed by livestock producers. 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. It is assumed that the decrease in water used for irrigation will be available for livestock use.

3.3.2 Conclusions

On a water user group basis, the total demands exceed the total developed supply starting in 2010, largely attributed to the geographical constraints of the demand centers and developed supplies. Most of the shortages are associated with large irrigation demands that cannot be met with groundwater sources beneath currently irrigated lands. Other shortages 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 shortage. Further review of the region's options and strategies to meet shortages is explored in more detail in Chapter 4 and the impacts of these strategies on water quality are discussed in Chapter 5.



Chapter 4

Identification, Evaluation, and Selection of Water Management Strategies Based on Needs

Identified Regional Shortages and Evaluation Procedures

The Panhandle Water Planning Group (PWPG) would like to note the following points for the reader to consider when reviewing this report:

- The impacts contained in this report represent a drought of record scenario. In order to produce the identified impacts assessed by the TWDB in Section 4.13, all identified water shortages per user group for the entire region would have to go un-met. While the report does consider meeting partial shortages per user group if the full need cannot be met, the impacts of the reduced shortages are not addressed.

- The shortages presented are cumulative in nature throughout the 50-year planning horizon. Without water management strategies, shortages are considered to be un-met in their entirety from the first point identified in the Regional Water Plan and continue to be entirely un-met through the year 2060.

- The predominant groundwater supply in the PWPA, Ogallala aquifer, is a finite resource. This limitation is addressed through allocation of supplies as adopted by the PWPG. At some point in the future (beyond this planning period) this water source will have limited water available to meet the projected demands in the region.

- As noted in the body of the report, the impacts presented in the report do not indicate a prediction or forecast of future water disasters.

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

- In June 2005, CRMWA completed and submitted a Management Plan for the Arkansas River Shiner. CRMWA and its partners in this endeavor consider a flexible, adaptive, and proactive management approach to be an appropriate and effective means of achieving continued conservation of the Arkansas River Shiner while contributing to national recovery efforts.

4.1 Regional Shortages

The comparison of current water supplies to demands presented in Chapter 3 identified 27 different water user groups with shortages greater than or equal to 10 acre-feet per year. Water management strategies were not developed for water user groups with shortages of less than 10 acre-feet per year during the planning period. Most of the shortages are located in five counties: Dallam, Hartley, Hutchinson, Moore, and Sherman Counties. A list of these users and their respective shortages are presented in Table 4-1.

Table 4-1: Identified Shortages in the PWPA

			Shortages (Ac-ft/yr)					
County Name	**Water User Group**	**Basin**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
DALLAM	IRRIGATION	CANADIAN	132,889	140,984	148,630	149,134	133,737	117,396
GRAY	LEFORS	RED	0	0	0	29	35	36
HALL	MEMPHIS	RED	0	81	140	140	140	142
HANSFORD	GRUVER	CANADIAN	0	77	229	282	333	334
HANSFORD	IRRIGATION	CANADIAN	150	1,005	1,484	4,548	3,077	1,640
HANSFORD	SPEARMAN	CANADIAN	0	0	276	611	831	849
HARTLEY	IRRIGATION	CANADIAN	181,732	180,523	183,457	179,983	161,368	142,079
HUTCHINSON	BORGER	CANADIAN	0	0	0	0	0	196
HUTCHINSON	IRRIGATION	CANADIAN	15,008	12,175	11,652	10,612	7,534	5,455
HUTCHINSON	MANUFACTURING	CANADIAN	0	0	64	469	784	1,270
MOORE	CACTUS	CANADIAN	0	0	204	262	309	354
MOORE	COUNTY-OTHER	CANADIAN	0	0	264	505	652	741
MOORE	DUMAS	CANADIAN	0	387	1,163	1,672	2,219	2,478
MOORE	IRRIGATION	CANADIAN	52,317	48,090	52,425	54,994	50,321	45,420
MOORE	MANUFACTURING	CANADIAN	173	800	1,033	1,396	1,718	2,067
MOORE	STEAM ELECTRIC POWER	CANADIAN	75	99	117	128	136	154
MOORE	SUNRAY	CANADIAN	0	0	0	27	108	127
POTTER	AMARILLO	CANADIAN	0	0	1,349	2,961	4,582	5,950
POTTER	AMARILLO	RED	0	0	961	2,110	3,266	4,241
POTTER	COUNTY-OTHER	CANADIAN	0	0	0	299	708	1,043
POTTER	COUNTY-OTHER	RED	0	103	329	586	866	1,096
POTTER	MANUFACTURING	CANADIAN	0	0	33	57	35	43
POTTER	MANUFACTURING	RED	0	0	187	923	1,675	2,486
RANDALL	AMARILLO	RED	0	0	1,787	3,971	6,217	8,146
RANDALL	CANYON	RED	0	422	1,245	1,903	2,452	2,859
RANDALL	COUNTY-OTHER	RED	0	5	597	1,273	2,009	2,619
SHERMAN	IRRIGATION	CANADIAN	72,532	69,367	79,690	82,955	77,118	69,190
Total			**454,876**	**454,118**	**487,316**	**501,830**	**462,230**	**418,411**

4.2 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 Panhandle Planning Area. The potentially feasible strategies identified in previous round of planning were considered as a starting point. Additionally, new strategies were developed to meet new shortages or based on input from the water user group. 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.

Water supply strategies were developed for water user groups with shortages. Most of these strategies were based on survey responses from the municipalities, as well as previous planning reports. General strategies were developed for mining, steam electric, and irrigation. In most cases, the potentially feasible strategy identified to meet water shortages was to develop existing groundwater rights or purchase and develop groundwater rights. Due to the large volume of water shortages for irrigation, management strategies that would reduce irrigation demands were examined. These included, but were not limited to, the evaluation of the North Plains Evapotranspiration Network (NPET) to schedule irrigation; improved irrigation equipment and scheduling; conservation tillage practices; use of drought tolerant crops, precipitation enhancement, and bioengineered crop types.

Strategies for municipal users with shortages are described in Section 4.4. Strategies for industrial users with shortages, i.e. manufacturing and steam electric, are presented in Sections 4.5 and 4.6, respectively. Discussion of the irrigation shortages and strategies are presented in Sections 4.7 and 4.8. There are no currently indentified shortages for livestock or mining. Attachment 4-1, which immediately follows this chapter, includes a list of potentially feasible strategies, recommended strategies and alternate strategies. Attachment 4-2 includes summaries for each municipal water user group. In addition, a summary sheet has been created for each county, which lists all users in that county and the proposed water management strategies for those with projected shortages. These summary sheets are included in Appendix B. Strategies for wholesale water providers are discussed in Section 4.9.

In accordance with state guidance, the potentially feasible strategies were evaluated with respect to:

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

The other considerations listed in TAC 357.7(a), 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 Panhandle Water Planning Area (PWPA) shortages.

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 shortages. 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 2008 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 6 percent interest rate. In the case of municipal and county-other water shortages, the cost estimates are only for development of the supply and delivery to the user's distribution system. There may be additional costs to actually deliver the water to the end users of the water 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. A water management strategy may have a positive or negative effect on a 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 actually 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 (such as mining), 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 issues affect water use options and treatment requirements. For the evaluations of the strategies, it was assumed that the final water product 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.

A summary of various factors evaluated to analyze and quantify the environmental and other impacts of each recommended strategy is shown in Table 4-2.

Table 4-2: Summary of Strategy Impacts and Cost Evaluation

Entity	County Used	Basin Used	Strategy	Quantity (Ac-Ft/Yr)						Cost ($/Ac-Ft)	Reliability	Impacts of Strategy on:				
				2010	2020	2030	2040	2050	2060			Environ-mental Factors	Agricultural Resources/ Rural Areas	Other Natural Resources	Possible Third Party	Key Water Quality Parameters
Name(s)											Low/Medium/High					
PANHANDLE	Carson	Red	Conservation	0	17	29	28	25	23	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	0	600	600	600	600	$736	Medium	Low	Low	Low	----	Low
TEXLINE	Dallam	Canadian	Conservation	0	7	12	12	12	11	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	250	250	250	250	250	$1,113	Medium	Low	Low	Low	----	Low
IRRIGATION	Dallam	Canadian	Conservation	0	59,275	108,476	121,561	122,958	122,958	Variable	Medium	Low	Varies	Low	----	N/A
LEFORS	Gray	Red	Conservation	0	3	4	4	4	4	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	0	0	100	100	100	$1,328	Medium	Low	Low	Low	----	Low
PAMPA	Gray	Canadian	Conservation	0	15	65	65	65	65	$490	Medium	N/A	N/A	N/A	----	N/A
			Purchase from CRMWA	0		0	0	1,000	1,000	N/A	Medium to High	Low	Low	Low	----	Medium
			New wells	0	968	2,581	0	0	0	$1,328	Medium	Low	Low	Low	----	Low
MEMPHIS	Hall	Red	Conservation	0	13	22	22	22	22	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	100	100	100	100	100	$1,212	Medium	N/A	N/A	N/A	----	Low
			Purchase from Greenbelt MIWA	0	0	100	100	100	100	N/A	High	Low	Low	Low	----	Low
SPEARMAN	Hansford	Canadian	Conservation	0	22	39	41	42	42	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	0	900	900	900	900	$594	Medium	Low	Low	Low	----	Low
IRRIGATION	Hansford	Canadian	Conservation	0	24,436	45,264	51,215	51,951	51,951	Variable	Medium	Low	Low	Low	----	n/a
GRUVER	Hansford	Canadian	Conservation	0	10	16	17	17	17	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	350	350	350	350	350	$731	Medium	Low	Low	Low	----	Low
IRRIGATION	Hartley	Canadian	Conservation	0	53,755	98,786	110,553	111,772	111,772	Variable	Medium	Low	Low	Low	----	N/A
FRITCH	Hutchinson	Canadian	Rehab well/ purchase system	200	200	200	200	200	200	$1,558	Medium	Low	Low	Low	----	Low
			New wells	0	200	200	200	200	200	$751	Medium	Low	Low	Low	----	Low
MANUFACTURING	Hutchinson	Canadian	Purchase from Borger	0	0	664	1,244	1,752	2,450	N/A	Medium	Low	Low	Low	----	Low
IRRIGATION	Hutchinson	Canadian	Conservation	0	7,514	14,044	15,905	16,128	16,128	Variable	Medium	Low	Low	Low	----	N/A
COUNTY-OTHER	Moore	Canadian	Conservation	0	29	63	75	83	87	$490	Medium	N/A	N/A	N/A	----	N/A
			Purchase from Cactus	0	0	50	100	100	100	N/A	Medium	Low	Low	Low	----	Low
			New wells	0	0	500	500	1,000	1,000	$474	Medium	Low	Low	Low	----	Low
DUMAS	Moore	Canadian	Conservation	0	89	158	166	171	174	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	387	1,163	1,672	2,219	2,500	$462	Medium	Low	Low	Low	----	Low
MANUFACTURING	Moore	Canadian	Purchase water from Cactus	200	800	1,100	1,400	1,800	2,100	N/A	Medium	Low	Low	Low	----	Low
IRRIGATION	Moore	Canadian	Conservation	0	31,602	58,995	66,995	67,846	67,846	Variable	Medium	Low	Low	Low	----	N/A

Table 4-2: Summary of Strategy Impacts and Cost Evaluation (Continued)

Entity	County Used	Basin Used	Strategy	Quantity (Ac-Ft/Yr)						Cost ($/Ac-Ft)	Reliability	Impacts of Strategy on:				
				2010	2020	2030	2040	2050	2060			Environ-mental Factors	Agricultural Resources/ Rural Areas	Other Natural Resources	Possible Third Party	Key Water Quality Parameters
STEAM ELECTRIC	Moore	Canadian	New wells	200	200	200	200	200	200	$1,017	Medium	Low	Low	Low	----	Low
SUNRAY	Moore	Canadian	Conservation	0	18	34	36	38	39	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	0	800	800	800	800	$567	Medium	Low	Low	Low	----	Low
PERRYTON	Ochiltree	Canadian	Conservation	0	64	113	118	120	123	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	0	0	0	600	1,200	$759	Medium	Low	Low	Low	----	Low
COUNTY-OTHER	Potter	Canadian	Conservation	0	41	85	103	124	140	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	0	1,000	1,000	1,000	1,000	$474	Medium	Low	Low	Low	----	Low
COUNTY-OTHER	Potter	Red	Conservation	0	28	58	71	85	96	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	600	600	600	1,200	1,200	$474	Medium	Low	Low	Low	----	Low
MANUFACTURING	Potter	Canadian	Purchase from Amarillo	0	0	200	328	313	225	N/A	Medium to High	Low	Low	Low	----	Medium
MANUFACTURING	Potter	Red	Purchase from Amarillo	0	0	444	1,087	1,846	2,638	N/A	Medium to High	Low	Low	Low	----	Medium
CANYON	Randall	Red	Conservation	0	81	146	159	174	186	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	700	1,400	2,100	2,800	2,800	3,800	$407	Medium	Low	Low	Low	----	Medium
COUNTY-OTHER	Randall	Red	Conservation	0	101	197	231	268	299	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	0	600	1,200	2,600	2,600	$386	Medium	Low	Low	Low	----	Medium
IRRIGATION	Sherman	Canadian	Conservation	0	41,127	77,102	86,803	87,896	87,896	Variable	Medium	Low	Low	Low	----	Low
WHEELER	Wheeler	Red	Conservation	0	9	15	15	15	15	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	0	0	0	200	200	$1,311	Medium	Low	Low	Low	----	Low
WHOLESALE WATER PROVIDERS:																
AMARILLO	Potter and Randall	Red and Canadian	Conservation	0	1,375	2,453	2,639	2,841	3,012	$490	Medium	N/A	N/A	N/A	----	N/A
			Potter Co. Well Field	0	9,467	10,292	11,182	11,141	10,831	$1,286	Medium	Low	Low	Low	----	Low
			Roberts Co. Well Field	0	0	0	11,210	11,210	22,420	$1,447	Medium to High	Low	Low	Low	----	Medium
BORGER	Hutchinson	Canadian	Conservation	0	24	71	114	107	102	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	0	0	1,000	1,000	2,000	2,000	$628	Medium	Low	Low	Low	----	Low
CACTUS	Moore	Canadian	Conservation	0	18	31	31	31	31	$490	Medium	N/A	N/A	N/A	----	N/A
			New wells	500	1,500	1,500	3,000	3,000	3,000	$537	Medium	Low	Low	Low	----	Low
CRMWA			Replacement Wells	0	0	15,000	15,000	15,000	15,000	$235	Medium to High	Low	Low	Low	----	Low
			Water rights purchase	0	0	0	0	0	0	NA	Medium to High	Low	Low	Low	----	Low
PALO DURO RIVER AUTHORITY			Palo Duro Transmission System	0	0	3,758	3,758	3,758	3,750	Varies	Low to Medium	Low	Low	Low	----	Low to Medium
GREENBELT M&IWA			New Wells	0	800	800	800	800	800	$288	Medium	Low	Low	Low	----	Low

4.3 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 the Region. Most of the water supply in the PWPA is from groundwater. For many of the identified shortages, 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 well capacity, depth of well and associated costs were developed.

4.3.1 Strategy Costs

The cost estimates for water management strategies identify both capital and annual costs. Capital costs are based on standard unit costs for installed pipe, pump stations and standard treatment facilities developed from experience with similar projects throughout the State of Texas. Assumptions for groundwater strategies include project location, well depth, and well capacity. The depth of a groundwater supply well was based on the average well depth by county and aquifer information gathered from local groundwater conservation districts. Costs for well installation were developed for different types of wells (e.g., municipal or industrial) per foot of well installed.

Table 4-3: Assumptions Made for Additional Groundwater Wells

Well Use	Assumed Depth (ft)	Cost ($) per foot
Municipal	500-800	$325-$525
Manufacturing	500	$350
Livestock	500	$200
Mining	500	$200

Transmission lines were assumed to follow existing highways or roads where possible. For new well fields that are not specifically identified, an average transmission distance was assumed. Costs to connect new transmission lines to existing systems were assumed to range from $50,000 to $125,000 per well depending on the amount of additional water required and the size and complexity of the infrastructure already in place. The cost for the purchase of rural easements was assumed to be $1,200 per acre. Costs for groundwater rights were assumed at $300 per acre-foot per year. Actual cost of water rights will be negotiated between a willing seller and willing buyer, and depend upon multiple factors including the saturated thickness and water quality of the groundwater. Summaries of the costs developed for each strategy are included in Appendix H.

4.3.2 Conservation

Conservation is a quantified water management strategy for all municipal water user groups with shortages during the planning period. Conservation and demand management are considered the first, practicable strategy to meet water shortages. There is some level of conservation included in the projected water demands, but this can vary significantly from one water user group to another. For municipal users, the conservation in the demands includes only the implementation of the plumbing fixture savings for projected growth. This translates into less than 1% savings for the PWPA. The other water user groups have conservation savings built into their demand projections, but the quantification is more difficult. For this plan, it is assumed that municipal water user groups with needs will implement additional conservation measures that result in water savings of up to 5 % of the demand.

Advanced conservation for municipal users is encouraged to achieve a 1% annual demand reduction until a goal of 140 gallons per capita per day consumption is achieved. These strategies should be adopted by all regional municipalities in their respective water conservation plans in order to sustain regional municipal supply sources for future generations.

Table 4-2 shows conservation savings for water user groups in the PWPA with needs for the planning period. It was assumed that municipalities will have a 0% conservation savings in 2010, 3% conservation savings in 2020, and 5% conservation savings from 2030 through 2060. The measures considered include the implementation of water efficient clothes washers for current populations, education and public awareness programs, reduction of unaccounted for water through water audits and system maintenance, and water rate structures that discourage water waste. Annual costs for municipal conservation are assumed to be $1.50 per thousand gallons ($490 per acre-foot). This is based on typical costs reported by municipalities for these types of strategies. Actual costs may differ pending the strategies implemented and the water supplier.

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. This strategy requires a source (municipal water users with treated effluent), sufficient quantity and industrial processes that can utilize non-potable water. Where possible, wastewater reuse will be considered for manufacturing water needs. Steam electric power generation in the region is on schedule to implement full utilization of reuse wastewater for supply generation by 2010.

Mining is another water category that often can use non-potable water, and its processes are conducive for recycling of water. Reuse (or recycling of water) will be considered as a conservation strategy for mining.

The agricultural water needs in the PWPA include livestock and irrigated agriculture. New water supply strategies to meet these needs are limited. For irrigated agriculture, the primary strategies identified to address irrigation shortages are demand reduction strategies (conservation). The agricultural water conservation strategies considered include the use of the NPET to schedule irrigation, irrigation equipment efficiency improvements, implementation of conservation tillage methods, precipitation enhancement, conversion to dryland farming and changes to crop types that use less water. These strategies are discussed in Section 4.8. There are no identified conservation strategies for livestock water use.

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 shortages during drought. Discussions of drought management plans for entities in the PWPA are included in Chapter 6.

4.4 Municipal Shortages

As shown in Table 4-1, there are ten cities and three county-other municipal water users that indicate a shortage during the planning period. In addition, there is one county-other user that has known water quality concerns that requires the development of new supplies. Based on a water rights survey conducted for the 2006 regional water plan, several cities own additional groundwater rights that are not fully developed. For cities with projected shortages, it was assumed that these rights would be fully developed. If this supply was sufficient to meet the city's shortages through 2060, no other strategies were developed.

The strategies for each city are discussed in the following subsections. Water supply projects that do not involve the development of or connection to a new water source are consistent with the regional water plan, even though not specifically recommended in the plan. These include, but are not limited to, such projects as repairing treatment plants, repairing pipelines, maintaining groundwater supplies, and constructing new water towers.

4.4.1 Amarillo

<u>Location</u>

County: Potter and Randall
River Basin: Canadian and Red

The City of Amarillo is a water user group and a wholesale water provider in PWPA. Additional information regarding Amarillo's recommended strategies is found in Section 4.9.2. The current sources of water include well fields in the Ogallala 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, the development of the Potters County well field, and development of the Roberts County well field.

4.4.2 Borger

<u>Location</u>

County: Hutchinson
River Basin: Canadian

The City of Borger is a water user group and a wholesale water provider in PWPA. The City is expected to need additional water supplies by 2030. Additional information regarding Borger's recommended strategies is found in Section 4.9.3. The current sources of water include well fields in the Ogallala aquifer, reuse, and purchasing surface water and groundwater from the Canadian River Municipal Water Authority (CRMWA). The recommended strategies for the City of Borger include water conservation and the development of the additional groundwater in Hutchinson County.

4.4.3 Cactus

<u>Location</u>

County: Moore
River Basin: Canadian

<u>Projected Shortage</u>

354 acre-feet per year

The City of Cactus in Moore County is a member of the Palo Duro River Authority and a wholesale water provider. The current supply for Cactus is the Ogallala aquifer in Moore County. Cactus is expected to need additional water supplies beginning in 2010 to serve its municipal and industrial customers. The recommended water management strategies for the City of Cactus are water conservation and purchasing additional groundwater rights in Moore County. Discussion of these strategies is found in Section 4.9.4.

4.4.4 Canyon

Location	Projected Shortage
County: Randall	2,859 acre-feet per year
River Basin: Red	

Canyon currently buys water from the City of Amarillo, as well as uses groundwater from its own wells in the Ogallala / Santa Rosa aquifer (Umbarger well field). This well field is showing rapid decline and will not be sustainable at the current pumpage amount. As a result, Canyon is shown to have shortages beginning in 2020 with a projected need of 2,859 acre-feet per year by 2060. In 2006, the City of Canyon purchased approximately 1,075 acres of undeveloped water rights in Randall County, northeast of the city. Two wells have been constructed at the Kim Road Well Field and the City plans to expand this well field and develop the Rockwell Road Well Field within the next five years. Both of these well fields are located in the Dockum formation. When fully developed, both well fields are expected to produce up to 8.5 MGD. This is an estimated 3,800 acre-feet per year of additional water supply. As the City develops these well fields, it may choose to reduce its water purchases from the City of Amarillo. At this time, it is assumed that Canyon will continue to purchase water from Amarillo.

Recommended Strategies
- Implement water conservation
- Develop groundwater rights in Randall County with associated infrastructure

Recommended Water Conservation Strategies
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions
The recommended strategies include implementing conservation measures and developing additional groundwater from the Dockum aquifer in Randall County with associated transmission system. Municipal water conservation is based on the goals reported in the City's water conservation plan: reduction of 5 gpcd in 2020, followed by reductions of 10 gpcd for subsequent decades. Data for the development of the Dockum well fields was provided by the City.

Time Intended to Complete
The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. Some of the additional groundwater supply is expected to be online by 2010, with expansions planned over the planning period.

Quantity, Reliability, and Cost

The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. 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 $9.5 million with a unit cost of water at $407 per acre-foot.

Environmental Issues

No significant environmental impacts are expected as a result of the implementation of the recommended strategies.

Impact on Water Resources and Other Management Strategies

The recommended strategies are not expected to have any impacts on water resources or 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.

Interbasin Transfer

The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts

No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements

The recommended strategies are not expected to have any impact on water rights, contracts, or option agreements. The City already owns the additional water rights included in this strategy.

Impact on Navigation

No impact on the navigable waters of the United States is expected.

Recommended Strategies for City of Canyon

-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	80	176	191	208	227
New Wells Dockum	$9,528,800	700	1,400	2,100	2,800	2,800	3,800

4.4.5 Dumas

Location
County: Moore
River Basin: Canadian

Projected Shortage
2,478 acre-feet per year

The City of Dumas is located in Moore County and is the largest member city of the Palo Duro River Authority (PDRA). Currently, Dumas obtains its water supply from its own wells in the Ogallala aquifer in Moore County. Dumas is expected to need additional water to meet its demand throughout most of the planning period (2020-2060). By 2060, the projected shortages for Dumas are nearly 2,500 acre-feet per year. Dumas recently developed its water rights in Hartley County, but additional water rights will need to be acquired to fully meet the City's projected shortages. The City intends to fully meet its projected demands with groundwater. As an alternative, Dumas may participate in the Palo Duro transmission project.

Recommended Strategies
- Implement water conservation strategies
- Develop groundwater in the Ogallala aquifer in Hartley and/ or Moore Counties with new wells and associated infrastructure

Recommended Water Conservation Strategies
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions
The recommended strategies for Dumas include implementing water conservation and developing additional supply from the Ogallala aquifer with four new wells and transmission system.

Time Intended to Complete
Water conservation strategies should be in place by 2010 with water savings being noticed in 2020. Dumas will need to develop additional groundwater before 2020.

Quantity, Reliability and Cost
The quantity of water should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supply is moderate to moderately-low since the aquifer is heavily used and availability depends on other water users. Assuming the expanded well field will be located within 5 miles of the City or the existing well field in Hartley County, the capital cost for new wells is estimated at $8 million. Unit cost of water would be $479 per acre-foot.

Environmental Issues
The environmental impacts from conservation and 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

Water conservation may impact the amount of water returned to the system that might be available for reuse. The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of the Ogallala, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

The recommended strategies are expected to have low to moderate impact on the agriculture and other natural resources. This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

There are no other identified relevant factors.

Interbasin Transfer

The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts

No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements

The recommended strategies are not expected to impact water rights, contracts, or option agreements.

Impact on Navigation

The recommended strategies should have no impact on the navigable waters of the United States.

Alternative Strategy

As a member of the PDRA, Dumas is interested in developing a regional transmission system to use water from Palo Duro Reservoir. The Palo Duro Reservoir transmission project is an alternative strategy for Dumas. The project would have very little impact on the environment, agricultural or other natural resources. Once the pipeline route is established, a more detailed analysis of the impacts should be considered. No interbasin transfer permits would be required for the Palo Duro transmission project. The use of this supply might decrease lake levels and impact recreation uses on the lake from time to time. No other impacts are expected from this project. Dumas is expected to have a capital cost of $36.7 million associated with their portion of the project.

Recommended Strategies for City of Dumas
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	89	158	166	171	174
New Wells Ogallala	$7,997,200	0	387	1,163	1,672	2,219	2,500

4.4.6 Fritch

Location

County: Hutchinson and Moore
River basin: Canadian

The City of Fritch currently obtains its water supply from the Ogallala aquifer in Carson County. The supply and demand comparison for Fritch did not show a shortage; however, the City is currently in the process of purchasing groundwater rights and existing well fields from the Hi Texas Water Supply Corporation. The City is planning to rehabilitate an existing well and drill a new well. For planning purposes, it is assumed that the existing well is located in Carson County and the new well will be drilled in Hutchinson County..

Recommended Strategies

- Purchase existing infrastructure form Hi Texas Water Supply Corporation and rehabilitate one well in Carson County in the Ogallala aquifer
- Drill an additional well in the Ogallala aquifer in Hutchinson County

Strategy Descriptions

The recommended strategies include developing additional supply from the Ogallala aquifer in Carson and Hutchinson County. For planning purposes, it is assumed that the rehabilitated well will provide 200 acre-feet per year beginning in 2010, and the new well in Hutchinson County will provide another 200 acre-feet per year. (Note: the actual number and location of wells will be determined at the time of the strategy development.)

Time Intended to Complete

The additional groundwater from the rehabilitated well will be available shortly after 2010 and the new well will be constructed by 2020.

Quantity, Reliability and Cost

The quantity of water from these strategies should be sufficient. 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 one mile of the City's existing transmission system. The capital cost for the system infrastructure, rehabilitation and a new well additional is approximately $4 million.

Environmental Issues

No significant environmental impact is expected for the recommended strategies. Once the specific locations of the additional well 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. To prolong the life of this water resource, other users may need to reduce their demands.

<u>Impact on Agriculture and Natural Resources</u>
No significant impact on agricultural or natural resources is expected for the recommended strategies.

<u>Other Relevant Factors</u>
There are no other identified relevant factors.

<u>Interbasin Transfer</u>
The recommended strategies do not require interbasin transfer permits.

<u>Social and Economic Impacts</u>
No negative social and economic impacts are expected from the implementation of these strategies.

<u>Impacts on Water Rights, Contracts, and Option Agreements</u>
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements. The acquisition of the water supply corporation is a mutual agreement.

<u>Impact on Navigation</u>
No impact on the navigable waters of the United States is expected.

Recommended Strategies for City of Fritch
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Rehabilitate well and purchase system	$2,850,300	200	200	200	200	200	200
New Wells Ogallala	$1,156,600	0	200	200	200	200	200

4.4.7 Gruver

<u>Location</u>
County: Hansford
River basin: Canadian

<u>Projected Shortage</u>
334 acre-feet per year

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 before 2020. Projected shortages for Gruver range from 77 acre-feet in 2020 to 334 acre-feet in 2060. 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 recommended strategies for Gruver include water conservation and developing additional groundwater from the Ogallala aquifer with a new well and associated infrastructure.

Recommended Strategies

- Implement water conservation strategies
- Drill additional wells in the Ogallala aquifer in Hansford County with transmission

Conservation Strategy Name

- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions

The recommended strategies include implementing conservation measures and developing additional supply from the Ogallala aquifer in Hansford County. For planning purposes, it is assumed that one new well providing 350 acre-feet per year (400 gpm) will be needed for the City's needs. (Note: the actual number and location of wells will be determined at the time of the strategy development.)

Time Intended to Complete

The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater will be needed by 2020.

Quantity, Reliability and Cost

The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. 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 three miles of the City. The capital cost for the additional groundwater well and transmission pipeline is approximately $2 million.

Environmental Issues

No significant environmental impact is expected for the recommended strategies. 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. 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.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
No impact on the navigable waters of the United States is expected.

Alternative Strategy
As a member of the PDRA, Gruver may be interested in developing a regional transmission system to use water from Palo Duro Reservoir. The Palo Duro Reservoir transmission project is an alternative strategy for Gruver. The project would have very little impact on the environment, agricultural or other natural resources. Once the pipeline route is established, a more detailed analysis of the impacts should be considered. No interbasin transfer permits would be required for the Palo Duro transmission project. The use of this supply might decrease lake levels and impact recreation uses on the lake from time to time. No other impacts are expected from this project. Gruver would expect to have a capital cost of $5.1 million associated with their portion of the project.

Recommended Strategies for City of Gruver
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	10	16	17	17	17
New Wells Ogallala	$1,968,500	0	350	350	350	350	350

4.4.8 Lefors

Location
County: Gray
River Basin: Red

Projected Shortage
36 acre-feet per year

Lefors currently obtains its water supply from the Ogallala aquifer in Gray County. Based on the availability of the City's current wells, Lefors will need to develop additional supplies by 2040. The recommended strategies for Lefors include water conservation and developing additional groundwater from the Ogallala aquifer with new wells and transmission system.

Recommended Strategies
- Implement water conservation strategies
- Purchase additional water rights and develop a new well in the Ogallala aquifer in Gray County with associated infrastructure

Conservation Strategy Name
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions
The recommended strategies include implementing conservation measures and developing additional supply from the Ogallala aquifer in Gray County. For planning purposes, it is assumed that one new well will be needed for the City's needs. This well is sized for 100 acre-feet per year and is assumed to be located within five miles of the City.

Time Intended to Complete
The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater will be needed by 2040.

Quantity, Reliability and Cost
The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for the additional groundwater well and transmission pipeline is $1.1 million.

Environmental Issues
No significant environmental impact is expected for the recommended strategies. 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. 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.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
No impact on the navigable waters of the United States is expected.

Recommended Strategies for City of Lefors
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	3	4	4	4	4
New Wells Ogallala	$1,132,500	0	0	0	100	100	100

4.4.9 Memphis

Location
County: Hall
River Basin: Red

Projected Shortage
142 acre-feet per year

The City of Memphis currently obtains its water supply from the Ogallala aquifer in Donley County and purchases treated surface water from Greenbelt Municipal and Industrial Water Authority. Due to the limited groundwater in Donley County, Memphis is projected to have a shortage of 81 acre-feet by 2020, increasing to approximately 140 acre-feet from 2030 through 2060. To meet this need, Memphis could develop additional groundwater in Donley County and/or purchase additional water from Greenbelt M&IWA. The recommended strategies for Memphis include water conservation, developing additional groundwater from the Ogallala aquifer with new wells and associated infrastructure, and purchasing additional water from Greenbelt M&IWA.

Recommended Strategies

- Implement water conservation strategies
- Purchase additional water rights and develop new well in the Ogallala aquifer in Donley County with associated infrastructure
- Purchase additional water from Greenbelt M&IWA

Conservation Strategy Name

- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions

The recommended strategies include implementing conservation measures, developing additional supply from the Ogallala aquifer in Donley County, and purchasing additional water from Greenbelt M&IWA. For planning purposes, it is assumed that one new well will be needed for the City's needs. The additional supply from Greenbelt M&IWA would be 100 acre-feet per year.

Time Intended to Complete

The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater will be needed by 2020, with additional treated surface water by 2030.

Quantity, Reliability and Cost

The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users and the nearest well field locations are near the boundary of the aquifer. The capital cost for the additional groundwater well is approximately $1 million. The reliability of the treated surface water supply is high. It is assumed that the additional surface water could be delivered through existing infrastructure and there are no additional capital costs.

Environmental Issues

No significant environmental impact is expected for the recommended strategies. 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. 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.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
No impact on the navigable waters of the United States is expected.

Recommended Strategies for City of Memphis
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	13	22	22	22	22
New Wells Ogallala	$1,042,100	0	100	100	100	100	100
Purchase from Greenbelt M&IWA	$0*	0	0	100	100	100	100

*This assumes no additional infrastructure is needed.

4.4.10 City of Pampa
The City of Pampa provides water to customers in Gray County, including TDCJ, and Titan Specialties and other manufactories. The City receives blended water from CRMWA and operates wells for groundwater from the Ogallala aquifer. The City also reuses treated wastewater to supply irrigation water to its municipal golf course. The supply and demand analysis shows that Pampa has sufficient supplies to meet its current demands. The City is currently planning to rehabilitate its existing well system and developing additional groundwater.

Recommended Strategies
- Implement conservation strategies
- Purchase additional water form CRMWA
- Develop additional groundwater (Ogallala aquifer) and rehabilitate existing wells

Recommended Conservation Strategies
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

<u>Strategy Descriptions</u>
The recommended strategies include implementing conservation measures, purchasing additional water from CRMWA and developing additional groundwater from the Ogallala aquifer in Gray County. The table below shows the amount of water supply associated with each of the recommended strategies. The yield of the City of Pampa well field is expected to decline over time. It is anticipated that Pampa will continue to operate groundwater system at levels similar to current pumpage. To do this, the City will need to install additional wells and rehabilitate existing wells. To provide for additional commercial demands, the City of Pampa can purchase additional water from CRMWA. For planning purposes, it is assumed that no additional infrastructure will be needed; however, pending the additional purchase amount, there may be insufficient capacity in the existing infrastructure and future improvements will be needed.

<u>Time intended to complete</u>
Water conservation strategies are in place with water savings being noticed in 2020. The Gray County well field rehabilitation is beginning in 2010. Additional expansion of the well field will be developed as needed. Additional supply from CRMWA will be developed as needed. For planning purposes, it is assumed to come online by 2040.

<u>Quality, Reliability and Cost</u>
The quantity of water should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for the additional groundwater is $1.7 million. It is assumed that are no capital associated with increasing the purchase amount form CRMWA.

<u>Environmental Issues</u>
The environmental impacts from conservation and groundwater development are expected to be low. Once the specific locations of additional wells and alignment associated with the infrastructure are identified, a detailed evaluation to determine environmental impacts, if any, will need to be performed.

<u>Impact on Water Resources and Other Management Strategies</u>
Water conservation may impact the amount of water returned to the system that might be available for reuse. 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 Gray County to support these demands.

<u>Impact on Agriculture and Natural Resources</u>
Water conservation and the possible development of the future well fields are expected to have minimal impact on the agriculture and other natural resources.

<u>Other Relevant Factors</u>
There are no other identified relevant factors.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
No impact on the navigable waters of the United States is expected.

Recommended Strategies for City of Pampa
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	15	65	65	65	65
New Wells Ogallala	$1,731,100	968	2,581	0	0	0	0
Purchase from CRMWA*	$0*	0	0	0	0	1,000	1,000

*This assumes no additional infrastructure is needed.

4.4.11 Panhandle

Location
County: Carson
River Basin: Red

Projected Shortage
556 acre-feet per year

The City of Panhandle currently obtains its water supply from the Ogallala aquifer in Carson County. Panhandle is not shown to have a shortage with the 2004 Northern Ogallala GAM; however, with the updated GAM the water supplies for Panhandle are substantially less. This is because the refined aquifer thickness shows decreases in the area with the city's current well field. As a result, Panhandle will need to develop additional supplies by 2030. The recommended strategies for Panhandle include water conservation and developing additional groundwater from the Ogallala aquifer with new wells and associated transmission.

Recommended Strategies
- Implement water conservation strategies
- Purchase additional water rights and develop new well field in the Ogallala aquifer in Carson County with associated transmission

Conservation Strategy Name
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions

The recommended strategies include implementing conservation measures and developing additional supply from the Ogallala aquifer in Carson County. For planning purposes, it is assumed that two new wells and associated transmission will be needed for the City's needs. The wells are sized for a total supply of 600 ac-ft per year and are assumed to be located within five miles of the City.

Time Intended to Complete

The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater will be needed by 2030.

Quantity, Reliability and Cost

The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users and location of new well field. The capital cost for the additional groundwater well and transmission pipeline is $3.3 million.

Environmental Issues

No significant environmental impact is expected for the recommended strategies. 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. 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.

Interbasin Transfer

The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts

No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements

The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
No impact on the navigable waters of the United States is expected.

Recommended Strategies for City of Panhandle
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	17	29	28	25	23
New Wells Ogallala	$3,309,300	0	0	600	600	600	600

4.4.12 Perryton

Location
County: Ochiltree
River Basin: Canadian

Projected Shortage
1,142 acre-feet per year

Perryton currently obtains its water supply from the Ogallala aquifer in Ochiltree County. The City of Perryton is not shown to have a shortage with the 2004 Northern Ogallala GAM; however, with the updated GAM the water supplies for Perryton are less. As a result, Perryton will need to develop additional supplies by 2050. The City owns 8 sections of undeveloped water rights in Ochiltree County, located about 5 to 15 miles from the city. The recommended strategies for Perryton include water conservation and developing the City's undeveloped water rights in the Ogallala aquifer with new wells and associated transmission.

Recommended Strategies
- Implement water conservation strategies
- Develop existing water rights with new wells in the Ogallala aquifer in Ochiltree County with associated transmission

Conservation Strategy Name
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions
The recommended strategies include implementing conservation measures and developing additional supply from the Ogallala aquifer in Ochiltree County. For planning purposes, it is assumed that four new wells will be needed for the City's needs. Collectively, the wells will provide 1,200 acre-feet per year and are assumed to be located within ten miles of the City.

Time Intended to Complete
The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater will be needed by 2050.

Quantity, Reliability and Cost
The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the

consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for the additional groundwater wells and transmission pipeline is $7.1 million.

Environmental Issues
No significant environmental impact is expected for the recommended strategies. 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. 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.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
No impact on the navigable waters of the United States is expected.

Recommended Strategies for City of Perryton
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	64	113	118	120	123
New Wells Ogallala	$7,087,000	0	0	0	0	600	1,200

4.4.13 Spearman

Location
County: Hansford
River Basin: Canadian

Projected Shortage
849 acre-feet per year

The City of Spearman currently obtains its water supply from the Ogallala aquifer in Hansford County. Based on the availability of the City's current wells, Spearman will need to develop additional supplies by 2030. The recommended strategies for Spearman include water conservation and developing additional groundwater from the Ogallala aquifer with new wells and transmission system.

Recommended Strategies
- Implement water conservation strategies
- Purchase additional water rights and develop new well in the Ogallala aquifer in Hansford County with associated infrastructure

Conservation Strategy Name
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions
The recommended strategies include implementing conservation measures and developing additional supply from the Ogallala aquifer in Hansford County. For planning purposes, it is assumed that two new wells will be needed to meet the City's needs, and these wells would be located within five miles of the City. (Note: the actual number and location of wells will be determined at the time the strategy is developed.)

Time Intended to Complete
The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater will be needed by 2030.

Quantity, Reliability and Cost
The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for the additional groundwater wells is approximately $4 million.

Environmental Issues
No significant environmental impact is expected for the recommended strategies. 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. 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.

Interbasin Transfer

The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts

No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements

The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation

No impact on the navigable waters of the United States is expected.

Alternative Strategy

As a member of the PDRA, Spearman may be interested in developing a regional transmission system to use water from Palo Duro Reservoir. The Palo Duro Reservoir transmission project is an alternative strategy for Spearman. The project would have very little impact on the environment, agricultural or other natural resources. Once the pipeline route is established, a more detailed analysis of the impacts should be considered. No interbasin transfer permits would be required for the Palo Duro transmission project. The use of this supply might decrease lake levels and impact recreation uses on the lake from time to time. No other impacts are expected from this project. Spearman would be expected to have a capital cost of $3.5 million associated with their portion of the project.

Recommended Strategies for City of Spearman

-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	22	39	41	42	42
New Wells Ogallala	$3,862,000	0	0	900	900	900	900

4.4.14 Sunray

Location
County: Moore
River Basin: Canadian

Projected Shortage
800 acre-feet per year

The City of Sunray is a member of the Palo Duro River Authority (PDRA). Sunray currently obtains its water supply from the Ogallala aquifer in Moore County. Sunray provides some water to rural county-other in Moore County, and it is assumed that Sunray will continue to supply water to a portion of Moore County-Other. By the end of the planning period, it is expected that Sunray will provide nearly 200 acre-feet for rural municipal needs. With the rural county-other demands, the projected shortages for the City of Sunray are greater than 300 acre-feet/year by 2060 based on the 2004 Ogallala GAM. With the update GAM, the shortages for Sunray are greater. To meet these shortages plus potential demands from future customers Sunray will need to develop additional supply totaling approximately 800 acre-feet of water per year. The recommended strategies for Sunray include water conservation and developing additional groundwater from the Ogallala aquifer with new wells and associated infrastructure.

Recommended Strategies
- Implement water conservation strategies
- Drill additional wells in the Ogallala aquifer in Moore County with associated infrastructure

Conservation Strategy Name
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions
The recommended strategies include implementing conservation measures and developing additional supply from the Ogallala aquifer in Moore County with associated transmission system. For planning purposes, it is assumed that three new wells will be needed for the City's needs and the wells will be located within two miles of the City. (Note: the actual number and location of wells will be determined at the time the strategy is developed.)

Time Intended to Complete
The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater will be needed by 2030.

Quantity, Reliability and Cost
The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for the additional groundwater well is $3.1 million. The unit cost of water is $567 per acre-foot.

Environmental Issues
No significant environmental impact is expected for the recommended strategies. 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. 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.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
No impact on the navigable waters of the United States is expected.

Alternative Strategy
As a member of the PDRA, Sunray is interested in developing a regional transmission system to use water from Palo Duro Reservoir. The Palo Duro Reservoir transmission project is an alternative strategy for Sunray. The project would have very little impact on the environment, agricultural or other natural resources. Once the pipeline route is established, a more detailed analysis of the impacts should be considered. No interbasin transfer permits would be required for the Palo Duro transmission project. The use of this supply might decrease lake levels and impact recreation uses on the lake from time to time. No other impacts are expected from this project. Sunray is expected to have a capital cost of $7.7 million associated with their portion of the project.

