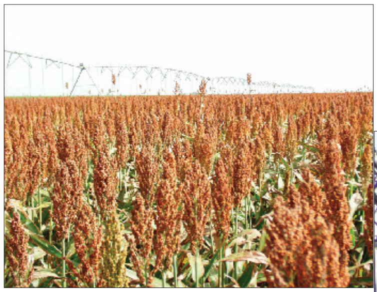


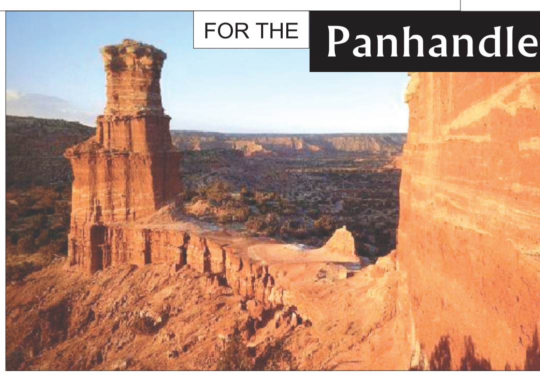
Prepared for:
PANHANDLE WATER
PLANNING GROUP
Amarillo, Texas

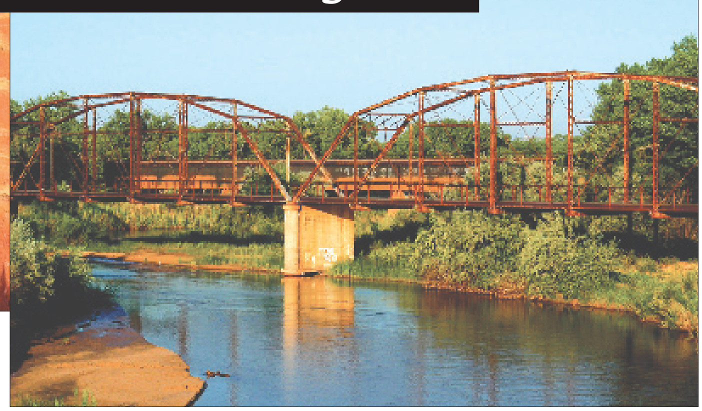
JANUARY 2006
Reissued May 2006

REGIONAL WATER PLAN

FOR THE

Panhandle Water Planning Area





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Panhandle Regional Planning Commission
The Texas Agricultural
Experiment Station
Texas Cooperative Extension
Bureau of Economic Geology

2005 Board Members of Region A Panhandle Water Planning Group and Their Respective Interest Group

C.E. Williams, Water Districts

Richard Bowers, Water Districts

John Williams, Water Districts

Bobbie Kidd, Water Districts

Charles Cooke, Water Utilities

Honorable Vernon Cook, Counties

Dan Coffey, Municipalities

David Landis, Municipalities

Bill Hallerburg, Industrial

Denise Jett, Industrial

Gale Henslee, Electric Generating

Ben Weinheimer, Agriculture

Rudie Tate, Agriculture

Janet Tregellas, Agriculture

B.A. Donelson, Agriculture

Dr. Nolan Clark, Environmental

Grady Skaggs, Environmental

Inge Brady Rapstine, Environmental

Rusty Gilmore, Small Business

Dr. John Sweeten, Higher Education

Jim Derrington, River Authorities

Janet Guthrie, General Public

2005 Ex-Officio Positions of Region A Panhandle Water Planning Group

Temple McKinnon, Texas Water Development Board (TWDB Rules)

Kent Satterwhite, Region O Liaison and 357.4G4 (Water Districts)

Lacy Crow -alternate

Steve Jones, Texas Department of Agriculture (TDA Rules)

Mickey Black, USDA/NRCS (Agriculture)

Bobbie Kidd, Voting Member Region B Liason (Water Districts)

Charles Munger. Texas Parks and Wildlife Department (TPWD Rules)

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). This plan is an update of the 2000 Regional Water Plan for the PWPA.

This plan is developed in accordance with the Planning Guidelines set forth in 31 Texas Administrative Code § 357.7 and all applicable rules. There are ten task chapters: 1 - Planning Area Description; 2 - Population and Water Demand Projections; 3 - Water Supply Analysis; 4 - Water Management Strategies; 5 - Key Parameters of Water Quality and Impacts of Moving Water From Rural and Agricultural Areas; 6 - Water Conservation and Drought Management Recommendations; 7 - Long-term Protection of the State’s Water, Agricultural and Natural Resources; 8 - Unique Stream Segments/Reservoir Sites/Legislative Recommendations; 9 - Report To Legislature on Water Infrastructure Funding Recommendations; and 10 - Key Findings and Recommendations.

1. 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. The economy of the Panhandle is 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. The Panhandle Region has designated eight Wholesale Water Providers:

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

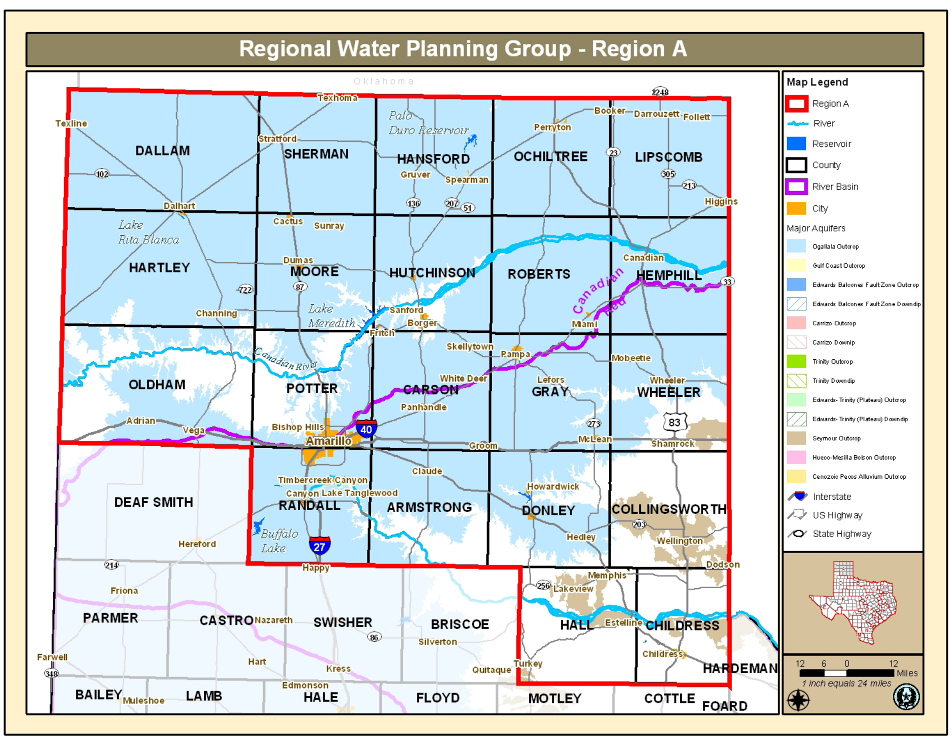


Figure ES-1: Panhandle Water Planning Area

2. Population and Water Demand Projections

In 2000, the region accounted for 1.7% of the state's total population and about 12% of the state's annual water demand. Projections show total water use for the region will decline over the 2000-2060 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. Projections for water demand indicate that total water usage in the PWPA will decrease from 1,943,551 acre-feet in 2000 to 1,435,357 acre-feet in 2060. Dallam County has the highest projected water use of 328,128 acre-feet in 2000 decreasing to 229,497 acre-feet by 2060. Counties with projected increases in demand during the planning period include Potter and Hemphill. The remaining 19 counties are projected to have slight decreases or no significant change in projected water demand during the planning period. The median gpcd consumption for the PWPA is 169 gpcd with a high of 334 and a low of 75 gallons per capita per day.

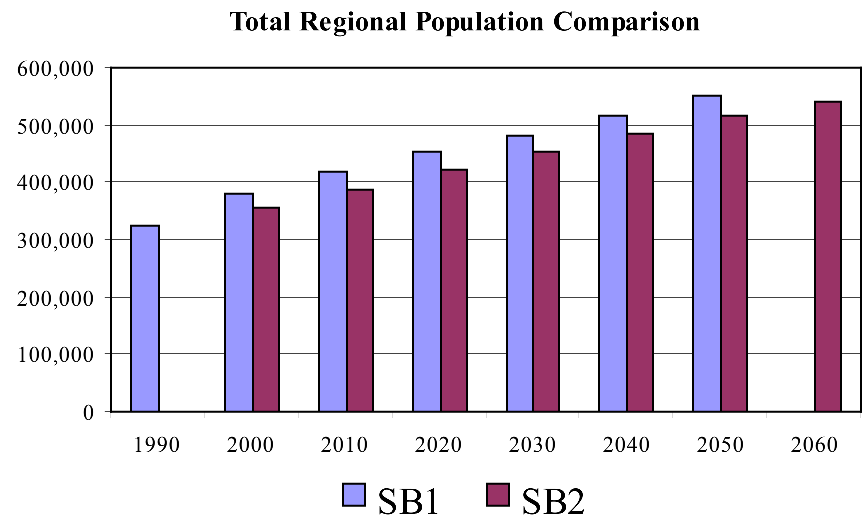


Figure ES-2: PWPA Population

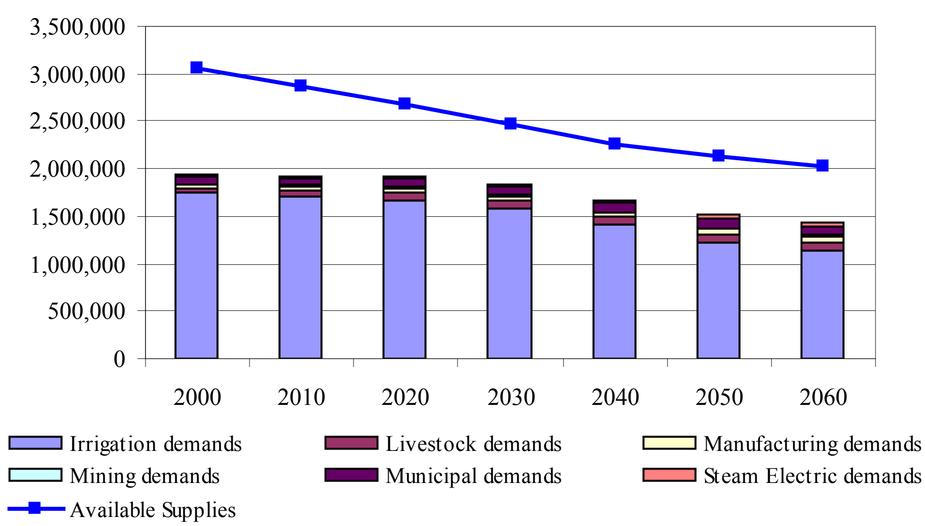


Figure ES-3: Supply and Demands in the PWPA Year 2000 – Year 2060

3. Water Supply Analysis

The PWPA is located within portions of the Canadian River Basin and Red River Basin. In 2000, only 3% of the total water use in the Canadian River Basin portion of the PWPA came from surface water sources. There are three major reservoirs in the Panhandle Region: 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, 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 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.

SB2 and TWDB guidelines require that availability be determined by surface (WAM) and groundwater (GAM) models, unless more site specific information is available. The GAM program, whose development was overseen by the TWDB, completed several groundwater models for both the northern and southern Ogallala aquifer models. In addition, GAM results were included for the Seymour and Blaine aquifers. The Dockum Aquifer GAM is not yet complete and availabilities are taken from a 2003 TWDB report.

Surface water supply available in the region was determined through the WAM of the Red and Canadian Basins which included evaluations of critical drought, water right diversions, and sedimentation rates. The firm yield for Lake Meredith is 69,750 acre-feet per year while the safe yield and available supply is 63,750 AFY. The firm yield of Palo Duro Reservoir is expected to decrease from 4,000 ac-ft in 2000 to 3,750 ac-ft by 2060. The firm yield of Greenbelt Reservoir expected to decrease from 9,170 ac-ft in 2000 to 8,752 ac-ft by 2060.

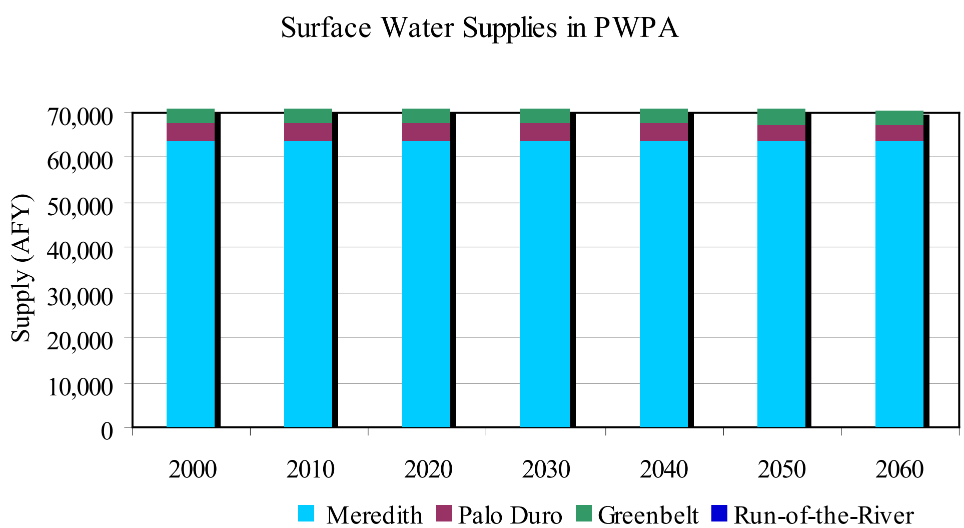


Figure ES-4: Surface Water Supplies in the PWPA

The groundwater management and availability policy for the PWPA is not greater than an annual 1.25% withdrawal of saturated thickness of the source aquifer, with a five-year recalculation of the saturated thickness remaining. All water availabilities from groundwater aquifers stated in this plan follow this management policy. All supplies listed as "available" or "availability" in regards to groundwater refer to this policy adjustment to the supply. The implementation of the policy for projections of water user group demand has resulted in several "overdrafts" of the policy that are shown in the analysis with demand as shortages. These shortages are shown primarily for agricultural uses including irrigated agriculture and livestock water.

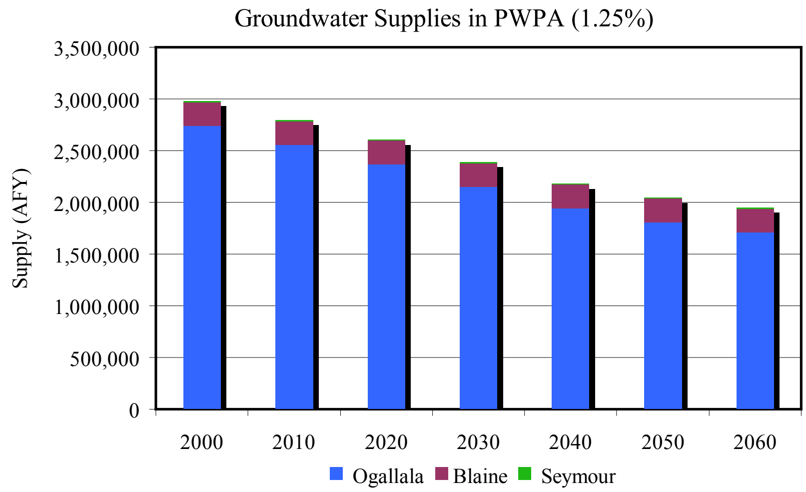


Figure ES-5: Groundwater Supplies in the PWPA

Applying the no greater than 1.25% to all groundwater supplies and accounting for CRMWA supplies for the Panhandle, the available supply exceeds the demands by nearly 1,515,496 acre-feet per year in the year 2000, 984,971 acre feet in 2030, and 956,808 acre feet in 2060. According to the results of the analysis for individual water user groups, there are 11 counties with 43 water user groups with projected water shortages during the planning period. There are eight cities and eight County-Other water users that are projected to experience a water shortage before 2060. The largest shortages are associated with irrigation use, followed by livestock and municipal. There is a regional shortage for Amarillo as a Wholesale Water Providers by 2050.

CRMWA provides drinking water to eight other member cities in the Llano Estacado RWPA and slightly over 30,000 AFY are allocated from Lake Meredith to water users group in PWPA.

Available Region A Water Supply (Acre Feet/year)							
	2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Meredith	63,750	63,750	63,750	63,750	63,750	63,750	63,750
Palo Duro	4,000	3,958	3,917	3,875	3,833	3,792	3,750
Greenbelt	9,170	9,100	9,031	8,961	8,891	8,822	8,752
Run-of-the-River	2,711	2,711	2,711	2,711	2,711	2,711	2,711
Surface	79,631	79,519	79,409	79,297	79,185	79,075	78,963
Ogallala (1.25%)	2,742,363	2,554,993	2,368,555	2,149,118	1,942,964	1,807,340	1,710,821
Blaine	228,750	228,750	228,750	228,750	228,750	228,750	228,750
Seymour	10,750	10,125	9,625	9,625	9,625	9,875	10,000
Dockum	1,821	1,821	1,821	2.057	2,054	2,054	2.054
Ground	2,983,684	2,796,939	2,608,751	2,389,550	2,183,015	2,048,019	1,951,625
TOTAL SUPPLY	3,063,315	2,875,208	2,688,160	2,468,847	2,262,578	2,127,094	2,030,588

Table ES-1: Available Water Supplies in PWPA

Total shortages for all water user groups is projected to be 317,237 acre feet in 2010, increasing to 535,182 acre feet in 2030 and 556,204 acre-feet per year by the year 2060. Of this amount, irrigation represents more than 90% in the 2010 projections and 85% of the total shortage of 2060 with nearly 487,345 acre-feet per year. The shortages attributed to the other water use categories total more than 80,000 AFY in 2060.

For water user groups, the total demands exceed the total available supply by 2010, in large part being attributed to the no greater than 1.25% policy limitation on the supply. 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, such as Palo Duro Reservoir, which could possibly be used for some of the identified shortages. The Ogallala in several counties could be further developed but often the needed infrastructure is not developed, spatial aquifer variability or the potential source is not located near a water supply shortage are factors that limit supply options. Conservation and demand management are an important source for offsetting dependence on expanding supply development. The PWPA considered conservation a priority and in maintaining future supplies.

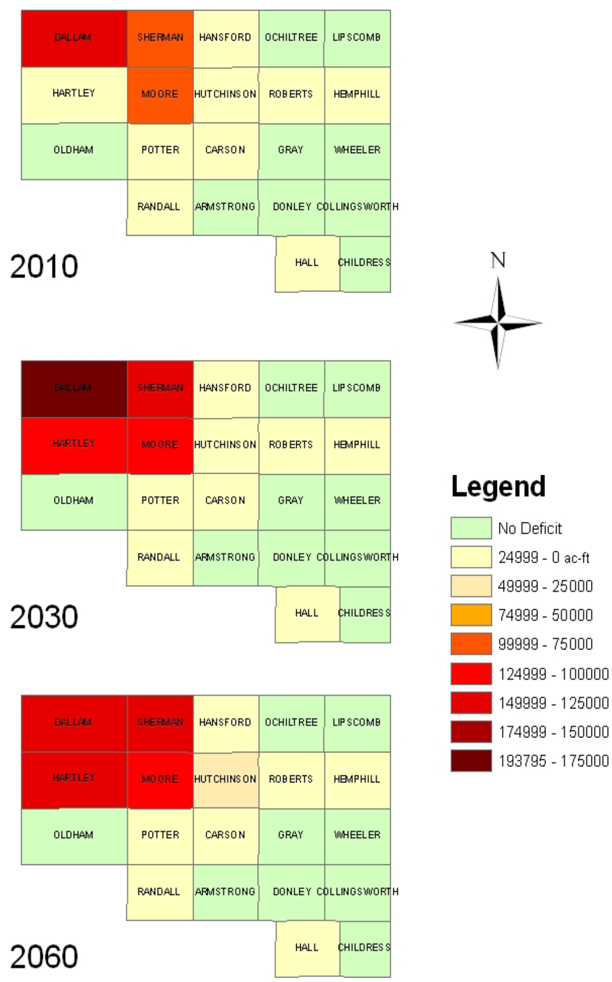


Figure ES-6: Shortages in Region A for Planning Period Year 2010 – Year 2060

4. Water Management Strategies

Water management strategies were developed to meet the water shortages greater than ten acre-feet per year for municipal, manufacturing, livestock 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 43 different water user groups with shortages greater than or equal to 10 acre-feet per year. Most of these shortages are located in the follwoing counties: Dallam, Hartley, Hutchinson, Moore, Potter, Randall, Roberts and Sherman Counties. Strategies were developed for water user groups in the context of their current supply sources, SB1 studies, previous supply studies and available supply within the Region. 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.

5. 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, SB2 requires 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 Panhandle region are generally potable, although Region-wide up to approximately 13% of the groundwater may be brackish. Groundwater quality issues in the region are generally related to elevated concentrations of nitrate (NO3), chloride (Cl), and total dissolved solids (TDS). Sources of elevated NO3 include cultivation of soils, which released soil NO3, and domestic and animal sources – for example, septic tanks and barnyard wastes. 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 and therefore long-term improvements in water quality.

6. Water Conservation and Drought Management Recommendations

The Texas legislature created the Water-Savings Plumbing Fixture Program on Jan. 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. The PWPG chose to only account for plumbing fixture savings on new growth and not on the entire population of the region. The PWPA recommends the implementation of a 1% annual municipal reduction in demand through conservation.

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 provides 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. The PWPA endorses the implementation of the BMPs and the recommendations of all regional conservation and drought management plans.

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

The Panhandle Water Planning Group balanced meeting water shortages with good stewardship of the water, agricultural, and natural resources within the region. The PWPG recommended water conservation as the first strategy applied to meet every projected shortage. In the strategy selection process, the yield and environmental impact of projects were given greater consideration than the unit cost of water. The not greater than 1.25% of saturated thickness availability management policy is 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 any recommendations for new water supply projects or interbasin transfers were considered. Wastewater reuse is a recommended strategy to meet long-term power generation water needs and several other municipal options 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. This plan recommends using not greater than 1.25% of annual saturated thickness within the aquifer as a management option for long-term sustainable management of the aquifers within the PWPA to meet local demands.

8. Unique Stream Segments/Reservoir Sites/Legislative Recommendations

The PWPG considered unique stream segments and reservoir sites but did not make any recommendations for designation.

9. Report to Legislature on Water Infrastructure Funding Recommendations

Municipal infrastructure funding surveys show that $12,606,546 out of a total capital cost of $41,446,464 (30% of the total capital costs) would be paid from local cash reserves, $15,133,705 (37% of the total capital costs) would paid through bonds. $3,651,909 (9% of the total capital costs) would be financed through state or federal government programs, and $241,623 (1% of the total capital costs) would be financed through other means, such as bank loans. The financial needs for the shortages experienced by irrigated agriculture are not known at this time.

10. Key Findings and Recommendations

- All groundwater availability is determined using not greater than an annual withdrawal of 1.25% of the saturated thickness for all aquifers.
- Regional shortages are concentrated in several counties: Dallam, Hartley, Hutchinson, Moore, Potter, Randall, Roberts and Sherman. Most shortages are due to overdrafts of the availability policy for irrigated agriculture.
- Conservation and demand management are encouraged as a priority for protection of all water, natural and agricultural resources.
- IFR survey results show that more than half of the financial need for water infrastructure will be paid through local cash or bonds with variable degrees of state or federal assistance.
- Energy costs are expected to significantly affect near-term irrigation and 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.

ARMSTRONG COUNTY

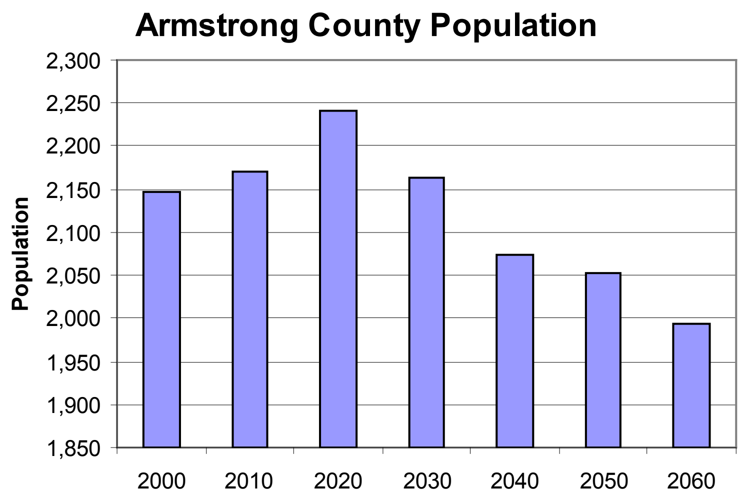
Who are my representatives?

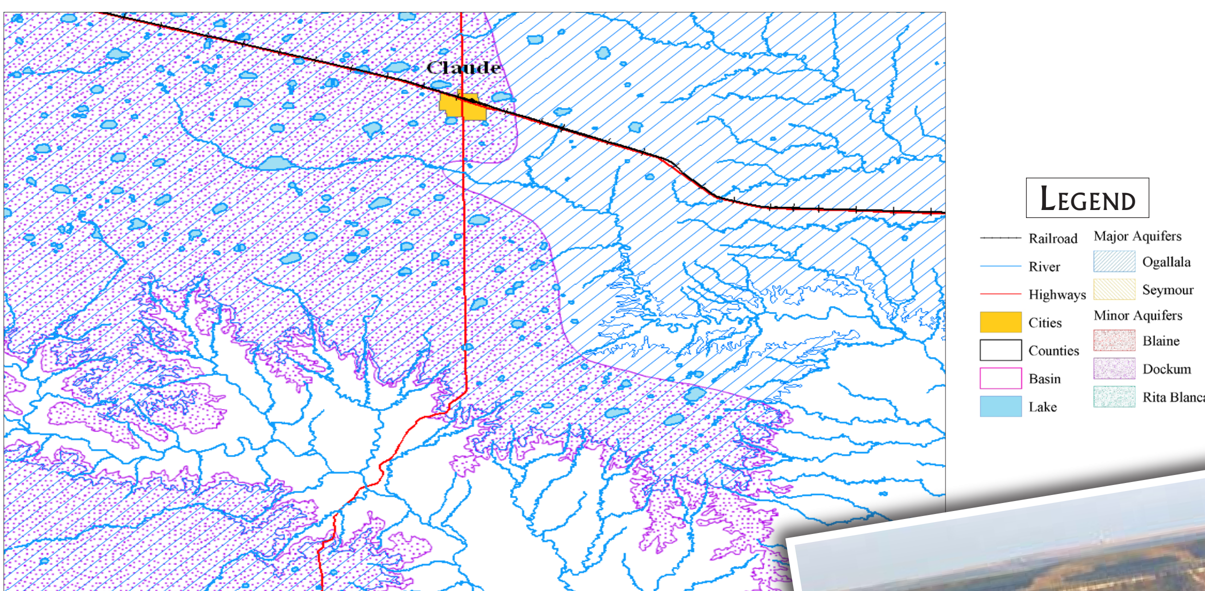
Dr. Nolan Clark - USDA-ARS
John Sweeten - Texas Agricultural Experiment Station
Gale Henslee - Xcel Energy
C.E. Williams - Panhandle GCD

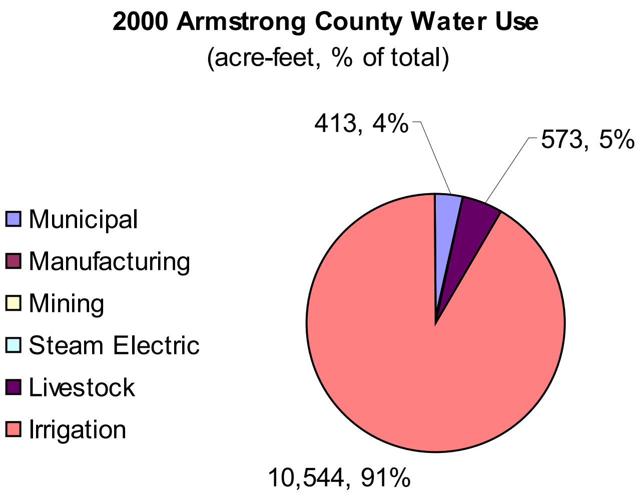
County Seat: City of Claude

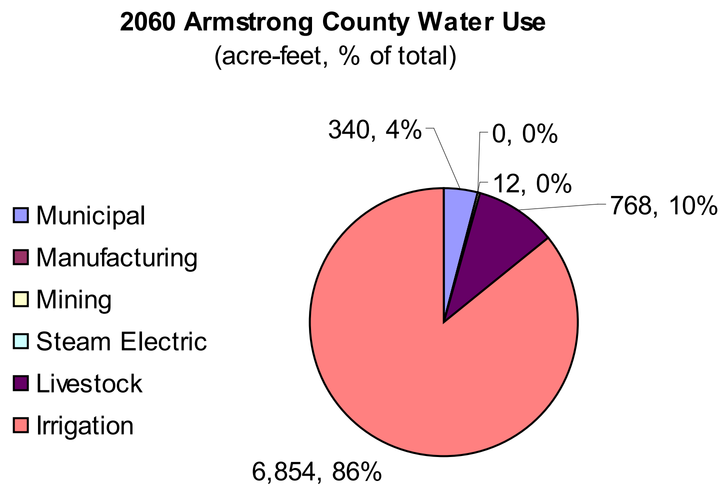
Economy: Agribusiness, tourism

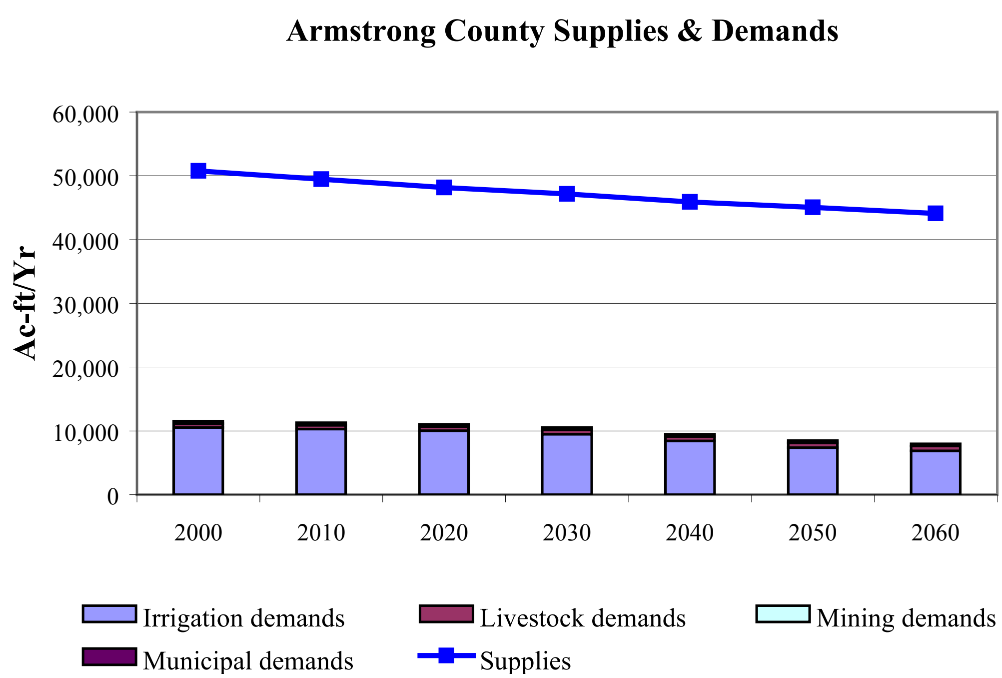
What is the source of my water? Ogallalla, Dockum Aquifers











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

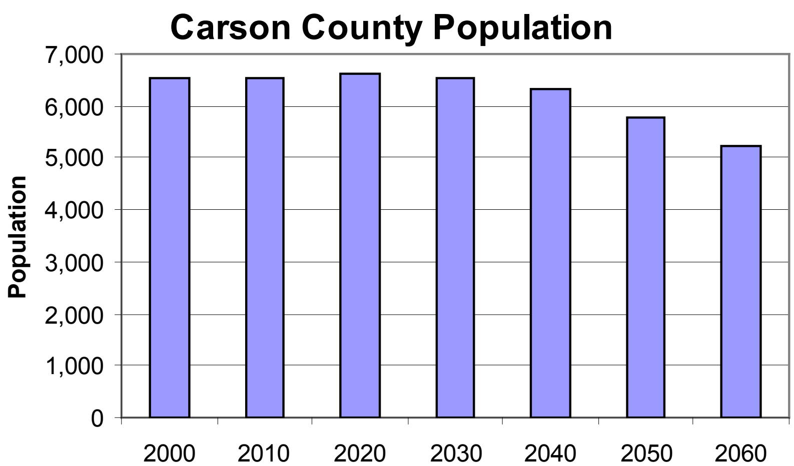
CARSON COUNTY

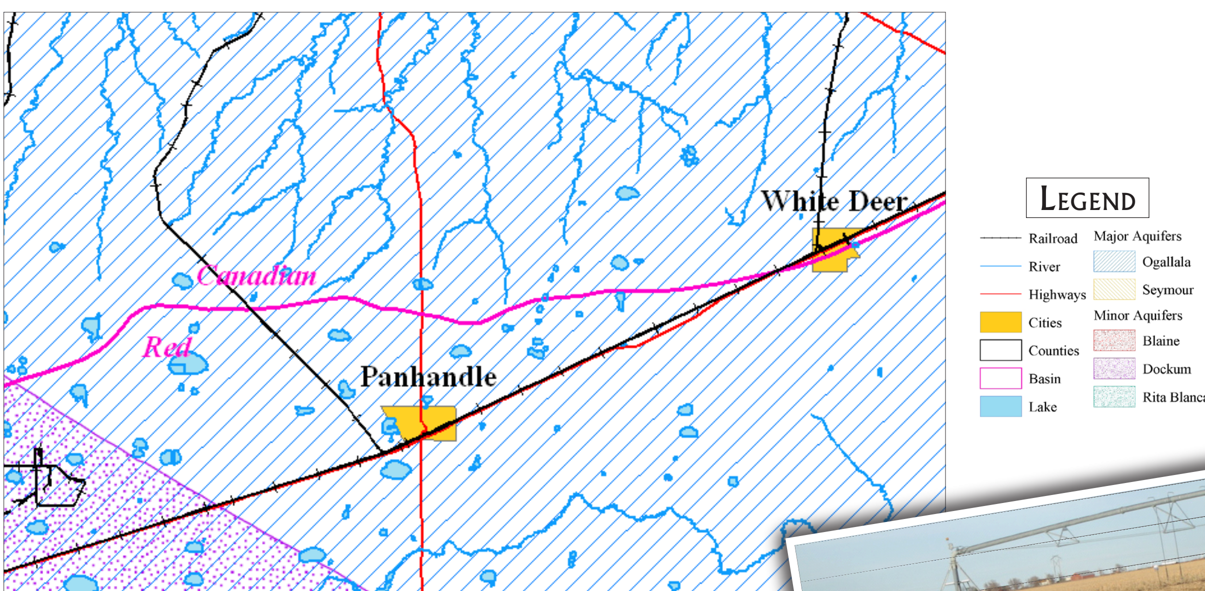
Who are my representatives?
Dr. Nolan Clark - USDA-ARS
Ben Weinheimer - Texas Cattle Feeders Assocation
C.E. Williams - Panhandle GCD
Gale Henslee - Xcel Energy

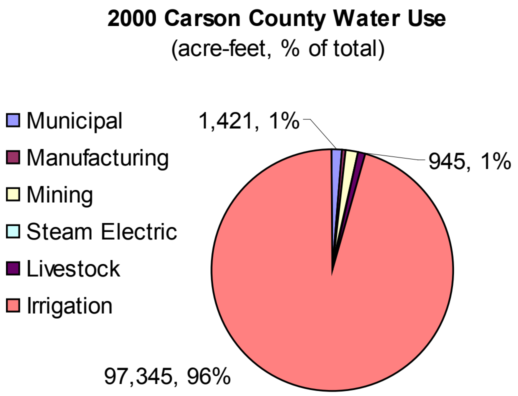
County Seat: City of Panhandle

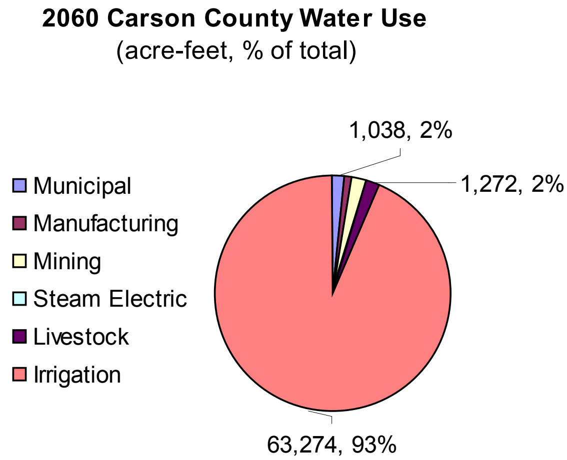
Economy: Agribusiness, Petroleum

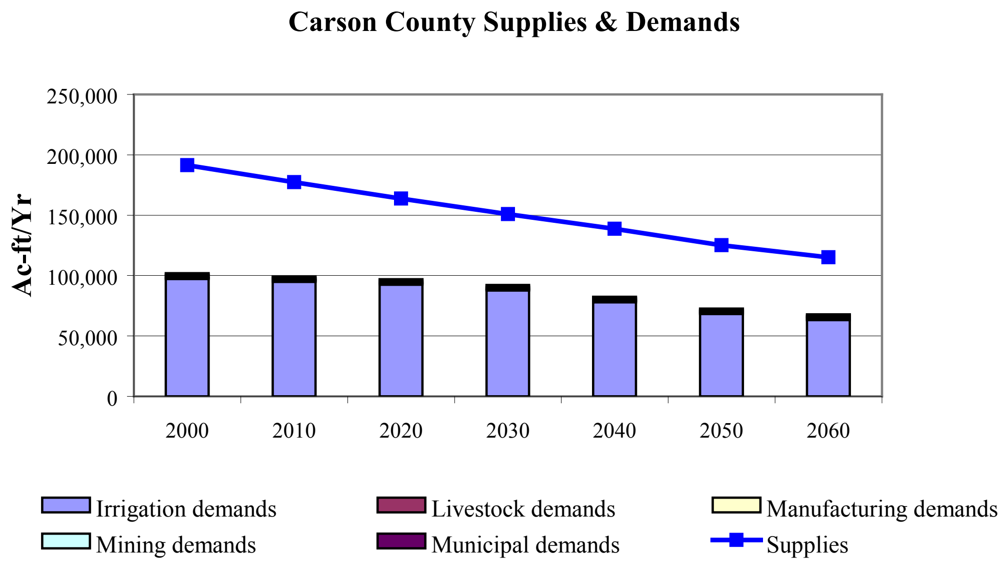
What is the source of my water? Ogallalla, Dockum Aquifers











Shortages for municipal, manufacturing and livestock are due to 1.25% allocations.

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

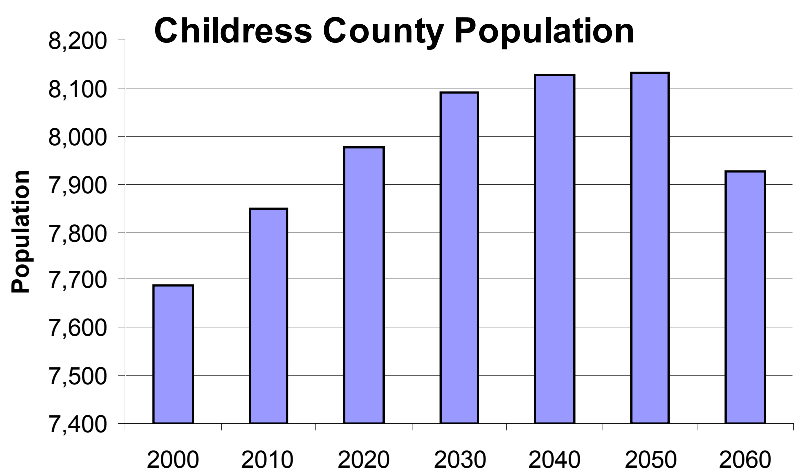
Who are my representatives?

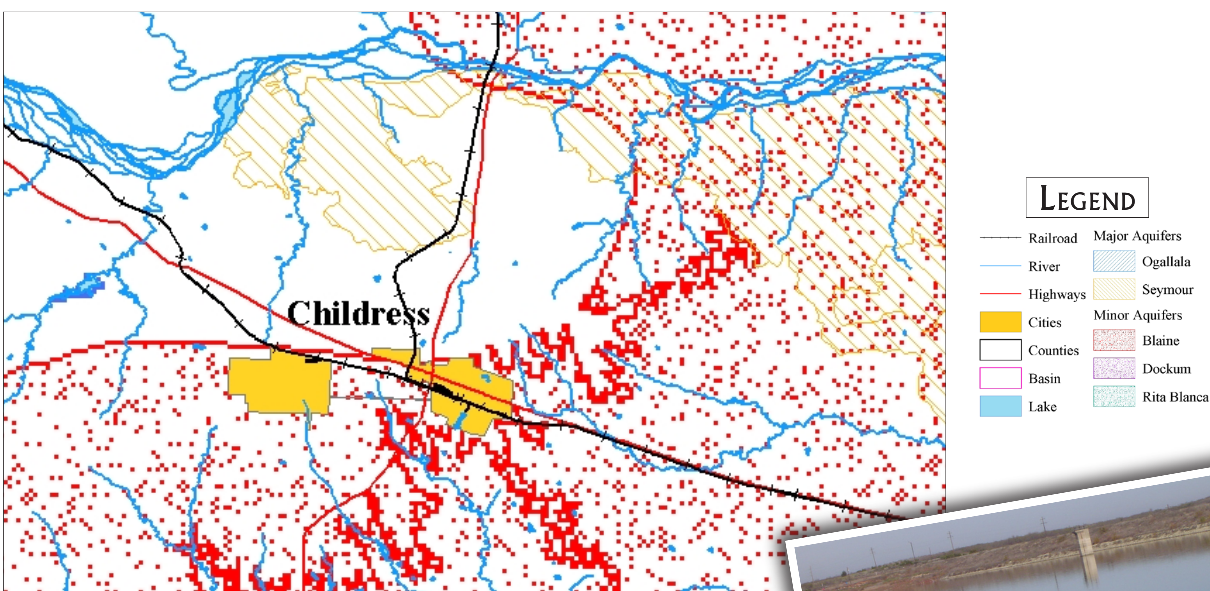
Dr. Nolan Clark - USDA-ARS
John Sweeten - Texas Agricultural Experiment Station
Gale Henslee - Xcel Energy
Bobbie Kidd - Greenbelt M&IWA

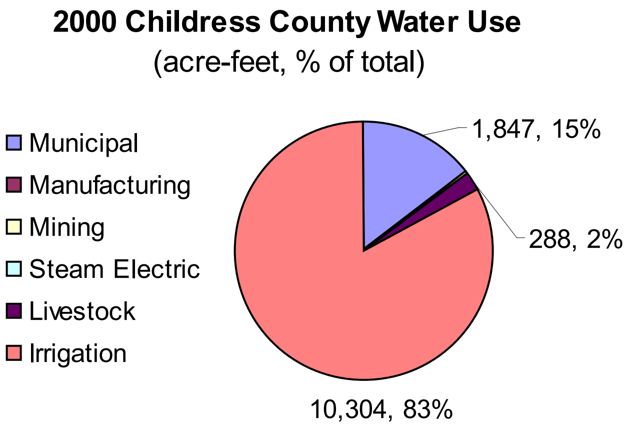
County Seat: City of Childress

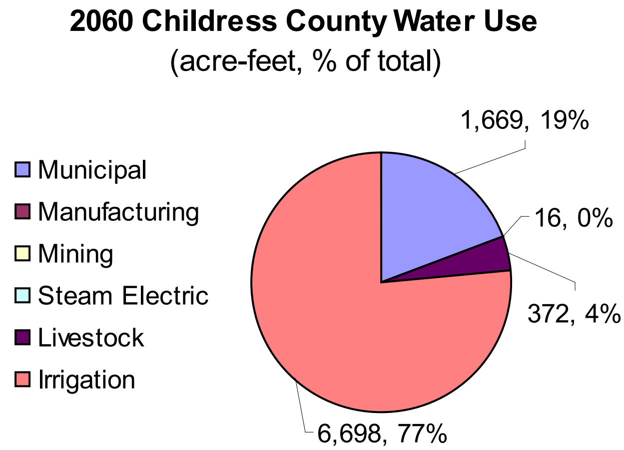
Economy: Agribusiness, Tourism

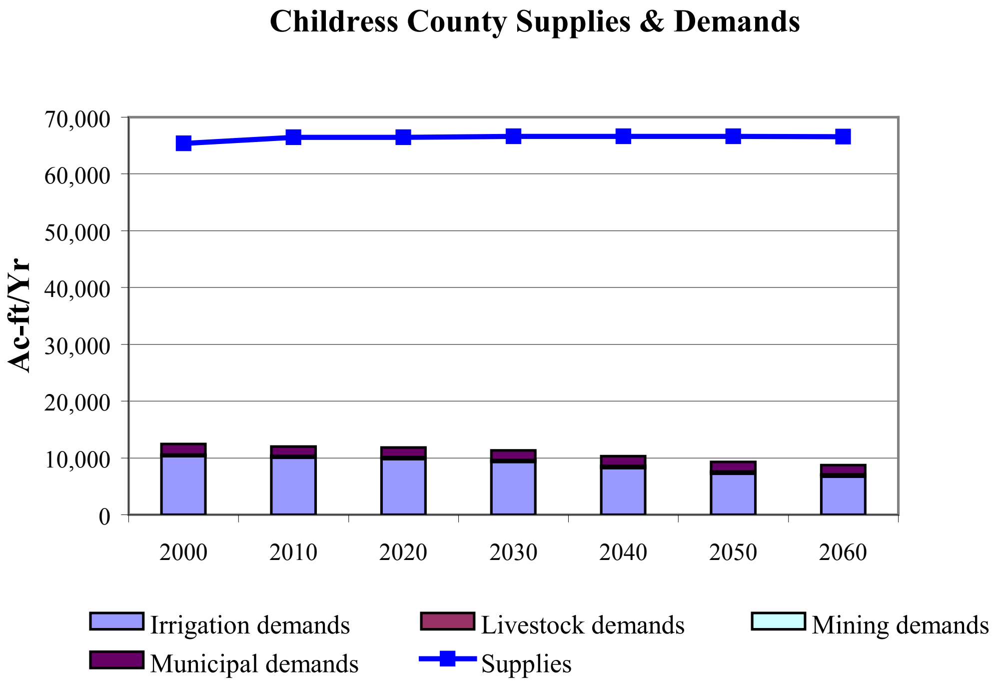
What is the source of my water? Seymour, Blaine Aquifers, Greenbelt Reservoir











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

COLLINGSWORTH COUNTY

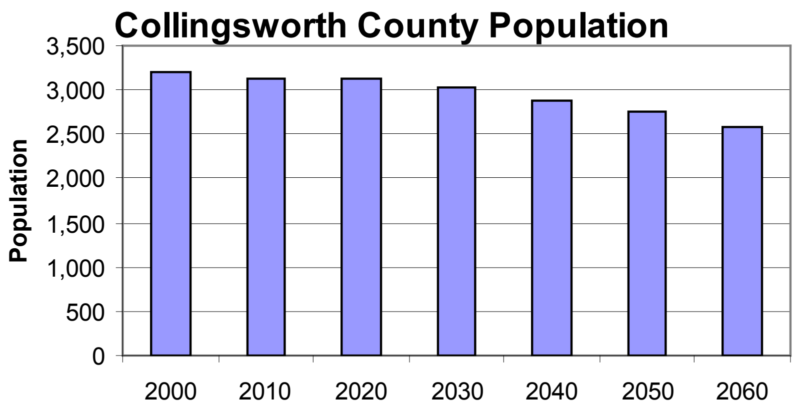
Who are my representatives?

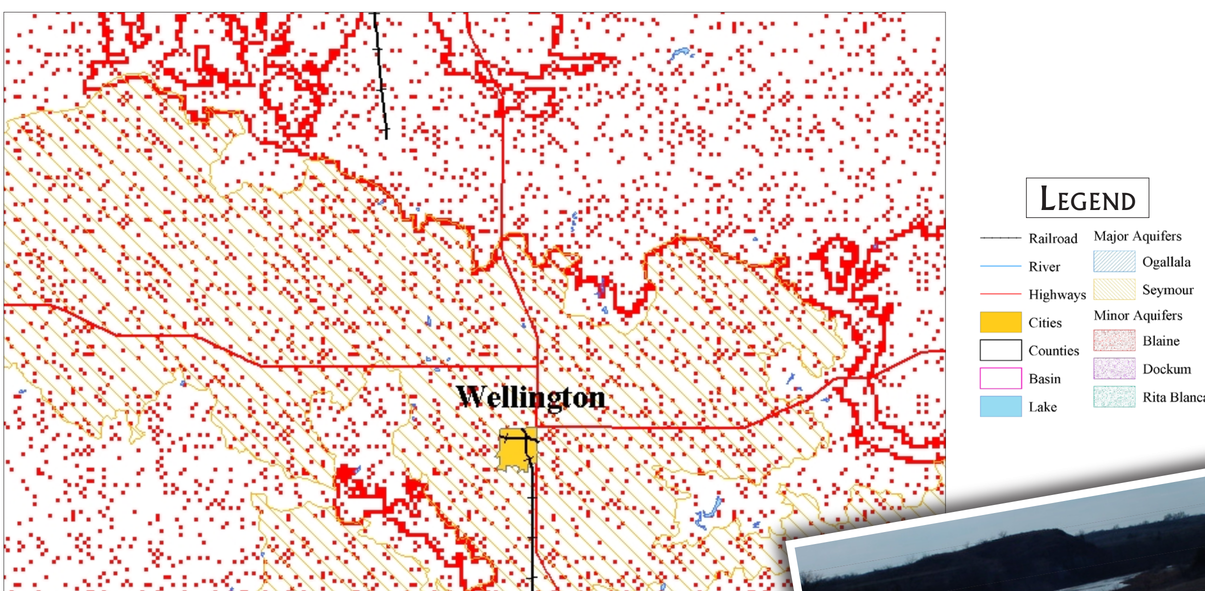
Dr. Nolan Clark - USDA-ARS
Rudie Tate - Farmer
John Sweeten - Texas Agricultural Experiment Station
Gale Henslee - Xcel Energy
Bobbie Kidd - Greenbelt M&IWA

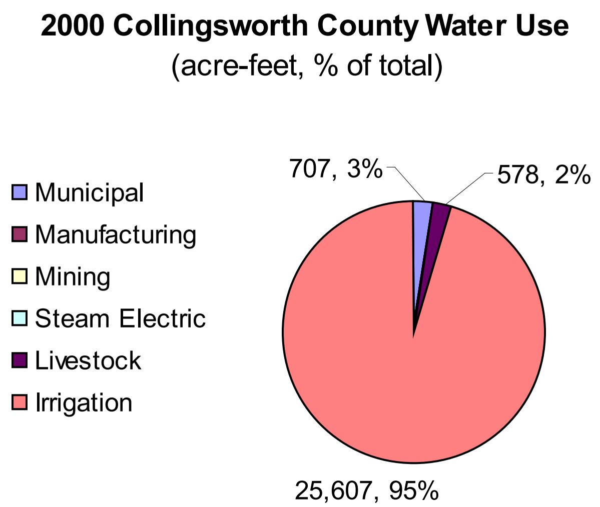
County Seat: City of Wellington

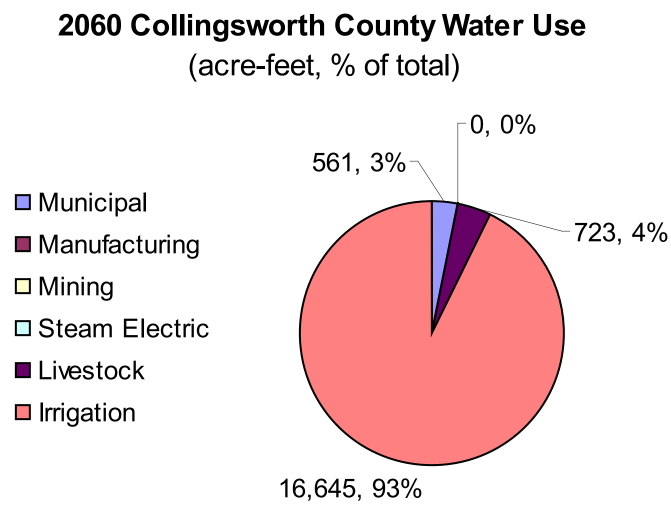
Economy: Agribusiness

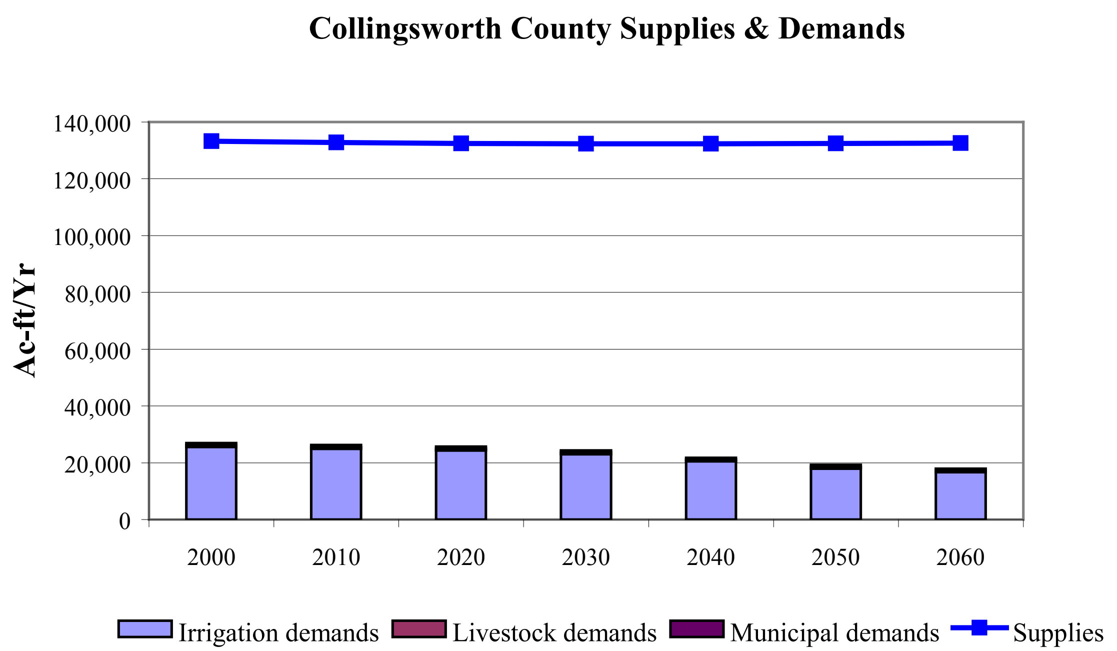
What is the source of my water? Seymour, Blaine Aquifers, Greenbelt Reservoir





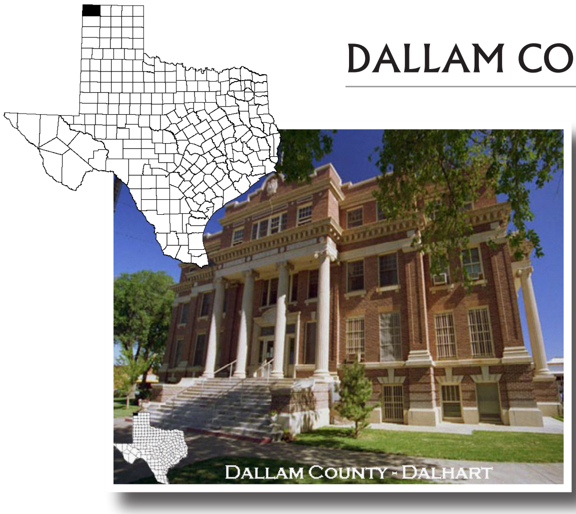






Water User Group	Strategy
Wellington	No Water Shortages Identified
County-Other	No Water Shortages Identified
Irrigation	No Water Shortages Identified
Manufacturing	No Demands In This Category
Livestock	No Water Shortages Identified
Mining	No Demands In This Category
Steam Electric Power	No Demands In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

DALLAM COUNTY



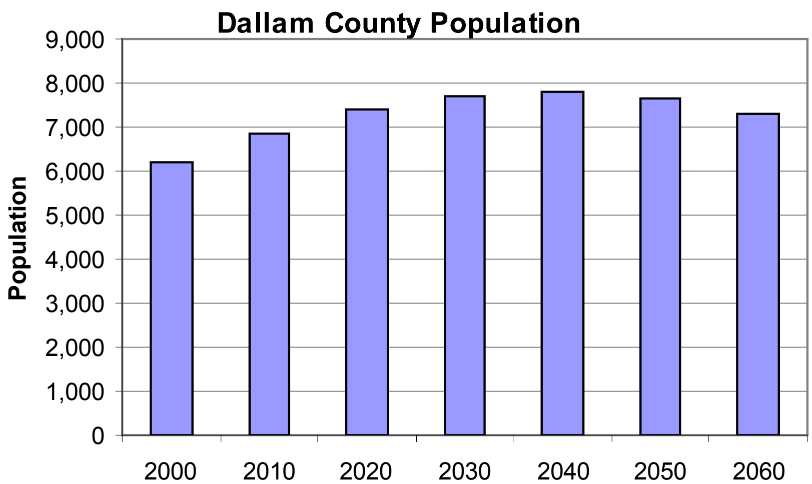
Who are my representatives?