Recommended Strategies for City of Sunray
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	18	34	36	38	39
New Wells Ogallala	$3,121,300	0	0	800	800	800	800

4.4.15 Texline

Location
County: Dallam
River Basin: Canadian

Projected Shortage
224 acre-feet per year

Texline currently obtains its water supply from the Ogallala aquifer in Dallam County. The City of Texline is not shown to have a shortage with the 2004 Northern Ogallala GAM; however, with the updated GAM the water supplies for Texline are substantially less. As a result, Texline will need to develop additional supplies by 2020. The recommended strategies for Texline include water conservation and developing additional groundwater in the Ogallala aquifer with new wells and transmission system.

Recommended Strategies
- Implement water conservation strategies
- Purchase additional water rights and develop a new well in the Ogallala aquifer in Dallam County with associated infrastructure

Conservation Strategy Name
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions
The recommended strategies include implementing conservation measures and developing additional supply from the Ogallala aquifer in Dallam County. For planning purposes, it is assumed that one new well will be needed for the City's needs. This well is sized for 250 acre-feet per year and is assumed to be located within five miles of the City.

Time Intended to Complete
The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater will be needed by 2020.

Quantity, Reliability and Cost
The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for the additional groundwater well and transmission pipeline is $2.3 million.

Environmental Issues
No significant environmental impact is expected for the recommended strategies. 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. 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.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
No impact on the navigable waters of the United States is expected.

Recommended Strategies for City of Texline
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	7	12	12	12	11
New Wells Ogallala	$2,304,000	0	250	250	250	250	250

4.4.16 Wheeler

Location
County: Wheeler
River Basin: Red

Projected Shortage
134 acre-feet per year

Wheeler currently obtains its water supply from the Ogallala aquifer in Wheeler County. The City of Wheeler is not shown to have a shortage with the 2004 Northern Ogallala GAM; however, with the updated GAM the water supplies for Wheeler are less. As a result, Wheeler will need to develop additional supplies by 2050. The recommended strategies for Wheeler include water conservation and developing additional groundwater in the Ogallala aquifer with new wells and associated transmission.

Recommended Strategies

- Implement water conservation strategies
- Purchase additional water rights and develop a new well in the Ogallala aquifer in Wheeler County with associated infrastructure

Conservation Strategy Name

- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions

The recommended strategies include implementing conservation measures and developing additional supply from the Ogallala aquifer in Wheeler County. For planning purposes, it is assumed that one new well will be needed for the City's needs. This well is sized for 200 acre-feet per year and is assumed to be located within five miles of the City.

Time Intended to Complete

The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater will be needed by 2050.

Quantity, Reliability and Cost

The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for the additional groundwater well and transmission pipeline is $2.2 million.

Environmental Issues

No significant environmental impact is expected for the recommended strategies. 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. 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.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
No impact on the navigable waters of the United States is expected.

Recommended Strategies for City of Wheeler
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	9	15	15	15	15
New Wells Ogallala	$2,233,300	0	0	0	0	200	200

4.4.17 County-Other, Moore County

Location
County: Moore
River Basin: Canadian

Projected Shortage
741 acre-feet per year

Moore County-Other shortages are approximately 260 acre-feet per year in 2030, increasing to 741 acre-feet per year by 2060. Some water is provided to County-Other users from local cities, including Cactus, Dumas and Sunray. The majority of Moore County-Other supply is from unincorporated rural wells in the Ogallala aquifer. There is a projected increase in demands in Moore County, which is expected to be provided in part by the local cities and in part by additional rural wells. The additional demand for County-Other provided by the cities is addressed with each city. For the remaining unmet demand, water conservation and additional wells in the Ogallala aquifer are the recommended strategies for Moore County-Other.

Recommended Strategies
- Implement water conservation strategies
- Drill additional wells in the Ogallala aquifer

Recommended Conservation Strategies
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions

Moore County-Other will apply water conservation measures and drill additional wells in the Ogallala aquifer to meet the future water demands It is assumed that additional water rights will be purchased and two new wells installed by 2060.

Time Intended to Complete

The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater wells will be needed by 2030.

Quantity, Reliability and Cost

The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for additional groundwater wells is $3,114,800

Environmental Issues

No significant environmental impact is expected for the recommended strategies. 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. In non-irrigated areas of Moore County there are sufficient supplies to meet this demand. Near irrigated areas, there is competition for water supplies.

Impact on Agriculture and Natural Resources

Assuming the new wells are located in non-irrigated areas, there would be minimal impacts to agriculture and other natural resources. If water rights are purchased from existing farmers, there will be a reduction in irrigated acreages. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors

The development of Moore County-Other water supply would be implemented as needed over the planning period. Coordination with the North Plains GCD may be required to ensure compliance with the District's rules for areas located within the GCD.

Recommended Strategies for Moore County-Other

-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	29	63	75	83	87
New Wells Ogallala	$3,114,800	0	0	500	500	1,000	1,000

4.4.18 County-Other, Potter County

Location
County: Potter
River Basin: Canadian and Red

Projected Shortage
2,139 acre-feet per year

Potter County-Other shortages are approximately 100 acre-feet per year in 2020, increasing to over 2,100 acre-feet per year by 2060 for the Red and Canadian basins combined. Small water supply corporations supply a portion of these demands. The majority of Potter County-Other supply is from unincorporated rural wells in the Ogallala aquifer. It is anticipated that this pattern will continue over the planning period. It is assumed that as demands increase, additional rural municipal wells will be installed. Water conservation and additional wells in the Ogallala aquifer are the recommended strategies for Potter County in both the Canadian and Red Basins.

Recommended Strategies
- Implement water conservation strategies
- Drill additional wells in the Ogallala aquifer

Recommended Conservation Strategies
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions
Potter County-Other will apply water conservation measures and drill additional wells in the Ogallala aquifer to meet the future water demands It is assumed that additional water rights will be purchased and six new wells installed by 2060.

Time Intended to Complete
The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. Due to the nature of the aggregated County-Other demand, additional wells may be needed before the projected need is shown. For purposes of this plan, it is assumed that additional groundwater wells are installed prior to 2020.

Quantity, Reliability and Cost
The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for additional groundwater wells is $8.9 million.

Environmental Issues
No significant environmental impact is expected for the recommended strategies. 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. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors
The development of Potter County-Other water supply would be implemented as needed over the planning period. Coordination with the local groundwater districts (Panhandle GCD and High Plains GCD) will be required to ensure compliance with the Districts' production limitations and property line setback requirements for well locations.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements

Impact on Navigation
The recommended strategies will have no impact on the navigable waters of the United States.

Recommended Strategies for Potter County-Other (Red Basin)
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	28	58	71	85	96
New Wells Ogallala	$5,444,600	0	600	600	600	1,200	1,200

Recommended Strategies for Potter County-Other (Canadian Basin)
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	41	85	103	124	140
New Wells Ogallala	$3,114,800	0	0	0	1,000	1,000	1,000

4.4.19 County-Other, Randall County

<u>Location</u>
County: Randall
River Basin: Red

<u>Projected Shortage</u>
2,619 acre-feet per year

The demands in Randall County for county-other municipal supply are expected to more than double from approximately 2,715 acre-feet per year to 5,970 acre-feet per year. The current supply to Randall County-Other is primarily the Ogallala aquifer. A small amount of supply comes from the Dockum aquifer, and a small quantity of water is provided from the City of Amarillo to the Palo Duro Canyon State park for municipal use. Groundwater is limited in parts of the county, with some residential wells in northeast Randall County experiencing significant reductions in production. To meet these projected needs, groundwater wells will likely need to be expanded and/or improved to access deeper water. Water conservation will also be needed as demand for additional water increase. As an alternate strategy, Amarillo may sell wholesale water to county-other water users provided that these users meet the City's requirements for municipal water sales.

<u>Recommended Strategies</u>
- Implement water conservation strategies
- Drill additional wells in Ogallala aquifer in Randall County, Red Basin

<u>Recommended Water Conservation Strategies</u>
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

<u>Strategy Descriptions</u>
Randall County-Other in the Red Basin will get additional supplies from water conservation measures and additional groundwater from the Ogallala aquifer. Additional water rights will need to be purchased and it is assumed that two new wells providing 600 acre-feet per year will be installed by 2030 with subsequent expansions needed to provide 2,400 acre-feet per year by 2060.

<u>Time Intended to Complete</u>
The water conservation strategies are assumed to be in place by 2010 with visible reductions in water demand being seen by 2020. The additional groundwater wells will be needed by 2030.

<u>Quantity, Reliability and Cost</u>
The quantity of water from these strategies should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for additional groundwater wells is approximately $10.9 million.

Environmental Issues
No significant environmental impact is expected for the recommended strategies. 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. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources
This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

Other Relevant Factors
Some areas in Randall County that currently do not lie within a groundwater conservation district are contemplating joining a GCD in the next 5 years. This may impact well locations and production amounts.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits..

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

Impact on Navigation
The recommended strategies will have no impact on the navigable waters of the United States.

Recommended Strategies for Randall County-Other
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
Conservation	$0	0	101	197	231	268	299
New Wells Ogallala	$10,889,200	0	0	600	1,200	1,800	2,400

4.4.20 County-Other, Hall County

Location	Projected Shortage
County: Hall	Estimated at 80 acre-feet per year
River Basin: Red	Water quality concerns

The supply and demand comparison for Hall County-Other shows that there are sufficient water supplies to meet the projected demands. However, there are water quality concerns for some users of the Seymour aquifer and localized shortages. The City of Turkey has been cited by the TCEQ for water quality exceedances for nitrates. The City considered advanced water treatment but this strategy was dismissed due to high costs. The City of Turkey is now planning to develop additional groundwater in Briscoe County in Region O and blending the new groundwater with its existing supplies. In addition, the Brice-Lesley Water Supply Corporation is experiencing significant reductions in production from its existing wells in Donley County. The WSC will need to expand its groundwater wells to maintain the current production capacities.

Recommended Strategies

- Drill additional wells in Ogallala aquifer in Briscoe and Donley Counties

Strategy Descriptions

The City of Turkey will develop additional groundwater in a new well field and blend the low nitrate water with its existing Seymour aquifer supply. For planning purposes, it is assumed that Turkey will develop 100 acre-feet per year of Ogallala water in Floyd County. To meet the needs of Brice-Lesley WSC and possibly other small water suppliers, it is assumed that additional wells will be drilled in the Ogallala aquifer in Donley County.

Time Intended to Complete

The strategies are assumed to be in design by 2010 with developed supplies shortly thereafter.

Quantity, Reliability and Cost

The quantity of water from these strategies should be sufficient. Reliability of Ogallala supplies is moderate since availability depends on other water users. The capital cost for additional groundwater wells is approximately $2.5 million.

Environmental Issues

No significant environmental impact is expected for the recommended strategies. 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. To prolong the life of this water resource, other users may need to reduce their demands.

Impact on Agriculture and Natural Resources

This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

<u>Other Relevant Factors</u>
No other relevant factors.

<u>Interbasin Transfer</u>
The recommended strategies do not require interbasin transfer permits..

<u>Social and Economic Impacts</u>
No negative social and economic impacts are expected from the implementation of these strategies.

<u>Impacts on Water Rights, Contracts, and Option Agreements</u>
The recommended strategies are not expected to have any impacts on water rights, contracts, or option agreements.

<u>Impact on Navigation</u>
The recommended strategies will have no impact on the navigable waters of the United States.

Recommended Strategies for Hall County-Other
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
New Wells Ogallala – Briscoe County	$1,261,200	100	100	100	100	100	100
New Wells Ogallala – Donley County	$1,261,200	50	50	100	100	100	100

4.5 Manufacturing Shortages

Manufacturing shortages were identified for Hutchinson, Moore, and Potter counties. The shortages identified for these counties are associated with shortages of supply for wholesale water providers. The demands for Hutchinson County are assumed to be met by the City of Borger. Amarillo is assumed to meet the manufacturing needs in Potter County and the City of Cactus is assumed to meet the needs in Moore County.

4.5.1 Hutchinson County Manufacturing

<u>Location</u>
County: Hutchinson
River Basin: Canadian

<u>Projected Shortage</u>
1,270 acre-feet per year

Hutchinson County manufacturers currently get water supply from the Ogallala aquifer in Hutchinson County and from the City of Borger's supplies in Lake Meredith, the Ogallala aquifer, and direct reuse. Hutchinson County manufacturing users have shortages ranging from nearly 70 to 1,270 acre-feet per year beginning in 2030 due to increasing demands and limited supplies from Borger. As Borger develops strategies to meet its demands, the needs for manufacturing in Hutchinson County will be met. The recommended strategies for additional supply include water conservation and purchasing water from Borger. The City of Borger is a wholesale water provider. The strategies recommended for Borger are discussed in Section 4.9.3.

4.5.2 Moore County Manufacturing

Location	Projected Shortage
County: Moore	2,067 acre-feet per year
River Basin: Canadian	

The manufacturing shortages in Moore County range from 173 to 2,067 acre-feet per year over the planning period. These shortages are associated with shortages for the City of Cactus, which will be met through the City of Cactus' water management strategies. The City of Cactus is a wholesale water provider and water management strategies for this entity are discussed in Section 4.9.4.

4.5.3 Potter County Manufacturing

Location	Projected Shortage
County: Potter	2,529 acre-feet per year
River Basin: Canadian and Red	

The current supplies for manufacturing in Potter County include self supplied Ogallala water 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. Approximately 2,500 acre-feet per year of additional water supplies are expected to be needed by 2060. The recommended strategies include additional water from Amarillo as Amarillo develops additional supplies. The strategies for Amarillo are discussed in Section 4.9.2.

4.6 Steam Electric Power Shortages

There is one shortage identified for steam electric power in Moore County (less than 200 af/y). In Moore County, water from the Ogallala aquifer is used for steam electric power demands. The steam electric need begins in 2010 and is the result of competition for this supply with other users. The recommended strategy to meet the shortages is to develop additional supply from the Ogallala aquifer in Moore County with additional wells.

4.6.1 Moore County Steam Electric Power

Location	Projected Shortage
County: Moore	154 acre-feet per year
River Basin: Canadian	

Recommended Strategy

- Develop new groundwater from the Ogallala aquifer with new wells

<u>Recommended Water Conservation Strategies</u>
The projected demands for steam electric power included water conservation when the demands were developed. Thus, no additional water conservation is recommended.

<u>Strategy Description</u>
The steam electric power shortages in Moore County will be met with additional water from the Ogallala aquifer in Moore County.

<u>Time Intended to Complete</u>
The recommended water management strategy should be implemented by 2010 to meet the expected shortage.

<u>Quantity, Reliability and Cost</u>
The quantity of water should be sufficient. Reliability would be moderate, depending on other Ogallala water users. The capital cost for additional wells is $1.85 million.

<u>Environmental Issues</u>
No significant environmental impact is expected for the recommended strategy. 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.

<u>Impact on Water Resources and Other Management Strategies</u>
There should be no impacts to water resources or other management strategies.

<u>Impact on Agriculture and Natural Resources</u>
This strategy may reduce the irrigated acreage for farming if additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

<u>Other Relevant Factors</u>
Other relevant factors that may affect the development of water rights include North Plains GCD rules affecting production limitations and property line setback requirements for locating wells.

<u>Interbasin Transfer</u>
The recommended strategy does not require an interbasin transfer permit.

<u>Social and Economic Impacts</u>
No negative social and economic impacts are expected from the implementation of this strategy.

<u>Impacts on Water Rights, Contracts, and Option Agreements</u>
The recommended strategy is not expected to have any impacts on water rights, contracts, or option agreements.

<u>Impact on Navigation</u>
The recommended strategy will have no impact on the navigable waters of the United States.

Recommended Strategies for Moore County Steam Electric Power
-Values are in Acre-Feet per Year-

Strategy	Capital Cost	2010	2020	2030	2040	2050	2060
New Wells Ogallala	$1,852,600	200	200	200	200	200	200

4.7 Irrigation Shortages

There are substantial irrigation shortages identified in the PWPA for the current and projected irrigation demands due to limitations of the available supply of the Ogallala aquifer. By 2060, these shortages are projected to be 381,036 acre-feet per year. There is no readily available water supply in or near the high demand irrigation counties that could be developed to fully meet these shortages. Therefore, water management strategies for reducing irrigation demands in the Ogallala aquifer for all 21 counties in the PWPA were examined. These strategies focus on Dallam, Hansford, Hartley, Hutchinson, Moore, and Sherman Counties, which are the only counties in the PWPA showing water demands that cannot be met with existing supplies (Table 4-4). A summary of the potential water savings for each county in the PWPA is included in Chapter 6, Table 6-3. While other counties do not show a shortage for irrigated agriculture, it is recommended that all counties implement irrigation conservation to preserve water supplies for future needs.

It needs to be emphasized that nearly all of the water used for irrigated agriculture within the PWPA currently comes from groundwater. The counties with projected shortages cannot meet the projected demands with the assumptions used for determining currently available supplies. These assumptions are for long-range water planning and do not necessarily reflect the actual timing of the use of stored water in the Ogallala aquifer (i.e., if more water is used early in the planning period, there will be less water available later in the period). It is the intent that the use of irrigation management strategies and local groundwater rules will prolong the life of irrigated agriculture within this region. The Ogallala Recharge study, conducted as part of this planning effort, showed little recharge to Ogallala aquifer in areas in the PWPA. The projected shortages shown in Table 4-4 should not be viewed as a demand which will be met. The use of groundwater will be reduced as well. One strategy in the future will have to be the conversion from irrigated agriculture to dryland agriculture. This conversion will have a significant impact on the economic value of agriculture in the PWPA. The numerical groundwater model simulations indicate that there may be other counties, in addition to the six noted above, that will experience localized shortages, although the tables in this report may not reflect that. Although the focus on this section of the regional water supply plan is on the six counties with identified shortages, the PWPA encourages irrigators throughout the region to adopt the following water management strategies in all of the PWPA's irrigated counties.

Table 4-4: Irrigation Shortages Identified in the PWPA

County	Projected Need (acre-feet per year)					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Dallam	132,889	140,984	148,630	149,134	133,737	117,396
Hansford	150	1,005	1,484	4,548	3,077	1,640
Hartley	181,732	180,523	183,457	179,983	161,368	142,079
Hutchinson	15,008	12,175	11,652	10,612	7,534	5,455
Moore	52,317	48,090	52,425	54,994	50,321	45,420
Sherman	72,532	69,367	79,690	82,955	77,118	69,190
Total	**454,628**	**452,144**	**477,338**	**482,226**	**433,155**	**381,180**

The following sections present an overview analysis of the agricultural water conservation strategies considered in PWPA. The analysis results are presented on a regional basis and include projected water savings, implementation cost, and the anticipated impact (positive or negative) that each of the strategies will have on the regional economy. Subsequent sections estimate the water savings of each strategy in the counties with projected irrigation deficits.

4.7.1 Overview Analysis of Agricultural Water Conservation Strategies

In the first round of planning, the PWPA Agricultural Demands and Projections Committee identified seven potential water management strategies for evaluation to reduce irrigation demand. These strategies included the use of the North Plains Evapotranspiration Network (NPET) to schedule irrigation, changes in crop variety, irrigation equipment efficiency improvements, change in crop type, implementation of conservation tillage methods, precipitation enhancement and conversion of irrigated land to dryland. In the second round of planning, considerable time was spent documenting water savings and levels of implementation of these strategies. For the 2011 regional water plan, the estimated cost of each of these strategies was updated to September 2008 dollars. In addition, their effectiveness with respect to water savings given the changing conditions in the region was re-estimated. Also, the PWPA Agricultural Demands and Projections Committee decided to add the adoption of drought resistant crop varieties that are currently under development with the assistance of biotechnology as a potential strategy. A description of each of these strategies is presented in Section 4.8.

It should be noted that the water savings associated with each of the agricultural conservation strategies represent the maximum level of savings associated with the individual strategy and may be mutually exclusive of other strategies. For example, the savings associated with the implementation of irrigation equipment efficiency improvements cannot be applied to irrigated land that is converted to dryland farming.

For this plan, seven of the irrigation conservation strategies are recommended in two different tiers. The first tier includes; biotechnology adoption of drought resistant crops, the use of the NPET to schedule irrigation, irrigation equipment efficiency improvements and implementation of conservation tillage methods. The second tier while recommended is considered less desirable because of their anticipated negative impact on the regional economy. The second tier includes: changes in crop variety, changes in crop type and converting irrigated acreage to dryland farming. Precipitation enhancement is considered an alternative strategy for counties not currently implementing this strategy. This is because it cannot be implemented by an individual producer and little participation has been shown in implementing this strategy by water districts in the region with exception of the Panhandle GCD. A list of the potentially feasible irrigation strategies is shown in Table 4-5. A synopsis of the potential water savings associated with all eight strategies is presented in Section 4.8 for each county with an irrigation need.

Table 4-5 List of Potentially Feasible Irrigation Strategies

Tier 1 Strategies:
- Biotechnology adoption of drought resistant crops
- NPET to schedule irrigation
- Irrigation equipment efficiency improvements
- Conservation tillage methods

Tier 2 Strategies:
- Changes in crop variety, and
- Changes in crop type
- Converting irrigated acreage to dryland farming

Alternate Strategy:
- Precipitation Enhancement

4.8 Description of Irrigation Strategies

<u>Use of North Plains Evapotranspiration Network (NPET)</u>
The NPET network offers a uniform and independent source of crop water use for both irrigators and the public. It is comprised of eight meteorological stations in PWPA and used to acquire localized crop weather data. The detailed weather data are then used to compute daily reference evapotranspiration and crop water use. These computed parameters help farmers know exactly when conditions are optimal to plant and irrigate. This information is especially critical when moisture is short, and when well capacity is limited, as producers must carefully schedule the timing of their applications to efficiently use their water resources (Howell et al., 1995).

<u>Change in Crop Variety</u>
Shifting from long season to short season corn and sorghum varieties is another water savings strategy. Water savings are possible by reducing the length of the growing season. However, lower yields are associated with short season varieties. Previous analysis by the Texas AgriLife staff indicated that other major crop changes resulted in no water savings. (FNI, 2006)

<u>Irrigation Equipment Efficiency Improvements</u>
Each irrigation system has a different level and range of efficiency and can be dramatically affected by operator management during the growing season. A study by Amosson et al. (2001) estimated conventional furrow, surge flow, mid-elevation spray application (MESA), low elevation spray application (LESA), low elevation precision application (LEPA) and subsurface drip (SD) with application efficiencies of 60 percent, 70 percent, 78 percent, 88 percent, 95 percent and 97 percent, respectively. These application efficiencies are the percentage of

irrigation water that is actually used by the crop, while the remainder is lost to runoff, evaporation or deep percolation and the differences were used as the basis of improvement for the strategy.

Change in Crop Type
Crops such as corn require a large amount of irrigation on the High Plains. By reducing the amount of acreage of high water use crops and shifting them to lower water use crops (cotton), substantial water savings would be generated.

Implementation of Conservation Tillage Methods
Converting from convention to conservation production practices essentially involves replacing tillage operations with herbicide applications. This conversion strategy generally results in reduced moisture losses, as well as, an improved soil profile.

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. The cloud seeding process involves the intentional treatment of individual clouds or storm systems in order to achieve a beneficial effect. The benefits that can be realized from increased rainfall through precipitation enhancement projects include: increased agricultural production, improved economic sustainability and future growth, decreased surface and ground water consumption, increased reservoir levels, increased and higher quality forage for livestock and wildlife, and fire and hail suppression.

Conversion from Irrigated to Dryland
Reducing the amount of irrigated acreage in PWPA will reduce the amount of water applied to crops in the area. While converting from an irrigated to dryland cropping system may be a viable economic alternative for many PWPA producers, research indicates that only a limited number of dryland crops can be produced profitability in this area. The primary dryland crops are winter wheat, grain sorghum, and upland cotton.

Biotechnology Adoption
The adoption of drought resistant varieties currently under development was added as a potential conservation strategy in the 2011 planning effort. Based on conversations with conventional breeders and Seed Company personnel utilizing biotechnology to develop drought resistant varieties, the first wave of drought resistant varieties for corn, cotton and soybeans are expected to be released within the next five years followed by a second wave that will improve drought tolerance even more. Industry experts believe the first round of drought resistant varieties could reduce water use 15 percent while the second round could double that impact.

It was assumed for modeling purposes that drought resistant varieties for corn, cotton and soybeans would be available by 2020 that reduced water use 15 percent and the adoption rate would be 50 percent. It was further assumed by 2030 that varieties of these crops which reduce water use 30 percent (total) would be available and the adoption rate would be 90 percent. No further improvements were modeled for the remainder of the planning horizon; however, the adoption rate was increased to 100 percent by 2040. The implementation cost of this strategy was assumed to be the additional cost of the drought resistant seed which was estimated at a dollar for every one percent reduction in water use. Therefore, it is assumed a 15 percent reduction in water use is expected to cost $15/acre and a 30 percent reduction will cost $30/acre.

It should be noted that similar breeding efforts are currently underway to develop drought resistant varieties for wheat. However, the release of these varieties could be as much as a decade behind the other three crops and an estimate of water savings is unknown at this time. Therefore, wheat was not included in this scenario for this planning session, but will be considered in the 2016 planning process.

In the 2001 effort, implementation levels and schedules were developed for seven strategies by the Agricultural Demands Subcommittee of the planning group. During the 2006 round of planning, extensive research on these strategies was conducted resulting in water savings and implementation levels being modified where appropriate. In the 2011 planning cycle, the water savings and implementation level were assumed to the same as identified in the 2006 planning effort for the seven strategies with the exception of precipitation enhancement. The water savings associated with precipitation enhancement was increased from .546 ac-in to one ac-in based on the recommendation of Panhandle GCD personnel who have utilized precipitation enhancement as a strategy in the district for several years. An additional strategy of adopting drought resistant varieties for corn, cotton and soybeans was added. The estimated water savings and implementation schedule used in the 2011 planning effort for each of the strategies is presented in Table 4-6.

Table 4-6: Possible Water Management Strategies for Reducing Irrigation Demands

Water Management Strategy	Annual Regional Water Savings (ac-ft/ac/yr)	Assumed Baseline Use 2010	Goal for Adoption 2020	Goal for Adoption 2030	Goal for Adoption 2040	Goal for Adoption 2050	Goal for Adoption 2060
Use of NPET	0.083	20%	27.5%	35%	42.5%	50%	50%
Change in Crop Variety	0.341-corn and 0.054-sorghum	40%	70%	70%	70%	70%	70%
Irrigation Equipment Changes	0.525	80%	85%	90%	95%	95%	95%
Change in Crop Type	0.692	20%	40%	40%	40%	40%	40%
Convert Irrigated Land to Dryland	0.892	5%	10%	15%	15%	15%	15%
Implement Conservation Tillage Methods	0.146	60%	70%	70%	70%	70%	70%
Precipitation Enhancement	0.083	0%	100%	100%	100%	100%	100%
Biotechnology Adoption	15 – 30% corn, cotton & soybeans	0%	50%	90%	100%	100%	100%

4.8.1 Methodology

Water savings, implementation cost and direction of impact in gross crop receipts were estimated for each proposed water management strategy identified in the planning effort and described in Section 4.8. The year 2010 was selected as the baseline for evaluating strategies. The proposed 2010 adoption rates from the 2006 plan from the seven previously identified water management strategies were assumed to have occurred. All strategies were evaluated over a 50-year planning horizon (2010 – 2060) using a three-year average (2006 – 2008) of Farm Service Agency (FSA) irrigated acreage for the region as the base. The three-year average of irrigated acreage was used to dampen distortions resulting from acreage shifts between crops caused by volatile crop prices. Water availability was assumed to remain constant in measuring the impacts of the various water conservation strategies.

Implementation costs were defined as the direct costs associated with implementing a strategy whether these costs would be borne by producers and/or the government. All costs were evaluated in September 2008 dollars. The impact on the regional economy estimated via the change in gross receipts was not estimated. However, the anticipated direction of gross receipts from implementing a strategy was identified.

4.8.2 Results

Cumulative water savings, implementation cost and the anticipated direction of regional impacts for each of the water conservation strategies are presented in Table 4-7. Biotechnology Adoption (drought resistant varieties) was estimated to generate by far the largest amount of water savings, 10.6 million ac-ft, which was 14.7 percent of the total irrigation water pumped over the 50-year planning horizon. Implementing this strategy was expected to cost $75.8 million resulting in an average cost of $7.13 per ac-ft of water saved.

The precipitation enhancement strategy was projected to save 4.8 million ac-ft under the assumption that increased rainfall would result in a one acre-inch reduction in pumping. The estimated implementation cost associated with this strategy was $29 million resulting in a cost of $6.01 per ac-ft of water saved. This strategy should yield a positive impact to gross receipts in the region, since additional rainfall will occur not only on irrigated land but on dryland and pasture operations increasing their productivity. It should be noted, that unlike the other strategies considered, this is not a strategy a producer can individually adopt. Currently, only the Panhandle GCD practices precipitation enhancement in PWPA, and there are no indications that any other areas of the region plan to incorporate this strategy.

Additional conversion of non-efficient irrigation delivery systems in the region, such as, furrow and MESA to more efficient systems (LESA, LEPA or subsurface drip irrigation) resulted in a savings of 4.0 million ac-ft (5.5% of total irrigation water pumped). Investment in these more efficient systems and reinvestment as they wore out resulted in an implementation cost of $217 million. This translates into a cost of $54.89 per ac-ft of water saved, by far the most expensive of the strategies considered from an implementation cost standpoint. However, this strategy was not expected to have any adverse effects on gross receipts while reducing pumping cost, thus, having a slightly positive impact on the regional economy.

Table 4-7: Estimated Total Water Savings and Costs Associated with Proposed Water Conservation Strategies in PWPA

Water Management Strategy	Cumulative Water Savings (WS)	WS/Total Irrigation Demand	Implementation Cost (IC)	IC/WS	Direct Regional Impact (DRI)[1]	DRI/WS
	ac-ft	**%**	**$1,000**	**$/ac-ft**	**$1,000**	**$/ac-ft**
Use of NPET	1,012,894	1.40	9,000	$8.89	+	+
Change in Crop Variety	2,265,030	3.14	-	-	-	-
Irrigation Equipment Changes	3,966,151	5.49	216,907	$54.69	+	+
Change in Crop Type	3,312,507	4.59	114,885	$34.68	-	-
Conservation Tillage Methods	848,437	1.18	-6,956	-$8.20	+	+
Precipitation Enhancement	4,823,304	6.68	28,994	$6.01	+	+
Irrigated to Dryland Farming	2,522,546	3.49	75,412	$29.90	-	-
Biotechnology Adoption	10,635,558	14.73	75,816	$7.13	+	+

[1] +indicates an anticipated positive impact that was not quantified.

The change in crop type was estimated to generate 3.3 million ac-ft of water savings, which was 4.6 percent of the total irrigation water pumped over the 60-year planning horizon. Implementing this strategy was expected to cost $114.9 million resulting in an average cost of $34.68 per ac-ft of water saved. However, achieving these water savings came at an additional cost. The move to lower productive crops resulted in a loss in gross crop receipts resulting in a negative impact on the regional economy.

Converting marginally irrigated land to dryland production yielded water savings of 2.5 million ac-ft or 3.5 percent of the total pumped. The estimated change in land values resulted in an implementation cost of $75.4 million and a resultant cost of $29.90 per ac-ft of water saved. The loss in gross receipts because of the lost production is estimated to have a negative impact on the regional economy.

The change to shorter season corn and sorghum varieties yielded the sixth largest water savings of 2.3 million ac-ft or 3.1 percent of the total pumped. It was not anticipated that changing crop variety would result in increased cost. However, changing crop variety led to a reduction in yields that resulted in a loss in gross cash receipts, thus having an anticipated negative impact on the regional economy.

Increased use of the NPET to improve the efficiency of irrigation scheduling was estimated to save 1.0 million ac-ft or approximately 1.4 percent of total water pumped. Implementation costs were estimated at $9.0 million resulting in the third lowest cost per ac-ft of water saved, $8.89. It should be noted that the water savings assumed a one acre-inch savings which may or may not be accurate for the region. Results of a very limited, previous survey of NPET users indicated that just as many producers increased pumping from use of the NPET (increased irrigated acreage) as decreased water usage. A study of the California ET network (CIMIS) yielded a significant increase in returns from a combination of water savings and yield increases, but the amount of water savings achieved was omitted from the study report.

Increasing the level of conservation tillage practices yielded water savings of 0.8 million ac-ft or 1.2 percent of total irrigation water pumped. The change in relative cost of fuel and chemicals over the last five years has resulted in the implementation of increased conservation tillage reducing costs to an estimated $7.0 million resulting in a negative cost per acre-foot of water saved (-$8.20). The resultant cost savings from increasing conservation tillage acreage was assumed to have a positive impact on the regional economy.

4.8.3 Dallam County: Irrigation Shortages and Water Savings from Conservation Strategies

It is projected that Dallam County will have an irrigation shortage of 132,889 ac-ft in 2010 (Table 4-7). This annual shortfall is expected to increase to 149,134 ac-ft in 2040 before falling to 117,396 ac-ft by 2060. The evaluation of the conservation strategies showed that Biotechnology Adoption is the most effective water saving strategy when fully implemented in Dallam County, reducing annual use by 57,968 ac-ft. The effectiveness of the remaining strategies once fully implemented rank as follows: Precipitation Enhancement (18,625 ac-ft), Improvement in Irrigation Equipment (17,673 ac-ft), Change in Crop Type (17,172 ac-ft), Change in Crop Variety (12,813 ac-ft), Conversion to Dryland (8,468 ac-ft), Irrigation Scheduling (5,588 ac-ft) and Conservation Tillage (3,276 ac-ft).

It is projected that implementing all strategies would result in a surplus (24,186 ac-ft) by 2060. However, implementation of certain strategies can diminish the effectiveness of others if they are also implemented. Also, Precipitation Enhancement is currently not practiced in Dallam County. Therefore, it is unlikely that the full potential water savings would be realized unless there were changes to the implementation rates and schedules or other strategies implemented.

Table 4-8: Dallam County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year), 2010-2060.

		2010	2020	2030	2040	2050	2060
Projected Shortage		-132,889	-140,984	-148,630	-149,134	-133,737	-117,396
Projected Water Savings							
Water Saving Strategies	Change in Crop Type	0	17,172	17,172	17,172	17,172	17,172
	Change in Crop Variety	0	12,813	12,813	12,813	12,813	12,813
	Conservation Tillage	0	3,276	3,276	3,276	3,276	3,276
	Convert to Dry	0	4,234	8,468	8,468	8,468	8,468
	Irrigation Equipment	0	5,891	11,782	17,673	17,673	17,673
	NPET Network	0	1,397	2,794	4,191	5,588	5,588
	Precipitation Enhancement	0	18,625	18,625	18,625	18,625	18,625
	Biotechnology Adoption	0	14,492	52,171	57,968	57,968	57,968
	Total Potential Water Savings	0	77,900	127,101	140,186	141,583	141,583
	Water Surplus / Deficit	-132,889	-63,084	-21,529	-8,948	7,846	24,187

4.8.4 Hansford County: Irrigation Shortages and Water Savings from Conservation Strategies

Hansford County is projected to have an irrigation shortage of 150 ac-ft by 2010 (Table 4-8). This annual shortfall will increase to a maximum of 4,548 ac-ft in 2040. Biotechnology Adoption is the most effective water saving strategy when fully implemented in Hansford County reducing annual use by 21,127 ac-ft. The effectiveness of the remaining strategies once fully implemented rank as follows: Precipitation Enhancement (9,811 ac-ft), Improvement in Irrigation Equipment (9,309 ac-ft), Conversion to Dryland (6,514 ac-ft), Change in Crop Type (5,928 ac-ft), Change in Crop Variety (4,404 ac-ft), Irrigation Scheduling (2,943 ac-ft) and Conservation Tillage (1,726 ac-ft).

The projected irrigation deficits in Hansford County are relatively small. Implementation of one or more (depending on the strategies selected) of the conservation strategies will rectify the projected irrigation shortfalls.

Table 4-9: Hansford County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year), 2010-2060.

		2010	2020	2030	2040	2050	2060
	Projected Shortage	150	1,005	1,484	4,548	3,077	1,640
	Projected Water Savings						
Water Saving Strategies	Change in Crop Type	0	5,928	5,928	5,928	5,928	5,928
	Change in Crop Variety	0	4,404	4,404	4,404	4,404	4,404
	Conservation Tillage	0	1,726	1,726	1,726	1,726	1,726
	Convert to Dry	0	3,257	6,514	6,514	6,514	6,514
	Irrigation Equipment	0	3,103	6,206	9,309	9,309	9,309
	NPET Network	0	736	1,472	2,207	2,943	2,943
	Precipitation Enhancement	0	9,811	9,811	9,811	9,811	9,811
	Biotechnology Adoption	0	5,282	19,014	21,127	21,127	21,127
	Total Potential Water Savings	0	34,247	55,075	61,026	61,762	61,762
	Water Surplus / Deficit	-150	33,242	53,591	56,478	58,685	60,122

4.8.5 Hartley County: Irrigation Shortages and Water Savings from Conservation Strategies

It is projected that Hartley County will have an irrigation shortage of 181,732 ac-ft in 2010 (Table 4-9). This annual shortfall will increase to 183,457 ac-ft in by 2030. Biotechnology Adoption is the most effective water saving strategy when fully implemented in Hartley County reducing annual use by 54,070 ac-ft. The effectiveness of the remaining strategies once fully implemented rank as follows: Precipitation Enhancement (16,255 ac-ft), Change in Crop Type (15,720 ac-ft), Improvement in Irrigation Equipment (15,423 ac-ft), Change in Crop Variety (11,772 ac-ft), Conversion to Dryland (7,052 ac-ft), Irrigation Scheduling (4,876 ac-ft) and Conservation Tillage (2,859 ac-ft).

Implementing all proposed conservation strategies will not meet the projected irrigation shortages. Also, implementation of certain strategies can diminish the effectiveness of others if implemented at the same time. Precipitation Enhancement, which is included as a potentially feasible strategy, is currently not practiced in Hartley County and is considered an alternate strategy for planning purposes. To fully meet the projected irrigation needs, improvements in the implementation level and/or schedule of the current strategies would be required and additional strategies would likely be needed to enhance water conservation.

Table 4-10: Hartley County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year), 2010-2060.

		2010	2020	2030	2040	2050	2060
	Projected Shortage	-181,732	-180,523	-183,457	-179,983	-161,368	-142,079
	Projected Water Savings						
Water Saving Strategies	Change in Crop Type	0	15,720	15,720	15,720	15,720	15,720
	Change in Crop Variety	0	11,772	11,772	11,772	11,772	11,772
	Conservation Tillage	0	2,859	2,859	2,859	2,859	2,859
	Convert to Dry	0	3,526	7,052	7,052	7,052	7,052
	Irrigation Equipment	0	5,141	10,282	15,423	15,423	15,423
	NPET Network	0	1,219	2,438	3,657	4,876	4,876
	Precipitation Enhancement	0	16,255	16,255	16,255	16,255	16,255
	Biotechnology Adoption	0	13,518	48,663	54,070	54,070	54,070
	Total Potential Water Savings	0	70,010	115,041	126,808	128,027	128,027
	Water Surplus / Deficit	-181,732	-110,513	-68,416	-53,175	-33,341	-14,052

4.8.6 Hutchinson County: Irrigation Shortages and Water Savings from Conservation Strategies

It is projected that Hutchinson County will have an irrigation shortage of 15,008 ac-ft in 2010 (Table 4-10). This annual shortfall is projected to still exist but is expected to fall to 5,455 ac-ft in 2060. Biotechnology Adoption is the most effective water saving strategy when fully implemented in Hutchinson County reducing annual use by 7,007 ac-ft. The effectiveness of the remaining strategies once fully implemented rank as follows: Precipitation Enhancement (2,965 ac-ft), Improvement in Irrigation Equipment (2,814 ac-ft), Change in Crop Type (1,863 ac-ft), Conversion to Dryland (1,631 ac-ft), Change in Crop Variety (1,401 ac-ft), Irrigation Scheduling (890 ac-ft) and Conservation Tillage (522 ac-ft).

It will be difficult to meet projected irrigation shortages in the short term with the current water conservation strategies identified. However, projected irrigation shortfalls are expected to decline in later years. Therefore, in the later years (2030 – 2060), implementing a combination of selected strategies should be adequate to meet projected irrigation shortfalls.

Table 4-11: Hutchinson County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year), 2010-2060.

		2010	2020	2030	2040	2050	2060
	Projected Shortage	-15,008	-12,175	-11,652	-10,612	-7,534	-5,455
	Projected Water Savings						
Water Saving Strategies	Change in Crop Type	0	1,863	1,863	1,863	1,863	1,863
	Change in Crop Variety	0	1,401	1,401	1,401	1,401	1,401
	Conservation Tillage	0	522	522	522	522	522
	Convert to Dry	0	816	1,631	1,631	1,631	1,631
	Irrigation Equipment	0	938	1,876	2,814	2,814	2,814
	NPET Network	0	222	445	667	890	890
	Precipitation Enhancement	0	2,965	2,965	2,965	2,965	2,965
	Biotechnology Adoption	0	1,752	6,306	7,007	7,007	7,007
	Total Potential Water Savings	0	10,479	17,009	18,870	19,093	19,093
	Water Surplus / Deficit	-15,008	-1,696	5,357	8,258	11,559	13,638

4.8.7 Moore County: Irrigation Shortages and Water Savings from Conservation Strategies

It is projected that Moore County will have an irrigation shortage of 52,317 ac-ft in 2010 (Table 4-11). This annual shortfall will increase to 54,494 ac-ft in 2040 before decreasing to 45,420 in 2060. Biotechnology Adoption is the most effective water saving strategy when fully implemented in Moore County reducing annual use by 30,699 ac-ft. The effectiveness of the remaining strategies once fully implemented rank as follows: Precipitation Enhancement (11,348 ac-ft), Improvement in Irrigation Equipment (10,767 ac-ft), Change in Crop Type (7,852 ac-ft), Conversion to Dryland (6,977 ac-ft), Change in Crop Variety (6,151 ac-ft), Irrigation Scheduling (3,404 ac-ft) and Conservation Tillage (1,996 ac-ft).

Implementing all the strategies identified would not completely meet the projected irrigation deficits in the early decades. Considering the decreased effectiveness with respect to water savings of certain combinations of strategies and no current sponsor for Precipitation Enhancement in Moore County, it is uncertain whether deficits in later decades could be met with the identified conservation strategies. Improvements to implementation rates and/or additional strategies to enhance water conservation would need to be developed.

Table 4-12: Moore County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year), 2010-2060.

		2010	2020	2030	2040	2050	2060
	Projected Shortage	-52,317	-48,090	-52,425	-54,994	-50,321	-45,420
	Projected Water Savings						
Water Saving Strategies	Change in Crop Type	0	7,852	7,852	7,852	7,852	7,852
	Change in Crop Variety	0	6,151	6,151	6,151	6,151	6,151
	Conservation Tillage	0	1,996	1,996	1,996	1,996	1,996
	Convert to Dry	0	3,488	6,977	6,977	6,977	6,977
	Irrigation Equipment	0	3,589	7,178	10,767	10,767	10,767
	NPET Network	0	851	1,702	2,553	3,404	3,404
	Precipitation Enhancement	0	11,348	11,348	11,348	11,348	11,348
	Biotechnology Adoption	0	7,675	27,629	30,699	30,699	30,699
	Total Potential Water Savings	0	42,950	70,343	78,343	79,194	79,194
	Water Surplus / Deficit	-52,317	-5,140	18,408	23,349	28,873	33,774

4.8.8 Sherman County: Irrigation Shortages and Water Savings from Conservation Strategies

It is projected that Sherman County will have an irrigation shortage of 72,532 ac-ft in 2010 (Table 4-12). This annual shortfall will increase to 82,955 ac-ft in 2040 before decreasing to 69,190 ac-ft in 2060. Biotechnology Adoption is the most effective water saving strategy when fully implemented in Sherman County reducing annual use by 40,022 ac-ft. The effectiveness of the remaining strategies once fully implemented rank as follows: Precipitation Enhancement (14,566 ac-ft), Improvement in Irrigation Equipment (13,821 ac-ft), Change in Crop Type (10,580 ac-ft), Conversion to Dryland (8,521 ac-ft), Change in Crop Variety (8,020 ac-ft), Irrigation Scheduling (4,370 ac-ft) and Conservation Tillage (2,562 ac-ft).

Implementing all the strategies identified would not completely cover the projected irrigation deficits in the early decades. Considering the decreased effectiveness with respect to water savings of certain combinations of strategies and no current sponsor for Precipitation Enhancement in Sherman County, it is uncertain whether deficits in later decades could be met with the identified conservation strategies. Therefore, an improvement in the implementation level and/or schedule of the current strategies especially in the early decades would be required to fully meet the irrigation needs and probably additional strategies to enhance water conservation would need to be developed.

Table 4-13: Sherman County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year), 2010-2060.

		2010	2020	2030	2040	2050	2060
	Projected Shortage	-72,532	-69,367	-79,690	-82,955	-77,118	-69,190
	Projected Water Savings						
Water Saving Strategies	Change in Crop Type	0	10,580	10,580	10,580	10,580	10,580
	Change in Crop Variety	0	8,020	8,020	8,020	8,020	8,020
	Conservation Tillage	0	2,562	2,562	2,562	2,562	2,562
	Convert to Dry	0	4,261	8,521	8,521	8,521	8,521
	Irrigation Equipment	0	4,607	9,214	13,821	13,821	13,821
	NPET Network	0	1,092	2,185	3,277	4,370	4,370
	Precipitation Enhancement	0	14,566	14,566	14,566	14,566	14,566
	Biotechnology Adoption	0	10,006	36,020	40,022	40,022	40,022
	Total Potential Water Savings	0	55,693	91,668	101,369	102,462	102,462
	Water Surplus / Deficit	-72,126	-13,674	11,978	18,414	25,344	33,272

4.8.9 Summary of Irrigation Conservation Strategies

Prioritizing and implementing the eight irrigation conservation strategies will depend on the individual irrigator and regional support of the strategy. The one strategy that yields the largest water savings is the adoption of drought resistant varieties of corn, cotton and soybeans which are being developed with the aid of biotechnology. It is estimated to have the potential to save 10.6 million ac-ft (cumulative savings), which was 14.7 percent of the total irrigation water pumped over the 50-year planning horizon significantly more than the other strategies evaluated. The cumulative effectiveness of the remaining strategies in millions of ac-ft ranked as follows: Precipitation Enhancement (4.8), Improvement in Irrigation Equipment (4.0), Change in Crop

Type (3.3), Conversion to Dryland (2.5), Change in Crop Variety (2.3), Irrigation Scheduling (1.0) and Conservation Tillage (0.8).

The estimated cost of implementing the various strategies as expressed in $/ac-ft of water savings varied considerably. The cost of implementing conservation tillage actually was projected to be negative suggesting that producers would save money by implementing conservation tillage techniques (-$8.20). In the 2006 water plan, this strategy had a relatively small cost to implementation but the relative change in fuel and chemical costs resulted in the cost of implementation becoming negative. Change in Crop Variety, Precipitation Enhancement, Biotechnology Adoption and Irrigation Scheduling are the next four most cost effective strategies at $0.00, $6.01, $7.13 and $8.89 per ac-ft, respectively. The remaining strategies which include Conversion to Dryland, Change in Crop Type and Improvement in Irrigation Equipment have implementation costs estimated at $29.90, $34.68 and $54.69 per ac-ft, respectively.

Water conservation strategies can have significantly different impacts on the regional economy that is often measured by the change in gross receipts or costs. The impact on the regional economy should be a major consideration in prioritizing strategies to be implemented. In this planning effort, no attempt was made to quantify the impacts of individual strategies on the regional economy; however, the anticipated direction of effect(s) was included. Change in crop type, change in crop variety and conversion to dryland are all anticipated to have a negative impact due to the reduction in production. The remaining five conservation strategies are all expected to have a positive impact either due to increased production or a reduction in costs without reducing yields leading to a freeing up of income to be spent in the economy.

The counties of Dallam, Hansford, Hartley, Hutchinson, Moore, and Sherman are projected to have irrigation shortfalls. Implementing one or a combination of identified water conservation strategies could readily eliminate projected deficits in Hansford and Hutchinson Counties. Implementing all strategies and development of additional conservation strategies may be necessary in the other four counties particularly in Dallam and Hartley counties to overcome projected irrigation shortfalls.

Several caveats to this analysis need to be mentioned. First, the associated water savings with these strategies are “potential” water savings. In the absence of water use constraints, most if not all the strategies considered will simply increase gross receipts. In fact, the improved water use efficiencies generated from some of these strategies may actually increase the depletion rate of the Ogallala aquifer. Second, potential water savings may be overestimated when combinations of strategies are implemented. For example, the savings associated with the implementation of irrigation equipment efficiency improvements cannot be applied to irrigated land that is converted to dryland farming. Finally, precipitation enhancement is not a strategy that a producer can implement. It has to be funded and implemented by a group such as a water district. Currently, only the Panhandle GCD practices precipitation enhancement. At this time, none of the other water districts have any plans to adopt precipitation enhancement; therefore, estimated total water savings may be overestimated depending on location. For this plan, precipitation enhancement is only recommended for counties within the Panhandle GCD. It is an alternate strategy for the other counties in the PWPA.

4.8.10 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, drilling new wells is an option for irrigation water users who require additional supplies. Approximate cost estimates were developed to determine the costs of installing irrigation wells. Calculations assumed that a well costs $95 per foot; and pumping equipment can be estimated at $75 per foot (based on September 2008 dollars). Table 4-14 summarizes two scenarios: a pumping rate of less than and greater than 700 gallons per minute.

Table 4-14: Estimated Costs of Irrigation Wells in PWPA

Pumping Rate (gpm)	Approximate Well Depth (ft)	Approximate Well Casing Diameter (in.)	Approximate Pumping Unit Diameter (in.)	Well Cost	Pumping Equipment Cost	Total Cost
Less than 700	375	12¾	4 - 6	$33,750	$25,500	$59,250
Greater than 700	500	16	8	$50,000	$38,400	$88,400

4.9 Wholesale Water Providers

There are seven wholesale water providers located in the PWPA. Of these entities, four are projected to have shortages within the planning period: CRMWA, City of Amarillo, City of Borger, and City of Cactus. Discussion of the water needs and recommended water management strategies for each of the wholesale water providers follows.

4.9.1 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 Region O. The total available safe supply from the CRMWA system is 90,000 acre-feet per year in 2010, and increases to 119,000 acre-feet per year in 2020 as additional groundwater becomes available through CRMWA's current infrastructure expansion and supplies from Lake Meredith are assumed to recover to 50,000 acre-feet per year. Should Lake Meredith not recover as expected, CRMWA may need to develop additional infrastructure to move additional groundwater from Roberts County to meet the projected demands. Current demands on CRMWA are estimated at approximately 100,000 acre-feet per year. Table 4-15 lists the demands by customer, current supplies, and projected shortages for CRMWA.

Table 4-15: Summary of Demands, Supplies, and Recommended Strategies for CRMWA

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
PWPA:						
City of Pampa	3,300	3,273	3,182	3,058	2,871	2,689
City of Borger	4,000	5,510	5,510	5,510	5,510	5,510
City of Amarillo	42,987	42,987	42,987	42,987	42,987	42,987
Region O:						
City of Lamesa	2,528	2,528	2,528	2,528	2,328	2,328
City of O'Donnell	322	322	322	322	292	292
City of Plainview	4,281	4,281	4,281	4,281	3,881	3,881
City of Levelland	3,236	3,236	3,236	3,236	2,808	2,808
City of Lubbock	32,000	34,000	34,000	34,000	32,000	32,000
City of Slaton	1,369	1,369	1,369	1,369	1,369	1,369
City of Tahoka	534	534	534	534	460	460
City of Brownfield	2,549	2,549	2,549	2,549	2,549	2,549
Total	**97,106**	**100,589**	**100,498**	**100,374**	**97,055**	**96,873**
	Current Water Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Lake Meredith	30,000	50,000	50,000	50,000	50,000	50,000
Roberts County Groundwater	60,000	69,000	69,000	69,000	69,000	69,000
Total Current Supply	**90,000**	**119,000**	**119,000**	**119,000**	**119,000**	**119,000**
Shortage	**Shortage (AF/Y)**					
Current Customers	(7,106)	0	0	0	0	0
	Supply from Strategy (AF/Y)					
Recommended Strategies	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Replace Well Capacity	0	0	15,000	15,000	15,000	15,000
Purchase additional water rights	0	0	0	0	0	0

<u>Recommended Strategies</u>

- Maintain current capacity of existing Roberts County well field through the development of additional wells and infrastructure
- Purchase up to 220,000 acres of additional water rights in Roberts County and surrounding counties to replace lost capacity of CRMWA's existing well field.

<u>Strategy Descriptions</u>

Due to continued lack of inflow for Lake Meredith, CRMWA is proceeding to expand their groundwater production and delivery capacity. The additional supply is expected to be online by 2010, and this supply is shown as currently available to CRMWA. CRMWA holds water rights to 263,000 acres in Roberts County. Presently, only a fraction of these rights are developed. Over the course of the planning period, CRMWA will need to develop additional areas to replace lost capacity of the existing system. This strategy will be needed when the existing well field can no longer support pumping at 69,000 acre-feet per year and meet groundwater district regulations. The replacement of the CRMWA groundwater capacity will offset this shortage.

If storage in Lake Meredith continues to decline, CRMWA may need to develop additional groundwater supplies beyond the system's current capacity. To support greater demands on the Roberts County well field, CRMWA would purchase up to 220,000 acres of additional water rights in the four-county area, including Roberts, Ochiltree, Lipscomb and Hemphill counties.

<u>Time Intended to Complete</u>
Maintenance of the existing well field will be ongoing. However, additional wells may need to be drilled by 2030 to maintain the current supply. The purchase of water rights would be on-going, pending agreements with willing sellers.

<u>Quantity, Reliability and Cost</u>
The quantity of water should be sufficient to meet the projected needs of CRMWA's customers. Depending on the future reliability of Lake Meredith, additional groundwater supplies beyond the total amount of 69,000 acre-feet per year from Roberts County may be needed to meet future demands. Any water management strategy will need to acquire an adequate quantity of groundwater water rights while complying with all applicable groundwater conservation district rules.

Reliability of Ogallala supplies is moderate to high. There are significant quantities of untapped water supplies in Roberts, Ochiltree, Lipscomb and Hemphill counties, but the availability of this water also depends on other water users. Costs to maintain the capacity of the existing Roberts County well field is estimated at $21.8 million. The cost to purchase the additional water rights is estimated at $88.2 million, but is dependent upon the location of the water rights relative to CRMWA operations, the saturated thickness and water quality of the groundwater, the amount of testing already completed, and when the water rights are purchased.

<u>Environmental Issues</u>
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.

<u>Impact on Water Resources and Other Management Strategies</u>
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.

<u>Impact on Agriculture and Natural Resources</u>
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.

<u>Other Relevant Factors</u>
In the event that Lake Meredith does not recover from the current drought, CRMWA will need to increase its supplies from Roberts County. This may generate the need for additional

transmission from Roberts County to near Amarillo. If this is needed, a joint pipeline with Amarillo (as Amarillo develops its Roberts County water rights) should be considered.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategies are not expected to impact water rights, contracts, or option agreements.

Impact on Navigation
The recommended strategies should have no impact on the navigable waters of the United States.

4.9.2 City of Amarillo
The City of Amarillo provides municipal water to city customers in Randall and Potter Counties, the City of Canyon, and Palo Duro State Park. It also provides 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 with Xcel Energy for treated wastewater effluent.

Amarillo owns water rights in Randall, Potter, Carson, Deaf Smith, Dallam, Hartley, Ochiltree and Roberts County, but only a portion of these groundwater rights are fully 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 of year of water. The total estimated current supply for the City is 50,198 acre-feet per year of potable water and 19,603 acre-feet of reuse supply. Potable water supplies are projected to increase to 55,035 acre-feet per year after CRMWA completes its Roberts County expansion and then decrease to 49,283 acre-feet per year by 2060. Reuse is expected is increase over time and is supplied to Xcel Energy for steam electric power use.

Table 4-16 lists the projected potable demands by customer, the current sources of supply available, and the recommended strategies. The projected shortages are expected to begin in 2030 with a shortfall of 4,852 acre-feet per year and increasing up to 21,597 acre-feet per year by 2060. The recommended water management strategies for Amarillo include completing the development of the Potter County well field and then developing the City's water rights in Roberts County. For planning purposes, it is assumed that the water rights in Hartley County will be developed after Roberts County. However, the timing of these strategies may change pending other developments.

Recommended Strategies
- Implement conservation strategies
- Develop Potter County Well Field (Ogallala aquifer)
- Develop Roberts County Well Field (Ogallala aquifer)

<u>Recommended Conservation Strategies</u>

- Implementation of water conservation plan
- Water conservation pricing
- System water audit

<u>Strategy Descriptions</u>

The recommended strategies include implementing conservation measures and developing the Potter and Roberts counties well fields. Table 4-16 shows the amount of water supply associated with each of the recommended strategies. The City of Amarillo has unused groundwater rights in the Ogallala aquifer in Potter and Roberts County. The City plans to fully develop the Potter County well field first and continue to purchase water from CRMWA. As part of this strategy, the City will need to develop a transmission system to deliver the Potter County water to the delivery points for distribution. This transmission system includes a 48-inch pipeline from the well field to Amarillo and a 36-inch pipeline to delivery locations in the northwest and southwest areas of the City.

As more supplies are needed, the City will develop its groundwater rights in Roberts County. It is assumed that the Roberts County strategy will be implemented in two phases, with phase 1 being developed by 2040 and phase 2 developed by 2060. These strategies and timing assume that CRMWA will continue to deliver 42,987 acre-feet of water to Amarillo. Should Lake Meredith not recover as expected and supplies from CRMWA be reduced, the quantities of water from Roberts County may increase and/or occur sooner.

<u>Time Intended to Complete</u>

Water conservation strategies should be in place by 2010 with water savings being noticed in 2020. The Potter County well field should be on-line by 2011. The Roberts County well field will be developed as additional supplies are needed. This is expected to occur by 2040.

<u>Quantity, Reliability and Cost</u>

The quantity of water should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them.

Approximately 11,182 acre-feet per year of additional water will be obtained from the Potter County well field and 11,210 acre-feet per year from each phase of the Roberts County well field. Reliability of groundwater in Potter County is moderate to high, depending on competing interests. The capital costs for developing the Potter County well field and transmission system are $128.5 million. 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 $287.4 million, $143.7 million for each phase. These costs could potentially be less if Amarillo and CRMWA jointly develop additional transmission capacity from Roberts County.

Table 4-16: Summary of Demands, Supplies, and Recommended Strategies for Amarillo

	Treated Water Demands (AF/Y)[1]					
Customers [1]	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Amarillo	42,329	45,817	49,079	52,794	56,848	60,188
Manufacturing - Potter County	6,516	7,169	7,721	8,260	8,726	9,367
City of Canyon	1,000	1,000	1,000	1,000	1,000	1,000
Manufacturing - Randall County	300	300	300	300	300	300
Palo Duro State Park	25	25	25	25	25	25
Total Demand	**50,170**	**54,311**	**58,125**	**62,379**	**66,899**	**70,880**
	Current Water Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Ogallala - Randall County	2,830	1,600	1,300	1,000	800	600
Ogallala - Potter County	0	0	0	0	0	0
Ogallala - Carson County	11,000	10,323	8,886	7,609	6,510	5,682
Ogallala - Roberts County	24,193	24,925	24,925	24,925	24,925	24,925
Meredith (CRMWA)	12,050	18,062	18,062	18,062	18,062	18,062
Ogallala - Deaf Smith	125	125	100	100	50	14
Total Current Supply	**50,198**	**55,035**	**53,273**	**51,696**	**50,347**	**49,283**
Surplus or (Shortage)	**28**	**724**	**(4,852)**	**(10,683)**	**(16,552)**	**(21,597)**
	Supply from Strategy (AF/Y)					
Recommended Strategies	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Conservation	0	1,375	2,453	2,639	2,841	3,012
Potter County Well Field	0	9,467	10,292	11,182	11,141	10,831
Roberts County Well Field	0	0	0	11,210	11,210	22,420
Total from Strategies	**0**	**10,842**	**12,745**	**25,031**	**25,192**	**36,263**

1. Amarillo also provides treated wastewater to Xcel Energy.

Environmental Issues
The environmental impacts from conservation and 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
Water conservation may impact the amount of water returned to the system that might be available for reuse. 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 Potter and Roberts Counties to support these demands.

Impact on Agriculture and Natural Resources
Water conservation and 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.

<u>Other Relevant Factors</u>
There are no other identified relevant factors.

<u>Interbasin Transfer</u>
The recommended strategies do not require interbasin transfer permits.

<u>Social and Economic Impacts</u>
No negative social and economic impacts are expected from the implementation of these strategies.

<u>Impacts on Water Rights, Contracts, and Option Agreements</u>
The recommended strategies are not expected to impact water rights, contracts, or option agreements.

<u>Impact on Navigation</u>
The recommended strategies should have no impact on the navigable waters of the United States.

4.9.3 City of Borger

The City of Borger provides water to customers in Hutchinson County, including TCW Supply, Inc. and Hutchinson and Carson County manufacturing. The City receives blended water from CRMWA and operates wells for groundwater from the Ogallala aquifer. 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 4-17 lists the projected demands and supplies for the City of Borger and its customers.

<u>Recommended Strategies</u>

- Implement conservation strategies
- Develop additional groundwater (Ogallala aquifer)

<u>Recommended Conservation Strategies</u>

- Implementation of water conservation plan
- Water conservation pricing
- System water audit

<u>Strategy Descriptions</u>
The recommended strategies include implementing conservation measures, and developing additional groundwater from the Ogallala in Hutchinson County. Table 4-17 shows the amount of water supply associated with each of the recommended strategies. The yield of the City of Borger's well field is expected to decline over time. It is anticipated that Borger will continue to operate groundwater system at levels similar to current pumpage. To do this, the City will need to install additional wells.

Table 4-17: Summary of Demands and Supplies for the City of Borger

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Borger	2,352	2,384	2,351	2,274	2,148	2,039
Manufacturing	6,360	6,820	7,190	7,550	7,860	8,380
County-other	56	57	57	55	52	49
TCW Supply	0	0	0	0	0	0
Total Demand	**8,768**	**9,261**	**9,598**	**9,879**	**10,060**	**10,468**
	Current Water Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Ogallala - Hutchinson Co.	4,500	3,825	3,251	2,764	2,349	1,997
Ogallala - Carson Co.	450	450	450	450	450	450
Reuse	1,045	1,045	1,045	1,045	1,045	1,045
Lake Meredith (CRMWA)	1,144	1,681	1,681	1,681	1,681	1,681
Ogallala - Roberts Co.	2,282	3,829	3,829	3,829	3,829	3,829
Total Current Supply	**9,418**	**10,830**	**10,256**	**9,769**	**9,354**	**9,002**
Surplus or (Shortage)	**650**	**1,569**	**658**	**-110**	**-706**	**-1,466**
Recommended Strategies:						
Conservation	0	24	71	114	107	102
Additional Ogallala – Hutchinson Co.	0	0	1,000	1,000	2,000	2,000
Total from Strategies	**0**	**24**	**1,071**	**1,114**	**2,107**	**2,102**

Time Intended to Complete
Water conservation strategies should be in place by 2010 with water savings being noticed in 2020. The Hutchinson County well field expansion should begin by 2030.

Quantity, Reliability and Cost
The quantity of water should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them.

Approximately 2,000 acre-feet per year of additional water will be obtained from the Hutchinson County well field. Reliability of groundwater in Hutchinson County is moderate to high, depending on location and competing interests. The capital costs for expanding the Hutchinson County well field are $9.4 million.

Environmental Issues
The environmental impacts from conservation and 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
Water conservation may impact the amount of water returned to the system that might be available for reuse. 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
Water conservation and 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.

Interbasin Transfer
The recommended strategies do not require interbasin transfer permits.

4.9.4 City of Cactus

The City of Cactus provides water to municipal and manufacturing customers in Moore County. Cactus currently obtains all of its supplies from the Ogallala aquifer in Moore County. Cactus is also a member of the Palo Duro River Authority. Table 4-18 lists the projected demands by customer, current supplies, and recommended strategies for Cactus to meet the projected water needs.

Recommended Strategies
- Implement conservation strategies
- Develop new wells in the Ogallala aquifer in Moore County

Recommended Conservation Strategies
- Implementation of water conservation plan
- Water conservation pricing
- System water audit

Strategy Descriptions
The recommended strategies for Cactus include implementing water conservation and developing new groundwater from the Ogallala aquifer with 6 new wells. The amount of water supply associated with each of these strategies is shown in Table 4-18.

Time Intended to Complete
Water conservation strategies should be in place by 2010 with water savings being noticed in 2020. Cactus will need to develop additional supplies between 2010 and 2020.

Table 4-18: Summary of Demands, Supplies, and Recommended Strategies for the City of Cactus

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Cactus	533	615	615	615	615	615
Moore County-Other	70	96	126	151	165	174
Moore County Manufacturing	2,758	2,958	3,120	3,280	3,421	3,587
Total Demand	**3,361**	**3,669**	**3,861**	**4,046**	**4,201**	**4,376**
	Current Water Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Ogallala - Moore County	3,188	2,869	2,582	2,324	2,092	1,882
Total Current Supply	**3,188**	**2,869**	**2,582**	**2,324**	**2,092**	**1,882**
Surplus or (Shortage)	**-173**	**-800**	**-1,279**	**-1,722**	**-2,109**	**-2,494**
	Supply from Strategy (AF/Y)					
Recommended Strategies	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Conservation	0	18	31	31	31	31
New Well Field -Ogallala	500	1,500	1,500	3,000	3,000	3,000
Total from Strategies	**500**	**1,518**	**1,531**	**3,031**	**3,031**	**3,031**
Alternate Strategy:	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Lake Palo Duro Project	0	0	1,744	1,744	1,744	1,744

Quantity, Reliability and Cost

The quantity of water should be sufficient. The reliability of conservation is considered moderate because much of the conservation plan must be implemented by the consumers. The conservation measures do not have any capital costs associated with them. Reliability of Ogallala supply is moderate to moderately-low since the aquifer is heavily used and availability depends on other water users. The capital cost for new wells is $10.9 million.

Environmental Issues

The environmental impacts from conservation and 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.

<u>Impact on Water Resources and Other Management Strategies</u>
Water conservation may impact the amount of water returned to the system that might be available for reuse. The increased demands on the Ogallala will continue to deplete the storage in the aquifer. To prolong the life of the Ogallala, other users may need to reduce their demands.

<u>Impact on Agriculture and Natural Resources</u>
The recommended strategies are expected to have low to moderate impact on the agriculture and other natural resources. This strategy may reduce the irrigated acreage for farming as additional water rights acreage is purchased. This acreage could be used for dry land farming if needed, but may require crop changes.

<u>Other Relevant Factors</u>
There are no other identified relevant factors.

<u>Interbasin Transfer</u>
The recommended strategies do not require interbasin transfer permits.

<u>Social and Economic Impacts</u>
No negative social and economic impacts are expected from the implementation of these strategies.

<u>Impacts on Water Rights, Contracts, and Option Agreements</u>
The recommended strategies are not expected to impact water rights, contracts, or option agreements.

<u>Impact on Navigation</u>
The recommended strategies should have no impact on the navigable waters of the United States.

<u>Alternative Strategy</u>
As a member of the PDRA, Cactus is interested in developing a regional transmission system to use water from Palo Duro Reservoir. The Palo Duro Reservoir transmission project is an alternative strategy for Cactus. The project would have very little impact on the environment, agricultural or other natural resources. Once the pipeline route is established, a more detailed analysis of the impacts should be considered. No interbasin transfer permits would be required for the Palo Duro transmission project. The use of this supply might decrease lake levels and impact recreation uses on the lake from time to time. No other impacts are expected from this project. Cactus is expected to have a capital cost of $54.8 million associated with their portion of the project.

4.9.5 Greenbelt Municipal and Industrial Water Authority
Greenbelt Municipal and Industrial Water Authority (Greenbelt M&IWA) owns and operates Greenbelt Reservoir on the Salt Fork of the Red River. As part of its water right, Greenbelt M&IWA also has the right to divert up to 4,030 acre-feet per year from Lelia Lake Creek. The Greenbelt M&IWA 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 M&IWA.

The estimated safe yield from the reservoir is nearly 6,900 acre-feet per year, reducing to 6,181 acre-feet per year by 2060. Greenbelt M&IWA provides water to several cities in the PWPA and Region B. Current projected demands on the Greenbelt M&IWA are shown in Table 4-19 and are not expected to exceed 5,000 acre-feet per year over the planning period. Based on the WAM analysis for Greenbelt Reservoir, Greenbelt M&IWA is not expected to have any water shortages during the planning period (2010-2060). However, recent drought in the PWPA has raised concerns about the reliability of the long-term supplies from the reservoir. Greenbelt M&IWA is currently investigating the possibility of supplementing its surface water supplies with groundwater. In addition to groundwater, the Authority has included the development of its water rights on Lelia Lake Creek as part of its long-range water supply plan. This is a long-term term project and will likely be developed beyond this planning period.

Table 4-19: Summary of Demands and Supplies for the Greenbelt M&IWA

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Childress	1,457	1,481	1,502	1,509	1,510	1,471
City of Chillicothe	61	55	53	51	50	49
City of Clarendon	440	440	440	440	440	440
City of Crowell	332	317	302	289	280	269
City of Memphis	100	100	100	100	100	100
Childress County-Other	196	199	202	203	203	198
Donley County-Other	219	210	191	171	154	128
Foard County-Other	68	68	68	68	68	68
Hall County-Other	152	152	152	152	152	152
Hardeman County-Other	210	210	210	210	210	210
Hardeman County Manufacturing	449	478	509	542	576	576
City of Quanah	652	612	589	544	511	463
Wilbarger County-Other	6	6	6	6	6	6
TOTAL	**4,342**	**4,328**	**4,324**	**4,285**	**4,260**	**4,130**
	Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Greenbelt Reservoir	6,864	6,728	6,592	6,456	6,320	6,181
Surplus or (Shortage)	**2,522**	**2,400**	**2,268**	**2,171**	**2,060**	**2,051**
	Supply from Strategy (AF/Y)					
Recommended Strategies	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
New Well Field -Ogallala	0	800	800	800	800	800

Recommended Strategy

- Develop new wells in the Ogallala aquifer in Donley County

Strategy Descriptions

The recommended strategy for Greenbelt M&IWA is to develop groundwater supplies from the Ogallala aquifer near Greenbelt Reservoir to supplement the yield of the reservoir. It is assumed that sufficient groundwater can be found within 1.5 miles of Greenbelt Reservoir or the Authority's raw water pipeline. Water may be pumped directly to the reservoir or the raw water pipeline. The amount of water supply is 800 acre-feet per year, as shown in Table 4-19.

Time Intended to Complete

This strategy is in the planning and preliminary design phase. It is expected that the strategy will be completed within the next five years.

Quantity, Reliability and Cost

The quantity of water should be sufficient. Reliability of groundwater supply is moderate since there is completion for water from the Ogallala in Donley County. The capital cost for a new well is $1.9 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 well is located near eth reservoir in an area with little competition for groundwater. The strategy should not significantly impact other water resources or management strategies. The strategy may improve the water quality and quantity stored in Greenbelt Reservoir.

Impact on Agriculture and Natural Resources

The recommended strategy is expected to have low impact on the agriculture and other natural resources.

Other Relevant Factors

Greenbelt M&IWA will need to seek a groundwater permit from the Panhandle GCD. If the water is placed in Greenbelt Reservoir, the Authority may need to submit a water rights accounting plan to TCEQ.

Interbasin Transfer

The recommended strategies do not require interbasin transfer permits.

Social and Economic Impacts

No negative social and economic impacts are expected from the implementation of these strategies.

Impacts on Water Rights, Contracts, and Option Agreements

The recommended strategy is not expected to impact existing water rights, contracts, or option agreements. The well will be operated in conjunction with Greenbelt Reservoir in accordance with its existing water rights.

Impact on Navigation

The recommended strategies should have no impact on the navigable waters of the United States.

4.9.6 Mesa Water Inc.

Mesa Water, Inc. currently owns and controls 210,000 acres of water rights in the PWPA. The majority of these water rights are in Roberts County with additional holdings in Ochiltree, Lipscomb, Hemphill, Hutchinson, Carson, Gray, and Wheeler Counties. Mesa's water rights are within the regulation areas of the Panhandle GCD, the North Plains GCD and the Hemphill County UWCD. The Panhandle GCD has issued initial production permits to Mesa for the intended use of "municipal use in Texas". The authorized rate is 1 acre-foot per acre of water right and is subject to District depletion management programs. Similar production limits are currently implemented by the North Plains GCD and Hemphill County UWCD. The term of the Panhandle CGD initial production permits is for five years and Mesa renewed many of their permits in 2005. Mesa has not yet obtained final well permits or export registration from the Panhandle GCD, nor final well, production, or export permits from the North Plains GCD or Hemphill County UWCD. Mesa will obtain these final permits prior to project initiation. Comparing the projected demand on the Ogallala aquifer (Table 3-19) with the available supply (Table 3-2) indicates water is available to support beneficial use from Roberts, Lipscomb, Ochiltree and Hemphill counties.

4.9.7 Palo Duro River Authority (PDRA)

The PDRA owns and operates the Palo Duro Reservoir in Hansford County, a potential future water supply source for cities in the PWPA. The PDRA was authorized to serve Hansford and Moore Counties and the City of Stinnett. The lake was completed in 1991, but the infrastructure to transport and treat the water has not been constructed. As such, the PDRA currently does not provide water to any member city. The PDRA has six member cities that are interested in receiving water from the Palo Duro Reservoir. Five of these cities are projected to have water shortages over the planning period: Cactus, Dumas, Gruver, Spearman and Sunray. The remaining member city, Stinnett, does not currently indicate needing additional supply. However, this city may consider joining the PDRA system at the same time as the other cities to extend the life of their groundwater resources.

To meet the water supply shortages of its member cities, PDRA is planning to complete a proposed transmission system to deliver water from the Palo Duro Reservoir to these cities by 2030. Based on the projected shortages and existing supplies, the amount of water each city is expected to receive from the Palo Duro Reservoir is presented in Table 4-20. Some of this water will be used by the cities for municipal and industrial sales. The PDRA's water rights and the Canadian River Compact allow use of water from the reservoir for manufacturing shortages if the water is supplied through a municipality.

Table 4-20: Distribution of Water from Palo Duro Reservoir

Water User	**Year 2030**	
	Peak (MGD)	**Acre-feet/Year**
Cactus	3.10	1,744
Dumas	2.42	1,356
Gruver	0.48	271
Spearman	0.21	116
Sunray	0.48	271
Unassigned	0.21	116
Total	**6.9**	**3,875**

Peak (MGD) was estimated based on a peaking factor of 2. Pipelines and pump stations were sized for peak flows.

For regional planning purposes, the supply from the reservoir has been allocated to avoid exceeding the firm yield. However, the PDRA intends to operate the reservoir on an overdraft basis, using groundwater to supplement supply during drought conditions. It is assumed that these cities will supplement their use of the Palo Duro Reservoir water with groundwater. This will allow the cities to conserve their groundwater resources when there is sufficient water in the reservoir. It will also allow them to increase the usage of the reservoir because they are not depending on it for water supply in dry years.

Recommended Strategy

- Develop Palo Duro Reservoir transmission system

Strategy Descriptions

The Palo Duro transmission system is a recommended strategy for the Palo Duro River Authority that would move water from Palo Duro Reservoir to the six member cities. Cactus, Dumas, and Sunray are identified with a shortage and are interested in keeping this project listed as an alternative strategy for their supply in this plan.

Time Intended to Complete

The Palo Duro Reservoir transmission system is expected to be completed by 2030.

Quantity, Reliability and Cost

The quantity of water should be sufficient. Reliability of the transmission system is high. The total capital cost for the transmission system is $114.7 million. The cost included in Appendix H shows the breakdown of cost for the participating cities.

Environmental Issues

The environmental impacts from the recommended strategy are expected to be low. Once the specific pipeline route is established, a detailed evaluation to determine environmental impacts, if any, will need to be performed.

Impact on Water Resources and Other Management Strategies

The use of this supply might decrease lake levels and impact recreation uses on the lake from time to time. No other impacts are expected from this project.

Impact on Agriculture and Natural Resources
The recommended strategy is expected to have positive impacts on the agriculture as there is less competition for groundwater. Impacts to other natural resources are expected to be minimal.

Other Relevant Factors
There are no other identified relevant factors.

Interbasin Transfer
The recommended strategy does not require an interbasin transfer permit.

Social and Economic Impacts
No negative social and economic impacts are expected from the implementation of this strategy.

Impacts on Water Rights, Contracts, and Option Agreements
The recommended strategy is not expected to impact water rights, contracts, or option agreements.

Impact on Navigation
The recommended strategy should have no impact on the navigable waters of the United States.

4.10 Water Transfers and Water Marketing Companies

Water users who have deficits and are considering alternative strategies for meeting shortages may consider purchasing water from other counties or nearby areas. To facilitate these water transfers, public and/or private water marketing companies may be formed. The PWPG recognizes that as it becomes economically feasible, there will be opportunities for public and/or private water marketing companies to transfer water from counties with developable groundwater supplies to counties currently showing deficits or counties outside of the PWPA. The economic feasibility of these transfers will depend on the distance the water must be transported, the ability of the water user group consuming the water to pay for the transported water, and the estimated project life-span for cost amortization.

The PWPG received preliminary ideas on several water transfer concepts. None of those transfer concepts were included as recommended water management strategies in this plan. However, the PWPG expects to study and evaluate as a potential future water management strategy, the procurement of additional groundwater rights and associated water transfer concept(s) during the next planning cycle. This study could include the procurement of additional groundwater rights in the vicinity of CRMWA's Roberts County well field and transmission line, other areas overlying the Ogallala aquifer, and construction of a second pipeline for the delivery of the additional groundwater to CRMWA's customers. Comparing the projected demand on the Ogallala aquifer (Table 3-19) with the available supply (Table 3-2) indicates water is available to support beneficial use from Roberts, Lipscomb, Ochiltree and Hemphill counties.

Any water management strategy will need to acquire an adequate quantity of groundwater rights while complying with all applicable water conservation district rules and honoring the PWPA planning guidelines.

4.11 Brush Control

In 2000, the Texas State Soil and Water Conservation Board (TSSWCB) sponsored a study of the potential effect of brush control in the Canadian River watershed on surface water availability[1]. The study was conducted on the premise that shifting the vegetation composition from species with high evapotranspiration potential (i.e. trees, brush) to plants with lower evapotranspiration potential (i.e. grass) would increase surface water runoff and average water availability. The analysis focused on brush control options and benefits in the Lake Meredith watershed. According to the study, removal of moderate to heavy concentrations of mesquite and mixed brush would increase water availability by an average of 0.040 acre-foot per treated acre per year. The cost for the additional water was estimated at an average of $111 per acre-foot for the entire watershed, with cost per sub basin ranging from $26 to $91,400 per acre-foot of added water. Brush removal treatment would be necessary approximately every ten years to maintain this level of benefit. The study also found that upland brush control was not economic in areas of less than 19 inches of annual rainfall.

CRMWA initiated a program of providing financial assistance to landowners along the Canadian River and its tributaries downstream from Ute Dam in New Mexico. The program uses the continuous sign-up provisions of the CRP program of the USDA-NRCS with CRMWA paying the local cost shares, resulting in the treatment of 855 acres of salt cedar in 2004 by aerial spraying. Total cost of this work was nearly $162,000, with CRMWA paying 72%, NRCS funding 25% and one landowner paying the remainder. A similar program was initiated along the Texas portion of the Canadian River, based on the USDA-NRCS EQIP program (using $600,000 in federal EQIP funds along with allocated CRMWA funding to pay the local cost share), but early dormancy of the plants prevented any spraying in Texas in 2004. Eleven Texas landowners, comprising a total area of 2,094 acres, signed contracts with USDA-NRCS to treat their land. The program was reinitiated in 2005 and has been on-going since with approximately $3.1 million spent through 2009 to control salt cedar through herbicidal spraying.

In addition to the chemical control of invasive species, CRMWA and Texas AgriLife Research Center at Bushland have been conducting pilot studies on biological control of salt cedar[2]. Three species of beetles have been released in the Lake Meredith watershed since April 2004. The success of these studies has been mixed. Texas AgriLife Research Entomology Program is continuing to adjust its methods to foster colonization of the beetles with the ultimate goal of significant salt cedar deforestation. The researchers are optimistic that the beetles will adapt within the Lake Meredith watershed and that biological control will be an integral component of reducing and controlling the infestation of salt cedar in the basin.

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[1] Texas State Soil and Water Conservation Board, "Canadian River Watershed, Brush Control Planning, Assessment and Feasibility Study," December 2000.
2 AgriLife Research, "Saltcedar Biological Control: Review of 2009 Activities in the Lake Meredith Area and 2010 Plans", 2009.

This is an important component of the recommended water management strategies for water supplies in the PWPA. Based on findings of the Lake Meredith study (Appendix G), the increase in salt cedar in the Lake Meredith watershed appears to be a contributing factor to the decrease in stream flows to Lake Meredith. While there are likely several factors contributing to the hydrologic loss in the Lake Meredith watershed, the control of salt cedar is an action that can be undertaken.

4.12 Summary of Recommended Water Management Strategies

The recommended water management strategies in the PWPA include:

- Conservation,
- Developing new groundwater well fields in the Ogallala and Dockum aquifers,
- Purchasing water from wholesale providers as they develop new strategies, and
- Acquiring additional groundwater rights.

Conservation is an important strategy in the region, as it is the only recommended strategy for the large irrigation deficits projected for the PWPA. There are potential cumulative water savings of up to 29 million acre-feet over the planning period from these strategies for the region. For the counties with shortages, the recommended irrigation conservation water savings total 458,551 acre-feet per year by 2060. If realized, this represents a large percentage of the projected need in the PWPA.

Conservation alone cannot meet the entire irrigation shortage, or the other projected shortages. Continued reliance on groundwater from the Ogallala will be needed. Users will likely continue to acquire additional water rights and develop those rights as needed. Voluntary transfers of water are recommended, and will likely occur through natural economic changes in the region. In addition, opportunities for reuse in the PWPA will continue to be explored to meet manufacturing needs. Lists of the recommended and alternate strategies and the recipients are included in Attachment 4-1, immediately following this chapter. Summaries by municipal water user are included in Attachment 4-2.

4.13 Socioeconomic Impact of Not Meeting Shortages

The TWDB provided technical assistance to regional water planning groups in the development of specific information on the socio-economic impacts of failing to meet projected water needs. The report, which can be found in Appendix I, details what would happen if identified water shortages in the region were to go unmet. The report is based on regionally generated data that have been analyzed through the IMPLAN model. The regional data is coupled with state level multipliers to produce the impacts presented.

The TWDB's analysis calculated the impacts of a severe drought occurring in a single year at each decadal period in the PWPA. It was assumed that all of the projected shortage was attributed to drought. Under these assumptions, the TWDB's findings can be summarized as follows:

- With the projected shortages, the region's projected 2060 population would be reduced by approximately 1 percent.
- Without any additional supplies, the projected water needs would reduce the region's projected 2060 employment by 5,700 jobs.
- Without any additional supplies, the projected water needs would reduce the region's projected annual income and taxes in 2060 by $381 million.

The projected impact on population and jobs over the planning period is shown on Figure 4-1. The impacts to income and local and state taxes are shown on Figure 4-2.