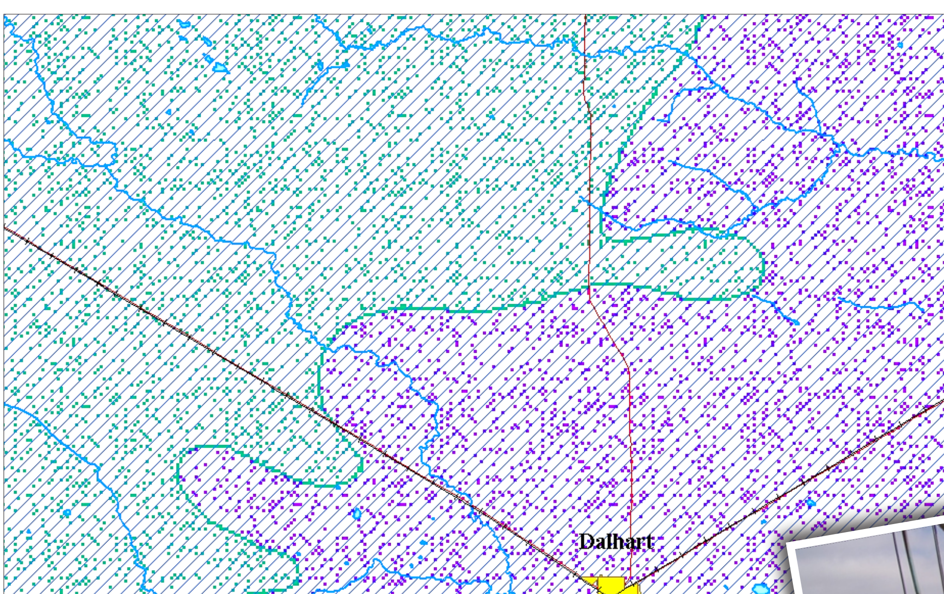
Dr. Nolan Clark	- USDA-ARS
Rusty Gilmore	- Water Well Driller
John Sweeten	- Texas Agricultural Experiment Station
Gale Henslee	- Xcel Energy
Richard Bowers	- North Plains GCD

County Seat: City of Dalhart

Economy: Agribusiness, Manufacturing, Tourism

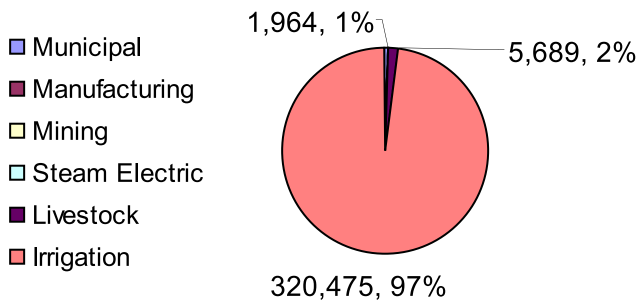
What is the source of my water? Ogallala, Dockum, Rita Blanca Aquifers



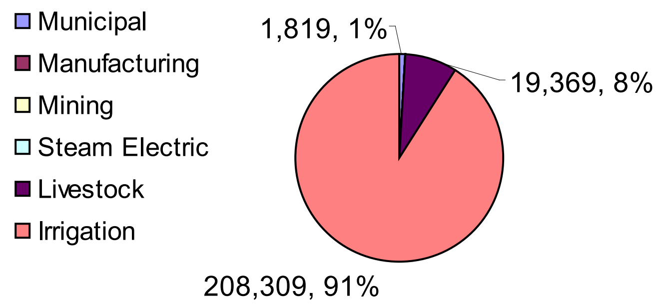


LESA irrigation system in use in Dallam

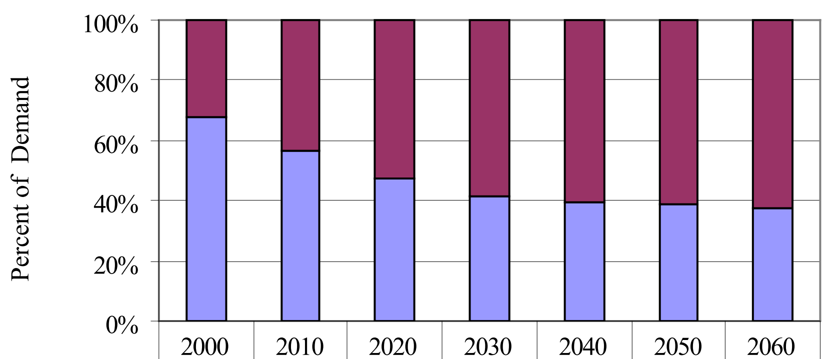
2000 Dallam County Water Use
(acre-feet, % of total)



2060 Dallam County Water Use
(acre-feet, % of total)



Dallam County



	2000	2010	2020	2030	2040	2050	2060
Shortage	106,700	142,303	171,638	180,844	168,655	149,856	143,631
1.25% Available Supply	221,428	184,158	153,048	128,126	108,525	95,487	85,866

1.25% Available Supply ■ Shortage

Water User Group	Strategy
Dalhart	New Groundwater Wells, Conservation
Texline	New Groundwater Wells, Conservation
County-Other	New Groundwater Wells, Conservation
Irrigation	NPET, Improved Irrigation Equipment, Conservation Tillage, Precipitation Enhancement
Manufacturing	No Demands In This Category
Livestock	Voluntary Transfer From Other Users, Conservation
Mining	No Demands In This Category
Steam Electric Power	No Demands In This Category

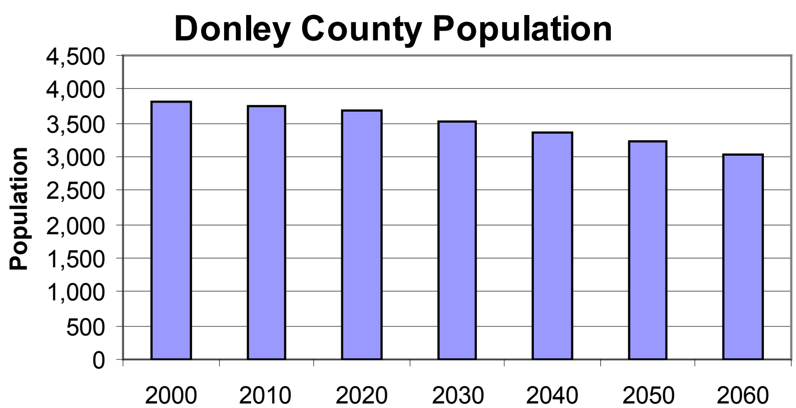
Who are my representatives?

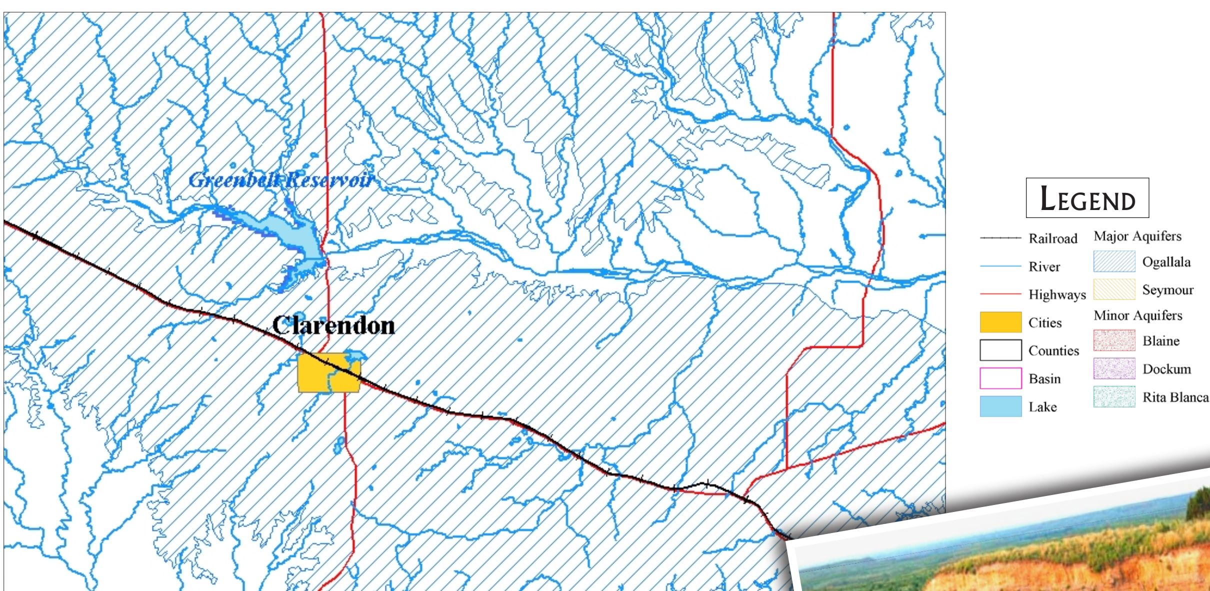
Dr. Nolan Clark	- USDA-ARS
Bobbie Kidd	- Greenbelt M&IWA
John Sweeten	- Texas Agricultural Experiment Station
Gale Henslee	- Xcel Energy
C.E. Williams	- Panhandle GCD

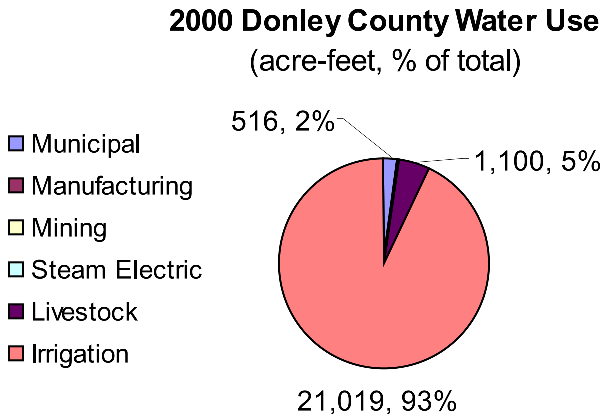
County Seat: City of Clarendon

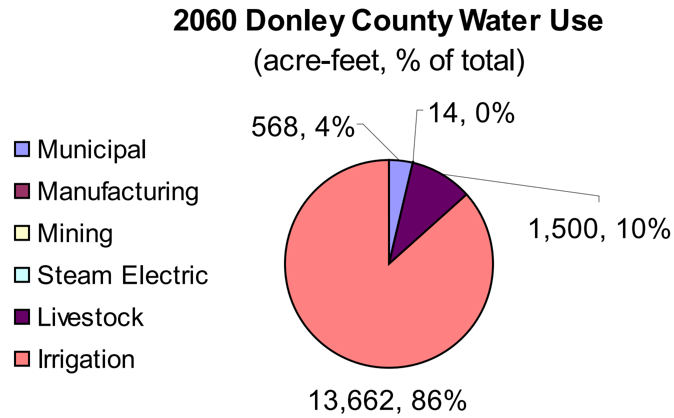
Economy: Agribusiness, Manufacturing, Tourism

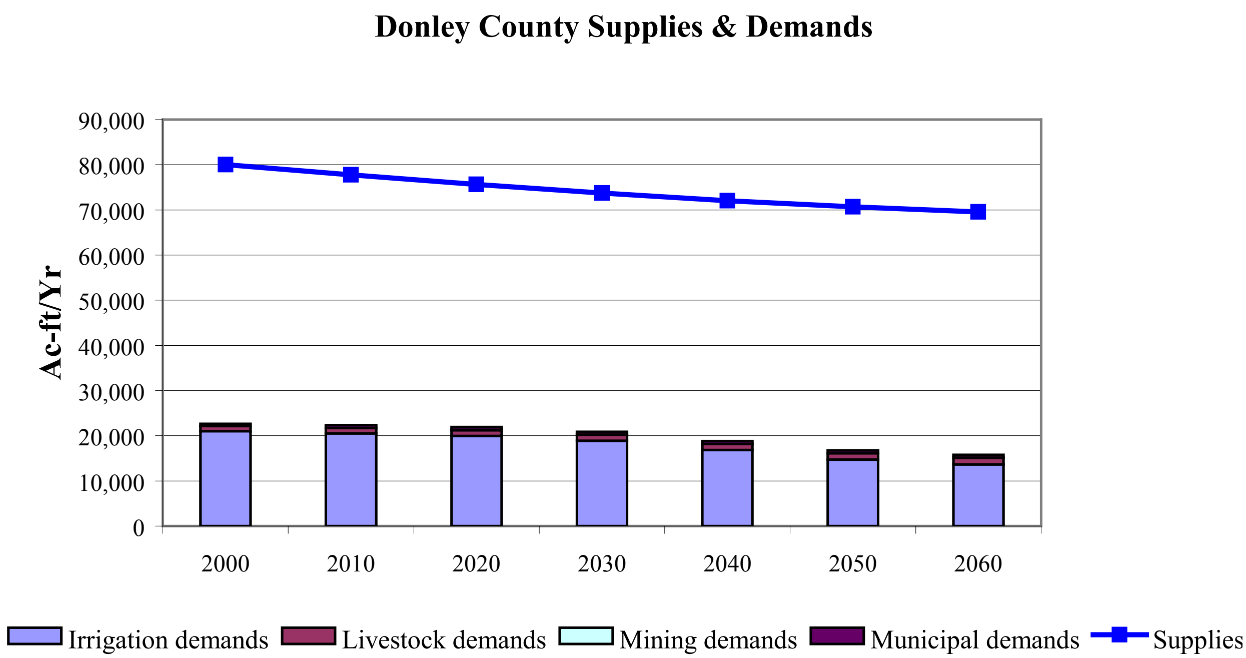
What is the source of my water? Ogallala Aquifer, Greenbelt Reservoir











WATER USER GROUP	STRATEGY
Clarendon	No Shortages Were Identified
County-Other	No Shortages Were Identified
Irrigation	No Shortages Were Identified
Manufacturing	No Demands In This Category
Livestock	No Shortages Were Identified
Mining	No Shortages Were Identified
Steam Electric Power	No Demands In This Category

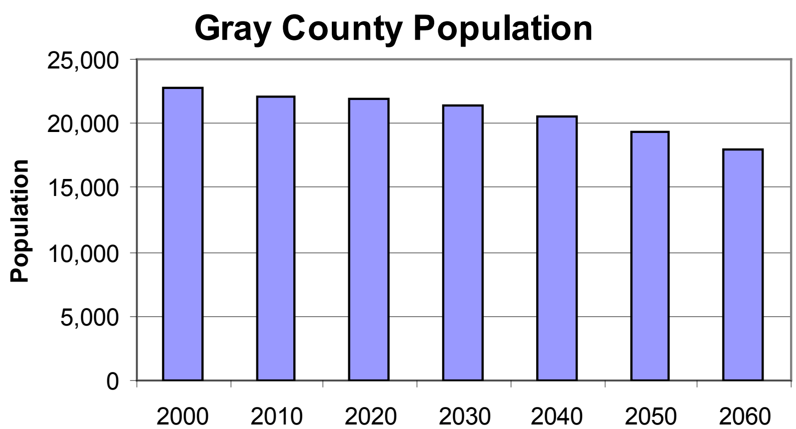
Who are my representatives?

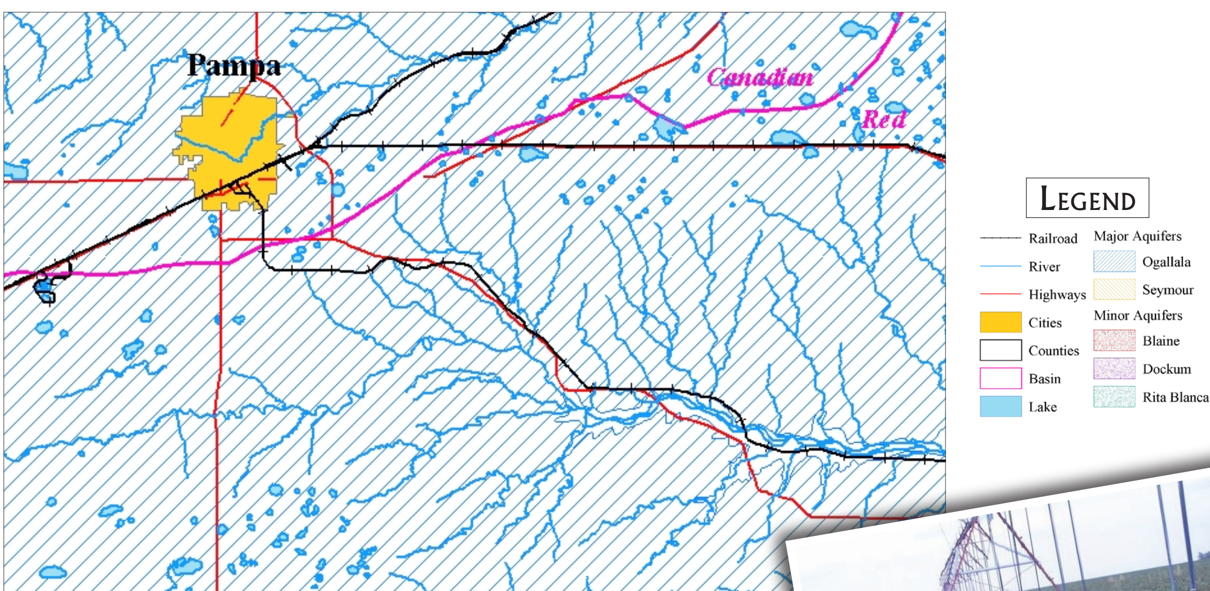
Dr. Nolan Clark	- USDA-ARS
Bill Hallerberg	- Industry
John Sweeten	- Texas Agricultural Experiment Station
Gale Henslee	- Xcel Energy
C.E. Williams	- Panhandle GCD
John Williams	- CRMWA

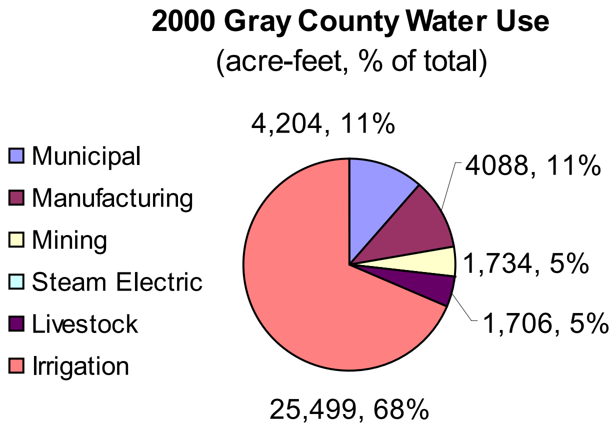
County Seat: City of Pampa

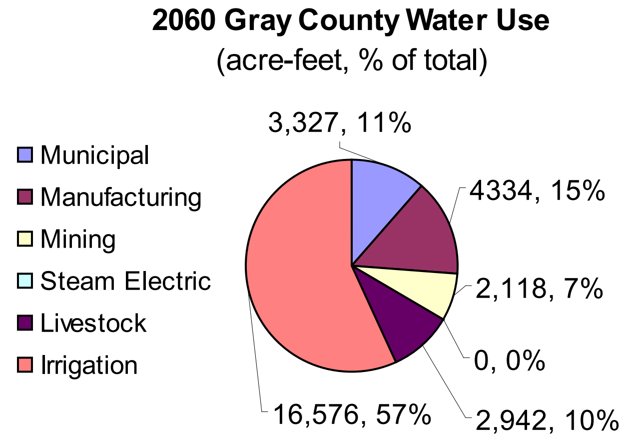
Economy: Agribusiness, Manufacturing, Tourism

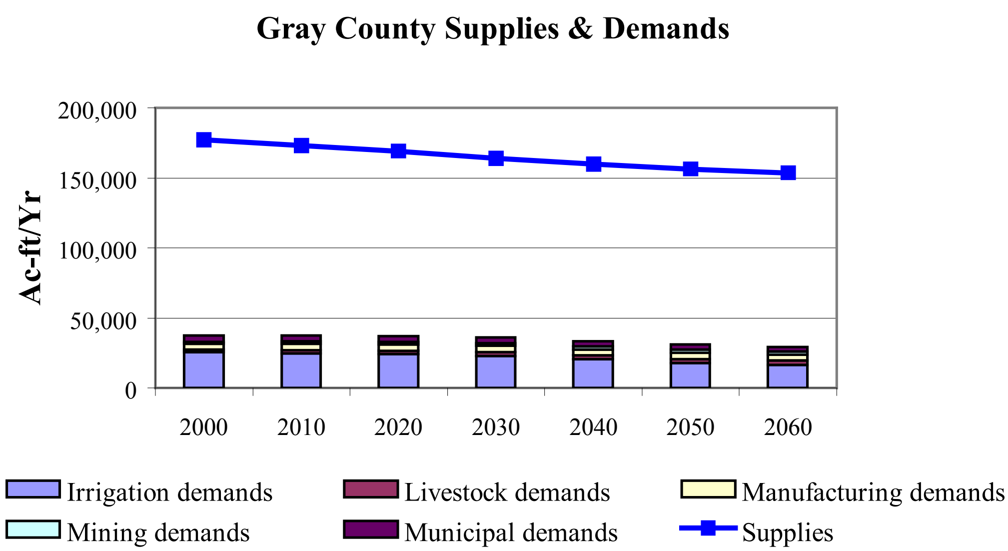
What is the source of my water? Ogallala Aquifer











WATER USER GROUP	STRATEGY
Lefors	No Shortages Were Identified
Mclean	No Shortages Were Identified
Pampa	No Shortages Were Identified
County-Other	No Shortages Were Identified
Irrigation	No Shortages Were Identified
Manufacturing	No Shortages Were Identified
Livestock	No Shortages Were Identified
Mining	No Shortages Were Identified
Steam Electric Power	No Demands In This Category

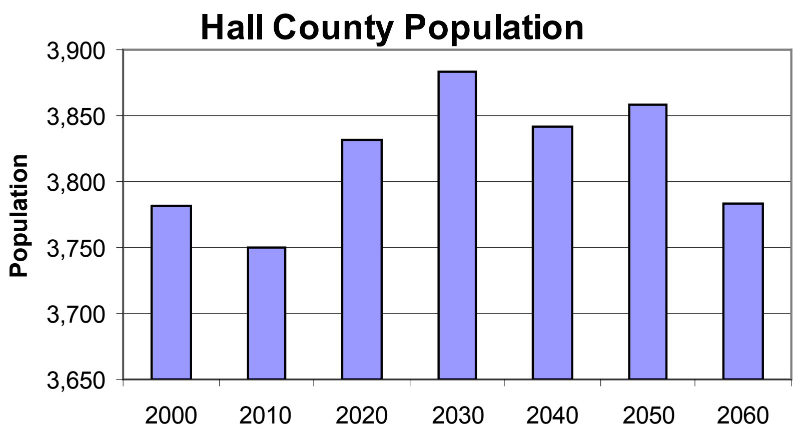
Who are my representatives?

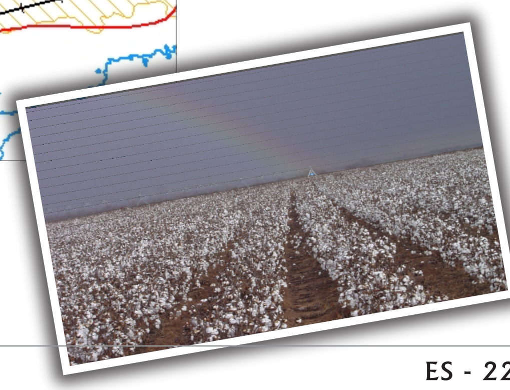
Dr. Nolan Clark - USDA-ARS
John Sweeten - Texas Agricultural Experiment Station
Gale Henslee - Xcel Energy
Bobbie Kidd - Greenbelt M&IWA

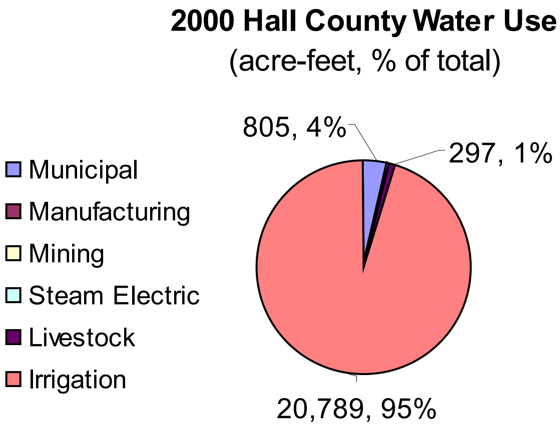
County Seat: City of Memphis

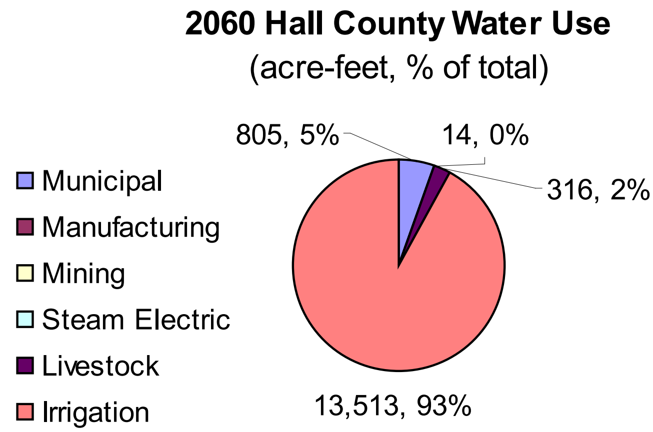
Economy: Agribusiness

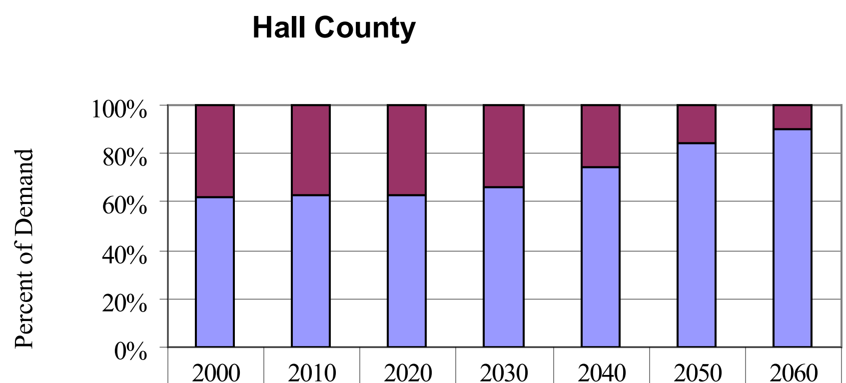
What is the source of my water? Seymour, Blaine Aquifers, Greenbelt Reservoir











	2000	2010	2020	2030	2040	2050	2060
Shortage	8,411	8,010	7,737	6,701	4,626	2,427	1,393
1.25% Available Supply	13,502	13,369	13,148	13,163	13,150	13,277	13,255

1.25% Available Supply Shortage

WATER USER GROUP	STRATEGY
Memphis (Shortage less than 10 AFY)	No Strategy Required
County-Other	No Shortages Were Identified
Irrigation	NPET, Improved Irrigation Equipment, Conservation Tillage, Precipitation Enhancement
Manufacturing	No Demands In This Category
Livestock	No Shortages Were Identified
Mining (Shortage less than 10 AFY)	New Groundwater Wells, Conservation
Steam Electric Power	No Demands In This Category

HANSFORD COUNTY

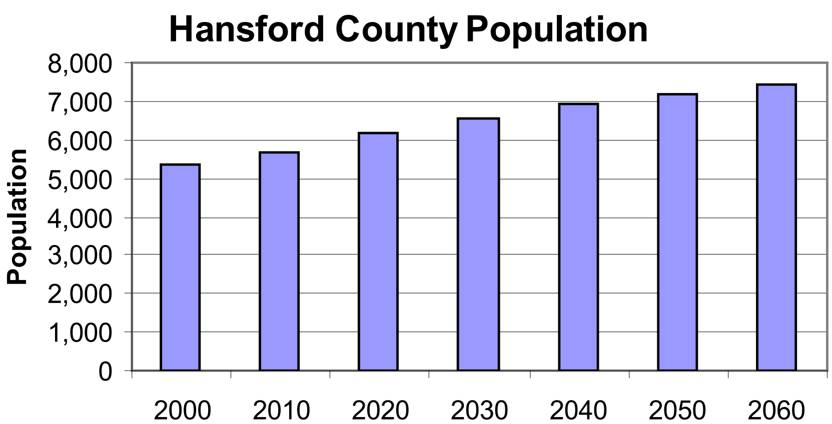
Who are my representatives?

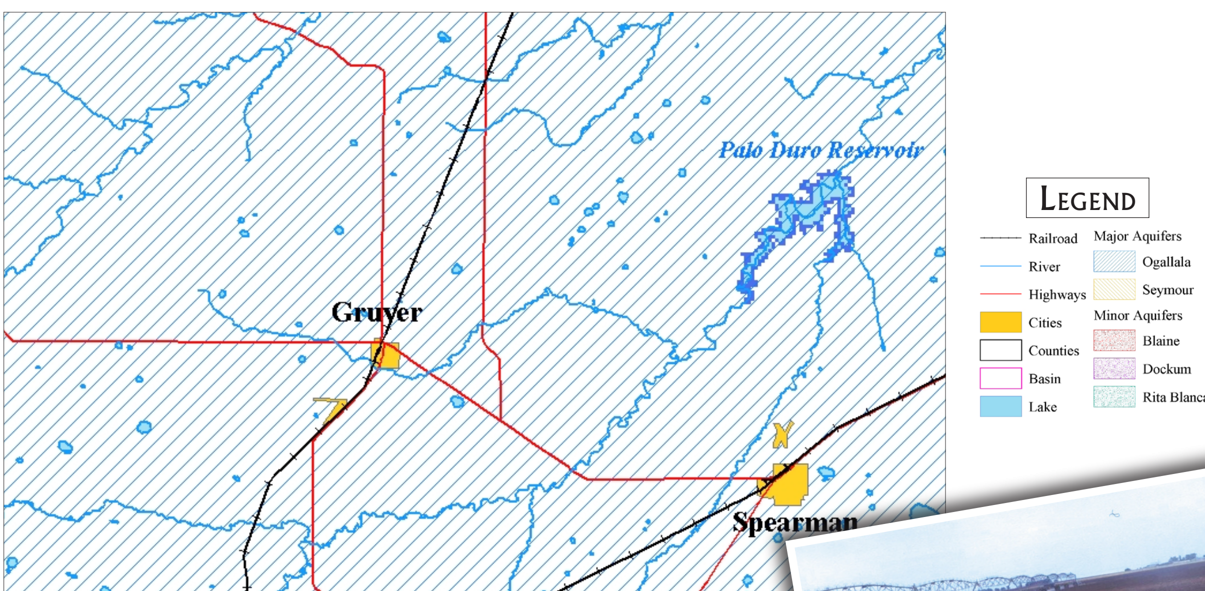
Dr. Nolan Clark - USDA-ARS
John Sweeten - Texas Agricultural Experiment Station
Gale Henslee - Xcel Energy
Richard Bowers - North Plains GCD
Jim Derington - Palo Duro River Authority

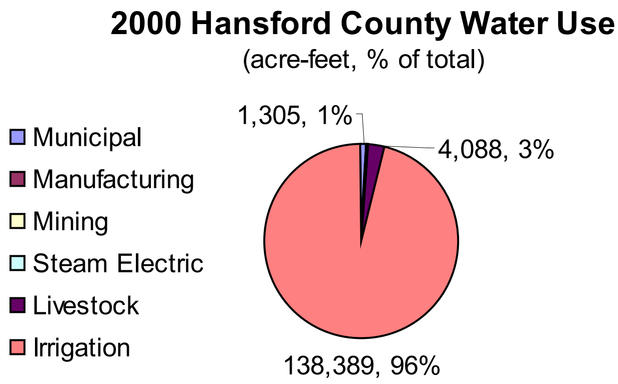
County Seat: City of Spearman

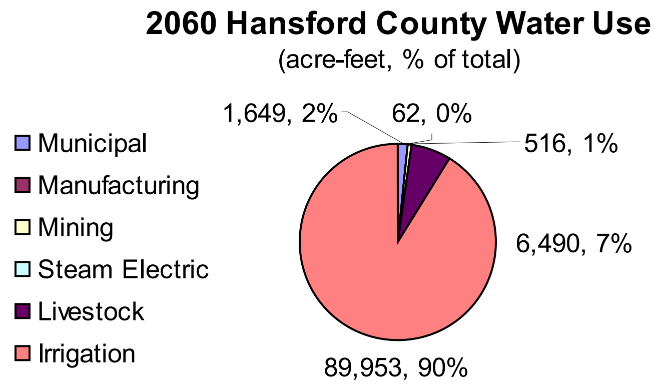
Economy: Agribusiness, Petroleum

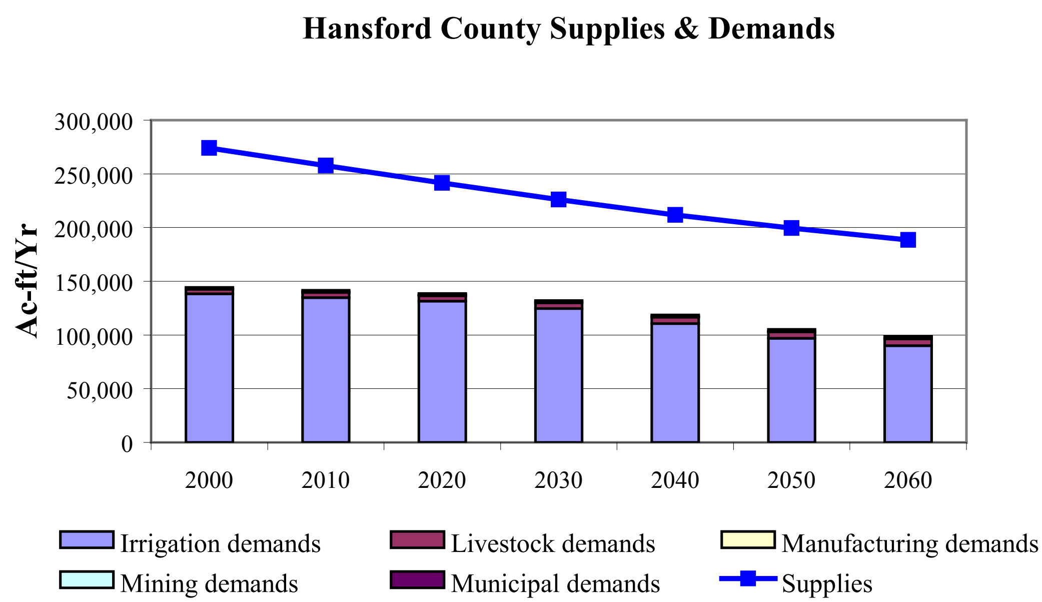
What is the source of my water? Ogallala Aquifer











Shortages for municipal county-other are due to 1.25% allocations.

WATER USER GROUP	STRATEGY
Gruver	No Shortages Identified
Spearman	No Shortages Identified
County-Other	New Groundwater Wells, Palo Duro Reservoir Project, Conservation
Irrigation	No Shortages Identified
Manufacturing (Shortage less than 10 AFY)	No Strategy Required
Livestock	No Shortages Identified
Mining	No Shortages Identified
Steam Electric Power	No Demands In This Category

HARTLEY COUNTY

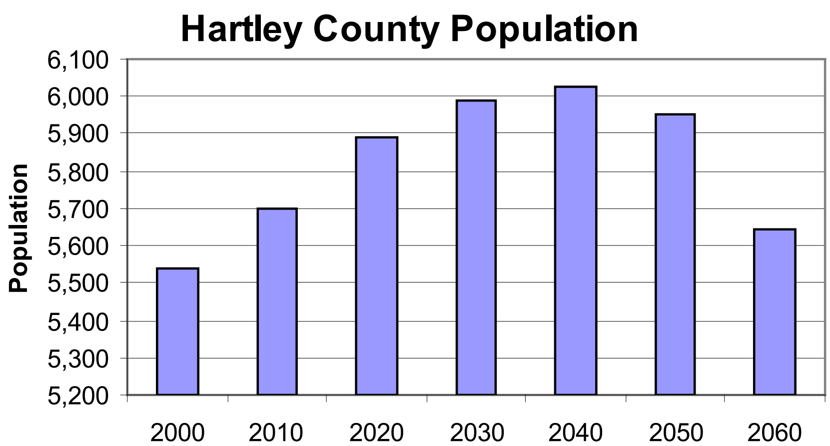
Who are my representatives?

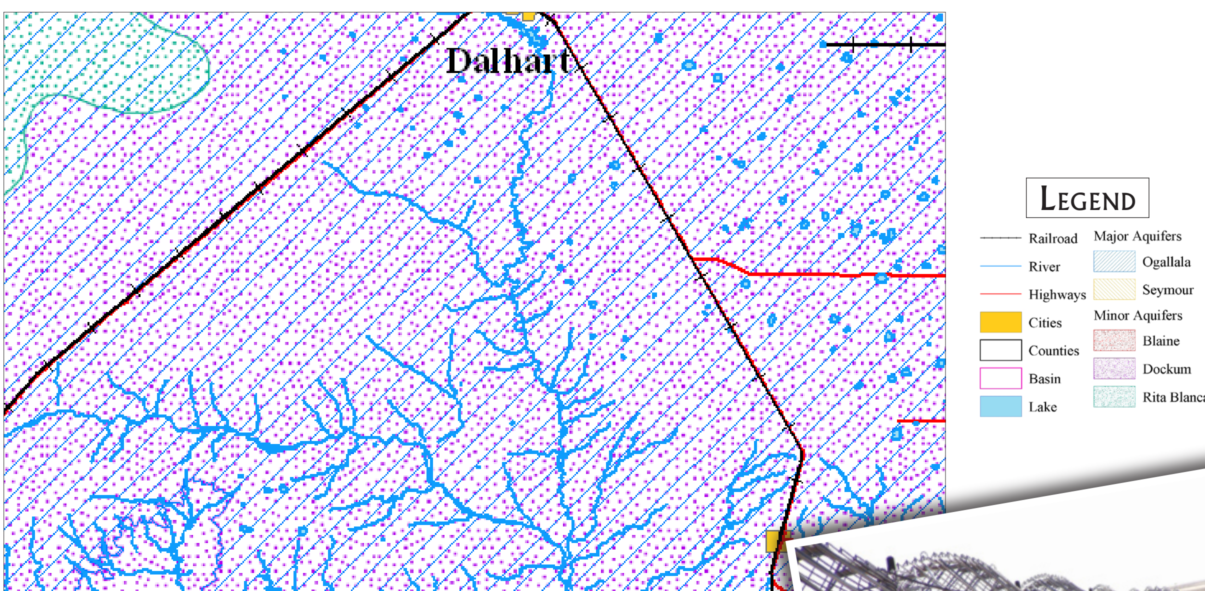
Dr. Nolan Clark - USDA-ARS
John Sweeten - Texas Agricultural Experiment Station
Gale Henslee - Xcel Energy
Richard Bowers - North Plains GCD

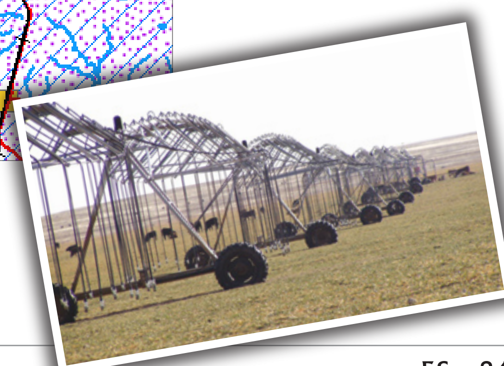
County Seat: City of Channing

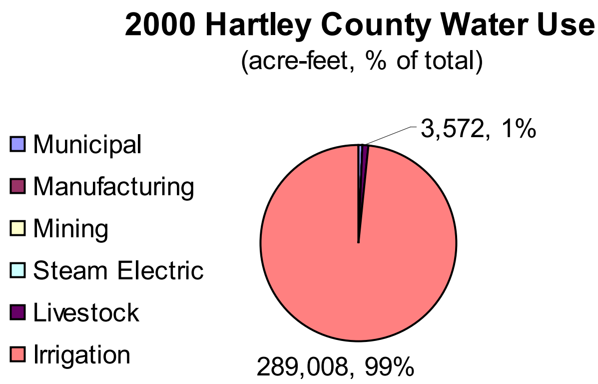
Economy: Agribusiness, Manufacturing, Petroleum

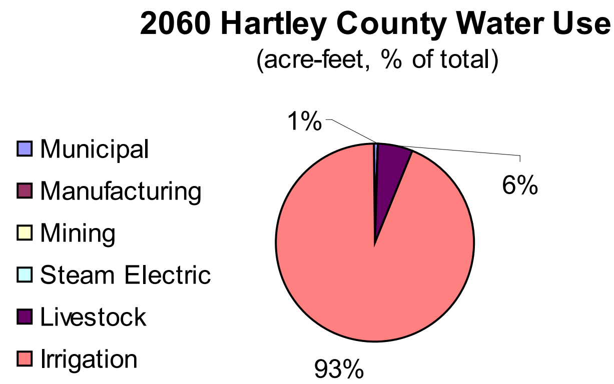
What is the source of my water? Ogallala, Dockum, Rita Blanca Aquifers

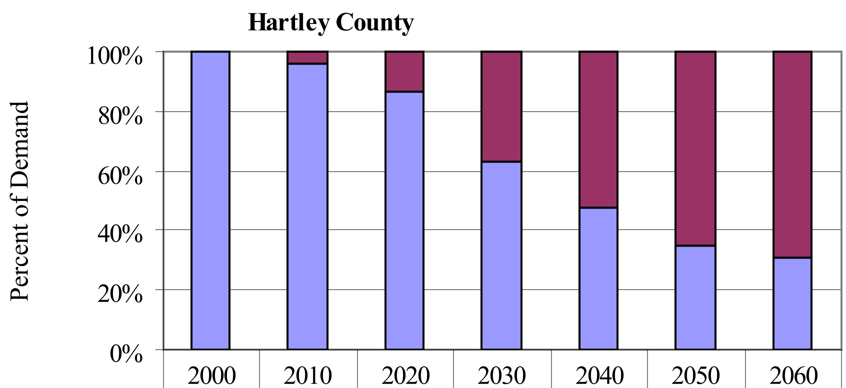










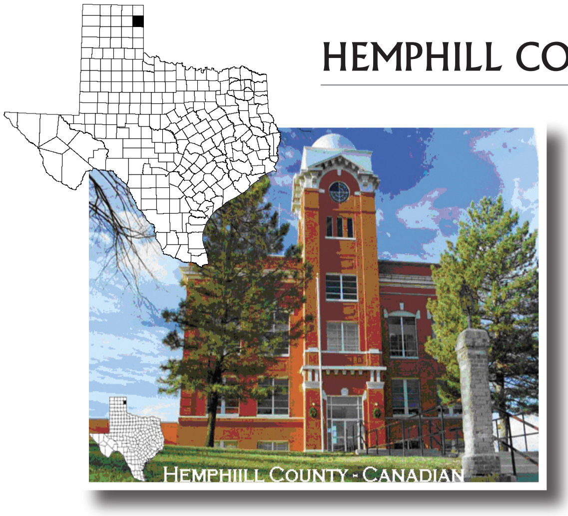


	2000	2010	2020	2030	2040	2050	2060
Shortage	0	10,976	38,546	100,879	127,041	139,198	139,000
1.25% Available Supply	313,895	279,109	247,503	171,010	116,241	75,472	61,477

1.25% Available Supply Shortage

Water User Group	Strategy
Dalhart	New Groundwater Wells, Conservation
County-Other	New Groundwater Wells, Conservation
Irrigation	NPET, Improved Irrigation Equipment, Conservation Tillage, Precipitation Enhancement
Manufacturing (Shortage less than 10 AFY)	No Strategy Required
Livestock	Voluntary Transfer From Other Users, Conservation
Mining	No Demands In This Category
Steam Electric Power	No Demands In This Category

HEMPHILL COUNTY



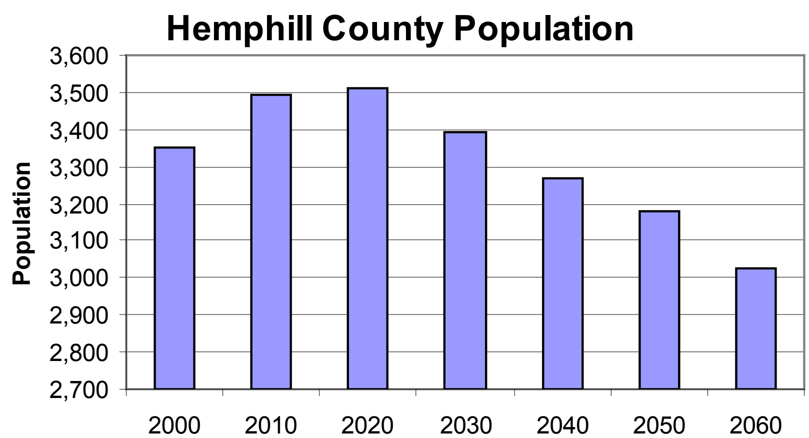
Who are my representatives?

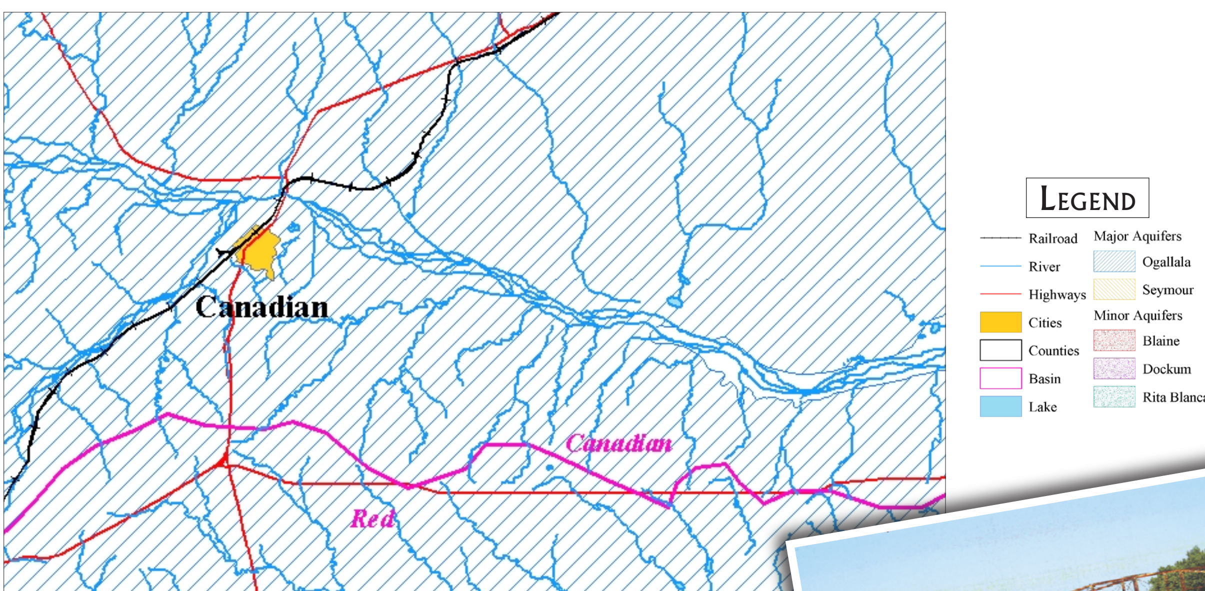
Dr. Nolan Clark - USDA-ARS
Janet Guthrie - Public
John Sweeten - Texas Agricultural Experiment Station
Gale Henslee - Xcel Energy

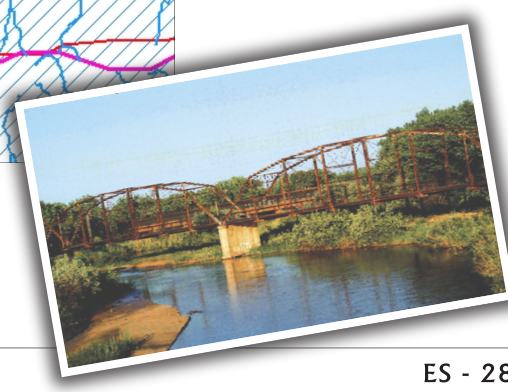
County Seat: City of Canadian

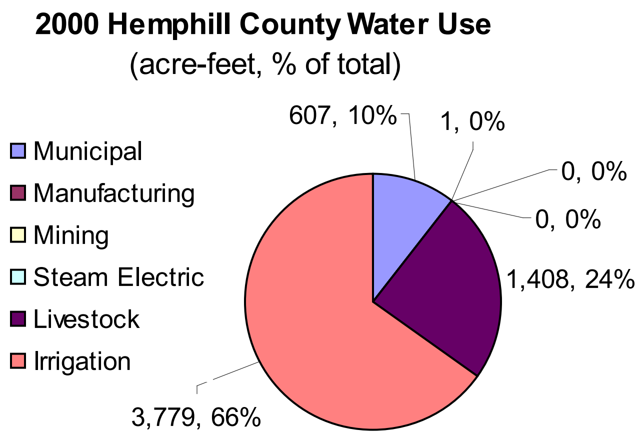
Economy: Agribusiness, Petroleum

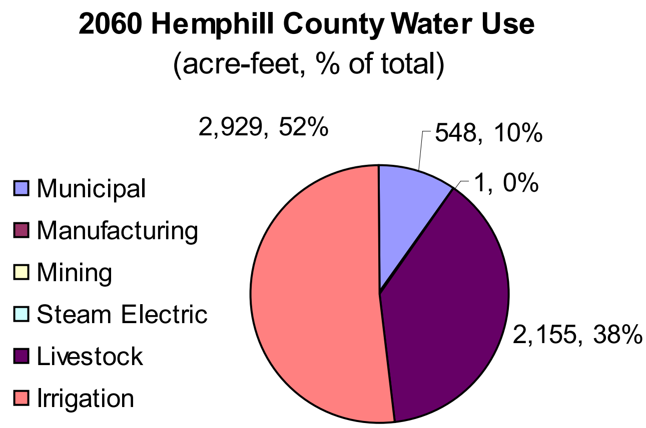
What is the source of my water? Ogallala Aquifer

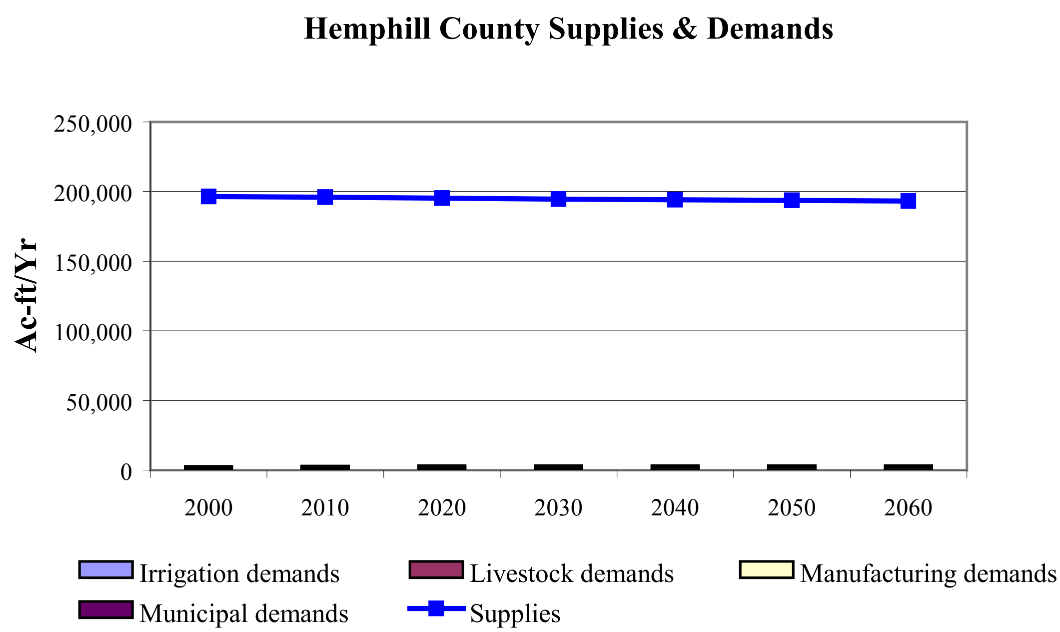












Water User Group	Strategy
Canadian	No Shortages Were Identified
County-Other	No Shortages Were Identified
Irrigation	No Shortages Were Identified
Manufacturing	No Shortages Were Identified
Livestock	No Shortages Were Identified
Mining	No Demands In This Category
Steam Electric Power	No Demands In This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

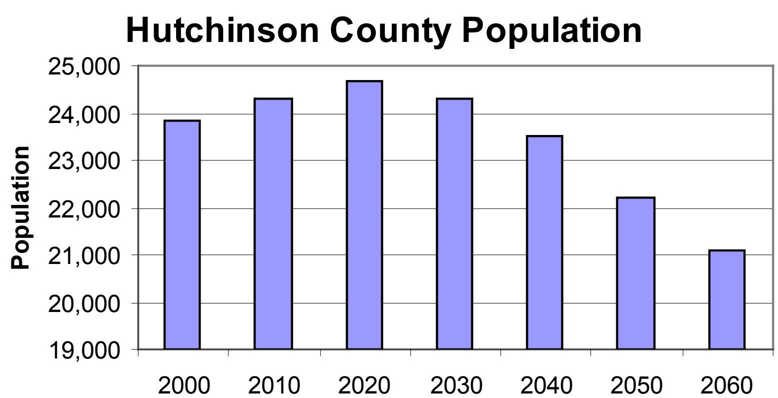
Who are my representatives?

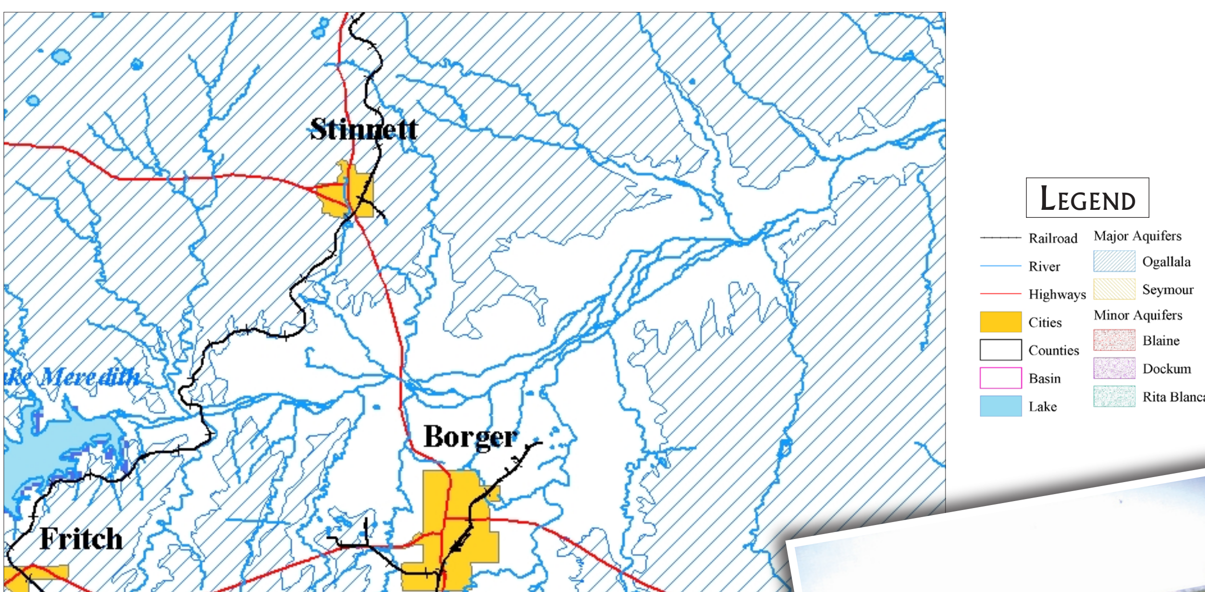
Dr. Nolan Clark - USDA-ARS
Denise Jett - ConocoPhillips
John C.Williams - Canadian River MWA
Gale Henslee - Xcel Energy
Richard Bowers - North Plains GCD
Jim Derington - Palo Duro River Authority
Charles Cooke - TCW Supply

County Seat: City of Stinnett

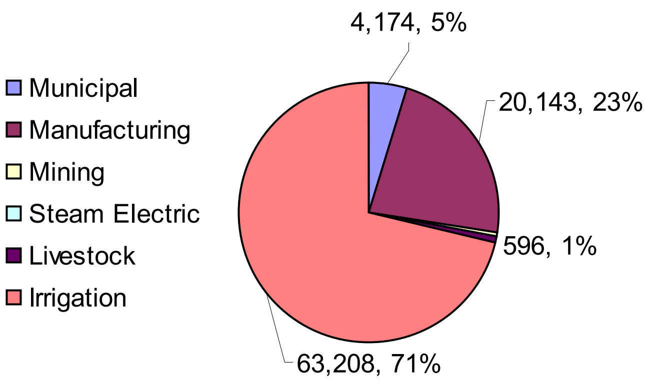
Economy: Agribusiness, Manufacturing, Petroleum, Tourism

What is the source of my water? Ogallala Aquifer

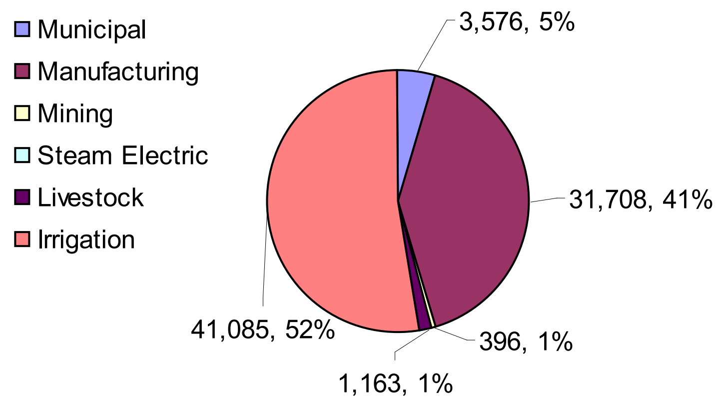


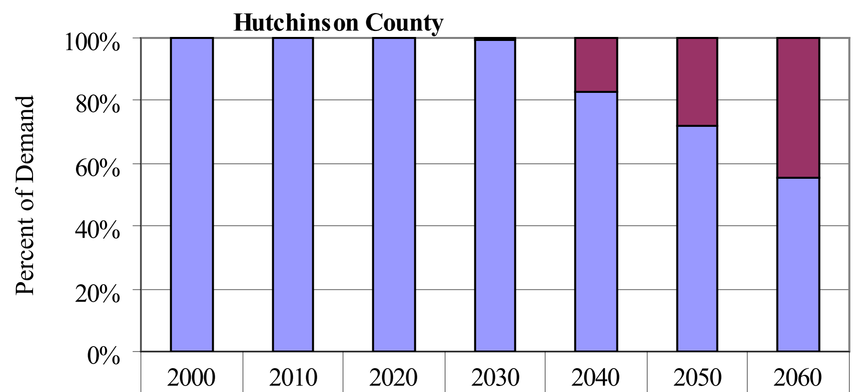


2000 Hutchinson County Water Use
(acre-feet, % of total)



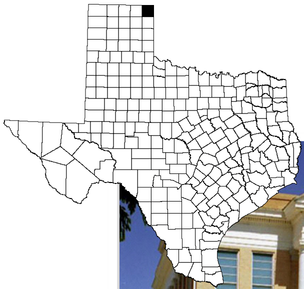
2060 Hutchinson County Water Use
(acre-feet, % of total)





	2000	2010	2020	2030	2040	2050	2060
Shortage	0	0	0	547	14,282	22,437	34,695
1.25% Available Supply	109,949	112,605	99,314	88,876	70,153	56,734	43,233

WATER USER GROUP	STRATEGY
Borger	New Groundwater Wells, Reuse, Conservation
Fritch	No Shortages Were Identified
Hi Texas Water Company	No Shortages Were Identified
Stinett	No Shortages Were Identified
TCW Water Supply Inc.	No Shortages Were Identified
County-Other	No Shortages Were Identified
Irrigation	NPET, Improved Irrigation Equipment, Conservation Tillage, Precipitation Enhancement
Manufacturing	New Groundwater Wells, Reuse, Conservation
Livestock	Voluntary Transfer From Other Users, Conservation
Mining	No Shortages Were Identified
Steam Electric Power	No Demands In This Category



LIPSCOMB COUNTY

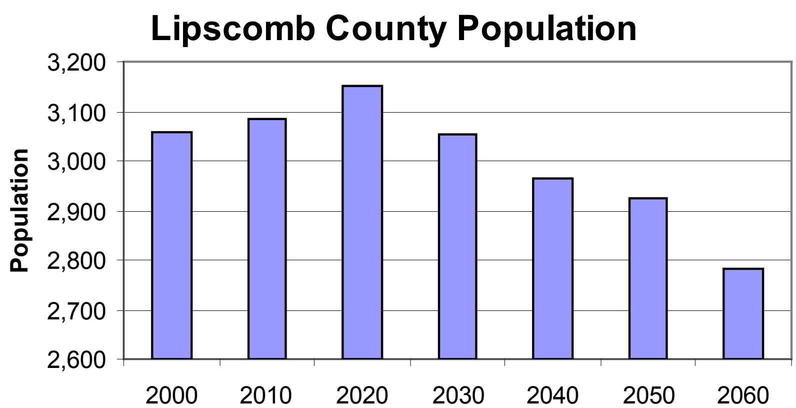
Who are my representatives?