Figure 4-1
Socio-Economic Impacts of Not Meeting Projected Demands

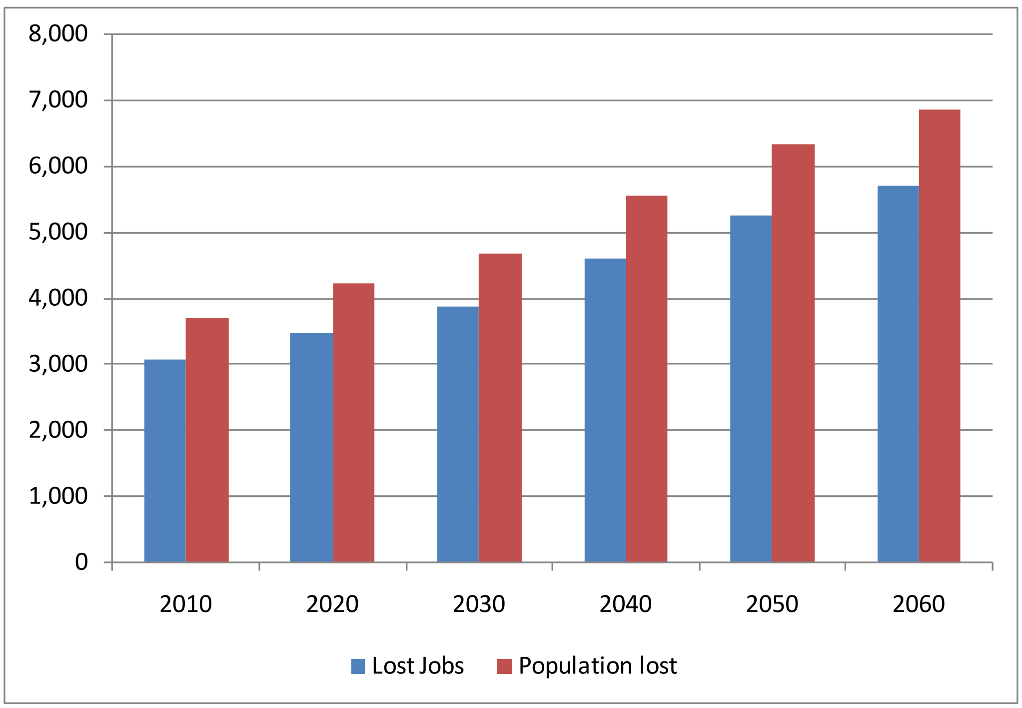
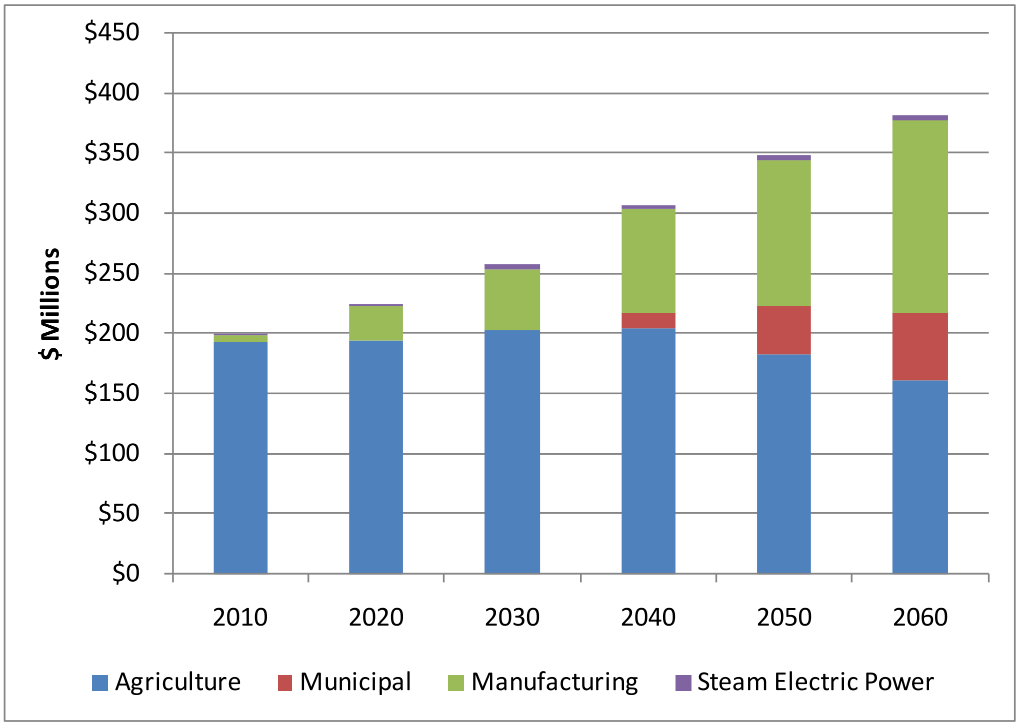


Figure 4-2
Projected Loss of Income and Taxes with Not Meeting Projected Demands



ATTACHMENT 4-1

Potentially Feasible Water Management Strategies

List of Potentially Feasible Strategies

CRMWA ROBERTS COUNTY WELL FIELD
DRILL ADDITIONAL GROUNDWATER WELL
CRMWA ACQUISITION OF WATER RIGHTS
IRRIGATION CONSERVATION
MANUFACTURING CONSERVATION
MUNICIPAL CONSERVATION
PALO DURO RESERVOIR
POTTER COUNTY WELL FIELD
PRECIPITATION ENHANCEMENT
ROBERTS COUNTY WELL FIELD - AMARILLO
VOLUNTARY TRANSFER FROM OTHER USERS

Summary of Recommended Water Management Strategies
Panhandle Water Planning Area

Entity	County Used	Basin Used	Total Capital Cost	1st Decade Unit Cost	2010	2020	2030	2040	2050	2060	2060 Unit Cost
Muncipal Conservation											
AMARILLO	Potter and Randall	Red and Canadian	$0	$490	0	1,375	2,453	2,639	2,841	3,012	$490
BORGER	Hutchinson	Canadian	$0	$490	0	24	71	114	107	102	$490
CACTUS	Moore	Canadian	$0	$490	0	18	31	31	31	31	$490
CANYON	Randall	Red	$0	$490	0	80	176	191	208	227	$490
COUNTY-OTHER	Moore	Canadian	$0	$490	0	29	63	75	83	87	$490
COUNTY-OTHER	Potter	Canadian	$0	$490	0	41	85	103	124	140	$490
COUNTY-OTHER	Potter	Red	$0	$490	0	28	58	71	85	96	$490
COUNTY-OTHER	Randall	Red	$0	$490	0	101	197	231	268	299	$490
DUMAS	Moore	Canadian	$0	$490	0	89	158	166	171	174	$490
GRUVER	Hansford	Canadian	$0	$490	0	10	16	17	17	17	$490
LEFORS	Gray	Red	$0	$490	0	3	4	4	4	4	$490
MEMPHIS	Hall	Red	$0	$490	0	13	22	22	22	22	$490
PAMPA	Gray	Canadian	$0	$490	0	15	65	65	65	65	$490
PANHANDLE	Carson	Red	$0	$490	0	17	29	28	25	23	$490
PERRYTON	Ochiltree	Canadian	$0	$490	0	64	113	118	120	123	$490
SPEARMAN	Hansford	Canadian	$0	$490	0	22	39	41	42	42	$490
SUNRAY	Moore	Canadian	$0	$490	0	18	34	36	38	39	$490
TEXLINE	Dallam	Canadian	$0	$490	0	7	12	12	12	11	$490
WHEELER	Wheeler	Red	$0	$490	0	9	15	15	15	15	$490
TOTAL			***$0***	***$490***	***0***	***1,963***	***3,641***	***3,979***	***4,278***	***4,529***	***$490***
Irrigation Conservation											
IRRIGATION	Armstrong	Red	$0	$24	0	2,170	2,251	2,397	2,478	2,558	$25
IRRIGATION	Carson	Canadian	$0	$23	0	4,096	4,247	4,520	4,672	4,824	$25
IRRIGATION	Carson	Red	$0	$23	0	13,220	13,710	14,592	15,082	15,571	$25
IRRIGATION	Childress	Red	$0	$24	0	1,640	1,704	1,819	1,883	1,946	$26
IRRIGATION	Collingsworth	Red	$0	$25	0	2,879	3,021	3,276	3,418	3,560	$27
IRRIGATION	Dallam	Canadian	$0	$19	0	59,275	108,476	121,561	122,958	122,958	$18
IRRIGATION	Donley	Red	$0	$24	0	2,910	3,031	3,249	3,370	3,490	$26
IRRIGATION	Gray	Canadian	$0	$23	0	1,310	1,359	1,446	1,494	1,542	$25
IRRIGATION	Gray	Red	$0	$23	0	3,969	4,116	4,379	4,525	4,672	$25
IRRIGATION	Hall	Red	$0	$24	0	3,220	3,354	3,595	3,728	3,862	$26
IRRIGATION	Hansford	Canadian	$0	$21	0	24,436	45,264	51,215	51,951	51,951	$21
IRRIGATION	Hartley	Canadian	$0	$19	0	53,755	98,786	110,553	111,772	111,772	$18
IRRIGATION	Hemphill	Canadian	$0	$23	0	187	194	207	213	220	$25
IRRIGATION	Hemphill	Red	$0	$24	0	41	43	46	47	48	$26
IRRIGATION	Hutchinson	Canadian	$0	$20	0	7,514	14,044	15,905	16,128	16,128	$20
IRRIGATION	Lipscomb	Canadian	$0	$23	0	2,279	2,360	2,506	2,587	2,668	$25
IRRIGATION	Moore	Canadian	$0	$20	0	31,602	58,995	66,995	67,846	67,846	$19
IRRIGATION	Ochiltree	Canadian	$0	$23	0	17,257	17,899	19,053	19,694	20,335	$25

Summary of Recommended Water Management Strategies
Panhandle Water Planning Area

Entity	County Used	Basin Used	Total Capital Cost	1st Decade Unit Cost	2010	2020	2030	2040	2050	2060	2060 Unit Cost
IRRIGATION	Oldham	Canadian	$0	$24	0	626	649	692	715	739	$25
IRRIGATION	Oldham	Red	$0	$24	0	188	195	208	215	222	$25
IRRIGATION	Potter	Canadian	$0	$24	0	446	464	496	513	531	$26
IRRIGATION	Potter	Red	$0	$24	0	490	510	545	564	583	$26
IRRIGATION	Randall	Red	$0	$23	0	18,028	18,673	19,835	20,481	21,126	$25
IRRIGATION	Roberts	Canadian	$0	$24	0	2,642	2,758	2,968	3,084	3,200	$26
IRRIGATION	Roberts	Red	$0	$24	0	130	135	146	152	157	$26
IRRIGATION	Sherman	Canadian	$0	$20	0	41,128	77,102	86,803	87,896	87,896	$19
IRRIGATION	Wheeler	Red	$0	$24	0	1,676	1,740	1,854	1,917	1,980	$25
TOTAL			***$0***	***$21***	***0***	***297,114***	***485,080***	***540,861***	***549,383***	***552,385***	***$20***
Irrigation Conservation - Precipitation Enhancement											
IRRIGATION	Armstrong	Red	$0	$6	0	785	785	785	785	785	$6
IRRIGATION	Carson	Canadian	$0	$6	0	1,471	1,471	1,471	1,471	1,471	$6
IRRIGATION	Carson	Red	$0	$6	0	4,750	4,750	4,750	4,750	4,750	$6
IRRIGATION	Donley	Red	$0	$6	0	1,179	1,179	1,179	1,179	1,179	$6
IRRIGATION	Gray	Canadian	$0	$6	0	468	468	468	468	468	$6
IRRIGATION	Gray	Red	$0	$6	0	1,418	1,418	1,418	1,418	1,418	$6
IRRIGATION	Hutchinson	Canadian	$0	$6	0	2,965	2,965	2,965	2,965	2,965	$6
IRRIGATION	Potter	Canadian	$0	$6	0	172	172	172	172	172	$6
IRRIGATION	Potter	Red	$0	$6	0	189	189	189	189	189	$6
IRRIGATION	Roberts	Canadian	$0	$6	0	1,138	1,138	1,138	1,138	1,138	$6
IRRIGATION	Roberts	Red	$0	$6	0	56	56	56	56	56	$6
IRRIGATION	Wheeler	Red	$0	$6	0	615	615	615	615	615	$6
TOTAL			***$0***	***$6***	***0***	***15,206***	***15,206***	***15,206***	***15,206***	***15,206***	***$6***
New Groundwater - Ogallala Aquifer											
PANHANDLE	Carson	Red	$3,309,300	$736	0	0	600	600	600	600	$255
TEXLINE	Dallam	Canadian	$2,304,000	$1,113	0	250	250	250	250	250	$310
LEFORS	Gray	Red	$1,132,500	$1,328	0	0	0	100	100	100	$341
PAMPA	Gray	Canadian	$1,731,100	$519	968	2,581	0	0	0	0	$0
MEMPHIS	Hall	Red	$1,042,100	$1,212	0	100	100	100	100	100	$303
COUNTY-OTHER	Hall	Red	$2,522,400	$1,456	100	100	100	100	100	100	$356
COUNTY-OTHER	Hall	Red	$2,522,400	$1,456	50	50	50	100	100	100	$356
SPEARMAN	Hansford	Canadian	$3,862,000	$594	0	0	900	900	900	900	$220
GRUVER	Hansford	Canadian	$1,968,500	$731	0	350	350	350	350	350	$241
FRITCH	Hutchinson	Canadian	$2,965,900	$1,154	200	400	400	400	400	400	$281
COUNTY-OTHER	Moore	Canadian	$3,114,800	$474	0	0	500	500	1,000	1,000	$338
DUMAS	Moore	Canadian	$7,997,200	$1,201	0	387	1,163	1,672	2,219	2,500	$200
STEAM ELECTRIC POWER	Moore	Canadian	$1,852,600	$1,017	200	200	200	200	200	200	$209
SUNRAY	Moore	Canadian	$3,121,300	$567	0	0	800	800	800	800	$227
PERRYTON	Ochiltree	Canadian	$7,087,000	$1,214	0	0	0	0	600	1200	$759

Summary of Recommended Water Management Strategies
Panhandle Water Planning Area

Entity	County Used	Basin Used	Total Capital Cost	1st Decade Unit Cost	2010	2020	2030	2040	2050	2060	2060 Unit Cost
COUNTY-OTHER	Potter	Canadian	$3,114,800	$474	0	0	0	1,000	1,000	1,000	$202
COUNTY-OTHER	Potter	Red	$5,444,600	$624	0	600	600	600	1,200	1,200	$426
COUNTY-OTHER	Randall	Red	$7,276,100	$624	0	0	600	1,200	2,600	2,600	$307
WHEELER	Wheeler	Red	$2,233,300	$1,311	0	0	0	0	200	200	$1,311
Wholesale Water Providers:											
AMARILLO (Potter Co. Wellfield)	Potter and Randall	Red and Canadian	$128,511,300	$1,518	0	9,467	10,295	11,186	11,148	10,840	$293
AMARILLO (Roberts Co. wellfeild)	Potter and Randall	Red and Canadian	$287,377,200	$1,447	0	0	0	11,210	11,210	22,420	$889
BORGER	Hutchinson	Canadian	$9,379,200	$628	0	0	1,000	1,000	2,000	2,000	$424
CACTUS	Moore	Canadian	$10,893,400	$537	500	1,500	1,500	3,000	3,000	3,000	$220
CRMWA (Roberts Co. wellfeild)	Multiple	Red and Canadian	$21,824,000	$235	0	0	15,000	15,000	15,000	15,000	$112
GREENBELT M&IWA	Multiple	Red	$1,865,900	$288	0	800	800	800	800	800	$84
TOTAL			***$522,587,000***	***$889***	***2,018***	***16,785***	***35,208***	***51,068***	***55,877***	***67,660***	***$458***
New Groundwater - Dockum Aquifer											
CANYON	Randall	Red	$9,528,800	$407	700	1,400	2,100	2,800	2,800	3,800	$188
Voluntary Transfer from Other Users (Sales/Contracts)											
MEMPHIS	Hall	Red	$0	$815	0	0	100	100	100	100	$815
PAMPA	Gray	Canadian	$0	NA					1,000	1,000	NA
MANUFACTURING	Hutchinson	Canadian	$0	$815	0	0	664	664	1,252	1,500	$815
MANUFACTURING	Moore	Canadian	$0	$815	200	800	1,100	1,400	1,800	2,100	$815
MANUFACTURING	Potter	Canadian	$0	$815	0	0	200	328	313	225	$815
MANUFACTURING	Potter	Red	$0	$815	0	0	444	1,087	1,846	2,638	$815
TOTAL			***$0***	***$815***	***200***	***800***	***2,508***	***3,579***	***6,311***	***7,563***	***$707***
Palo Duro Transmission System											
PDRA	Multiple	Canadian	$114,730,000	$3,362	0	0	3,875	3,833	3,792	3,750	$411
Acquisition of Water Rights											
CRMWA			$88,200,000	NA	0	0	0	0	0	0	NA
REGION TOTAL			***$735,045,800***		***2,918***	***333,268***	***547,618***	***621,326***	***637,647***	***654,893***	

Summary of Alternate Water Management Strategies
Panhandle Water Planning Area

Entity	County Used	Basin Used	Total Capital Cost	1st Decade Unit Cost	2010	2020	2030	2040	2050	2060	2060 Unit Cost
Irrigation Conservation - Precipitation Enhancement											
IRRIGATION	Childress	Red	$0	$6	0	620	620	620	620	620	$6
IRRIGATION	Collingsworth	Red	$0	$6	0	1,397	1,397	1,397	1,397	1,397	$6
IRRIGATION	Dallam	Canadian	$0	$6	0	18,625	18,625	18,625	18,625	18,625	$6
IRRIGATION	Hall	Red	$0	$6	0	1,304	1,304	1,304	1,304	1,304	$6
IRRIGATION	Hansford	Canadian	$0	$6	0	9,811	9,811	9,811	9,811	9,811	$6
IRRIGATION	Hartley	Canadian	$0	$6	0	16,255	16,255	16,255	16,255	16,255	$6
IRRIGATION	Hemphill	Red	$0	$6	0	15	15	15	15	15	$6
IRRIGATION	Hemphill	Canadian	$0	$6	0	67	67	67	67	67	$6
IRRIGATION	Lipscomb	Canadian	$0	$6	0	784	784	784	784	784	$6
IRRIGATION	Moore	Canadian	$0	$6	0	11,348	11,348	11,348	11,348	11,348	$6
IRRIGATION	Ochiltree	Canadian	$0	$6	0	6,220	6,220	6,220	6,220	6,220	$6
IRRIGATION	Oldham	Red	$0	$6	0	68	68	68	68	68	$6
IRRIGATION	Oldham	Canadian	$0	$6	0	227	227	227	227	227	$6
IRRIGATION	Randall	Red	$0	$6	0	6,251	6,251	6,251	6,251	6,251	$6
IRRIGATION	Sherman	Canadian	$0	$6	0	14,566	14,566	14,566	14,566	14,566	$6
TOTAL			***$0***	***$6***	***0***	***87,558***	***87,558***	***87,558***	***87,558***	***87,558***	***$6***
Voluntary Transfer from Other Users (Sales/Contracts)											
County-Other	Randall	Red	$3,116,400	$1,142	0	0	300	500	800	1,000	$871
TOTAL			***$3,116,400***	***$1,142***	***0***	***0***	***300***	***500***	***800***	***1,000***	***$871***
Palo Duro Transmission System											
Dumas			$36,695,500	$2,737	0	1,356	1,356	1,356	1,356	1,352	$378
Gruver			$5,127,000	$4,303	0	116	116	116	116	116	$458
Spearman			$3,482,800	$1,366	0	271	271	271	271	271	$246
Sunray			$7,692,100	$2,879	0	271	271	271	271	271	$407
Cactus			$54,842,300	$3,155	0	1,744	1,744	1,744	1,744	1,740	$413
TOTAL			***$114,072,500***	***$2,891***	***0***	***3,758***	***3,758***	***3,758***	***3,758***	***3,750***	***$389***
REGION TOTAL			***$117,188,900***		***0***	***91,316***	***91,616***	***91,816***	***92,116***	***92,308***	

ATTACHMENT 4-2

Municipal Water User Group Summaries

Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
Amarillo	**Projected Population**	188,004	203,497	217,987	234,486	252,493	267,324
	Projected Water Demand	42,329	45,817	49,079	52,794	56,848	60,188
	Available Supplies						
	Ogallala Aquifer	38,147	37,033	35,211	33,634	32,285	31,221
	Meredith Lake/Reservoir	4,206	9,568	9,771	10,118	10,498	10,630
	Total Available Supplies	42,353	46,601	44,982	43,752	42,783	41,851
	Shortage/Surplus	24	784	-4,097	-9,042	-14,065	-18,337
	Recommended Water Management Strategies						
	Municipal Conservation	0	1,375	2,453	2,639	2,841	3,012
	Potter County Well Field - Ogallala Aquifer	0	9,467	9,540	9,545	8,661	7,580
	Roberts County Well Field - Ogallala Aquifer	0	0	0	11,210	11,210	22,420
	Total Recommended Water Management Strategies	**0**	**10,842**	**11,993**	**23,394**	**22,712**	**33,012**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**24**	**11,626**	**7,896**	**14,352**	**8,647**	**14,675**
Booker	**Projected Population**	1,327	1,354	1,314	1,276	1,259	1,198
	Projected Water Demand	356	364	353	343	338	322
	Available Supplies						
	Ogallala Aquifer	358	366	355	345	340	324
	Total Available Supplies	**358**	**366**	**355**	**345**	**340**	**324**
	Shortage/Surplus	2	2	2	2	2	2
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**2**	**2**	**2**	**2**	**2**	**2**
Borger	**Projected Population**	14,580	14,780	14,574	14,096	13,314	12,641
	Projected Water Demand	2,352	2,384	2,351	2,274	2,148	2,039
	Available Supplies						
	Ogallala Aquifer	3,002	3,780	3,073	2,633	2,226	1,843
	Total Available Supplies	3,002	3,780	3,073	2,633	2,226	1,843
	Shortage/Surplus	650	1,396	722	359	78	-196
	Recommended Water Management Strategies						
	Municipal Conservation	0	24	71	114	107	102
	Drill Additional Well - Ogallala Aquifer	0	0	336	336	748	500
	Total Recommended Water Management Strategies	**0**	**24**	**407**	**870**	**855**	**602**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**650**	**1,420**	**1,129**	**1,229**	**933**	**406**
Cactus	**Projected Population**	2,600	3,000	3,000	3,000	3,000	3,000
	Projected Water Demand	533	615	615	615	615	615
	Available Supplies						
	Ogallala Aquifer	533	615	411	353	306	261
	Total Available Supplies	533	615	411	353	306	261
	Shortage/Surplus	0	0	-204	-262	-309	-354
	Recommended Water Management Strategies						
	Municipal Conservation	0	18	31	31	31	31
	Drill Additional Well - Ogallala Aquifer	300	700	350	1,500	1,100	800
	Total Recommended Water Management Strategies	**300**	**718**	**381**	**1,531**	**1,131**	**831**
	Alternative Strategies						
	Palo Duro Reservoir	0	0	1,744	1,744	1,744	1,744
	Total Alternative Strategies	0	0	1,744	1,744	1,744	1,744
	Total Supply Less Projected Demand	**300**	**718**	**177**	**1,269**	**822**	**477**
Canadian	**Projected Population**	2,330	2,340	2,262	2,178	2,120	2,015
	Projected Water Demand	475	477	461	444	432	411
	Available Supplies						
	Ogallala Aquifer	475	477	461	444	432	411
	Total Available Supplies	**475**	**477**	**461**	**444**	**432**	**411**
	Shortage/Surplus	0	0	0	0	0	0
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**0**	**0**	**0**	**0**	**0**

*All Demand and Supply
values are in Acre-Feet

Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
Canyon	**Projected Population**	14,227	15,684	17,047	18,599	20,293	21,695
	Projected Water Demand	2,438	2,688	2,922	3,188	3,478	3,718
	Available Supplies						
	Meredith Lake/Reservoir	1,000	1,000	964	872	790	728
	Ogallala Aquifer	2,110	1,266	760	456	273	164
	Total Available Supplies	**3,110**	**2,266**	**1,724**	**1,328**	**1,063**	**892**
	Shortage/Surplus	672	-422	-1,198	-1,860	-2,415	-2,826
	Recommended Water Management Strategies						
	Municipal Conservation	0	80	176	191	208	227
	New Wells - Dockum Aquifer	700	1,400	2,100	2,800	2,800	3,800
	Total Recommended Water Management Strategies	**700**	**1,480**	**2,276**	**2,991**	**3,008**	**4,027**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**1,372**	**1,058**	**1,078**	**1,131**	**593**	**1,201**
Childress	**Projected Population**	6,918	7,033	7,132	7,167	7,170	6,987
	Projected Water Demand	1,457	1,481	1,502	1,509	1,510	1,471
	Available Supplies						
	Greenbelt Lake/Reservoir	1,457	1,481	1,502	1,509	1,510	1,471
	Ogallala Aquifer						
	Total Available Supplies	**1,457**	**1,481**	**1,502**	**1,509**	**1,510**	**1,471**
	Shortage/Surplus	0	0	0	0	0	0
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**0**	**0**	**0**	**0**	**0**
Clarendon	**Projected Population**	1,974	1,974	1,974	1,974	1,974	1,974
	Projected Water Demand	440	440	440	440	440	440
	Available Supplies						
	Greenbelt Lake/Reservoir	440	440	440	440	440	440
	Total Available Supplies	**440**	**440**	**440**	**440**	**440**	**440**
	Shortage/Surplus	0	0	0	0	0	0
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**0**	**0**	**0**	**0**	**0**
Claude	**Projected Population**	1,327	1,369	1,322	1,268	1,255	1,219
	Projected Water Demand	262	270	261	250	247	240
	Available Supplies						
	Ogallala Aquifer	532	479	431	387	347	310
	Total Available Supplies	**532**	**479**	**431**	**387**	**347**	**310**
	Shortage/Surplus	270	209	170	137	100	70
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**270**	**209**	**170**	**137**	**100**	**70**
County-Other (Armstrong)	**Projected Population**	844	871	841	806	798	775
	Projected Water Demand	109	112	108	104	103	100
	Available Supplies						
	Ogallala Aquifer	400	400	400	400	400	400
	Total Available Supplies	**400**	**400**	**400**	**400**	**400**	**400**
	Shortage/Surplus	291	288	292	296	297	300
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**291**	**288**	**292**	**296**	**297**	**300**

*All Demand and Supply
values are in Acre-Feet

Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
County-Other (Carson)	**Projected Population**	1,182	1,195	1,186	1,147	1,043	947
	Projected Water Demand	256	259	258	249	227	206
	Available Supplies						
	Ogallala Aquifer	464	442	425	419	388	345
	Total Available Supplies	**464**	**442**	**425**	**419**	**388**	**345**
	Shortage/Surplus	208	183	167	170	161	139
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**208**	**183**	**167**	**170**	**161**	**139**
County-Other (Childress)	**Projected Population**	929	944	958	962	963	938
	Projected Water Demand	196	199	202	203	203	198
	Available Supplies						
	Greenbelt Lake/Reservoir	196	199	202	203	203	198
	Seymour Aquifer	20	20	20	20	20	20
	Total Available Supplies	**216**	**219**	**222**	**223**	**223**	**218**
	Shortage/Surplus	20	20	20	20	20	20
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**20**	**20**	**20**	**20**	**20**	**20**
County-Other (Collingsworth)	**Projected Population**	895	898	842	766	709	613
	Projected Water Demand	234	234	220	200	185	160
	Available Supplies						
	Blaine Aquifer	83	83	83	83	83	83
	Other Aquifer	6	6	6	6	6	6
	Seymour Aquifer	158	158	158	158	158	158
	Total Available Supplies	**247**	**247**	**247**	**247**	**247**	**247**
	Shortage/Surplus	13	13	27	47	62	87
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**13**	**13**	**27**	**47**	**62**	**87**
County-Other (Dallam)	**Projected Population**	1,170	1,262	1,320	1,334	1,306	1,245
	Projected Water Demand	181	195	204	206	202	192
	Available Supplies						
	Ogallala Aquifer	181	195	204	206	202	192
	Total Available Supplies	**181**	**195**	**204**	**206**	**202**	**192**
	Shortage/Surplus	0	0	0	0	0	0
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**0**	**0**	**0**	**0**	**0**
County-Other (Donley)	**Projected Population**	1,790	1,720	1,562	1,401	1,264	1,052
	Projected Water Demand	219	210	191	171	154	128
	Available Supplies						
	Greenbelt Lake/Reservoir	219	210	191	171	154	128
	Ogallala Aquifer	180	180	180	180	180	180
	Total Available Supplies	**399**	**390**	**371**	**351**	**334**	**308**
	Shortage/Surplus	180	180	180	180	180	180
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**180**	**180**	**180**	**180**	**180**	**180**

*All Demand and Supply
values are in Acre-Feet

Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
County-Other (Gray)	**Projected Population**	3,379	3,354	3,259	3,132	2,941	2,755
	Projected Water Demand	511	507	493	473	444	417
	Available Supplies						
	Ogallala Aquifer	629	629	629	629	629	629
	Total Available Supplies	**629**	**629**	**629**	**629**	**629**	**629**
	Shortage/Surplus	118	122	136	156	185	212
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**118**	**122**	**136**	**156**	**185**	**212**
County-Other (Hall)	**Projected Population**	1,267	1,358	1,416	1,368	1,388	1,303
	Projected Water Demand	353	379	395	382	387	363
	Available Supplies						
	Greenbelt Lake/Reservoir	152	152	152	152	152	152
	Ogallala Aquifer	85	85	85	85	85	85
	Seymour Aquifer	192	192	192	192	192	192
	Total Available Supplies	**429**	**429**	**429**	**429**	**429**	**429**
	Shortage/Surplus	76	50	34	47	42	66
	Recommended Water Management Strategies						
	New Ogallala wells in Briscoe County	100	100	100	100	100	100
	New Ogallala wells in Donley County	50	50	50	100	100	100
	Total Recommended Water Management Strategies	**150**	**150**	**150**	**200**	**200**	**200**
	Total Supply Less Projected Demand	**226**	**200**	**184**	**247**	**242**	**266**
County-Other (Hansford)	**Projected Population**	1,388	1,663	1,898	2,152	2,301	2,433
	Projected Water Demand	266	319	364	412	441	466
	Available Supplies						
	Ogallala Aquifer	413	424	440	487	535	554
	Total Available Supplies	**413**	**424**	**440**	**487**	**535**	**554**
	Shortage/Surplus	147	105	76	75	94	88
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**147**	**105**	**76**	**75**	**94**	**88**
County-Other (Hartley)	**Projected Population**	3,033	3,135	3,189	3,208	3,168	3,006
	Projected Water Demand	523	541	550	553	546	519
	Available Supplies						
	Ogallala Aquifer	523	541	550	553	546	519
	Total Available Supplies	**523**	**541**	**550**	**553**	**546**	**519**
	Shortage/Surplus	0	0	0	0	0	0
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**0**	**0**	**0**	**0**	**0**
County-Other (Hemphill)	**Projected Population**	1,166	1,171	1,132	1,091	1,061	1,009
	Projected Water Demand	158	159	153	148	143	137
	Available Supplies						
	Ogallala Aquifer	222	222	222	222	222	222
	Total Available Supplies	**222**	**222**	**222**	**222**	**222**	**222**
	Shortage/Surplus	64	63	69	74	79	85
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**64**	**63**	**69**	**74**	**79**	**85**

*All Demand and Supply
values are in Acre-Feet

WUG	Description	2010	2020	2030	2040	2050	2060
County-Other (Hutchinson)	**Projected Population**	308	314	310	299	283	268
	Projected Water Demand	56	57	57	55	52	49
	Available Supplies						
	Ogallala Aquifer	56	57	57	55	52	49
	Total Available Supplies	**56**	**57**	**57**	**55**	**52**	**49**
	Shortage/Surplus	0	0	0	0	0	0
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**0**	**0**	**0**	**0**	**0**
County-Other (Lipscomb)	**Projected Population**	1,766	1,804	1,749	1,699	1,675	1,595
	Projected Water Demand	394	402	390	379	373	356
	Available Supplies						
	Ogallala Aquifer	473	473	473	473	473	473
	Total Available Supplies	**473**	**473**	**473**	**473**	**473**	**473**
	Shortage/Surplus	79	71	83	94	100	117
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**79**	**71**	**83**	**94**	**100**	**117**
County-Other (Moore)	**Projected Population**	3,307	4,534	5,970	7,110	7,805	8,223
	Projected Water Demand	700	960	1,264	1,505	1,652	1,741
	Available Supplies						
	Ogallala Aquifer	700	960	1,000	1,000	1,000	1,000
	Total Available Supplies	**700**	**960**	**1,000**	**1,000**	**1,000**	**1,000**
	Shortage/Surplus	0	0	-264	-505	-652	-741
	Recommended Water Management Strategies						
	Municipal Conservation	0	29	63	75	83	87
	New Wells - Ogallala Aquifer	0	0	500	500	1,000	1,000
	Total Recommended Water Management Strategies	**0**	**29**	**563**	**575**	**1,083**	**1,087**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**29**	**299**	**70**	**431**	**346**
County-Other (Ochiltree)	**Projected Population**	1,223	1,223	1,223	1,223	1,223	1,223
	Projected Water Demand	181	181	181	181	181	181
	Available Supplies						
	Ogallala Aquifer	386	406	429	474	523	550
	Total Available Supplies	**386**	**406**	**429**	**474**	**523**	**550**
	Shortage/Surplus	205	225	248	293	342	369
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**205**	**225**	**248**	**293**	**342**	**369**
County-Other (Oldham)	**Projected Population**	1,327	1,356	1,260	1,110	965	780
	Projected Water Demand	174	178	165	146	126	102
	Available Supplies						
	Dockum Aquifer	384	384	384	384	384	384
	Ogallala Aquifer	206	206	205	204	204	204
	Total Available Supplies	**590**	**590**	**589**	**588**	**588**	**588**
	Shortage/Surplus	416	412	424	442	462	486
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**416**	**412**	**424**	**442**	**462**	**486**

*All Demand and Supply
values are in Acre-Feet

Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
County-Other (Potter)	**Projected Population**	20,264	27,323	33,924	41,440	49,644	56,369
	Projected Water Demand	1,703	2,295	2,850	3,482	4,171	4,736
	Available Supplies						
	Dockum Aquifer	566	566	566	566	566	566
	Ogallala Aquifer	2,031	2,031	2,031	2,031	2,031	2,031
	Total Available Supplies	**2,597**	**2,597**	**2,597**	**2,597**	**2,597**	**2,597**
	Shortage/Surplus	894	302	-253	-885	-1,574	-2,139
	Recommended Water Management Strategies						
	Municipal Conservation	0	69	143	174	209	236
	New Wells - Ogallala Aquifer	0	600	600	1,600	2,200	2,200
	Total Recommended Water Management Strategies	**0**	**669**	**743**	**1,774**	**2,409**	**2,436**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**894**	**971**	**490**	**889**	**835**	**297**
County-Other (Randall)	**Projected Population**	21,446	26,471	31,169	36,520	42,359	47,194
	Projected Water Demand	2,715	3,351	3,945	4,623	5,361	5,973
	Available Supplies						
	Meredith Lake/Reservoir	25	25	24	22	20	19
	Dockum Aquifer	85	85	85	85	85	85
	Ogallala Aquifer	2,982	3,250	3,250	3,250	3,250	3,250
	Total Available Supplies	**3,092**	**3,360**	**3,359**	**3,357**	**3,355**	**3,354**
	Shortage/Surplus	377	9	-586	-1,266	-2,006	-2,619
	Recommended Water Management Strategies						
	Municipal Conservation	0	101	197	231	268	299
	New Wells - Ogallala Aquifer	0	0	600	1,200	2,600	2,600
	Total Recommended Water Management Strategies	**0**	**101**	**797**	**1,431**	**2,868**	**2,899**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**377**	**110**	**211**	**165**	**862**	**280**
County-Other (Roberts)	**Projected Population**	313	322	289	242	210	189
	Projected Water Demand	44	45	41	34	30	27
	Available Supplies						
	Ogallala Aquifer	65	65	65	65	65	65
	Total Available Supplies	**65**	**65**	**65**	**65**	**65**	**65**
	Shortage/Surplus	21	20	24	31	35	38
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**21**	**20**	**24**	**31**	**35**	**38**
County-Other (Sherman)	**Projected Population**	1,297	1,405	1,447	1,490	1,528	1,547
	Projected Water Demand	218	236	243	250	257	260
	Available Supplies						
	Ogallala Aquifer	218	236	243	250	257	260
	Total Available Supplies	**218**	**236**	**243**	**250**	**257**	**260**
	Shortage/Surplus	0	0	0	0	0	0
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**0**	**0**	**0**	**0**	**0**
County-Other (Wheeler)	**Projected Population**	1,795	1,796	1,785	1,805	1,799	1,766
	Projected Water Demand	277	278	276	279	278	273
	Available Supplies						
	Blaine Aquifer	15	15	15	15	15	15
	Ogallala Aquifer	348	348	348	348	348	348
	Other Aquifer	22	22	22	22	22	22
	Seymour Aquifer	21	21	21	21	21	21
	Total Available Supplies	**406**	**406**	**406**	**406**	**406**	**406**
	Shortage/Surplus	129	128	130	127	128	133
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**129**	**128**	**130**	**127**	**128**	**133**

*All Demand and Supply
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Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
Dalhart	**Projected Population**	7,782	8,272	8,570	8,651	8,493	8,087
	Projected Water Demand	2,005	2,132	2,208	2,229	2,188	2,083
	Available Supplies						
	Ogallala Aquifer	2,005	2,132	2,208	2,229	2,188	2,083
	Total Available Supplies	**2,005**	**2,132**	**2,208**	**2,229**	**2,188**	**2,083**
	Shortage/Surplus	0	0	0	0	0	0
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**0**	**0**	**0**	**0**	**0**
Dumas	**Projected Population**	14,884	16,123	17,216	18,084	18,613	18,931
	Projected Water Demand	2,734	2,962	3,163	3,322	3,419	3,478
	Available Supplies						
	Ogallala Aquifer - Hartley County	1,823	1,975	1,500	1,300	1,000	900
	Ogallala Aquifer - Moore County	911	600	500	350	200	100
	Total Available Supplies	**2,734**	**2,575**	**2,000**	**1,650**	**1,200**	**1,000**
	Shortage/Surplus	0	-387	-1,163	-1,672	-2,219	-2,478
	Recommended Water Management Strategies						
	Municipal Conservation	0	89	158	166	171	174
	New Wells - Ogallala Aquifer	0	387	1,163	1,672	2,219	2,500
	Total Recommended Water Management Strategies	**0**	**476**	**1,321**	**1,838**	**2,390**	**2,674**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**89**	**158**	**166**	**171**	**196**
Fritch	**Projected Population**	2,290	2,334	2,313	2,248	2,131	2,030
	Projected Water Demand	411	418	414	403	382	364
	Available Supplies						
	Ogallala Aquifer	591	551	514	492	469	430
	Total Available Supplies	**591**	**551**	**514**	**492**	**469**	**430**
	Shortage/Surplus	180	133	100	89	87	66
	Recommended Water Management Strategies						
	Drill Additional Well - Ogallala Aquifer	200	400	400	400	400	400
	Total Recommended Water Management Strategies	**200**	**400**	**400**	**400**	**400**	**400**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**380**	**533**	**500**	**489**	**487**	**466**
Groom	**Projected Population**	589	595	591	572	520	472
	Projected Water Demand	142	143	142	138	125	114
	Available Supplies						
	Ogallala Aquifer	166	158	152	150	139	124
	Total Available Supplies	**166**	**158**	**152**	**150**	**139**	**124**
	Shortage/Surplus	24	15	10	12	14	10
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**24**	**15**	**10**	**12**	**14**	**10**
Gruver	**Projected Population**	1,169	1,178	1,186	1,195	1,200	1,204
	Projected Water Demand	325	327	329	332	333	334
	Available Supplies						
	Ogallala Aquifer	400	250	100	50	0	0
	Total Available Supplies	**400**	**250**	**100**	**50**	**0**	**0**
	Shortage/Surplus	75	-77	-229	-282	-333	-334
	Recommended Water Management Strategies						
	Municipal Conservation	0	10	16	17	17	17
	New Wells - Ogallala Aquifer	0	350	350	350	350	350
	Total Recommended Water Management Strategies	**0**	**360**	**366**	**367**	**367**	**367**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**75**	**283**	**137**	**85**	**34**	**33**

*All Demand and Supply
values are in Acre-Feet

Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
Happy	**Projected Population**	66	100	132	168	207	239
	Projected Water Demand	11	17	22	27	33	38
	Available Supplies						
	Dockum Aquifer	50	50	50	50	50	50
	Other Aquifer	40	40	37	35	35	35
	Total Available Supplies	**90**	**90**	**87**	**85**	**85**	**85**
	Shortage/Surplus	79	73	65	58	52	47
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**79**	**73**	**65**	**58**	**52**	**47**
HI Texas Water Company	**Projected Population**	3,573	3,620	3,572	3,455	3,246	3,064
	Projected Water Demand	396	401	396	383	360	340
	Available Supplies						
	Ogallala Aquifer	500	500	500	500	500	500
	Total Available Supplies	**500**	**500**	**500**	**500**	**500**	**500**
	Shortage/Surplus	104	99	104	117	140	160
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**104**	**99**	**104**	**117**	**140**	**160**
Lake Tanglewood	**Projected Population**	993	1,174	1,344	1,537	1,748	1,923
	Projected Water Demand	160	189	217	248	282	310
	Available Supplies						
	Ogallala Aquifer	160	189	217	248	282	310
	Total Available Supplies	**160**	**189**	**217**	**248**	**282**	**310**
	Shortage/Surplus	0	0	0	0	0	0
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**0**	**0**	**0**	**0**	**0**
Lefors	**Projected Population**	545	540	525	505	474	444
	Projected Water Demand	86	85	83	80	75	70
	Available Supplies						
	Ogallala Aquifer	200	137	87	51	40	34
	Total Available Supplies	**150**	**137**	**87**	**51**	**40**	**34**
	Shortage/Surplus	64	52	4	-29	-35	-36
	Recommended Water Management Strategies						
	Municipal Conservation	0	3	4	4	4	4
	New Wells - Ogallala Aquifer	0	0	0	100	100	100
	Total Recommended Water Management Strategies	**0**	**3**	**4**	**104**	**104**	**104**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**64**	**55**	**8**	**75**	**69**	**68**
McLean	**Projected Population**	809	802	780	750	704	659
	Projected Water Demand	185	183	178	171	161	151
	Available Supplies						
	Ogallala Aquifer	462	462	462	447	425	400
	Total Available Supplies	**462**	**462**	**462**	**447**	**425**	**400**
	Shortage/Surplus	277	279	284	276	264	249
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**277**	**279**	**284**	**276**	**264**	**249**

*All Demand and Supply
values are in Acre-Feet

Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
Memphis	**Projected Population**	2,483	2,474	2,468	2,473	2,471	2,480
	Projected Water Demand	442	441	440	440	440	442
	Available Supplies						
	Greenbelt Lake/Reservoir	100	100	100	100	100	100
	Ogallala Aquifer	342	260	200	200	200	200
	Total Available Supplies	**442**	**360**	**300**	**300**	**300**	**300**
	Shortage/Surplus	0	-81	-140	-140	-140	-142
	Recommended Water Management Strategies						
	Municipal Conservation	0	13	22	22	22	22
	New Wells - Ogallala Aquifer	0	100	100	100	100	100
	Purchase Supply from Greenbelt MWA	0	0	100	100	100	100
	Total Recommended Water Management Strategies	**0**	**113**	**222**	**222**	**222**	**222**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**32**	**82**	**82**	**82**	**80**
Miami	**Projected Population**	617	633	568	477	412	372
	Projected Water Demand	145	149	134	112	97	88
	Available Supplies						
	Ogallala Aquifer	541	541	541	541	541	541
	Total Available Supplies	**541**	**541**	**541**	**541**	**541**	**541**
	Shortage/Surplus	396	392	407	429	444	453
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**396**	**392**	**407**	**429**	**444**	**453**
Pampa	**Projected Population**	17,430	17,292	16,807	16,155	15,167	14,206
	Projected Water Demand	3,300	3,273	3,182	3,058	2,871	2,689
	Available Supplies						
	Meredith Lake/Reservoir	944	1,375	1,337	1,285	1,206	1,130
	Ogallala Aquifer - Gray County	1,000	750	563	422	317	238
	Ogallala Aquifer - Roberts County	1,888	1,898	1,845	1,773	1,665	1,559
	Total Available Supplies	**3,832**	**4,023**	**3,745**	**3,480**	**3,188**	**2,927**
	Shortage/Surplus	532	750	563	422	317	238
	Recommended Water Management Strategies						
	Municipal Conservation	0	15	65	65	65	65
	Drill Additional Well - Ogallala Aquifer	968	2,581	**0**	**0**	**0**	**0**
	CRMWA - Ogallalla Aquifer	0	0	0	0	1,000	1,000
	Total Recommended Water Management Strategies	**968**	**2,596**	**65**	**65**	**1,065**	**1,065**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**1,500**	**3,346**	**628**	**487**	**1,382**	**1,303**
Panhandle	**Projected Population**	2,599	2,626	2,605	2,521	2,291	2,081
	Projected Water Demand	574	579	575	556	506	459
	Available Supplies						
	Ogallala Aquifer	672	641	615	608	562	501
	Total Available Supplies	**672**	**641**	**615**	**608**	**562**	**501**
	Shortage/Surplus	98	62	40	52	56	42
	Recommended Water Management Strategies						
	Municipal Conservation	0	17	29	28	25	23
	New Wells - Ogallala Aquifer	0	0	600	600	600	600
	Total Recommended Water Management Strategies	**0**	**17**	**629**	**628**	**625**	**623**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**98**	**79**	**669**	**680**	**681**	**665**
Perryton	**Projected Population**	8,453	9,208	9,769	10,148	10,334	10,571
	Projected Water Demand	1,960	2,135	2,265	2,353	2,396	2,451
	Available Supplies						
	Ogallala Aquifer	3,130	3,130	3,130	3,130	3,130	3,130
	Total Available Supplies	**3,130**	**3,130**	**3,130**	**3,130**	**3,130**	**3,130**
	Shortage/Surplus	1,170	995	865	777	734	679
	Recommended Water Management Strategies						
	Municipal Conservation	0	64	113	118	120	123
	New Wells - Ogallala Aquifer	0	0	0	0	600	1,200
	Total Recommended Water Management Strategies	**0**	**64**	**113**	**118**	**720**	**1,323**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**1,170**	**1,059**	**978**	**895**	**1,454**	**2,002**