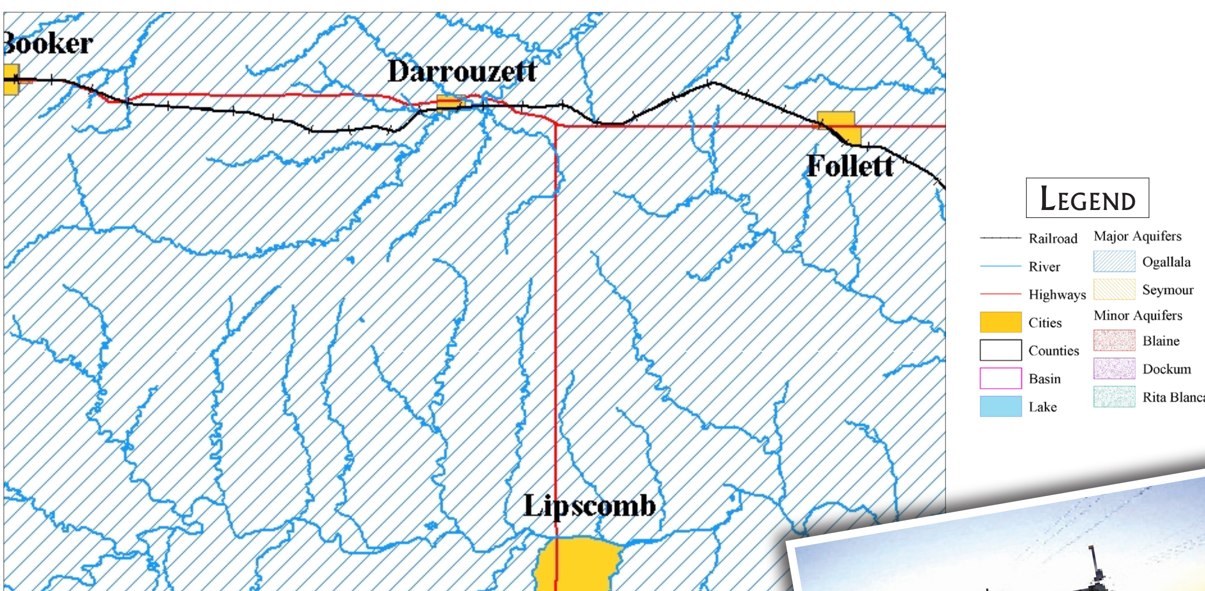
Dr. Nolan Clark	- USDA-ARS
Janet Tregallas	- Farmer/Rancher
John Sweeten	- Texas Agricultural Experiment Station
Gale Henslee	- Xcel Energy
Richard Bowers	- North Plains GCD

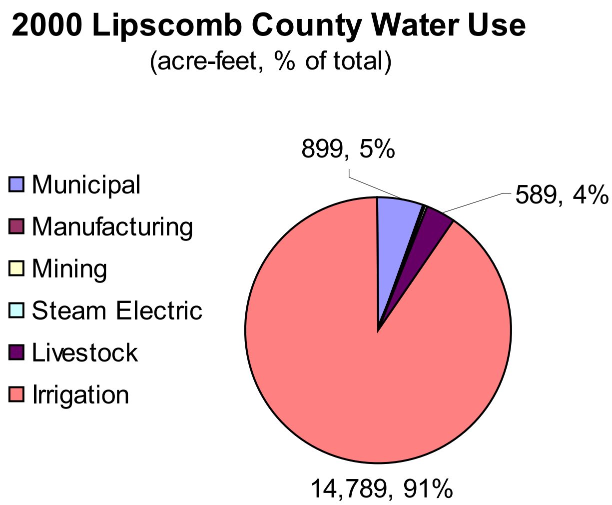
County Seat: City of Lipscomb

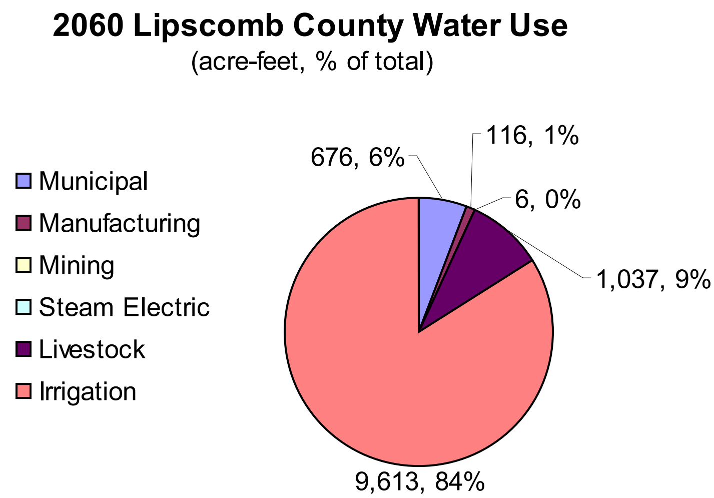
Economy: Agribusiness, Petroleum

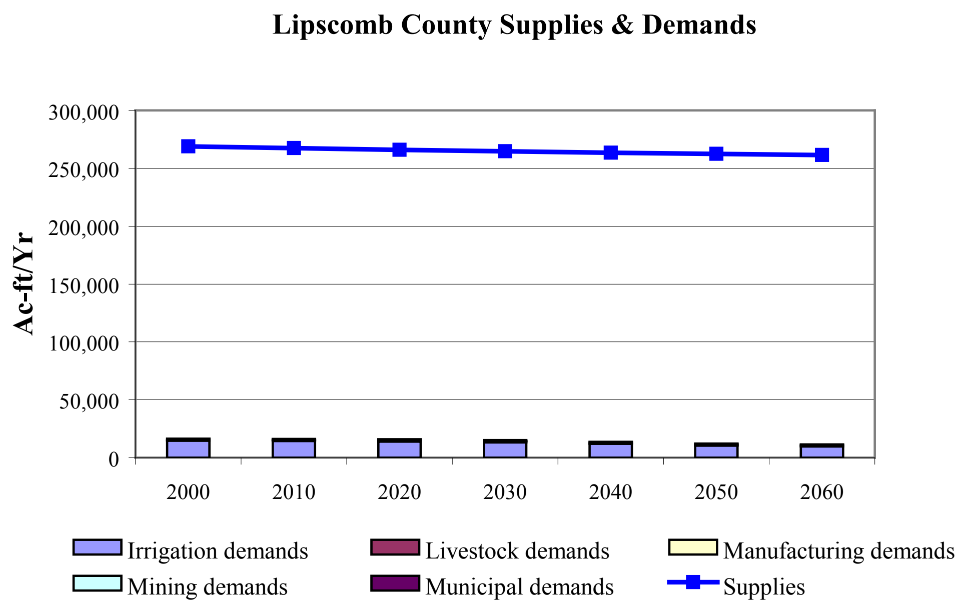
What is the source of my water? Ogallala Aquifer











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

MOORE COUNTY

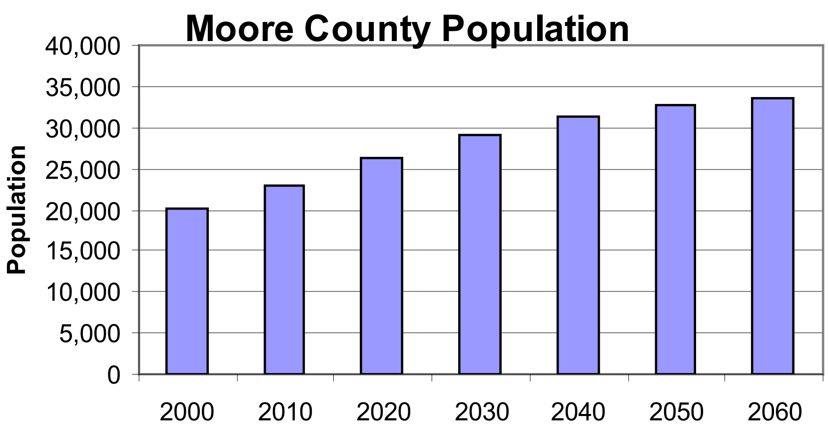
Who are my representatives?

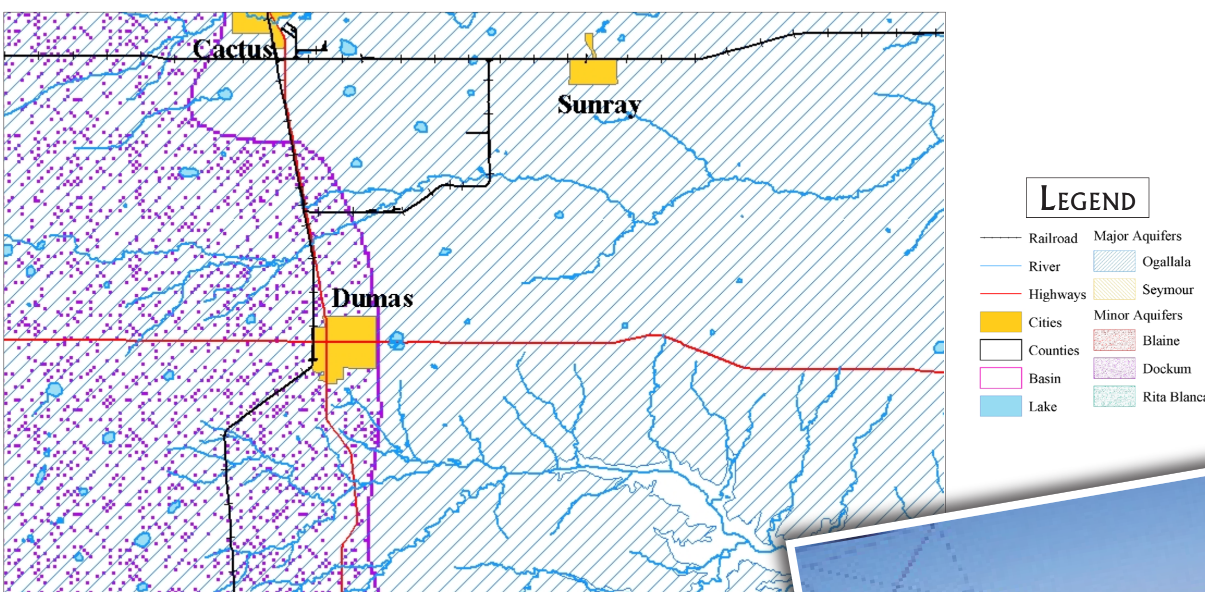
Dr. Nolan Clark	- USDA-ARS
Richard Bowers	- North Plains GCD
John Sweeten	- Texas Agricultural Experiment Station
Gale Henslee	- Xcel Energy
Jim Derington	- Palo Duro River Authority

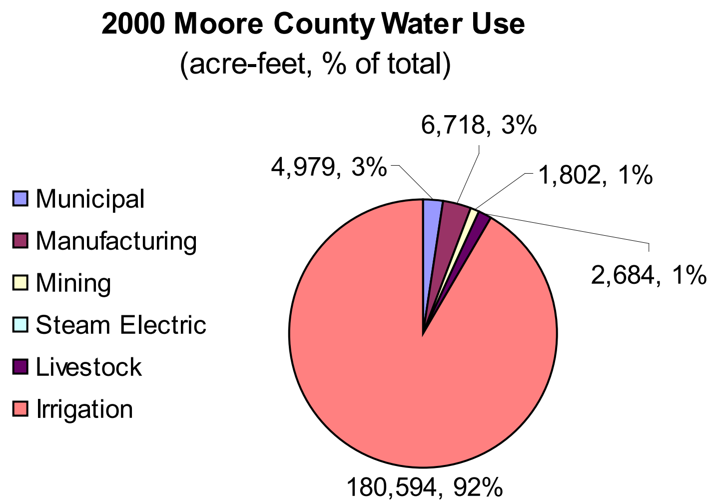
County Seat: City of Dumas

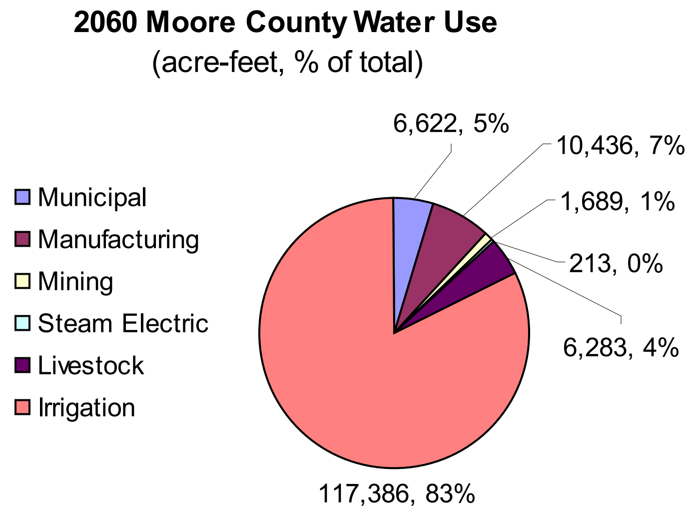
Economy: Agribusiness, Petroleum

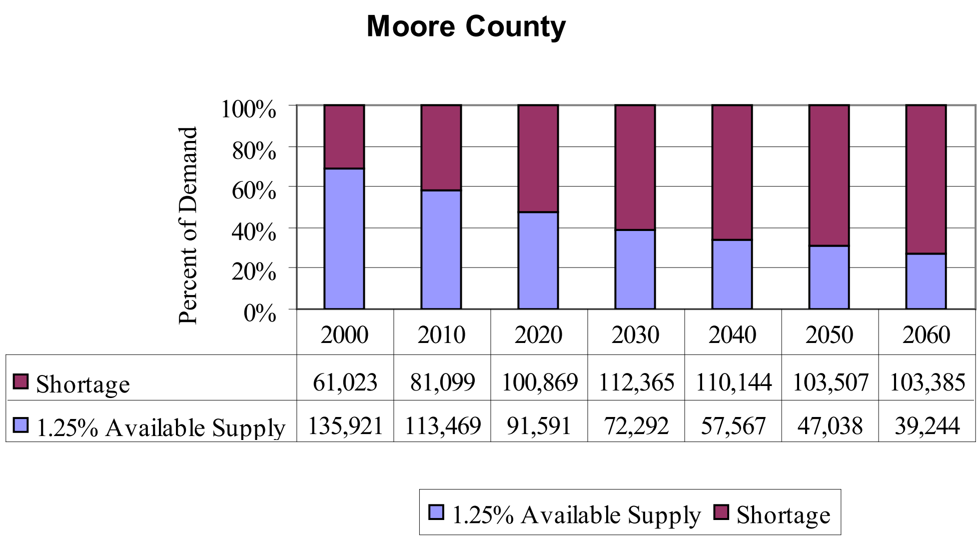
What is the source of my water? Ogallala, Dockum Aquifers







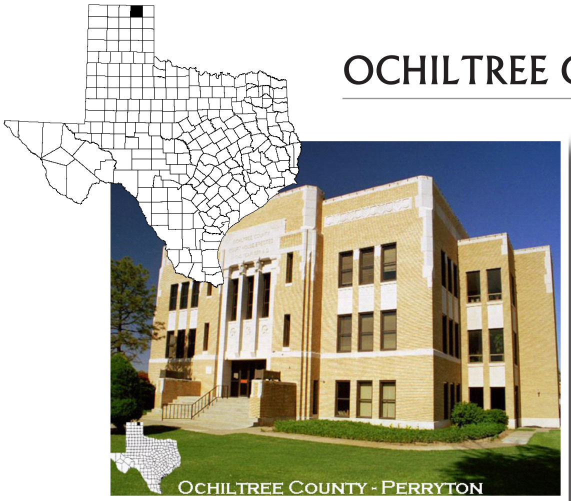




	2000	2010	2020	2030	2040	2050	2060
Shortage	61,023	81,099	100,869	112,365	110,144	103,507	103,385
1.25% Available Supply	135,921	113,469	91,591	72,292	57,567	47,038	39,244

Water User Group	Strategy
Cactus	New groundwater wells, Palo Duro Reservoir Project, Conservation
Dumas	New groundwater wells, Palo Duro Reservoir Project, Conservation
Sunray	New groundwater wells, Palo Duro Reservoir Project, Conservation
County-Other	New Groundwater Wells, Conservation
Irrigation	NPET, Improved Irrigation Equipment, Conservation Tillage, Precipitation Enhancement
Manufacturing	New Groundwater Wells, Reuse, Conservation

OCHILTREE COUNTY



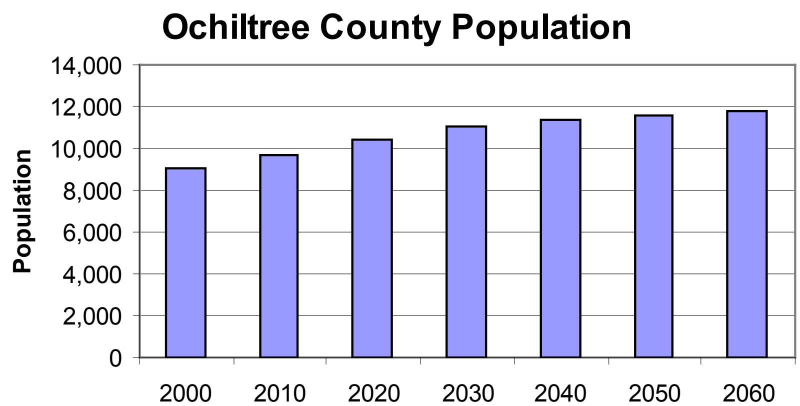
Who are my representatives?

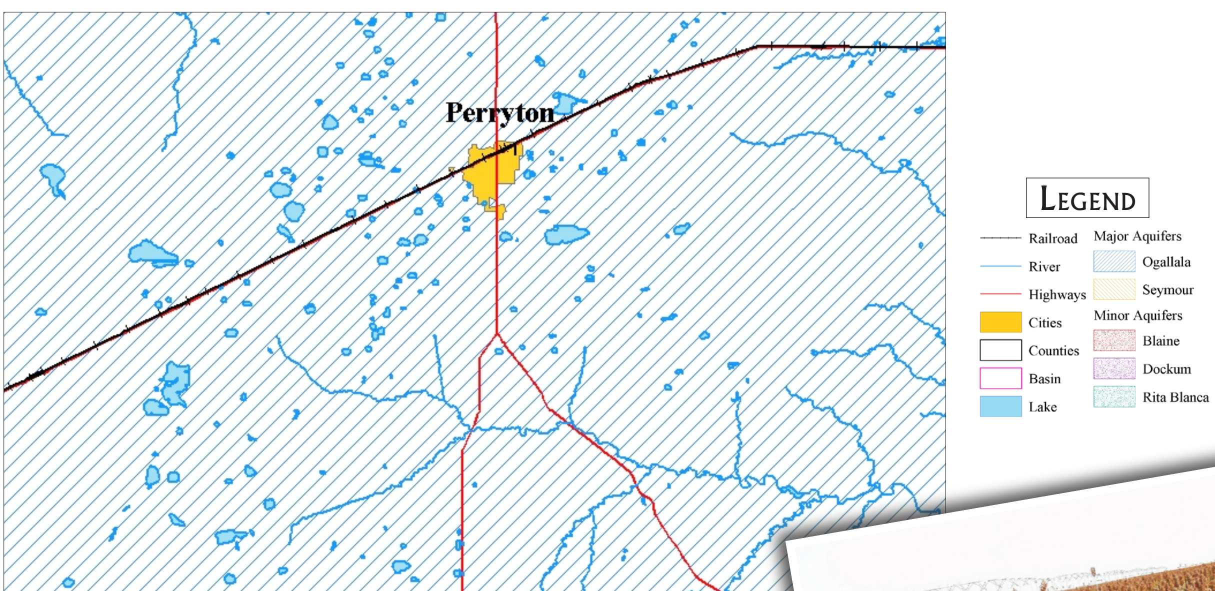
Dr. Nolan Clark - USDA-ARS
David Landis - City of Perryton
John Sweeten - Texas Agricultural Experiment Station
Gale Henslee - Xcel Energy
Richard Bowers - North Plains GCD

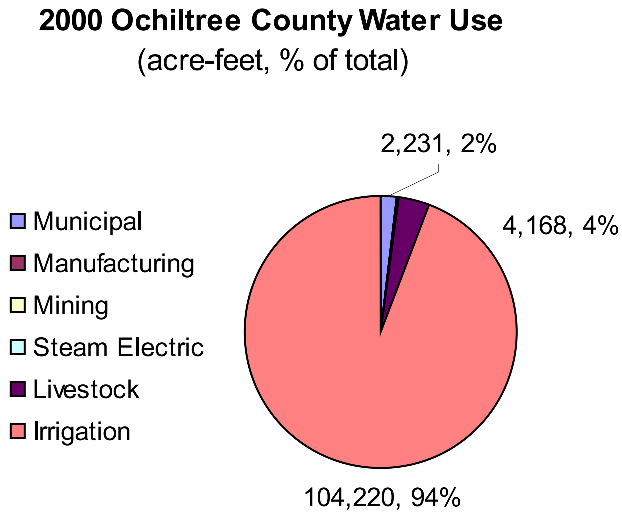
County Seat: City of Perryton

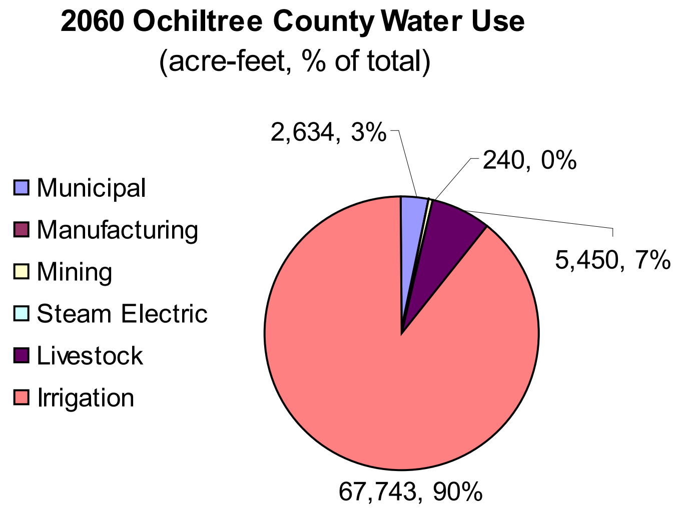
Economy: Agribusiness, Petroleum

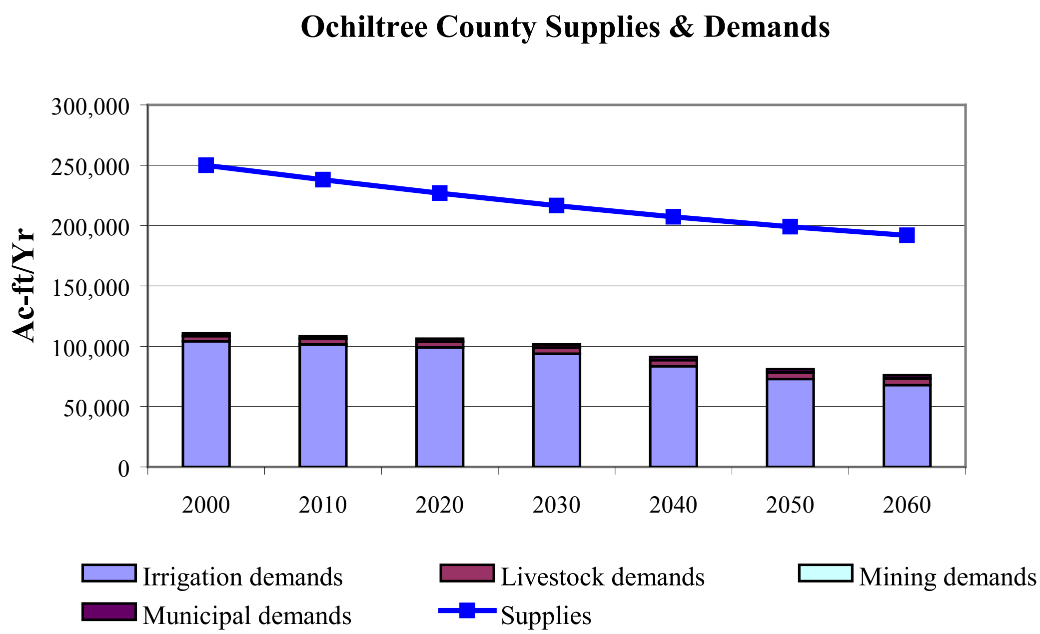
What is the source of my water? Ogallala Aquifers











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

OLDHAM COUNTY

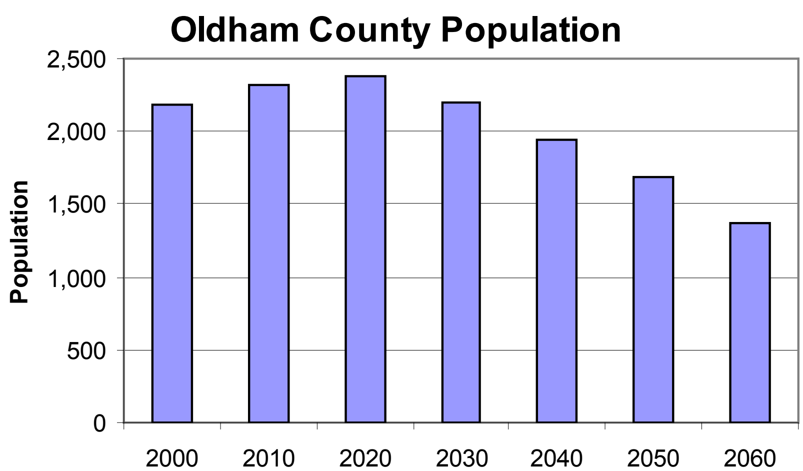
Who are my representatives?

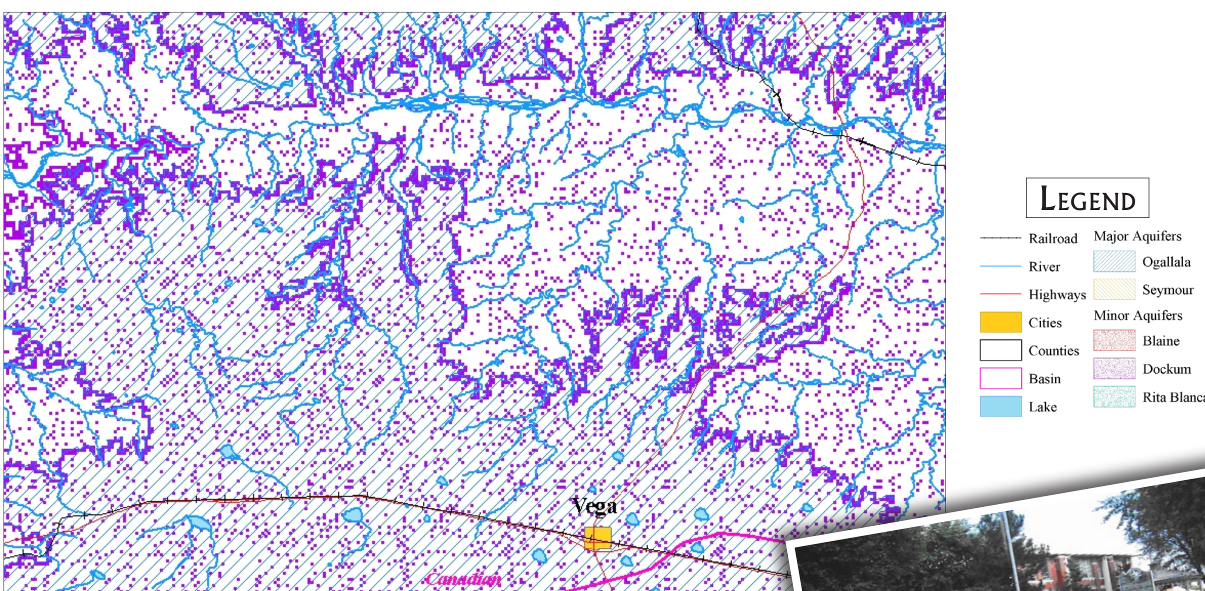
Dr. Nolan Clark - USDA-ARS
Grady Skaggs - Farmer
John Sweeten - Texas Agricultural Experiment Station
Gale Henslee - Xcel Energy

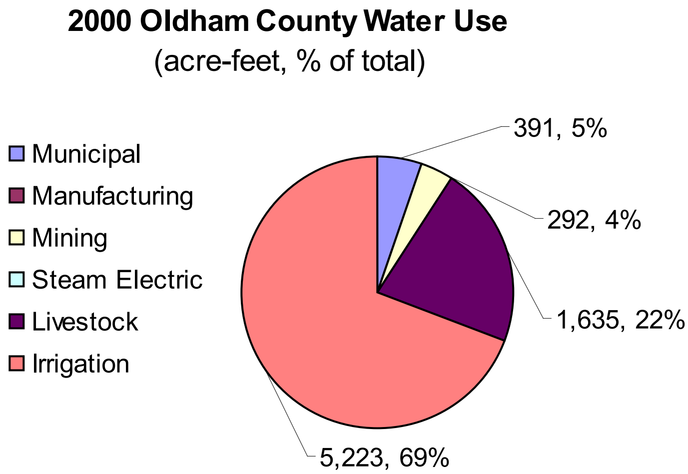
County Seat: City of Vega

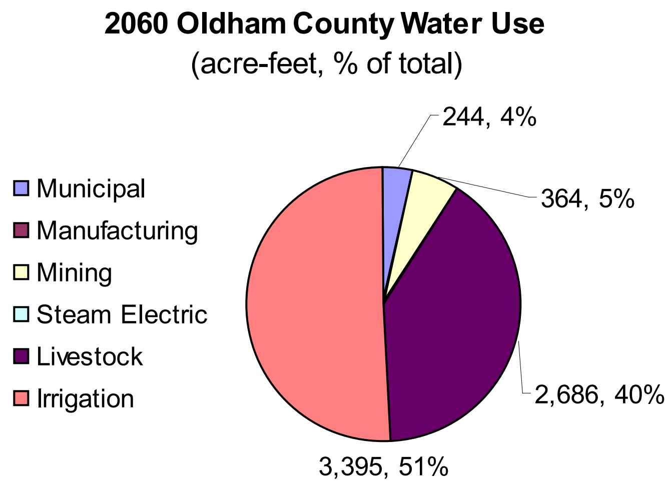
Economy: Agribusiness

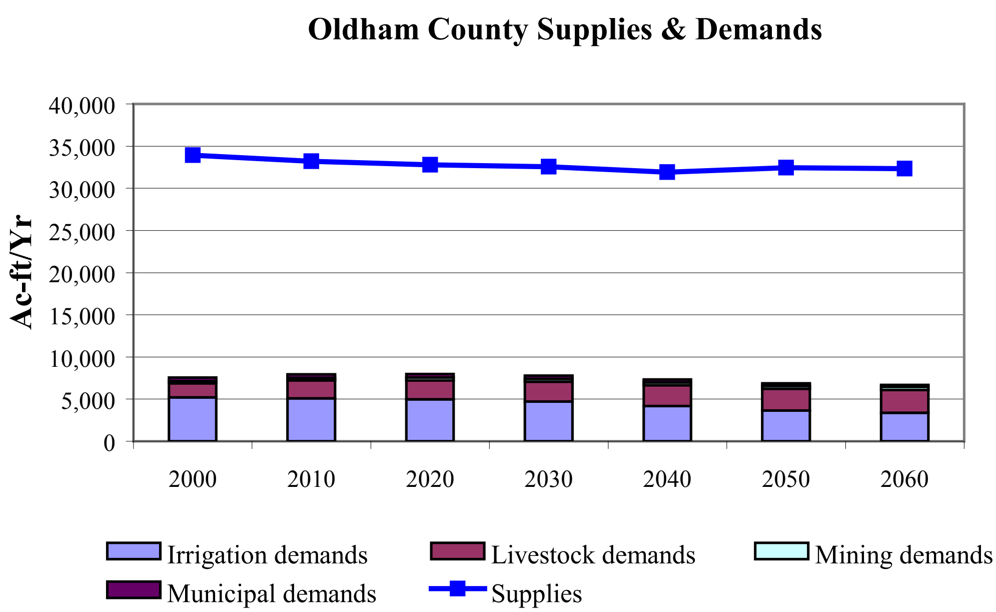
What is the source of my water? Ogallala, Dockum Aquifers



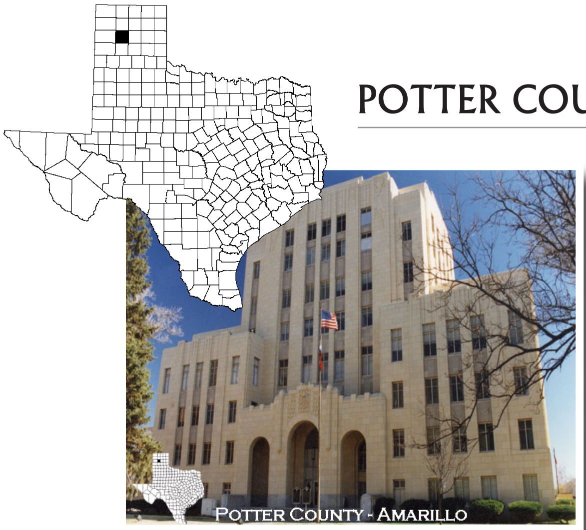








Water User Group	Strategy
Vega	No Shortages Were Identified
County-Other	No Shortages Were Identified
Irrigation	No Shortages Were Identified
Manufacturing	No Demands In This Category
Livestock	No Shortages Were Identified
Mining	No Shortages Were Identified
Steam Electric Power	No Demands In This Category



POTTER COUNTY

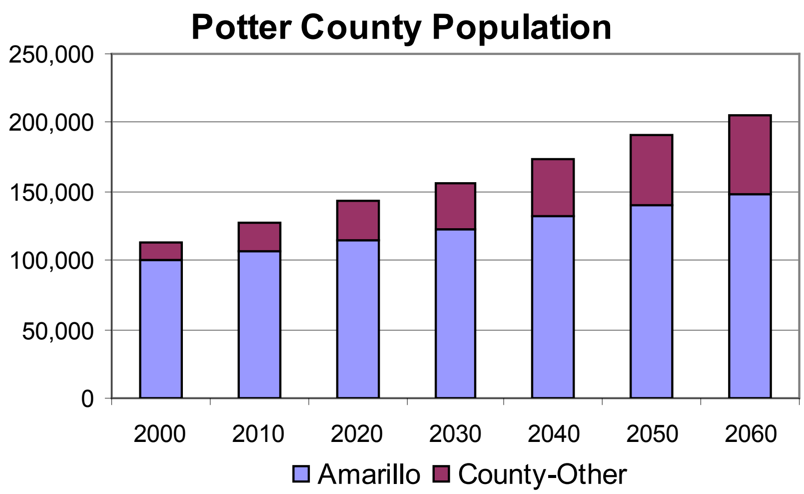
Who are my representatives?

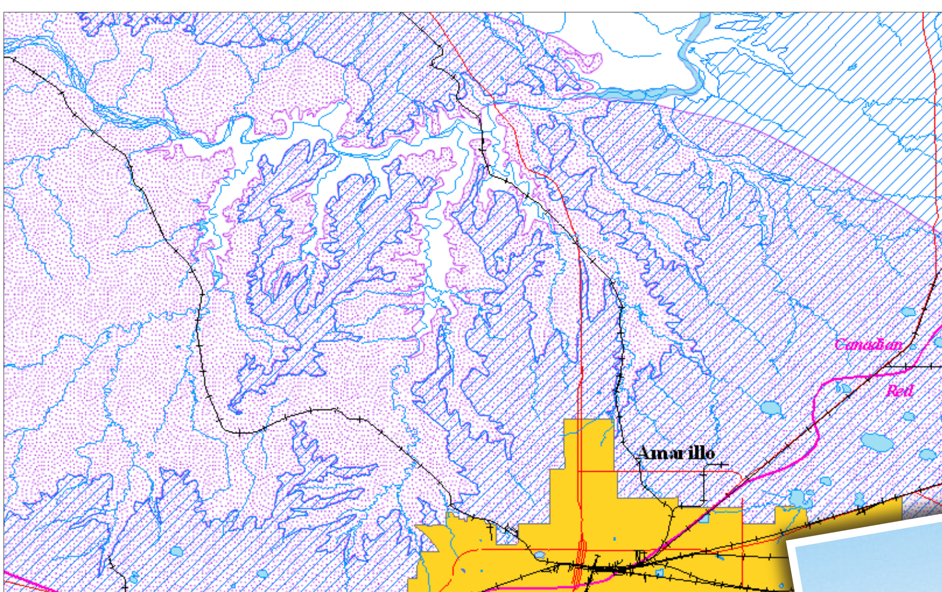
Dan Coffey	- City of Amarillo
Dr. Nolan Clark	- USDA-ARS
Gale Henslee	- Xcel Energy
C.E. Williams	- Panhandle GCD
John Williams	- CRMWA
John Sweeten	- Higher Education

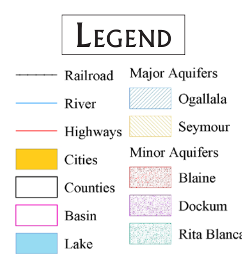
County Seat: City of Amarillo

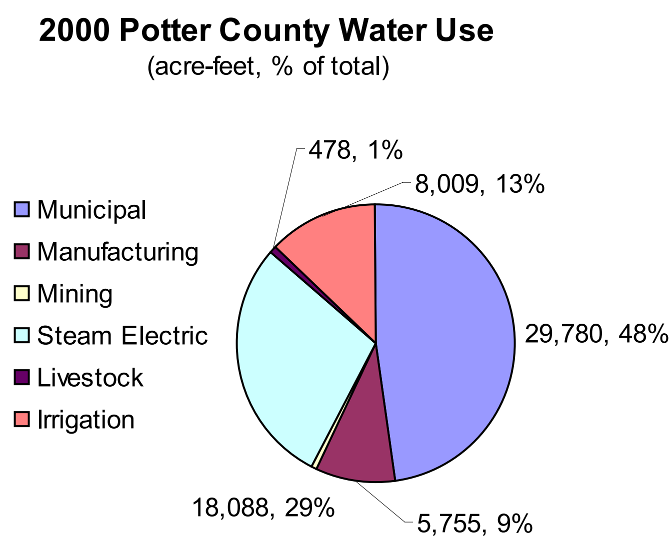
Economy: Agribusiness, Manufacturing, Petroleum, Tourism

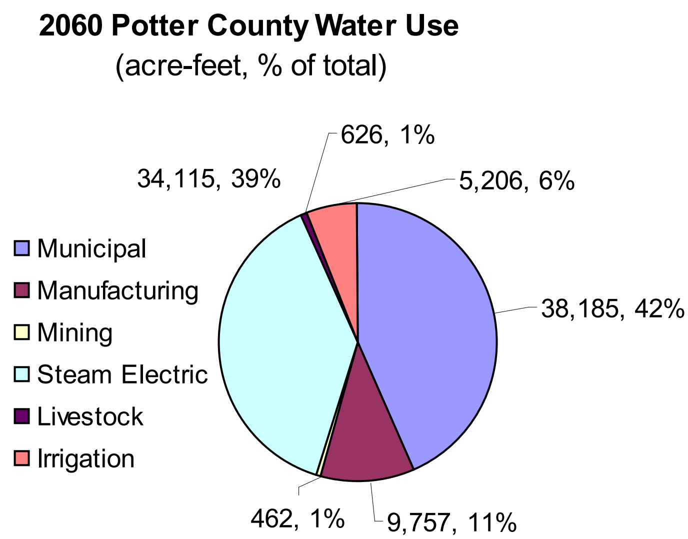
What is the source of my water? Ogallala, Dockum Aquifers; Lake Meredith

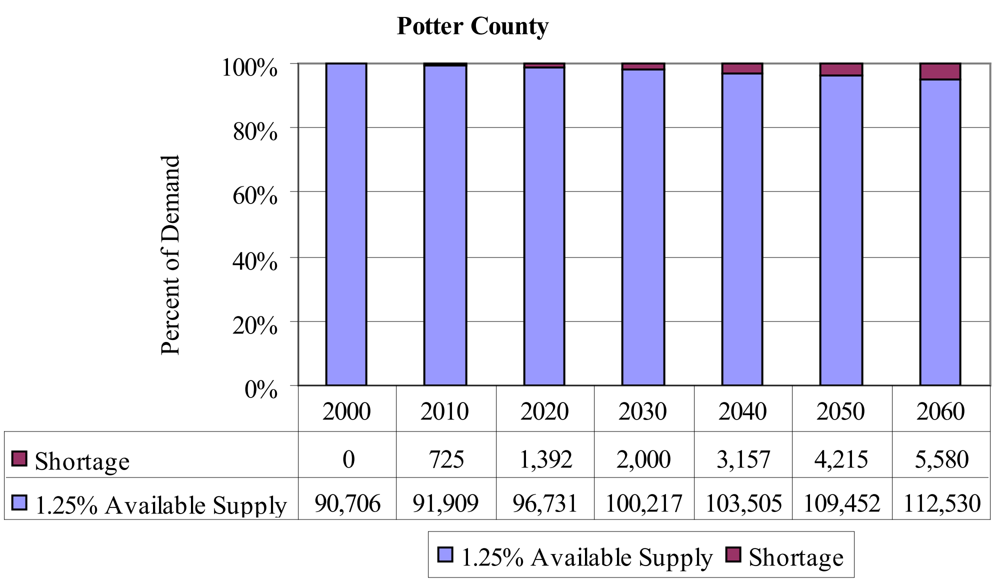












	2000	2010	2020	2030	2040	2050	2060
Shortage	0	725	1,392	2,000	3,157	4,215	5,580
1.25% Available Supply	90,706	91,909	96,731	100,217	103,505	109,452	112,530

Water User Group	Water Management Strategy
Amarillo	No Shortages Were Identified
County-Other	New Groundwater Wells, Conservation
Irrigation	No Shortages Were Identified
Manufacturing	New Groundwater Wells, Reuse, Conservation
Livestock	No Shortages Were Identified
Mining	New Groundwater Wells, Reuse, Conservation
Steam Electric Power	No shortages Were Identified

RANDALL COUNTY

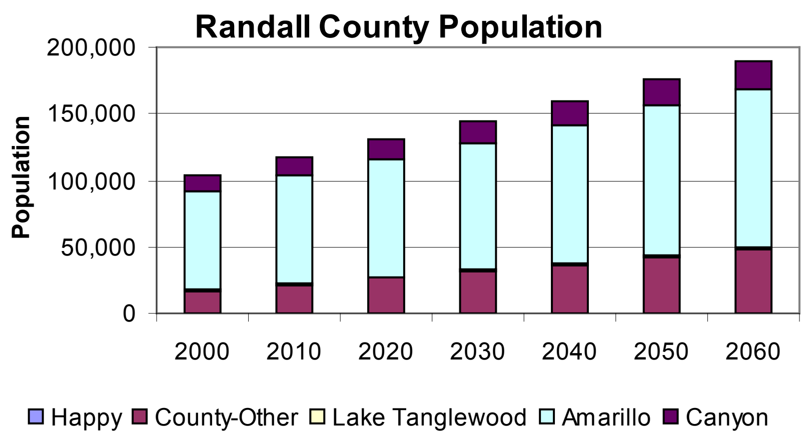
Who are my representatives?

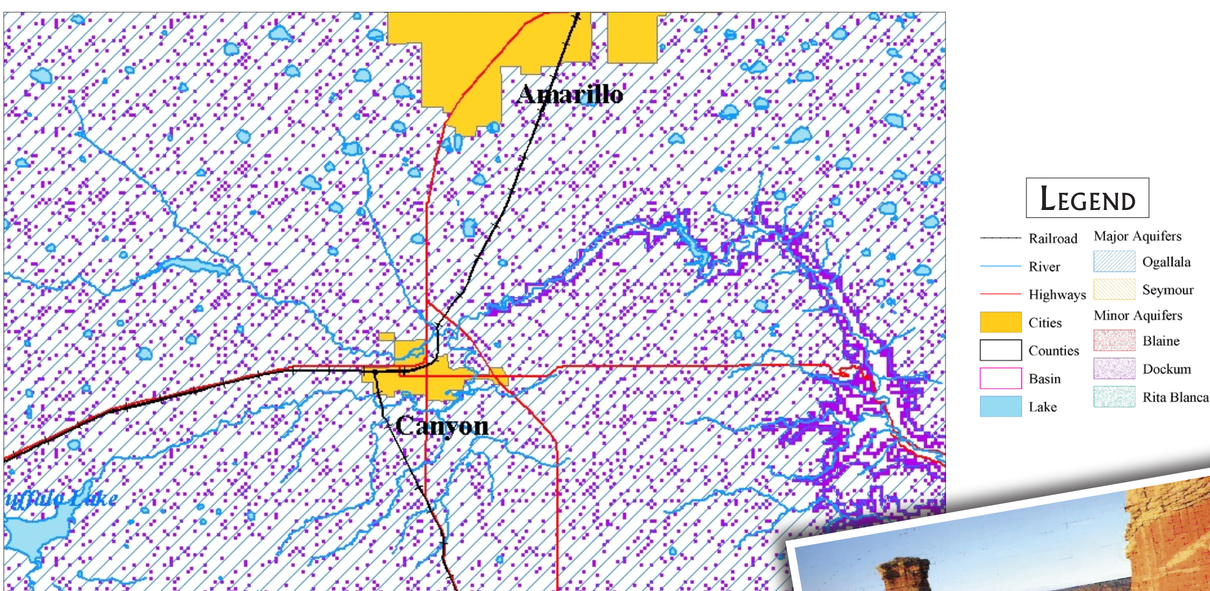
Dr. Nolan Clark	- USDA-ARS
Dan Coffey	- City of Amarillo
Inge Brady	- City of Amarillo
Gale Henslee	- Xcel Energy
John Williams	- CRMWA

County Seat: City of Canyon

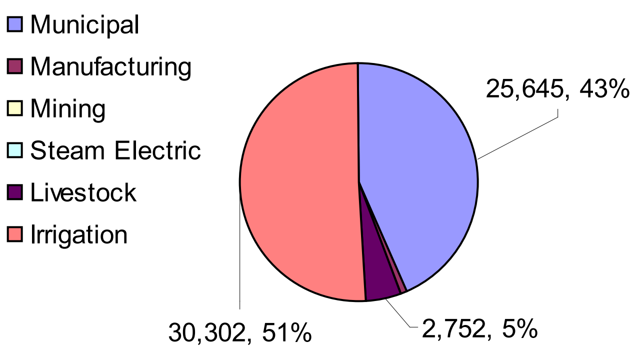
Economy: Agribusiness, Manufacturing, Tourism

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

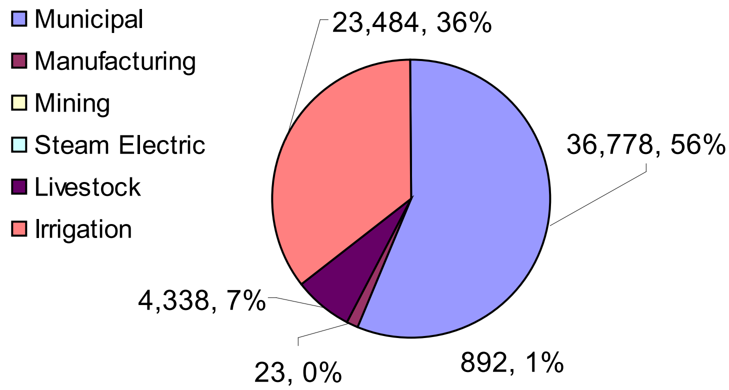




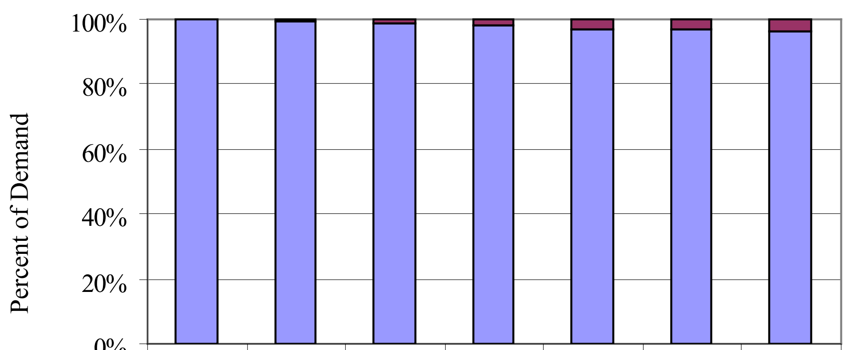
2000 Randall County Water Use
(acre-feet, % of total)



2060 Randall County Water Use
(acre-feet, % of total)



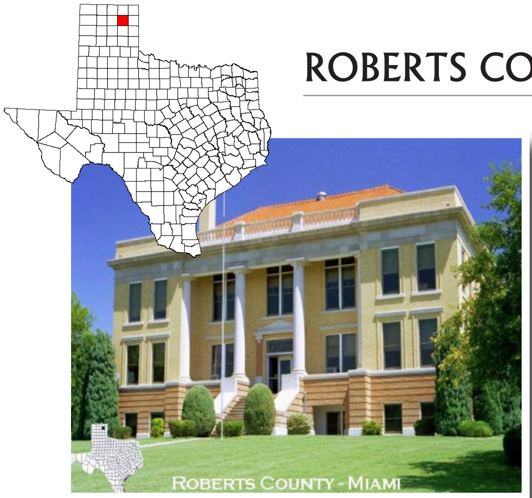
Randall County



	2000	2010	2020	2030	2040	2050	2060
Shortage	0	464	1,274	1,955	2,888	3,403	4,022
1.25% Available Supply	104,102	95,758	93,413	92,680	90,757	99,002	100,475

1.25% Available Supply Shortage

WATER USER GROUP	STRATEGY
Amarillo	No Shortages Were Identified
Canyon	No Shortages Were Identified
Lake Tanglewood	New Groundwater Wells, Conservation
County-Other	New Groundwater Wells, Conservation
Irrigation	No Shortages Were Identified
Manufacturing	New Groundwater Wells, Reuse, Conservation
Livestock	Voluntary Transfer From Other Users, New Groundwater Wells, Conservation
Mining (Shortage less than 10 AFY)	No Strategy Required
Steam Electric Power	No Demands In This Category



ROBERTS COUNTY

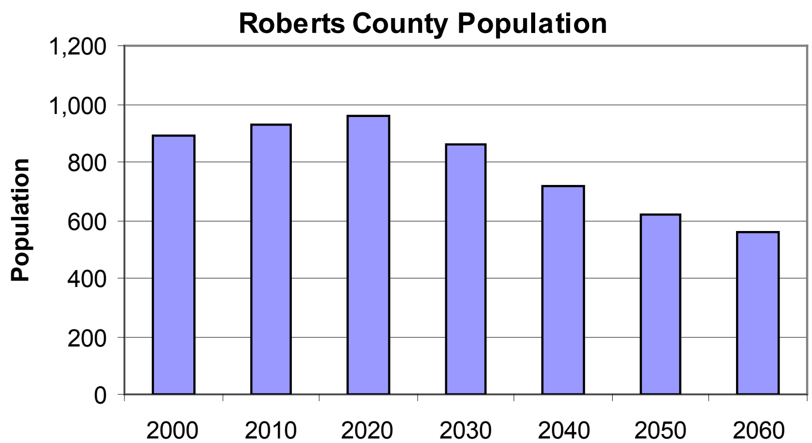
Who are my representatives?

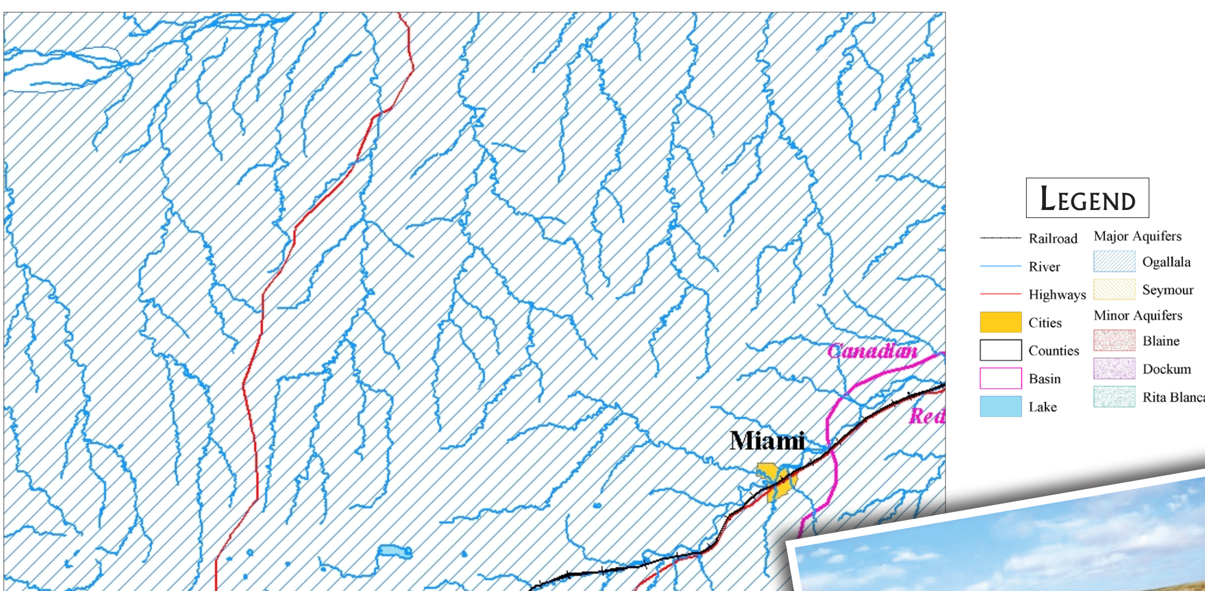
Dr. Nolan Clark	- USDA-ARS
Judge Vernon Cook	- Roberts County
John Sweeten	- Texas Agricultural Experiment Station
Gale Henslee	- Xcel Energy
C.E. Williams	- Panhandle GCD
John Williams	- CRMWA

County Seat: City of Miami

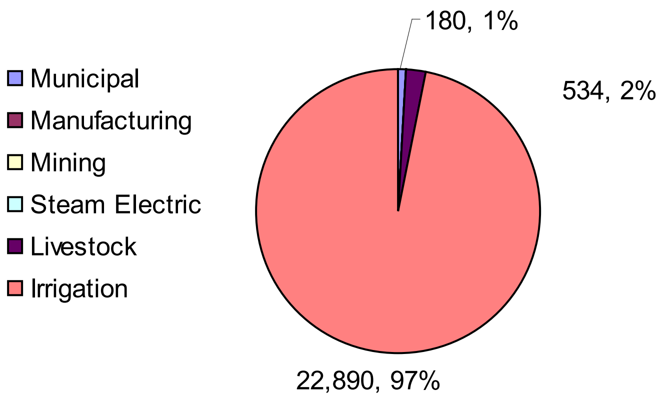
Economy: Agribusiness, Petroleum

What is the source of my water? Ogallala Aquifer

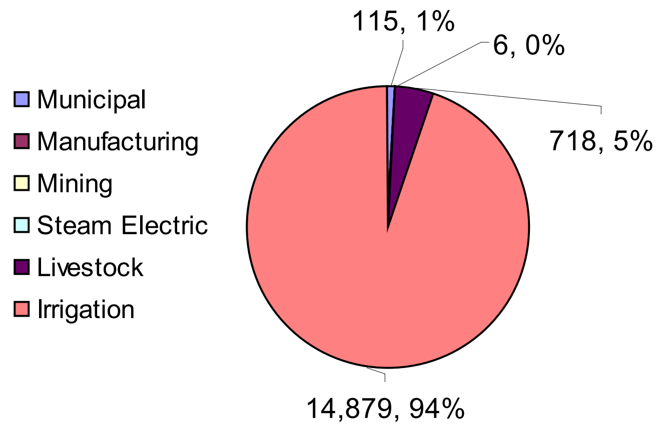




2000 Roberts County Water Use
(acre-feet, % of total)

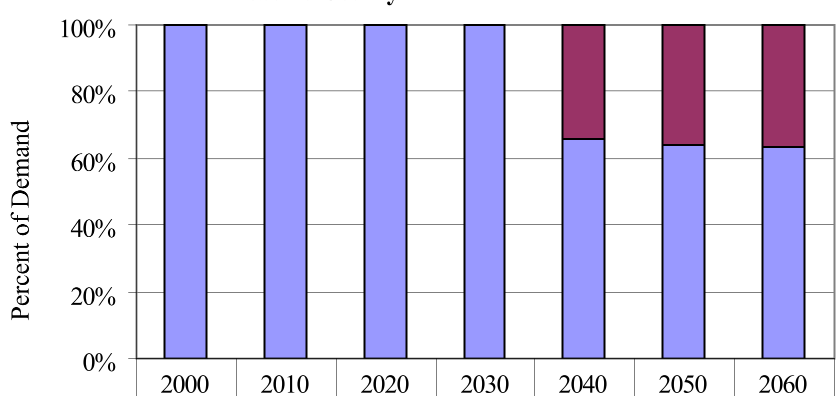


2060 Roberts County Water Use
(acre-feet, % of total)



Water Use pie charts reflect only in-county demands.

Roberts County



	2000	2010	2020	2030	2040	2050	2060
Shortage	0	0	0	0	20,306	20,314	20,316
1.25% Available Supply	70,012	69,947	69,397	62,172	38,829	36,536	35,402

1.25% Available Supply Shortage

Water User Group	Strategy
Municipal - CRMWA	Additional Groundwater Wells
Miami	No Shortages Were Identified
County-Other	No Shortages Were Identified
Irrigation	No Shortages Were Identified
Manufacturing	No Demands In This Category
Livestock	No Shortages Were Identified
Mining	No Shortages Were Identified
Steam Electric Power	No Demands In This Category

SHERMAN COUNTY

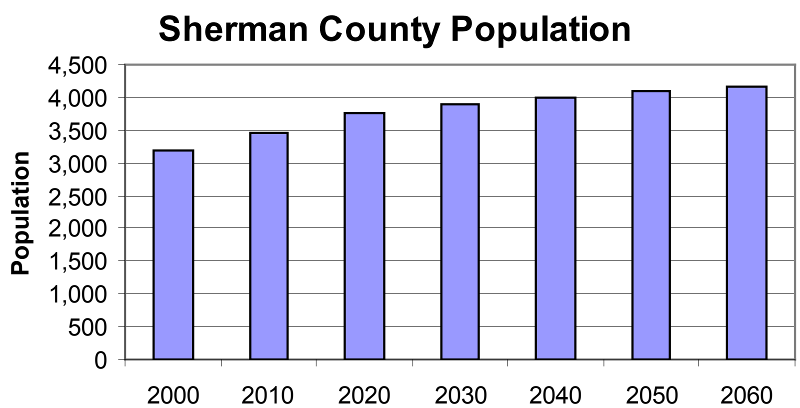
Who are my representatives?