*All Demand and Supply
values are in Acre-Feet

Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
Shamrock	**Projected Population**	1,963	1,963	1,954	1,970	1,966	1,941
	Projected Water Demand	312	312	311	313	313	309
	Available Supplies						
	Ogallala Aquifer	1,248	1,248	1,248	1,248	1,248	1,248
	Total Available Supplies	**1,248**	**1,248**	**1,248**	**1,248**	**1,248**	**1,248**
	Shortage/Surplus	936	936	937	935	935	939
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**936**	**936**	**937**	**935**	**935**	**939**
Skellytown	**Projected Population**	612	619	614	594	540	490
	Projected Water Demand	106	107	106	102	93	85
	Available Supplies						
	Ogallala Aquifer	357	341	327	323	299	266
	Total Available Supplies	**357**	**341**	**327**	**323**	**299**	**266**
	Shortage/Surplus	251	234	221	221	206	181
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**251**	**234**	**221**	**221**	**206**	**181**
Spearman	**Projected Population**	3,142	3,307	3,448	3,601	3,690	3,769
	Projected Water Demand	707	745	776	811	831	849
	Available Supplies						
	Ogallala Aquifer	1,250	800	500	200	0	0
	Total Available Supplies	**1,250**	**800**	**500**	**200**	**0**	**0**
	Shortage/Surplus	543	55	-276	-611	-831	-849
	Recommended Water Management Strategies						
	Municipal Conservation	0	22	39	41	42	42
	New Wells - Ogallala Aquifer	0	0	900	900	900	900
	Total Recommended Water Management Strategies	**0**	**22**	**939**	**941**	**942**	**942**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**543**	**77**	**663**	**330**	**111**	**93**
Stinnett	**Projected Population**	1,974	2,001	1,973	1,908	1,802	1,711
	Projected Water Demand	365	370	365	353	333	316
	Available Supplies						
	Ogallala Aquifer	594	552	512	488	463	425
	Total Available Supplies	**594**	**552**	**512**	**488**	**463**	**425**
	Shortage/Surplus	229	182	147	135	130	109
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**229**	**182**	**147**	**135**	**130**	**109**
Stratford	**Projected Population**	2,172	2,365	2,439	2,515	2,582	2,617
	Projected Water Demand	628	683	705	727	746	756
	Available Supplies						
	Ogallala Aquifer	1,000	1,000	1,000	1,000	1,000	1,000
	Total Available Supplies	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**	**1,000**
	Shortage/Surplus	372	317	295	273	254	244
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**372**	**317**	**295**	**273**	**254**	**244**

*All Demand and Supply
values are in Acre-Feet

Attachment 4-2
Municipal WUG Summaries

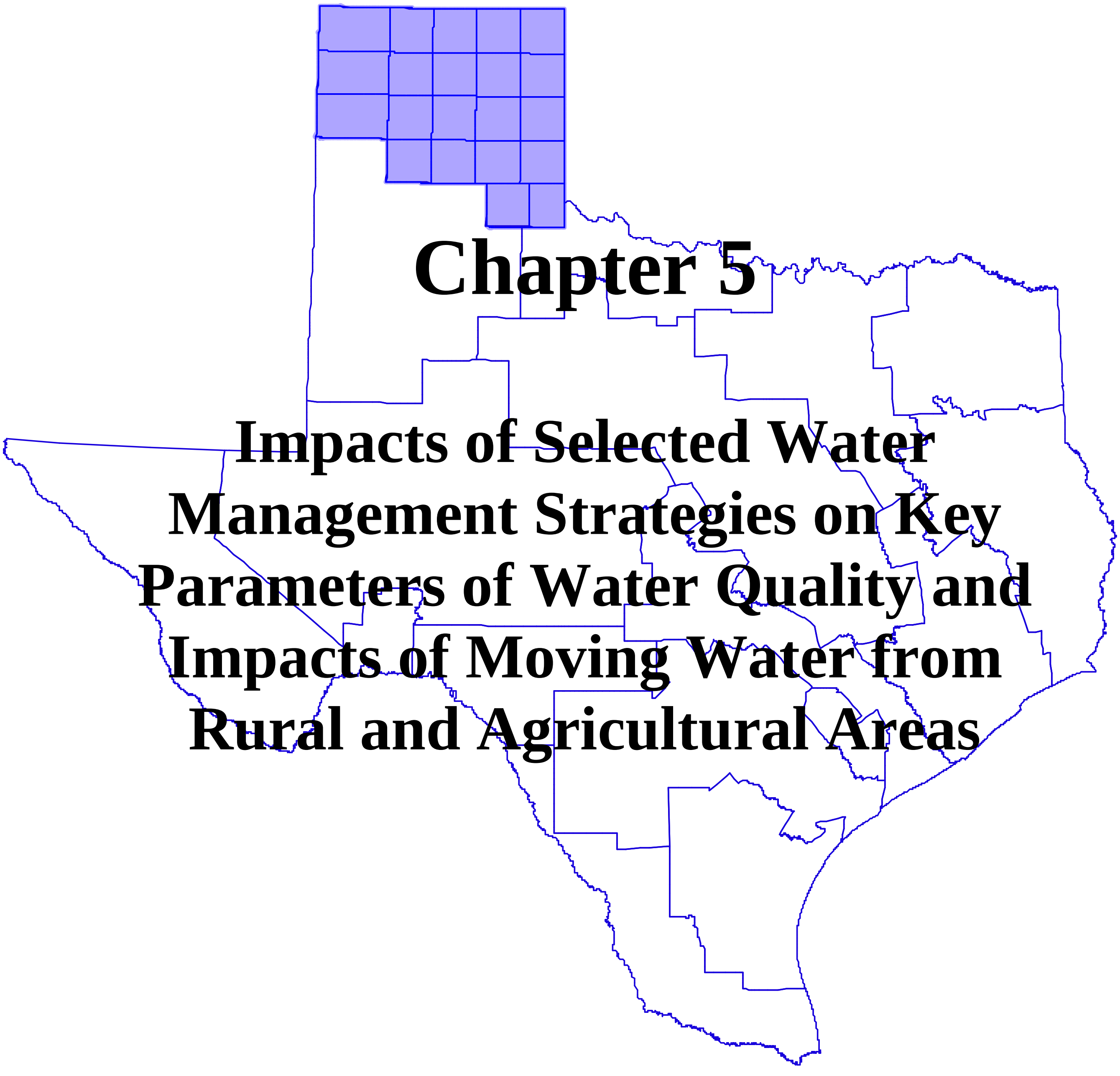
WUG	Description	2010	2020	2030	2040	2050	2060
Sunray	**Projected Population**	2,237	2,550	2,826	3,045	3,178	3,258
	Projected Water Demand	534	608	674	727	758	777
	Available Supplies						
	Ogallala Aquifer	534	608	674	700	650	650
	Total Available Supplies	**534**	**608**	**674**	**700**	**650**	**650**
	Shortage/Surplus	0	0	0	-27	-108	-127
	Recommended Water Management Strategies						
	Municipal Conservation	0	18	34	36	38	39
	New Wells - Ogallala Aquifer	0	0	800	800	800	800
	Total Recommended Water Management Strategies	**0**	**18**	**834**	**836**	**838**	**839**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**0**	**18**	**834**	**809**	**730**	**712**
TCW Supply INC	**Projected Population**	2,110	2,139	2,109	2,040	1,927	1,830
	Projected Water Demand	603	611	602	583	550	523
	Available Supplies						
	Ogallala Aquifer	787	730	678	646	613	562
	Total Available Supplies	**787**	**730**	**678**	**646**	**613**	**562**
	Shortage/Surplus	184	119	76	63	63	39
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**184**	**119**	**76**	**63**	**63**	**39**
Texline	**Projected Population**	563	607	634	641	628	599
	Projected Water Demand	211	227	237	240	235	224
	Available Supplies						
	Rita Blanca Aquifer	250	250	250	250	250	250
	Total Available Supplies	**250**	**250**	**250**	**250**	**250**	**250**
	Shortage/Surplus	39	23	13	10	15	26
	Recommended Water Management Strategies						
	Municipal Conservation	0	7	12	12	12	11
	New Wells - Ogallala Aquifer	0	250	250	250	250	250
	Total Recommended Water Management Strategies	**0**	**257**	**262**	**262**	**262**	**261**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**39**	**280**	**275**	**272**	**277**	**287**
Vega	**Projected Population**	995	1,017	944	832	724	584
	Projected Water Demand	242	247	229	202	176	142
	Available Supplies						
	Ogallala Aquifer	529	529	529	529	529	529
	Total Available Supplies	**529**	**529**	**529**	**529**	**529**	**529**
	Shortage/Surplus	287	282	300	327	353	387
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**287**	**282**	**300**	**327**	**353**	**387**
Wellington	**Projected Population**	2,239	2,241	2,187	2,114	2,058	1,965
	Projected Water Demand	456	457	446	431	420	401
	Available Supplies						
	Seymour Aquifer	500	500	500	500	500	500
	Total Available Supplies	**500**	**500**	**500**	**500**	**500**	**500**
	Shortage/Surplus	44	43	54	69	80	99
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**44**	**43**	**54**	**69**	**80**	**99**

*All Demand and Supply
values are in Acre-Feet

Attachment 4-2
Municipal WUG Summaries

WUG	Description	2010	2020	2030	2040	2050	2060
Wheeler	**Projected Population**	1,374	1,374	1,373	1,374	1,374	1,373
	Projected Water Demand	291	291	291	291	291	291
	Available Supplies						
	Ogallala Aquifer	318	318	318	318	318	318
	Total Available Supplies	**318**	**318**	**318**	**318**	**318**	**318**
	Shortage/Surplus	27	27	27	27	27	27
	Recommended Water Management Strategies						
	Municipal Conservation	0	9	15	15	15	15
	New Wells - Ogallala Aquifer	0	0	0	0	200	200
	Total Recommended Water Management Strategies	**0**	**9**	**15**	**15**	**215**	**215**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**27**	**36**	**42**	**42**	**242**	**242**
White Deer	**Projected Population**	1,065	1,076	1,066	1,032	938	852
	Projected Water Demand	164	165	164	159	144	130
	Available Supplies						
	Ogallala Aquifer	370	370	370	370	370	370
	Total Available Supplies	**370**	**370**	**370**	**370**	**370**	**370**
	Shortage/Surplus	206	205	206	211	226	240
	Recommended Water Management Strategies						
	Total Recommended Water Management Strategies	**0**	**0**	**0**	**0**	**0**	**0**
	Alternative Strategies						
	Total Alternative Strategies						
	Total Supply Less Projected Demand	**206**	**205**	**206**	**211**	**226**	**240**

*All Demand and Supply values are in Acre-Feet



Chapter 5

Impacts of Selected Water Management Strategies on Key Parameters of Water Quality and Impacts of Moving Water from Rural and Agricultural Areas

5.1 Introduction

Water quality plays an important role in determining the availability of water supplies to meet current and future water needs in the region. In addition, SB2 requires that water management strategy evaluations consider the impacts to water quality. This chapter describes the general water quality of the surface water and groundwater sources in the region, discusses specific water quality concerns/issues, and details potential impacts on water quality that water management strategies may have for the region.

5.2 Water Quality Standards

Screening levels for public drinking water supplies were used for comparisons of water quality data for the region. Drinking water standards are based on Maximum Contaminant Levels (MCLs) and secondary constituent levels ("secondary standards") established in the Texas Administrative Code (30 TAC, Chapter 290, Subchapter F). Primary MCLs are legally enforceable standards that apply to public drinking water supplies in order to protect human health from contaminants in drinking water. Secondary standards are non-enforceable guidelines based on aesthetic effects that these constituents may cause (taste, color, odor, etc.). In addition to primary MCLs and secondary standards, two constituents, lead and copper, have action levels specified. These action levels apply to community and non-transient non-community water systems, and to new water systems when notified by the Texas Commission on Environmental Quality (TCEQ). A summary of the public drinking water supply parameters used to evaluate water quality is provided in Table 5-1.

Table 5-1: Selected Public Drinking Water Supply Parameters

Constituent	Screening Level (mg/L unless otherwise noted)	Type of Standard
Nitrate-N	10	MCL
Fluoride	4	MCL
Barium	2	MCL
Alpha	15 pc/L	MCL
Cadmium	0.005	MCL
Chromium	0.1	MCL
Selenium	0.05	MCL
Arsenic	0.01	MCL
Mercury	0.002	MCL
Lead	0.015	Action Level
Copper	1.3	Action Level

Table 5-1 (continued)

Constituent	Screening Level (mg/L unless otherwise noted)	Type of Standard
TDS	1000	SS
Chloride	300	SS
Sulfate	300	SS
pH	6.5 – 8.5	SS
Fluoride	2	SS
Iron	0.3	SS
Manganese	0.05	SS
Copper	1	SS

MCL- Primary drinking water standard (maximum contaminant level) from 30 TAC Chapter 290.104(b) Subchapter F
Action Level- Copper and Lead have action levels as defined by 30 TAC 290.117
SS- Secondary Standard from 30 TAC from 30 TAC 290.105(b)

5.2.1 Surface Water Quality

The state's Clean Water Program administers federal Clean Water Act directives through TCEQ's Water Quality Inventories. TCEQ is the responsible agency for identifying water-quality problems within the Water Quality Inventory. However, the Inventory does not identify sources of water-quality problems, as in most cases, the problems are "non-point source" pollutants. TCEQ, EPA and other agencies have discussed and researched methodologies by which non-point source pollution could be modeled, but thus far modeling efforts have been less than satisfactory. Under the Clean Water Program, water quality is managed statewide through the Texas Clean Rivers Program (TCRP) and locally through TCRP partners such as the Canadian River Municipal Water and Red River Authorities.

The TCRP is a unique water quality monitoring, assessment, and public outreach program that is funded by state fees. The CRP is a collaboration of 15 regional water agencies along with the TCEQ, and is authorized by Senate Bill 818.

The TCRP program within the PWPA includes portions of the Canadian River and Red River Basins. The major reservoirs in the PWPA are Lake Meredith, Greenbelt Lake, and Palo Duro Reservoir. According to the TCEQ's 2008 State of Texas Water Quality Inventory (TCEQ, 2008), the principal water quality problems in the Canadian and Red River Basins are elevated dissolved solids and bacteria. 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 and agricultural runoff.

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 2008 303(d) list. Constituents of concern and 303(d) listing of segments in the PWPA are shown in Table 5-2.

Table 5-2: 2008 303d Listed Segments in the PWPA

		Constituents of Concern						
Water Body	**Segment Number**	**bacteria**	**pH**	**mercury in edible tissue**	**dissolved oxygen**	**total dissolved solids**	**Chloride**	**Sulfate**
Canadian River Basin								
Dixon Creek	0101A	X			X			
Rock Creek	0101B	X						
Lake Meredith	0102			X		X	X	X
Canadian River above Lake Meredith	0103						X	
Rita Blanca Lake	0105		X					
Palo Duro Reservoir	0199A				X			
Red River Basin								
South Groesbeck Creek	0206B	X						
Lower Prairie Dog Town Fork of Red River	0207	X						
Buck Creek	0207A	X						
Upper Prairie Dog Town Fork of Red River	0229		X					
Sweetwater Creek	0299A	X						

Table 5-3: Surface Water Segments in the PWPA and Associated Water Quality Issues

Canadian River Basin				
Water Body	**Segment Number**	**Constituents of Concern**	**Use Concern/Water Quality Concern**	**Potential Contaminant Sources**
Canadian River below Lake Meredith	0101	Ammonia	Nutrient Enrichment Concern	Agriculture, Grazing-related sources
Dixon Creek	0101A	Bacteria, Depressed Dissolved Oxygen, Chlorophyll-a, Nitrate, Orthophosphorus	Contact Recreation Use Concern, Nutrient Enrichment Concern	Grazing-related sources
Rock Creek	0101B	Bacteria, Nitrate	Contact Recreation Use Concern	Grazing-related sources, Underground injection control wells, Petroleum/natural gas activities
Lake Meredith	0102	Chloride, Sulfate Total Dissolved Solids, Mercury	Public Water Supply Concern, Fish Consumption Concern	Natural/Upstream sources Possible atmospheric deposition (mercury)
Canadian River above Lake Meredith	0103	Chloride		Natural/Upstream sources
East Amarillo Creek	0103A	Chlorophyll-a, Nitrate	Nutrient Enrichment Concern	Municipal runoff/discharges, urban runoff/storm sewers
Wolf Creek	0104	Chlorophyll-a		Unknown
Rita Blanca Lake	0105	Ammonia, pH, Chlorophyll-a, Orthophosphorus, Total Phosphorus	Nutrient Enrichment Concern	Natural sources, Waterfoul
Palo Duro Reservoir	0199A	Ammonia, Depressed Dissolved Oxygen	Nutrient Enrichment Concern	Grazing-related sources, Animal feeding operations, Impacts from hydrostructure flow regulation/modifications
South Groesbeck Creek	0206B	Bacteria, Nitrate	Contact Recreation Use Concern	Grazing-related sources

Table 5-3 (continued)

Red River Basin				
Water Body	**Segment Number**	**Constituents of Concern**	**Use Concern/Water Quality Concern**	**Potential Contaminant Sources**
Lower Prairie Dog Town Fork of Red River	0207	Bacteria, Chlorophyll-a, Orthophosphorus	Contact Recreation Use Concern, Nutrient Enrichment Concern	Grazing-related sources
Buck Creek	0207A	Bacteria, Nitrate	Contact Recreation Use Concern	Grazing-related sources, Wildlife other than waterfoul
Upper Prairie Dog Town Fork of Red River	0229	pH, Chlorophyll-a, Nitrate, Orthophosphorus, Total Phosphorus	Nutrient Enrichment Concern	On-site treatment systems, Impacts from hydrostructure flow regulation/modifications, Municipal Discharges/Runoff
Lake Tanglewood	0229A	Nitrate, Chlorophyll-a Orthophosphorus Total phosphorus	Nutrient Enrichment Concern	Golf Courses, On-site treatment systems, Impacts from hydrostructure flow regulation/modifications, Municipal Discharges/Runoff
Sweetwater Creek	0229A	Bacteria	Contact Recreation Use Concern	Grazing-related sources

Source: http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/08twqi/08_list.html

Table 5-3 shows stream segments within the PWPA that did not meet standards laid out in the 2008 Water Quality Inventory and identifies concerns and potential sources of contamination. The Total Maximum Daily Load (TMDL) Program works to improve water quality in impaired or threatened water bodies in Texas. The program is authorized by and created to fulfill the requirements of Section 303(d) of the federal Clean Water Act.

The goal of a TMDL is to determine the amount (or load) of a pollutant that a body of water can receive and still support its beneficial uses. The load is then allocated among all the potential sources of pollution within the watershed, and measures to reduce pollutant loads are developed as necessary. The 2008 Index of Water Quality Impairments show no TMDL assessments scheduled or currently underway in the PWPA

The 2008 303(d) list was created by the TCEQ on March 19, 2008. This list, with the addition of Corpus Christi Bay, was approved by the EPA on July 9, 2008.

5.2.2 Groundwater Quality

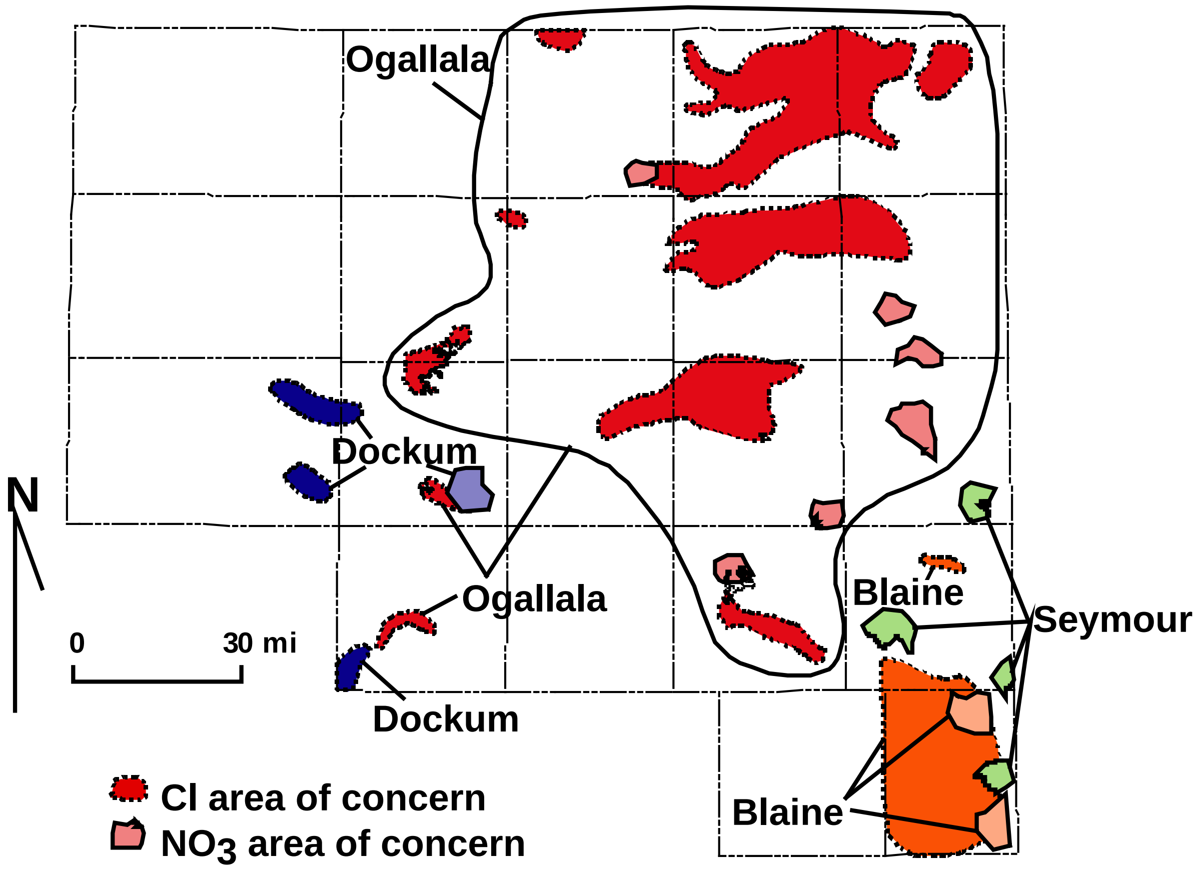
All groundwater contains minerals carried in solution and their concentration is rarely uniform throughout the extent of an aquifer. The degree and type of mineralization of groundwater determines its suitability for municipal, industrial, irrigation and other uses. Groundwater resources in the Panhandle 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 (NO_3), chloride (Cl), and total dissolved solids (TDS). Sources of elevated NO_3 include cultivation of soils, which released soil NO_3, and domestic and animal sources – for example, septic tanks and barnyard wastes (Dutton, 2005). Elevated concentrations of Cl 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.

As of 2008, 113 reported or confirmed cases of groundwater contamination, 2.4 percent of the statewide total, were in the PWPA and were being investigated, monitored, or remediated by governmental agencies. Fuel hydrocarbons (gasoline, diesel, and kerosene) are the most frequently cited constituents in the PWPA. Potter, Hutchinson, and Randall Counties have nearly half of the groundwater contamination cases, which probably reflects the greater population and industrial activity in those counties than in the rest of the PWPA.

Areas of concern for dissolved chloride and nitrate in groundwater in the major and minor aquifers were identified to evaluate whether there are water-quality issues to be addressed along with water-supply issues in the Panhandle Water Planning Area (PWPA). It is generally assumed that water supply shortages are the result of a lack of a quantity of supply; however, impaired water quality can lower the amount of usable supply. The areas of concern were defined on the basis of the following criteria. For Cl: (a) individual reported analyses with Cl>250 mg/L, or (b) clusters or groups where Cl>50 mg/L. For NO_3: (a) individual reported analyses with NO_3 >44 mg/L, or (b) clusters or groups where NO_3 >20 mg/L. The Cl area of concern covers approximately13 percent and the NO_3 area of concern covers approximately2 percent of the aquifer areas of the PWPA. Not all of the area within each area of concern has solute concentrations that exceed maximum contaminant levels. Some wells have concentrations less than MCLs and many even have concentrations less than the cut-off values used to define the clusters.

The identified areas of concern are shown in Figure 5-1 for the five aquifers included in this study of the PWPA. The areas includes apparent clusters of wells with Cl>50 mg/L or with NO_3 >20 mg/L, in addition to wells that exceed the MCL for either Cl or NO_3. Other wells with concentrations less than the MCLs and less than the cut-off values used to define the clusters may lie within the identified areas of concern. The purpose of identifying the areas of concern is to draw attention to these areas and to raise the question of whether there are water-quality issues to be addressed along with water-

Figure 5-1: Areas of Concern within PWPA for Nitrates and Chlorides



supply issues. Pinpointing the hydrogeologic controls, sources, or local causes of contamination may require collection and further analysis of additional water samples and consideration of local hydrogeologic conditions.

5.2.2.1 Ogallala Aquifer

Areas of concern for Cl along the Canadian River and in Carson and Gray counties (Figure 5-1) match those areas marked by Mehta and others (2000) as having Cl greater than 50 mg/L. Another large area extends from southeastern Hansford County to northwestern Lipscomb County. There are other smaller areas in parts of Randall, Potter, Moore, Hansford, and Donley Counties, where elevated Cl might reflect movement of water from the underlying Permian section, as suggested by Mehta and others (2000). Some of these areas are defined by one or just a few samples. Some of the samples may come from wells completed not only in the Ogallala aquifer but also partly in the Permian section. Samples from dual-completion wells could falsely indicate a Cl problem for the Ogallala aquifer.

Areas of concern are smaller for NO_3 than Cl in the Ogallala aquifer. Most of the areas fall near the eastern side of the Panhandle (Figs. 5.1). Some are defined by single samples. Individual samples might reflect local problems with well completion allowing vertical migration of contaminated water, and might not reflect widespread contamination of the aquifer.

The Cl areas of concern in the Ogallala aquifer include public-water-supply well fields (Figure 5-2) operated by:

- City of Perryton in Ochiltree County,
- City of Pampa in Gray County,
- City of Lefors in Gray County, and
- Red River Authority in Donley County.

Elevated Cl concentrations in most of the reported samples are less than the secondary MCL for dissolved chloride.

The NO_3 areas of concern in the Ogallala aquifer include public-water-supply well fields operated by:

- City of McLean in Gray County,
- City of Wheeler in Wheeler County, and
- Red River Authority in Donley County, which well field also lies in the Cl area of concern.

A more recent study examining nitrate levels was discussed in the 2008 State Of Texas Water Quality Inventory Groundwater Assessment. TCEQ entered into a cooperative agreement with the Bureau of Economic Geology, Jackson School of Geosciences, and University of Texas at Austin to characterize nitrate reservoirs beneath natural ecosystems and irrigated and rainfed agricultural ecosystems. Areas of high groundwater nitrate contamination in Seymour, southern High Plains (Ogallala), and southern Gulf Coast aquifers were included in the study. Profiles were drilled beneath natural and irrigated and nonirrigated ecosystems in the aquifers previously listed. Nitrate levels beneath natural rangeland ecosystems tended to be low in the various aquifer regions. Much higher nitrate concentrations were found at depth beneath cultivated areas which reflect precultivation rangeland conditions. These findings suggest that nitrate accumulations under current rangeland conditions may not be typical of those beneath rangeland conditions prior to cultivation. The profiles drilled beneath rainfed agricultural areas showed moderate nitrate concentrations because of generally low to moderate fertilizer application rates combined with frequent precipitation. High nitrate concentrations were found beneath irrigated agriculture. In the southern High Plains (Ogallala) this is likely due to lack of flushing associated with deficit irrigation and may indicate salt buildup in the soil rather than groundwater contamination. Figure 5-3 shows nitrate concentrations in the Ogallala aquifer.

Figure 5-2: Locations of Public Water-Supply Wells located in Areas of Concern

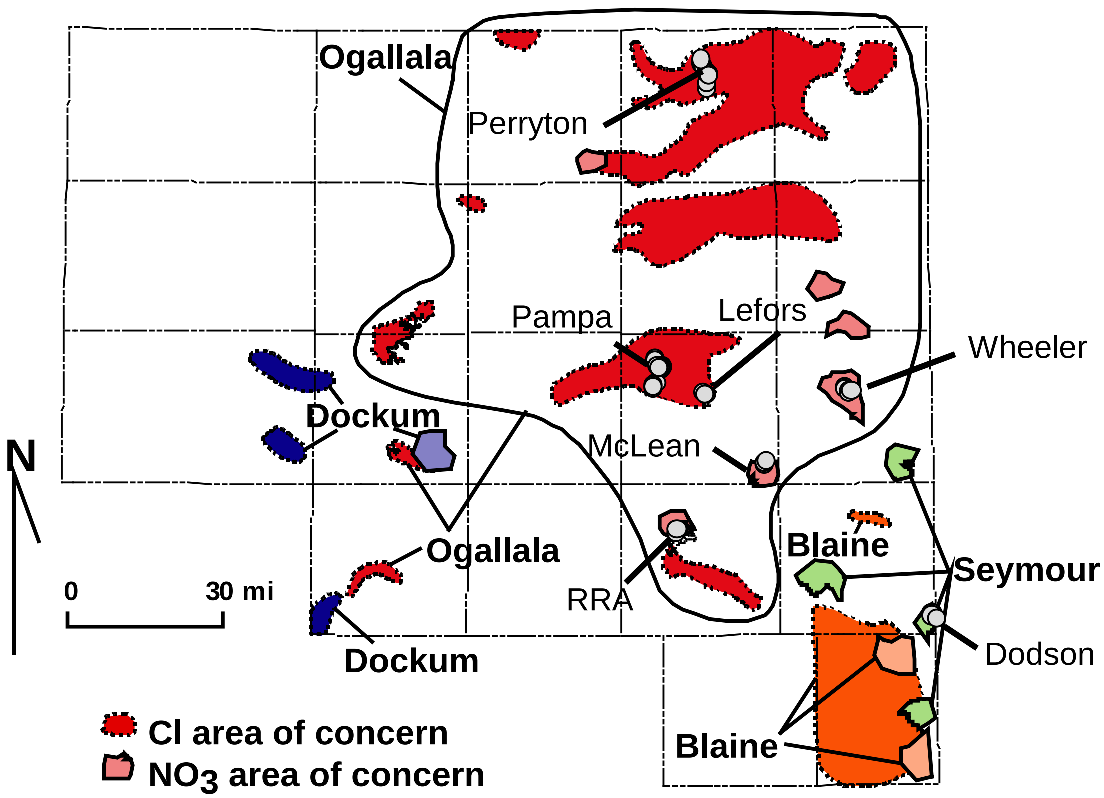
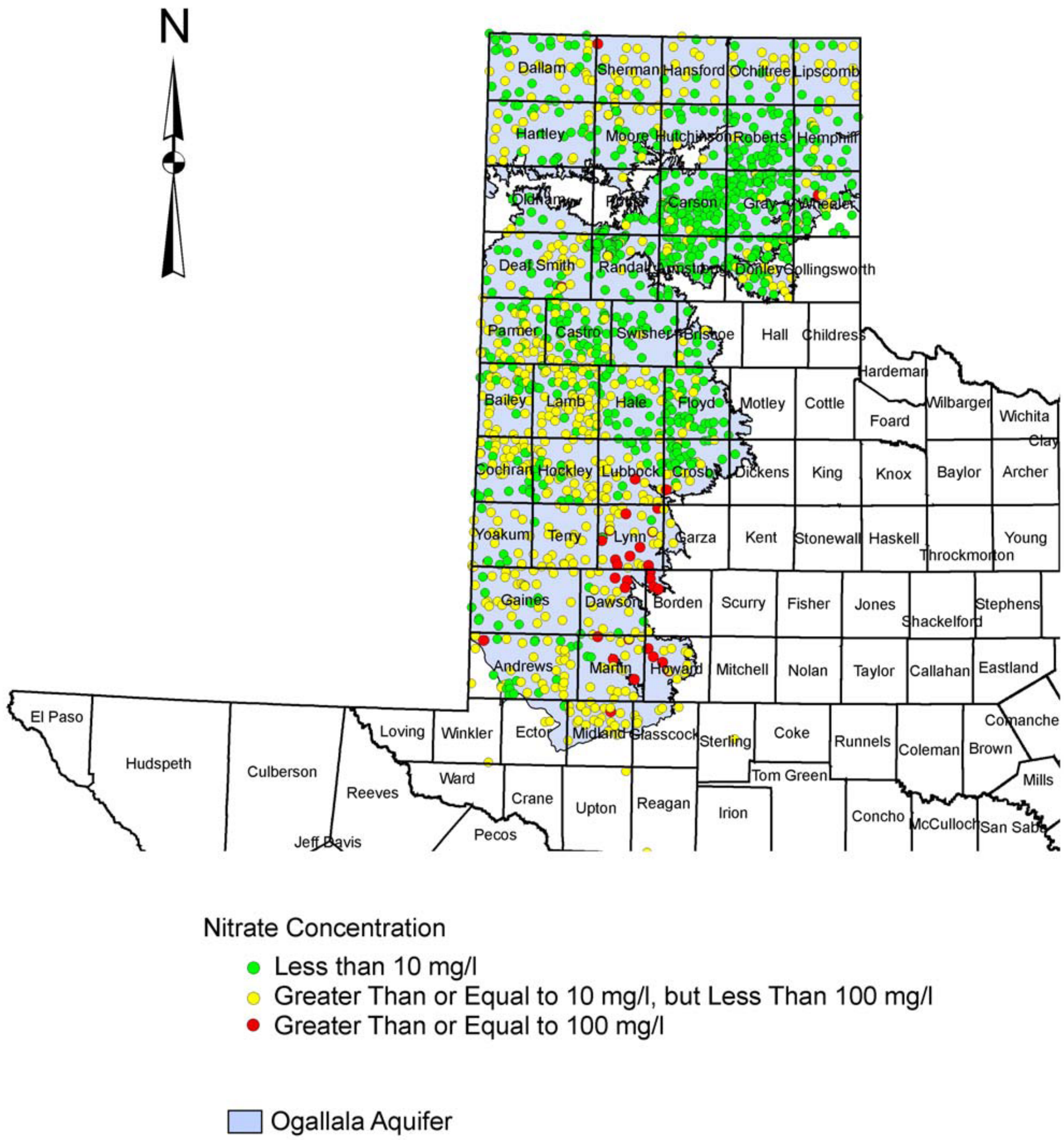


Table 5-4: List of public water supply well fields occurring in areas of concern for dissolved chloride and nitrate in groundwater

Map label	County	Constituent of concern	Public water supply wells	Aquifer
1	Ochiltree	Chloride	City of Perryton	Ogallala
2	Gray	Chloride	City of Pampa	Ogallala
3	Gray	Chloride	City of Lefors	Ogallala
4	Gray	Nitrate	City of McLean	Ogallala
5	Wheeler	Nitrate	City of Wheeler	Ogallala
6	Donley	Chloride and Nitrate	Red River Authority	Ogallala
7	Collingsworth	Nitrate	City of Dodson and Red River Authority - Dodson Water Authority	Seymour and Blaine

Figure 5-3: Distribution of Nitrate in the Ogallala Aquifer



Source: Texas Commission on Environmental Quality: *2008 State of Texas Water Quality Inventory Groundwater Assessment (March 19, 2008)*, [Online], Available URL: http://www.tceq.state.tx.us/assets/public/compliance/monops/water/08twqi/08twqi_groundwater.pdf

A study was conducted by the Bureau of Economic Geology to evaluate how increased pumping of groundwater in the Ogallala aquifer in the Roberts County area might affect future water quality in the aquifer. This was evaluated using a cross-sectional flow model with variable density using the numerical code SUTRA (Voss, 1984). Much of the construction and calibration of the cross-sectional flow model followed the practice of Mehta and others (2001b). Many of the same general findings previously shown by Mehta and others (2001b) were obtained:

- Upward directed TDS gradient,
- Comparable flow velocities in the Ogallala aquifer,
- Range of TDS concentrations in the Ogallala aquifer that reasonably match recorded concentrations,
- Elevated TDS concentrations were simulated for areas observed to have elevated concentrations.

This analysis generally followed the same approach and procedures for construction of the numerical model as did Mehta and others (2000b) and obtained similar results. Model simulations showed that a natural area of elevated TDS would be expected in western Roberts County. The same hydrogeological controls apply to that area as to the one further south (Mehta and others, 2000b):

- Cross-formational flow from underlying units containing evaporate deposits with saline-to-brine water,
- Interaction of cross-formational flow and geometries of formational units partly determines the location of elevated TDS,
- Topographically-driven cross-formational flow locally controls intermediate-scale flow paths that move downward from the Ogallala into underlying units and back into the Ogallala.

Mehta and others (2000b) stated that pumping during a 30-yr period resulted in a small increase in TDS concentration in the Ogallala aquifer. Local concentration increases over a 50-yr period of <500 mg/L in the Ogallala aquifer were simulated in this study. The simulated increase is greater where the drawdown in fluid pressure is greater. A greater increase in TDS was simulated for the Amarillo-Carson County well field than for the CRMWA well field for a 50-yr period. The simulated increase in TDS for the Amarillo-Carson County well field, however, is much greater than the reported increase for that area. The expected change in TDS was small as it takes time to move a mass of water. The distance for moving groundwater vertically from the underlying salt-bearing formations, however, is small.

Additional work should focus on:

(1) Determining the sensitivity of transient TDS change to varying levels of groundwater withdrawal included in the simulation, and
(2) Evaluating which hydrogeologic parameters have the greatest influence on the transient simulation of TDS in the model.

The simulated increase in TDS was greater in this model than reported by Mehta and others. A <500 mg/L local increase in TDS averages to < 10 mg/L increase per year. This rate of change, however, has not been previously recorded for the Amarillo Carson County well field. Therefore, additional work is needed to confirm whether this finding is reasonable, determine how the result depends on the rate of groundwater withdrawal from simulated well fields, and evaluate which hydrogeologic parameters have the greatest influence on the transient simulation of TDS in the model. The entire study report and findings can be found in Appendix X of the PWPA Regional Water Plan (Freese and Nichols, 2006).

5.2.2.2 Dockum Aquifer

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).

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 (Bradley, 1997). 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).

Areas of concern for Cl in the Dockum aquifer may all occur beneath and alongside topographically low-lying areas, where there may be cross-formational flow of water from the Permian section into the Dockum aquifer. Most of the area with poor water quality in the Dockum aquifer lies south of the PWPA (Dutton and Simpkins, 1986).

5.2.2.3 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 (TWDB, 1995).

Chronic water quality problems in the Blaine aquifer, especially elevated concentrations of Cl (Fig. 5.1) and sulfate, are typically related to the aquifer's position down-gradient of the salt-dissolution zone beneath the eastern rim of the High Plains. Cl and TDS are expected to be greater beneath valleys in the confined part of the aquifer than in upland areas in the unconfined part.

5.2.2.4 Rita Blanca Aquifer

No areas of concern were defined for Cl or NO_3 on the basis of criteria defined in this study.

Table 5-5 below lists the areas of groundwater contamination in the PWPA according to TCEQ.