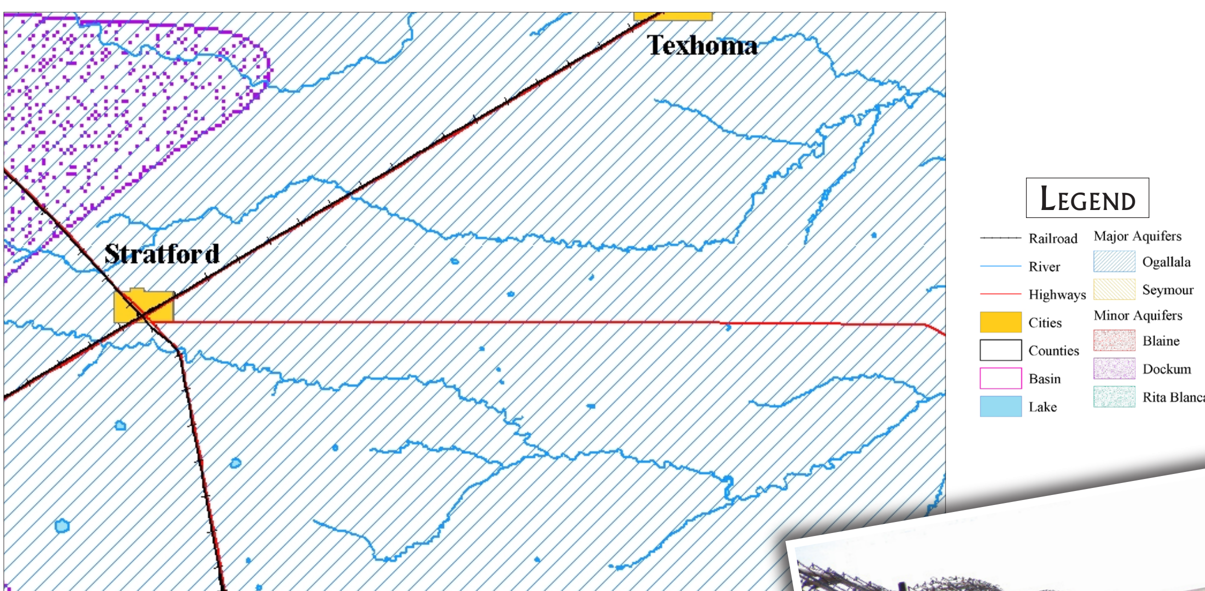
Dr. Nolan Clark	- USDA-ARS
B. A. Donelson	- Agriculture/Banker
John Sweeten	- Texas Agricultural Experiment Station
Gale Henslee	- Xcel Energy
Richard Bowers	- North Plains GCD

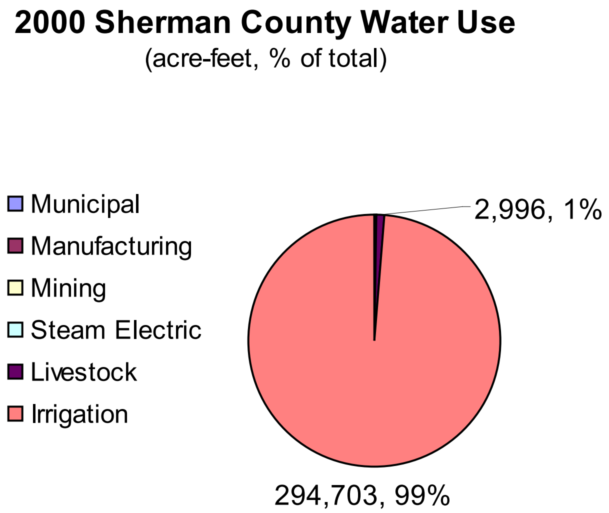
County Seat: City of Stratford

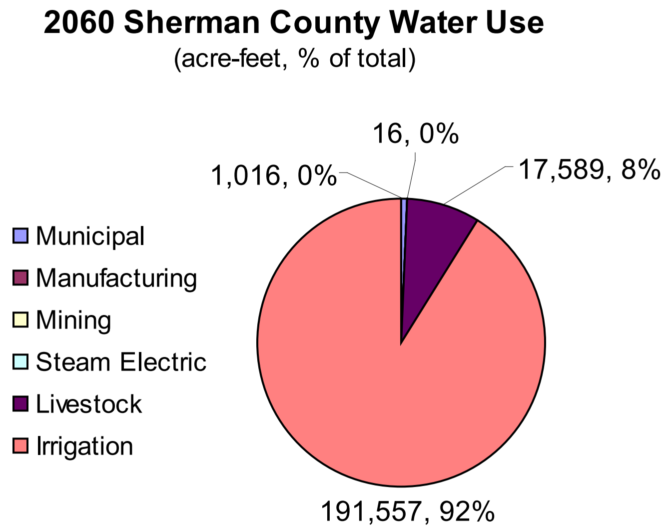
Economy: Agribusiness, Petroleum

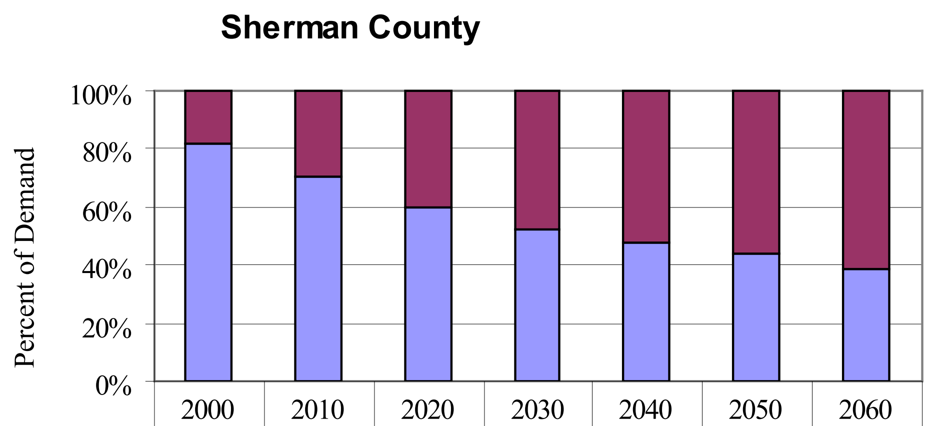
What is the source of my water? Ogallala, Dockum Aquifers











	2000	2010	2020	2030	2040	2050	2060
Shortage	53,657	87,793	119,145	135,641	133,453	126,126	129,196
1.25% Available Supply	244,838	211,286	178,459	147,459	120,421	98,532	80,982

1.25% Available Supply Shortage

Water User Group	Strategy
Stratford	New Groundwater Wells, Conservation
County-Other	New Groundwater Wells, Conservation
Irrigation	NPET, Improved Irrigation Equipment, Conservation Tillage, Precipitation Enhancement
Manufacturing	No Demands In This Category
Livestock	Voluntary Transfer From Other Users, Conservation
Mining	New Groundwater Wells, Reuse, Conservation
Steam Electric Power	No Demands In This Category

WHEELER COUNTY

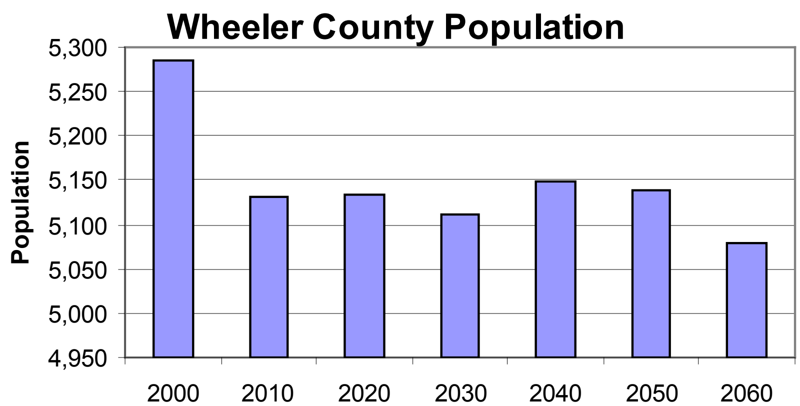
Who are my representatives?

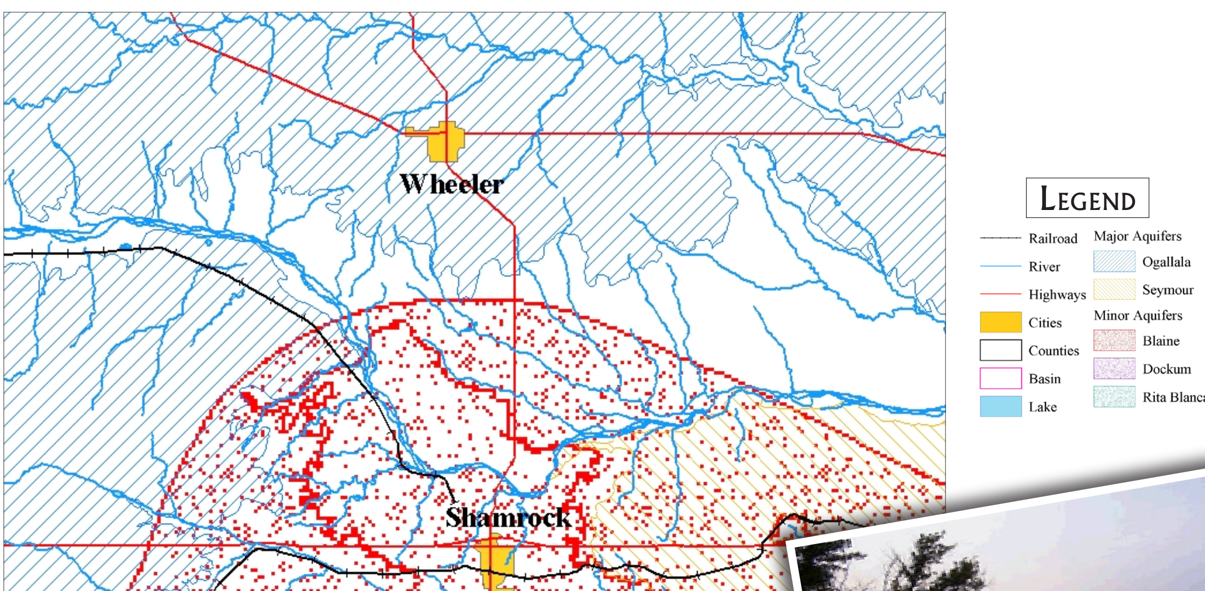
Dr. Nolan Clark	- USDA-ARS
John Sweeten	- Texas Agricultural Experiment Station
Gale Henslee	- Xcel Energy
C.E. Williams	- Panhandle GCD

County Seat: City of Wheeler

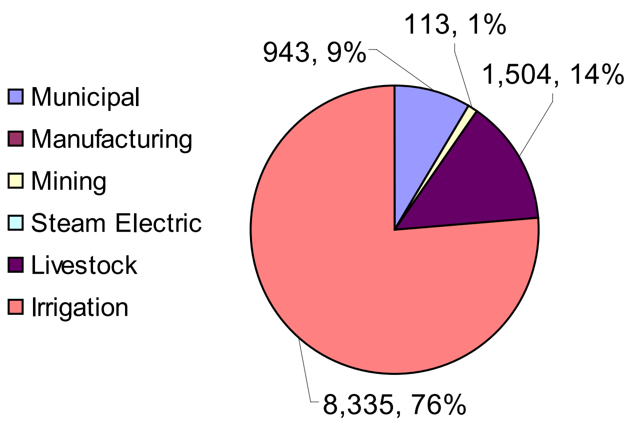
Economy: Agribusiness, Petroleum, Tourism

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

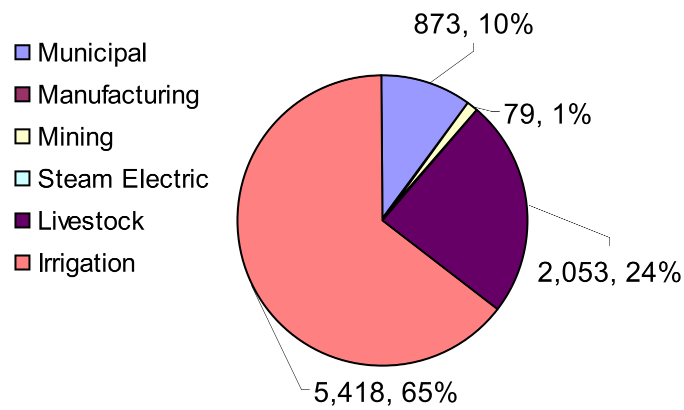




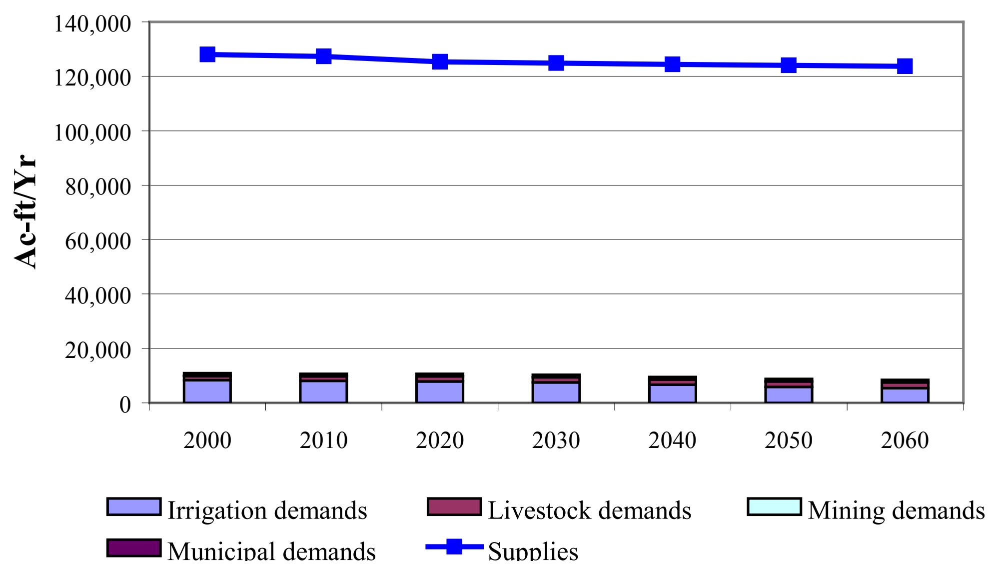
2000 Wheeler County Water Use
(acre-feet, % of total)



2060 Wheeler County Water Use
(acre-feet, % of total)



Wheeler County Supplies & Demands



Water User Group	Strategy
Shamrock	No Shortages Were Identified
Wheeler	No Shortages Were Identified
County-Other	No Shortages Were Identified
Irrigation	No Shortages Were Identified
Manufacturing	No Demands In This Category
Livestock	No Shortages Were Identified
Mining	No Shortages Were Identified
Steam Electric Power	No Demands In This Category

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Task 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 groups across the state and established guidelines and rules governing regional planning efforts.

The regional water planning groups created pursuant to SB1 are in charge of the regional planning process. TWDB regulations require each regional planning group to include representatives of 11 designated interest groups. Table 1-1 shows the members of the Region A water planning group and the interests they represent. The Panhandle water planning group 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 included Freese and Nichols, Inc., The Texas Agricultural Experiment Station, The Extension Service, and the Bureau of Economic Geology. The Panhandle Regional Planning Commission served as political subdivision and contractor.

Texas Water Development Board planning guidelines require each regional water plan to include ten tasks, which are addressed in the following sections of this report. The tasks 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 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 second regional water supply plan that has been developed for the Panhandle Regional Planning Area (PWPA) since the passage and implementation of SB1.

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

- Population and water demand projections
- Groundwater Availability Models (GAM)
- Surface water Availability Models (WAM)

- Increased focus on conservation
- Impacts of water quality on supply availability
- Evaluation of potential new water management strategies
- Recommendations on sources of funding for water infrastructure needs
- Legislative and other recommendations

The report also includes a number of appendices providing more detailed data and information on the planning efforts.

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 2002 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, builds on policies created in SB1. There are several new requirements and improvements called for within SB2. Planning groups are required to:

- 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.

Conservation is a major component of this round of planning and a separate chapter on conservation is also included in this plan.

The 16 regional water plans must be completed by January 1, 2006 and the TWDB must then approve and incorporate these plans into an all-inclusive state plan that is due in January 2007. The plans will continue to be updated every five years.

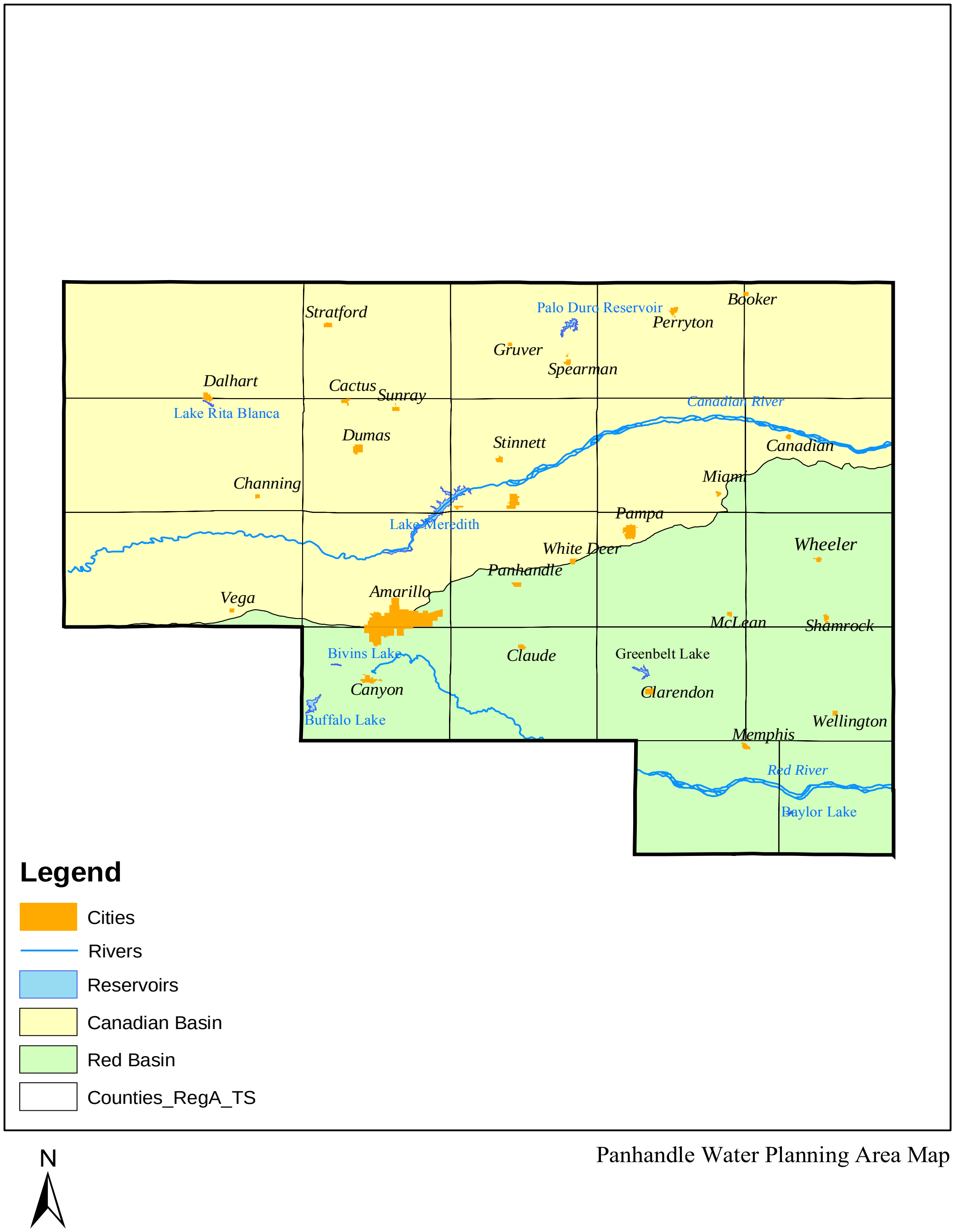


Figure 1-1: Panhandle Water Planning Area Map

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 2000, the region accounted for 1.7 percent of the State's total population and about 12 percent of the State's annual water demand. The TWDB projects that total water use for the region will decline over the 2000-2060 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.

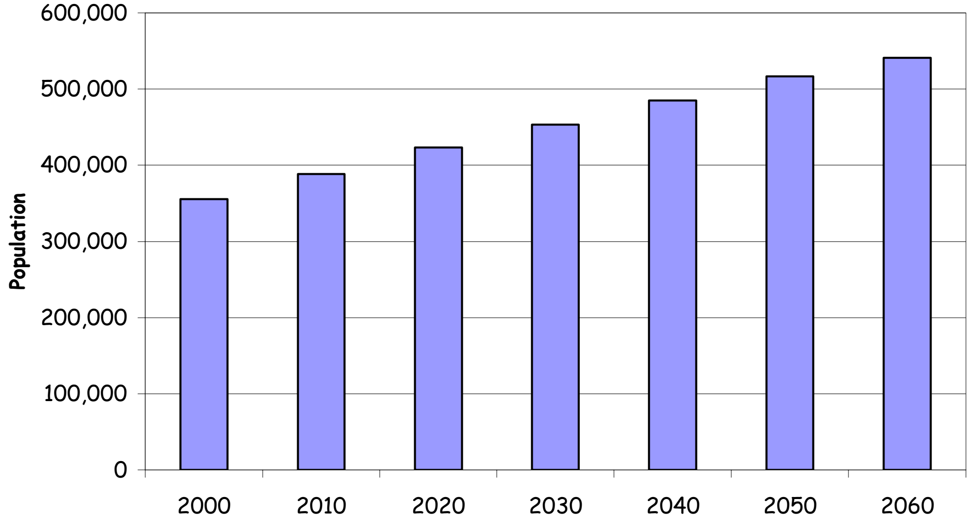
The Panhandle Water Planning Group (PWPG) is composed of 22 members (Table 1-1), each of whom represent the interest of the public, industry, agriculture, environment, river authorities, counties, municipalities, water districts, higher education and water utilities. An additional 6 non-voting members serve as federal and state agency and neighboring regional water planning region liaisons. Panhandle Regional Planning Commission (PRPC) serves as the political subdivision and contracting agency for the Panhandle Water Planning Area.

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.

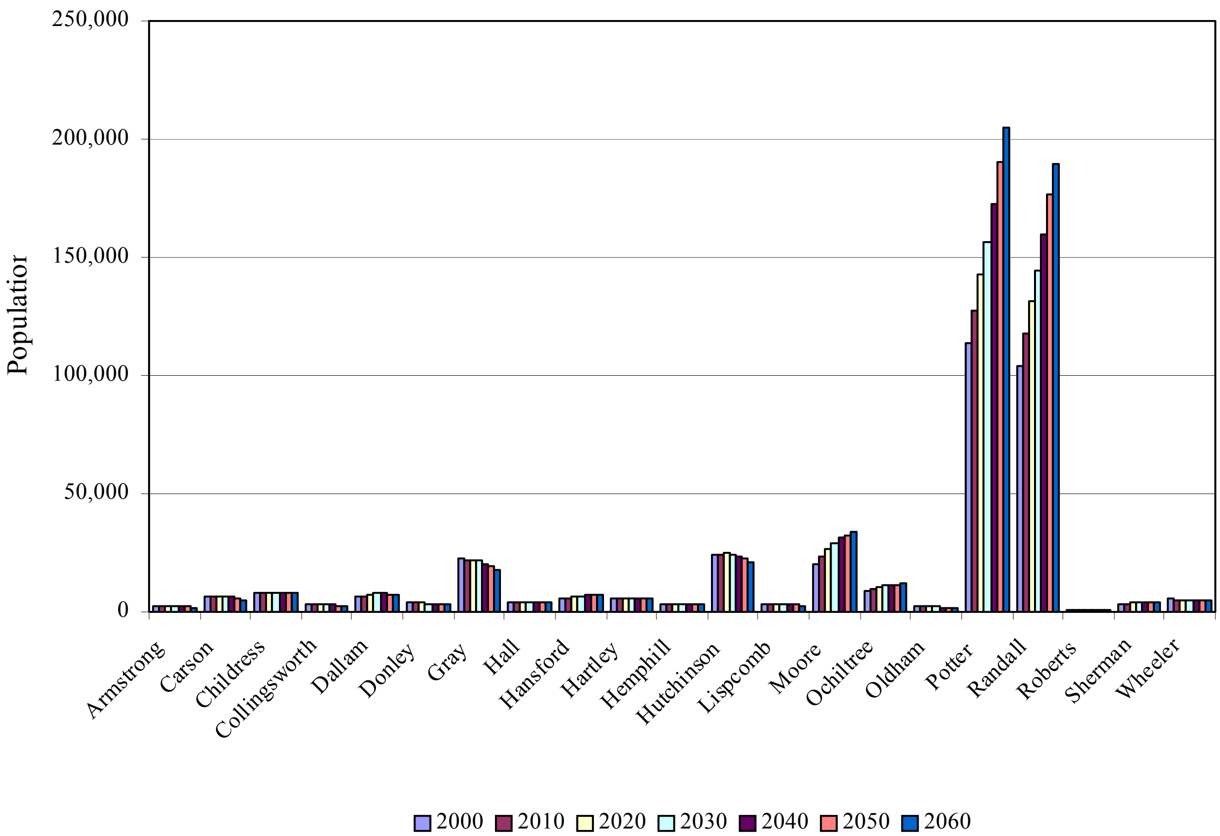
Table 1-1: Voting Members of the Panhandle Water Planning Group

Interest	Name	Entity	County (Location of Interest)
Public	Janet Guthrie	Hemphill County GCD	Hemphill
Counties	Judge Vernon Cook	Roberts County	Roberts
Municipalities	Dan Coffey	City of Amarillo	Potter and Randall
	David Landis	City of Perryton	Ochiltree
Industries	Bill Hallerberg	Industry (Retired)	Potter
	Denise Jett	Conoco Phillips	Hutchinson
Agricultural	Ben Weinheimer	Texas Cattle Feeders Association	Serves Entire Region
	Janet Tregellas	Farmer/Rancher	Lipscomb
	B. A. Donelson	Agriculture/Banker (First State Bank)	Sherman
	Rudie Tate	Farmer	Collingsworth
Environmental	Grady Skaggs	Farmer	Oldham
	Dr. Nolan Clark	USDA-ARS	Potter
	Inge Brady		Randall
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
Water Districts	Richard Bowers	North Plains Groundwater Conservation Dist.	Moore and 7 other counties in the region
	C. E. Williams	Panhandle Groundwater Conservation Dist.	Carson and 7 other counties in the region
	Bobbie Kidd	Greenbelt M&I Water Authority, Region B	Donley and 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 Agricultural Experiment Station	Entire Region



Source: TWDB, 2002.

Figure 1-2: Panhandle Population Projections



Source: TWDB, 2002.

Figure 1-3: Panhandle Population Projections by County

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 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

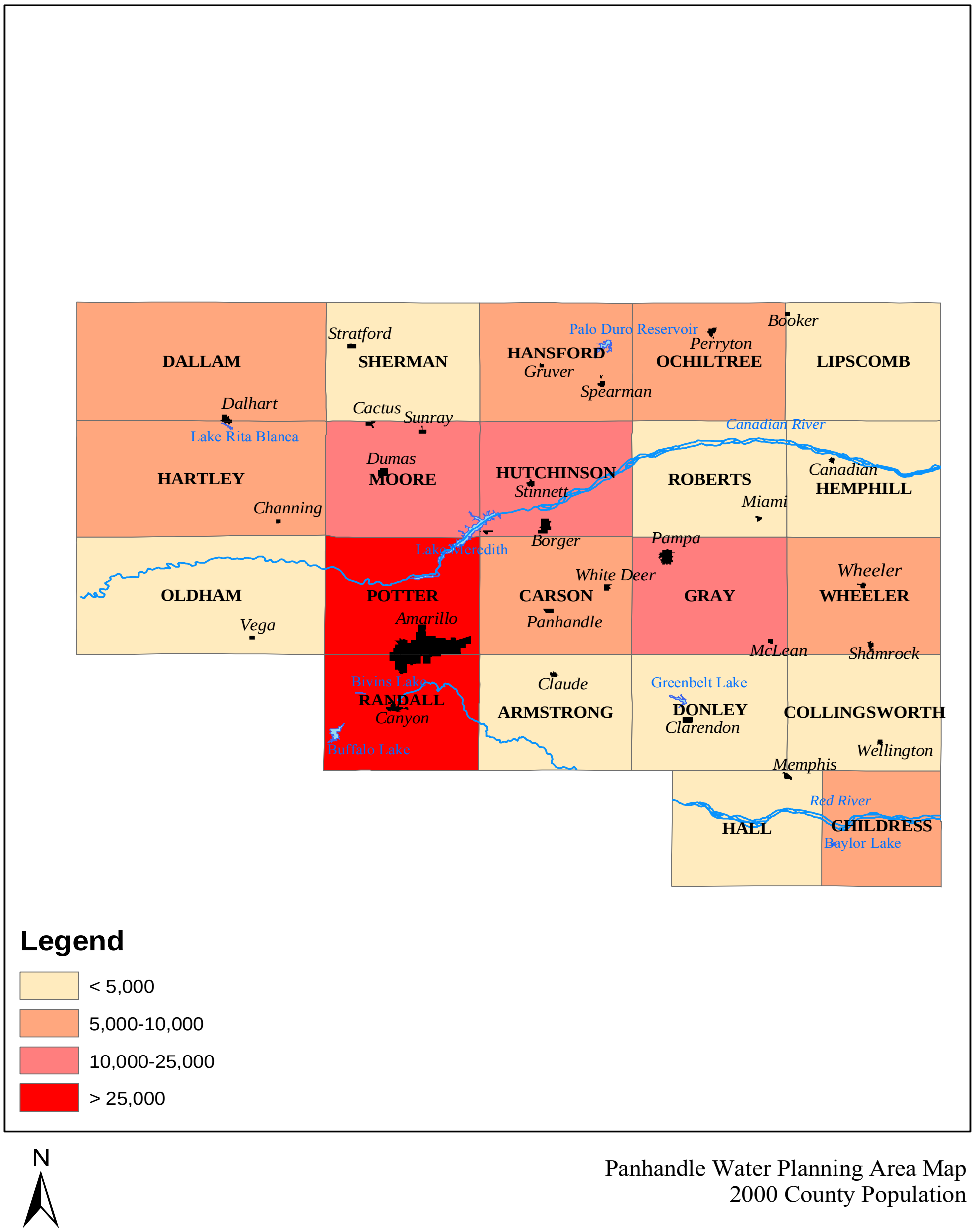


Figure 1-4: 2000 PWPA Population Distribution

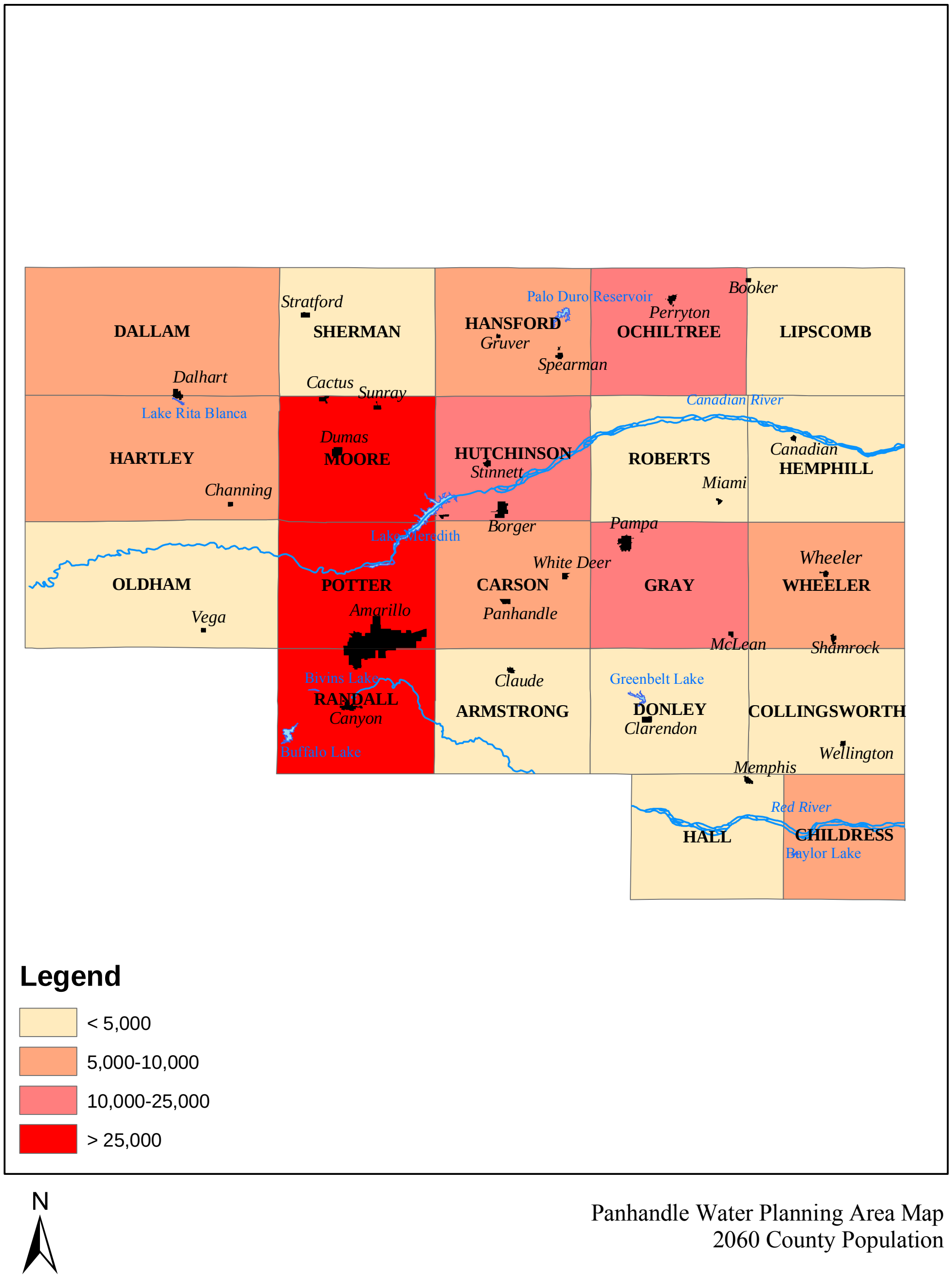


Figure 1-5: 2060 PWPA Population Distribution

1.3.2 Economic Activities

The economy of the Panhandle Region 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 1997 are listed in Table 1-3. In comparison to 1992 economic census data, 1997 retail sales values have substantially increased. Retail sales have increased 32% from $2,453,092,000 in 1992 to $3,236,345,000 in 1997. In the ten year period from 1989 to 1999, per capita income has also increased. The average per capita income for counties in the Panhandle region has increased 42% from $11,641 in 1989 to $16,552 in 1999.

1.3.3 Climate

The climate of the Panhandle Region is characterized by rapid, large temperature changes, wind, and low humidity. The Panhandle Region 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 5 years (National Weather Service, http://www.srh.noaa.gov/ama/html/clistn.htm). According to the National Climatic Data Center, the average yearly temperature and precipitation measured at the city of Amarillo are 57 degrees Fahrenheit and 19.85 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)		Per capita income (dollars)		Major Economic Activities			
County	**1992**	**1997**	**1989**	**1999**	**Agribusiness**	**Manufacturing**	**Petroleum**	**Tourism**
Armstrong	3,174,000	2,940,000	11,212	17,151	X			X
Carson	16,740,000	25,239,000	11,710	19,368	X		X	
Childress	36,822,000	43,683,000	9,888	12,452	X			X
Collingsworth	12,035,000	17,396,000	9,425	15,318	X			
Dallam	33,270,000	65,337,000	9,250	13,653	X	X		X
Donley	16,915,000	23,567,000	9,388	15,958	X	X		X
Gray	155,119,000	169,059,000	12,771	16,702	X	X	X	
Hall	10,464,000	43,135,000	9,376	13,210	X			
Hansford	23,198,000	38,965,000	12,136	17,408	X		X	
Hartley	(D)	14,370,000	14,254	18,067	X	X	X	
Hemphill	21,727,000	19,687,000	14,244	16,929	X		X	
Hutchinson	145,230,000	150,983,000	11,677	17,317	X	X	X	X
Lipscomb	7,670,000	10,612,000	11,997	16,328	X		X	
Moore	102,423,000	127,459,000	11,195	15,214	X		X	
Ochiltree	52,877,000	63,322,000	13,325	16,707	X		X	
Oldham	8,569,000	8,040,000	10,577	14,806	X			
Potter	1,027,408,000	1,531,297,000	10,230	14,947	X	X	X	X
Randall	738,418,000	838,250,000	15,369	21,840	X	X		X
Roberts	1,569,000	1,749,000	15,679	20,923	X		X	
Sherman	8,376,000	8,108,000	10,396	17,210	X			X
Wheeler	31,088,000	33,147,000	10,370	16,083	X		X	X
Total	2,453,092,000	3,236,345,000	244,469	347,591				
Average	122,654,600	154,111,667	11,641	16,552				

Source: U.S. Census Bureau, www.census.gov
1992 retail sales data available online at
http://www.census.gov/prod/1/bus/retail/92area/rca44.pdf

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. Many of these providers were classified as Major Water Providers during the SB1 planning cycle. 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 Panhandle Region has designated eight WWPs.

- Canadian River Municipal Water Authority
- City of Amarillo
- City of Borger
- City of Cactus
- City of Dumas
- 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 51,000 acre-feet for use by industries. Eleven cities formed the Authority with the following three in the PWPA: Amarillo, Borger, Pampa, and the remaining 8 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. and continues to explore additional groundwater supply options to supplement surface water supplies from the lake.

1.4.2 City of Amarillo

The City of Amarillo currently operates with an average production of 42 million gallons per day to approximately 180,000 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, manufacturing, and Steam Electric Power needs. The City plans to expand their groundwater supply capacity through developing existing water rights in Roberts County.

1.4.3 City of Borger

The City of Borger currently services over 6,200 active water accounts. The source of supply for Borger is 11groundwater 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, County other, and manufacturing needs.

1.4.4 City of Cactus

The City of Cactus currently services over 925 active water accounts. The source of supply for Cactus is 8 wells pumping from the Ogallala serving a population of 2,538 people. Cactus supplies water to County other and manufacturing needs. Cactus plans to continue to supplies these needs through groundwater from the Ogallala aquifer.

1.4.5 City of Dumas

The City of Dumas currently services 5,469 active water accounts and a population of 13,747. The city also serves water to County other customers located outside of the city. Dumas is listed as a WWP due to its potential to deliver more than 1,000 AFY to a customer outside the city. The source of supply for Dumas is 10 wells pumping at a peak delivery rate of 7.7 million gallons per day. Of these 10 wells, 4 are located in a well field approximately 12 miles west of the city in Hartley County. The city plans to drill additional wells in the Ogallala aquifer to meet projected demands.

1.4.6 Mesa Water, Inc.

Mesa Water, Inc. currently does not provide water to any customers. The group of land owners led by Boone Pickens currently holds 10 permits for groundwater withdrawals of up to 150,000 AFY in Roberts County. The term permits are contingent on a signed contract within 5 years of authorization.

1.4.7 Greenbelt Municipal and Industrial Water Authority (GM&IWA)

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

1.4.8 Palo Duro River Authority (PDRA)

The Palo Duro River Authority currently does not provide water to any member cities. The Palo Duro Reservoir is located on Palo Duro River in Hansford County. The Authority was authorized to serve Hansford and Moore Counties and the City of Stinnett. The lake was completed in 1991. PDRA 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.

Table1-4: 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 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 new provisions will require TCEQ to determine areas that warrant special consideration and for those areas to encourage the formation of a new groundwater district or the incorporation of these areas into existing districts. Each groundwater district is required to submit a water management plan to the Texas Water Development Board for certification.

SB 2 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 make an effort to follow aquifer boundaries, groundwater district boundaries, and planning regions. The region contains 2 GMAs.

Groundwater conservation districts have played a major role in the management of water resources in the PWPA. Parts or all of 18 counties in the PWPA study area are included in the five groundwater districts presented in Table 1-5. The counties of Hall, Childress, and Oldham are not included in groundwater districts. Districts can regulate well spacing, well size, well construction, 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
Collingsworth County Underground Water District	Collingsworth	Seymour Blaine
Hemphill County Underground Water District	Hemphill	Ogallala
High Plains Underground Water Conservation District	Potter, Randall & Armstrong	Ogallala Dockum

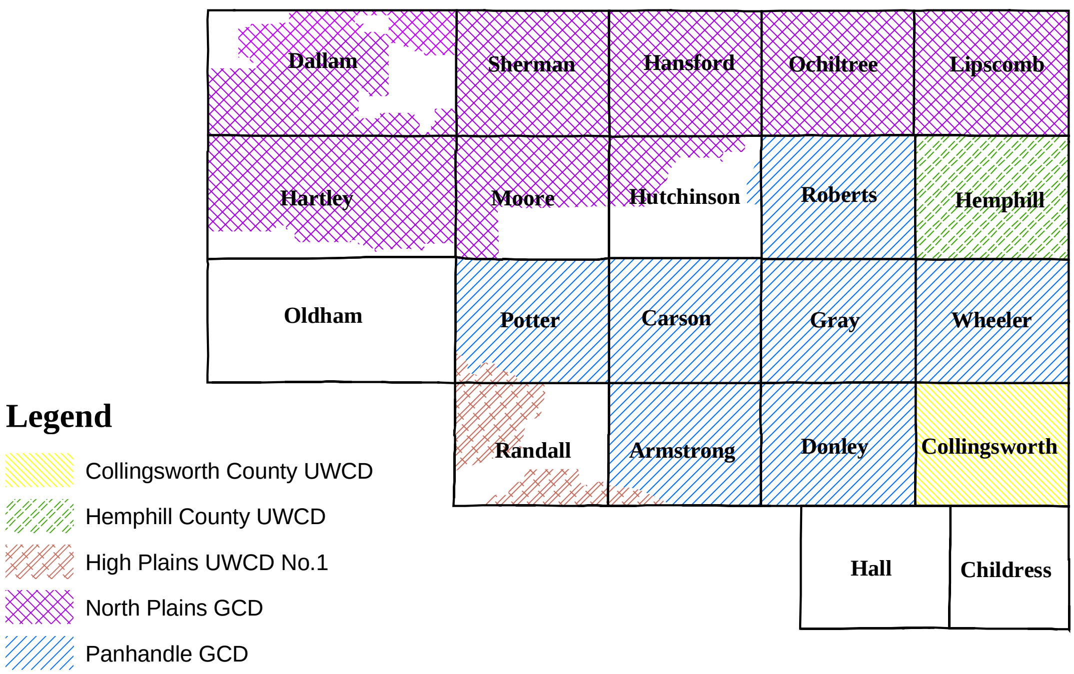


Figure 1-6: Groundwater Conservation Districts in PWPA

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 Ogallala Aquifer

The Ogallala Aquifer is the major water-bearing formation of the Panhandle Region. 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.

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. It is estimated that the long term average annual recharge rate is less than 3 inches per year. Playa basins appear to be the focal point 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, and reduced commodity prices have resulted in a reduction in the rate of water level declines.

The TWDB reported that groundwater depletion in the Ogallala Aquifer in the 18 counties underlain by this aquifer in PWPA was expected to average a total of 5.9 percent for the ten-year period between 1990 and 2000. The estimated water in storage in the Ogallala Aquifer in the PWPA was about 265 million acre feet in 1990, and was projected to decline to 249 million acre feet in 2000 according to previous studies. (see Table 1-6)

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). Under an approved request for supplemental funding, 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. The results of this study can be found later in this report.

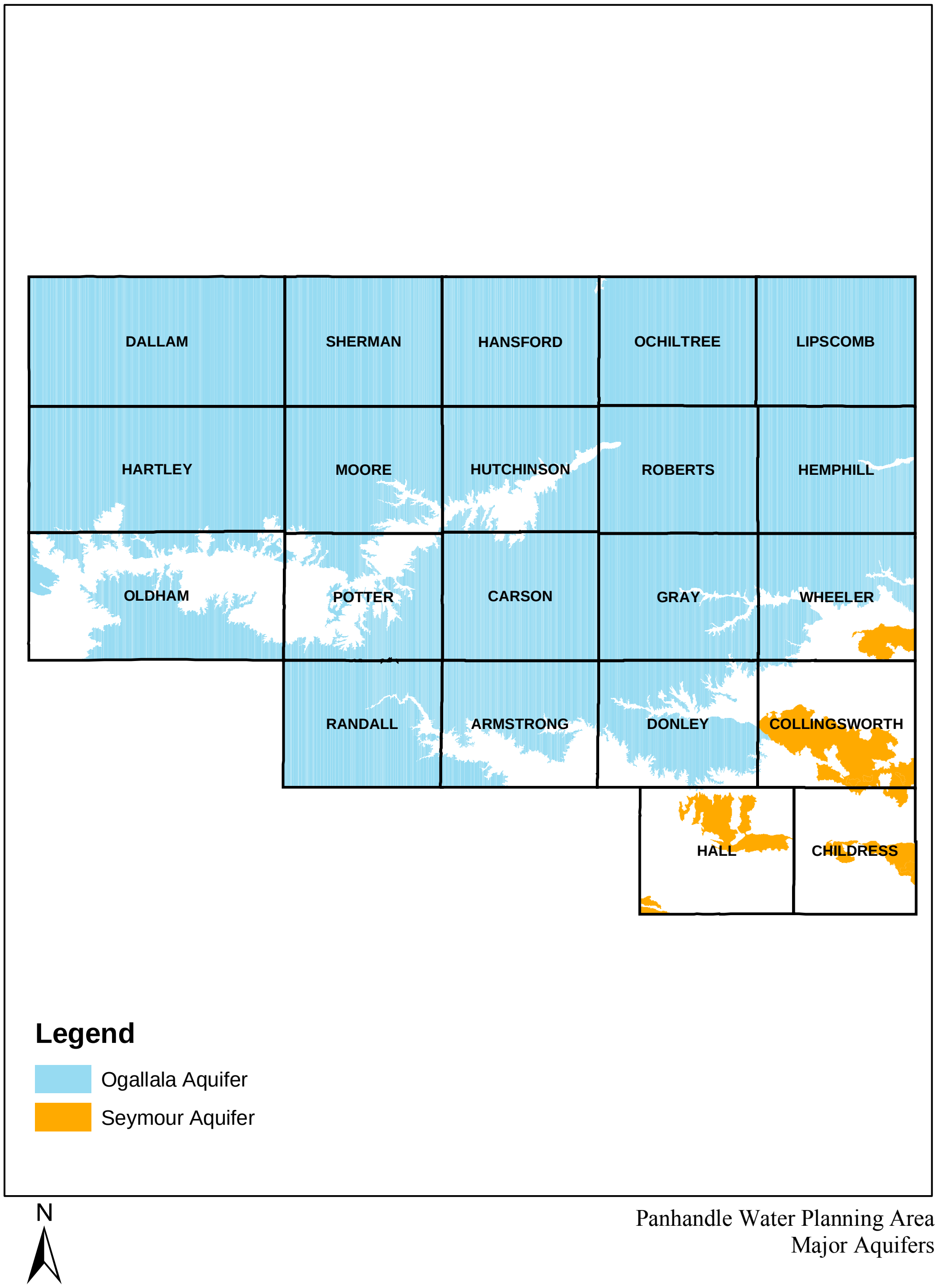


Figure 1-7: Major Aquifers in the PWPA

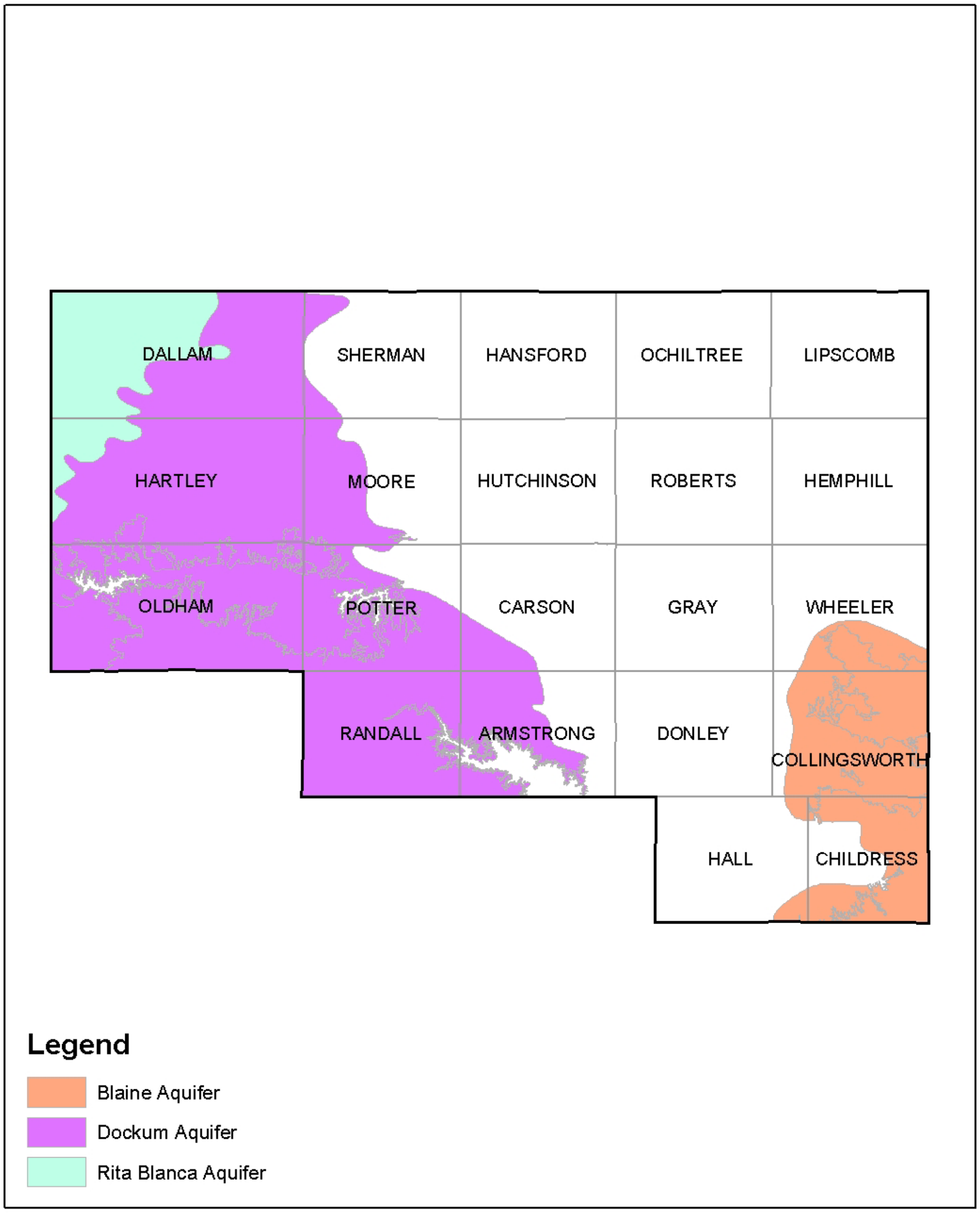


Figure 1-8: Minor Aquifers in the PWPA

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

County	1990 Storage	2000 Storage	Percent Depletion	2000 GAM Storage	2010 GAM Storage	Percent Depletion
Armstrong	3.64	3.50	3.80%	4.05	3.95	2.53%
Carson	13.19	12.53	5%	15.28	14.16	7.91%
Childress	NA	NA	NA	NA	NA	NA
Collingsworth	NA	NA	NA	0.86	0.86	0.00%
Dallam	29.97	25.71	14.20%	17.60	14.62	20.38%
Donley	8.09	8.10	-0.10%	6.25	6.07	2.97%
Gray	12.96	12.30	5.10%	13.65	13.29	2.71%
Hall	NA	NA	NA	NA	NA	NA
Hansford	23.27	21.36	8.20%	21.69	20.39	6.38%
Hartley	27.82	26.06	6.30%	24.93	22.14	12.60%
Hemphill	16.57	16.74	-1.00%	15.64	15.59	0.32%
Hutchinson	10.54	9.97	5.40%	11.11	10.28	8.07%
Lipscomb	20.82	20.74	0.40%	18.64	18.53	0.59%
Moore	13.2	11.11	15.80%	10.66	8.87	20.18%
Ochiltree	18.57	17.67	4.80%	19.80	18.85	5.04%
Oldham	1.14	1.07	6.10%	2.52	2.46	2.44%
Potter	3.07	2.76	10.10%	3.05	2.86	6.64%
Randall	4.51	4.00	11.30%	6.26	5.85	7.01%
Roberts	27.62	27.70	-0.30%	27.49	26.81	2.54%
Sherman	21.88	19.79	9.60%	19.50	16.81	16.00%
Wheeler	8.45	8.36	1.10%	7.49	7.42	0.94%
Total Storage	265.31	249.47		246.47	229.81	
Estimated Average 10-year Total Depletion			5.90%			7.34%

Source: Wyatt, 1996 and TWDB, 2005

NA = 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 Water Quantity Section 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 183,090 ac-ft/year and reported use ranging from 73,916 ac-ft/yr to 74,975 ac-ft/yr from 1994 to 2000.

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	Use(1)	Use in 1994(2)	Use in 1995(2)	Use in 1996(2)	Use in 2000	Permitted Amount(3)
Canadian River Basin									
Hutchinson	CRMWA	Lake Meredith	69,750	1	69,481	70,688	68,422	45,000	100,000
				2	0	0	6,103	28,000	51,200
Hansford	Palo Duro River Authority	Palo Duro Reservoir	4,000 *	1	0	0	0	0	10,460
Red River Basin									
Donley	Greenbelt M&I WA	Greenbelt Reservoir	8,985	1	4,435	4,238	451*	4,528	14,530
				2	0	0	0	0	500
				3	0	0	0	0	250
				4	0	0	0	0	750
Totals					73,916	74,926	74,975	77,528	183,090

Source: TCEQ, 2005

Notes:

1) Use Types: 1=Municipal; 2=Industrial; 3=Irrigation; 4=Mining; 7=Recreation; 8=Other

2) A "0" means that zero AF 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.

Water rights known to include only saline water are not included in this table.

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.

* Palo Duro Reservoir is experiencing a new drought of record. The yield is based on a WAM analysis conducted in 2005 but is uncertain until reservoir refills.

N/A - Not Available

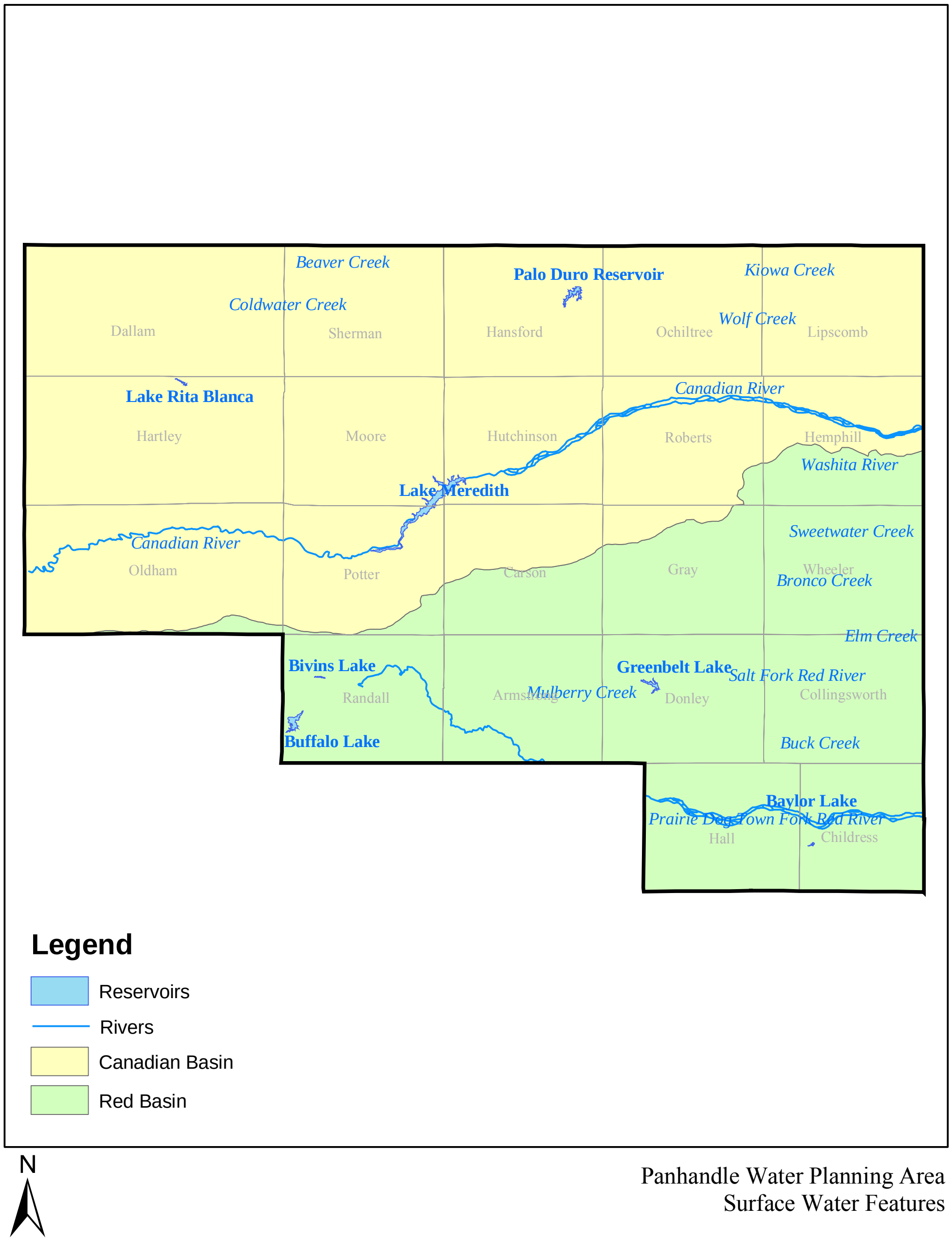


Figure 1-9: Surface Water Feature in the PWPA

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. According to the TCEQ's 2002 State of Texas Water Quality Inventory (TCEQ, 2002), 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. Six segments in the PWPA were identified on the final 2002 303(d) list and are shown in Table 1-9. All six segments are classified by TCEQ as low priority and may be scheduled for Total Maximum Daily Load (TMDL) development between 2001 and 2009.