Table 5-5: Areas of Groundwater Contamination in the PWPA

Number	County	Division	File name	Location	Contamination description
1	Carson	RMD/CA	USDOE Pantex Plant	Amarillo 79120	Benzene, TCE, High explosives, Chromium
2	Carson	RMD/CA	USDOE Pantex Plant	Amarillo 79120	Organic solvents, Metals, Explosives
3	Carson	RMD/CA	Pantex Plant (USDOE)	Hwy 60	Trichloroethylene, 1-2 Dichloroethane, Chromium
4	Carson	RMD/PST	Panhandle Butane & Oil Co Inc	Panhandle	Gasoline
5	Carson	Oil & Gas	Walt Poling vs. Unknown (Frank Sheehan)	Fritch	Drip gas or condensate
6	Childress	RMD/CA	TXDOT (Childress Maintenance Facility)	Childress	Chloroform
7	Childress	RMD/PST	TXDOT	Childress	Gasoline
8	Childress	RMD/PST	Jimmy Bridges	Childress	Gasoline, Diesel
9	Childress	RMD/PST	Joe Tarrant Oil Co	Childress	Gasoline, Diesel
10	Childress	RMD/PST	Anadarko Development Co	Childress	Unknown
11	Childress	RMD/PST	Geo Bit Exploration Inc	Childress	Unknown
12	Childress	RMD/PST	RDJ Investments	Childress	Unknown
13	Childress	RMD/PST	Fred Garrison Oil Co.	Childress	Gasoline
14	Childress	RMD/PST	Havins Distributors Inc.	Childress	Gasoline, Diesel
15	Childress	RMD/VC	Burlington Northern Railroad	Childress	Chlorinated solvents
16	Collingsworth	RMD/CA	TXDOT	Wellington	TPH

Table 5-5 (Continued)

Number	County	Division	File name	Location	Contamination description
17	Collingsworth	RMD/PST	Holton Oil Co.	Wellington	Gasoline
18	Collingsworth	RMD/PST	Owens Trust	Wellington	Gasoline
19	Collingsworth	RMD/PST	TXDOT	Wellington	Gasoline, Waste oil
20	Dallam	RMD/PST	Dalhart Consumers Fuel Assoc	Dalhart	Unknown
21	Dallam	RMD/PST	Sam & Gerrie Putts Estate	Dalhart	Unknown
22	Dallam	RMD/PST	State LeadPerforming	Dalhart	Unknown
23	Gray	RMD/CA	Celenese Ltd	Pampa	Benzene, Acetone, MTBE
24	Gray	RMD/PST	Brock Crockett	Alanree	Gasoline
25	Gray	RMD/PST	Taylor Petroleum	Lefors	Gasoline
26	Gray	Oil & Gas	Matt Hinton Complaint		BTEX
27	Gray	Oil & Gas	Plains Marketing, LP	Lefors	BTEX
28	Gray	Oil & Gas	Plains Marketing, LP	Bowers	PSH, BTEX, TPH
29	Gray	Oil & Gas	Plains Marketing, LP	Lefors	Crude Oil (PSH)
30	Hall	RMD/PST	OR Saye Enterprises	Memphis	Gasoline
31	Hall	RMD/PST	TXDOT	Memphis	Gasoline
32	Hall	RMD/PST	Bobby Maddox	Memphis	Gasoline
33	Hemphill	RMD/PST	Canadian Fuel Supply Inc	Canadian	Gasoline
34	Hemphill	RMD/PST	Small Business Administration	Canadian	Gasoline
35	Hemphill	RMD/PST	Canadian Fuel Properties LLC	Canadian	Gasoline
36	Hemphill	RMD/VCIO	BNSF Canadian Property	Canadian	VOCS, TPH
37	Hemphill	Oil & Gas	BP American Prod. Forgery 94 #2094 Gas Line		BTEX, TPH
38	Hemphill	Oil & Gas	Enbridge Gathering LP (Texas Gathering)	Hobart Ranch Gas Plant	PTEX
39	Hemphill	Oil & Gas	Oneok Field Services	Lora Booster Station	PTEX
40	Hutchinson	RMD/CA	Agrium US Inc	Borger	Arsenic

Table 5-5 (Continued)

Number	County	Division	File name	Location	Contamination description
41	Hutchinson	RMD/CA	Chevron Phillips Chemical Company LP (Philtex-Ryton Plant)	Borger	Hydrocarbons, Sulfolane, 1,4-Dichlorobenzene
42	Hutchinson	RMD/CA	Phillips 66 Co	Borger	Organics, Inorganics
43	Hutchinson	RMD/CA	Phillips Rubber Chemical Complex	Borger	Organics, Metals
44	Hutchinson	RMD/CA	Dowell Schlumberger Inc	Borger	TPH, VOCs
45	Hutchinson	RMD/PST	Blaine Edwards	Borger	Gasoline
46	Hutchinson	RMD/PST	Claude P Robinson	Borger	Gasoline
47	Hutchinson	RMD/PST	National Park Service	Sanford Marina	Gasoline
48	Hutchinson	RMD/PST	Phillips 66 Co	Borger	Kerosene
49	Hutchinson	Oil & Gas	C & C Oil Producers, Hill Lease		NACL
50	Hutchinson	Oil & Gas	Ranger Gathering Corp (Sanford Yard)	Sanford	Benzene & free phase HC
51	Hutchinson	Oil & Gas	El Paso Corp.	Sanford	Free phase HC & BTEX
52	Hutchinson	Oil & Gas	Phillips Petroleum Co (Patton Creek)	Borger	Hydrocarbons & SW
53	Hutchinson	Oil & Gas	Pioneer Natural Resources USA	Panhandle Field Compressor No. 6	BTEX
54	Lipscomb	Oil & Gas	Northern Natural Gas		BTEX, TPH
55	Moore	RMD/CA	Diamond Shamrock Refining Co (McKee)	Sunray	Benzene, LNAPL
56	Moore	RMD/SSDAT	Cactus Ordnance Works	12 mi N of Dumas	Bis(2-Ethylhexy)Phthlate
57	Moore	RMD/VC	Cactus Plant	Cactus	Nitrates, Metals
58	Moore	Oil & Gas	Colorado Interstate Gas (Bivins Sta)	Masterson	VOCs
59	Moore	Oil & Gas	Pioneer Natural Resources USA	Panhandle Field Compressor No. 2	BTEX

Table 5-5 (Continued)

Number	County	Division	File name	Location	Contamination description
60	Moore	Oil & Gas	Pioneer Natural Resources USA	Panhandle Field Compressor No.10	BTEX
61	Moore	Oil & Gas	Pioneer Natural Resources USA	Panhandle Field Compressor No. 11	BTEX
62	Moore	Oil & Gas	Pioneer Natural Resources USA	Panhandle Field Compressor No. 15	BTEX
63	Moore	WPD/HW	Diamond Shamrock Refining Co. LLC	Sunray	BTEX, Barium, Chromium, lead, zinc
64	Moore	RMD/VC	Exell Helium Plant	Masterson	VOCs, SVOCs, metals, chlorinated solvents, TP
65	Ochiltree	RMD/SC	City of Perryton Well 2	Perryton	Carbon tetrachloride, Nitrates
66	Ochiltree	Oil & Gas	DCP Midstream	Perryton-Barlow	BTEX, TPH
67	Potter	RMD/CA	Elementis LTP Inc	Amarillo	Chromium
68	Potter	RMD/CA	Texaco Refining & Marketing Inc	Amarillo	Hydrocarbons
69	Potter	RMD/CA	Diamond Shamrock Refining & Marketing Co	Amarillo	TPH, Benzene
70	Potter	RMD/CA	Amarillo Copper Refinery	Amarillo	Selenium
71	Potter	RMD/PST	Petro Shopping Centers	Amarillo	Diesel
72	Potter	RMD/PST	Buffalo Energy	Amarillo	Gasoline
73	Potter	RMD/PST	Burlington Northern Railroad	Amarillo	Gasoline
74	Potter	RMD/PST	Chevron Products Co.	Amarillo	Gasoline
75	Potter	RMD/PST	Macks Super Market	Amarillo	Gasoline
76	Potter	RMD/PST	James Smithson Estate	Amarillo	Gasoline
77	Potter	RMD/PST	Triple S Refining Corporation	Amarillo	Gasoline
78	Potter	RMD/PST	Toot N Totum Food Stores	Amarillo	Gasoline

Table 5-5 (Continued)

Number	County	Division	File name	Location	Contamination description
79	Potter	RMD/PST	Toot N Totum Food Stores	Amarillo	Gasoline
80	Potter	RMD/PST	Toot N Totum Food Stores	Amarillo	Gasoline
81	Potter	RMD/PST	Toot N Totum Food Stores	Amarillo	Gasoline
82	Potter	RMD/PST	Toot N Totum Food Stores	Amarillo	Gasoline
83	Potter	RMD/PST	Toot N Totum Food Stores	Amarillo	Gasoline
84	Potter	RMD/PST	W A Innes	Amarillo	Gasoline
85	Potter	RMD/PST	Katharine O'Brien	Amarillo	Gasoline, Diesel
86	Potter	RMD/PST	Pro Am III Truck Stop	Amarillo	Gasoline, Diesel
87	Potter	WQD/WQAS	Southwestern Public Service Co	NE of Amarillo	Nitrate, Chloride, Sulfate
88	Potter	Oil & Gas	Williams Energy Service, Inc.	Pioneer Tank Battery #2	BTEX, Condensate
89	Potter	Oil & Gas	Pioneer Natural Resources USA	Panhandle Field Compressor No. 20	BTEX
90	Potter	Oil & Gas	Pioneer Natural Resources USA	Fain Gas Plant	BTEX, TPH
91	Potter	Oil & Gas	Turkey Creek Ranch	Fritch	BTEX
92	Potter	WPD/MSW	City of Amarillo Landfill	Amarillo	MW: Nickel, MW: VOCs
93	Randall	RMD/CA	Valero Logistics	Palo Duro	Gasoline
94	Randall	RMD/PST	Jo Ray Energy Co.	Amarillo	Gasoline, Diesel
95	Randall	RMD/PST	Glenna Scott	Amarillo	Gasoline, Waste oil
96	Randall	RMD/PST	City of Canyon	Canyon	Gasoline
97	Randall	RMD/PST	Consumers Fuel Association	Canyon	Gasoline
98	Randall	RMD/PST	Estate of Annie Weaver	Canyon	Gasoline
99	Randall	RMD/PST	Exxon Mobile	Canyon	Gasoline
100	Randall	RMD/PST	Lagrone H. Odell	Canyon	Gasoline
101	Randall	RMD/PST	Weingarten Realty	Amarillo	Gasoline
102	Randall	RMD/PST	BFI / Southwest Landfill	N of Canyon	MW-12: VOCs (Methlyene chloride)
103	Randall	RMD/PST	SJKR, Inc.	Canyon	Unknown
104	Randall	RMD/PST	Sun Country, Inc.	Canyon	Unknown
105	Roberts	RMD/PST	Bailey Oil Products, Co.	Miami	Gasoline

Table 5-5 (Continued)

Number	County	Division	File name	Location	Contamination description
106	Roberts	RMD/PST	Environmental Impact	Miami	Gasoline
107	Roberts	RMD/PST	FFP Operating Partners	Miami	Gasoline
108	Roberts	Oil & Gas	Duke Energy	Parsell Booster Station	BTEX
109	Wheeler	RMD/PST	Anadarko Development Co.	Shamrock	Gasoline
110	Wheeler	RMD/PST	C&H Supply, Inc.	Shamrock	Gasoline
111	Wheeler	RMD/PST	Kelton ISD	Wheeler	Gasoline
112	Wheeler	RMD/PST	Royce Cantrell Corp.	Shamrock	Gasoline
113	Wheeler	RMD/PST	Tindall Wholesale	Shamrock	Gasoline

RMD/CA	TCEQ Remediation Division Corrective Action Section
RMD/PST	TCEQ Remediation Division Petroleum Storage Tank Section
RMD/SC	TCEQ Remediation Division Superfund Cleanup Section
RMD/SSDAT	TCEQ Remediation Division Superfund Site Discovery and Assessment Team
RMD/VC	TCEQ Remediation Division Voluntary Cleanup
WQD/WQAS	Water Quality Division Water Quality Assessment Section

Source: TCEQ (January 2008)

5.3 Water Quality Issues

Water quality issues have the potential to significantly impact and are impacted by water management strategies for the region. Based on the existing water quality of the surface water and groundwater sources, few impacts are expected to occur due to water quality concerns. Of the four primary groundwater sources in the region, most have acceptable water quality, with only a few parameters of potential concern. The areas of concern should be monitored and records of water quality changes should be maintained.

Surface water quality issues within the Panhandle region were discussed in detail in Section 5.2.1. A brief summary is provided below. Similarly, specific groundwater quality issues were discussed in some detail in Section 5.2.2, and have been summarized as follows. Additionally, both groundwater and surface water qualities are impacted by urban runoff, i.e. from non-point sources and from agricultural runoff.

Groundwater concerns include the presence of nitrate in the Ogallala and Dockum aquifers. Serious water quality issues of the past in the Seymour aquifer associated with nitrate concentrations, and chronic water quality problems with the Blaine aquifer, especially elevated chloride and sulfate concentrations, seem to have stabilized but should be a focus for further study and evaluation in the future. There are seven public water supply systems located within areas of concern for dissolved chloride and nitrates. The TCEQ groundwater contamination file contains 113 reported or confirmed contamination cases within the PWPA. Surface water quality concerns include elevated dissolved solids, nutrients, and dissolved metals in the Canadian River Basin and elevated nutrients and dissolved solids in the Red River Basin.

Another potential water quality issue relating to agricultural activity is the use of pesticides, which poses a potential threat to water quality of the groundwater supply. The propensity for pesticides to leach past the root zone depends on which pesticide is chosen and on the soil's leaching potential. Water quality problems sometimes pose potential threats to natural resources and the ecological environments. Watercourses where high levels of nutrients have been identified have the potential to experience algal blooms, which may consume too much of the available dissolved oxygen in the water, leaving less oxygen for fish. High levels of dissolved minerals such as sodium in water used to irrigate crops can harm or kill the crops. The best preventative for agricultural activities is to minimize usage and not over apply many of the common agricultural chemicals.

In 2003, a survey was sent to all municipal water providers in the region and included several questions relating to parameters of concern regarding water quality. The parameters included nitrates, pH, chlorides, pesticides, hydrocarbons, TDS, DO, metals, fertilizers, and other. Of the 34 respondents, seven indicated that nitrates were an issue, three indicated pH, four responded to chlorides, three for pesticides and TDS, and an entry each for write-in concerns for radon, benzene, and hardness. According to the TCEQ's list of public water systems that currently violate any of the chemical maximum contaminant levels, Shamrock Municipal Water System and Wheeler Municipal Water System both had nitrate violations in 2009. No other violations were noted[1].

5.3.1 Urban Runoff

Increasing population impacts water quality in many ways, one of which is the increase in urban runoff that comes with the increase in impervious cover in populated areas. Within the Panhandle region, urban runoff can impact both surface water and groundwater in a variety of ways. First is the increase in runoff. Impervious cover concentrates runoff into storm sewers and drains, which then discharges into streams, increasing the flow, which also increases the erosion power of the water. Groundwater can also be impacted due to this increase in runoff, including a decrease in the infiltration of precipitation into the ground due to impervious cover, impacting recharge to the aquifers.

In addition to the problem with increase in runoff, urbanization also causes increased pollutant loads, including sediment, oil/grease/toxic chemicals from motor vehicles, pesticides/herbicides/fertilizers from gardens and lawns, viruses/bacteria/ nutrients from human and animal wastes including septic systems, heavy metals from a variety of sources, and higher temperatures of the runoff. All of these can have significant adverse impacts on the water quality in both surface waters and groundwater, as all of the contaminants that are increased in surface waters through runoff from impervious cover can be introduced into groundwater via the infiltration of the runoff.

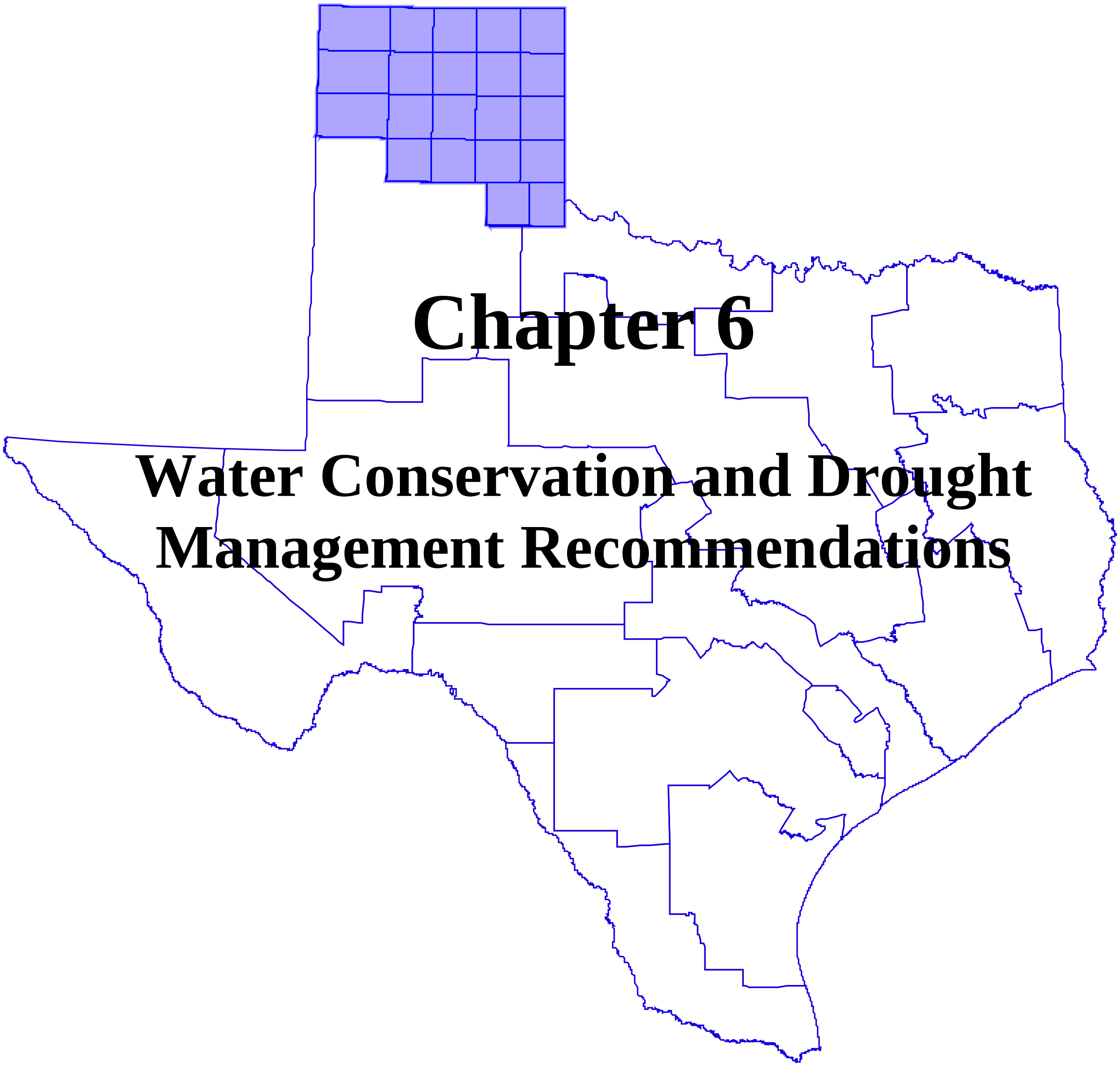
[1] Correspondence with TCEQ, December 2009.

5.4 Water Quality Impacts of Implementing Water Management Strategies

The implementation of water management strategies recommended in Chapter 4 of this regional plan is not expected to have any impact on native water quality. However, local groundwater conditions may limit availability due to water quality considerations. A previous study conducted by the Bureau of Economic Geology concluded that no identifiable relationship can be found at this time relating increased pumping to the deterioration of water quality (Freese and Nichols, Inc., 2006).

5.5 Impacts of Moving Water From Agricultural Areas

The implementation of water management strategies recommended in Chapter 4 of this regional plan is not expected to impact water supplies that are currently in use for agricultural purposes. The voluntary transfer of water from agricultural use to municipal use is 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 of water rights for this regional water plan protects the existing supplies of all current and future users.



Chapter 6

Water Conservation and Drought Management Recommendations

6.1 Introduction

Water conservation is a potentially feasible water savings strategy that can be used to preserve the supplies of all existing water resources and must be considered for all water user groups with needs, or shortages. For municipalities and manufacturers, advanced drought planning and conservation can be used to protect their water supplies and increase reliability during drought conditions. Some of the demand projections developed for regional water planning incorporate an expected level of conservation to be implemented over the planning period. For municipal use, the assumed reductions in per capita water use are the result of the implementation of the State Water-Efficiency Plumbing Act. Additional municipal water savings can be expected from the Federal mandate for energy efficient clothes washing machines, which went into effect in 2007.

The Panhandle Regional Water Planning Group (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. The term "advanced" conservation means conservation techniques that go beyond implementation of the state's plumbing fixture requirements and beyond the adoption and implementation of water conservation education programs. Advanced conservation efforts for municipal users should include a 1 percent annual demand reduction until the region reaches an average of 140 gpcd use. This demand management strategy will achieve this target sometime in the 2040 decade. All retail public water suppliers that are required to prepare and submit water conservation plans should establish targets for water conservation including specific goals for per-capita water user and for water loss programs using appropriate water conservation best-management practices (BMPs) or other water conservation techniques to achieve their targets and goals in an effort to increase efficiency in water use and achieve conservation as defined in Chapter 11 of the Texas Water Code.

Reductions in demands due to conservation were not specifically quantified by the TWDB for manufacturing, mining, irrigation and livestock needs. Conservation savings are incorporated into the implementation of new methods and technologies in livestock operations. For Livestock uses, any future reduction in demands due to the use of such technologies is already reflected in the projected demands as developed by regional agricultural experts and users. Agricultural conservation savings can be achieved through the implementation of demand reduction strategies as outlined in Chapter 4 and summarized in this chapter. Steam electric power generation will achieve future conservation savings through the implementation and construction of more efficient generating facilities. In addition, steam electric power generation will practice conservation by utilizing reuse supplies for future demands. Conservation was considered during the development of power demands.

Regional water guidelines require each region's water plan to address drought management and conservation for each supply source within the region. This includes both groundwater and surface water. The PWPG believes that utilizing advanced water conservation measures (i.e. savings associated with active conservation measures for municipal and industrial uses) will be implemented by local governing entities or water users as conditions arise. The PWPG encourages water conservation as a means of meeting future water demands.

Currently, one of the 56 municipal water users in the Panhandle have per capita water use less than 100 gallons per person per day and 13 entities are less than the Water Conservation Task Force recommended state average of 140 gallons per person per day. As shown in Table 6-1, the Panhandle regional gpcd numbers vary from a high of 334 to a low of 99 gpcd, both for County-Other water users, while the regional median is 191 and an average of 195 gpcd. Based on average gpcd use, a 1 percent annual decrease in municipal consumption would take over 30 years to reach the Conservation Task Force recommended target of 140 gpcd. While municipal use represents approximately 5 percent of the total regional water demands in 2010, the potential savings from advanced municipal conservation compared to agricultural conservation are relatively small. However, conservation savings in the irrigated agriculture sector would provide significant amounts of savings and sustainability for other users as groundwater supplies in the region continue to decline.

Table 6-1 shows the 1980-2002 average, the 2003-2007 average (5 years) and the 1980-2007 average gallons per capita per day (gpcd) for the recognized municipal user groups located in the PWPA. The 2003-2007 averages represent the most recent 5-year increment for which data were available. It also represents the time period following implementation of the State Water-Efficiency Plumbing Act. The statistical evaluation on Table 6-2 includes the uses for County-Other category which attempts to capture water use among communities with less than 500 in population. These demand numbers are compiled by the TWDB through water use surveys conducted annually of all retail and wholesale providers.

Table 6-1: Municipal Water Users Gallons Per Capita Per Day

Municipal Water User	1980-2002 Average GPCD	2003-2007 Average GPCD	27 year Average GPCD
Amarillo	202	223	205
Booker	243	235	242
Borger	144	134	142
Cactus	181	249	194
Canadian	206	202	206
Canyon	162	175	164
Childress	188	201	191
Clarendon	197	144	188
Claude	177	216	184
Dalhart	237	252	239
Dumas	168	224	178
Fritch	163	181	166
Groom	216	212	215
Gruver	247	233	245
High Texas Water Co.	99	99	99
Lake Tanglewood	145	182	156
Lefors	148	182	155
McLean	251	260	253
Memphis	169	193	174
Miami	222	246	226
Pampa	164	152	163
Panhandle	196	157	191
Perryton	208	217	209
Shamrock	143	146	144
Skellytown	95	134	107
Spearman	203	248	211
Stinnett	167	177	169
Stratford	267	221	259
Sunray	212	203	210
TCW Supply Co.	255	255	255
Texline*	334	334	334
Vega	225	252	230
Wellington	182	180	182
Wheeler	190	213	193
White Deer	156	197	161
REGIONAL STATISTICS (including County-Other)			
Average GPCD	193	204	195
Median GPCD	190	203	191
Highest GPCD	334	334	334
Lowest GPCD	95	99	99

* Texline supplies commercial water to a local fertilizer plant that was not historically metered separately.
* Source: TWDB Water Use Survey (http://www.twdb.state.tx.us/wushistorical/)

Table 6-2: County-Other Water Users Gallons per Capita per Day

County	GPCD
Armstrong	115
Carson	194
Childress	188
Collingsworth	233
Dallam	138
Donley	109
Gray	135
Hall	249
Hansford	171
Hartley	154
Hemphill	121
Hutchinson	163
Lipscomb	199
Moore	189
Ochiltree	132
Oldham	117
Potter	75
Randall	113
Roberts	125
Sherman	150
Wheeler	138

* Source: TWDB Water Use Survey (http://www.twdb.state.tx.us/wushistorical/)

6.2 Agricultural Conservation

Agricultural conservation savings can provide for a significant amount of the water demand in the PWPA. According to TWDB and other agricultural conservation experts, the potential benefit of water conservation is most dramatically demonstrated in on-farm irrigation. While on-farm irrigation improvements are still an important component to the overall conservation savings associated with irrigated agriculture, the one strategy that yields the largest water savings in the PWPA is the adoption of drought resistant varieties of corn, cotton and soybeans which are being developed with the aid of biotechnology. This strategy is estimated to have the potential to save 10.6 million acre-feet (cumulative savings), which equates to 14.7 percent of the total irrigation water pumped over the 50-year planning horizon. The next significant water saving strategy includes the application of five major on-farm irrigation water conservation practices. These five practices include: (1) Low Elevation Precision Application (LEPA) sprinklers, (2) surge flow furrow irrigation valves, (3) drip irrigation, (4) soil moisture measurement and irrigation scheduling, and (5) the use of on-farm underground water distribution pipelines. Working in conjunction with the USDA-NRCS, State Soil and Water Conservation Board, local soil and water conservation districts, and local groundwater conservation districts, many local experts assists farmers in maximizing irrigation efficiency. Other strategies considered and recommended include Change in Crop Type, Conversion to Dryland, Change in Crop Variety and Conservation Tillage. Precipitation

Enhancement shows great potential in increased water savings for irrigated agriculture, but it is currently practiced in counties within the Panhandle GCD.

Based on the evaluation of agricultural conservation strategies discussed in Chapter 4, it was concluded that the following conservation strategies can be implemented in the area: (1) Use of North Plains Evapotranspiration Network (NPET), (2) Change in Crop Variety, (3) Irrigation Equipment Efficiency Improvements, (4) Change in Crop Type, (5) Implementation of Conservation Tillage Methods, (6) Precipitation Enhancement, (7) Conversion from Irrigated to Dryland and (8) Biotechnology. Using these strategies and the assumptions discussed in Chapter 4, Table 6.3 shows the maximum potential conservation savings that could be achieved within the PWPA during the planning cycle.

Table 6.3 Potential Agricultural Conservation Savings

Agricultural Conservation Savings (acre-feet/year)						
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Armstrong	0	2,955	3,036	3,182	3,263	3,343
Carson	0	23,537	24,179	25,333	25,975	26,616
Childress	0	2,260	2,324	2,439	2,503	2,566
Collingsworth	0	4,276	4,418	4,673	4,815	4,957
Dallam	0	77,900	127,101	140,186	141,582	141,582
Donley	0	4,089	4,210	4,428	4,549	4,669
Gray	0	7,166	7,361	7,711	7,905	8,100
Hall	0	4,524	4,658	4,899	5,032	5,166
Hansford	0	34,246	55,074	61,026	61,762	61,762
Hartley	0	70,010	115,042	126,809	128,028	128,028
Hemphill	0	310	318	334	342	350
Hutchinson	0	10,478	17,009	18,870	19,092	19,092
Lipscomb	0	3,063	3,144	3,290	3,371	3,452
Moore	0	42,950	70,343	78,343	79,194	79,194
Ochiltree	0	23,477	24,119	25,273	25,914	26,555
Oldham	0	1,110	1,140	1,195	1,225	1,256
Potter	0	1,298	1,335	1,402	1,439	1,476
Randall	0	24,279	24,924	26,086	26,732	27,377
Roberts	0	3,965	4,087	4,307	4,429	4,551
Sherman	0	55,693	91,668	101,369	102,462	102,462
Wheeler	0	2,291	2,355	2,469	2,532	2,595
TOTAL	**0**	**399,879**	**587,845**	**643,622**	**652,146**	**655,152**

Based on the relative potential for water savings and the potential impact on the regional economy, the irrigation conservation strategies are recommended in two different tiers. The first tier represents the strategies that result in the highest level of conservation and have a positive impact to the regional economy. These include biotechnology adoption of drought resistant crops, the use of the NPET to schedule irrigation, irrigation equipment efficiency improvements and implementation of conservation tillage methods. The second tier while recommended is considered less desirable because of their anticipated negative impact on the regional economy. The second tier includes: changes in crop variety, changes in crop type and converting irrigated acreage to dryland farming. Since there are no current sponsors for precipitation enhancement in 14 of the 21 counties in the PWPA, precipitation enhancement is considered an alternative strategy in these 14 counties. This is because it cannot be implemented by an individual producer and little participation has been shown in implementing this strategy by water districts in the region with exception of the Panhandle GCD.

The associated water savings with these strategies are "potential" water savings. In the absence of water use constraints, most if not all the strategies considered will simply increase gross receipts. The improved water use efficiencies generated from some of these strategies may actually increase the depletion rate of the Ogallala aquifer. Also, potential water savings may be overestimated when combinations of strategies are implemented. In some cases, some of the recommended strategies are mutually exclusive on the same irrigated land (for example, irrigation efficiencies and conversion to dryland farming).

6.3 Water Conservation Plans

The TCEQ defines water conservation as "a strategy or combination of strategies for reducing the volume of water withdrawn from a water supply source, for reducing the loss or waste of water, for maintaining or improving the efficiency in the use of water, for increasing the recycling and reuse of water, and for preventing the pollution of water."

The TCEQ 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. Water conservation plans are also required for all water users applying for a State water right, and 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. All updated water conservation plans were to be submitted to the Executive Director of the TCEQ by May 1, 2005. In 2007 legislation was passed that requires all public water suppliers with greater than 3,300 connections to submit a conservation plan to the TWDB by May 1, 2009.

In the PWPA, eight 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. Presently, these water users are not required to develop water conservation plans unless the user is seeking State funding; however, a wholesale water provider may request that its customers prepare a conservation plan to assist in meeting the goals and targets of the wholesale water provider's plan. A list of the users in the PWPG required to submit water conservation plans is shown in Table 6-4.

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 these users. The GCD is required to submit a groundwater management plan to the TWDB for approval.

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 are included in Appendix J. 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.

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, and
- Water rate structures that discourage water waste.

Industrial water users include manufacturing and processing industries as well as smaller local manufacturers. Conservation activities associated with industries are very 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.

Table 6-4: Water Users in the PWPA that are Required to Prepare Water Conservation Plans

Municipal and Industrial Water Users	Irrigation Water Users
City of Amarillo	None in Region A
Canadian River Municipal Water Authority	
Greenbelt Municipal Water Authority	
Palo Duro River Authority	
Borger	
Canyon	
Dumas	
Pampa	

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.

6.4 Groundwater Conservation Districts

The Texas Legislature has established a process for local management of groundwater resources through Groundwater Conservation Districts (GCD). The districts are charged with managing groundwater by providing for the conservation, preservation, protection, recharging and prevention of waste of groundwater within their jurisdictions. An elected board governs these districts and establishes rules, programs and activities specifically designed to address local problems and opportunities. Texas Water Code §36.0015 states, in part, "Groundwater Conservation Districts created as provided by this chapter are the state's preferred method of groundwater management."

All GCDs are required to develop a groundwater management plan and submit it to the TWDB for certification. A newly created district is required to submit its management plan no later than two years after its creation. If a district requires a confirmation election after its creation, a management plan should be submitted no later than two years after the confirmation election (§356.3, Texas Administrative Code, relating to Required Management Plan). 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).

There are currently six GCDs in operation in the PWPA. Their management plan goals and objectives are summarized as follows:

6.4.1 Mesquite Groundwater Conservation District (Mesquite GCD)

The District was created in November 1986 and expanded in October 2007. The district covers the whole of Collingsworth County, Hall County and portions of Childress County. The District is dominated by agricultural production. About 65 percent of the District is rangeland, 30 percent is cropland and the rest is urban, transportation or water areas. According to District records, there are slightly more than 600 active irrigation wells within the District. There are several municipal or public supply wells within the District. The remaining wells are non-permitted water supplies for household and livestock consumption. The District's overall management goal is to have 50 percent of the underground water supplies (saturated thickness) that was available in 2008 still available by 2058. The District's specific goals as outlined in their water management plan are listed below.

- Implement measures to provide for the conservation of the groundwater resources of the District
- Provide for the most efficient use of groundwater
- Implement management strategies that will control and prevent waste and contamination of groundwater

- Implement strategies to address drought conditions
- Implement Strategies to enhance water supplies.

The District has specified the following management objectives in order to meet the goals stated above:

- Monitor static water levels in selected wells
- Conduct water quality analysis of selected wells
- Publicize groundwater conservation issues through local newspapers, group presentations, schools and other media opportunities.
- Monitor selected flowmeters on wells to facilitate water usage efficiency standards
- Publicize the need for efficient use of groundwater through local newspapers, group presentations, schools, and other media opportunities
- Identify and address local irrigation practices which are wasteful of groundwater resources
- Maintain a program to identify, locate and obtain closures of abandoned wells
- Maintain the District drought contingency plan
- Recharge Enhancement
- Rainwater Harvesting

6.4.2 Hemphill County Underground Water Conservation District

The Hemphill County Underground Water Conservation District (Hemphill County UWCD) was created in 1995 and an updated management plan was adopted in July 2007. The purpose of the District is to provide for the conservation, preservation, protection, recharging, and prevention of waste of the groundwater, and of groundwater reservoirs or their subdivisions. This will be achieved through rules, education programs, District-provided services, and through mutual cooperation of local, state, and federal agencies. The District issues water well permits, collects groundwater information, performs water quality analyses, and provides well system tests and other services.

The primary goals of the District are to ensure that its activities are consistent with sound business practices, that the public interest will always be considered in District business, that impropriety shall be avoided to ensure and maintain public confidence in the District, and that the Board shall control and manage the affairs of the District lawfully, fairly, impartially, and in accordance with the stated purposes of the District.

The District has outlined the following management goals.

- Providing the most efficient use of groundwater
- Controlling and preventing waste of groundwater
- Natural resource issues which impact the use and availability of groundwater and which are impacted by the use of groundwater
- Addressing conjunctive surface water management issues

- Addressing drought conditions
- Addressing conservation, recharge enhancement, rainwater harvesting, precipitation enhancement, and brush control.
- Addressing, in a quantitative manner, the desired future conditions of the groundwater resources selected pursuant to the Water Code

The District has outlined the following management objectives in order to meet the above goals.

- All new or permitted wells are to be registered or permitted with the District
- Maintain a system of permitted the use and production of groundwater
- Establish a monitor well network
- Evaluate district rules on an annual basis
- Provide information to the public on reducing wasteful practices
- Reduce the waste of water as far as is reasonably and economically viable. Work with the Texas Railroad Commission (TRC) to monitor for waste of water and develop economical methods to prevent contamination.
- Publish notice for the drilling and operation of salt water disposal wells
- Review potential groundwater contamination from oil and gas activities on an annual basis
- Review potential groundwater contamination from agricultural activated on an annual basis
- Participate in the regional planning process by attend regional planning group meetings
- Monthly review of Palmer drought index
- Quarterly assessment of the status of drought in the District
- Sponsor public education at board meeting
- Submit an article regarding water conservation to local newspaper
- Educate students on the importance of water as a natural resource, water conservation or the prevention of contamination.

6.4.3 North Plains Groundwater Conservation District No. 2

The North Plains Groundwater Conservation District No. 2 (North Plains GCD) was created in 1955. The district encompasses all of Sherman, Hansford, Ochiltree, Lipscomb and parts of Dallam, Hartley, Moore, and Hutchinson counties. The District adopted a water management plan on August 18, 1998 and a revised water management plan dated May 2008. The overall goal of the District is to ensure that its activities are consistent with sound business practices; that the interest of the public shall always be considered in conducting District business; that impropriety or the appearance of impropriety shall be avoided to ensure and maintain public confidence in the District; and that the Board shall control and manage the affairs of the District lawfully, fairly, impartially, and in accordance with the stated purposes of the District. The water management plan lists the following specific goals:

- Providing the most efficient use of groundwater
- Controlling and preventing the waste of groundwater
- Conjunctive surface water management issues
- Natural resource issues that impact the use and availability of groundwater and which are impacted by the use of groundwater
- Addressing drought conditions
- Promote water conservation, recharge enhancement, rainwater harvesting, precipitation enhancement, or brush control
- Determine desired future conditions of the groundwater resources

The District has outlined the following management objectives in order to achieve the above goals:

- Evaluate the requirement that all new wells be properly spaced and comply with well density standards
- Limit groundwater withdrawal amounts based on an allowable production limitation and contiguous water right acres limitation
- Analyze the current and future socio-economic impacts to water rights owners from schedule reduction of the allowable production limit to promote conservation
- Installation of water well flow meters on each non-exempt and non-domestic well
- Calculate total annual groundwater withdrawals by all water rights owners that have wells capable of producing more than 25,000 gallons of water a day
- Track the location of all domestic, livestock and rig supply water wells within the district
- Track the location and dispositions of all non-exempt water wells capable of producing more than 25,000 gallons of groundwater a day
- Conduct groundwater level monitoring
- Provide pump tests and pump plant efficiency tests for water users
- Update, publish and distribute hydrologic maps
- Control and prevent waste of groundwater through education and mitigation
- Promote beneficial use of groundwater through research and education
- Assist well owners with water quality testing
- Protect the quality of the aquifer through Check Valve Program and requirements
- Provide public information regarding Xeriscape and drip irrigation to address drought conditions
- Continue supporting water conservation research addressing drought conditions with Texas Agrilife Research
- Maintain current partnership with Texas Agrilife Research to promote in agricultural water conservation
- Implement the eight water management strategies recommended by the 2007 State Water Plan
- Participate in the Ogallala Aquifer Project as part of the industry review committee for modeling the economic impacts of water conservation policy

- Provide the public information regarding rainwater harvesting
- Provide the public information regarding brush control

6.4.4 The High Plains Underground Water Conservation District No. 1

The High Plains Underground Water Conservation District No. 1 (High Plains UWCD) created its water management plan on August 11, 1998 and amended the plan in January, 2004. This plan will remain in effect, unless a revised is approved. The High Plains UWCD has jurisdiction in the PWPA in Potter and Randall Counties. The District has outlined the following goals under the water management plan:

- Providing the most efficient use of Ground Water
- Controlling and preventing the waste of Ground Water
- Controlling and preventing subsidence
- Addressing conjunctive and surface water management issues.
- Natural resources issues that impact the use and availability of Ground Water
- Addressing drought conditions
- Addressing conservation
- Other management goals

The District states the following objectives as the means to achieve the above goals:

- Continue water level monitoring program
- Continue to update, publish and distribute county hydrologic atlases
- Continue to issue well permits according to District's spacing rules
- Continue to administer the low interest agricultural water conservation equipment loan program
- Continue pre-plant soil moisture monitoring program
- Continue potential evaportranspiration irrigation scheduling program
- Maintain irrigation tailwater abatement program
- Promote efficient Ag irrigation technologies
- Address urban water waste
- Assist residents with water quality testing
- Continue to assure proper closing, destruction, or re-equipping of abandoned or replaces wells under District rules
- Continue to enforce the District's rule on the closing of open or uncovered wells
- Monthly newsletter
- Continue to provide news releases to print and electronic media
- Continue to produce radio and TV public service announcements and distribute them to stations within the district
- Continue to make public presentations
- Continue to maintain public information boards at the District office
- Continue to design public information displays for use at fairs/meetings
- Continue to provide information via internet website

- Continue to sponsor classroom education programs
- Continue to make classroom presentations
- Continue to make audio-visual materials available to teachers

6.4.5 Panhandle Groundwater Conservation District

The Panhandle Groundwater Conservation District (Panhandle GCD) was created by legislature in 1955. It covers Carson, Donley, Gray, Roberts, and Wheeler counties and also parts of Armstrong, Hutchinson, Hemphill, and Potter counties. The Panhandle GCD adopted a water management plan on August 20, 2008. The plan will remain in effect for a period of ten years, unless it is revised before that period. The District's overall management standard is to have 50 percent of current supplies, or saturated thickness, still available 50 years after the first certification of this plan. The Panhandle GCD has listed the following goals within its water management plan:

- Retain 50 percent of current supplies in 50 years (overall goal)
- Implement strategies that will provide the most efficient groundwater use
- Implement strategies that will control and prevent groundwater waste or contamination
- Implement strategies to address drought conditions
- Implement strategies to address conjunctive surface water management strategies
- Implement strategies that address natural resources issues which impact the use and availability of groundwater
- Improve operating efficiency and customer service
- Operate a rainfall enhancement program
- Conservation

In order for the above goals to be achieved, the following objectives need to be fulfilled, per the District's water management plan:

- Develop a system for measurement and evaluation of groundwater supplies
- Develop a groundwater modeling capability
- Encourage efficient groundwater use by implementing various programs
- Take positive and prompt action to identify all reported wasteful practices
- Prevent waste by implementing PGCD rule 15 – "depletion"
- Control and prevent contamination of groundwater
- Continue and possibly expand groundwater conservation programs
- Conduct emergency response/drought contingency planning
- Evaluate the impact of surface water use on groundwater
- Monitor and report on impacts of endangered species on local groundwater resources
- Monitor the possible effects of pumping on White Deer Creek
- Strive to stabilize water measurement and sampling costs per well
- Continue to provide timely response to customer assistance requests
- Operate a rainfall enhancement program and plan future activities

6.4.6 Gateway Groundwater Conservation District (Gateway GCD)

The Gateway Groundwater Conservation District (Gateway GCD) was created in May 2002. It covers a portion of Childress County in the PWPA. The District is currently developing its Groundwater Management Plan. It has been submitted to the TWDB, but it has not been approved to date.

6.5 Water Conservation Management and Drought Contingency Plans

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. TCEQ now also requires all retail public water suppliers serving less than 3,300 connections to prepare and adopt drought contingency plans by no later than May 1, 2009. All drought contingency plans shall be available for inspection upon request.

6.5.1 Drought Contingency Plans

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 shortages 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.

Drought contingency plans 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. As with the water conservation plans, drought contingency plans are to be updated and submitted to the TCEQ by May 1, 2009.

Model drought contingency plans were developed for the PWPG and are included in Appendix J. 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.

6.5.2 Regional Drought Triggers

Thirteen drought contingency plans were submitted to the PWPG. The majority of the submitted plans use trigger conditions based on the demands placed on the water distribution system. Of the plans reviewed one user based trigger actions on well levels, five based actions on storage reservoir levels and seven based actions on demands/consumption. A brief description of each plan is provided below, followed by a summary of the submitted plans in Table 6-5.

6.5.2.1 City of Amarillo

The City of Amarillo updated their Drought Contingency Plan on July 29, 2009. The triggering criteria of this plan are based on prolonged conditions of no rain usually associated with hot summer like conditions, high water demands and the vulnerability of the water sources under drought conditions including unforeseen natural disasters, equipment failure and contamination problems. The trigger criteria are listed below.

- **Mild:** Total consumption has reached 80 percent of production capacity for five consecutive days **and/or** CRMWA has requested initiation of their stage I (mild water shortage) requirement based on projected 3 year future supply at Lake Meredith **and/or** equipment failure causes reduction of capacity by 5 percent for 3 days when total consumption is at 80 percent production capacity.
- **Moderate:** Total consumption has reached 85 percent of production capacity for five consecutive days **and/or** CRMWA has requested initiation of their stage II (moderate water shortage) requirement based on projected 2 year future supply at Lake Meredith **and/or** equipment failure causes reduction of capacity by 10 percent for 3 days when total consumption is at 80 percent production capacity.
- **Severe**: Total consumption has reached 90 percent of production capacity for five consecutive days **and/or** CRMWA has requested initiation of their stage III (mild water shortage) requirement based on projected 1.5 year future supply at Lake Meredith **and/or** equipment failure causes reduction of capacity by 15 percent for 3 days when total consumption is at 80 percent production capacity.
- **Critical:** Total consumption has reached 95 percent of production capacity for five consecutive days **and/or** equipment failure causes reduction of capacity by 25 percent for 3 days when total consumption is at 70 percent production capacity.