Table 1-9: 2002 303d Listed Segments in the PWPA

		Constituents of Concern				
Water Body	**Segment Number**	**bacteria**	**pH**	**mercury in walleye**	**dissolved oxygen**	**total dissolved solids**
Canadian River Basin						
Dixon Creek	0101A	X			X	
Lake Meredith	0102			X		
Rita Blanca Lake	0105	X	X			X
Palo Duro Reservoir	0199A				X	
Red River Basin						
Buck Creek	0207A	X				
Upper Prairie Dog Town Fork of Red River	0229				X	
Sweetwater Creek	0299A	X				

Source: TCEQ 2002

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 2000, total water use in the Canadian River Basin portion of the PWPA continues to be from groundwater sources, with less than three percent contributed by surface water sources. The greatest surface water contribution to total water use by county were Potter and Oldham (42 percent from surface water, each), Hemphill (29 percent surface water), and Gray (23 percent surface water). The remaining counties in the PWPA utilize surface waters for less than 10 percent of their total water use (TWDB, 2004).

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 21,000 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 permitted to use a maximum of 40,000 ac-ft of groundwater per year from these wells, and up to 50,000 ac-ft under unusual or emergency conditions. Since the SB1 PWPA plan was completed, the region has experienced record low inflows to Lake Meredith and Palo Duro 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 Canadian River Municipal Water Authority jointly constructed an injection well salinity control project near Logan, New Mexico. The injection well field, operated by the Canadian River Municipal Water Authority, 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 2000, 273,289 acre-feet of water were used in the portion of the PWPA located in the Red River Basin. Water used for irrigated agriculture accounted for about 76 percent of the total water use, with municipal use accounting for approximately 15 percent, and industrial uses accounting for less than 10 percent (TWDB, 2004).

Although surface water supplies account for a larger percent of the total water use in the Red River portion of the PWPA than in the Canadian River portion of the PWPA, less than 15 percent of the total water use in the Red River portion of the PWPA is provided by surface water sources. The counties which relied most heavily on surface water sources in 2000 were Potter (46 percent surface water), Wheeler (36 percent surface water), Hemphill (30 percent surface water), Childress (29 percent surface water), and Randall (23 percent surface water) Counties. The remaining counties each used surface water sources to supply less than 20 percent of their water needs (TWDB, 2004).

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 2000, agricultural water use accounts for 92% of total water use and includes both irrigation and livestock watering. Irrigated crop use accounts for 89% of the total water use, while livestock production accounts for 3% 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 2000, the total municipal water use in the PWPA was 85,192 ac-ft (TWDB, 2002 (Table 1-10), which is slightly over 4% of total water use. Potter and Randall Counties, which contain the city of Amarillo, comprised 61 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)

County	1990	2000	2010	2020	2030	2040	2050	2060
Armstrong	353	414	371	382	369	354	350	340
Carson	1,361	1,422	1,297	1,308	1,300	1,257	1,143	1,038
Childress	1,191	1,847	1,653	1,680	1,704	1,712	1,713	1,669
Collingsworth	739	707	690	691	666	631	605	561
Dallam	1,134	1,964	1,711	1,844	1,928	1,949	1,908	1,819
Donley	701	516	659	650	631	611	594	568
Gray	4,816	4,204	4,082	4,048	3,936	3,782	3,551	3,327
Hall	843	805	795	820	835	822	827	805
Hansford	1,413	1,304	1,298	1,391	1,469	1,555	1,605	1,649
Hartley	756	1,405	1,209	1,251	1,271	1,279	1,263	1,199
Hemphill	729	607	633	636	614	592	575	548
Hutchinson	3,498	4,174	4,124	4,180	4,122	3,988	3,766	3,576
Lipscomb	769	899	748	764	741	720	709	676
Moore	3,810	4,979	4,505	5,151	5,724	6,179	6,455	6,622
Ochiltree	2,611	2,231	2,143	2,318	2,448	2,536	2,579	2,634
Oldham	2,753	392	416	425	394	348	302	244
Potter	24,845	29,780	25,865	28,273	30,525	33,091	35,890	38,185
Randall	21,321	25,645	23,491	26,084	28,510	31,271	34,283	36,778
Roberts	235	180	189	194	175	146	127	115
Sherman	614	776	846	919	948	977	1,003	1,016
Wheeler	901	942	880	881	878	883	882	873
TOTAL	**75,393**	**85,193**	**77,605**	**83,890**	**89,188**	**94,683**	**100,130**	**104,242**

Source: TWDB, 2004

The city of Amarillo has a target of providing 30% groundwater and 70% surface water to all its customers. Presently, the city is supplying 35% groundwater and 65% surface water for water supply, not including its major industrial customers. When major industrial customers (IBP, Excel Energy., Asarco, etc.), are included, the city of Amarillo is currently providing 45% groundwater and 55% surface water. The groundwater comes from well fields in Carson, Potter, Randall, and Deaf Smith counties.

The Canadian River Municipal Water Authority (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 2000, 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 2000 is summarized in Table 1-11.

Table 1-11: Water Used by CRMWA Member Cities in the PWPA during 2000

	Municipal Water Supplied, 1000 gal/yr		
City	Wells Groundwater	Surface Water CRMWA	Total
Amarillo	7,077,000	9,645,525	16,722,525
Borger	867,040	878,234	1,745,274
Pampa	484,162	871,638	1,355,800
Total (1,000 gal/yr)	8,428,202	11,395,397	19,823,599
Total (ac-ft/yr)	25,865	34,971	60,836

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 85,193 ac-ft in 2000 to 104,242 ac-ft 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.

GM&IWA provides surface water from Greenbelt Reservoir for municipal, industrial, mining and irrigation uses. In 2000, GM&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, 2004)

1.6.2 Industrial Use

Industrial use includes mining, manufacturing, and power generation, and accounted for approximately 63,292 ac-ft in 2000. Table 1-12 contains the historical and projected industrial water use for counties in the PWPA.

1.6.2.1 Mining

Mining water use totaled approximately 7,229 ac-feet for the entire region in 2000, approximately 11 percent of the total industrial water used. Moore County had the highest use with 1,802 acre-feet (TWDB, 2003).

1.6.2.2 Manufacturing

According to the TWDB, manufacturing water use totaled approximately 37,808 ac-feet for the entire region in 2000, approximately 60 percent of the total industrial water used. Hutchinson County had the highest use with 20,143 acre-feet.

1.6.2.3 Power Generation

Power generation use includes only water consumed during the power generation process (typically losses due to evaporation during cooling). Water that is diverted and not consumed (i.e., return flow) is not included in the power generation total. According to the TWDB, Potter and Moore are the only counties to have reported water use for power generation activities in 2000. Water use of 18,255 acre-feet accounts for approximately 29 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 2000 was 16,679 acre-feet, or approximately 36 percent of the total industrial use in the PWPA as reported by the TWDB (PWPG, 1999). Xcel obtains water from groundwater (Ogallala aquifer), surface water (Lake Meredith), and municipal effluent (city of Amarillo). 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 Hartley and Hemphill are projected to use the least. 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)

County	1997	2000	2010	2020	2030	2040	2050	2060
Armstrong	19	19	13	12	12	12	12	12
Carson	2,268	2,201	2,052	2,081	2,128	2,173	2,209	2,259
Childress	20	20	17	16	16	16	16	16
Collingsworth	0	0	0	0	0	0	0	0
Dallam	0	0	0	0	0	0	0	0
Donley	22	22	15	14	14	14	14	14
Gray	5,211	5,822	6,193	6,382	6,479	6,553	6,598	6,452
Hall	22	22	15	14	14	14	14	14
Hansford	800	630	592	585	583	581	579	578
Hartley	0	5	5	5	5	5	5	5
Hemphill	1	1	1	1	1	1	1	1
Hutchinson	16,584	20,575	24,057	25,875	27,363	28,794	30,036	32,104
Lipscomb	87	82	95	101	106	110	114	122
Moore	8,979	8,687	9,812	10,366	10,823	11,274	11,670	12,338
Ochiltree	204	164	198	213	220	226	232	240
Oldham	548	292	328	341	347	352	357	364
Potter	10,807	24,104	29,549	33,222	35,239	37,429	39,543	44,334
Randall	490	504	623	689	746	799	843	915
Roberts	9	9	6	6	6	6	6	6
Sherman	23	20	17	16	16	16	16	16
Wheeler	113	113	89	85	83	82	81	79
TOTAL	**46,207**	**63,292**	**73,677**	**80,024**	**84,201**	**88,457**	**92,346**	**99,869**

Source: TWDB 2003

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 2002 Census of Agriculture estimates presented in Table 1-13, the number of farms has decreased in the period between 1978 and 2002. In the period between 1978 and 2002, the acres of harvested cropland decreased appreciably, however, accuracy was compromised by avoiding disclosure of individual farm data. By 2002, total harvested cropland in the PWPA approximated 1,523,839 acres and was distributed between 2,762 farms. In 2002, approximately 66 percent of the harvested cropland was contained in six counties (Carson, Dallam, Hansford, Hartley, Moore, and Sherman) on 973 farms.

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

	1978		1982		1987		1992		1997		2002	
County Name	Farms	Acres	Farms	Acres	Farms	Acres	Farms	Acres	Farms	Acres	Farms	Acres
Armstrong	189	73,120	194	100,434	173	81,576	148	74,910	125	67,217	118	(D)
Carson	293	146,423	295	191,154	266	154,361	242	172,506	227	174,821	151	105,259
Childress	304	76,960	259	93,197	199	66,295	179	86,806	166	96,967	119	63,879
Collingsworth	363	105,762	296	86,337	248	78,250	258	83,752	290	90,387	215	89,709
Dallam	308	250,252	295	261,412	293	203,239	272	230,710	263	299,352	213	250,350
Donley	274	59,083	243	57,784	190	32,035	160	30,073	176	41,188	151	37,271
Gray	241	102,060	217	105,053	193	77,615	164	92,719	162	95,724	118	58,177
Hall	364	122,739	286	105,052	216	78,598	200	86,363	177	90,783	126	99,041
Hansford	275	203,143	260	203,607	259	169,195	221	203,150	189	212,647	147	127,477
Hartley	157	132,816	157	157,962	178	115,245	159	140,626	142	153,346	140	159,433
Hemphill	131	34,926	133	44,703	125	33,748	105	29,505	106	26,971	71	16,331
Hutchinson	100	61,551	82	60,335	87	55,412	94	74,740	68	87,885	61	(D)
Lipscomb	240	81,877	229	89,262	206	74,940*	177	75,212	142	67,255	111	(D)
Moore	204	148,631	205	169,202	224	133,869	203	162,528	160	177,769	139	147,854
Ochiltree	334	212,118	339	267,989	334	214,199	301	233,663	240	239,796	179	(D)
Oldham	113	58,713	109	72,739	94	57,818	82	60,996	75	47,391	40	14,541
Potter	66	27,491	58	21,878	68	25,900*	50	21,925	53	23,109	40	(D)
Randall	363	112,746	380	161,471	364	130,238	315	120,833	278	131,938	194	71,410
Roberts	58	29,309	47	24,906	58	23,399	47	25,999	40	24,832	22	15,535
Sherman	252	207,680	226	194,465	241	168,821	194	181,527	155	186,873	183	220,226
Wheeler	348	75,685	360	91,421	291	65,477	265	62,249	237	57,366	224	47,346
Totals	4,977	2,323,085	4,670	2,560,363	4,307	2,040,220	3,836	2,250,792	3,471	2,393,617	2,762	1,523,839

Source: 1978-1992 Data, USDOC, 1998; 1997-2002 Data, National Agricultural Statistics Service, Table 9, 2002 Census of Agriculture available at http://www.nass.usda.gov/census/

* estimated county average

(D) Withheld to avoid disclosing data for individual farms

1.6.3.2 Irrigation

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 1,756,886 acre-feet in 2000. Five counties, Dallam, Hansford, Hartley, Moore, and Sherman, accounted for approximately 70 percent of the total irrigation water applied in 2000 (TWDB, 2003).

Table 1-14: Projected Irrigation Water Use for the PWPA (acre feet)

County	2000	2010	2020	2030	2040	2050	2060
Armstrong	10,544	10,280	10,017	9,490	8,435	7,381	6,854
Carson	97,345	94,912	92,478	87,611	77,876	68,142	63,274
Childress	10,304	10,046	9,789	9,273	8,243	7,213	6,698
Collingsworth	25,607	24,967	24,327	23,046	20,486	17,925	16,645
Dallam	320,475	312,463	304,452	288,428	256,380	224,333	208,309
Donley	21,019	20,493	19,968	18,917	16,815	14,713	13,662
Gray	25,499	24,862	24,224	22,949	20,399	17,850	16,576
Hall	20,789	20,269	19,749	18,710	16,631	14,552	13,513
Hansford	138,389	134,929	131,470	124,550	110,711	96,872	89,953
Hartley	289,008	281,783	274,557	260,107	231,206	202,306	187,855
Hemphill	3,779	3,637	3,496	3,354	3,212	3,070	2,929
Hutchinson	63,208	61,628	60,048	56,887	50,567	44,246	41,085
Lipscomb	14,789	14,419	14,049	13,310	11,831	10,352	9,613
Moore	180,594	176,079	171,564	162,535	144,475	126,416	117,386
Ochiltree	104,220	101,615	99,009	93,798	83,376	72,954	67,743
Oldham	5,223	5,092	4,962	4,700	4,178	3,656	3,395
Potter	8,009	7,809	7,608	7,208	6,407	5,606	5,206
Randall	30,302	29,166	28,029	26,893	25,757	24,620	23,484
Roberts	22,890	22,318	21,746	20,601	18,312	16,023	14,879
Sherman	294,703	287,336	279,968	265,233	235,763	206,292	191,557
Wheeler	8,335	8,127	7,919	7,502	6,668	5,835	5,418
TOTAL	**1,695,031**	**1,652,230**	**1,609,429**	**1,525,102**	**1,357,728**	**1,190,357**	**1,106,034**

Source: TWDB, 2005

The five counties of highest irrigation water use (Dallam, Hansford, Hartley, Moore, and Sherman) are projected to utilize approximately 70 percent of the total irrigation water use in the PWPA. The irrigation water use projections for future decades in the planning period may change and will need to be revised with each plan update to accurately reflect changes in the farming community due to new technologies, economic considerations, and crop acreages.

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.

Estimating livestock water consumption is a straightforward procedure that consists of estimating water consumption for a livestock unit and the total number of livestock. Texas A&M University Cooperative Extension Service provides information 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. The Texas Agricultural Statistics service provides current and historical numbers of livestock by livestock type and county. 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). Increased levels of protein or salt in cattle diets increase water consumption. The TWDB 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 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 2000 was 38,180 acre-feet. Table 1-15 contains TWDB estimates of livestock water use by county supplied by surface and groundwater sources. Dallam County and Ochiltree County accounted for the most livestock water use in the region with Dallam using 5,689 acre-feet and Ochiltree using 4,168 acre-feet. Approximately 52 percent of the total livestock water use was supplied from groundwater sources.

Table 1-15: Estimates of Livestock Water Use in the PWPA during 2000 (acre-feet)

County	Surface Water	Groundwater	Total
Armstrong	128	513	641
Carson	289	1,156	1,445
Childress	438	49	487
Collingsworth	705	78	783
Dallam	717	2,869	3,586
Donley	663	74	737
Gray	2,567	285	2,852
Hall	313	35	348
Hansford	4,061	2,707	6,768
Hartley	2,938	2,938	5,876
Hemphill	1,234	822	2,056
Hutchinson	466	52	518
Lipscomb	867	96	963
Moore	1,600	6,402	8,002
Ochiltree	1,562	174	1,736
Oldham	1,582	176	1,758
Potter	68	610	678
Randall	982	3,928	4,910
Roberts	289	32	321
Sherman	825	3,299	4,124
Wheeler	2,006	223	2,229
TOTAL	**18,257**	**19,922**	**38,179**

Source: TWDB, 2002

The majority of 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 an annual growth rate of approximately 8 percent for 11 years and then 1.5 percent thereafter, with a corresponding increase in water demand (PWPG 2003).

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 68 percent of the total livestock water use in the PWPA in 2000, and more than 79 percent by 2060.

Table 1-16: Projections for Livestock Water Use in the PWPA (acre-feet)

County	2000	2010	2020	2030	2040	2050	2060
Armstrong	573	612	645	673	703	734	768
Carson	945	1,016	1,074	1,120	1,168	1,219	1,272
Childress	288	292	348	353	359	366	372
Collingsworth	578	592	656	672	688	705	723
Dallam	5,689	12,287	18,390	18,614	18,851	19,102	19,369
Donley	1,100	1,206	1,283	1,332	1,385	1,440	1,500
Gray	1,706	2,183	2,485	2,589	2,700	2,871	2,942
Hall	297	300	302	305	309	311	316
Hansford	4,088	4,744	5,218	5,509	5,817	6,144	6,490
Hartley	3,572	7,088	10,236	10,506	10,792	11,096	11,418
Hemphill	1,408	1,635	1,811	1,889	1,972	2,061	2,155
Hutchinson	596	814	1,018	1,051	1,086	1,123	1,163
Lipscomb	589	831	958	976	996	1,016	1,037
Moore	2,684	4,172	5,379	5,575	5,783	6,004	6,283
Ochiltree	4,168	4,538	4,787	4,938	5,098	5,268	5,450
Oldham	1,635	2,116	2,258	2,358	2,460	2,569	2,685
Potter	478	503	527	550	574	599	626
Randall	2,752	3,173	3,489	3,683	3,888	4,106	4,338
Roberts	534	609	628	649	671	694	718
Sherman	2,996	10,880	16,701	16,903	17,118	17,347	17,589
Wheeler	1,504	1,645	1,793	1,852	1,915	1,982	2,053
TOTAL	**38,180**	**61,236**	**79,986**	**82,097**	**84,333**	**86,757**	**89,267**

Source: PWPG, 2003

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.

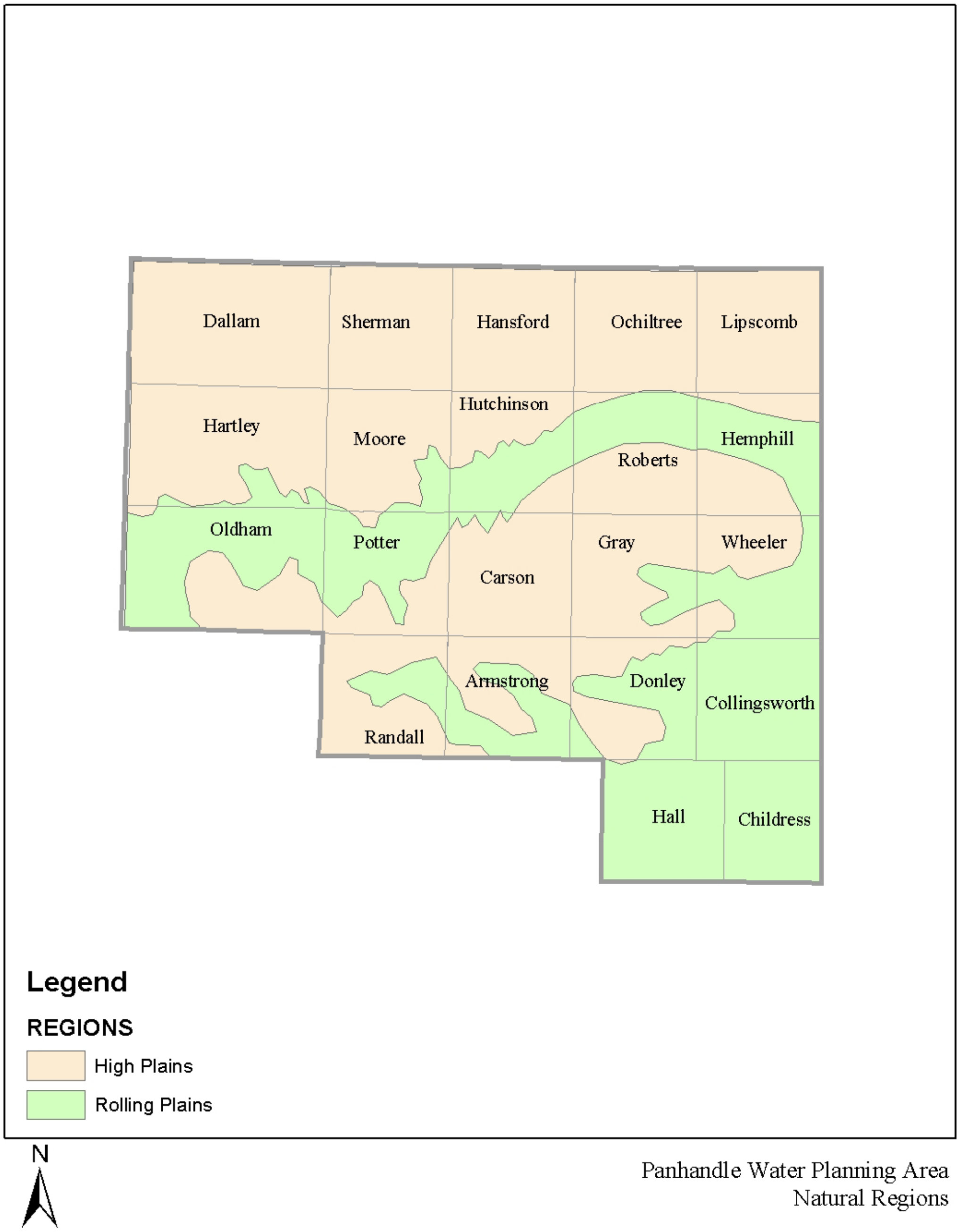


Figure 1-10: Natural Regions in the PWPA

1.7.2 Regional Vegetation

The PWPA is located in two vegetation regions which generally correspond to the natural regions described in the previous section – the High Plains and Rolling Plains. Figure 1-11 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: 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) In addition, on of the conclusions of the study found that upland brush control was not economic in areas of less than 19 inches of annual rainfall.

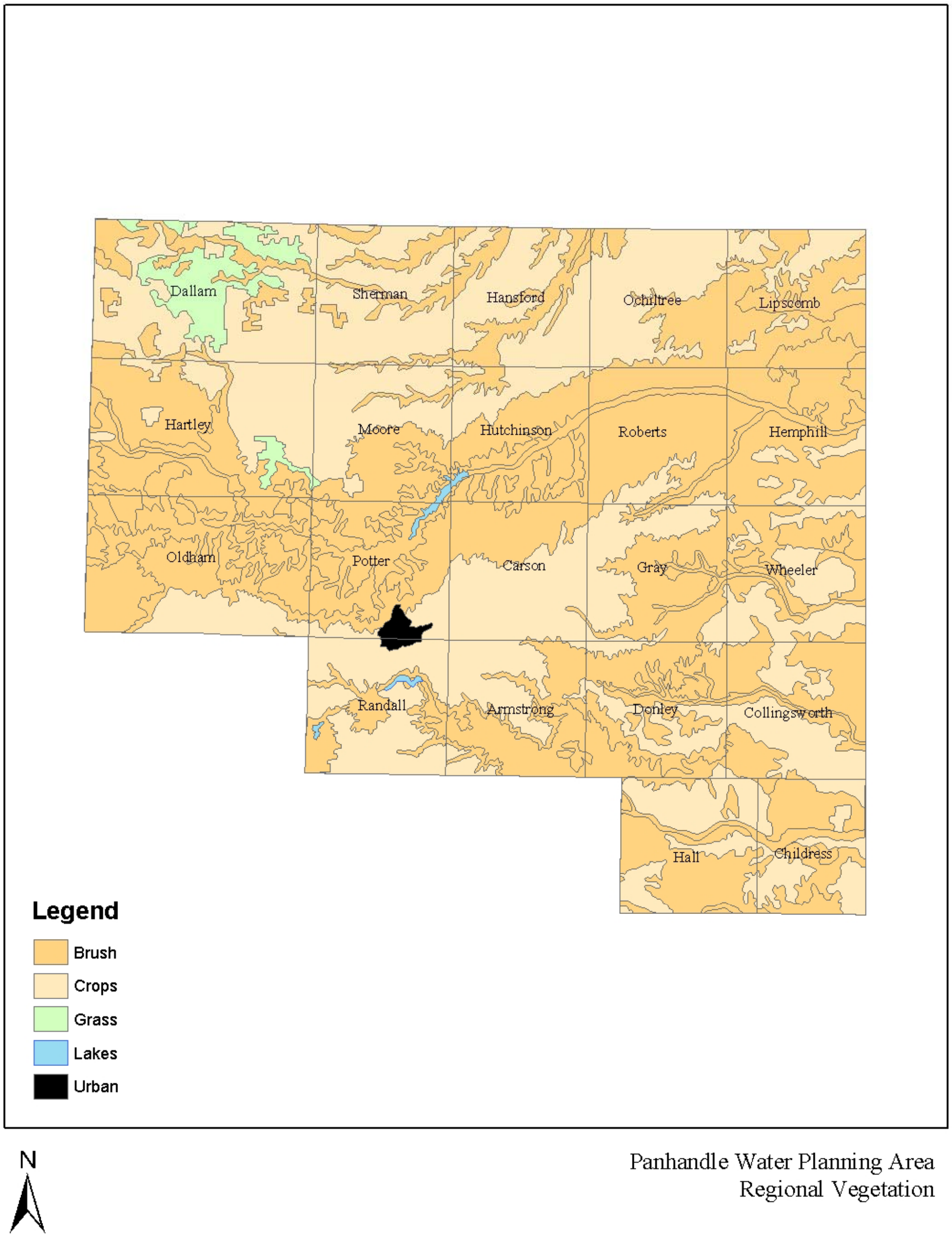


Figure 1-11: Regional Vegetation in the PWPA

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 Mineral Resources

Mineral resources produced in the PWPA (Table1-17) are primarily oil and natural gas. Non-petroleum minerals produced include sand, gravel, caliche, stone. and helium. Three counties, Dallam, Hall, and Randall, reportedly do not have any significant mineral production.

Table 1-17: Mineral Resource Production 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

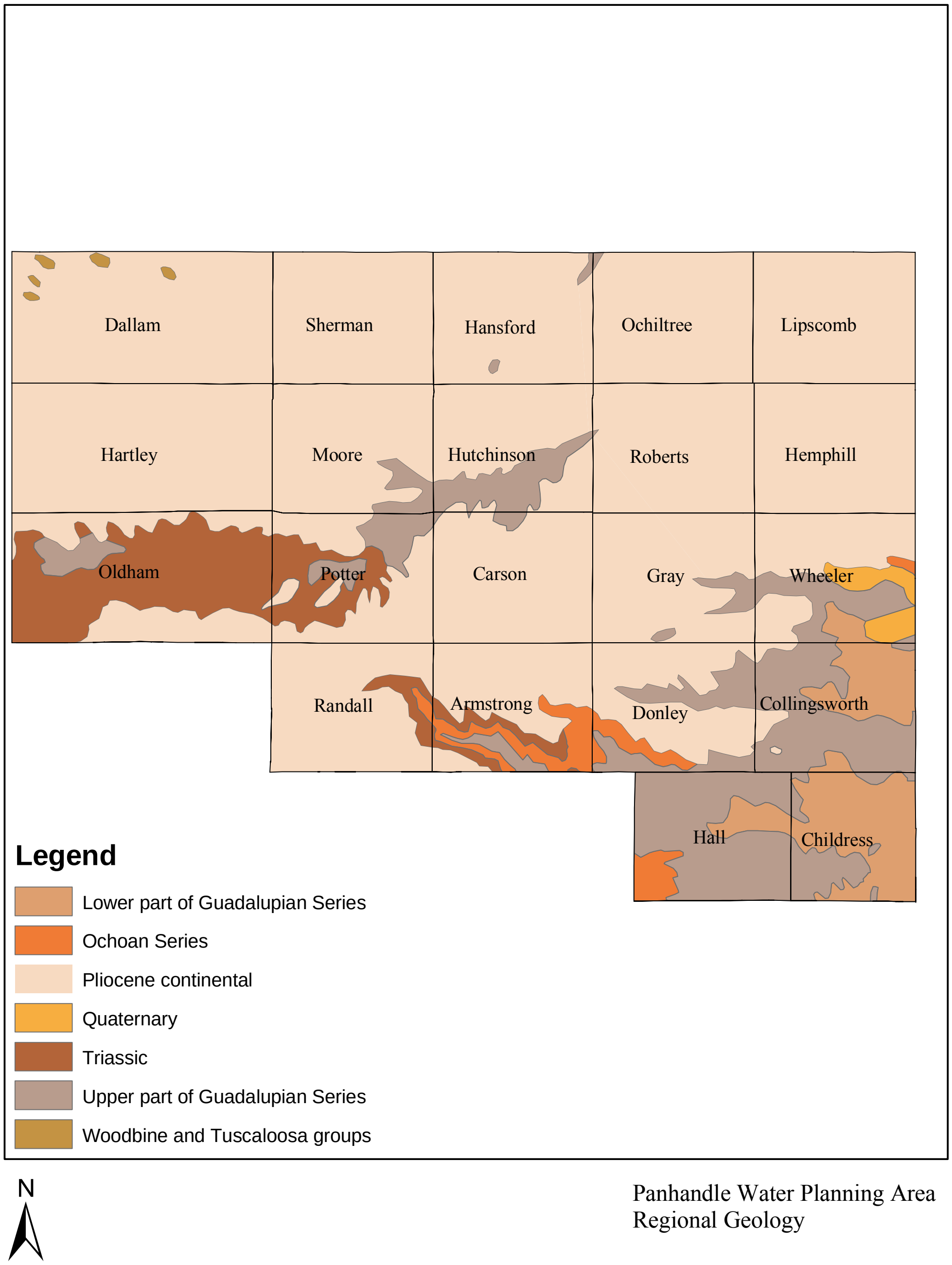


Figure 1-12: Regional Geology of the PWPA

1.7.5 Soils

Soils of the High Plains formed under grass cover in Rocky Mountain outwash and sediment of variable sand, silt, clay, and lime content (Runkles, 1968). Calcium carbonate and, to some extent, gypsum are present in most soil profiles, and rainfall has been insufficient to leach these carbonates from the soil profiles. Many of the surface soils are moderately alkaline to calcareous and low in organic matter. The major soil associations found in the PWPA may be characterized as nearly level or outwash soils (Figure 1-13). 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.

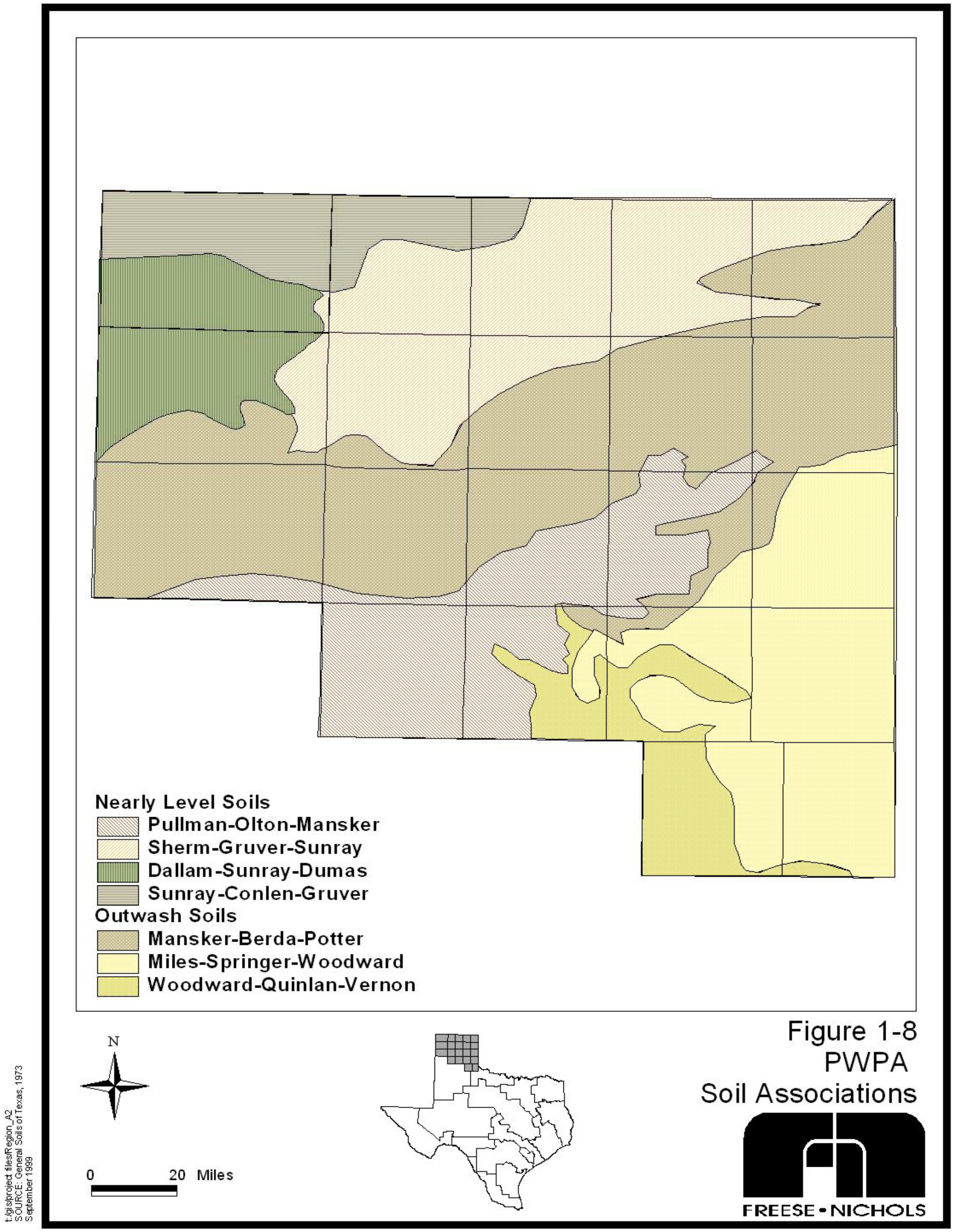


Figure 1-13: Regional Soils of the PWPA

1.7.6 Wetlands

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

The most visible and abundant 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	675	15,177	2.6%	356	1	0.6
Carson	544	18,270	3.1%	404	<1	0.7
Childress	8	116	<0.1%	24	7	0.6
Collingsworth	0	0	0.0%	0	0	0.0
Dallam	219	4,125	0.4%	201	2	0.6
Donley	107	1,903	0.3%	181	1	0.5
Gray	748	12,907	2.2%	388	1	0.5
Hall	0	0	0.0%	0	0	0.0
Hansford	342	6,981	1.2%	399	1	0.6
Hartley	125	3,791	0.4%	126	4	0.8
Hemphill	8	100	<0.1%	34	5	0.5
Hutchinson	167	3,297	0.6%	141	2	0.6
Lipscomb	18	234	<0.1%	36	3	0.5
Moore	190	4,635	0.8%	165	1	0.6
Ochiltree	593	15,836	2.7%	843	1	0.7
Oldham	160	4,336	0.5%	438	1	0.6
Potter	96	3,203	0.6%	292	2	0.7
Randall	561	16,792	2.9%	243	1	0.7
Roberts	109	1,368	0.2%	278	1	0.4
Sherman	214	4,498	0.8%	212	2	0.6
Wheeler	0	0	0.0%	0	0	0.0
REGION TOTAL	**4,884**	**117,569**	**0.9%**	**843.35**	**<1**	**0.6**

Source: NRCS, 2000

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 SB 1 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.

1.7.8 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 Texas Parks and Wildlife Department (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	Federal Status*	State Status*	County of Potential Occurrence																				
			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)*	DL	E	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Arctic Peregrine Falcon *(Falco peregrinus tundrius)*	DL	T	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Bald Eagle *(Haliaeetus leucocephalus)*	LT-PDL	T	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Interior Least Tern *(Sterna antillarum athalassos)*	LE	E	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Lesser Prairie Chicken (*Tympanuchus pallidicinctus)*	C1		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Whooping Crane *(Grus americana)*	LE	E	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Fishes																							
Arkansas River Shiner *(Notropis girardi)*	LT	LT											⊙	⊙				⊙	⊙		⊙		
Mammals																							
Black-footed Ferret *(Mustela nigripes)*	LE	E	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Black-tailed Prairie Dog (*Cynomys ludovicianus)*	C1		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Palo Duro Mouse *(Peromyscus truei comanche)*		T	•																	•			
Texas Kangaroo Rat *(Dipodomys elator)*		T			•					•													
Reptiles																							
Texas Horned Lizard (*Phrynosoma cornutum*)		T	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

Sources: Texas Parks and Wildlife Annotated County Lists of Rare Species;
U.S. Fish and Wildlife List of species by county for Texas (http://ifw2es.fws.gov/endangeredspecies/lists/ListSpecies.cfm)

* Key

LE,LT Federally Listed Endangered/Threatened

E/SA,T/SA Federally Endangered/Threatened by Similarity of Appearance

DL,PDL Federally Delisted/Proposed Delisted

C1 Federal Candidate, Category 1; information supports proposing to list as emdangered /threatened

PT Federally Proposed Endangered/Threatened

E,T State Endangered/Threatened

Occurs on State List for County	•
Occurs on Federal List for County	○
Occurs on both State and Federal Lists for County	⊙

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 water use in the PWPA is primarily for agriculture, some of the constraints to use are not as severe as 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; contamination of surface water and groundwater; and drought related shortages for both surface water and groundwater. Potential groundwater contamination 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.

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 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.

SB-1 requires that 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 prepare a water conservation plan and submit it to TCEQ. According to TCEQ (1999c), entities required to submit a plan in accordance with SB-1 are the Canadian River MWA, Greenbelt M & IWA, and Palo Duro River Authority.

Drought contingency plans have been prepared by different stakeholders in the planning area. Canadian River Municipal Water Authority, Greenbelt Municipal and Industrial Water Authority, City of Gruver, City of Canyon, City of Borger, Pantex Water System, TCW Supply Inc., and Moortex Water Supply Corporation are the major water suppliers with available drought contingency plans within 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 will be those detailed in each of the respective reservoir operators' drought contingency plans. Drought triggers for all groundwater sources will be based on local atmospheric conditions using the currently available PET stations.

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 will be 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.

Below is the breakdown of drought trigger and response zones in the PWPA:

Table 1-20 Drought Triggers 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

1.8.2 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, water districts, etc. are all 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. The PWPG has defined available groundwater as not more than 1.25 percent of the total annual water in storage to allow for water to remain for future planning cycles beyond the current 50-year period.

1.9 Existing Programs and Goals

1.9.1 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.

Farm Security and Rural Investment Act of 2002 - The 2002 Farm Bill, governing federal farm programs for the next 6 years, was signed into law on May 13, 2002. Its provisions 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. Whereas the 1996 policy intended to wean farmers from government subsidies by gradually reducing them, the 2002 farm legislation increases agriculture spending by 78 percent -- or $83 billion spread over 10 years -- while increasing by two-thirds the subsidies for large corn, wheat, rice and cotton farmers. The bill institutes payments to peanut farmers and restores price supports for wool and mohair. The bill provides funding for agricultural research centers, forest programs, nutrition programs, rural development projects and school meals for poor children. But the bulk of the increased spending goes to the producers of basic commodity crops. The 2002 farm bill will cost the average household more than $200 in taxes every year for the next 10 years. (The $200 figure is based on calculations by the Heritage Foundation in combination with revised government estimates putting the total cost of the farm bill at $190 billion.) The bill provides $12.9 billion in new conservation spending over the next six years.

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

1.9.2 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.

1.9.3 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:

- 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, if 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 (2002) - The Water for Texas Plan was adopted by the TWDB in December 2001. 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 800 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. Eight major and ten 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 $17.87 billion, including $4.41 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 2002 State Water Plan is the culmination of a 3-year effort by local, regional, and State representatives. Clearly, the most significant difference in this planning effort as compared with previous efforts is the broad level of public involvement that occurred throughout the process. Nearly 900 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 2002 State Water Plan, during the month of October, 26 public meetings were held in 16 cities. In addition, for the first time, videoconferences were held in 10 cities to receive comments on the draft 2002 State Water Plan. Finally, in November, two public hearings were held in Austin. Throughout this effort, more than 600 individuals attended to provide comments on the draft 2002 State Water Plan.

State Authority and Programs for Groundwater Protection - Following are major TCEQ departments that may have relevance to municipal, industrial, agricultural, and utility users of groundwater (TCEQ, 2002):

- Office of Permitting, Remediation and Registration.- water quality, water supply, and remediation and permit registration.
- Office of Compliance and Enforcement--Field Operations Division, Compliance Support Division, and Enforcement Division.
- 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

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.

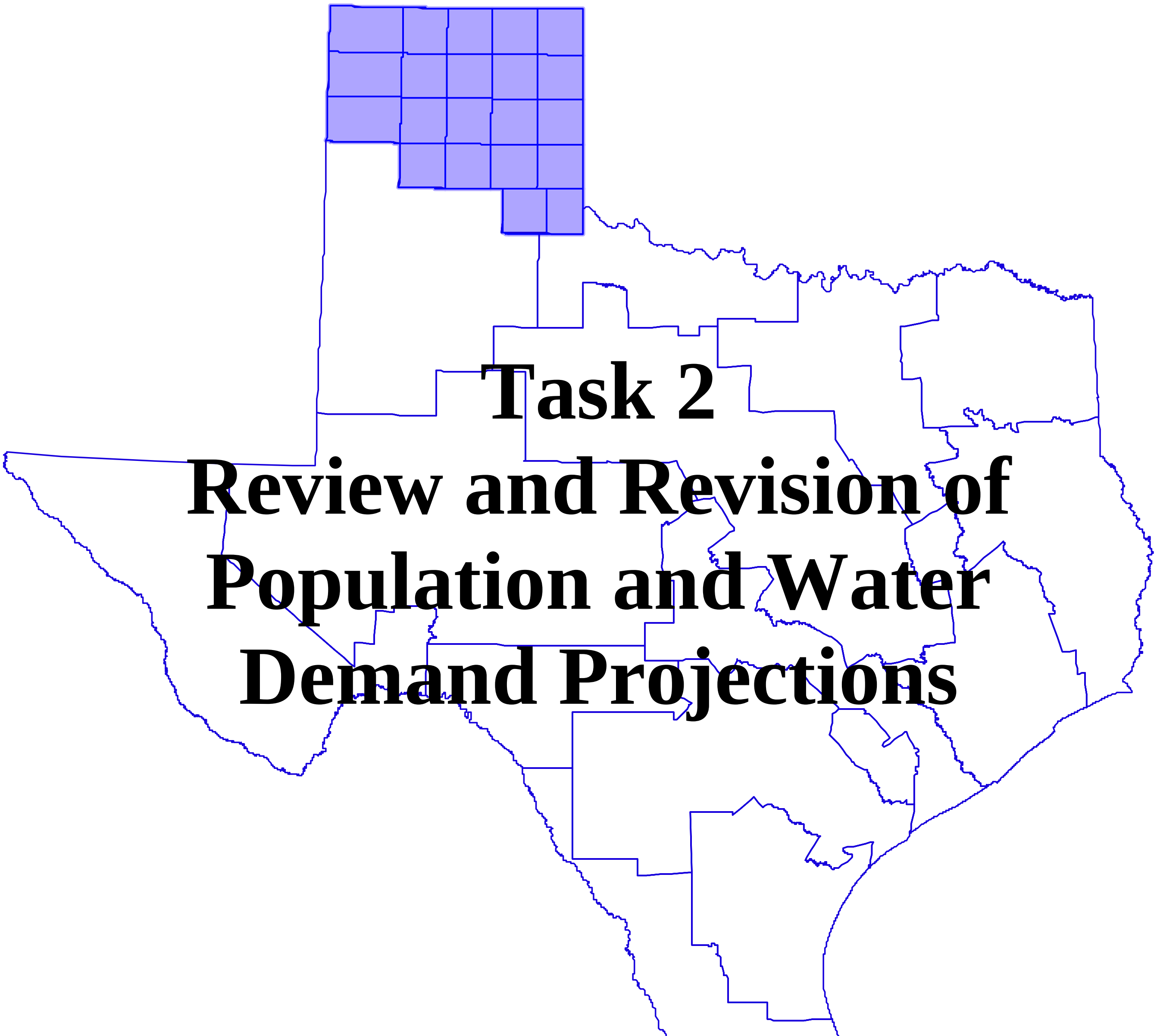
   The Texas Water Code further provides for all wells to be designed and constructed according to TCEQ well construction standards (30 TAC 290). These standards require new wells to be encased with concrete extending down to a depth of 20 feet, or to the water table or a restrictive layer, whichever is 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.

1.9.4 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. CRMWA has implemented the recommendations of the study with the development of a well field in western Roberts County from which up to 50,000 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 procuring additional groundwater rights, expanding the Roberts County wellfield, and reviewing the need for additional aqueduct capacity in future plans.

City of Amarillo – In 1996, the City of Amarillo conducted a study to evaluate the adequacy of the Amarillo water supply and distribution system facilities and to determine the improvements needed to meet the City's water requirements through 2040 (Black & Veatch, 1996). Recommendations of the study included a 30 mgd expansion to the Osage WTP and associated improvements, participation in the CRMWA's Roberts County project, additional wells, and additional water rights. The Roberts County project would provide pre-blended surface and groundwater to Amarillo and increase the City's average CRMWA allocation from about 27 mgd to about 40 mgd. The project will provide an additional supply source to meet projected increases in water demands. It was suggested in the study that additional water rights in Carson and Potter Counties be evaluated before new wells are constructed.



Task 2
Review and Revision of Population and Water Demand Projections

2.1 Current and Projected Population and Water Demand for the Region

Population projections for the Panhandle regional water plan are developed from consensus-based population and water demand projections provided by the Texas Water Development Board (TWDB) and are based on data collected by the 2000 U.S. Census. These consensus-based population projections are distributed and quality controlled by the State Data Center and TWDB in coordination with the Texas Commission on Environmental Quality (TCEQ) and the Texas Parks Wildlife Department (TPWD). The PWPG has developed revised population and water demand projections that are based on changed conditions and the availability of new information. Several water user groups water demand projections were also revised to account for drought of record conditions. TWDB-adopted population and demand projections can be found at the end of this chapter.

The PWPG has compiled a database containing municipal, industrial, and agricultural water demands for the region. Municipal demands were identified and verified using a survey questionnaire that was distributed to more than 47 public water supply entities identified as municipal suppliers and stakeholders in the region. The 95% response rate that was received from the questionnaire indicates the willingness of regional entities to participate in the planning process and an interest in providing accurate information for the Panhandle Regional Water Plan. The demands identified by stakeholders were compared to the consensus-based projections previously adopted by the TWDB and were used to develop several revisions to TWDB population and water use projections. Gallons per capita per day (gpcd) consumption rates for several municipalities were adjusted according to historical TWDB water use survey records to more accurately reflect current demands. The most common method of reporting municipal water use is through an assessment of per capita water use. While this measurement appears to be straightforward, the calculations and meanings of these values are widely debated. The TWDB has historically calculated per capita water use as: (Total water pumped – wholesale water sales – industrial sales) / population / 365 days.

Industrial and manufacturing use projections were supplied from TWDB under separate state-contracted reports to characterize the distribution and document changed conditions. These reports indicated that although manufacturing has shifted between counties, the overall regional demand has not changed significantly from the previous regional plan. Manufacturing use remains as a small component of the overall use in the future. Steam electric use was also characterized and developed by the TWDB and reflects growth in the future. The projections were adopted by the planning group with anticipation that these numbers will be reviewed during the next round of planning.

Demographers and agricultural experts from the local Texas Agricultural Experiment Station and the Texas Agricultural Extension Service reviewed and recommended adjustments to agricultural water demand projections for the region. These experts examined methodologies used by the TWDB to develop projections for livestock and irrigation water use. New methodologies were developed and proposed and revised agricultural water demand projections were adopted by the PWPA.

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. Discussions of population and water demands are contained in the following sections, with detailed data located in the appendices. Revisions to population and water demand projections discussed in this chapter have been approved by the TWDB.

2.1.1 Population

In 1990, the population of the State of Texas was approximately 17,000,000. By 2000, the state had grown to over 20,000,000 people. The PWPA represents approximately 1.7 percent of the state's population during those years. Figure 2-1a compares the population projections from the previous round of planning to the population numbers used in this plan. Figure 2-1b shows populations of counties in the PWPA in 2000. The population of the region was estimated to be 355,832, with 61 percent of the total region's population located in Potter and Randall Counties surrounding Amarillo. Approximately 39 percent of the population in the PWPA is distributed among the remaining 19 counties, ranging from 887 in Roberts County to 23,857 in Hutchinson County.

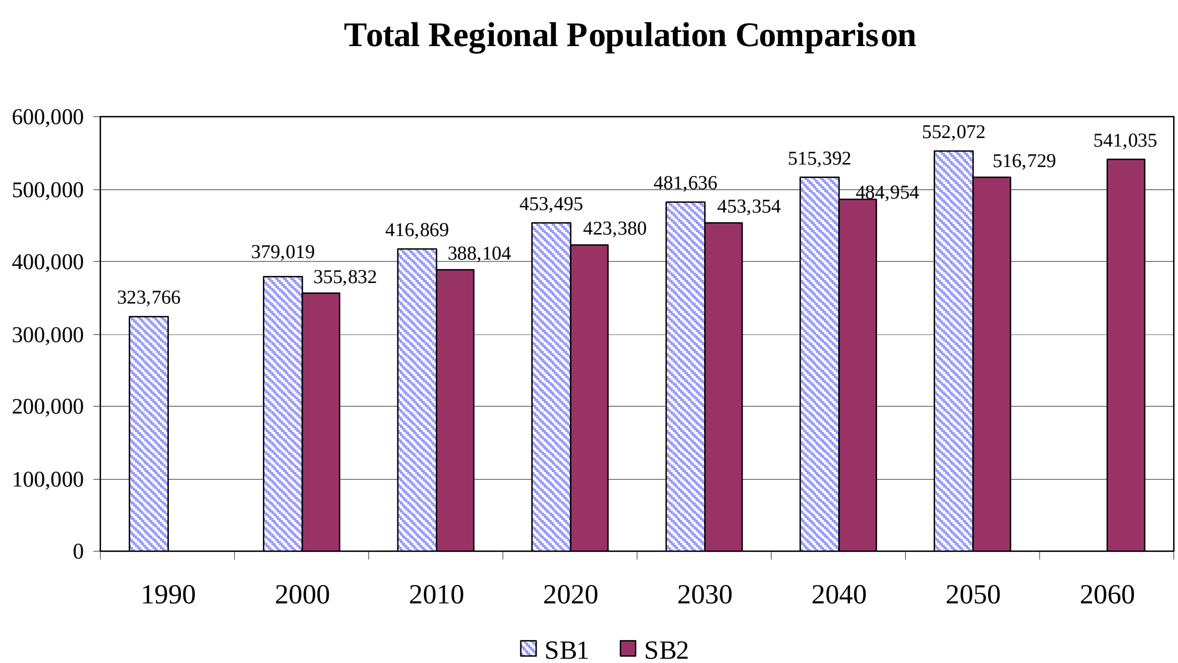


Figure 2-1a: 2000 Populations for Counties in the PWPA

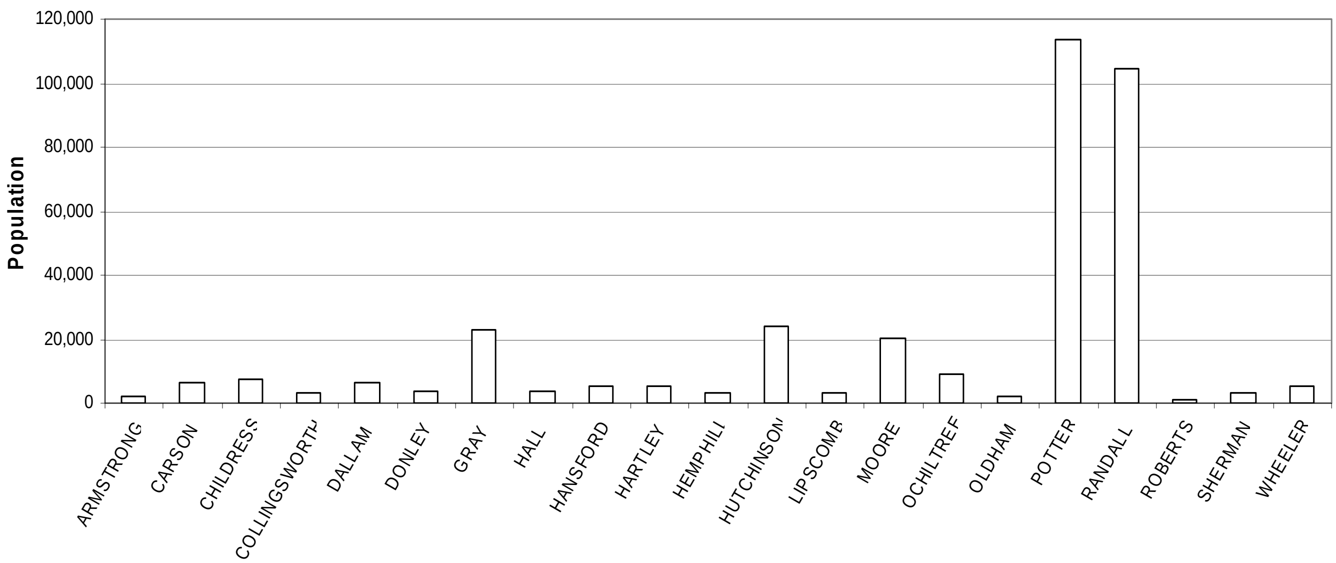
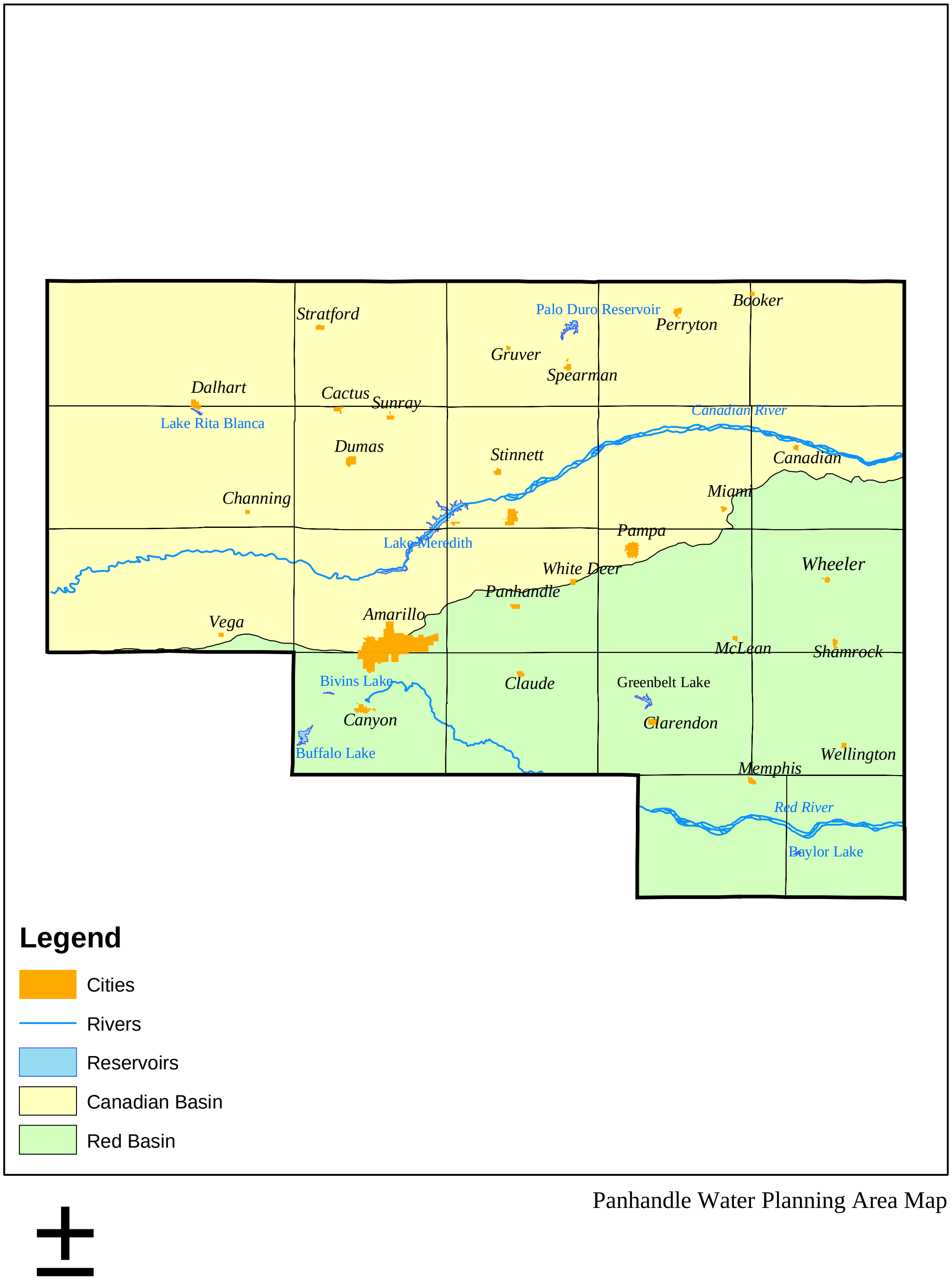


Figure 2-1b: 2000 Populations for Counties in the PWPA

TWDB population growth projections based on the 2000 Census (U.S. Census, 2000) and analyzed by the State Data Center indicate that by 2060 the population of Texas will more than double, reaching over 45,500,000. Population for the PWPA is projected to be 541,035 in 2060, or approximately 1.2 percent of the projected state population for that decade.



Panhandle Water Planning Area Map

Figure 2-2: PWPA Regional Map

No revisions were requested by the PWPG to the overall regional population and projections presented by the TWDB, although several county and city population distribution adjustments were made. The only municipal entity that adjusted population projections due to current or anticipated development is the City of Cactus which asked that its population be capped at 3,000 beginning in 2020. This adjustment also required appropriate adjustment to Moore County-Other populations in order to maintain the overall county and regional total distribution. The redistribution does not change the overall population projections as presented by the TWDB.

Total PWPA population is projected to increase from 355,832 in 2000 to 541,035 people in 2060. This represents an increase of 35 percent over the course of the planning period but a 7% decrease in population projections from the previous planning cycle. The data indicate that a major portion of the projected increase occurs in counties with larger communities, such as Amarillo. Increases in population are projected for Childress, Hansford, Moore, Ochiltree, Potter, Randall and Sherman counties. Decreases in population are projected for Collingsworth, Donley, Gray, and Wheeler counties. The counties of Armstrong, Carson, Dallam, Hall, Hartley, Hemphill, Hutchinson, Lipscomb, Oldham, and Roberts are projected to have an initial increase followed by a decrease, or are expected to have no significant change in population during the planning period. Figure 2-3a illustrates the current projected populations by county for the planning period.