6.5.2.2 City of Borger

The City of Borger updated their Drought Contingency Plan by passing Ordinance No. O-07-05 on September 6, 2005, which amended Chapter 51, Texas Water Code. The goal of the plan is to regulate and/or prohibit non-essential water uses during times of water shortage or other water supply conditions. Trigger conditions are based on water use patterns, weather conditions and water production and delivering capabilities and are defined as follows:

- **Mild:** (i) When water supply allocations from CRMWA to the municipal water system are equal to or less than 3,300 acre-feet per year, and the projected use from the municipal water system’s owned water wells exceeds 2,700 acre-feet per year.

(ii) When pursuant to the requirements specified in the municipal water system's wholesale water purchase contract with CRMWA, notification is received from the authority requesting initiation of Stage 1 of the drought contingency plan
(iii) When due to declining water level, mechanical failure, or any other unforeseen event in the municipal water system's owned wells, an amount of water less than or equal to 2,760 acre-feet of water cannot reasonably be expected to be produced, and there are not adequate allocations from CRMWA to bring the total available water to 6,000 acre-feet per calendar year.
(iv) Any mechanical, accidental regulatory or unforeseen event that might negatively affect the daily safe operating capacity of the municipal water system to continually provide a safe and reliable supply of drinking water that meets all state and federal standards. This condition or triggering even must also be expected to persist for several days or weeks.

- **Moderate:**
  (i)When water supply allocations from CRMWA to the municipal water system are equal to or less than 2,825 acre-feet per year, and the projected use from the municipal water system's owned water wells exceeds 2,700 acre-feet per year.
  (ii) When pursuant to the requirements specified in the municipal water system's wholesale water purchase contract with CRMWA, notification is received from the authority requesting initiation of Stage 2 of the drought contingency plan
  (iii) When due to declining water level, mechanical failure, or any other unforeseen event in the municipal water system's owned wells, an amount of water less than or equal to 2,300 acre-feet of water cannot reasonably be expected to be produced, and there are not adequate allocations from CRMWA to bring the total available water to 5,525 acre-feet per calendar year.
  (iv) Any mechanical, accidental regulatory or unforeseen event that might negatively affect the daily safe operating capacity of the municipal water system to continually provide a safe and reliable supply of drinking water that meets all state and federal standards. This condition or triggering even must also be expected to persist for several days or weeks.

- **Severe:**
- (i)When water supply allocations from CRMWA to the municipal water system are equal to or less than 2,314 acre-feet per year, and the projected use from the municipal water system's owned water wells exceeds 2,750 acre-feet per year.
  (ii) When pursuant to the requirements specified in the municipal water system's wholesale water purchase contract with CRMWA, notification is received from the authority requesting initiation of Stage 3 of the drought contingency plan
  (iii) When due to declining water level, mechanical failure, or any other unforeseen event in the municipal water system's owned wells, an amount of water less than or equal to 2,150 acre-feet of water cannot reasonably be expected to be produced, and there are not adequate allocations from CRMWA to bring the total available water to 5,064 acre-feet per calendar year.
  (iv) Any mechanical, accidental regulatory or unforeseen event that might negatively affect the daily safe operating capacity of the municipal water system

to continually provide a safe and reliable supply of drinking water that meets all state and federal standards. This condition or triggering even must also be expected to persist for several days or weeks.

- **Critical:**
- (i)When water supply allocations from CRMWA to the municipal water system are equal to or less than 1,803 acre-feet per year, and the projected use from the municipal water system's owned water wells exceeds 2,800 acre-feet per year.
  (ii) When pursuant to the requirements specified in the municipal water system's wholesale water purchase contract with CRMWA, notification is received from the authority requesting initiation of Stage 4 of the drought contingency plan
  (iii) When due to declining water level, mechanical failure, or any other unforeseen event in the municipal water system's owned wells, an amount of water less than or equal to 2,000 acre-feet of water cannot reasonably be expected to be produced, and there are not adequate allocations from CRMWA to bring the total available water to 4,603 acre-feet per calendar year.
  (iv) Any mechanical, accidental regulatory or unforeseen event that might negatively affect the daily safe operating capacity of the municipal water system to continually provide a safe and reliable supply of drinking water that meets all state and federal standards. This condition or triggering even must also be expected to persist for several days or weeks.

- **Emergency:**
  (i) Major water line breaks, pump, or other system failures that occur, which cause unprecedented loss of capacity to provide safe and adequate supply of water to all or portions of the system
  (ii) Extended electrical power failures, natural or manmade contamination of the water supply sources(s) that might cause unprecedented outages.

6.5.2.3 <u>City of Canyon</u>

Ordinance No. 730 passed January 1, 2000, resulted in the adoption of a Drought Contingency Plan by The City of Canyon. The Ordinance is aimed at establishing criteria for the initiation and termination of drought response stages; establishing restrictions on certain water uses; establishing penalties for the violation of and provisions for enforcement of these restrictions; establishing procedures for granting variances and providing severability and an effective date. The City of Canyon's triggering criteria are based on vulnerability of their water supply to shortages during drought conditions, periods of high water demand, and the potential for natural disasters, equipment failure, or contamination of the supply and are defined as follows:

- **Mild:** Total consumption has reached 65% of total production capacity for five consecutive days, **or** any combination of mechanical failures in production, transmission or distribution that reduces the total production capacity, or contamination of water supply.

- **Moderate:** Total consumption has reached 75% of total production capacity for five consecutive days, **or** any combination of mechanical failures in production, transmission or distribution that reduces the total production capacity, or contamination of water supply.
- **Severe:** Total consumption has reached 80% of total production capacity for five consecutive days, **or** any combination of mechanical failures in production, transmission or distribution that reduces the total production capacity, or contamination of water supply.
- **Critical:** Total consumption has reached 90% of total production capacity for five consecutive days, **or** any combination of mechanical failures in production, transmission or distribution that reduces the total production capacity, or contamination of water supply.
- **Emergency:** As conditions warrant, per the decision of City Manager

6.5.2.4 City of Dalhart

The City of Dalhart created a Drought Contingency Plan on August 24, 1999. Triggering criteria of this plan, as outlined below, are based on an analysis of the City's Water System consisting of 8 underground water wells and existing main pumping station.

- **Mild:** Dry weather conditions occur before and during the normal landscape growing season, annually from May 1 through September 30.
- **Moderate:** Total daily water demand equals or exceeds 90 percent of system capacity (5.7 million gallons) for three consecutive days, or equals or exceeds 95 percent of system capacity (6 million gallons) on a single day.
- **Severe:** Total daily water demand equals or exceeds 6 million gallons for three consecutive days, or equals or exceeds 100 percent of system capacity (6.3 million gallons) on a single day.
- **Emergency:** City Manager, Director of Public Works, Water Superintendent, or designee determines that an emergency exists due to equipment failure, causing loss of capacity to provide water service, or natural or man-made contamination of the water supply source or system.

6.5.2.5 City of Dumas

The Drought Contingency Plan for City of Dumas was created on June 28, 1999, but has not been adopted yet in the form of an Ordinance. The triggering conditions are based on the City's water demand exceeding the water supply, as outlined below.

- **Mild:** City's water demand exceeds 90 percent of the water production capacity, for three consecutive days.
- **Moderate:** City's water demand exceeds 95 percent of the water production capacity, for three consecutive days.
- **Severe:** City's water demand meets or exceeds the water production capacity for three consecutive days.

- **Critical:** City's water demand exceeds water production capacity by 5 percent for three consecutive days
- **Emergency:** The Mayor or designee determines that a water supply emergency exists due to an equipment failure, causing loss of capability to provide water service, or natural or man-made contamination of water supply source.

6.5.2.6 City of Higgins

The City of Higgins passed an Ordinance to adopt a Drought Contingency Plan on September 11, 2000. The triggering criteria are based on an imbalance of water supply and demand, as described briefly below.

- **Mild:** Specific capacity of City of Higgins well(s) is equal to or less than 90 percent of the well's original capacity or total daily water demand equals or exceeds 300 thousand gallons for three consecutive days.
- **Moderate:** Specific capacity of City of Higgins well(s) exceeds 90 percent of the well's original capacity for three days.
- **Severe:** Specific capacity of City of Higgins well(s) exceeds 95 percent of the well's original capacity for three days.
- **Critical:** System outage
- **Emergency:** Mayor or designee determines that a water supply emergency exists due to equipment failure, causing a loss of capability to provide water service or a natural or man-made contamination of the water supply source (s).

6.5.2.7 City of Pampa

The City of Pampa adopted the Drought Contingency Plan on April 27, 2009. Triggering conditions are based on water supply, and are detailed as follows:

- **Mild:** CRMWA informs Pampa that Lake Meredith has dropped to a projected three year future water supply level. Continuously falling water storage levels do not refill above 70 percent overnight.
- **Moderate:** CRMWA informs Pampa that Lake Meredith has dropped to a projected two year future water supply level. Continuously falling water storage levels do not refill above 50 percent overnight.
- **Severe:** CRMWA informs Pampa that Lake Meredith has dropped to a projected 1.5 year future water supply level. Continuously falling water storage levels do not refill above 40 percent overnight.
- **Emergency:** CRMWA informs Pampa of equipment failure, causing loss of capability to provide water services, or a natural or man-made contamination of the water supply source. When city wells, supply lines, pumps or storage system failures occur causing unprecedented loss of capability to provide water service or contamination of source has occurred.

6.5.2.8 City of Shamrock

Ordinance 02-01 resulted in the adoption of a Drought Contingency Plan for the City of Shamrock on June 6, 2002. The triggering criteria are based on the vulnerability of the City of Shamrock's water supply to shortages during drought conditions, periods of high demand, and the potential for natural disasters, equipment failures, or contamination of the water supply. These criteria are described briefly below.

- **Mild:** Total consumption has reached 65 percent of the total production capacity for five consecutive days, or the Mayor determines that there is a mechanical failure that causes loss of capacity by a significant amount, or contamination of water supply.
- **Moderate:** Total consumption has reached 75 percent of the total production capacity for five consecutive days, or the Mayor determines that there is a mechanical failure that causes loss of capacity by a significant amount, or contamination of water supply.
- **Severe:** Total consumption has reached 80 percent of the total production capacity for five consecutive days, or the Mayor determines that there is a mechanical failure that causes loss of capacity by a significant amount, or contamination of water supply.
- **Critical:** Total consumption has reached 90 percent of the total production capacity for five consecutive days, or the Mayor determines that there is a mechanical failure that causes loss of capacity by a significant amount, or contamination of water supply.
- **Emergency:** Mayor determines that the water supply is in a state of emergency.

6.5.2.9 City of Turkey

The City of Turkey adopted a Drought Contingency Plan by the passage of Ordinance No. 0110 on October 11, 2001. The triggering criteria are based on water well location in a heavy use farming community, and are described briefly as follows:

- **Mild:** Combined storage in the reservoir equal to or less than 75 percent storage capacity.
- **Moderate:** Combined storage in the reservoir equal to or less than 50 percent storage capacity.
- **Severe:** Combined storage in the reservoir equal to or less than 25 percent storage capacity.
- **Emergency:** The City of Turkey determines that an equipment failure has caused loss of capability to provide water service.

6.5.2.10 City of Wellington

The City of Wellington adopted a Drought Contingency Plan on October 2, 2000. The triggering criteria are based on total system capacity and /or total gallons per day produced, as described below.

- **Mild:** Total daily water demand equals or exceeds 90 percent of system capacity for five consecutive days.
- **Moderate:** Total daily water demand equals or exceeds 95 percent of system capacity for three consecutive days.
- **Severe:** Total daily water demand equals or exceeds 100 percent of system capacity for three consecutive days.
- **Emergency:** Mayor or designee determines that an equipment failure caused a loss of capability to provide water service, or natural or man-made contamination of water supply source.

6.5.2.11 City of White Deer

The City of White Deer has adopted a Drought Contingency Plan. The triggering criteria are based on an analysis of the City's water system consisting of four underground water wells and one pump station with two 1,000 gallon pumps. These criteria are outlined as follows:

- **Mild:** Period of dry weather conditions during normal landscape growing season from May 1 through September 30.
- **Moderate:** Total daily water demand equals or exceeds 550 thousand gallons for three consecutive days, or equals or exceeds 625 thousand gallons on a single day.
- **Severe:** Total daily water demand equals or exceeds 575 thousand gallons for three consecutive days, or equals or exceeds 650 thousand gallons on a single day.
- **Critical:** Mayor or designee determines that an equipment failure has caused a loss of capacity to provide water service.

Drought Trigger Conditions for Surface Water Supply

Drought trigger conditions for surface water supply are customarily related to reservoir levels. The PWPG will be working with the regional operators of reservoirs to coordinate the trigger conditions. Trigger conditions which have been ascertained for the region's reservoirs as follows:

6.5.2.12 Canadian River Municipal Water Authority (Lake Meredith)

CRMWA adopted a Drought Contingency Plan on July 14, 1999 and the same was revised on January 14, 2009. CRMWA will recognize that a water shortage condition exists when the total supply is expected to be available to the member cities from CRMWA in the coming year has been determined to be less than the amounts given in the following table, at the time of any review of the supply by the CRMWA Board of Directors

- **Mild:** 65,000 AF – 74,499 AF.
- **Moderate:** 55,000 AF – 64,999 AF.
- **Severe:** 0 AF - 54,999 AF.

Table 6-5: Type of Trigger Condition for Entities with Drought Contingency Plans in PWPA

Entity	Type Trigger Condition	
	Demand	**Supply**
Carson County		
White Deer	X	
Collingsworth County		
Wellington	X	
Dallam County		
Dalhart	X	
Gray County		
Pampa		X
CRMWA		X
Hall County		
Turkey		X
Hartley County		
Dalhart	X	
Hutchinson County		
Borger	X	X
CRMWA		X
Lipscomb County		
Higgins		X
Moore County		
Dumas	X	
Potter County		
Amarillo	X	X
CRMWA		X
Randall County		
Amarillo	X	X
CRMWA		X
Randall County		
Canyon	X	
Roberts County		
CRMWA		X
Wheeler County		
Shamrock	X	

6.5.2.13 Greenbelt Municipal and Industrial Water Authority/Greenbelt Reservoir

The Board of Directors for Greenbelt Municipal and Industrial Water Authority passed a resolution adopting a Drought Contingency Plan on August 19, 1999. Triggering criteria are based on water storage levels in the Greenbelt Reservoir and are described as follows:

- **Mild:** Water storage level reaches an elevation of 2,637.
- **Moderate:** Water storage level reaches an elevation of 2,634 and daily flow or daily demand for water equals or exceeds 7.5 million gallons.
- **Severe:** Water storage level reaches an elevation of 2,631 and daily flow or daily demand for water equals or exceeds 7.5 million gallons.
- **Emergency:** Water storage level reaches an elevation of 2,628 and daily flow or daily demand for water equals or exceeds 7.5 million gallons, or there is an equipment failure, causing a failure to provide water service, or a natural or man-made contamination of water supply.

6.5.2.14 Palo Duro Reservoir

Palo Duro River Authority adopted a conservation plan for Palo Duro Creek Reservoir in May of 1987. Triggering criteria are based on water storage levels in Palo Duro Reservoir and are described as follows:

- **Mild:** Water storage level reaches an elevation of 2,876 feet.
- **Moderate:** Water storage level varies between 2,876 and 2,864 feet.
- **Severe:** Water storage level drops below 2,864 feet.
- **Emergency:** One or more of the major pumps or transmission line in the raw or treated water supply systems should fail, impairing the capability of the delivery system.

Table 6-6: Reservoirs in the Panhandle Region Planning Area

Condition	**Reservoir Capacity**		
	Greenbelt Reservoir	Lake Meredith	Palo Duro Reservoir
Mild	75%	75%	75%
Moderate	66%	66%	66%
Severe	50%	50%	50%

6.6 Water Conservation Recommendations

6.6.1 Water-Saving Plumbing Fixture Program

The Texas Legislature created the Water-Savings Plumbing Fixture Program on January 1, 1992 to promote water conservation. Manufacturers of plumbing fixtures sold in Texas must comply with the Environmental Performance Standards for Plumbing Fixtures, which requires all plumbing fixtures such as showerheads, toilets and faucets sold in Texas to conform with specific water use efficiency standards.

Because more water is used in the bathroom than any other place in the home, water-efficient plumbing fixtures play an integral role in reducing water consumption, wastewater production, and consumers' water bills. It is estimated that switching to water-efficient fixtures can save the average household between $50 and $100 per year on water and sewer bills. Many hotels and office buildings find that water-efficient fixtures can save 20 percent on water and wastewater costs.

6.6.2 Water Conservation Best Management Practices

The 78th Texas Legislature under Senate Bill 1094 created the Texas Water Conservation Implementation Task Force and charged the group with reviewing, evaluating, and recommending optimum levels of water use efficiency and conservation for the state. TWDB Report 362, Water Conservation Best Management Practices Guide was prepared in partial fulfillment of this charge. The Guide is organized into three sections, for municipal, industrial, and agricultural water user groups with a total of 55 Best Management Practices (BMPs). Each BMP has several elements that describe the efficiency measures, implementation techniques, schedule of implementation, scope, water savings estimating procedures, cost effectiveness considerations, and references to assist end-users in implementation. This document can be accessed at the following TWDB web site:

http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITFBMPGuide.pdf

6.6.3 Water Conservation Tips

The TWDB provides a significant amount of information and services pertaining to water conservation that can be accessed at:

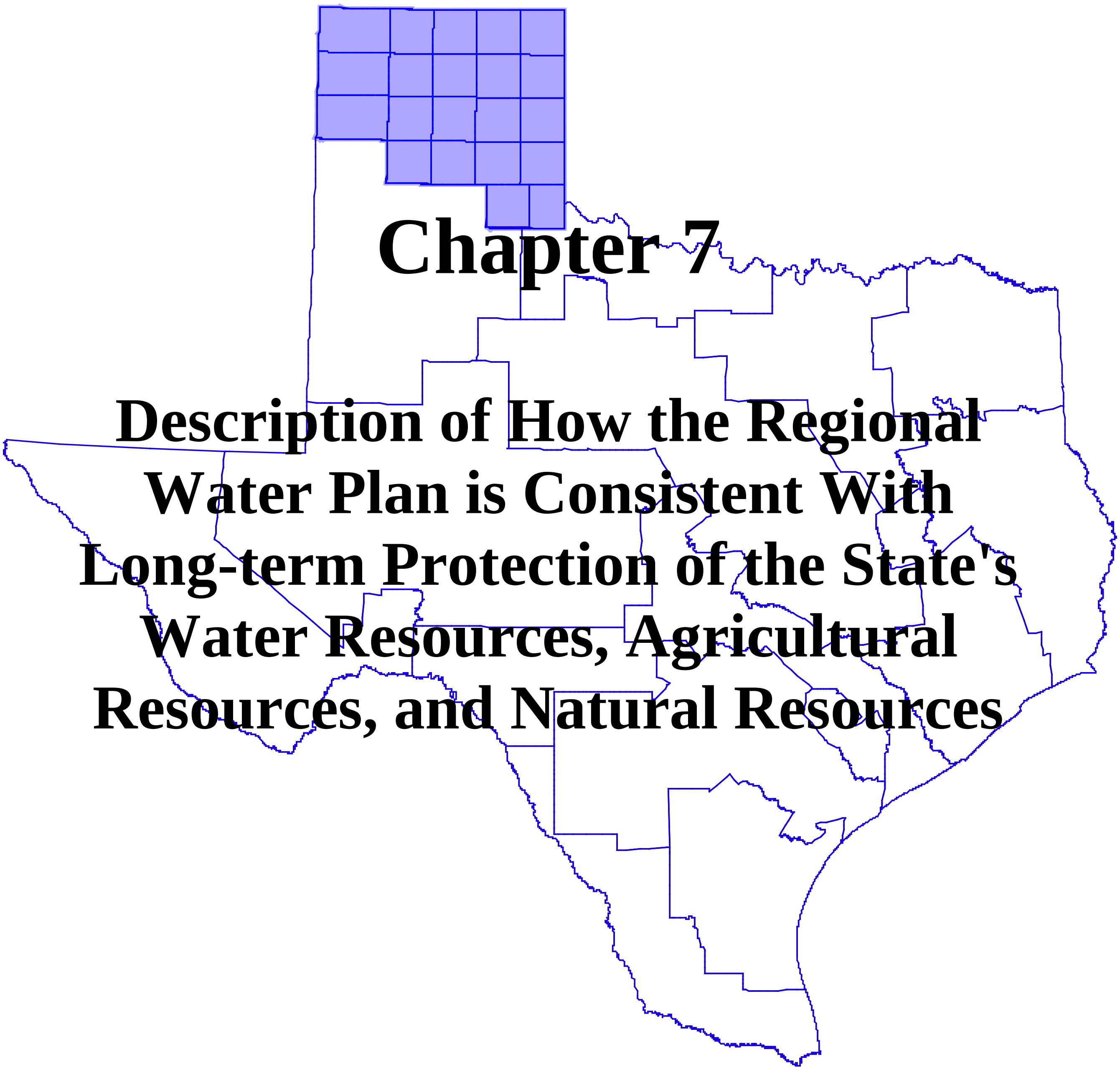
http://www.twdb.state.tx.us/assistance/conservation/consindex.asp .

6.7 Model Water Conservation Plan

Model Water Conservation Plans for municipal, industrial and irrigation water users were developed for the PWPA and are found in Appendix J. These can be obtained through the Texas Water Development Board planning website. General model water conservation plan forms are also available from TCEQ in WordPerfect and PDF formats. A printed copy of the form from TCEQ can be obtained by calling TCEQ at 512/239-4691 or by email to wras@tceq.state.tx.us.

Chapter 7

Description of How the Regional Water Plan is Consistent With Long-term Protection of the State's Water Resources, Agricultural Resources, and Natural Resources



7.1 Introduction

The Panhandle Water Planning Group (PWPG) balanced meeting water shortages with good stewardship of the water, agricultural, and natural resources within the region. The greatest shortages identified in the region are associated with irrigated agriculture. The plan assumes a level of demand reduction over time and the PWPG recommended water conservation to meet the remaining needs. The PWPG also recognized the benefits of recommending conservation for all irrigation users to conserve and preserve limited water sources for future use. During the strategy selection process, long-term protection of the State's resources were 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 or interbasin transfers were considered. Wastewater reuse is an active water source to meet long-term power generation and industrial water needs in the PWPA. The plan assumes that this resource will be fully utilized to meet the growing demands of the power industry in the region.

The PWPG believes that local groundwater conservation districts are best-suited to manage groundwater resources in which the individual GCDs have the responsibility to regulate. The newly formed GMAs provide additional guidance to managing groundwater resources. This plan recommends following policies adopted by the GMAs for the Northern Ogallala and Rita Blanca aquifers for groundwater management. If no desired future conditions have been adopted, this plan recommends using not more than 1.25% of annual saturated thickness within the aquifer as a management option. The PWPG believes these approaches are appropriate for the long-term sustainable management of the aquifers within the PWPA to meet local demands.

7.2 Water Resources within the Panhandle Water Planning Area

Existing surface water sources include supplies in the Red River and Canadian River basins. Supplies from these sources were allocated considering the long-term reliability of the sources. No new surface water strategies are recommended. Water resources available by basin within the PWPA are discussed in further detail below.

7.2.1 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.

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. (RRA, 1999)

7.2.2 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 measured near Canadian, Texas, approximately 22 miles upstream of the Texas-Oklahoma state line, averages 89 cubic feet per second (CFS), or 64,700 acre-feet per annum.

7.3 Agricultural Resources within the Panhandle Water Planning Area

According to the 2007 Census of Agriculture, the PWPA has approximately 2,640,293 acres of land in 2,952 farms. The number of farms has increased in the period between 1978 and 2007. During this time, the acres of harvested cropland have increased by approximately 14 percent. In 2007, approximately 65 percent of the harvested cropland was contained in seven counties (Carson, Dallam, Hansford, Hartley, Moore, Ochiltree, and Sherman) on 1,269 farms. Agricultural land use in the PWPA includes irrigated cropland, dryland cropland, and pastureland. Major crops include corn, cotton, hay, peanuts, sorghum, sunflower, soybeans, and wheat.

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 shortages.

7.4 Natural Resources within the Panhandle Water Planning Area

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.

7.4.1 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 13 state or federally protected species which have the potential to occur within the PWPA. This does not include species without official protection such as those proposed for listing or species that are considered rare or otherwise of special concern.

7.4.2 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 Region 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. Implementation of water management strategies should not directly impact these lands.

7.5 Impacts of Water Management Strategies on Other Water Resources

Implementation of water management strategies can adversely affect surface water and groundwater supplies in the region if these sources are overallocated. Issues that are of concern for water supply in the PWPA include aquifer depletions due to pumping exceeding recharge; surface water and groundwater quality; and drought related shortages for both surface water and groundwater. Potential groundwater quality may supersede water quantity as a consideration in evaluating the amount of water available for a use.

Most water used in the PWPA is supplied from aquifers such as the Ogallala, making aquifer depletion a potentially major constraint on water sources 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. "Recent consideration by the U. S. Fish and Wildlife Service of the designation of critical habitat for the federally threatened Arkansas River shiner had the potential to affect water resource projects and other activities in Hemphill, Hutchinson, Oldham, Potter, and Roberts Counties. However, based on the provisions of a management plan developed by the Canadian River Municipal Water Authority which includes plans for flow augmentation by performing salt cedar control work, and for other reasons, the Service did not designate any critical habitat areas for the species in Texas. Therefore there should be no federal intervention with activities in the PWPG area for protection of this species."

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; 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, such as Lake Meredith, for certain uses.

7.6 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 358.3
- 31 TAC Chapter 357.5
- 31 TAC Chapter 357.7
- 31 TAC Chapter 357.8
- 31 TAC Chapter 357.9

The information, data, evaluation, and recommendations included in the 2011 Plan collectively demonstrate compliance with these regulations. Table 7-1 presents a summary of the major components of the plan and references the regulations. The content of the 2011 Plan has been evaluated against this regulatory matrix.

Table 7-1: Summary of Regulatory Compliance

Regulatory Citation (Col 1)	Summary of Requirement (Col 2)	*Response (Yes/No/ NA)* (Col 3)	Location(s) in Regional Plan and/or Commentary (Col 4)	Regulatory Cross References (Col 5)
31 TAC §358.3				
358.3(a)	TWDB shall develop a State Water Plan (SWP) with 50-year planning cycle, and based on the Regional Water Plan (RWP)	NA	Applies to the State Water Plan. The Regional Water Plan is based on a 50-year planning cycle, however.	
358.3(b)	RWP is guided by the following principles			
(b)(1)	Identified policies and actions so that water will be available at reasonable cost, to satisfy reasonable projected use and protect resources	Yes	Chapters 4 and 8	§358.3(b)(4), §357.5 (a); §357.7 (a)(9)
(b)(2)	Open and accountable decision-making based on accurate, objective information	Yes	Regular public meetings of the PWPG;	§357.5 (e)(6)
(b)(3)	Consideration of effects of plan on the public interest, and on entities providing water supply	Yes	Chapters 4 and 7	
(b)(4)	Consideration and approval of cost-effective strategies that meet needs and respond to drought, and are consistent with long-term protection of resources	Yes	Chapters 4, 6, and 7	§358.3(b)(1), §357.5 (e)(4) and §357.5 (e)(6); §357.7(a)(9)
(b)(5)	Consideration of opportunities that encourage the voluntary transfer of water resources	Yes	Chapter 4	
(b) (6)	Consideration of a balance of economic, social, aesthetic, and ecological viability	Yes	Chapters 4 and 7	
(b) (7)	The use of information from the adopted SWP for regions without a RWP	NA		
(b) (8)	The orderly development, management, and conservation of water resources	Yes	Chapters 4, 6, and 7	§357.5(a)
(b) (9)	Surface waters are held in trust by the State, and governed by doctrine of prior appropriation	Yes	Chapters 3	
(b) (10)	Existing water rights, contracts, and option agreements are protected	Yes	Chapter 4	§357.5(e)(3)
(b) (11)	Groundwater is governed by the right of capture unless under local control of a groundwater management district	Yes	Chapter 3	
(b) (12)	Consideration of recommendation of stream segments of unique ecological value	Yes	Chapter 8. PWPG did not recommend designation of any of the Region's Stream segments as an ecologically unique segment.	§357.8

Table 7-1: Summary of Regulatory Compliance

Regulatory Citation (Col 1)	Summary of Requirement (Col 2)	*Response (Yes/No/ NA)* (Col 3)	Location(s) in Regional Plan and/or Commentary (Col 4)	Regulatory Cross References (Col 5)
(b) (13)	Consideration of recommendation of sites of unique value for the construction of reservoirs	Yes	Chapter 8. The PWPG did not recommend any site in the region as a unique reservoir site.	§357.9
(b) (14)	Local, regional, state, and federal agency water planning coordination	Yes	Local, State and Federal levels of coordination	
(b) (15)	Improvement or maintenance of water quality and related uses as designated by the State Water Quality Plan	Yes	Chapters 4 and 5	
(b)(16)	Cooperation between neighboring water planning regions to identify common needs and issues	Yes	Coordination with neighboring planning regions as needed	
(b)(17)	WMS described sufficiently to allow a state agency making financial or regulatory decisions to determine consistency of the WMS with the RWP	NA	To be determined by the State after completion of the RWP	§357.7(a)(9)
(b) (18)	Environmental evaluations are based on site-specific information or state environmental planning criteria	Yes	To the extent that such information and criteria exist; Chapter 4	§357.5(e)(1); §357.5 (e)(6); §357.5(k)(1)(H)
(b) (19)	Consideration of environmental water needs, including instream flows and bay and estuary inflows	Yes	Chapter 4	§357.5(e)(1); §357.5(l); §357.7 (a)(8)(A)(ii)
(b) (20)	Planning is consistent with all laws applicable to water use for state and regional water planning	Yes	Applicable water planning laws have been considered in preparing this plan	§357.5(f)
(b) (21)	Ongoing permitted water development projects are included	Yes	Chapter 4	
31 TAC §357.5				
(a)	The RWP: provides for the orderly development, management, and conservation of water resources; prepares for drought conditions; and protects agricultural, natural, and water resources	Yes	Chapter 4, water conservation strategies and Chapter 6	§358.3(b)(1). §358.3(b)(8)
(b)	The RWP submitted by January 5, 2011	NA	To be submitted	
(c)	The RWP is consistent with 31 TAC §358 and 31 TAC §357, and guided by State and local water plans	Yes	Throughout RWP	
(d)(1) & (2)	The RWP uses State population and water demand projections from the SWP; or revised population or water demand projections that are adopted by the State	Yes	Chapter 2; Population and water demand projections adopted by TWDB	

Table 7-1: Summary of Regulatory Compliance

Regulatory Citation (Col 1)	**Summary of Requirement** (Col 2)	*Response (Yes/No/ NA)* (Col 3)	Location(s) in Regional Plan and/or Commentary (Col 4)	Regulatory Cross References (Col 5)
(e)(1)	The RWP provides WMS adjusted for appropriate environmental water needs; environmental evaluations are based on site-specific information or state environmental planning criteria	Yes	Chapter 4	§358.3(b)(1); §358.3(b)(18); §357.7 (a)(8)(A)(ii)
(e)(2)	The RWP provides WMS that may be used during a drought of record	Yes	Chapter 4	
(e)(3)	The RWP protects existing water rights, contracts, and option agreements	Yes	Chapter 4	§358.3(b)(10)
(e)(4)	The RWP provides cost-effective and environmentally sensitive WMS based on comparisons of all potentially feasible WMS; The process is documented and presented to the public for comment.	Yes	Chapter 4; Presented at a PWPG meeting on May 13, 2009	§358.3(b)(4)
(e)(5)	The RWP incorporates water conservation planning and drought contingency planning	Yes	Chapters 4 and 6	§357.5(k)(1)(A)&(B); §357.7(a)(7)(B)
(e)(6)	The RWP achieves efficient use of existing supplies and promotes regional water supplies or regional management of existing supplies; Public involvement is included in the decision-making process	Yes	Chapter 4; public process utilized in consideration WMS	§358.3(b)(2)
(e)(7)(A)&(B)	The RWP identifies (A) drought triggers, and (B) drought responses for designated water supplies	Yes	Chapter 6	§357.5(e)(5); §357.5(k)(1)(A)&(B)
(e)(8)	The RWP considers the effect of the plan on navigation	Yes	Navigation impacts considered to the extent necessary	
(f)	Planning is consistent with all laws applicable to water use in the Region	Yes	Applicable water planning laws considered in adopting the plan	§358.3(b)(20)
(g)	The following characteristics of a candidate special water resource are considered:			
(g)(1)	The surface water rights are owned by an entity headquartered in another region.	NA		
(g)(2)	A water supply contract commits water to an entity headquartered in another region.	Yes	CRMWA, Greenbelt M&IWA	
(g)(3)	An option agreement may result in water being supplied to an entity headquartered in another region.	NA		
(h)	Water rights, contracts, and option agreements of special water resources are protected in the RWP	Yes	Lake Meredith and Greenbelt Reservoir	

Table 7-1: Summary of Regulatory Compliance

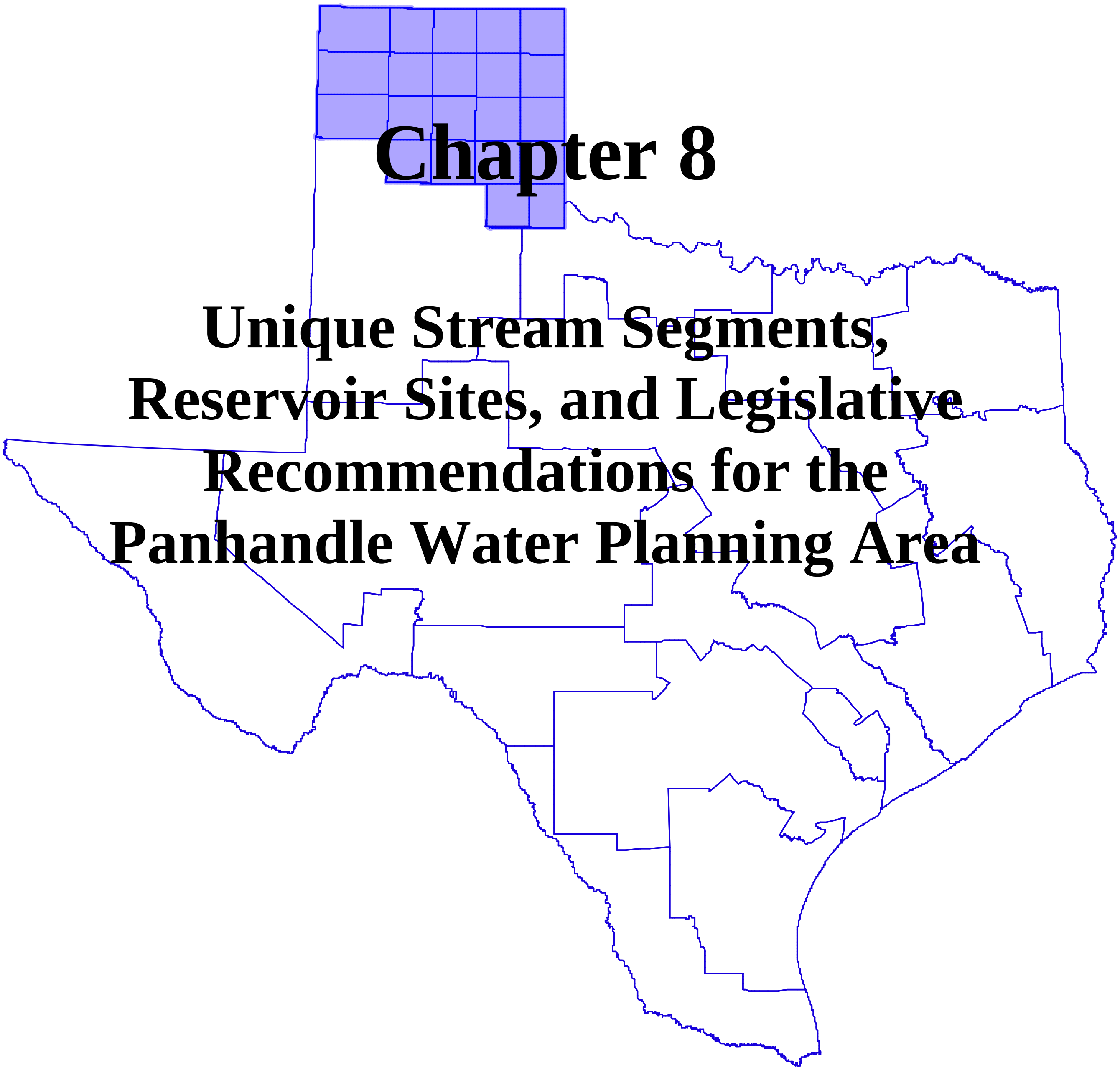
Regulatory Citation (Col 1)	**Summary of Requirement** (Col 2)	*Response (Yes/No/NA)* (Col 3)	Location(s) in Regional Plan and/or Commentary (Col 4)	Regulatory Cross References (Col 5)
(i)	The RWP considers emergency transfers of surface water rights	NA	Emergency transfers of water not considered in the RWP	
(j)(1)-(3)	Simplified planning is used in the RWP in accordance with TWDB rules	NA	Normal water planning process utilized	
(k)(1)&(2)	The RWP shall consider existing plans and information, and existing programs and goals related to local or regional water planning	Yes	Chapters 1, 4, and 6	§357.5(e)(7)
(l)	The RWP considers environmental water needs including instream flows and bays and estuary flows	Yes	Chapter 4	§358.3(b)(19); §357.7 (a)(8)(A)(ii)
31 TAC §357.7				
(a)(1)(A)-(M)	The RWP shall describe the region, including specific requirements of paragraphs A through M of this section of the regulations	Yes	Chapters 1 and 6	§357.7(a)(8)(A)(iii); §357.7(a)(8)(D); §357.5(k)(1)(C); §357.7(a)(7)(A)(iv) § 358.6 (a)-(b)
(a)(2)(A)-(C)	The RWP includes a presentation of current and projected population and water demands, reported in accordance with paragraphs A through C of this section of the regulations	Yes	Chapter 2	
(a)(3)(A)-(G)	The RWP includes the evaluation of current water supplies available (including a presentation of reservoir firm yields) to the Region for use during drought of record conditions, reported by the type of entity and wholesale providers	Yes	Chapter 3	
(a)(4) (A)&(B)	The RWP includes water supply and demand analysis, comparing the type of entity and wholesale providers	Yes	Chapter 4	
(a)(5)(A)-(C)	The RWP provides sufficient water supply to meet the identified needs, in accordance with requirements of paragraphs A through C of this section of the regulations	Yes	Chapter 4	
(a)(6)	The RWP presents data required in paragraphs (2) - (5) of this subsection in subdivisions of the reporting units required, if desired by the PWPG	Yes	Chapters 2, 3, and 4	

Table 7-1: Summary of Regulatory Compliance

Regulatory Citation (Col 1)	Summary of Requirement (Col 2)	*Response (Yes/No/ NA)* (Col 3)	Location(s) in Regional Plan and/or Commentary (Col 4)	Regulatory Cross References (Col 5)
(a)(7)(A)-(H)	The RWP evaluates all WMS determined to be potentially feasible, in accordance with paragraphs A through H of this section of the regulations	Yes	Chapters 1 and 6	§357.5(k)(1)(C); §357.7(a)(1)(M); §357.5(e)(5); §357.5(k)(1)(B) § 358.6 (a)-(b)
(a)(8)(A)-(H)	The RWP evaluates all WMS determined to be potentially feasible, by considering the requirements of paragraphs A through H of this section of the regulations	Yes	Chapter 4	§358.3(b)(19); §357.5(e)(1); §357.5(l); §357.7(a)(1)(L); §357.7(a)(8)(D); §357.7(a)(8)(A)(iii)
(a)(9)	The RWP makes specific recommendations of WMS in sufficient detail to allow state agencies to make financial or regulatory decisions to determine the consistency of the proposed action with an approved RWP	NA	To be determined by the State after completion of the RWP	§358.3(b)(1); §358.3(b)(4); §358.3(b)(17)
(a)(10)	The RWP includes regulatory, administrative, or legislative recommendations to facilitate the orderly development, management, and conservation of water resources; prepares for drought conditions; and protects agricultural, natural, and water resources	Yes	Chapter 8	§358.3(b)(1) §357.5(a)
(a)(11)	The RWP includes a chapter consolidating the water conservation and drought management recommendations	Yes	Chapter 6	
(a)(12)	The RWP includes a chapter describing the major impacts of recommended WMS on key parameters of water quality	Yes	Chapter 5	
(a)(13)	The RWP includes a chapter describing how it is consistent with long-term protection of the state's water, agricultural, and natural resources	Yes	Chapter 7	
(a)(14)	The RWP includes a chapter describing the financing needed to implement the water management strategies recommended	Yes	Chapter 9; due later	
(b)	The RWP excludes WMS for political subdivisions that object to inclusion and provide reasons for objection	NA		
(c)	The RWP includes model water conservation plan(s)	Yes	Chapter 6	
(d)	The RWP includes model drought contingency plan(s)	Yes	Chapter 6	
(e)	The RWP includes provisions for assistance of the TWDB in performing regional water planning activities and/or resolving conflicts within the Region	Yes	PWPG requested the TWDB to conduct the socioeconomic analysis for the region	

Table 7-1: Summary of Regulatory Compliance

Regulatory Citation (Col 1)	Summary of Requirement (Col 2)	*Response (Yes/No/ NA)* (Col 3)	Location(s) in Regional Plan and/or Commentary (Col 4)	Regulatory Cross References (Col 5)
31 TAC §357.8				
(a)	The RWP considers the inclusion of recommendations for the designation of river and stream segments of unique ecological value within the Region	Yes	Chapter 8. The PWPG did not recommend designation of any of the Region's stream segments as ecologically unique	§358.3(b)(12)
(b)	If river or stream segments of unique ecological value are recommended, such recommendations are made in the plan on the basis of the criteria established in this section of the regulations	NA		
(c)	If the RWP recommends designation of river or stream segments of unique ecological value, the impact of the regional water plan on these segments is assessed	NA		
31 TAC §357.9				
(1)	The RWP considers the inclusion of recommendations for the designation of sites of unique value for construction of reservoirs	Yes	The PWPG did not recommend any locations in the Region as a site of unique value for construction of reservoirs	§358.3(b)(13)
(2)	If sites of unique value for construction of reservoirs are recommended, such recommendations are made in the plan on the basis of criteria established in this section of the regulations	NA		



Chapter 8

Unique Stream Segments, Reservoir Sites, and Legislative Recommendations for the Panhandle Water Planning Area

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 requires that the following criteria 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.

TPWD has compiled a listing of ecologically significant stream segments located in PWPA. These stream segments were selected by TPWD because of the above-listed criteria.