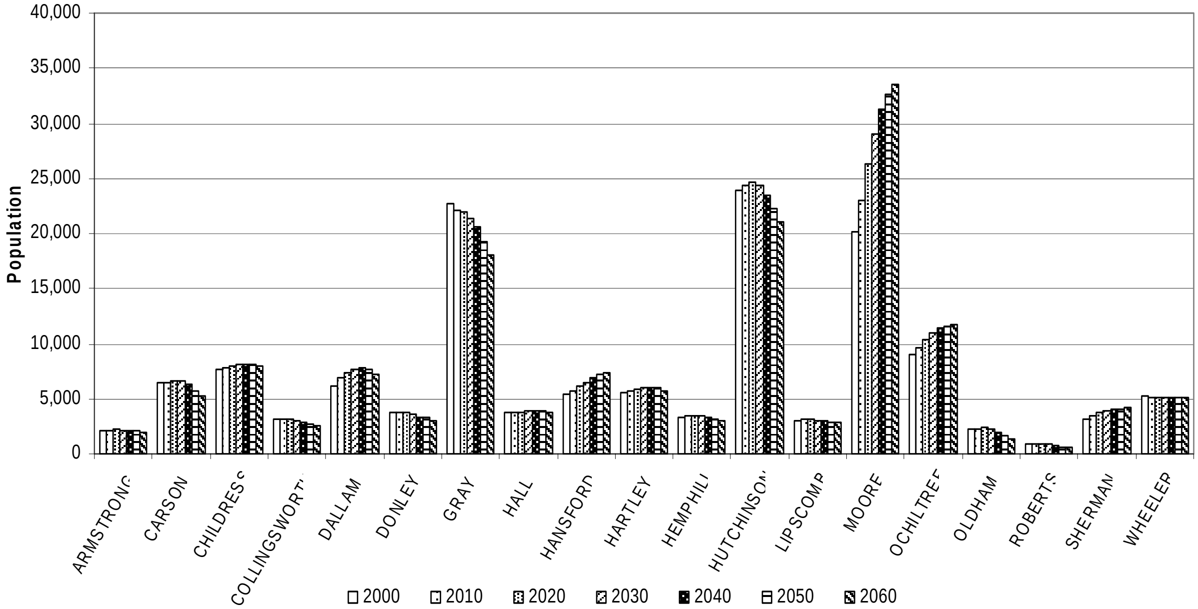


Figure 2-3a: Projected Populations for Counties in the PWPA, excluding Potter and Randall Counties

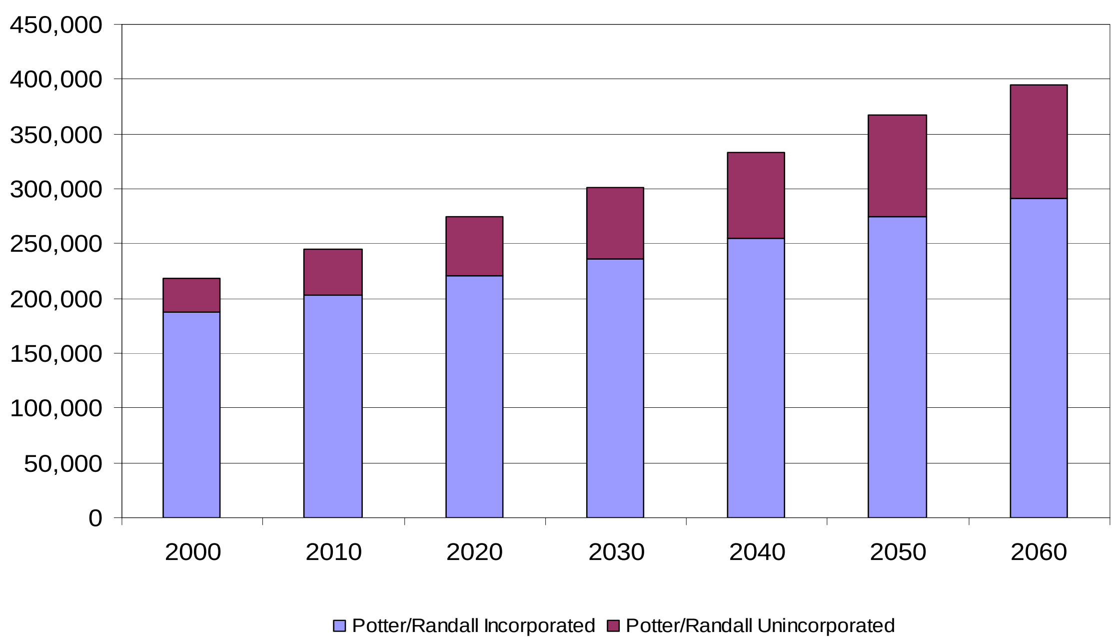


Figure 2-3b: Projected Populations for Potter and Randall Counties

Figure 2-3b shows the aggressive growth of unincorporated areas within Potter and Randall counties. Population in the County-Other municipal water user group is 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 need to be carefully considered.

2.2 Historical Water Use and Projected Water Demand

Total water use in the PWPA during 2000 totaled over 1,943,551 acre-feet, or approximately 12 percent of the state total. Five counties in the PWPA, Dallam, Hansford, Hartley, Moore, and Sherman, reported a combined water use of more than 1.2 million acre-feet in 2000, ranging from 144,411 acre-feet in Hansford County to 328,128 acre-feet in Dallam County. Water use by these five counties represents approximately 65 percent of the total water use in the PWPA during 2000. Total water use of the remaining 16 counties totaled over 600,000 acre-feet and ranged from 2,729 acre-feet in Hemphill County to 110,783 acre-feet in Ochiltree County.

Figure 2-4 illustrates the 2000 reported water use for counties in the PWPA and compares these values with county populations.

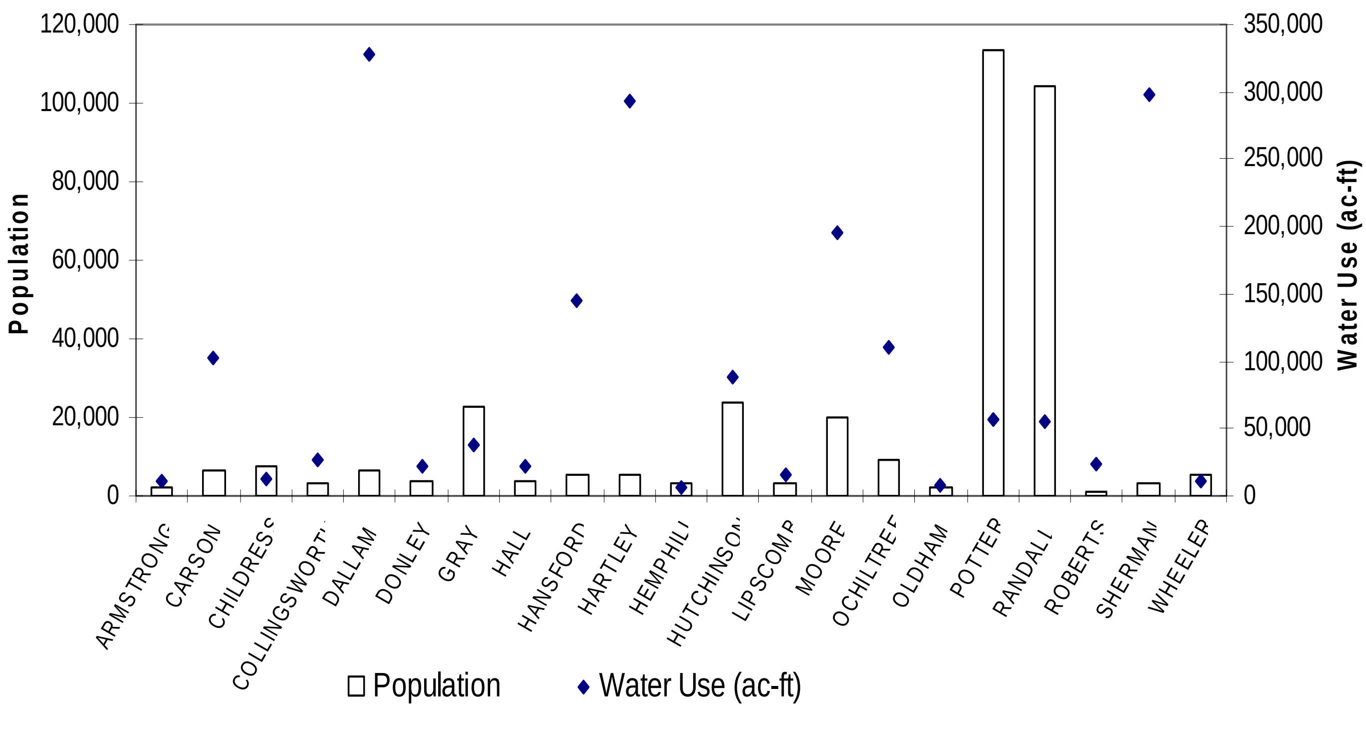


Figure 2-4: 2000 Water Use and Population for Counties in the PWPA

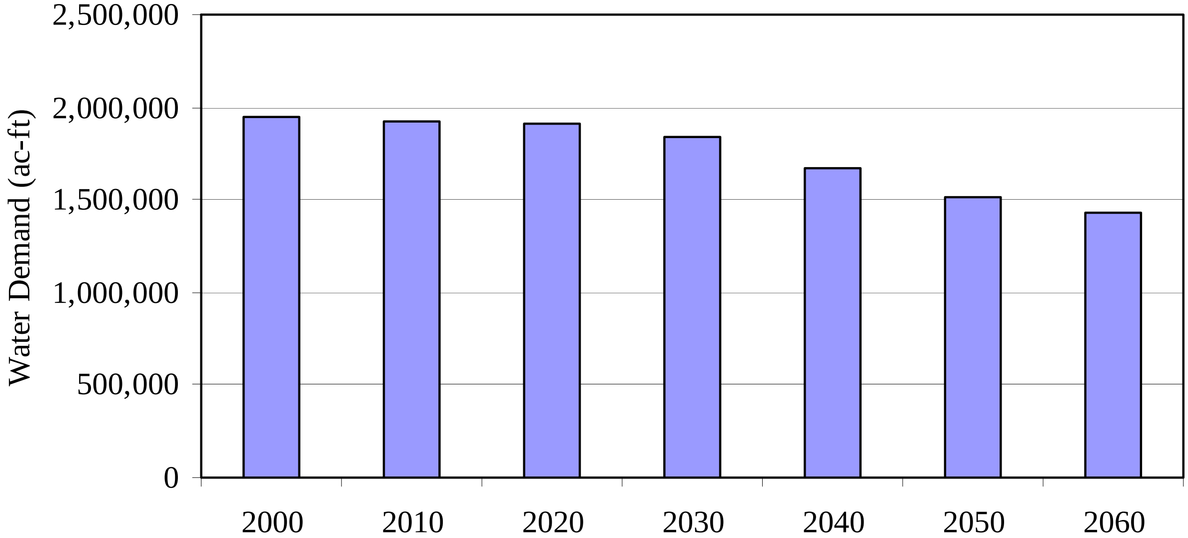


Figure 2-5: Total Water Use for PWPA 2000-2060

Projections for water demand indicate that total water usage in the PWPA will decrease from 1,881,696 acre-feet in 2000 to 1,399,412 acre-feet in 2060. (Figure 2-5) Revisions to projected water demands for municipal, irrigation, power generation, and industrial uses were developed based on available data provided by the TWDB and input from regional water users. Tables at the end of this chapter contain detailed information on previous and current TWDB projected water use by municipal, agricultural, steam-electric, and industrial water users and the impact on projected demands.

Figure 2-6 shows the current TWDB-approved revised projected water demands for counties in the PWPA. A listing of PWPA projected WUG demands can be found at the end of this chapter. The county with the highest projected water demand is Dallam County, with a use of 328,128 acre-feet in 2000 decreasing to 229,497 acre-feet by 2060. This is approximately 30,000 acre-feet more than Sherman County, the county with the next highest demands. Counties with projected increases in demand during the planning period include Potter and Hemphill. The remaining 19 counties are projected to have slight decreases or no significant change in projected water demand during the planning period.

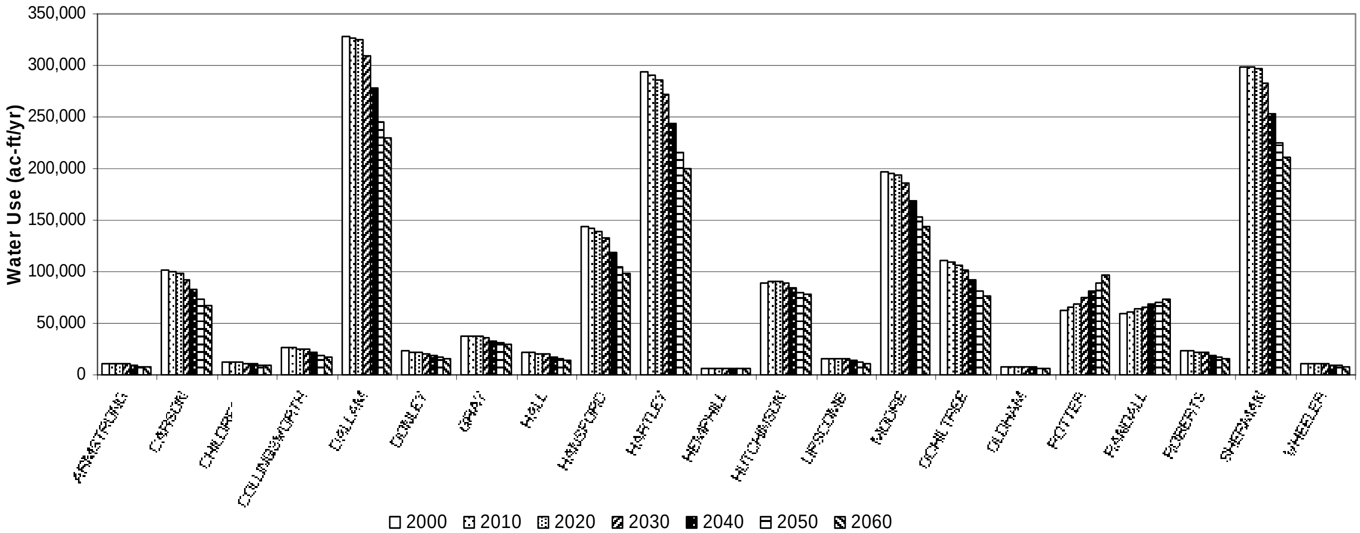


Figure 2-6: Projected Total PWPA Water Demand by County

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.

Revisions to previous TWDB projections for municipal water use were made for those cities and counties for which population projections were revised and those which did not match their 2000 gpcd with a 20-year historical average from 1980 to 2000. The median gpcd consumption for the PWPA is 185 gpcd with a high of 333 and a low of 75 gallons per capita per day.

Municipal water use in the PWPA was reported to be 85,193 acre-feet in 2000, or approximately four percent of total water use in the PWPA for that year. The municipal water demand for the PWPA is projected to increase from 85,193 acre-feet in 2000 to 104,242 acre-feet in 2060. This represents approximately a 20 percent increase in water demand, of which Potter and Randall Counties represent 77 percent of the increase for the 2000 – 2060 planning period.

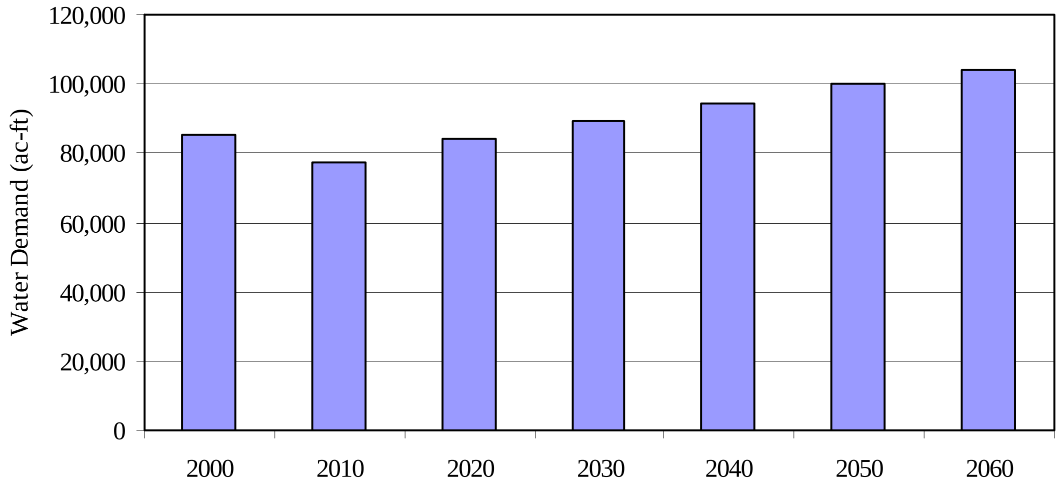


Figure 2-7: Projected Municipal Water Use for Counties in the PWPA

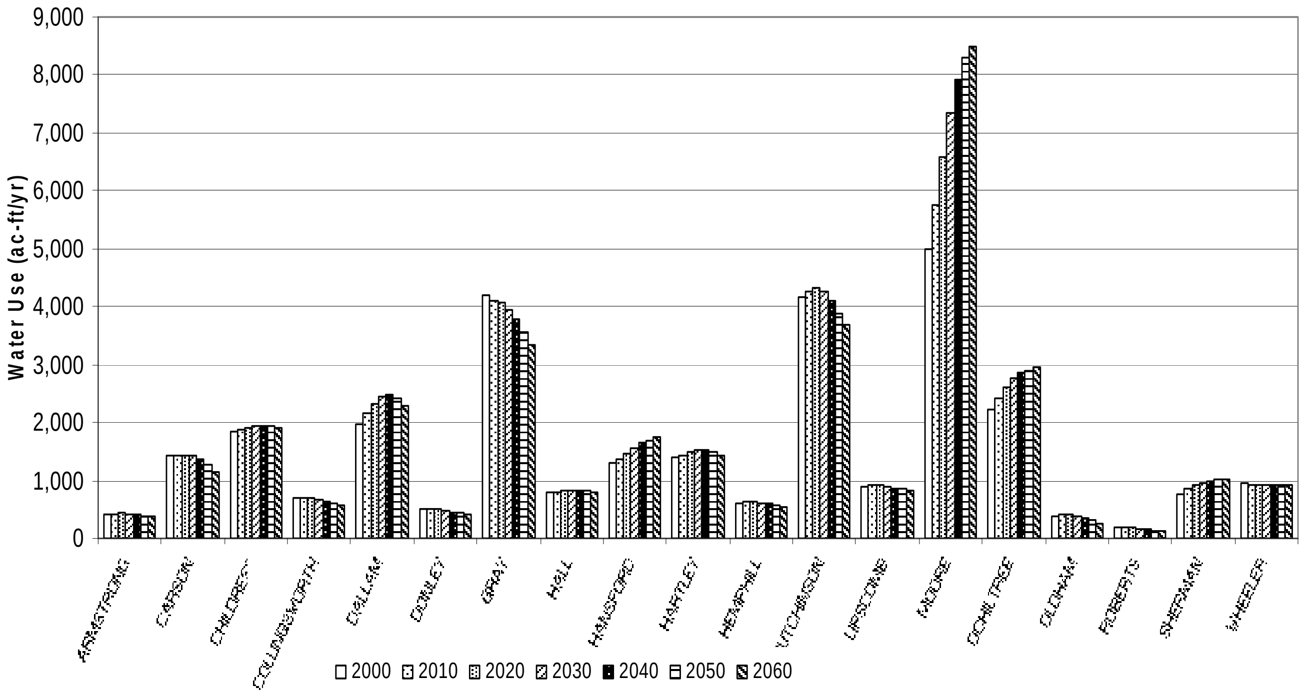


Figure 2-8: Projected Municipal Water Use for Counties in the PWPA, excluding Potter and Randall Counties

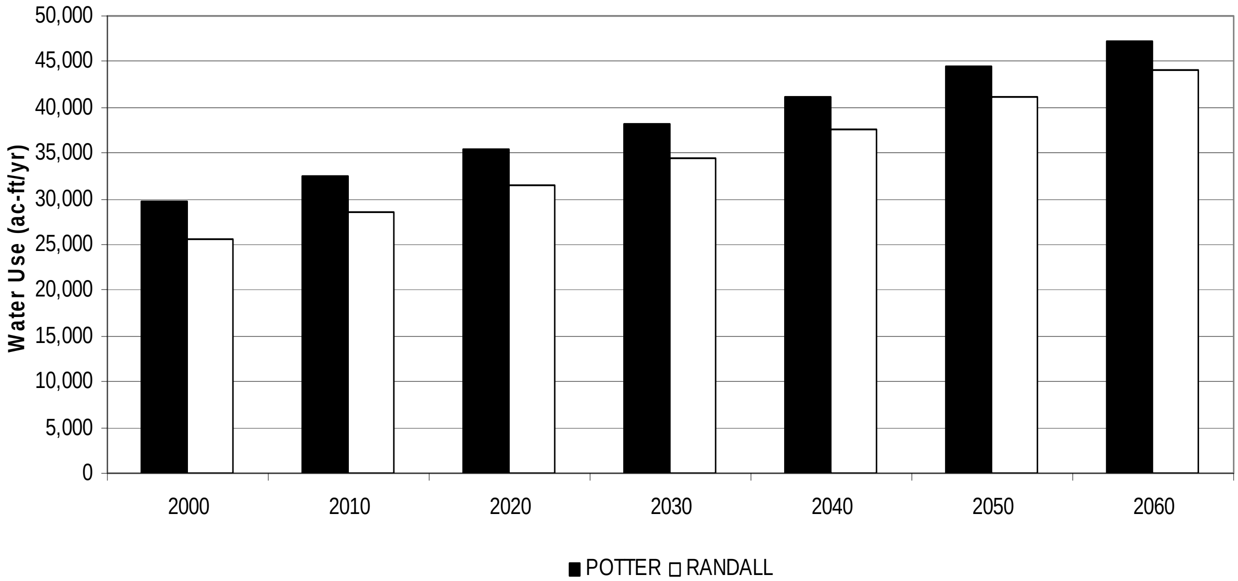


Figure 2-9: Projected Municipal Water Demand for Potter and Randall Counties

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.

2.2.2.1 <u>Manufacturing</u>

Manufacturing water use in 2000 was 37,808 acre-feet for the ten counties with documented manufacturing water usage. Manufacturing water use in these counties ranged from one acre-foot in Hemphill County to 20,143 acre-feet in Hutchinson County. Hutchinson County accounted for 53 percent of the manufacturing water use in the PWPA reported for 2000.

Manufacturing water demand numbers were taken from the TWDB projections which were developed under a separate state contract. The report did not contain county specific documentation on changes and although cumulative totals closely match previous regional totals, individual county uses may not have been accurately represented. Figure 2-11 shows the 2000 water use and the projected water demand of manufacturing users. Total manufacturing water demand for the PWPA is projected to increase from 37,808 acre-feet in 2000 to 58,231 acre-feet by 2060. This represents 2 percent of the total water use in the PWPA in 2000, increasing to 4.2 percent by 2060.

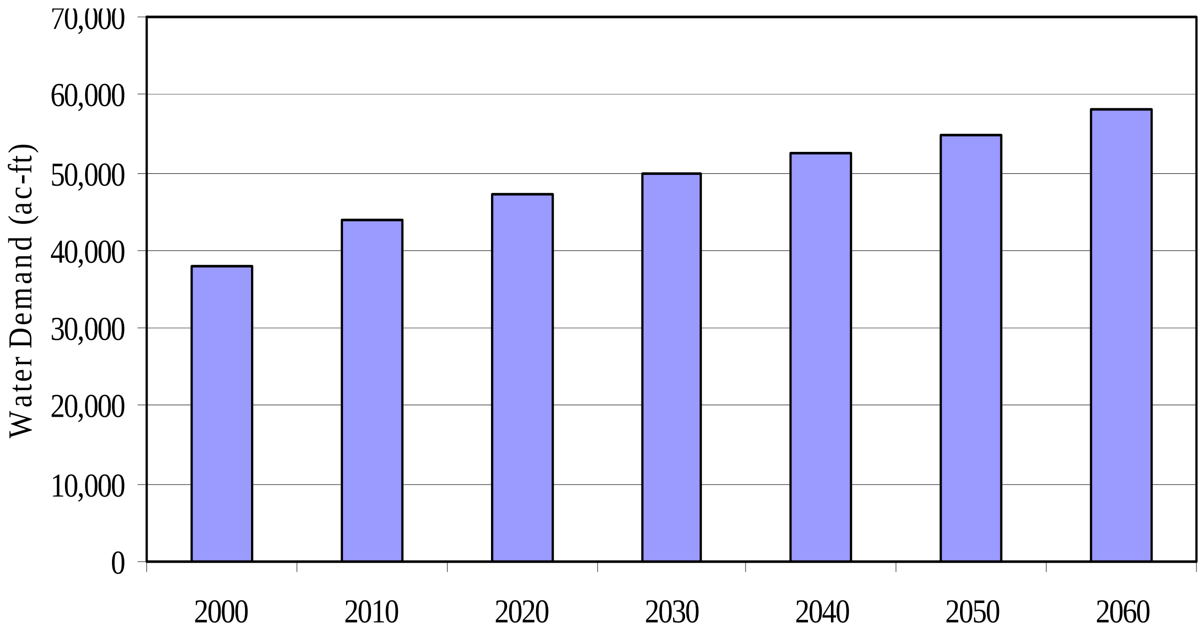


Figure 2-10: Projected Manufacturing Water Use for Counties in the PWPA

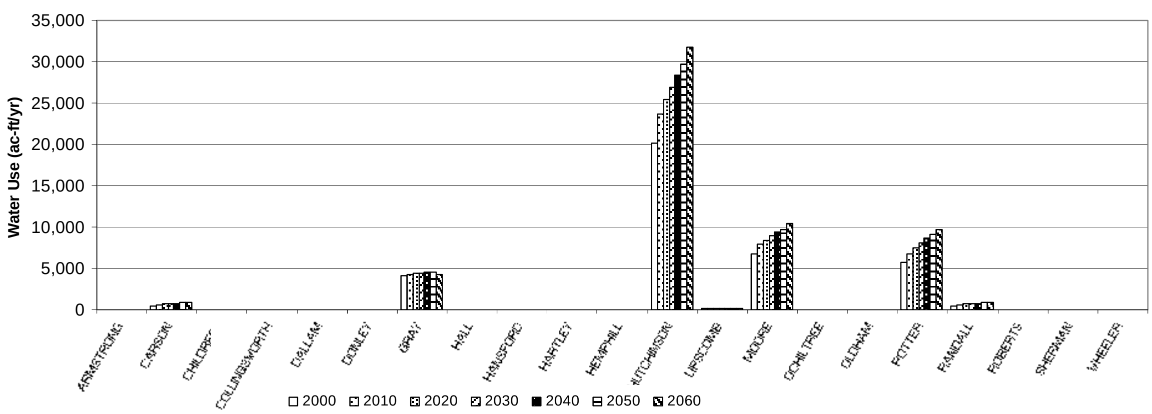


Figure 2-11: Historical and Projected Manufacturing Water Use for Counties in the PWPA

2.2.2.2 <u>Steam Electric Power</u>

Xcel Energy has power generation plants located in Moore and Potter counties that account for all of the water use by power generators in the PWPA. In 2000, a reported 18,255 acre-feet were used for steam power generation. 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. The TWDB presented power generation projections that were developed under a separate state contract and results closely match previous regional projections.

Water demand for power generation is projected to increase from 18,255 acre-feet in 2000 to 34,328 acre-feet by 2060. This represents approximately 1 percent of the total water use in the PWPA in 2000 and 1.7 percent by 2060. Figure 2-12 shows projected steam electric power water use for counties in the PWPA. Figure 213 illustrates the historical water needs and projected water demands of steam power generators in the PWPA. All future demands for power generation are expected to be supplied from reuse sources.

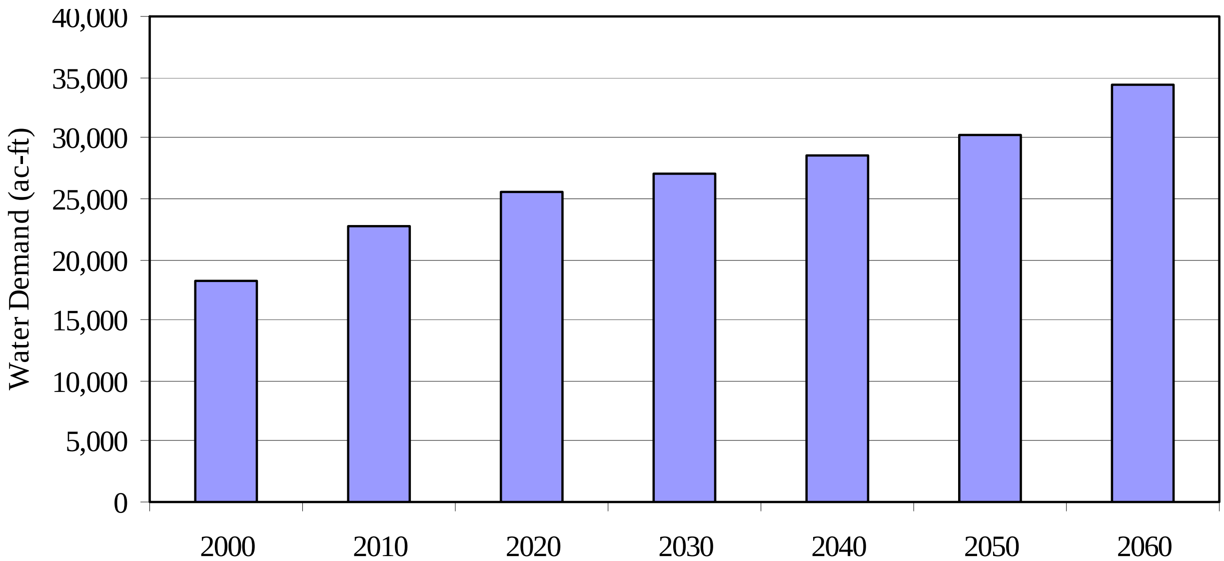


Figure 2-12: Projected Steam Power Water Use for Counties in the PWPA

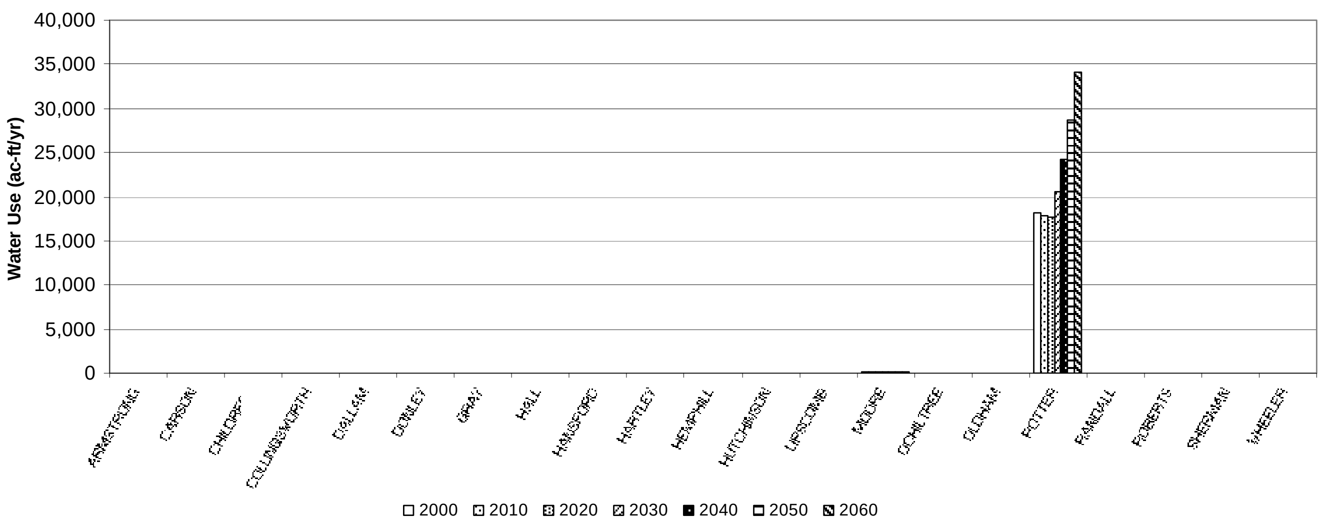


Figure 2-13: Historical and Projected Steam Power Water Use for Counties in the PWPA

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. Mining water use was reported in 2000 for 17 counties in the PWPA, totaling 7,229 acre-feet, or 0.4 percent of the total water use in the PWPA. No revisions were proposed to TWDB projections for the planning period. It is estimated that mining water demand will increase slightly from 7,229 acre-feet in 2000 to 7,310 acre-feet by 2060. Figures 2-14 and 2-15 illustrate historical water use and projected water demands by mining in the PWPA.

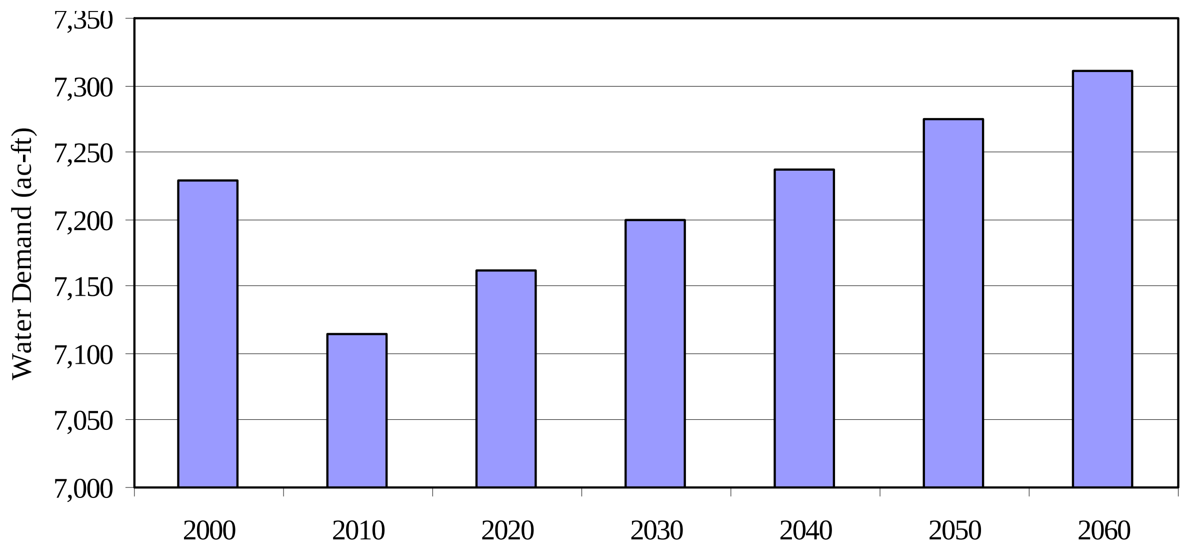


Figure 2-14 Projected Mining Water Use for Counties in the PWPA

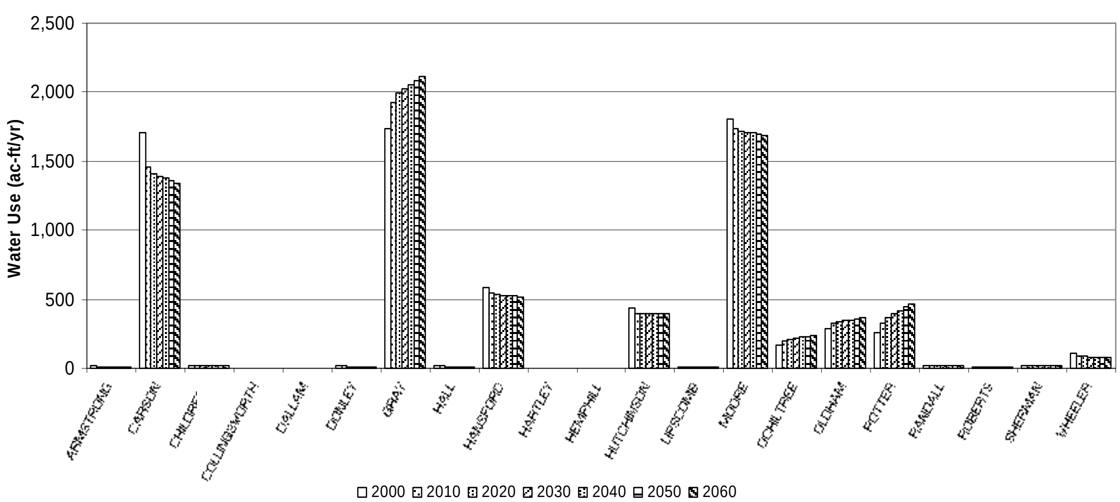


Figure 2-15: Historical and Projected Mining Water Use for Counties in the PWPA

2.2.3 Agricultural Water Demands

2.2.3.1 Irrigation Water Demands

During the SB2 planning cycle, the TAES/TAEX team began by developing and documenting a methodology for estimating the amount of irrigation water pumped in a county during a given year based on the Agricultural Census, which is conducted every five years. The revised methodology included estimates of water usage by irrigated crops based on optimal water use (based on potential evapotranspiration), sub optimal water application by producers (determined by agri-partner demonstration data), effective rainfall received during the growing season, and seasonal usable soil moisture from the soil profile. Projections of annual future water use were made using planted irrigated acreage (pia) and the long-term averages for rainfall and potential evapotranspiration (PET) by county. The crop mix and acreage was assumed to remain unchanged from what was reported in 2000 for the Agricultural Census. Where available, demonstration data and well depletion data was used to verify the model estimates.

The results of the evaluation and modeling efforts represent a comparison based on best available current data and have been included in the planning process as projections through 2060. The irrigation water use projections should be re-evaluated as more data becomes available to accurately reflect changes in the farming community due to new technologies, economic considerations, or crop acreages. The current annual projections for the 2000 – 2060 planning period show a 35 percent reduction in the demand for water. Methodologies used in the development of the irrigation water use projections are discussed in greater detail in Appendix N. Figures 2-16 & 2-17 illustrate the TWDB reported 2000 water use and TWDB-approved projections of irrigation water demand for counties in the PWPA.

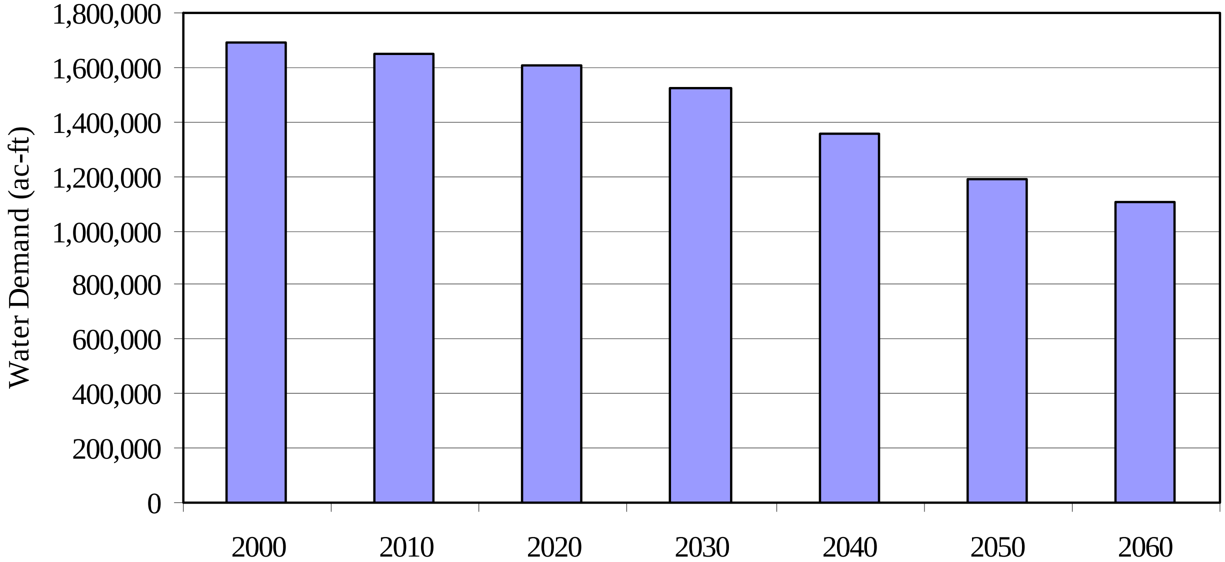


Figure 2-16: Projected Water Use for Irrigation for Counties in the PWPA

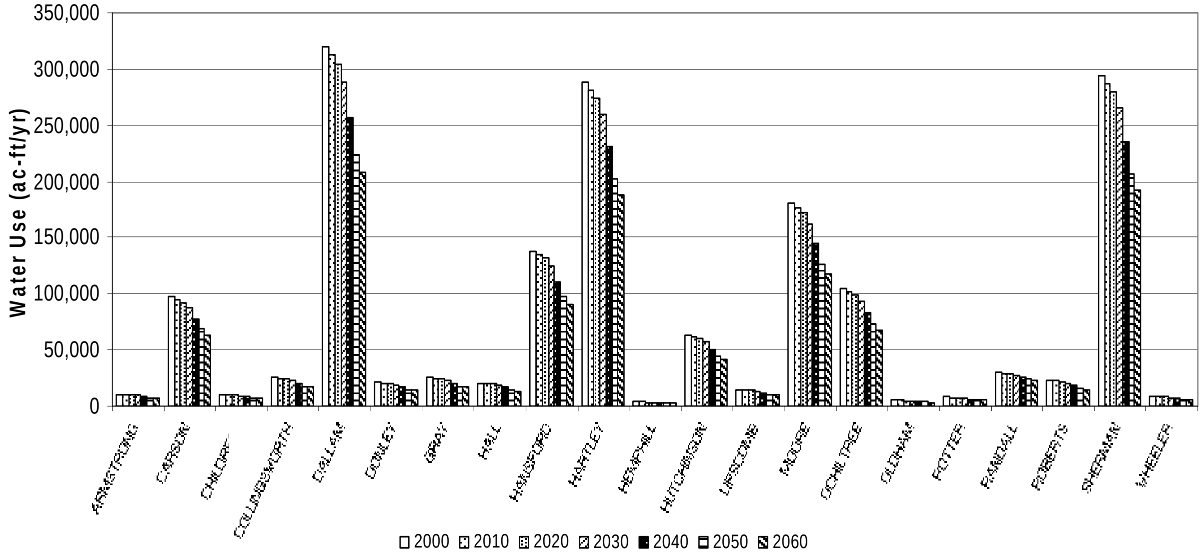


Figure 2-17: Historical Water Use and Projected Demands for Irrigation Water Use for Counties in the PWPA

2.2.3.2 Livestock Water Demands

According to research conducted by TAES, water used for livestock totaled 38,197 acre-feet in 2000 and ranged from a low value of 288 acre-feet in Childress County to a high value of 5,689 acre-feet in Dallam County. This represents approximately 2 percent of the total water used in the PWPA in the year 2000. As in the case of irrigation water demands, the methodologies used by the TWDB were evaluated and revised as part of the regional water planning process. Concerns expressed by commodity groups and producers include the under estimation of future livestock water demands.

New projections were developed by TAES/TAEX which included the most recent inventories of various livestock species for each county, estimates of annual industry growth rates, and regional species-level water use estimates as recorded in the 2000 Agricultural Census. TAES/TAEX staff developed estimates of livestock inventories and water use for beef cattle feedlots, summer and winter stockers, beef cows, swine, horses, dairy cattle, and poultry for each county in the PWPA. Water use values were obtained from regional and national studies and were used to determine the relative water demand for each livestock category.

Figures 2-18& 2-19 illustrate the projected livestock water demand by livestock category for the planning period. Detailed livestock population and water demand data is contained in tables at the end of this chapter. Annual growth rates were determined by TAES/TAEX staff based on published studies, knowledge of the local agricultural economy and environment, and in consultation with industry sources. This methodology incorporates a larger body of information for the determination of projected water uses than the more traditional methodology utilized by the TWDB. Methodologies used in the development and evaluation of current livestock water use projections are found in tables at the end of this chapter.

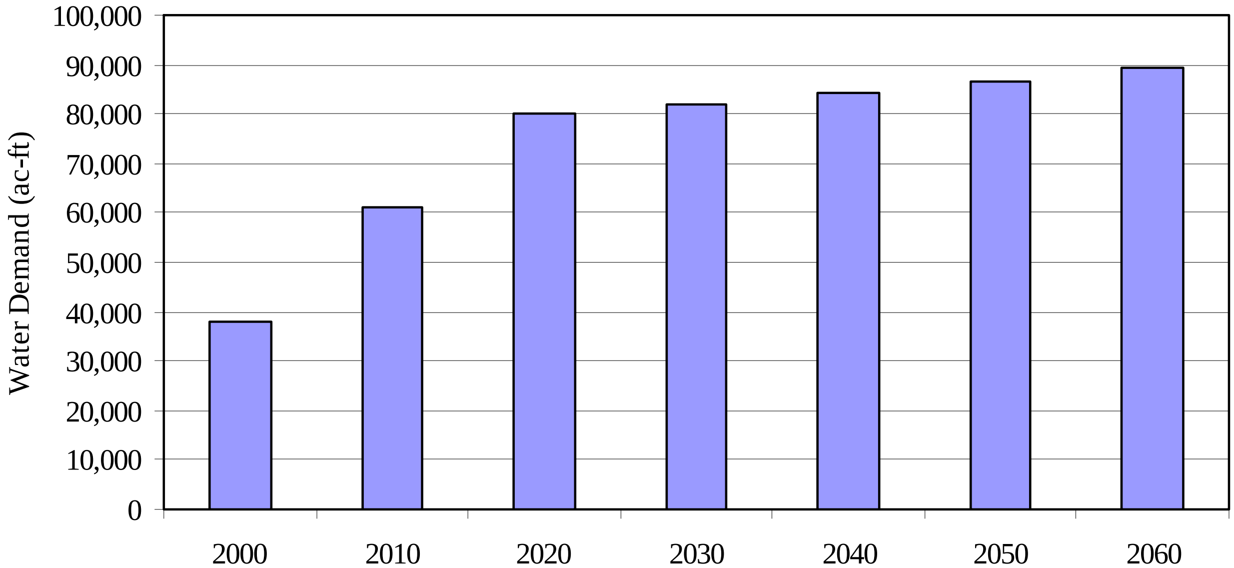


Figure 2-18: Projected Livestock Water Demands for PWPA

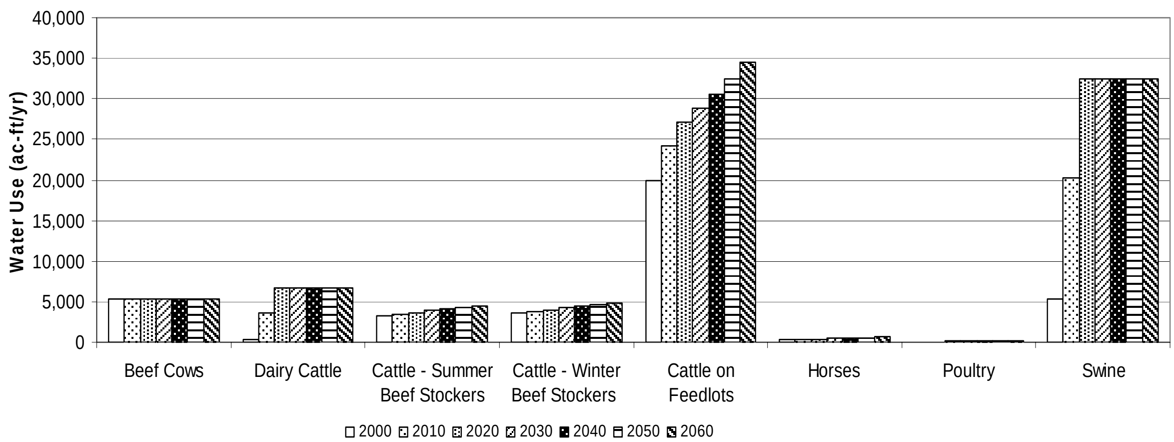


Figure 2-19: Projected Livestock Water Demands by Animal Category

Livestock water demands are projected to increase from 38,180 acre-feet in 2000 to 89,267 acre-feet by 2060. This represents approximately 2 percent of the total water use in the PWPA in 2000, increasing steadily to approximately 4.8 percent of the total projected water use by 2060. Figure 2-21 illustrates the historical water use and projected water demands for livestock use in the PWPA. Increases in livestock water demands are projected for every county in the PWPA, with the largest increases projected for Dallam and Sherman Counties.

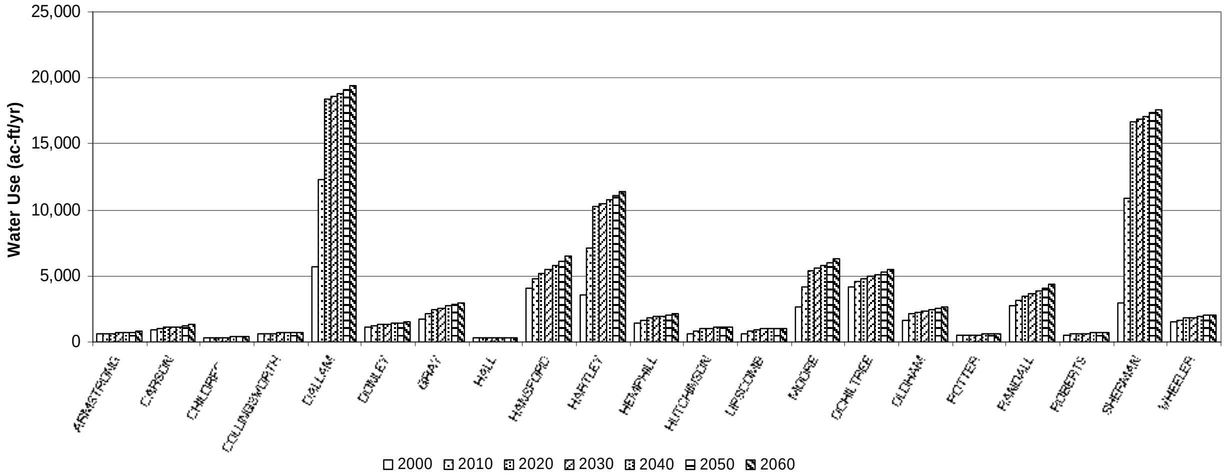


Figure 2-20: Historical and Projected Livestock Water Use for Counties in the PWPA

2.3 Wholesale Water Providers

The term Wholesale Water Provider (WWP) was created within Senate Bill 2 in order to include major providers of water for municipal and manufacturing use in the regional planning process. The PWPG has designated 8 WWPs in the region. Coordination with adjoining planning Region B and the Llano Estacado Water Planning Region (Region O) was necessary to develop projections for CRMWA and GM&IWA because several member cities are located in those regions.

In 2000, the combined water sales of the designated WWPs for municipal and manufacturing use was approximately 137,961 acre-feet. In 2000, the city of Amarillo accounted for approximately 42 percent, GM&IWA for three percent, and CRMWA for 55 percent of the combined demand on WWPs in the PWPA. Demands on these WWPs are projected to increase from 136,799 acre-feet in 2010 to 150,890 acre-feet by 2060. These numbers include demands outside this planning area. Total demands on Amarillo as a WWP are projected to increase from 77,602 acre-feet in 2010 to 104,995 acre-feet in 2060; CRMWA's total demands are projected to stay nearly constant from 103,855 acre-feet in 2010 to 103,388 acre-feet in 2060. GM&IWA is expected to see a slight decrease in demands as a WWP from 3,792 acre-feet to 3,599 acre-feet during the planning period. Figure 2-21 illustrates the historical and projected water demands for each of the eight designated WWPs during the planning period.

2.3.1 City of Amarillo

In 2010, the City of Amarillo is projected to supply a total of 72,602 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. Projected demands on the city of Amarillo were developed based on each recipient's projected water demand and what percentage of their historical water demands the city of Amarillo had supplied. Water demand for municipal and manufacturing use within Amarillo is anticipated to increase from 44,374 acre-feet in 2000 to 62,621 acre-feet in 2060.

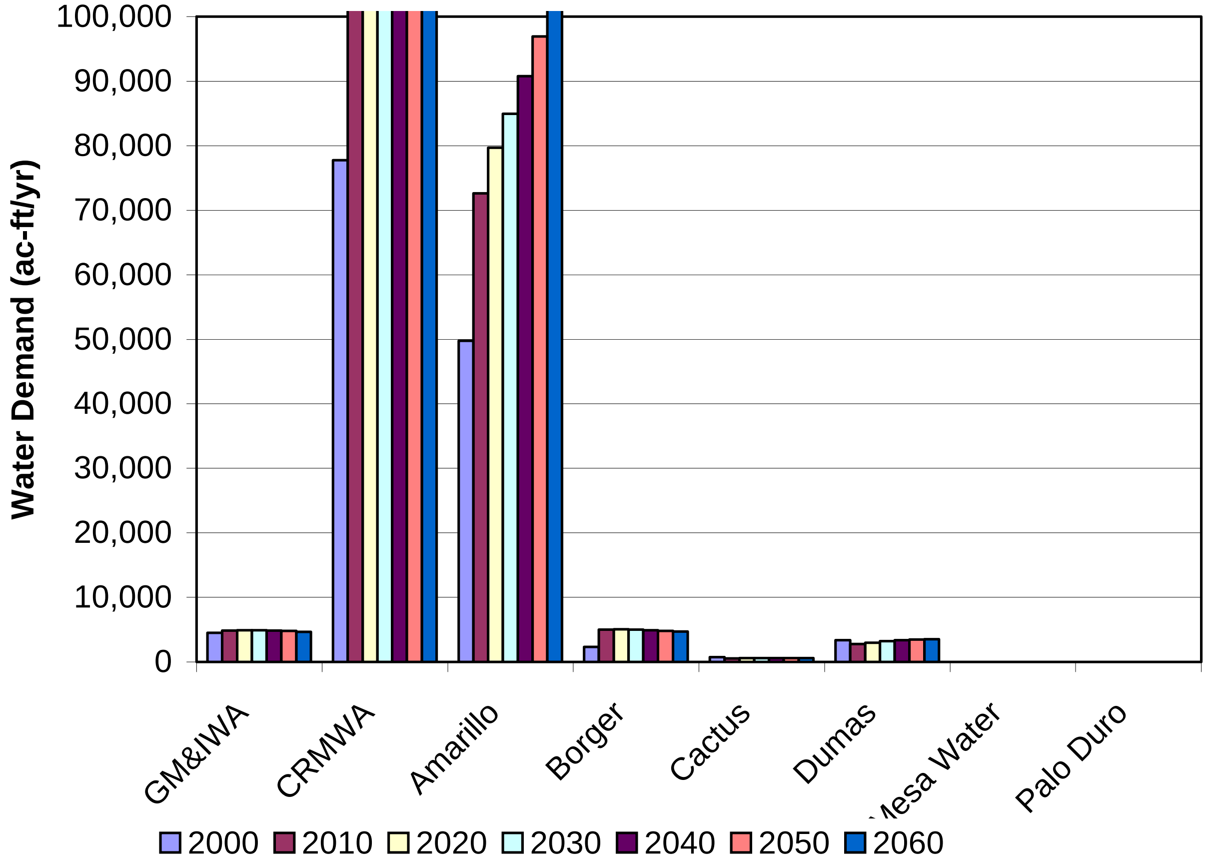


Figure 2-21: Historical and Projected Water Demands on Major Water Providers in the PWPA

2.3.2 Greenbelt Municipal and Industrial Water Authority

In 2000, GM&IWA supplied 3,905 acre-feet to four cities in the PWPA, three cities in Region B, and to the Red River Authority for subsequent sales in both regions (TWDB, 1998). Approximately 59 percent of the sales by GM&IWA were to the cities of Childress, Clarendon, Hedley, and Memphis, and to the RRA for sales in the PWPA. The remaining sales were to the cities of Chillicothe, Crowell, and Quanah, and to the RRA in Region B. Demand projections for GM&IWA as a MWP were developed based on each recipient's projected water demand and what percentage of their historical water demands the GM&IWA had supplied. The percentage of the projected demand that is anticipated to remain in the PWPA is expected to remain at approximately 58 percent throughout the planning period.

2.3.3 Canadian River Municipal Water Authority

In 2000, CRMWA supplied 76,631 acre-feet of water, of which approximately 51 percent was delivered to three cities in the PWPA, Amarillo, Borger, and Pampa. In 2010, CRMWA is projected to supply 103,855 AFY to all 11 member cities. Deliveries directly to and through member cities also include several industries including Xcel Energy, ASARCO, Wrangler, and Agrium. The remaining 49 percent was sold to eight cities in the Llano Estacado Water Planning Region. These include Brownfield, Lamesa, Levelland, Lubbock, O'Donnell, Plainview, Slaton, and Tahoka. Projected demands for recipients of CRMWA water were developed based on historical demands by recipients, projected demands of recipients, and increased availability of new ground water sources to supplement CRMWA's surface water supply. Approximately 47 percent of water supplied by CRMWA is projected to remain in the PWPA through 2060.