As part of the planning process, fourteen segments were evaluated by the PWPG for potential recommendation as unique stream segments. After careful consideration of the unknown consequences of recommendation, the PWPG makes no recommendations for river and stream segments of unique ecological value. The following stream segments were presented to the planning group for consideration by TPWD:

- 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 northwest 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 Dallas 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

8.2 Sites of Unique Value for the Construction of Reservoirs

Regional water planning guidelines (§357.9) instruct that 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:

(1) site-specific reservoir development is recommended as a specific water management strategy or in an alternative long-term scenario in an adopted plan; or

(2) 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:

(A) reservoir development to provide water supply for the current planning period; or
(B) where it might reasonably be needed to meet needs beyond the 50-year planning period.

The same 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.

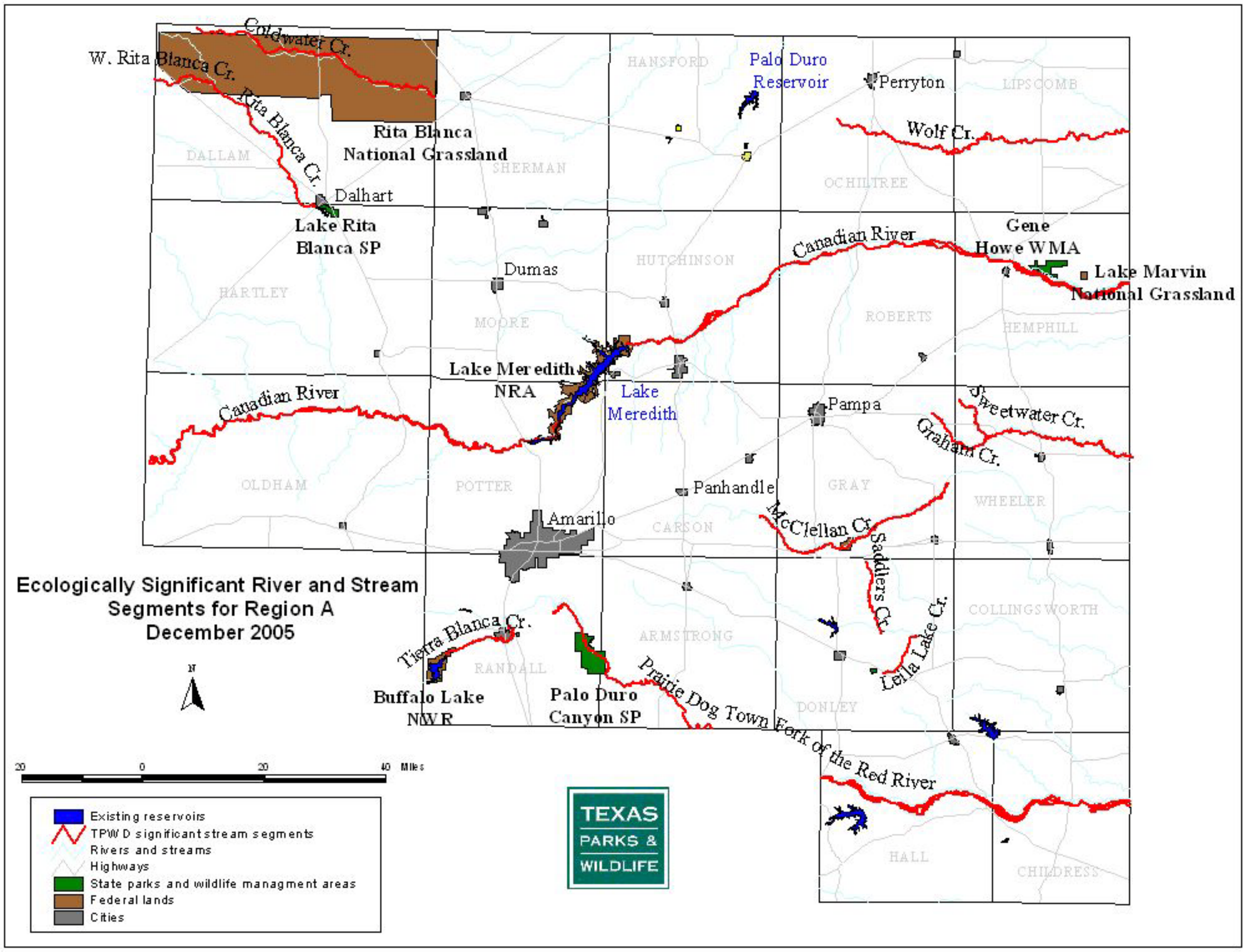


Figure 8-1: Ecologically Significant River and Stream Segments in Region A

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) §357.7(a)(9) states that the regional water plans will include: "regulatory, administrative, or legislative recommendations that the regional water planning group believes are needed and desirable to: facilitate 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 state and regional water planning area." Following is a list of recommendations:

8.3.1 Regulatory Issues

a) *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.

b) *Assessments and evaluation of the Ogallala aquifer in the Region A Planning Area need to consider the minimal recharge rates comparable to other major aquifers in the State of Texas.* The Ogallala aquifer is a mined and finite resource that has minimal recharge as identified in recharge study conducted for the PWPA (BEG, 2009).

8.3.2 Legislative Issues

a) *Continue state-sponsored water availability modeling for minor aquifers.* This information is particularly important in the evaluation of the minor aquifers in the Panhandle. There was extremely limited information available regarding supplies which are anticipated to be available from the minor aquifers in the region.

b) *Expand funding for implementation of water supply strategies.* Many water supply strategies, particularly those associated with brush control, water conservation and irrigated agriculture, have limited means of implementation other than public outreach and education. The PWPG recommends that the state and federal governments sponsor programs to implement these strategies.

c) *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. In order to create an equitable situation with regard to groundwater management, these areas should be included in a local district contained within the regional planning area.

d) *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.

e) *Encourage the federal government to continue to support Conservation Reserve Program (CRP) participation.* As properties currently in CRP are coming out, property owners may convert and reestablish the properties to irrigated agriculture and utilizing higher volumes of groundwater. From 2008 to 2010, there are an estimated 1.2 million acres in the High Plains that will no longer be enrolled in the CRP.

f) *Develop or improve grant and loan programs for utilities to replace/repair aging infrastructure.* Development of a program similar to the TWDB Wastewater Revolving Loan Program to address aging water infrastructure and metering programs.

g) *Provide funding for continuation of the High Plains-PET.* This support should be administered through the network team annually, through groundwater conservation districts within the network area. The State should provide funding to allow continuation and/or cost sharing of operating costs of the High Plains-PET network and its integration into a statewide network.

h) *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.

i) *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.

j) *Adopt recognized definitions for gallons per capita per day (GPCD) proposed by the Water Conservation Advisory Council.* Recognized standard definitions for GPCD will allow better communication across the state on water conservation.

8.4 Recommendations for Future State Water Plans

a) *TWDB should establish and continue to promote clear guidelines for eligibility for funding and needs assessment for very small cities, unincorporated areas.* Statements to the effect that those "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 appropriate Regional Water Plan" would greatly enhance the ability of these small systems to provide their users with a safe and adequate supply of water.

b) *TWDB should 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.*

c) *TCEQ should be made at least an ex-officio member of the RWPGs and be required to attend RWPG meetings to provide input on known water quality/quantity problems.*

d) *Allow development of alternative near term water supply strategies for water systems that service fewer than 3,300 population.*

e) *Clarification of relationship between drought contingency planning and regional water supply planning.* It is not clear what role drought contingency planning has in the regional planning process.

f) *Include an economic impact analysis for the result of implementing water management strategies.* The current planning rules provide for an economic analysis of not meeting water demands. However, there is no provision for economic analysis of implementing a water management strategy. The analysis should include impacts on water suppliers, users and major economic sectors.

g) *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.

h) *Include projects for future groundwater quality in the region.* Salinity, nitrates, arsenic, and other contaminants have become concerns for municipal water supplies in the region.

i) *Interbasin/Intrabasin water transfers.* Future state water plans should provide for a detailed assessment of the potential for transporting water into or out of the PWPA.

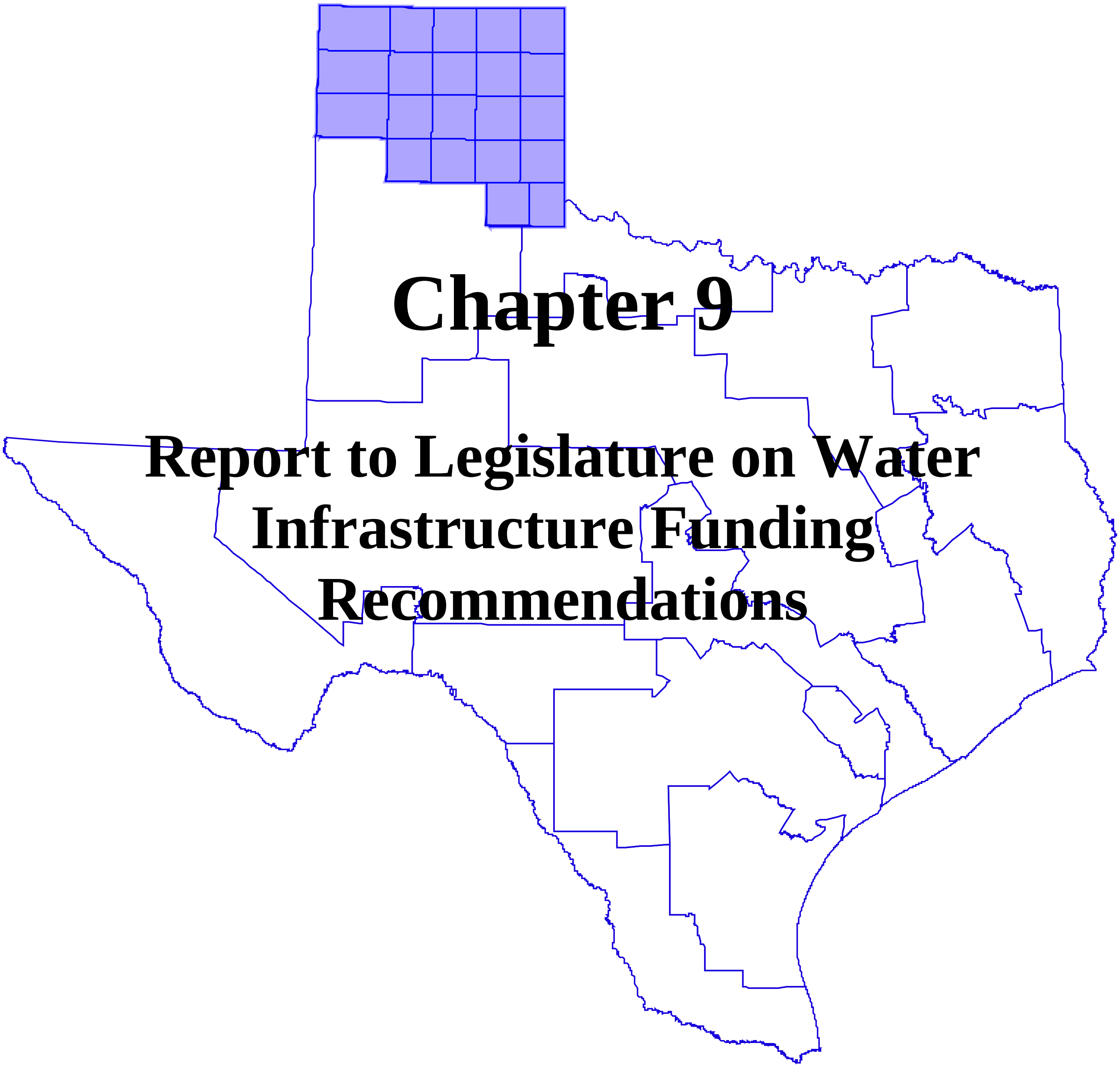
j) *Brush control*. TWDB guidance is needed on how to account for brush control projects in the context of a source of "new surface water" for municipal, industrial, agricultural, and other uses. The Canadian River watershed has more than 50% cover of mixed brush species that are amenable to control for rangeland improvement and water enhancement purposes.

k) *Analysis of means to improve groundwater recharge*.

l) *Updated analysis of surface water supply inflows and availability*. The regional surface water supply has steadily decreased over a ten year period to the extent that regional lakes are at all time lows.

Chapter 9

Report to Legislature on Water Infrastructure Funding Recommendations



9.1 Introduction

The TWDB and Legislative Action governing the regional water planning process require that an Infrastructure Financing Report (IFR) be incorporated into the 2011 Regional Water Plan. In order to meet this requirement, each regional water planning group is required to examine the funding needed to implement the water management strategies and projects identified and recommended in the region's 2011 Regional Water Plan.

9.2 Objectives of the Infrastructure Financing Report

The objectives of the IFR area as follow:

- To determine the financing options proposed by political subdivisions to meet future water infrastructure needs (including the identification of any State funding sources considered); and
- To determine what role(s) the RWPGs propose for the State in financing the recommended water supply projects

9.3 Methods and Procedures

For the PWPA, all municipal water user groups having identified water needs and recommended water management strategies in the regional plan with an associated cost were surveyed using the questionnaire provided by the TWDB to the region on March 24, 2010. These surveys are included in this chapter. For individual cities, the survey was mailed to the mayor, city manager, or utility manager as deemed appropriate by the Panhandle Water Planning Group (PWPG) Chairman. Surveys were mailed, along with supporting documentation that summarized the regional water planning process, the purpose of the IFR survey, and the water management strategies included in the Initially Prepared Plan (IPP) for the respective entity. Follow up phone contact was made with each political subdivision contacted that did not respond to the survey by the due date. Those entities that had still not responded were mailed a second IFR survey packet to ensure that they had the document readily accessible.

9.4 Survey Responses

The PWPG mailed survey packages to multiple municipal water user groups and wholesale providers and received a 100% response rate. Copies of the completed surveys and related documentation are included in this chapter. As shown in Table 9-1, the responses represent the vast majority of the capital costs associated with water management strategies included in the plan. Since almost all other strategies are targeted at individual owners or operators, no capital costs were calculated for these mostly agricultural entities. Of the responses, the surveys show that $703,451,200 in projects are included to meet projected municipal water deficits in the next 50 years. (Note: Borger's strategy to purchase additional water from CRMWA was removed for the final plan.) The majority of these projects are projected to be needed in the next 10 years. The TWDB survey form for the 2011 Regional Water Plan no longer identifies the percentages of these funds anticipated to be sought in the form of bonds or State and Federal programs as was done in previous planning cycles. However, with respect to the role the State in financing recommended water supply projects, the PWPG recommends that the Legislature provide adequate funding for the implementation of water management strategies in the plan as local capacity to generate funds for large scale projects continues to be restricted.

Table 9-1: Municipal Water User Groups with Shortages

Entity	County	Project	Amount	Construction Year
Amarillo	Potter/Randall	Roberts County Well Field	$287,377,200.00	2040
Amarillo	Potter/Randall	Potter County Well Field	$128,511,300.00	2011
Borger	Hutchinson	Drill Additional Groundwater Well	$850,000.00	2012
Cactus	Moore	Drill Additional Groundwater Well	$10,893,400.00	2011
CRMWA	Hutchinson	Roberts County Well Field	$21,824,000.00	2010
CRMWA	Hutchinson	Roberts County Water Rights*	$88,200,000.00	2015
Canyon	Randall	Drill Additional Groundwater Well*	$9,528,800.00	2015
Dumas	Moore	Drill Additional Groundwater Well	$7,997,200.00	2015
Fritch	Hutchinson	Purchase infrastructure	$2,850,300	2010
Fritch	Hutchinson	Drill Additional Groundwater Well	$1,156,600	2020
Greenbelt	Collingsworth	Drill Additional Groundwater Well	$1,865,900.00	2012
Gruver	Hansford	Drill Additional Groundwater Well	$1,968,500.00	2020
Lefors	Gray	Drill Additional Groundwater Well	$1,132,500.00	2015
Memphis	Hall	Drill Additional Groundwater Well	$1,042,100.00	2013
PDRA	Ochiltree	Palo Duro Reservoir	$114,730,000.00	2030
Pampa	Gray	Drill Additional Groundwater Well	$1,731,100	2010
Panhandle	Carson	Drill Additional Groundwater Well	$3,309,300.00	2020
Perryton	Ochiltree	Drill Additional Groundwater Well	$7,087,000.00	2012
Spearman	Hansford	Drill Additional Groundwater Well	$3,862,000.00	2020
Sunray	Moore	Groundwater Well/Storage Basin	$3,121,300.00	2015
Texline	Dallam	Drill Additional Groundwater Well	$2,304,000.00	2020
Wheeler	Wheeler	Drill Additional Groundwater Well	$2,108,700.00	2020
		TOTAL	**$703,451,200.00**	
**Notes Project Differs From Original Issuance of Survey*				

SAMPLE SURVEY & INFORMATION PACKET TO OBTAIN:
INFRASTRUCTUE FINANCING INFORMATION FROM
POLITICAL SUBDIVISIONS WITH NEEDS

PANHANDLE WATER PLANNING GROUP

P.O. Box 9257
Phone: 806-372-3381

Amarillo, Texas 79105
Fax: 806-373-3268

Randy Criswell,
City Manager
City of Canyon
301 16th Street
Canyon, TX 79015

Randy,

The Panhandle Water Planning Group (PWPG) has recently adopted the Initially Prepared 2011 Panhandle Regional Water Plan (IPP). The plan includes projects that will increase the City of Canyon's available water supplies have been identified. The strategies were identified and confirmed in the Water User Group Survey completed by your entity in late 2009.

As part of the review of the IPP, the Texas Water Development Board (TWDB) requires that large water user groups that may seek TWDB funding for these projects in the futre complete an Infrastructure Financing Survey Report (IFR). Enclosed you will find an IFR for the City of Canyon that includes a description of TWDBs funding programs, the types of programs allowable under the funding, and a brief survey pertaining to the City's strategies. Please read the attached IFR and complete the cost and timeframe survey included. I have enclosed a prepaid return envelope for you to utilize in returning your completed IFR. This information must be completed and included in the final 2011 Panhandle Regional Water Plan for your projects to be eligible for TWDB funding.

Thank you for your timely assistance in getting this information into the Plan. If you have any questions please contact Kyle Ingham at (806) 372-3381. Thank you for all that you do for your community and regional water planning in the Texas Panhandle.

Thanks,

C.E. Williams
Chairman
Panhandle Water Planning Group

cc: Virginia Sabia, TWDB
Kyle G. Ingham, PRPC
Simone Kiel, Freese & Nichols

Infrastructure Financing Survey Report

329: CANYON

As part of the regional and state water planning process, regional water planning groups recommend water supply projects for each of their respective regions. The purpose of this survey is gather information from your organization regarding how you plan to finance water supply projects recommended for the 2012 state water plan, and determine whether you intend to use financial assistance programs offered by the State of Texas and administered by the Texas Water Development Board (TWDB).

The TWDB has several funding programs for water projects identified in the 2012 state water plan. Funds are targeted toward: 1) construction of water supply projects, 2) planning and design and permitting for projects that have long development time frames meaning that construction would require 5-10 years of planning, design and permitting, and 3) projects that would be built with excess capacity intended to meet future water needs. These programs offer various attractive financing options such as subsidized interest rates, deferral of principal and interest during planning, design and permitting phase, partial deferral of interest and principal for those portions of the project which are optimally sized for future needs. Additionally, grant funding is available for those service areas which qualify as rural or economically disadvantaged. More information on these financial assistance programs (i.e., the Water Infrastructure Fund, the State Participation Fund, and the Economically Disadvantaged Areas Program) can be found at the TWDB website at:

http://www.twdb.state.tx.us/assistance/financial/financial_main.asp

Your cooperation and responses to these questions are crucial in helping the state in ensuring that our communities and our citizens have adequate water supplies. If you have any questions related to the financial programs offered by the TWDB or about the survey questions, please contact Kyle Ingham by phone at (806)372-3381 or by email at kingham@theprpc.org. If you have any computer or technology related problems with the survey, please contact Wendy Barron by phone at (512) 936-0886 or by email at wendy.barron@twdb.state.tx.us.

Section 1: Project Financing Information

For project(s) identified in the State Water Plan, the TWDB has funding available for different aspects of a project. The different programs available are:

•WIF-Deferred offers subsidized interest and deferral of principal and interest for up to 10 years for planning, design and permitting costs.

•WIF-Construction offers subsidized interest for all construction costs, including planning, acquisition, design, and construction.

•State Participation funding offers partial interest and principal deferral for the incremental cost of project elements which are designed and built to serve needs beyond 10 years.

•Rural areas funding offers grants and 0% interest loans for service areas which are not in a Metropolitan Statistical Area (MSA) and in which the population does not exceed 5,000. The service area must also meet the EDAP eligibility criteria.

•Economically Distressed Areas Program (EDAP) offers funding through grants and loans for service areas within a project which meet the EDAP eligibility criteria. Eligibility for the TWDB's EDAP requires that the median household income of the area to be served by the proposed project be less than 75 percent of the Texas median household income ($39,927), as shown in the 2000 Census. EDAP eligibility also requires adoption of Model Subdivision rules by the appropriate planning entities.

•State Participation funding offers partial interest and principal deferral for the incremental cost of project elements which are designed and built to serve needs beyond 10 years.

If you are interested in receiving funds from the above programs, please complete the remainder of the survey.

Infrastructure Financing Survey Report

Please enter only the amounts you wish to receive from TWDB program in the Project Costs fields and do not enter a specific project cost more than once.

Section 2: Projects

For each of the project(s) listed below, please enter only the amounts you wish to receive from TWDB programs in the 'Cost' field and the earliest date you wish to receive these amounts. In addition, the total amount entered into all five categories cannot exceed the total cost of the project. Each of the five categories corresponds to a funding program available at the TWDB. Each of the funding programs and categories are described below.

•Planning, design, permitting: Enter costs into the 'Planning, design, permitting' category if you want to participate in the WIF-Deferred program. The WIF-Deferred program offers subsidized interest and deferral of principal and interest for up to 10 years for planning, design and permitting costs.

•Acquisition and construction: Enter costs into the 'Acquisition and construction' category if you want to participate in the WIF-Construction program. The WIF-Construction program offers subsidized interest for all construction costs, including planning, acquisition, design, and construction.

•Excess Capacity: Enter costs into the 'Excess capacity' category if you want to participate in the State Participation program. State Participating funding offers partial interest and principal deferral for the incremental cost of project elements which are designed and built to serve needs beyond 10 years.

•Rural: Enter costs into the 'Rural' category if you want to participate in the Rural areas funding program. Rural areas funding offers grants and 0% interest loans for service areas which are not in a Metropolitan Statistical Area (MSA) and in which the population does not exceed 5,000. The service area must also meet the EDAP eligibility criteria.

•Disadvantaged: Enter costs into the 'Disadvantaged' category if you want to participate in the Economically Distressed Areas Program (EDAP). EDAP offers funding through grants and loans for service areas within a project which meet the EDAP eligibility criteria. Eligibility for the TWDB's EDAP requires that the median household income of the area to be served by the proposed project be less than 75 percent of the Texas median household income ($39,927), as shown in the 2000 Census. EDAP eligibility also requires adoption of Model Subdivision rules by the appropriate planning entities.

194 - DRILL ADDITIONAL GROUNDWATER WELL **$8,218,000.00**

Planning, design, permitting	Cost:		Year:	
Acquisition and contruction	Cost:		Year:	
Excess Capacity	Cost:		Year:	
Rural	Cost:		Year:	
Disadvantaged	Cost:		Year:	
	Total:			

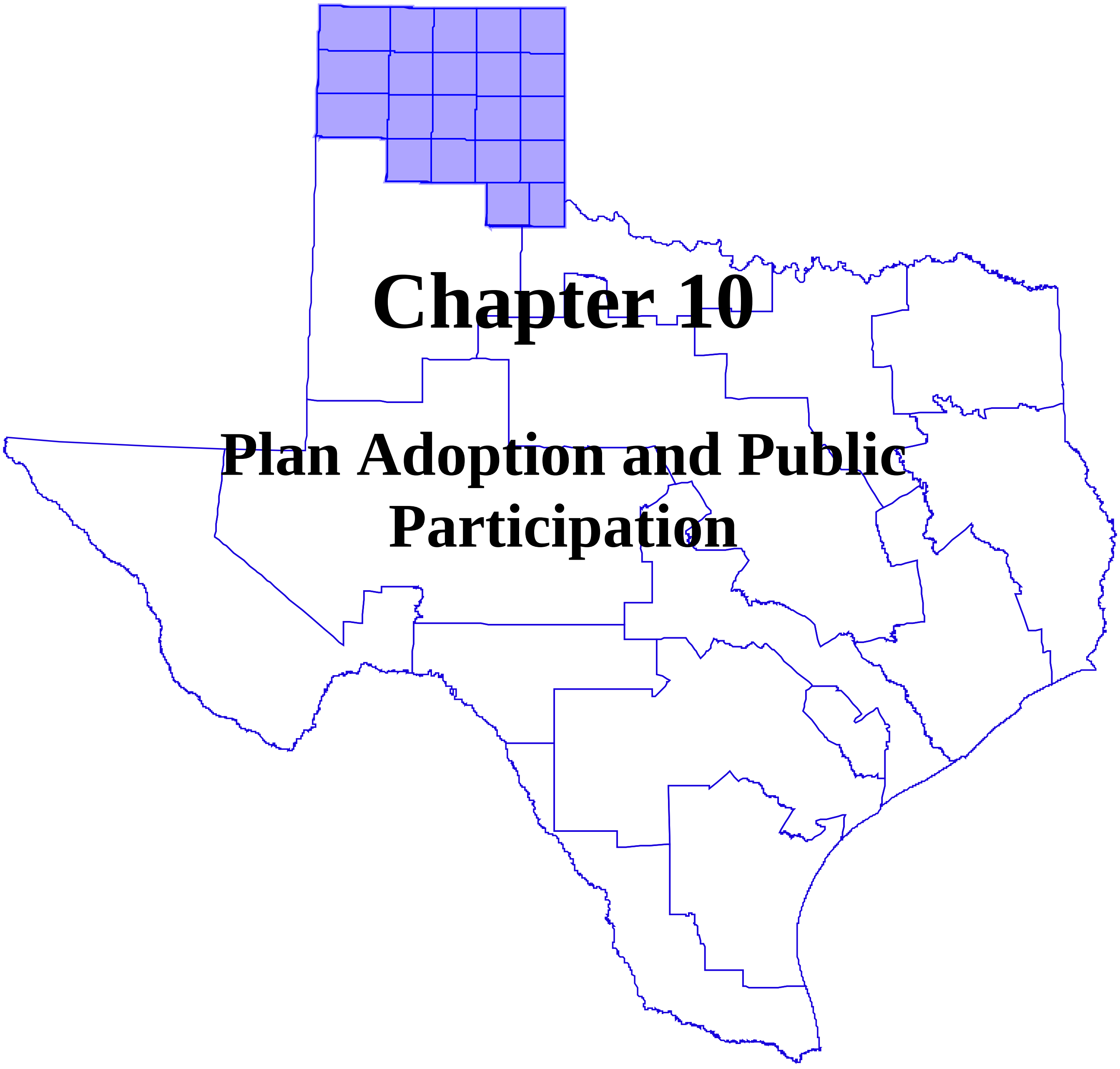
Infrastructure Financing Survey Report

Section 3: Contact Information

1. Name: ______________________
2. Phone Number: ______________________
3. Email: ______________________
4. Comments ______________________

Chapter 10

Plan Adoption and Public Participation



Plan Adoption and Public Participation

The first purpose of this chapter is to describe 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 second purpose of this chapter is to detail the plan adoption process followed by the PWPG. The process explains the required hearing, receipt of comment, 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 (1997), updated with SB2 (2001), and under the requirements of SB3 (2007). The enabling legislation and subsequent 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. The following lists the twelve interest groups represented by the 22 voting members of the PWPG:

General Public
Counties
Municipalities
Industrial
Agricultural
Environmental
Small Business
Electric Generating Utilities
River Authorities
Water Districts
Water Utilities
Higher Education (added interest group)

Table 10-1 lists the voting members of the PWPG, their respective interest groups, and their principle county of interest. Table 10-2 lists the seven former members of the PWPG who also participated in the planning process. 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

PWPG Member	*Interest Group*	*County of Interest*
Janet Guthrie	General Public	Hemphill
Vernon Cook	Counties	Roberts
Emmett Autrey	Municipalities	Potter/Randall
David Landis	Municipalities	Ochiltree
Bill Hallerberg	Industrial	Potter
Denise Jett	Industrial	Hutchinson
Ben Weinheimer	Agricultural	Region
Kendal Harris	Agricultural	Collingsworth
Janet Tregellas	Agricultural	Lipscomb
Joe Baumgardner	Agricultural	Collingsworth
Dr. Nolan Clark	Environmental	Potter/Randall
Grady Skaggs	Environmental	Oldham
Cole Camp	Environmental	Potter/Randall
Rusty Gilmore	Small Business	Dallam
Gale Henslee	Electric Generating	Utility Region
Jim Derington	River Authorities	Hansford
Steve Walthour	Water Districts	Moore
C.E. Williams	Water Districts	Carson
John Williams	Water Districts	Hutchinson
Tom Baliff	Water Districts	Childress
Charles Cooke	Water Utilities	Hutchinson
Dr. John Sweeten	Higher Education	Region

Table 10-2. Panhandle Water Planning Group - Former Members

PWPG Member	*Interest Group*	*County of Interest*
Dan Coffey	Municipal	Potter/Randall
Rudie Tate	Agriculture	Collingsworth
B.A. Donelson	Agriculture	Sherman
Inge Brady	Environmental	Potter/Randall
Bobbie Kidd	Water Districts	Donley
Jenny Pluhar	Environmental	Potter/Randall
John Schmucker	Agriculture	Moore County

In addition to the 22 voting members, the PWPG has six ex-officio positions in accordance with the appropriate regulations governing the process. Table 10-3 lists the six ex-officio positions on the PWPG and their respective interests:

Table 10-3. Panhandle Water Planning Group Ex-Officio Positions

PWPG Member	*Ex-Officio Position*	*Interest Group*
Virginia Sabia	Texas Water Development Board	TWDB (Rules)
Steve Jones	Texas Department of Agriculture	TDA (Rules)
Robert Kincaid	Region B Liaison	Region B
Kent Satterwhite	Region O Liaison & 357.4G4	Water Districts
Mickey Black	USDA/NRCS	Agricultural
Charles Munger	Texas Parks & Wildlife Department	TPWD (Rules)

10.1.1 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. These efforts are spearheaded by the Public Participation Committee chaired by Judge Vernon Cook, Roberts County. Committee members are Charles Cooke, Janet Tregellas, Dr. John Sweeten, Kent Satterwhite, Kendal Harris, Bill Hallerberg, Jim Derington, and Cole Camp. Participation in the Regional Water Planning Effort by local entities and the public was excellent throughout the process. Public Participation opportunities were afforded to the region through the following broad categories. The Committee targeted efforts towards public involvement in the following broad categories:

• Special Regional Water Planning Presentations – Working primarily through the Panhandle Regional Planning Commission (PRPC), the PWPG provided speakers to interest groups throughout the planning process. PWPG members also provided presentations to various civic organizations throughout the planning process. Presentations were given throughout the region and no invitations to speak were declined.

• Media – Media throughout the region were provided notification of all Planning Group activities. Media outlets participated in various planning activities throughout the process, with Planning Group 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.

• Electronic Communication – Web Access to Planning Information - The PWPG has developed and placed on-line a dedicated project website. The site, www.panhandlewater.org, has been available to the public 24 hours a day since June of 1999. The site is updated on a regular basis and provides the general public with quick, reliable access to planning data at any time. A comprehensive website redesign was completed in Fall of 2009 to make accessing PWPG documents easier.

• 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 Panhandle 20/Twenty, The High Plains Irrigation Conference, The Ogallala Aquifer Program Workshop, County Extension Agent Trainings, 4H, Lions Clubs, Texas Panhandle Groundwater Workshop in Borger, Retired School Administrators Association, Texas A&M University Graduate Program, and other public forums.

• Required Public Meeting – One public meeting was conducted to solicit input and comments on the scope of work for development of the updated regional water plan. This meeting was held in Amarillo at the PRPC office on April 16, 2008.

• Required Public Hearing – One formal hearing was conducted during the planning process to present and review the Initially Prepared Plan to the Region on April 28, 2010. An excess of 30 people were in attendance of this public hearing.

• Panhandle Water Planning Group Meetings – The PWPG conducted 12 meetings. While most meetings were held in Amarillo at the offices of the PRPC, meetings were also conducted in Plainview, Texas to focus on joint-planning with Region O. Sub-groups of the PWPG met 13 times throughout the planning process. All meetings of the PWPG are conducted as open meetings and public attendance has been as high as 50 plus people at one time.

10.2 Public Participation Activities

Specific details on public participation activities conducted during the Regional Water Planning Process are summarized and detailed in this section.

10.2.1 Special Regional Water Planning Presentations

Special Regional Water Planning Presentations – PWPG members delivered numerous presentations to various interest groups throughout the region. The scope and content of these presentations was tailored specifically to each unique interest group. In order to accurately document that special presentations are reaching the appropriate interests, presentations were tracked by category to ensure that the public outreach activities being conducted are achieving maximum effectiveness. To this end, special presentations have been broken down and analyzed in the following specific categories: Civic Groups; Special Interest Groups; Agricultural Groups; and Government Entities.

A. Civic Groups:

This category is comprised of traditional civic clubs, organizations, and other similar entities. Organizations of this nature provide an excellent vehicle to reach a broad segment of the general public in each particular location. Examples of organizations in this category include Rotary Clubs, Lions Clubs, Kiwanis Clubs, and Chambers of Commerce.

B. Agricultural Groups:

The largest single water user group in the PWPA is the Agricultural sector, which accounts for approximately 91% of all water used. The PWPG felt that outreach to this segment was vital to ensure that the plan adequately addressed all issues and protected all interests. In order to reach the agricultural sector, the PWPG targeted ag-specific groups for special presentations.

C. Government Entities:

A key focus of SB1 was on municipal water use, the PWPG also undertook an effort to reach those entities with specific responsibility to provide water for municipal use.

10.2.2 Media Events and Coverage

Media Events: The PWPG has since its inception in 1997 held a commitment to communicate with and be available to the local media. While media coverage of the regional water planning process has declined with each cycle of planning, it is advantageous to continue receiving both print and video news coverage. The detail below lists several of the many media avenues enjoyed by the PWPG. The PWPG would like to specifically thank the many local media outlets which provided excellent assistance and coverage of this effort.

A. Television Coverage of Meetings and Events:

All local television stations were notified of each meeting and were invited to attend. PWPG representatives were on occasion interviewed in association with the regular meetings that were held.

D. Radio Coverage:

Radio coverage of PWPG activities has been greatly appreciated. Several stations throughout the region have provided event notification, including KGNC, KEYE, and KGRO.

E. Newspaper Coverage: Regional newspapers have been a great assistance to the PWPG in providing notice and coverage of events. In addition, the largest regional circulation newspaper, Amarillo Globe News, has provided various feature reports with reporter Kevin Welch attending many PWPG meetings. Smaller newspapers throughout the region have also provided articles, publication notices, and features on water planning. Livestock Weekly regularly included news from PWPG meetings in its articles on state water issues.

10.2.3 Electronic Outreach

Electronic Communications: The PWPG recognizes the importance of electronic communications as a means to keep the public informed and provided with regional planning documents. Accordingly, the PWPG included the development and maintenance of a project website as a public participation goal. The website was developed and placed online in June of 1999 and has been in operation continuously since that time. The website has proved to be an excellent communications tool and has been updated an average of at least twice per month since its inception. Information contained on the website includes general descriptions of the regional water planning process, listings of all PWPG members, regional water demand and projections information, an on-going calendar of events, and a large download section. The download section contains meeting minutes, regional maps, aquifer maps, public presentations, and the current PWPA Regional Water Plan, including public comments, references, appendices, and the Executive Summary. Of recent addition to the site is a comprehensive Groundwater Management Area #1 (GMA 1) link providing meeting notices, minutes, and work documents from the GMA 1. In the fall of 2009 the site was comprehensively updated to make use easier and more user friendly. Additionally, in April of 2010 the site began employing the use of Issuu technology that makes reviewing draft plans and large documents like reading a book online. The website contains links to numerous water-related entities and has produced responses from as far away as Canada. The PWPG's project website is located at www.panhandlewater.org and is served by a comprehensive 2009 Server Upgrade.

10.2.4 Formal Public Hearing and Public Modeling Committee Meetings

Public Hearing and Public Modeling Committee Meetings: The PWPG has conducted a public hearing providing the general public an opportunity to comment on the Initially Prepared Plan and three Public Modeling Committee Meetings at which Groundwater Availability Model (GAM) information was discussed. These meetings have been conducted at key milestones in the process and were designed to keep the region informed and to ultimately solicit input at important junctures in the plan from citizens and stakeholders.

A. Public Modeling Committee Meetings:

On August 7, 2009 the Modeling Committee conducted a public meeting at which the specifications and guidelines to be utilized in the Northern Ogallala GAM for the 2011 Regional Water Plan were outlined. Members of the public were in attendance at this meeting and contributed their insight into the methodology. On November 19, 2009 the Modeling Committee held a public meeting at which the progress on the GAM update and availability modeling was laid out in detail with members and the public commenting to engineers regarding how best to proceed with the GAM for regional water planning. On January 19, 2010 the Modeling Committee met a final time in a public forum to review the finalizing of the 2011 Intera GAM. These meetings dealt with the details of the updates to Northern Ogallala GAM and provided the public an opportunity to comment on the process as it progressed.

B. Public Hearing:

The Public Hearing was conducted on April 28, 2010 to relay information regarding the Initially Prepared Regional Water Plan. The hearing was attended by 30 people including representatives from agriculture, municipal, industrial, and other interest groups from the region.

10.2.5 Surveys

Surveys: In addition to the activities described above, the PWPG also undertook a series of surveys to assist local entities in participating in the planning process.

Throughout the planning process, the PWPG conducted three surveys. The first was to collect information from wholesale water providers regarding historical water use and confirm the projected water use demands and recommended strategies that were used for the 2006 water plan. A second survey was prepared for each identified municipal water user group in the region. The information obtained during this process was used to validate water supply data and to confirm recommended water management strategies as applicable. The third survey conducted by the PWPG was the IFR survey, which targeted the cost associated with meeting the needs as specified in Task 9 Infrastructure Finance Reports. Only wholesale water providers and municipal water users with an identified capital expense were sent an IFR survey.

10.3 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 approximately 1,202 non-reimbursed hours of time. In addition, PWPG members have traveled over 32,700 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 only a very small amount (less than approximately 2,000) 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. Of the 28 members, four are from either state or federal agencies and seven represent entities whose primary responsibilities are water resources. Three members represent entities that provide end-user water. The remaining 14 members do not hold employment with organizations who traditionally provide water to end-users or who are normally involved in water resource management or planning. Appendix L details functions conducted by the PWPG or their committees while Appendix M details the commitment in terms of hours and miles traveled of the PWPG members.

10.3.1 Panhandle Water Planning Group Meetings

Through the 60 month planning process, the PWPG has conducted 12 formal, Planning Group meetings. Attendance at the meetings by the 28 member PWPG (including voting and ex-officio members) has been excellent, with appropriate quorums in attendance far exceeded at all meetings. PWPG meetings have been conducted in Amarillo and Plainview, with the majority of the meetings being held in the office of the political subdivision, the PRPC. Frequency of PWPG meetings has averaged one per five months. The frequency of PWPG meetings has declined from the previous two cycles for two reasons. First, PWPG members have a greater understanding at this point of how to meet planning objectives more efficiently now that they have two cycles of experience. Second, the GMA process has shared some of the responsibility in groundwater modeling and setting desired future conditions. GMA 1 has held over 20 meetings in the same 60 month period and is monitored very closely by PWPG membership with regular reports presented at PWPG meetings.

10.3.2 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.

The PWPG has authorized five active and three standing but non-active committees. The active committees are composed of the Executive Committee, Public Participation Committee, Municipal and Industrial Demands & Projections Committee, Agricultural Demands & Projections Committee, and Groundwater Modeling Committee. The three additional standing committees are the Consultant Selection Committee, Scope of Work Committee, and Contact Committee (local funding). The committee structure as described has been very effective in assisting the Regional Planning Process. Throughout the process, 13 committee meetings have been held, for a frequency of approximately .22 per month.

Appendix N contains a full listing of the PWPG committees and their membership.

10.3.3 Interregional Coordination

As part of the planning process, the PWPG determined that coordination with adjacent Region B and 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.

Further, in 2006 and 2007 three meetings were held in Plainview, Texas where PWPG and Region O members met together to discuss joint planning activities. In both PWPA and Region O's interim studies digital communication options were explored that could improve further interregional coordination.

10.4 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 $63,000 annually in local funds would be needed to cover these costs. Working through the public participation committee, the original formula from the first round of planning was implemented to attempt to 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 almost $340,000 for regional water planning over the 5 year planning cycle. Ninety percent of 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 the plan.

Appendix O contains a full listing of the entities and organizations who voluntarily contributed to the regional planning process.

10.5 Plan Adoption Process

Plan Adoption: In accordance with Texas Administrative Code Ch. 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 final adoption of the completed Regional Water Plan.

10.5.1 Public Hearing

Required Public Hearing: The PWPG conducted the required public hearing on April 28, 2010. The hearing was held at the Texas A&M Research and Extension facility in Amarillo, Texas. All required notifications for the hearing were posted prior to the 30-day cut-off. Over 200 direct mail notices were sent to interested parties, interest groups, agencies, individuals, water rights holders, public utilities, and local officials. Copies of the Initially Prepared Regional Plan were placed in the County Clerks office of each of the 21 counties in the region and were 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 were conducted. Finally, the newspaper of general circulation in each county ran the Hearing Notice over 30 days prior to the Hearing. Attendance at the Hearing totaled over 30 individuals. Oral comments were received at the hearing and written comments were received through Monday, June 28, 2010.

10.5.2 Initially Prepared Plan Adoption

IPP Adoption: The PWPG conducted a formal Planning Group meeting prior to the Public Hearing on February 22, 2010. Twenty-two of the 28 PWPG members (including ex-officio members) were in attendance and the IPP was given unanimous approval for submission to the TWDB.

10.5.3 Response to Comments

Response to Comments: Overall, the PWPG received comments from multiple agencies and individuals regarding the IPP. Comments with draft responses were distributed to the PWPG in July. The PWPG carefully considered the comments and proposed responses at the meeting held in August 2010. Formal responses to all comments were made and were added to the plan as directed by the entire board. Overall, comments received from the public were generally favorable, and many covered items already addressed in relevant sections of the IPP. In addition to the comments from the public, the PWPG also addressed comments provided by the TWDB and the Texas Parks and Wildlife Department on the various plan components in the IPP submission. Comment responses were handled by the entire Planning Group, and approved comments are included in the Regional Water Plan. A summation of the comments received and the approved responses is included in Appendix P.

10.5.4 Final Regional Water Plan Adoption

The PWPG adopted the final Regional Water Plan for the PWPA on August 12, 2010 and approved the same for submission to the TWDB. The Plan was adopted by a unanimous vote.

10.6 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.

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