TWDB Population and Demand Projections

Texas Water Development Board

2006 Regional Water Plan Population Projections for 2000 - 2060:

Region A - Panhandle

REGION	WATER USER GROUP	COUNTY NAME	P2000 [1)]	P2010	P2020	P2030	P2040	P2050	P2060
A	CLAUDE	ARMSTRONG	1,313	1,327	1,369	1,322	1,268	1,255	1,219
A	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**
A	COUNTY-OTHER	CARSON	1,178	1,182	1,195	1,186	1,147	1,043	947
A	GROOM	CARSON	587	589	595	591	572	520	472
A	HI TEXAS WATER COMPANY	CARSON	492	494	499	495	479	435	395
A	PANHANDLE	CARSON	2,589	2,599	2,626	2,605	2,521	2,291	2,081
A	SKELLYTOWN	CARSON	610	612	619	614	594	540	490
A	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**
A	CHILDRESS	CHILDRESS	6,778	6,918	7,033	7,132	7,167	7,170	6,987
A	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**
A	COUNTY-OTHER	COLLINGSWORTH	931	895	898	842	766	709	613
A	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**
A	COUNTY-OTHER	DALLAM	1,063	1,170	1,262	1,320	1,334	1,306	1,245
A	DALHART	DALLAM	4,648	5,118	5,518	5,770	5,833	5,711	5,447
A	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**
A	CLARENDON	DONLEY	1,974	1,974	1,974	1,974	1,974	1,974	1,974
A	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**
A	COUNTY-OTHER	GRAY	3,468	3,379	3,354	3,259	3,132	2,941	2,755
A	LEFORS	GRAY	559	545	540	525	505	474	444
A	MCLEAN	GRAY	830	809	802	780	750	704	659
A	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**
A	COUNTY-OTHER	HALL	1,303	1,267	1,358	1,416	1,368	1,388	1,303
A	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**
A	COUNTY-OTHER	HANSFORD	1,186	1,388	1,663	1,898	2,152	2,301	2,433
A	GRUVER	HANSFORD	1,162	1,169	1,178	1,186	1,195	1,200	1,204
A	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**
A	COUNTY-OTHER	HARTLEY	2,948	3,033	3,135	3,189	3,208	3,168	3,006
A	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**
A	CANADIAN	HEMPHILL	2,233	2,330	2,340	2,262	2,178	2,120	2,015
A	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**
A	BORGER	HUTCHINSON	14,302	14,580	14,780	14,574	14,096	13,314	12,641
A	COUNTY-OTHER	HUTCHINSON	303	308	314	310	299	283	268
A	FRITCH	HUTCHINSON	2,226	2,269	2,300	2,268	2,194	2,072	1,968
A	HI TEXAS WATER COMPANY	HUTCHINSON	3,020	3,079	3,121	3,077	2,976	2,811	2,669
A	STINNETT	HUTCHINSON	1,936	1,974	2,001	1,973	1,908	1,802	1,711
A	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**

Texas Water Development Board

2006 Regional Water Plan Population Projections for 2000 - 2060:

Region A - Panhandle

REGION	WATER USER GROUP	COUNTY NAME	P2000 [1)]	P2010	P2020	P2030	P2040	P2050	P2060
A	BOOKER	LIPSCOMB	1,306	1,318	1,345	1,305	1,267	1,250	1,189
A	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**
A	CACTUS	MOORE	2,538	2,600	3,000	3,000	3,000	3,000	3,000
A	COUNTY-OTHER	MOORE	1,877	3,307	4,534	5,970	7,110	7,805	8,223
A	DUMAS	MOORE	13,747	14,884	16,123	17,216	18,084	18,613	18,931
A	FRITCH	MOORE	9	21	34	45	54	59	62
A	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**
A	BOOKER	OCHILTREE	9	9	9	9	9	9	9
A	COUNTY-OTHER	OCHILTREE	1,223	1,223	1,223	1,223	1,223	1,223	1,223
A	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**
A	COUNTY-OTHER	OLDHAM	1,249	1,327	1,356	1,260	1,110	965	780
A	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**
A	AMARILLO	POTTER	99,833	107,316	115,380	122,922	131,510	140,882	148,564
A	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**
A	AMARILLO	RANDALL	73,794	80,688	88,117	95,065	102,976	111,611	118,760
A	CANYON	RANDALL	12,875	14,227	15,684	17,047	18,599	20,293	21,695
A	COUNTY-OTHER	RANDALL	16,783	21,446	26,471	31,169	36,520	42,359	47,194
A	HAPPY	RANDALL	35	66	100	132	168	207	239
A	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**
A	COUNTY-OTHER	ROBERTS	299	313	322	289	242	210	189
A	MIAMI	ROBERTS	588	617	633	568	477	412	372
		ROBERTS Total	**887**	**930**	**955**	**857**	**719**	**622**	**561**
A	COUNTY-OTHER	SHERMAN	1,195	1,297	1,405	1,447	1,490	1,528	1,547
A	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**
A	COUNTY-OTHER	WHEELER	1,877	1,795	1,796	1,785	1,805	1,799	1,766
A	SHAMROCK	WHEELER	2,029	1,963	1,963	1,954	1,970	1,966	1,941
A	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**

1) The year 2000 population for cities and county totals are from the 2000 Census. For utilities, TWDB staff estimated the population served by the utility in 2000. Some of the 2000 population estimates for utilities were revised by the Regional Water Planning Groups. The County-Other population was derived by summing all of the city and utility population within a county and subtracting it from the county total population.

2) If "P" is present in this column, the Water User Group (WUG) is located in more than one Region and the projections listed in the row represent only the WUG's population projections within that particular Region, not the WUG's total population projections. If the "P" is present for a county total entry, then the county has been split by Regional boundaries and the projections listed in the row represent only the county's populations within the particular Region, not the county's total population projections.

3) If "P" is present in this column, the Water User Group (WUG) is located in more than one county and the projections listed in the row represent only the WUG's population projections within that particular county, not the WUG's total population projections.

2006 Regional Water Plan

Irrigation Water Demand Projections for 2000 - 2060 (in acft[1])

Region A

County Name[2]	D2000	D2010	D2020	D2030	D2040	D2050	D2060
ARMSTRONG	10,544	10,280	10,017	9,490	8,435	7,381	6,854
CARSON	97,345	94,912	92,478	87,611	77,876	68,142	63,274
CHILDRESS	10,304	10,046	9,789	9,273	8,243	7,213	6,698
COLLINGSWORTH	25,607	24,967	24,327	23,046	20,486	17,925	16,645
DALLAM	320,475	312,463	304,452	288,428	256,380	224,333	208,309
DONLEY	21,019	20,493	19,968	18,917	16,815	14,713	13,662
GRAY	25,499	24,862	24,224	22,949	20,399	17,850	16,576
HALL	20,789	20,269	19,749	18,710	16,631	14,552	13,513
HANSFORD	138,389	134,929	131,470	124,550	110,711	96,872	89,953
HARTLEY	289,008	281,783	274,557	260,107	231,206	202,306	187,855
HEMPHILL	**3,779**	**3,637**	**3,496**	**3,354**	**3,212**	**3,070**	**2,929**
HUTCHINSON	63,208	61,628	60,048	56,887	50,567	44,246	41,085
LIPSCOMB	14,789	14,419	14,049	13,310	11,831	10,352	9,613
MOORE	180,594	176,079	171,564	162,535	144,475	126,416	117,386
OCHILTREE	104,220	101,615	99,009	93,798	83,376	72,954	67,743
OLDHAM	5,223	5,092	4,962	4,700	4,178	3,656	3,395
POTTER	8,009	7,809	7,608	7,208	6,407	5,606	5,206
RANDALL	**30,302**	**29,166**	**28,029**	**26,893**	**25,757**	**24,620**	**23,484**
ROBERTS	22,890	22,318	21,746	20,601	18,312	16,023	14,879
SHERMAN	294,703	287,336	279,968	265,233	235,763	206,292	191,557
WHEELER	8,335	8,127	7,919	7,502	6,668	5,835	5,418
Region A Total	**1,695,031**	**1,652,230**	**1,609,429**	**1,525,102**	**1,357,728**	**1,190,357**	**1,106,034**

[1)] An acft is an amount of water to cover one acre with one foot of water and equals

[2)] If the "(P)" is present for a county entry, then the county has been split by Regional boundaries and the data listed in the row represent only the county's water demands within the particular region, not the county's total.

Projections last updated on 9/20/05

2006 Regional Water Plan

Livestock Water Demand Projections for 2000 - 2060 (in acft[1])

Region A

Region	County Name[2)]	D2000	D2010	D2020	D2030	D2040	D2050	D2060
A	ARMSTRONG	573	612	645	673	703	734	768
A	CARSON	945	1,016	1,074	1,120	1,168	1,219	1,272
A	CHILDRESS	288	292	348	353	359	366	372
A	COLLINGSWORTH	578	592	656	672	688	705	723
A	DALLAM	5,689	12,287	18,390	18,614	18,851	19,102	19,369
A	DONLEY	1,100	1,206	1,283	1,332	1,385	1,440	1,500
A	GRAY	1,706	2,183	2,485	2,589	2,700	2,871	2,942
A	HALL	297	300	302	305	309	311	316
A	HANSFORD	4,088	4,744	5,218	5,509	5,817	6,144	6,490
A	HARTLEY	3,572	7,088	10,236	10,506	10,792	11,096	11,418
A	HEMPHILL	1,408	1,635	1,811	1,889	1,972	2,061	2,155
A	HUTCHINSON	596	814	1,018	1,051	1,086	1,123	1,163
A	LIPSCOMB	589	831	958	976	996	1,016	1,037
A	MOORE	2,684	4,172	5,379	5,575	5,783	6,004	6,283
A	OCHILTREE	4,168	4,538	4,787	4,938	5,098	5,268	5,450
A	OLDHAM	1,635	2,116	2,258	2,358	2,460	2,569	2,685
A	POTTER	478	503	527	550	574	599	626
A	RANDALL	2,752	3,173	3,489	3,683	3,888	4,106	4,338
A	ROBERTS	534	609	628	649	671	694	718
A	SHERMAN	2,996	10,880	16,701	16,903	17,118	17,347	17,589
A	WHEELER	1,504	1,645	1,793	1,852	1,915	1,982	2,053
	Region A Total	**38,180**	**61,236**	**79,986**	**82,097**	**84,333**	**86,757**	**89,267**

1) An acft is an amount of water to cover one acre with one foot of water and equals 325,851 gallons.
2) If the "(P)" is present for a county entry, then the county has been split by Regional boundaries and the data listed in the row represent only the county's water demands within the particular region, not the county's total.

Projections last updated on 9/17/03

2006 Regional Water Plan

Manufacturing Water Demand Projections for 2000 - 2060 (in acft[1])

Region A

Region	County Name[2)]	D2000	D2010	D2020	D2030	D2040	D2050	D2060
A	ARMSTRONG	0	0	0	0	0	0	0
A	CARSON	491	591	669	735	797	849	920
A	CHILDRESS	0	0	0	0	0	0	0
A	COLLINGSWORTH	0	0	0	0	0	0	0
A	DALLAM	0	0	0	0	0	0	0
A	DONLEY	0	0	0	0	0	0	0
A	GRAY	4,088	4,264	4,383	4,451	4,497	4,515	4,334
A	HALL	0	0	0	0	0	0	0
A	HANSFORD	42	49	52	54	56	58	62
A	HARTLEY	5	5	5	5	5	5	5
A	HEMPHILL	1	1	1	1	1	1	1
A	HUTCHINSON	20,143	23,659	25,482	26,969	28,399	29,640	31,708
A	LIPSCOMB	76	89	95	100	104	108	116
A	MOORE	6,718	7,879	8,450	8,914	9,371	9,773	10,436
A	OCHILTREE	0	0	0	0	0	0	0
A	OLDHAM	0	0	0	0	0	0	0
A	POTTER	5,755	6,788	7,468	8,043	8,604	9,090	9,757
A	RANDALL	489	605	670	726	778	821	892
A	ROBERTS	0	0	0	0	0	0	0
A	SHERMAN	0	0	0	0	0	0	0
A	WHEELER	0	0	0	0	0	0	0
	Region A Total	**37,808**	**43,930**	**47,275**	**49,998**	**52,612**	**54,860**	**58,231**

1) An acft is an amount of water to cover one acre with one foot of water and equals 325,851 gallons.
2) If the "(P)" is present for a county entry, then the county has been split by Regional boundaries and the data listed in the row represent only the county's water demands within the particular region, not the county's total.

Projections last updated on 9/17/03

2006 Regional Water Plan

Mining Water Demand Projections for 2000 - 2060 (in acft[1])

Region A

Region	County Name[2)]	D2000	D2010	D2020	D2030	D2040	D2050	D2060
A	ARMSTRONG	19	13	12	12	12	12	12
A	CARSON	1,710	1,461	1,412	1,393	1,376	1,360	1,339
A	CHILDRESS	20	17	16	16	16	16	16
A	COLLINGSWORTH	0	0	0	0	0	0	0
A	DALLAM	0	0	0	0	0	0	0
A	DONLEY	22	15	14	14	14	14	14
A	GRAY	1,734	1,929	1,999	2,028	2,056	2,083	2,118
A	HALL	22	15	14	14	14	14	14
A	HANSFORD	588	543	533	529	525	521	516
A	HARTLEY	0	0	0	0	0	0	0
A	HEMPHILL	0	0	0	0	0	0	0
A	HUTCHINSON	432	398	393	394	395	396	396
A	LIPSCOMB	6	6	6	6	6	6	6
A	MOORE	1,802	1,733	1,716	1,709	1,703	1,697	1,689
A	OCHILTREE	164	198	213	220	226	232	240
A	OLDHAM	292	328	341	347	352	357	364
A	POTTER	261	329	367	392	417	442	462
A	RANDALL	15	18	19	20	21	22	23
A	ROBERTS	9	6	6	6	6	6	6
A	SHERMAN	20	17	16	16	16	16	16
A	WHEELER	113	89	85	83	82	81	79
	Region A Total	**7,229**	**7,115**	**7,162**	**7,199**	**7,237**	**7,275**	**7,310**

1) An acft is an amount of water to cover one acre with one foot of water and equals 325,851 gallons.

2) If the "(P)" is present for a county entry, then the county has been split by Regional boundaries and the data listed in the row represent only the county's water demands within the particular region, not the county's total.

Projections last updated on 9/17/03

2006 Regional Water Plan

Municipal Water Demand Projections for 2000 - 2060 (in acft[1])

Region A

Region	WUG Name	County Name	D2000	D2010	D2020	D2030	D2040	D2050	D2060
A	CLAUDE	ARMSTRONG	306	262	270	261	250	247	240
A	COUNTY-OTHER	ARMSTRONG	108	109	112	108	104	103	100
		ARMSTRONG Total	**414**	**371**	**382**	**369**	**354**	**350**	**340**
A	COUNTY-OTHER	CARSON	256	256	259	258	249	227	206
A	GROOM	CARSON	160	142	143	142	138	125	114
A	HI TEXAS WATER COMPANY	CARSON	55	55	55	55	53	48	44
A	PANHANDLE	CARSON	647	574	579	575	556	506	459
A	SKELLYTOWN	CARSON	105	106	107	106	102	93	85
A	WHITE DEER	CARSON	199	164	165	164	159	144	130
		CARSON Total	**1,422**	**1,297**	**1,308**	**1,300**	**1,257**	**1,143**	**1,038**
A	CHILDRESS	CHILDRESS	1,655	1,457	1,481	1,502	1,509	1,510	1,471
A	COUNTY-OTHER	CHILDRESS	192	196	199	202	203	203	198
		CHILDRESS Total	**1,847**	**1,653**	**1,680**	**1,704**	**1,712**	**1,713**	**1,669**
A	COUNTY-OTHER	COLLINGSWORTH	243	234	234	220	200	185	160
A	WELLINGTON	COLLINGSWORTH	464	456	457	446	431	420	401
		COLLINGSWORTH Total	**707**	**690**	**691**	**666**	**631**	**605**	**561**
A	COUNTY-OTHER	DALLAM	164	181	195	204	206	202	192
A	DALHART	DALLAM	1,609	1,319	1,422	1,487	1,503	1,471	1,403
A	TEXLINE	DALLAM	191	211	227	237	240	235	224
		DALLAM Total	**1,964**	**1,711**	**1,844**	**1,928**	**1,949**	**1,908**	**1,819**
A	CLARENDON	DONLEY	290	440	440	440	440	440	440
A	COUNTY-OTHER	DONLEY	226	219	210	191	171	154	128
		DONLEY Total	**516**	**659**	**650**	**631**	**611**	**594**	**568**
A	COUNTY-OTHER	GRAY	524	511	507	493	473	444	417
A	LEFORS	GRAY	104	86	85	83	80	75	70
A	MCLEAN	GRAY	190	185	183	178	171	161	151
A	PAMPA	GRAY	3,386	3,300	3,273	3,182	3,058	2,871	2,689
		GRAY Total	**4,204**	**4,082**	**4,048**	**3,936**	**3,782**	**3,551**	**3,327**
A	COUNTY-OTHER	HALL	363	353	379	395	382	387	363
A	MEMPHIS	HALL	442	442	441	440	440	440	442
		HALL Total	**805**	**795**	**820**	**835**	**822**	**827**	**805**
A	COUNTY-OTHER	HANSFORD	227	266	319	364	412	441	466
A	GRUVER	HANSFORD	333	325	327	329	332	333	334
A	SPEARMAN	HANSFORD	744	707	745	776	811	831	849
		HANSFORD Total	**1,304**	**1,298**	**1,391**	**1,469**	**1,555**	**1,605**	**1,649**
A	COUNTY-OTHER	HARTLEY	509	523	541	550	553	546	519
A	DALHART	HARTLEY	896	686	710	721	726	717	680
		HARTLEY Total	**1,405**	**1,209**	**1,251**	**1,271**	**1,279**	**1,263**	**1,199**
A	CANADIAN	HEMPHILL	455	475	477	461	444	432	411
A	COUNTY-OTHER	HEMPHILL	152	158	159	153	148	143	137
		HEMPHILL Total	**607**	**633**	**636**	**614**	**592**	**575**	**548**
A	BORGER	HUTCHINSON	2,307	2,352	2,384	2,351	2,274	2,148	2,039
A	COUNTY-OTHER	HUTCHINSON	55	56	57	57	55	52	49
A	FRITCH	HUTCHINSON	439	407	412	406	393	371	353
A	HI TEXAS WATER COMPANY	HUTCHINSON	335	341	346	341	330	312	296
A	STINNETT	HUTCHINSON	447	365	370	365	353	333	316
A	TCW SUPPLY INC	HUTCHINSON	591	603	611	602	583	550	523
		HUTCHINSON Total	**4,174**	**4,124**	**4,180**	**4,122**	**3,988**	**3,766**	**3,576**

2006 Regional Water Plan
Municipal Water Demand Projections for 2000 - 2060 (in acft[1])
Region A

Region	WUG Name	County Name	D2000	D2010	D2020	D2030	D2040	D2050	D2060
A	BOOKER	LIPSCOMB	509	354	362	351	341	336	320
A	COUNTY-OTHER	LIPSCOMB	390	394	402	390	379	373	356
		LIPSCOMB Total	**899**	**748**	**764**	**741**	**720**	**709**	**676**
A	CACTUS	MOORE	745	533	615	615	615	615	615
A	COUNTY-OTHER	MOORE	397	700	960	1,264	1,505	1,652	1,741
A	DUMAS	MOORE	3,357	2,734	2,962	3,163	3,322	3,419	3,478
A	FRITCH	MOORE	2	4	6	8	10	11	11
A	SUNRAY	MOORE	478	534	608	674	727	758	777
		MOORE Total	**4,979**	**4,505**	**5,151**	**5,724**	**6,179**	**6,455**	**6,622**
A	BOOKER	OCHILTREE	4	2	2	2	2	2	2
A	COUNTY-OTHER	OCHILTREE	181	181	181	181	181	181	181
A	PERRYTON	OCHILTREE	2,046	1,960	2,135	2,265	2,353	2,396	2,451
		OCHILTREE Total	**2,231**	**2,143**	**2,318**	**2,448**	**2,536**	**2,579**	**2,634**
A	COUNTY-OTHER	OLDHAM	164	174	178	165	146	126	102
A	VEGA	OLDHAM	228	242	247	229	202	176	142
		OLDHAM Total	**392**	**416**	**425**	**394**	**348**	**302**	**244**
A	AMARILLO	POTTER	28,628	24,162	25,978	27,675	29,609	31,719	33,449
A	COUNTY-OTHER	POTTER	1,152	1,703	2,295	2,850	3,482	4,171	4,736
		POTTER Total	**29,780**	**25,865**	**28,273**	**30,525**	**33,091**	**35,890**	**38,185**
A	AMARILLO	RANDALL	21,161	18,167	19,839	21,404	23,185	25,129	26,739
A	CANYON	RANDALL	2,207	2,438	2,688	2,922	3,188	3,478	3,718
A	COUNTY-OTHER	RANDALL	2,124	2,715	3,351	3,945	4,623	5,361	5,973
A	HAPPY	RANDALL	6	**11**	**17**	**22**	**27**	**33**	**38**
A	LAKE TANGLEWOOD	RANDALL	147	160	189	217	248	282	310
		RANDALL Total	**25,645**	**23,491**	**26,084**	**28,510**	**31,271**	**34,283**	**36,778**
A	COUNTY-OTHER	ROBERTS	42	44	45	41	34	30	27
A	MIAMI	ROBERTS	138	145	149	134	112	97	88
		ROBERTS Total	**180**	**189**	**194**	**175**	**146**	**127**	**115**
A	COUNTY-OTHER	SHERMAN	201	218	236	243	250	257	260
A	STRATFORD	SHERMAN	575	628	683	705	727	746	756
		SHERMAN Total	**776**	**846**	**919**	**948**	**977**	**1,003**	**1,016**
A	COUNTY-OTHER	WHEELER	290	277	278	276	279	278	273
A	SHAMROCK	WHEELER	345	312	312	311	313	313	309
A	WHEELER	WHEELER	307	291	291	291	291	291	291
		WHEELER Total	**942**	**880**	**881**	**878**	**883**	**882**	**873**
		Region A Total	**85,193**	**77,605**	**83,890**	**89,188**	**94,683**	**100,130**	**104,242**

[1)] An acft is an amount of water to cover one acre with one foot of water and equals 325,851 gallons.

Projections last updated on 9/17/03

2006 Regional Water Plan

Steam Electric Water Demand Projections for 2000 - 2060 (in acft[1])

Region A

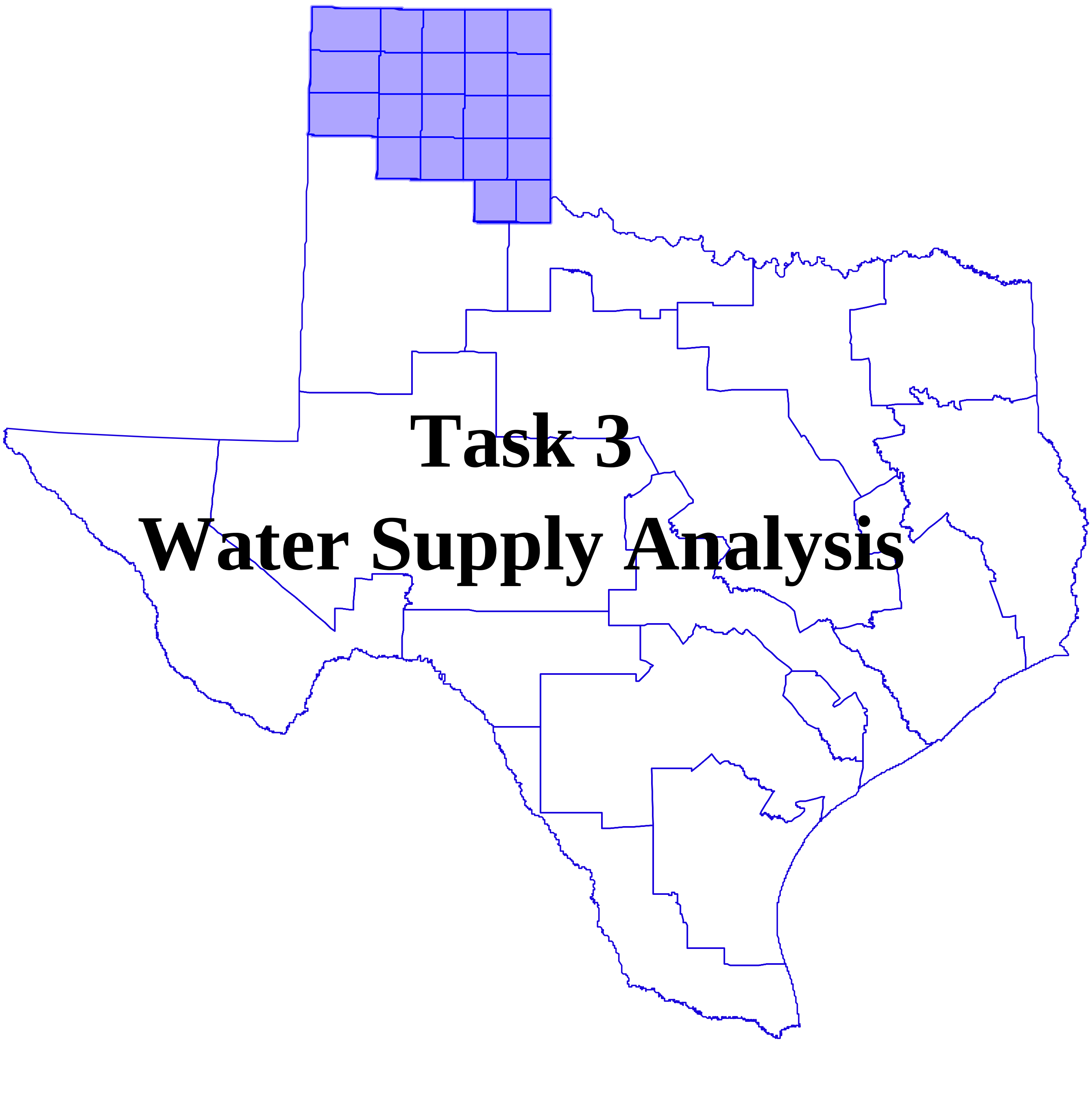
Region	County Name[2)]	D2000	D2010	D2020	D2030	D2040	D2050	D2060
A	ARMSTRONG	0	0	0	0	0	0	0
A	CARSON	0	0	0	0	0	0	0
A	CHILDRESS	0	0	0	0	0	0	0
A	COLLINGSWORTH	0	0	0	0	0	0	0
A	DALLAM	0	0	0	0	0	0	0
A	DONLEY	0	0	0	0	0	0	0
A	GRAY	0	0	0	0	0	0	0
A	HALL	0	0	0	0	0	0	0
A	HANSFORD	0	0	0	0	0	0	0
A	HARTLEY	0	0	0	0	0	0	0
A	HEMPHILL	0	0	0	0	0	0	0
A	HUTCHINSON	0	0	0	0	0	0	0
A	LIPSCOMB	0	0	0	0	0	0	0
A	MOORE	167	200	200	200	200	200	213
A	OCHILTREE	0	0	0	0	0	0	0
A	OLDHAM	0	0	0	0	0	0	0
A	POTTER	18,088	22,432	25,387	26,804	28,408	30,011	34,115
A	RANDALL	0	0	0	0	0	0	0
A	ROBERTS	0	0	0	0	0	0	0
A	SHERMAN	0	0	0	0	0	0	0
A	WHEELER	0	0	0	0	0	0	0
	Region A Total	**18,255**	**22,632**	**25,587**	**27,004**	**28,608**	**30,211**	**34,328**

1) An acft is an amount of water to cover one acre with one foot of water and equals 325,851 gallons.

2) If the "(P)" is present for a county entry, then the county has been split by Regional boundaries and the data listed in the row represent only the county's water demands within the particular region, not the county's total.

Projections last updated on 9/17/03

Task 3
Water Supply Analysis



3.1 Evaluation of Adequacy of Current Water Supplies

This chapter of the regional water plan presents an evaluation of current groundwater and surface water supplies available to the Panhandle region for use during a repeat of the drought of record. An analysis of supplies versus demands for all water user groups was conducted to determine shortages or adequacy of supplies. The sources described in this narrative are quantified throughout this report and in the attached Appendix D & V.

Groundwater sources which are identified in this chapter include two major and three minor aquifers. These include the Ogallala, Seymour, Blaine, Dockum, and Rita Blanca aquifers. The Whitehorse was not included in the analysis during this round of planning due to the lack of data specifically tied to this aquifer. SB2 and 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, GAM results were included for the Seymour and Blaine aquifers. The Dockum Aquifer GAM is not yet complete and availabilities calculated for the Dockum are based on data reported in published reports.

Developing a GAM involves gathering much information about the aquifer of interest, including rate of recharge, pumping rates, physical boundaries of the aquifer, geology, and historical water levels. This information is used as inputs into a mathematical computer model that can show the changes in water levels of the aquifer over time as a result of climate and pumping changes.

The volume of water available from the Ogallala, Seymour and Blaine aquifers was determined using the GAMs. Available supplies of water from the Dockum were determined using estimates of saturated thickness, specific yield, and recharge rates from historical studies and published reports. In Carson, Dallam, Hartley, Hutchinson, Moore, Roberts, and Sherman counties, the Ogallala GAM model could not supply the demands which were input as requested pumpage for some decades. This was due in part to the spatial locations of the demands rather than the total water availability within the county. To address these spatial limitations, the available water supplies to water user groups were reduced to reflect the GAM results. The total availability of groundwater from the Ogallala is limited to 1.25% of the water in storage as reported by the Ogallala GAM.

In the previous round of planning, the PWPG selected a 50/50 methodology for groundwater availability. The policy simply stated that the group wanted to have 50% of the 1998 saturated thickness of the aquifer left in 50 years. After deliberation and extensive discussion on the proper implementation and quantification of such a policy, the planning group proposed a revised methodology for the current round of planning. The current management policy for the PWPA is not more than an annual 1.25% withdrawal of current saturated thickness of the aquifer with a 5-year recalculation of the saturated thickness remaining. All water availabilities from groundwater stated in this plan do not exceed this 1.25% policy.

Available surface water supplies were determined using TCEQ-approved Water Availability Models (WAMs). WAMs have now been completed 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 these adjustments can be found in the Surface Water Supplies section of this chapter. Surface water supplies identified in the regional water plan include three reservoirs designated for drinking water supply. The three major reservoirs that were identified as significant sources of surface water in the PWPA are Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir.

Ten smaller reservoirs are discussed with respect to their use as potential future surface water supplies. These reservoirs are currently used for limited water supply, recreation, flood control, soil erosion control, and wildlife habitat. These include Lake McClellan, Buffalo Lake, Lake Tanglewood, Rita Blanca Lake, Lake Marvin, Baylor Lake, Lake Childress, Lake Fryer, Club Lake, and Bivens Lake. Because yield studies are not routinely performed on smaller reservoirs designated for uses other than drinking water supply, no firm yield information is available for these reservoirs.

As required by TWDB rules [§357.5(k)(1)F], county judges in each of the 21 counties were contacted to determine if any of the county commissioner's courts had water availability requirements. No specific requirements were identified within the PWPA.

3.1.1 Groundwater Supplies

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.

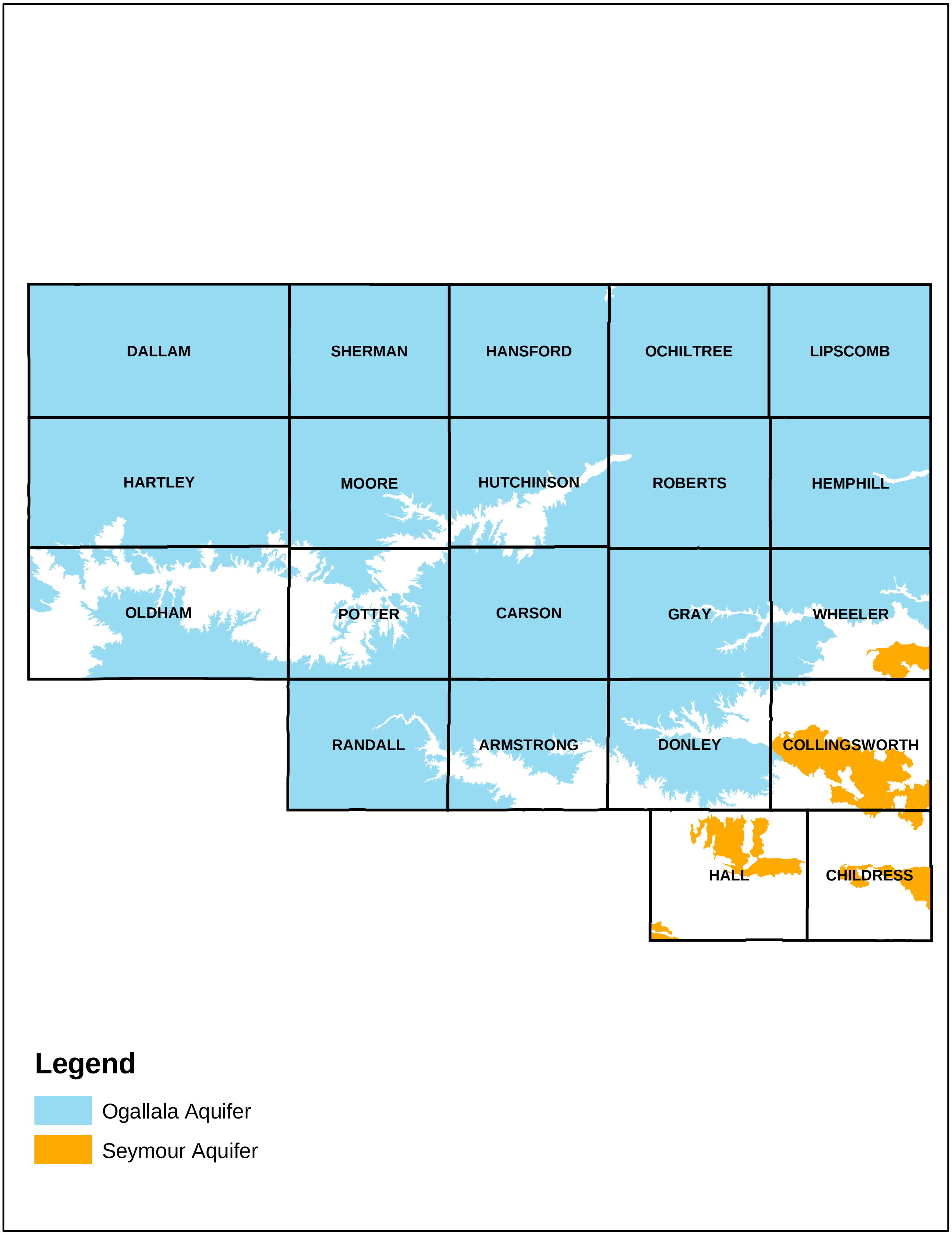


Figure 3-1: Major Aquifers in the Panhandle Water Planning Area

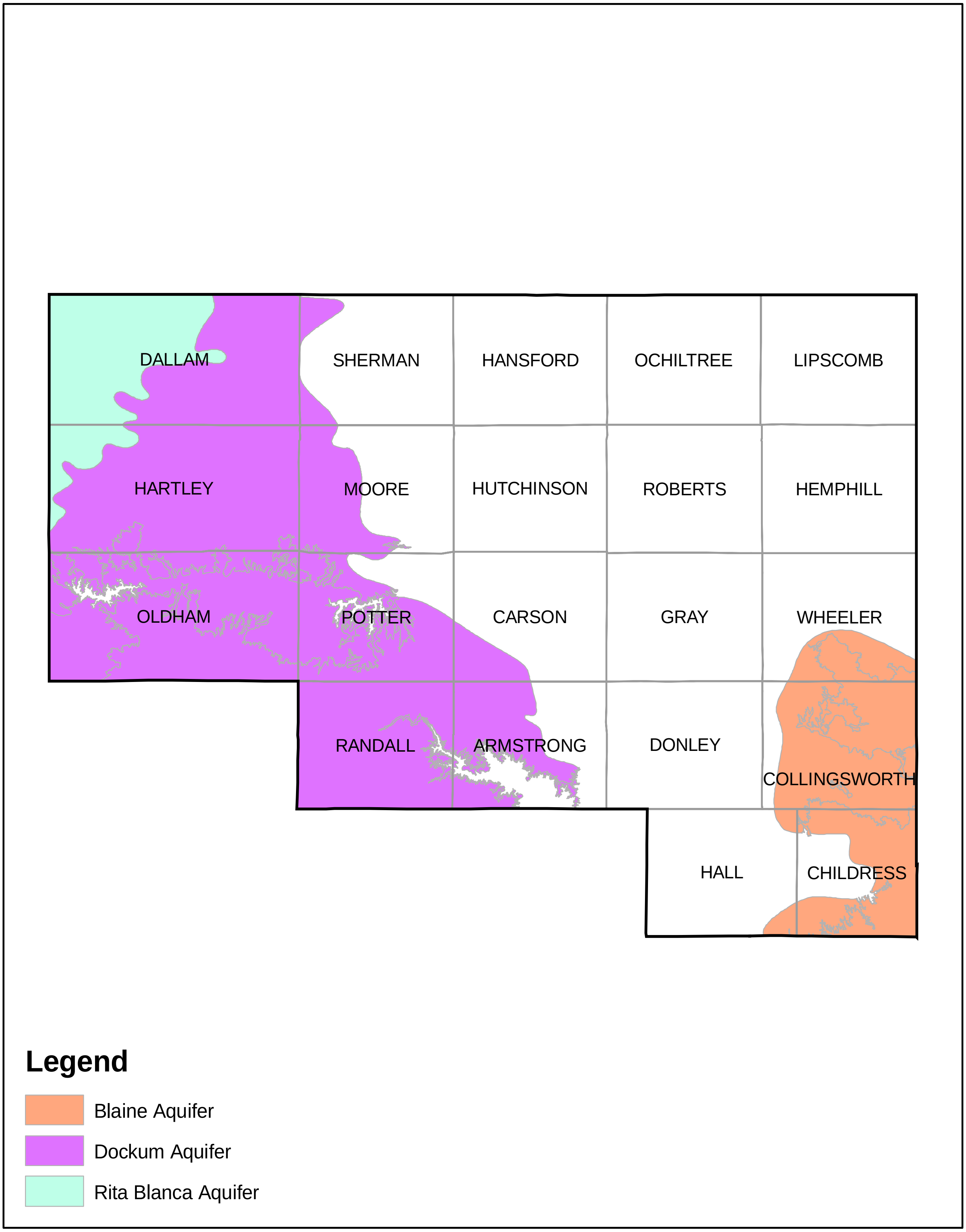


Figure 3-2: Minor Aquifers in the Panhandle Water Planning Area

For this round of planning, the PWPA provided an updated and recalibrated version of the Ogallala GAM to the state. This effort focused on providing more representative aquifer bottom elevations and refined recharge inputs. The TWDB then took the revisions and ran the GAM to determine groundwater from the Ogallala aquifer for each county in the region for the planning period. The total projected water in storage in the Ogallala is shown in Table 3-1. Figure 3-3 shows the 2000 comparison of the available supply from the Ogallala aquifer and Figure 3-4 shows the change of availability of supplies over the planning period. GAMs for the Seymour and Blaine aquifers were completed in early 2005 and are included in this analysis. The availability of water from the remaining aquifers was determined using estimates of saturated thickness, specific yield, and recharge rates. In cases where these data were not available, historical reports of pumpage and local well level data were used.

A description of the aquifers with regard to their location, geologic and hydrogeologic characteristics, historical yields, chemical quality, and available supply is provided below.

3.1.2 Major Aquifers

3.1.2.1 <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).

Table 3-1: Total Water in Storage in the Ogallala Aquifer (GAM 2005 Results in AF)

County	2000	2010	2020	2030	2040	2050	2060
Armstrong	4,051,267	3,946,527	3,841,987	3,762,122	3,660,019	3,594,351	3,516,472
Carson	15,280,781	14,159,377	13,081,706	12,044,288	11,076,423	9,990,939	9,189,765
Collingsworth	85,870	85,792	85,703	85,608	85,514	85,420	85,329
Dallam	17,604,513	14,622,921	12,134,853	10,126,050	8,591,459	7,549,367	6,779,683
Donley	6,249,296	6,071,878	5,906,044	5,754,021	5,622,240	5,514,375	5,424,345
Gray	13,648,169	13,287,191	12,937,973	12,604,708	12,297,143	12,022,161	11,774,680
Hansford	21,693,703	20,385,024	19,092,753	17,850,094	16,716,209	15,729,410	14,852,445
Hartley	24,925,026	22,140,753	19,612,912	17,620,595	16,366,457	15,570,650	15,033,727
Hemphill	15,638,152	15,587,716	15,537,912	15,492,137	15,450,805	15,413,991	15,381,202
Hutchinson	11,112,029	10,275,488	9,463,673	8,736,497	8,113,675	7,629,968	7,245,126
Lipscomb	18,640,279	18,526,166	18,413,261	18,305,998	18,210,229	18,128,137	18,055,287
Moore	10,662,411	8,866,273	7,116,002	5,572,033	4,394,052	3,551,754	2,928,227
Ochiltree	19,795,557	18,847,872	17,955,425	17,118,070	16,368,979	15,724,576	15,156,476
Oldham	2,521,470	2,464,330	2,431,378	2,410,964	2,354,849	2,369,351	2,359,118
Potter	3,045,673	2,857,232	2,716,565	2,602,259	2,417,728	2,396,881	2,304,503
Randall	6,258,380	5,846,443	5,475,627	5,318,727	4,932,887	5,326,169	5,355,003
Roberts	27,494,610	26,805,037	26,098,600	25,455,105	25,011,760	24,689,458	24,396,671
Sherman	19,498,315	16,814,464	14,188,402	11,708,499	9,545,592	7,794,612	6,390,606
Wheeler	7,485,439	7,423,165	7,367,619	7,325,079	7,288,085	7,257,973	7,232,521
TOTAL	**245,690,940**	**229,013,649**	**213,458,395**	**199,892,854**	**188,504,105**	**180,339,543**	**173,461,186**

The PWPG is tasked to plan for water supplies to meet the future water shortages of the Panhandle and has selected a management policy to assure such conditions. The initial 50/50 policy goal to have 50% of saturated thickness remaining in 50 years has been translated for implementation to mean not greater than a 1.25% of annual saturated thickness as an available supply. Aquifer volumes presented in Table 3-1 are used to determine the 1.25% of supply available on a county basis. Table 3-2 shows the availability of supply for the PWPA during the planning period.

Table 3-2: Available Water Supply from the Ogallala (1.25% Available Supplies in Storage in AFY)

County	2010	2020	2030	2040	2050	2060
Armstrong	49,332	48,025	47,027	45,750	44,929	43,956
Carson	176,992	163,521	150,554	138,455	124,887	114,872
Collingsworth	1,072	1,071	1,070	1,069	1,068	1,067
Dallam	182,787	151,686	126,576	107,393	94,367	84,746
Donley	75,898	73,826	71,925	70,278	68,930	67,804
Gray	166,090	161,725	157,559	153,714	150,277	147,184
Hansford	254,813	238,659	223,126	208,953	196,618	185,656
Hartley	276,759	245,161	220,257	204,581	194,633	187,922
Hemphill	194,846	194,224	193,652	193,135	192,675	192,265
Hutchinson	128,444	118,296	109,206	101,421	95,375	90,564
Lipscomb	231,577	230,166	228,825	227,628	226,602	225,691
Moore	110,828	88,950	69,650	54,926	44,397	36,603
Ochiltree	235,598	224,443	213,976	204,612	196,557	189,456
Oldham	30,804	30,392	30,137	29,436	29,617	29,489
Potter	35,715	33,957	32,528	30,222	29,961	28,806
Randall	73,081	68,445	66,484	61,661	66,577	66,938
Roberts	315,000	305,000	295,000	285,000	275,000	265,000
Sherman	210,181	177,355	146,356	119,320	97,433	79,883
Wheeler	92,790	92,095	91,563	91,101	90,725	90,407
TOTAL	**2,842,607**	**2,646,997**	**2,475,471**	**2,328,655**	**2,220,628**	**2,128,309**

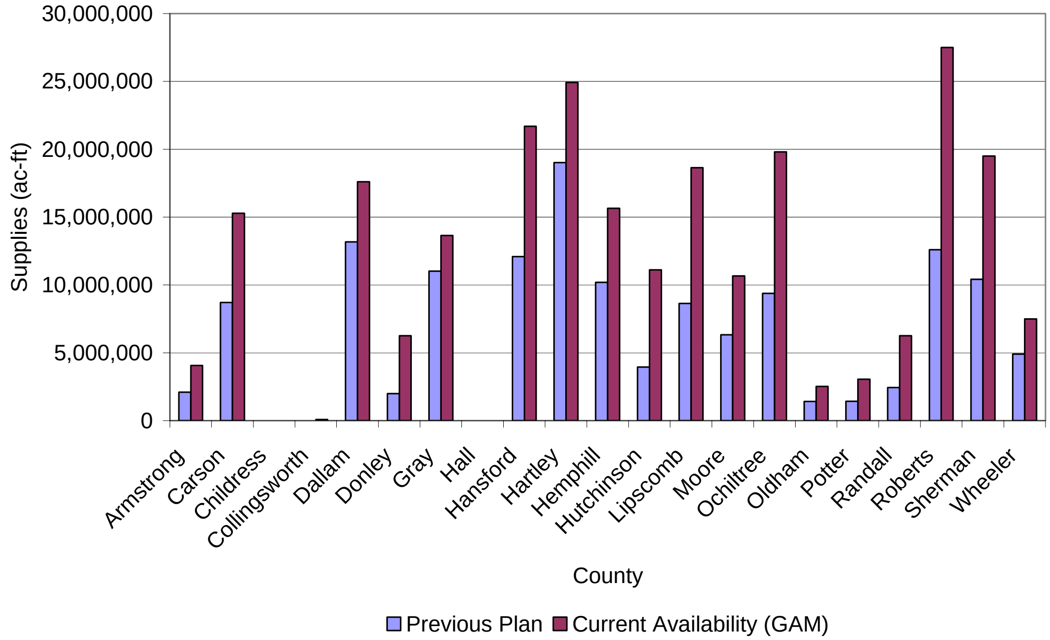


Figure 3-3: Total GAM Supplies from the Ogallala Aquifer

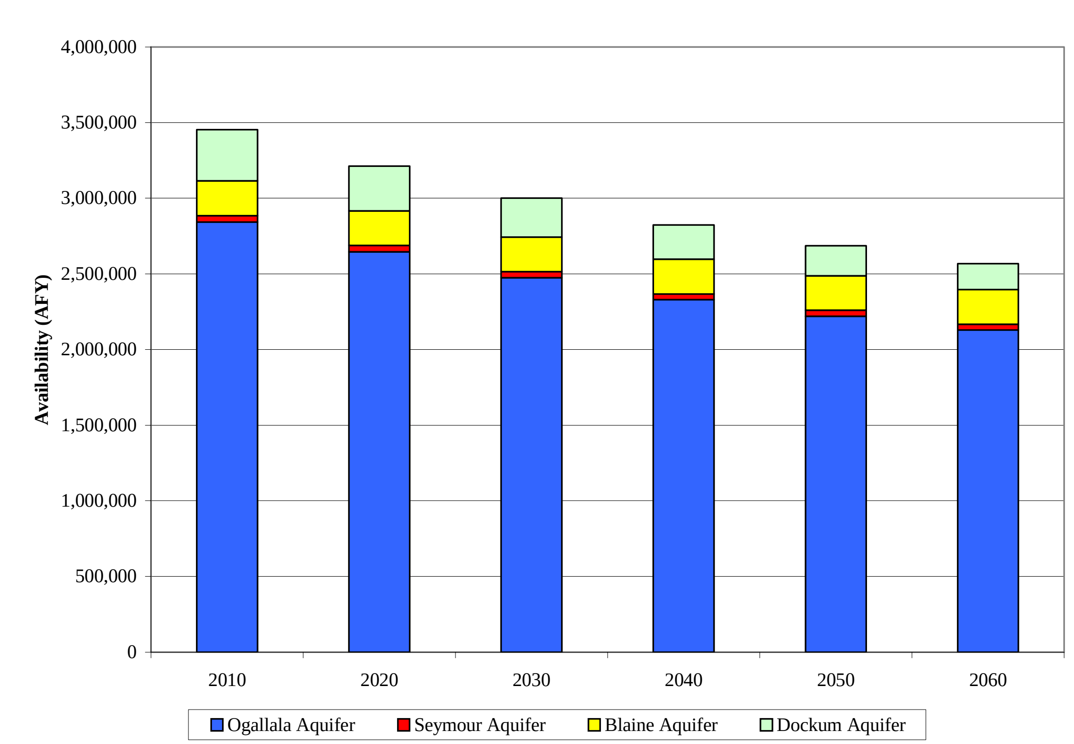


Figure 3-4: Available Supplies from Groundwater Sources in PWPA

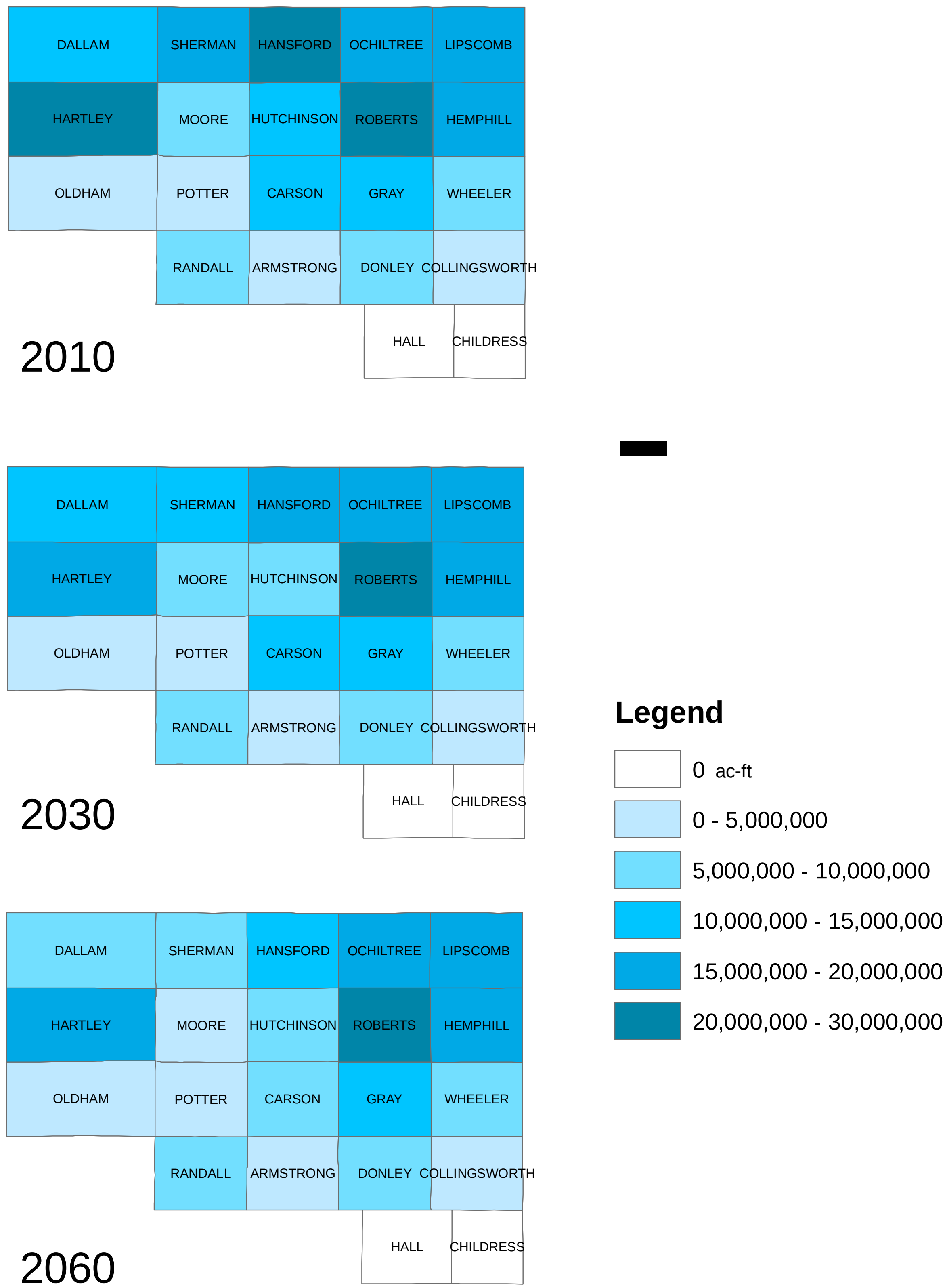


Figure 3-5: Total Volume in Storage in the Ogallala Aquifer (AF)

3.1.2.2 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, Hall, Wheeler, and a very small portion of Donley 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 as 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	2000	2010	2020	2030	2040	2050	2060
Childress	130,000	130,000	130,000	140,000	140,000	140,000	140,000
Collingsworth	520,000	480,000	460,000	450,000	450,000	460,000	470,000
Hall	210,000	200,000	180,000	180,000	180,000	190,000	190,000

Source: TWDB 2005

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

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	1,7900
Hall	20,500	20,000	19,000	19,000	19,000	19,000
Wheeler	88	88	88	88	88	88

Source: TWDB 2005

3.1.3 Minor Aquifers

3.1.3.1 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 occurred in the Blaine aquifer. Declines that have occurred are due to heavy irrigation use and are quickly recharged after seasonal rainfall (TWDB, 1997). As shown in Table 3-6, 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	2000	2010	2020	2030	2040	2050	2060
Childress	4,900,000	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	10,000,000
Hall	800,000	800,000	800,000	800,000	800,000	800,000	800,000
Wheeler	2,600,000	2,600,000	2,500,000	2,500,000	2,500,000	2,500,000	2,500,000

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

County	2000	2010	2020	2030	2040	2050	2060
Childress	61,250	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	125,000
Hall	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Wheeler	32,500	32,500	31,250	31,250	31,250	31,250	31,250

3.1.3.2 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).

Groundwater availability of the Dockum aquifer is presented in Table 3-7. 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: Available Annual Water Supply from the Dockum Aquifer (1.25% Available Supplies in Storage in ac-ft)

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	74,000	64,800	56,700	49,600	43,400	38,000
Potter	33,600	29,400	25,800	22,500	19,700	17,300
Randall	43,500	38,000	33,300	29,100	25,500	22,300

Source: TWDB Report 359, 2003

3.1.3.3 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 (Table 3-8). 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.

Table 3-8: Average Pumpage and Projected Groundwater Availability in the Rita Blanca Aquifer for Counties in the PWPA

County	Average Pumpage 1980-1997* (acre-feet/yr)
Dallam	5,419
Hartley	n/a
Total	5,419

Source: TWDB, 2005

3.2 Surface Water Supplies

Major surface water supplies in the PWPA include Lake Meredith, Palo Duro Reservoir, and Greenbelt Reservoir. 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 amount of water held for later release for usual purposes such as municipal water supply, power, or irrigation in contrast with storage capacity used for flood control. The following sections contain an evaluation of these reservoirs based on the Red River and Canadian River Water Availability Models and water rights.

As part of the water supply analysis for PWPA, the consultants compared reservoir yields from the Red and Canadian Rivers WAMs to previous work. Some of the yields in both basins were quite different and represent changed conditions. Several procedural problems with the flow naturalization were identified which may explain some of the differences in reservoir yields including:

- Inappropriate application of loss factors
- Inappropriate estimation of missing flow data
- Unjustified adjustments for construction of Lake Meredith
- Use of unadjusted historical flows originating in New Mexico, specifically no adjustments for the construction of major upstream reservoirs
- Selection of inappropriate base for calculation of naturalized or adjusted historical inflow to Lake Meredith, specifically the use of the Canadian gauge in lieu of the Amarillo gauge or derived inflow from historical reservoir changes for the period since 1965

The following list describes the changes made to the TCEQ Canadian River WAM to improve the evaluation surface water supplies for the PWPA:

1 - Extension of the period of record
2- Adjustments for Lake Meredith
3- Adjustment for New Mexico development
4- Channel Loss Correction
5- Changes in the Canadian WAM

The hydrologic period of the model was extended from the period of record of the TCEQ Canadian WAM which was January 1948 through December 1997. The new period is January 1940 through September 2004. The extension allows covering the years before the drought of the 1950's and the recent drought. This extension was made in all primary control points of the Canadian WAM.

Inflows to Lake Meredith were computed with historical data provided by CRMWA. The inflows into Lake Meredith computed by mass balance are generally less than the historical flows at the gage on the Canadian River near Amarillo. The difference is greater after the reservoir was completed than in recent years. The firm yield study of Lake Meredith completed by Lee Wilson and Associates in 1993 acknowledged these losses and suggested that they occurred because of bank and flood plain storage after the initial impoundment. The reductions in the losses over time seem to confirm the theory of bank storage. Once the banks are saturated, lower losses would occur. Bank storage estimates for each month were computed and considered during the recomputation of the naturalized flows Historical diversion by CRMWA were used during the recomputation of naturalized flows. For some months, they are slightly different from the values used in the TCEQ Canadian WAM.

A new control point was created for the gage at the Canadian River near Logan, located a few miles downstream of Ute Reservoir. Historical flows at this gage were adjusted for impoundment, releases, and evaporation losses in the reservoir. This affects the flows entering Texas. Ute reservoir was completed in 1963 with a conservation storage of 110,000 acre-feet. It was then enlarged to 272,770 acre-feet of storage in 1984. Current storage as reported by USGS is 229,710 acre-feet. Plans to provide a firm supply of 24,000 acre-feet per year are being developed by the Eastern New Mexico Rural Water System. This development will reduce the yield of Lake Meredith and should be considered in the Canadian WAM.

Naturalized flows of the TCEQ Canadian WAM assumed a constant loss factor of 30% basin wide. This loss factor was applied to diversion or return flows regardless of the location. The recomputed channel loss factors are listed in Table 3-9.

Table 3-9: Recalculated Channel Losses

From gage	To gage	Loss factor	Source
Canadian River near Logan	Canadian River near Amarillo	5%	Lee Wilson and Associates 1993 Report
Canadian River near Amarillo	Lake Meredith	4%	Historical record analysis
Canadian River near Amarillo	Canadian River near Canadian	38%	Historical record analysis

Other adjustments to the Canadian River WAM include the addition of Ute Reservoir with a diversion of 24,000 acre-feet per year as the most senior right. In addition, minimum storage of Lake Meredith is considered its dead storage of 55,000 acre-feet.

Table 3-10 summarizes the existing yield studies for the three main water supply reservoirs in the PWPA: Lake Meredith, Palo Duro Reservoir, and Greenbelt. According to the existing yield studies for these reservoirs, all of them appear to be currently experiencing their critical drought period.

The firm yield of the three surface water supply reservoirs for the PWPA will very likely be reduced if low flows continue after 2004. However, the firm yield for Palo Duro Reservoir will remain difficult to define using the available hydrologic records in the area.

Table 3-10: Descriptive Information of Water Supply Reservoirs in the PWPA

	Palo Duro Reservoir	Lake Meredith	Greenbelt Reservoir
Owner/Operator	PDRA	National Park Service, BuRec and 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
Date of Impoundment	January 1991	January 1965	December 1966
Sources of Information	PDRA, TWDB, and USGS	CRMWA, TWDB, and USGS	GMIWA, TWDB, and USGS
Conservation Storage (most recent survey)	60,897 acre-feet (1974)	817,970 acre-feet* (1995) (includes sediment storage)	59,110 acre-feet (1965)
Permitted Diversion	10,460 acre-feet/yr	151,200 acre-feet/yr	16,230 acre-feet/yr
Firm Yield	4,000 acre-feet/yr	69,750 acre-feet/yr	8,985 acre-feet/yr

*The Canadian River Compact allows 500,000 acre-feet of conservation storage. Any water stored in excess of 500,000 acre-feet is subject to release at the call of the State of Oklahoma.

3.2.1 Water Rights

According to the TCEQ water rights database there are 104 water rights permit holders in the PWPA representing a total of 185,679 acre-feet/yr. (TCEQ 2004) As shown in Table 3-11, three water rights permits have been assigned to divert more than 1,000 acre-feet/year. These represent a total of 177,690 acre-feet/year, or approximately 95 percent of the total water rights allocated in the PWPA. Table 3-12 summarizes the remaining 101 water rights in the PWPA which are less than 1,000 acre-feet/yr, representing 7,989 acre-feet/year.

Table 3-11: Water Rights in the PWPA Greater Than 1,000 Acre-feet/Year

Water Right Number	Water Right Owner	Authorized Diversion (ac-ft)	Authorized Use	Priority Date	Reservoir	Stream	County
3782	Canadian River Municipal Water Authority	100,000	Municipal/ Domestic	1/30/1956	Lake Meredith	Canadian River	Hutchinson
3782	Canadian River Municipal Water Authority	51,200	Industrial	1/30/1956	Lake Meredith	Canadian River	Hutchinson
3803	Palo Duro River Authority	10,460	Municipal/ Domestic	4/23/1974	Palo Duro Reservoir	Palo Duro Creek	Hansford
5233	Greenbelt Municipal and Industrial River Authority	16,030	Municipal/ Domestic	8/11/1958	Greenbelt Reservoir	Salt Fork Red River	Donley

Table 3-12: Total Water Rights by County in the PWPA Less Than 1,000 Acre-feet/Year

County	Basin Name	Total
Carson	Red	335
Childress	Red	435.5
Collingsworth	Red	1,194
Dallam	Canadian	190
Donley	Red	464
Gray	Canadian	4
Gray	Red	259
Hall	Red	101
Hansford	Canadian	530
Hartley	Canadian	0
Hemphill	Canadian	0
Hemphill	Red	0
Hutchinson	Canadian	646
Lipscomb	Canadian	122
Moore	Canadian	345
Ochiltree	Canadian	0
Oldham	Canadian	30
Potter	Canadian	349
Randall	Red	1,021.5
Roberts	Canadian	640
Sherman	Canadian	275
Wheeler	Red	1,048
Total		**7,989**

3.2.2 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 (CRC). 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)

Four 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/yr. and that development of New Mexico projects might further reduce the yield to 66,000 acre-feet/yr. 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 CRC limits the conservation storage to 500,000 acre-feet. The Freese and Nichols, Inc. study of the Water Availability Model of the Canadian Basin with the hydrology ending in December 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.

Projections of conservation storage, firm yield, and available supply for Lake Meredith during planning period of 2000 through 2060 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 3-13 shows the projected storage, yield, and available supply of Lake Meredith by decade for the planning period.

Table 3-13: Projected Yield and Available Supply of Lake Meredith

	2000	2010	2020	2030	2040	2050	2060
Storage Capacity (acre-feet)	815,989	811,687	807,384	803,082	798,780	794,477	790,175
Conservation Storage * (acre-feet)	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Firm Yield (acre-feet/yr)	69,750	69,750	69,750	69,750	69,750	69,750	69,750
Safe Yield (acre-feet)	63,750	63,750	63,750	63,750	63,750	63,750	63,750

* Limited by provisions of the Canadian River Compact

A large portion of Lake Meredith's inflow (about 90%) originates upstream of the Canadian River gage near Amarillo. The most recent yield study of Lake Meredith was performed in February 1993 (Lee Wilson and Associates, 1993). Total inflows for this study were estimated through a volumetric water balance, subtracting evaporation, diversions, releases and seepage from the observed change in storage. In this analysis, the runoff below the Amarillo gage amounted to about 10% of the total inflow.

Inflow data sources for Lake Meredith have been adequate for previous firm yield studies. The U.S. Geological Survey gage on the Canadian River near Amarillo has supplied important hydrologic records for these computations. The critical period for the reservoir extends beyond the most recent period of analysis. The Amarillo gaging station should continue to serve as the best estimate of the majority of Lake Meredith inflows in future yield studies. Appendices V and W provide more information on the latest hydrology, water availability modeling, and vulnerability assessment of Lake Meredith and Palo Duro.

3.2.3 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. 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 3-14 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 3-14: Projected Yield and Available Supply of Palo Duro Reservoir

	2000	2010	2020	2030	2040	2050	2060
Conservation Capacity (acre-feet)	59,702	58,822	57,942	57,062	56,182	55,302	54,422
Firm Yield (acre-feet/yr)	4,000	3,958	3,917	3,875	3,833	3,792	3,750
Available Supply (acre-feet/yr)	--	--	--	--	--	--	

3.2.4 Greenbelt Reservoir

Greenbelt Reservoir is owned and operated by the Greenbelt Municipal and Industrial Water Authority (GM&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 8,854 acre-ft per year in 2010, 8,592 acre-feet per year in 2030, and 8,200 acre-feet per year in 2060. These findings are summarized in Table 3-15 below.

Table 3-15: Projected Yield and Available Supply of Greenbelt Reservoir

	2000	2010	2020	2030	2040	2050	2060
Conservation Capacity (acre-feet)	52,673	50,651	48,628	46,606	44,584	42,562	40,540
Firm Yield (acre-feet/yr)	8,985	8,854	8,723	8,592	8,461	8,330	8,200
Available Supply (acre-feet/yr)	8,985	8,854	8,723	8,592	8,461	8,330	8,200
Safe Yield (acre-feet/yr)	7,470	7,331	7,192	7,053	6,914	6,775	6,635

The safe yield of the reservoir is estimated to be 7,470 acre-feet/yr (6.66 MGD).

Inflow estimates prior to September 1967 were based on USGS gages near Mangum, Wellington, and Clarendon. Inflows after September 1967 were based on a volumetric balance of the reservoir with USGS surface elevation measurements taken at the dam. Net reservoir evaporation rates were derived from 1-degree quadrangle data published by the TWDB (TWDB, 1967). Reservoir operation studies also included an estimate of historical low-flow releases. Sedimentation rates characteristic of the area were used to estimate a reservoir capacity reduction of 5,770 acre-feet by 1996 (Freese & Nichols, 1997).

Evaluation of Reservoir Yield Studies

The critical period for each of the three reservoirs extends beyond the most recent periods of analyses ending in September 2004. If low flows continue after September 2004, firm yields may be reduced still further. Firm yield analyses based on portions of a critical period rather than the entire critical period may overestimate yields. Values of firm yield already include information through September 2004.

The firm yield estimates using the Water Availability Models consider the latest available evaporation rates computed by TWDB. Most of the previous yield studies for Palo Duro Reservoir and Greenbelt Reservoir used the TWDB's net reservoir evaporation rates available before 1998. Evaporation rates for Lake Meredith for the period after 1965 are determined by on-site measurements. The previous TWDB evaporation data is generally lower than the latest data in the Panhandle Region. Each of the existing yield studies has been completed using estimates of the area-capacity relationships for the planning period 2000-2060 based on the most recent sedimentation surveys. As more recent surveys are conducted, the new area-capacity information should be used to revise the yield estimates. New sedimentation surveys are not available for either Palo Duro or Greenbelt, and the estimates of area-capacity relationships were based on the original surveys before the initial impoundment. The most recent volumetric survey for Lake Meredith was completed in 1995 and considered in the firm yield estimates.

3.2.5 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 Bivens 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 3-16 summarizes descriptive information about each of the minor reservoirs.

Table 3-16: 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	4,600 (as built)
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
Bivens Lake	Palo Duro Creek	Red	ground water recharge	n/a	1926	5,120

Source: Breeding, 1999
*TCEQ, 2000
n/a – data are not available

3.2.5.1 Lake McClellan

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

3.2.5.2 Buffalo Lake

Buffalo Lake is a reservoir impounded by Umbarger Dam, three miles south of the city of Umbarger on upper Tierra Blanca Creek in western Randall County. The reservoir is in the Red River basin. The original dam was built in 1938 by the Federal Farm Securities Administration to store water for recreational purposes. The lake's drainage area is 2,075 square miles, of which 1,500 square miles are probably noncontributing.

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.

3.2.5.3 Lake Tanglewood

Lake Tanglewood is located in the Red River Basin and is formed by an impoundment constructed in the early 1960's on Palo Duro Creek in northeastern Randall County. Lake Tanglewood, Inc., a small residential development is located along the lake shore (Breeding, 1999). Lake Tanglewood has a water right for storage of 4,897 acre-feet for recreational purposes without a right for diversion.

3.2.5.4 Rita Blanca Lake

Rita Blanca Lake is on Rita Blanca Creek, a tributary of the Canadian River, in the Canadian River basin three miles south of Dalhart in Hartley County. The Rita Blanca Lake project was started in 1938 by the WPA in association with the Panhandle Water Conservation Authority. In June 1951, Dalhart obtained a ninety-nine-year lease for the operation of the project as a recreational facility without any right of diversion (Breeding, 1999). The lake is currently owned by the Texas Parks and Wildlife Department and is operated and managed jointly by Hartley and Dallam county commissioners for recreational purposes. The two counties have joint recreational water rights (TCEQ, 2000). 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.

3.2.5.5 Lake Marvin

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

3.2.5.6 Baylor Lake

Baylor Lake is on Baylor Creek in the Red River Basin, ten miles northwest of Childress in western Childress County. The reservoir is owned and operated by the city of Childress. Although the City has water rights to divert up to 397 acre-feet per year from the reservoir (TWDB, 1999), there is currently no infrastructure remaining 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).

3.2.5.7 Lake Childress

Lake Childress is eight miles northwest of Childress in Childress County. This reservoir, built in 1923 on a tributary of Baylor Creek, in the Red River Basin, had an original capacity of 4,600 acre-feet; it is 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]. There are no water rights shown for the lake in TCEQ's water rights database (TCEQ, 2000).

3.2.5.8 Lake Fryer

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

3.2.5.9 Club Lake

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.

3.2.5.10 Bivens Lake

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).

3.2.5.11 Playa Lakes

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.

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 4,884 playa lakes are located in the PWPA, covering approximately one percent of the surface area (NRCS, 1999). 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 3-17 shows the estimated acreage and water storage for playa lakes in the PWPA.

Table 3-17: Acreage and Estimated Maximum Storage of Playa Lakes in the PWPA

County	Estimated Area (acres)	Estimated Maximum Storage* (acre-feet)
Armstrong	15,177	45,532
Carson	18,270	54,810
Childress	116	347
Collingsworth	0	0
Dallam	4,125	12,374
Donley	1,903	5,710
Gray	12,907	38,722
Hall	0	0
Hansford	6,981	20,942
Hartley	3,791	11,373
Hemphill	100	299
Hutchinson	3,297	9,890
Lipscomb	234	703
Moore	4,635	13,906
Ochiltree	15,836	47,509
Oldham	4,336	13,009
Potter	3,203	9,609
Randall	16,793	50,378
Roberts	1,368	4,103
Sherman	4,499	13,496
Wheeler	0	0
TOTAL	**117,571**	**352,712**

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.

3.2.6 Reuse Supplies

Direct reuse is used in the PWPA for irrigation and industrial water uses. Currently, the largest producer of treated effluent for reuse is the city of Amarillo. Most of the city’s wastewater is sold to Xcel Energy for steam electric power use. The city of Borger also sells a portion of its wastewater effluent for manufacturing and industrial use. Most of the other reuse in the PWPA is used for irrigation. A summary of the estimated direct reuse in the PWPA is shown in Table 3-18.

Table 3-18 Direct Reuse in the PWPA
-Values in Acre-feet per Year-

County	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Carson	14	13	13	13	13	13
Childress	120	117	117	118	120	120
Collingsworth	300	300	300	300	300	300
Dallam	430	421	409	391	379	379
Gray	1,902	1,879	1,615	1,568	1,525	1,525
Hall	7	6	6	6	5	5
Hemphill	13	12	11	10	10	10
Hutchinson	1,332	1,270	1,198	1,112	1,073	1,073
Lipscomb	34	34	34	34	34	34
Moore	547	592	633	664	684	696
Potter	19,381	23,241	24,658	26,262	27,865	31,969
Randall	2,936	2,943	2,956	2,970	2,985	2,995
Roberts	25	23	22	20	18	18
Wheeler	16	15	15	15	14	14
Total	**27,057**	**30,866**	**31,987**	**33,483**	**35,025**	**39,151**

3.2.7 Local Supplies

Local supplies include stock ponds for livestock use and local supplies for mining and irrigation. 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 3-19.

Table 3-19: Summary of Local Supplies in the PWPA
-Values in Acre-feet per Year-

	2010	**2020**	**2030**	**2040**	**2050**	**2060**
IRRIGATION LOCAL SUPPLY						
Hansford	150	149	147	146	144	144
Potter	1,686	1,685	1,683	1,682	1,679	1,679
Randall	634	630	627	624	621	621
Sherman	406	405	404	402	400	400
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

Table 3-19 (continued)

LIVESTOCK LOCAL SUPPLY						
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	516	516	516	516	516	516
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
Moore	1,658	1,658	1,658	1,658	1,658	1,658
Total Local Supply	**25,756**	**25,749**	**25,741**	**25,734**	**25,724**	**25,724**

3.2.7 Summary of Available Water Supplies in the PWPA

The currently available water supplies in the PWPA total nearly 3,600,000 acre-feet per year in 2010, decreasing to 2,700,000 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 3-20 represent the amount of supply that is currently developed and potential future supplies that could be developed. These values do not consider infrastructure constraints, contractual agreements, or the economic feasibility of developing these sources. In some counties the available groundwater supplies is significantly greater than the historical use. In other counties, current groundwater use exceeds the available supply based on the 1.25% policy. Consideration of the amount of water that is currently connected and available to water users in the PWPA is discussed in Section 3.3.

Table 3-20: Summary of Water Supplies in the PWPA
-Values in Acre-feet per Year-

Source	2010	2020	2030	2040	2050	2060
Lake Meredith	69,750	69,750	69,750	69,750	69,750	69,750
Greenbelt Lake	8,854	8,723	8,592	8,461	8,330	8,200
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	**85,026**	**84,854**	**84,681**	**84,508**	**84,336**	**84,164**
Ogallala Aquifer	2,842,607	2,646,997	2,475,470	2,328,655	2,220,628	2,128,308
Seymour Aquifer	41,613	40,613	38,738	38,738	38,738	38,738
Blaine Aquifer	230,000	228,750	228,750	228,750	228,750	228,750
Dockum Aquifer	337,500	295,200	258,400	226,100	197,900	173,200
Other Aquifers	6,098	6,097	6,094	6,091	6,091	6,091
Total Groundwater	**3,457,818**	**3,217,657**	**3,007,452**	**2,828,334**	**2,692,107**	**2,575,087**
Local Supply	25,756	25,749	25,741	25,734	25,724	25,724
Direct Reuse	27,057	30,866	31,987	33,483	35,025	39,151
Total Other Supplies	**52,813**	**56,615**	**57,728**	**59,217**	**60,749**	**64,875**
Total Supply in PWPA	**3,595,657**	**3,359,126**	**3,149,861**	**2,972,059**	**2,837,192**	**2,724,126**

3.3 Water Supply and Demand Summary

This section discusses the comparison of the developed supply in the Panhandle Water Planning Area (PWPA) to the projected demands developed in Chapter 2. Developed supplies are defined as the amount of water available to water user groups considering existing infrastructure, contractual agreements and source availability. 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 available 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.

The management policy for the PWPA is a maximum annual 1.25% withdrawal of the recoverable volume of water of the source aquifer, with a 5-year recalculation of the volume remaining. All water availabilities from groundwater aquifers stated in this plan comply with this management policy. All supplies listed as “available” or “availability” in regards to groundwater refer to this policy adjustment to the supply. The implementation of the policy for projections of water user group demand has resulted in several “overdrafts” of the policy that are shown in the analysis with demand as shortages. These shortages are shown primarily for agricultural uses including irrigated agriculture and livestock water. The PWPG has prioritized livestock use over irrigation in areas where shortages where identified. Voluntary transfers of these supplies usually add to the unmet irrigation demand. In addition, local Groundwater Conservation District rules may be more restrictive in certain areas as permitting requirements based on geographic extent may limit withdrawals beyond the county-wide 1.25% availability shown in this plan.

3.3.1 Regional Demands

Summarized from Chapter 2, the total demands for the PWPA are projected to decrease from 1,864,748 acre-feet in the year 2010 to 1,780,588 acre-feet per year in 2030 and 1,399,412 acre-feet per year by 2060. The largest water user group demand category is irrigation, which accounted for nearly 90 percent of the total demand in the region in the year 2000, but decreased slightly to 80 percent by year 2060 as municipal demands increased. Municipal is the next largest water user in the PWPA, and livestock is the third largest demand.

3.3.2 Current Supply

The currently developed supply in the PWPA consists mainly of groundwater, 95% 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 over 90 percent of the total supply in year 2010. For cities, the supplies were limited to the developed water rights reported to the PWPA and/or 50% of the well field capacity reported to the TCEQ. For other users, such as local supplies for livestock, the water supplies were limited to historical use as reported to the TWDB.

The total volume of the developed supply for the PWPA in year 2010 was approximately 1,894,000 acre-feet per year and projected to decrease to 1,521,000 by the year 2030 and ultimately to 1,131,000 acre-feet per year in 2060. These supply volumes are shown in Table 3-21.

Table 3-21: Developed Water Supplies to Water User Groups in PWPA

-Values in Acre-feet per Year-

Source	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Meredith[1]	30,305	30,305	30,305	30,304	30,305	30,305
Palo Duro[2]	0	0	0	0	0	0
Greenbelt[1]	2,564	2,582	2,587	2,575	2,559	2,489
Run-of-the-River	2,464	2,464	2,464	2,464	2,464	2,464
Total surface water	**35,333**	**35,351**	**35,356**	**35,343**	**35,328**	**35,258**
Ogallala	1,715,250	1,551,180	1,341,189	1,164,337	1,033,574	948,141
Blaine	19,740	19,740	19,740	19,740	19,740	19,740
Seymour	41,271	40,271	38,271	38,271	38,271	38,271
Dockum	24,420	24,420	23,620	21,920	20,520	19,220
Other Aquifers (Rita Blanca, Other)	6,095	6,095	6,092	6,090	6,090	6,090
Total groundwater	**1,806,776**	**1,641,706**	**1,428,912**	**1,250,358**	**1,118,195**	**1,031,462**
Local Supplies	25,756	25,749	25,741	25,734	25,724	25,724
Reuse	26,067	29,934	31,116	32,687	34,255	38,407
Total Supply	**1,893,932**	**1,732,740**	**1,521,125**	**1,344,122**	**1,213,502**	**1,130,851**

1. Quantity of water available is for PWPA users only. Supplies from these sources are also used in other regions.
2. There is no currently available supply from Palo Duro Reservoir because there is no infrastructure.

Table 3-21 is the total available supplies available for use within the PWPA. CRMWA provides drinking water to eight other member cities in the Llano Estacado RWPA and slightly over 30,000 acre-feet per year are allocated from Lake Meredith to water users group in PWPA. CRMWA also supplies water from their Roberts County well field to member cities in the Llano Estacado RWPA.

3.4 Comparison of Demand to Currently Available Supplies

Considering only developed and connected supplies for the Panhandle, on a regional basis the available supply exceeds the demands by only 29,200 acre-feet per year in the year 2010, and is less than the projected demands by nearly 259,500 acre feet per year in 2030, and 268,500 acre feet per year in 2060. This is shown graphically on Figure 3-6.

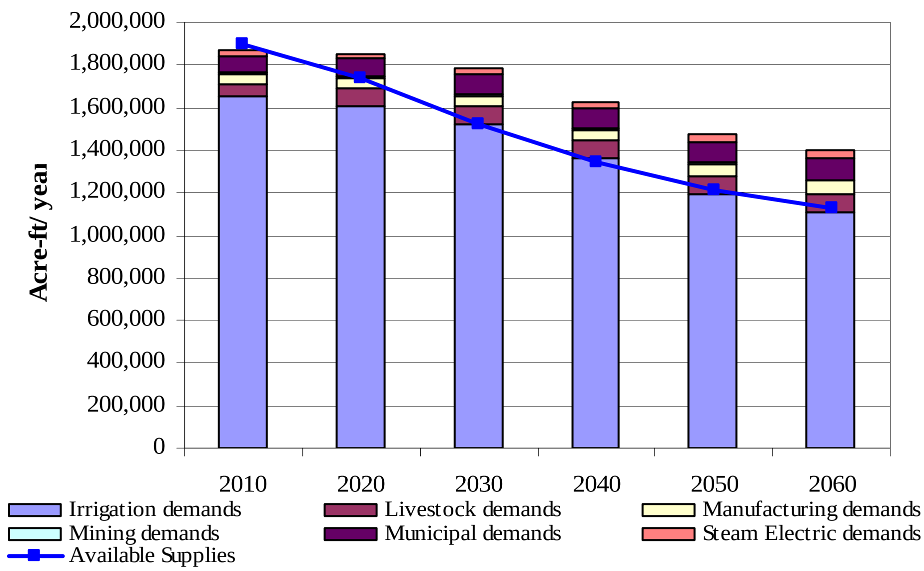


Figure 3-6: PWPA Supplies and Demands (ac-ft/yr)

On a county-basis, there are seven counties with shortages over the planning period. These include Dallam, Hartley, Hutchinson, Moore, Potter, Randall and Sherman. Table 3-22 presents current available supply versus demand by county. Figure 3-7 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 3-23, 3-24 and 3-25, 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.

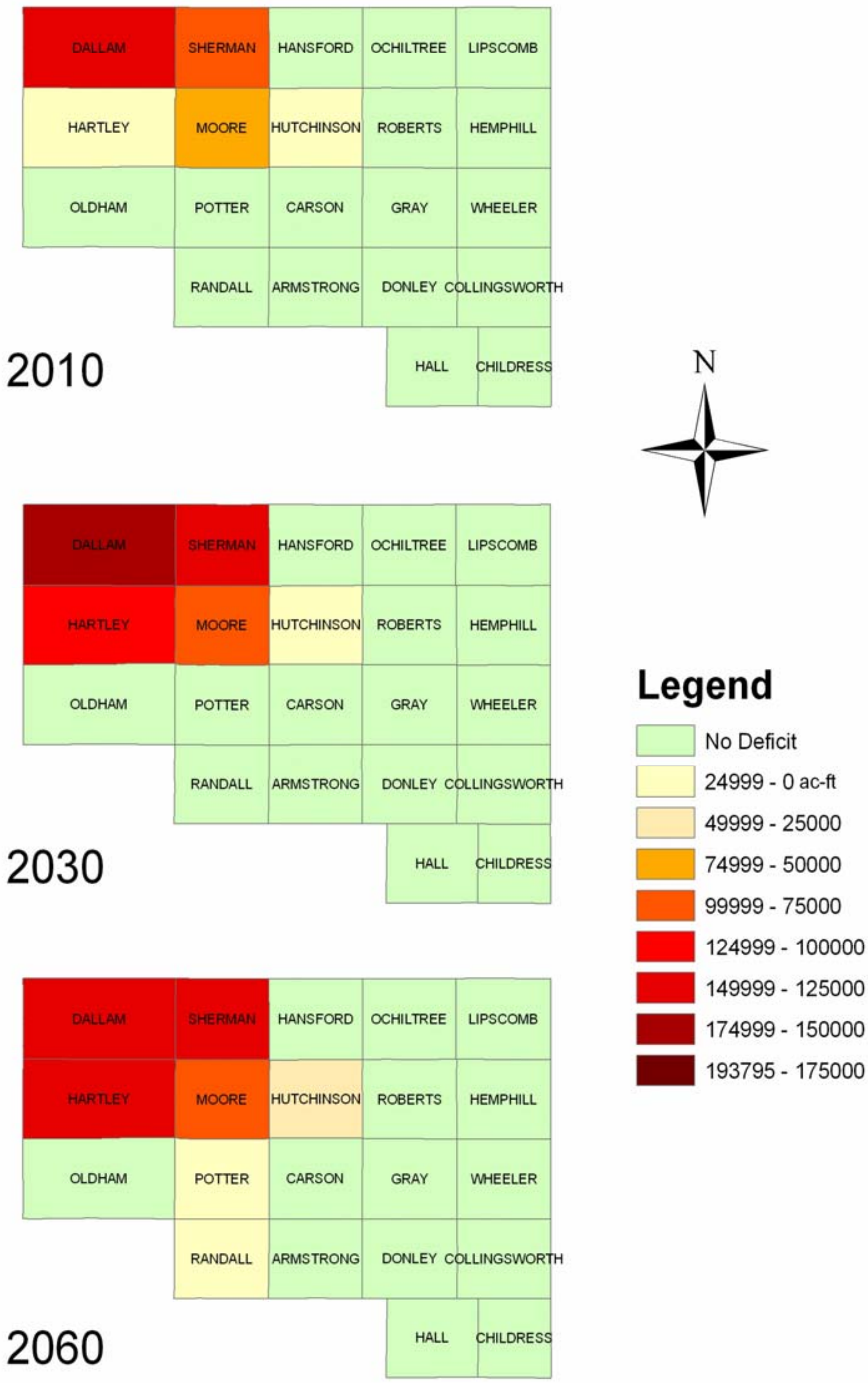


Figure 3-7: Shortages in Region A for Planning Period 2010-2060

Table 3-22: Comparison of Supply and Demand by County

County	Basin	Year 2010		Year 2030		Year 2060	
		Currently Available Supply	Demand	Currently Available Supply	Demand	Currently Available Supply	Demand
Armstrong	Red	17,260	11,276	17,302	10,544	17,759	7,974
Carson	Canadian	42,845	32,088	42,646	29,753	42,605	21,936
	Red	88,110	67,189	74,836	62,406	57,041	45,907
Childress	Red	12,497	12,008	12,545	11,346	12,513	8,755
Collingsworth	Red	32,991	26,249	31,489	24,384	31,486	17,929
Dallam	Canadian	196,097	326,461	139,881	308,970	98,030	229,497
Donley	Red	37,003	22,373	32,703	20,894	23,110	15,744
Gray	Canadian	22,767	13,776	21,934	13,473	21,268	11,461
	Red	33,115	23,544	31,062	22,480	27,277	17,836
Hall	Red	21,741	21,379	20,240	19,864	20,239	14,648
Hansford	Canadian	257,448	141,563	225,759	132,111	188,164	98,670
Hartley	Canadian	273,439	290,085	165,780	271,889	58,655	200,477
Hemphill	Canadian	5,895	2,339	6,028	2,415	6,205	2,417
	Red	7,306	3,567	7,062	3,443	6,805	3,216
Hutchinson	Canadian	83,160	90,623	65,188	89,423	32,557	77,928
Lipscomb	Canadian	35,550	16,093	37,987	15,133	40,923	11,448
Moore	Canadian	128,115	194,568	86,016	184,657	48,706	142,629
Ochiltree	Canadian	141,649	108,494	134,238	101,404	119,739	76,067
Oldham	Canadian	25,106	4,118	24,057	4,214	22,462	3,992
	Red	4,434	3,834	4,347	3,585	4,324	2696
Potter	Canadian	56,668	43,215	53,344	50,295	53,155	61,471
	Red	24,020	20,511	22,224	23,227	18,200	26,880
Randall	Canadian	369	334	349	321	313	300
	Red	86,036	56,119	70,610	59,511	56,642	65,215
Roberts	Canadian	25,256	20,417	22,575	18,931	16,763	13,904
	Red	4,059	2,705	3,595	2,500	2,643	1,814
Sherman	Canadian	211,318	299,079	147,490	283,100	81,013	210,178
Wheeler	Red	19,678	10,741	19,838	10,315	22,254	8,423
TOTAL		**1,893,932**	**1,864,748**	**1,521,125**	**1,780,588**	**1,130,851**	**1,399,412**

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

Insert Table 3-23: Year 2010 Shortages by County and Category
Found in Final Report folder/ Table3-23to3-25_updated.xls

Insert Table 3-24: Year 2030 Shortages by County and Category

Insert Table 3-25: Year 2060 Shortages by County and Category

3.5 Identified Shortages for the PWPA

A shortage occurs when currently available supplies are not sufficient to meet projected demands. In the PWPA there are 30 water user groups (accounting for basin and county designations) with identified shortages during the planning period. Of these, there are 7 cities and several county other water users that are projected to experience a water shortage before 2060. The largest shortages are attributed to high irrigation use and limited groundwater resources in Dallam, Hartley, Moore, and Sherman Counties.

Total shortages for all water user groups are projected to be 310,554 acre feet per year in 2010, increasing to 542,805 acre feet per year in 2030 and 575,637 acre-feet per year by the year 2060. Of this amount, irrigation represents more than 90% in the 2010 projections and 85% of the total shortage of 2060 with nearly 486,365 acre-feet per year. The shortages attributed to the other water use categories total approximately 89,300 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 3-26. 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.

Table 3-26: Decade Shortage Begins by County and Category

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

3.5.1 Irrigation

Irrigation shortages are identified for Dallam, Hartley, Hutchinson, Moore, and Sherman counties. All these counties rely heavily on the Ogallala for irrigation supplies. Shortages are observed in Dallam, Hartley, Hutchinson, Moore, and Sherman Counties starting in 2010. Shortages for Hartley and Hutchinson counties are partially attributed to high agricultural use that is confined to only a portion of the county.

3.5.2 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. This includes Gruver and Perryton. At this time, these cities do not show a shortage during the present planning period. Other cities do not appear to have sufficient water rights through the planning period. A list of the municipalities indicating a shortage is presented in Table 3-27. All but two of these cities rely exclusively on groundwater.

Table 3-27: Municipalities with Identified Shortage

City	Surface Water Supply	Groundwater Supply	Year Shortage Begins
Amarillo	X	X	2030
Cactus[1]	-	X	2010
Canyon	X	X	2050
Dalhart	-	X	2010
Dumas[1]	-	X	2010
Stratford	-	X	2010
Sunray[1]	-	X	2010

[1.] A member city of PDRA, but there is no current infrastructure to transmit water from Palo Duro reservoir.

3.5.3 Manufacturing

There are three counties with manufacturing shortages identified in PWPA. Most manufacturing interests buy water from retail providers or develop their own groundwater supplies. For Moore County, these shortages are the result of limited groundwater supplies and competition for the Ogallala aquifer for other shortages. In Hutchinson County, the shortage is attributed to developed infrastructure and significant increases in the projected demands, while in Potter County the shortage is associated with shortages identified with Amarillo.

3.5.4 Mining

Mining is a relatively small demand in the PWPA, and there are no supply shortages.

3.5.5 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 160 acre-feet per year. All of these shortages are expected to be met by increasing the supply coming from reuse.

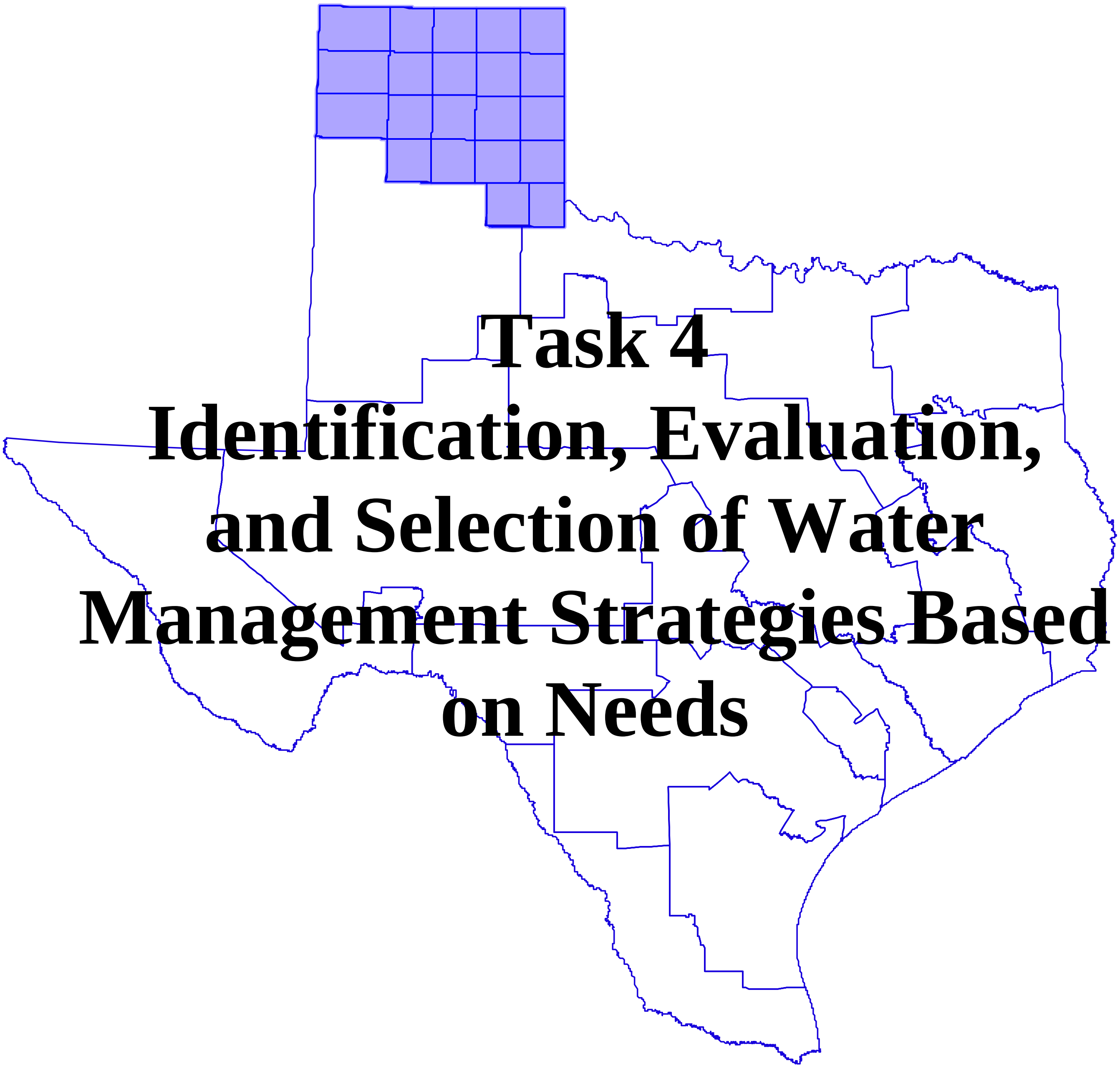
3.5.6 Livestock

Livestock shortages in the PWPA are due in part to the competition for Ogallala water in those counties with high use and partly due to significant increases in demands. As previously discussed, the livestock water supply from the Ogallala in Dallam, Hartley, Moore and Sherman counties is limited because of competition for other shortages. Within the PWPA, priority has been given to livestock uses over irrigated agriculture and shortages for livestock water users is made up by voluntary transfers from irrigated agriculture in the county of shortage.

3.6 Conclusions

On a water user group basis, the total demands exceed the total available supply starting in 2010, in large part being attributed to the 1.25% policy limitation on the supply. 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, such as Palo Duro Reservoir, which could possibly be used for some of the identified shortages. The Ogallala in several counties 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 existing supplies and other options and strategies to meet shortages is explored in more detail in Chapter 4 and the impacts of these strategies on water quality is discussed in Chapter 5.

Task 4
Identification, Evaluation, and Selection of Water Management Strategies Based on Needs



Identified Regional Shortages and Evaluation Procedures

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

- The impacts contained in this report represent a worst-case scenario. In order to produce the identified impacts, all identified water shortages per user group for the entire region would have to go un-met. The report does not allow the consideration of meeting partial shortages per user group.

- The impacts presented are cumulative in nature throughout the 50-year planning horizon. 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 methodology employed does not allow for recognition of the fact that, in the Panhandle Water Planning Area, the predominant groundwater supply is a finite resource.

- 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 no management strategies to meet any identified shortages are employed or implemented.

- The alternative of conversion of irrigated land to dryland was not considered.

- 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 30 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

County Name	Water User Group	Basin	Shortages (AF/Y)					
			2010	2020	2030	2040	2050	2060
Dallam	County-Other	Canadian	-108	-129	-143	-148	-145	-140
Dallam	Dalhart	Canadian	-602	-777	-894	-933	-914	-891
Dallam	Irrigation	Canadian	-124,918	-149,794	-157,887	-144,732	-125,804	-119,181
Dallam	Livestock	Canadian	-4,775	-9,012	-10,178	-10,695	-10,850	-11,281
Hartley	County-Other	Canadian	-89	-124	-142	-124	-94	-98
Hartley	Dalhart	Canadian	-117	-163	-187	-163	-125	-128
Hartley	Irrigation	Canadian	-16,286	-37,118	-104,394	-130,928	-142,803	-141,176
Hartley	Livestock	Canadian	-154	-990	-1,386	-1,182	-668	-420
Hutchinson	Irrigation	Canadian	-6,974	-14,728	-18,705	-24,269	-26,018	-30,431
Hutchinson	Manufacturing	Canadian	-2,300	-4,945	-6,643	-10,269	-12,500	-15,931
Moore	Cactus	Canadian	-113	-225	-262	-284	-304	-338
Moore	County-Other	Canadian	-495	-770	-1,092	-1,344	-1,500	-1,605
Moore	Dumas	Canadian	-866	-1,342	-1,756	-2,032	-2,195	-2,334
Moore	Irrigation	Canadian	-60,475	-77,157	-86,988	-84,649	-78,056	-77,491
Moore	Livestock	Canadian	-1,202	-2,172	-2,698	-3,083	-3,404	-3,822
Moore	Manufacturing	Canadian	-3,028	-4,249	-5,333	-6,129	-6,735	-7,627
Moore	Steam Electric	Canadian	-75	-99	-117	-128	-136	-154
Moore	Sunray	Canadian	-201	-300	-395	-467	-513	-560
Potter	Amarillo	Canadian	0	0	-2,324	-4,739	-6,891	-8,297
Potter	Amarillo	Red	0	0	-1,656	-3,379	-4,911	-5,913
Potter	County-Other	Canadian	0	0	0	-299	-708	-1,043
Potter	County-Other	Red	0	-103	-329	-586	-866	-1,096
Potter	Manufacturing	Red	0	0	0	-44	-1,046	-1,871
Randall	Amarillo	Red	0	0	-3,077	-6,355	-9,350	-11,362
Randall	Canyon	Red	0	0	0	0	-349	-653
Randall	County-Other	Red	0	-5	-597	-1,273	-2,009	-2,619
Sherman	County-Other	Canadian	-64	-94	-116	-131	-144	-160
Sherman	Irrigation	Canadian	-84,506	-112,303	-127,348	-124,225	-116,123	-118,086
Sherman	Livestock	Canadian	-3,019	-6,453	-7,816	-8,691	-9,415	-10,459
Sherman	Stratford	Canadian	-187	-277	-342	-387	-424	-470
Total Shortage			**-310,554**	**-423,329**	**-542,805**	**-571,668**	**-565,000**	**-575,637**

4.2 Evaluation Procedures

The consideration and selection of water management strategies for water user groups with needs followed TWDB Exhibit B guidelines and were conducted in open meetings within the Panhandle Planning Area. The potentially feasible strategies considered in Table 11 of the previous round of planning were considered as a starting point. Additionally, new strategies were considered for application for meeting a shortage. A detailed study was conducted on the cost-benefit of water management strategies for meeting agricultural water use shortages. This study indicated that potential evapotranspiration (PET) for scheduling irrigation, irrigation equipment efficiency improvements, implementation of conservation tillage methods and precipitation enhancement were the most effective and therefore, selected strategies. 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 evaluation of the North Plains Evapotranspiration Network (NPET) to schedule irrigation; improved irrigation equipment and scheduling; conservation tillage practices; and precipitation enhancement.

Strategies for municipal users with shortages are described in Section 4.4. Strategies for industrial users with shortages, i.e. manufacturing, steam electric and mining, are presented in Sections 4.5, 4.6 and 4.7, respectively. Irrigation strategies are presented in Section 4.8 and livestock in Section 4.9. 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 4.10.

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 Exhibit B guidelines for cost considerations and identify capital and annual costs by decade. Project capital costs are based on 2002 price levels and include construction costs, engineering, land acquisition, mitigation, right-of-way, contingencies and other project costs. 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 evaluation 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) 2010	2020	2030	2040	2050	2060	Cost ($/Ac-Ft)	Reliability	Impacts of Strategy on: Environmental Factors	Agricultural Resources/ Rural Areas	Other Natural Resources	Possible Third Party	Key Water Quality Parameters	Political Feasibility	Comments
Name(s)											Low/Medium/High							
COUNTY-OTHER	Dallam	Canadian	Conservation	0	6	10	10	10	10	$490	Medium	N/A	N/A	N/A	----	N/A		
			Overdraft Ogallala	150	150	150	150	150	150	$670	Medium	Low	Low	Low	----	Low	High	
DALHART	Dallam	Canadian	Conservation	0	43	74	75	74	70	$490	Medium	N/A	N/A	N/A	----	N/A		
			Overdraft Ogallala	900	900	900	900	900	900	$303	Medium	Low	Low	Low	----	Low	High	
IRRIGATION	Dallam	Canadian	Conservation	21,104	27,177	33,249	39,322	45,395	49,895	Variable	Medium	Low	Low	Low	----	N/A		
LIVESTOCK	Dallam	Canadian	Voluntary Transfer from Other Users	4,800	9,100	10,200	10,800	10,900	11,300	$44	Medium	N/A	N/A	N/A	----	N/A		Varies depending on county participants.
COUNTY-OTHER	Hartley	Canadian	Conservation	0	16	28	28	27	26	$490	Medium	N/A	N/A	N/A	----	N/A		
			Overdraft Ogallala	125	125	125	125	125	125	$805	Medium	Low	Low	Low	----	Low	High	
DALHART	Hartley	Canadian	Conservation	0	21	36	36	36	34	$490	Medium	N/A	N/A	N/A	----	N/A		
			Overdraft Ogallala	180	180	180	180	180	180	$529	Medium	Low	Low	Low	----	Low	High	
IRRIGATION	Hartley	Canadian	Conservation	18,540	23,909	29,278	34,646	40,015	44,034	Variable	Medium	Low	Low	Low	----	Low		
LIVESTOCK	Hartley	Canadian	Voluntary Transfer from Other Users	200	1,000	1,400	1,200	700	500	$57	Medium	N/A	N/A	N/A	----	N/A		Varies depending on county participants.
MANUFACTURING	Hutchinson	Canadian	Conservation	0	500	1,000	1,000	1,000	1,000	$490	High	N/A	N/A	N/A	----	N/A		
			Additional well in Ogallala	2,500	5,000	10,600	10,600	14,200	14,200	$200	Medium	Low	Low	Low	----	Low	High	
			Direct Reuse	1,000	1,000	1,000	1,000	1,000	1,000	$276	High	Low	Low	Low	----	Low	High	
IRRIGATION	Hutchinson	Canadian	Conservation	4,705	6,018	7,331	8,645	9,958	10,888	Variable	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		
			Overdrraft Ogallala	250	250	250	350	350	350	$238	Medium	Low	Low	Low	----	Low	High	
COUNTY-OTHER	Moore	Canadian	Conservation	0	29	63	75	83	87	$490	Medium	N/A	N/A	N/A	----	N/A		
			Overdrraft Ogallala	800	800	1,300	1,300	1,600	1,600	$352	Medium	Low	Low	Low	----	Low	High	

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:					Political Feasibility	Comments
				2010	2020	2030	2040	2050	2060			Environmental Factors	Agricultural Resources/ Rural Areas	Other Natural Resources	Possible Third Party	Key Water Quality Parameters		
Name(s)											Low/Medium/High							
DUMAS	Moore	Canadian	Conservation	0	89	158	166	171	174	$490	Medium	N/A	N/A	N/A	----	N/A		
			Overdrraft Ogallala	1,092	1,486	1,756	2,032	2,195	2,334	$342	Medium	Low	Low	Low	----	Low	High	
IRRIGATION	Moore	Canadian	Conservation	12,914	16,480	20,045	23,610	27,176	29,764	Variable	Medium	Low	Low	Low	----	Low		
LIVESTOCK	Moore	Canadian	Voluntary Transfer from Other Users	1,300	2,200	2,800	3,200	3,500	3,900	$44	Medium	N/A	N/A	N/A	----	N/A		Varies depending on county participants.
MANUFACTURING	Moore	Canadian	Conservation	236	254	446	469	489	522	$490	High	N/A	N/A	N/A	----	N/A		
			Overdraft Ogallala	3,039	3,461	3,833	6,106	6,318	6,633	$133	Medium	Low	Low	Low	----	Low	High	
			Direct Reuse	1,300	1,400	1,500	1,600	1,700	1,700	$213	High	Low	Low	Low	----	Low	High	
STEAM ELECTRIC POWER	Moore	Canadian	Overdraft Ogallala	200	200	200	200	200	200	$503	Medium	Low	Low	Low	----	Low	High	
SUNRAY	Moore	Canadian	Conservation	0	18	34	36	38	39	$490	Medium	N/A	N/A	N/A	----	N/A		
			Overdrraft Ogallala	550	550	550	550	550	550	$308	Medium	Low	Low	Low	----	Low	High	
AMARILLO	Potter	Canadian	Conservation	0	455	808	865	925	975	$490	Medium	N/A	N/A	N/A	----	N/A		
			Potter Co. Well Field	0	0	2,600	2,500	2,300	2,000	$429	Medium to High	Low	Low	Low	----	Low		
			Roberts Co. Well Field	0	0	0	3,517	3,100	6,870	$690	Medium to High	Low	Low	Low	----	Medium		
			Additional CRMWA supply	517	507	1,366	2,215	2,912	2,900	$0	Medium to High	Low	Low	Low	----	Medium		
AMARILLO	Potter	Red	Conservation	0	325	575	615	660	700	$490	Medium	N/A	N/A	N/A	----	N/A		
			Potter Co. Well Field			1,900	1,800	1,700	1,500	$429	Medium to High	Low	Low	Low	----	Low	High	
			Roberts Co. Well Field	0	0	0	2,501	2,100	3,940	$690	Medium to High	Low	Low	Low	----	Medium		
			Additional CRMWA supply	368	362	973	1,578	2,071	2,061	$0	Medium to High	Low	Low	Low	----	Medium		
COUNTY-OTHER	Potter	Canadian	Conservation	0	41	85	103	124	140	$490	Medium	N/A	N/A	N/A	----	N/A		
			Drill Additional Well	0	0	0	1,000	1,000	1,000	$281	Medium to High	Low	Low	Low	----	Low	High	

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:					Political Feasibility	Comments
				2010	2020	2030	2040	2050	2060			Environmental Factors	Agricultural Resources/ Rural Areas	Other Natural Resources	Possible Third Party	Key Water Quality Parameters		
Name(s)											Low/Medium/High							
COUNTY-OTHER	Potter	Red	Conservation	0	28	58	71	85	96	$490	Medium	N/A	N/A	N/A	----	N/A		
			Drill Additional Well	0	600	600	600	1,100	1,100	$256	Medium	Low	Low	Low	----	Low	High	
MANUFACTURING	Potter	Red	Conservation	100	120	150	150	150	150	$490	High	Low	Low	Low	----	Medium		
			Additional Amarillo water	0	0	0	500	1,500	2,210	$0	Medium to High	Low	Low	Low	----	Medium		
AMARILLO	Randall	Red	Conservation	0	595	1,070	1,159	1,256	1,337	$490	Medium	N/A	N/A	N/A	----	N/A		
			Potter Co. Well Field			3,500	3,200	3,000	2,500	$429	Medium to High	Low	Low	Low	----	Low		
			Roberts Co. Well Field	0	0	0	4,612	4,190	8,790	$690	Medium to High	Low	Low	Low	----	Medium		
			Additional CRMWA supply	665	664	1,809	2,970	3,951	3,971	$0	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		
			Additional Amarillo supply	0	0	0	60	270	540	$0	Medium to High	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		
			Drill Additional Well	0	0	600	1,200	2,400	2,400	$350	Medium	Low	Low	Low	----	Medium		
			Additional CRMWA supply	0	0	0	1	4	6	$0	Medium to High	Low	Low	Low	----	Medium		
MANUFACTURING	Randall	Red	Additional Amarillo supply	0	0	0	20	50	70	$0	Medium to High	Low	Low	Low	----	Medium		
COUNTY-OTHER	Sherman	Canadian	Conservation	0	7	12	13	13	13	$490	Medium	N/A	N/A	N/A	----	N/A		
			Overdrraft Ogallala	180	180	180	180	180	180	$559	Medium	Low	Low	Low	----	Low	High	
IRRIGATION	Sherman	Canadian	Conservation	19,260	24,883	30,506	36,129	41,752	45,904	Variable	Medium	Low	Low	Low	----	Low		
LIVESTOCK	Sherman	Canadian	Voluntary Transfer from Other Users	3,100	6,500	7,900	8,700	9,500	10,600	$44	Medium	N/A	N/A	N/A	----	N/A		Varies depending on county participants.
STRATFORD	Sherman	Canadian	Conservation	0	20	35	36	37	38	$490	Medium	N/A	N/A	N/A	----	N/A		
			Overdrraft Ogallala	450	450	450	450	450	450	$281	Medium	Low	Low	Low	----	Low	High	

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	$275-$400
Manufacturing	500	$280
Livestock	500	$150
Mining	500	$150

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 was assumed to be $80,000 or $100,000 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 $500 per acre. Summaries of the costs developed for each strategy are included in Appendix E.

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).

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. In lieu of specific conservation strategies for manufacturing, costs for improved efficiencies will be assumed at $1.50 per 1,000 gallons of supply ($490 per acre-foot). 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 and precipitation enhancement. 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 seven cities and six county-other municipal water users that indicate a shortage during the planning period. Based on a water rights survey conducted as part of this regional water planning effort, 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.

For the seven cities identified with shortages, additional water management 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 Region A. Additional information regarding Amarillo's recommended strategies is found in Section 4.10.2. 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, additional water from CRMWA as CRMWA increases its available supply, and development of the Roberts County well field.

4.4.2 Cactus

<u>Location</u>

County: Moore
River Basin: Canadian

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. The recommended water management strategies for the City of Cactus is water conservation, overdrafting the Ogallala and purchasing additional groundwater rights. Discussion of these strategies is found in Section 4.10.4.

4.4.3 Canyon

<u>Location</u>

County: Randall
River Basin: Red

Canyon currently buys water from the City of Amarillo, as well as using groundwater from its own wells in the Ogallala aquifer. Canyon is shown to have shortages in 2050 and 2060, which are partially due to the limited supplies from Amarillo. As Amarillo develops their strategies, the supply to Canyon will increase to meet these needs. The current contract amount with Amarillo is sufficient to meet the increased needs.

Recommended Strategies

- Implement water conservation
- Obtain additional water from Amarillo as Amarillo brings in additional supplies

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 obtaining supplies from Amarillo as Amarillo develops its recommended strategies.

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 supply from Amarillo will be needed in 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. The reliability of the additional supply from Amarillo is high. The current infrastructure should be sufficient to transport the additional Amarillo water. Therefore, no capital costs are associated with this strategy.

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.

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

4.4.4 Dalhart

Location

County: Dallam and Hartley
River Basin: Canadian

The Ogallala aquifer is the current water supply source for Dalhart. Shortages are imminent due to competing demands from other water users for the Ogallala supply. Dalhart is expected to have water shortages ranging from 719 to 1,019 acre-feet per year over the planning period (2010-2060).

Recommended Strategies

- Implement water conservation
- Overdraft Ogallala aquifer in Dallam and Hartley Counties with new wells

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 overdrafting the Ogallala aquifer in Dallam and Hartley Counties. Some overdrafting may be accomplished through the City's existing wells. For planning purposes, it is assumed that three new wells will be needed over the planning period.

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. Overdrafting of groundwater will be needed by 2010.

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 $3,029,500.

Environmental Issues

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

In late November 2005, the construction of a cheese plant in Dalhart was announced. Financial incentives provided by the Texas Governor's office in cooperation with local entities have resulted in a high probability that this facility will be constructed. Impacts from these changed conditions in projections of demands and associated agribusiness impacts will need to be evaluated in the future.

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.

Impact on Navigation

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

4.4.5 Dumas

Location

County: Moore
River Basin: Canadian

The City of Dumas is located in Moore County and is the largest member city of the Palo Duro River Authority (PDRA). Dumas is also considered as a wholesale water provider in Region A. 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 the planning period (2010-2060). Dumas has approximately 27,800 acre-feet of undeveloped groundwater rights that will be used to meet its shortage. The discussion of the recommended strategies for Dumas is under wholesale providers in Section 4.10.5.

4.4.6 Stratford

Location

County: Sherman
River Basin: Canadian

Stratford is located in Sherman County approximately eighty miles north of Amarillo. Stratford's current water supply comes entirely from the Ogallala aquifer, similar to most of the water users in the planning area. Shortages are imminent due to competing demands from other water users for Ogallala supply, especially irrigation. Stratford is projected to have shortages ranging from 187 to 470 acre-feet per year, and will need to drill additional groundwater wells in the Ogallala aquifer to meet its water needs for the duration of the planning period (2010-2060).

Recommended Strategies

- Implement water conservation strategies
- Overdraft Ogallala aquifer in Sherman County with new wells

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 overdrafting the Ogallala aquifer in Sherman County. Some overdrafting may be accomplished through the City's existing wells. For planning purposes, it is assumed that one new well will be needed over the planning period.

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 2010.

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 $984,300.

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 impact water rights, contracts, or option agreements.

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

4.4.7 Sunray

Location

County: Moore
River Basin: Canadian

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. It is assumed that Sunray will continue to supply a portion of Moore County-Other. In addition, Sunray is expected to supply 250 million gallons per year to a local ethanol plant by 2008. By the end of the planning period, it is expected that Sunray will provide just over 200 acre-feet for rural municipal shortages. The projected shortages for the City of Sunray range from 200 to almost 600 acre-feet/year over the planning period. To meet these shortages plus additional demands from current and future customers Sunray will need to additionally supply approximately 1,000 acre-feet of water per year. By the end of the planning period, the City will need two new wells to meet demands. The recommended strategies for Sunray include water conservation and overdrafting the Ogallala aquifer with new wells.

Recommended Strategies

- Implement water conservation strategies
- Drill additional wells in the Ogallala aquifer in Moore County

Conservation Strategy Name

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

Strategy Descriptions

The recommended strategies include implementing conservation measures and overdrafting the Ogallala aquifer in Moore County. Some overdrafting may be accomplished through the City's existing wells. For planning purposes, it is assumed that one new well will be needed for the City's needs and another new well for additional customer demands. [Note: the costs and supplies for Moore County manufacturing and County-Other are discussed in the respective subsections.]

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 2010.

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 $1,348,200.

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 $5,136,400 associated with their portion of the project.

4.4.8 County-Other, Dallam County

Location

County: Dallam
River Basin: Canadian

Dallam County-Other currently gets its water from the Ogallala aquifer in Dallam County through local wells or sales from municipal providers. Dallam County-Other is expected to have water shortages of less than 150 acre-feet per year throughout the planning period (2010-2060). The recommended strategies include conservation and overdraft groundwater.

Recommended Strategies

- Implement water conservation strategies
- Overdraft Ogallala aquifer in Dallam County

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 overdrafting the Ogallala aquifer in Dallam County. Some overdrafting may be accomplished through existing wells. For planning purposes, it is assumed that one new well will be needed over the planning period.

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 2010.

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 $870,100.

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
No significant impact on other water resources is expected from the recommended strategies.

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

Other Relevant Factors
There are no other identified relevant factors.

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.

4.4.9 County-Other, Hartley County

Location

County: Hartley
River Basin: Canadian

Hartley County-Other currently gets water supply from the Ogallala aquifer in Hartley County. Hartley County-Other is expected to need additional water supplies of less than 150 acre-feet per year over the planning period (2010-2060). The recommended strategies for Hartley County-Other include water conservation and the overdraft of the Ogallala aquifer in Hartley County.

Recommended Strategies

- Implement water conservation strategies
- Overdraft Ogallala aquifer in Hartley County and drill additional wells

Recommended Water Conservation Strategies

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

Strategy Descriptions

Hartley County-Other will apply water conservation measures and overdraft the Ogallala aquifer in the county to meet the future water demands. Some overdrafting may be accomplished through existing wells. For planning purposes, it is assumed that one new well will be needed over the planning period.

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 well will be needed by 2010.

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 $870,100.

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

No significant impact on other water resources is expected for the recommended strategies.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

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.

4.4.10 County-Other, Moore County

Location

County: Moore
River Basin: Canadian

Moore County-Other shortages range from nearly 500 acre-feet per year in 2010 up to roughly 1,600 acre-feet per year in 2060. Moore County has considerable demands from other water users. Approximately half of the supply for Moore County-Other demands comes from local wells in the Ogallala aquifer, with the remaining half supplied by cities within the county. It is assumed that the cities of Fritch, Dumas, Cactus and Sunray will continue to supply water to Moore County-Other in the future. The recommended strategies for Moore County-Other include water conservation and additional water from the Ogallala aquifer by overdrafting the aquifer through local wells and through purchases from municipal providers.

Recommended Strategies

- Implement water conservation strategies
- Overdraft the Ogallala aquifer in Moore County with additional wells

Recommended Water Conservation Strategies

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

Strategy Descriptions

Moore County-Other will apply water conservation measures and overdraft the Ogallala aquifer in the county to meet the future water demands Some overdrafting may be accomplished through existing wells. For planning purposes, it is assumed that four new wells will be needed over the planning period.

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 2010.

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 $3,911,100.

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
No significant impact on other water resources is expected for the recommended strategies.

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

Other Relevant Factors
There are no other identified relevant factors.

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.

4.4.11 County-Other, Potter County

Location

County: Potter
River Basin: Canadian and Red

Potter County-Other shortages are approximately 100 acre-feet per year in 2010, increasing to 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 four 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 2010.

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 $4,412,200.

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 Panhandle Groundwater Conservation District will be required to ensure compliance with the District's 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.

4.4.12 County-Other, Randall County

Location

County: Randall
River Basin: Red

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. To meet the projected growth in demands, Randall County-Other will need additional supplies from conservation and additional wells in the Ogallala aquifer.

Recommended Strategies

- Implement water conservation strategies
- Drill additional wells in Ogallala aquifer in Randall County, Red Basin

Recommended Water Conservation Strategies

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

Strategy Descriptions
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 five new wells will be needed to provide 2,400 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 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 $4,849,100.

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

4.4.13 County-Other, Sherman County

Location

County: Sherman
River Basin: Canadian

The current supply for Sherman County-Other is the Ogallala aquifer in Sherman County. Sherman County-Other is expected to have water shortages varying from 64 to 160 acre-feet per year throughout the planning period (2010-2060). As in other counties in the planning area that are irrigation and livestock intensive, there is a competition for Ogallala supplies in Sherman

County. The recommended strategies for Sherman County-Other include implementing water conservation measures and overdrafting the Ogallala aquifer.

Recommended Strategies

- Implement water conservation strategies
- Overdraft Ogallala aquifer in Sherman County with additional wells

Recommended Water Conservation Strategies

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

Strategy Descriptions

Sherman County-Other will apply water conservation measures and overdraft the Ogallala aquifer in the county to meet the future water demands. Some overdrafting may be accomplished through existing wells. For planning purposes, it is assumed that one new well will be needed over the planning period.

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 well will be needed by 2010.

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 $2,206,100.

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

No significant impact on other water resources is expected for the recommended strategies.

Impact on Agriculture and Natural Resources

No significant impact on agricultural or natural resources is expected for the recommended strategies.

Other Relevant Factors

There are no other identified relevant factors.

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.

4.5 Manufacturing Shortages

Manufacturing shortages were identified for Hutchinson, Moore, and Potter counties. The shortages identified for Moore and Potter counties are due to competition for Ogallala water with other users in each county. To provide for manufacturing demands in these counties, additional water rights will need to be purchased or alternative supplies will need to be developed.

4.5.1 Hutchinson County Manufacturing

Location
County: Hutchinson
River Basin: Canadian

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 2,300 to 16,000 acre-feet per year over the planning period (2010-2060) due to increasing demands and limited developed supplies. The recommended strategies for additional supply include water conservation, additional Ogallala supply, and additional direct reuse from Borger.

Recommended Strategies
- Implement water conservation strategies
- Drill additional wells in the Ogallala aquifer in Hutchinson County
- Purchase additional direct reuse from the City of Borger

Recommended Water Conservation Strategies
- System water audit
- Water waste reduction

Strategy Descriptions
Manufacturing water needs in Hutchinson County are expected to be met by implementing water conservation strategies, drilling additional wells in the Ogallala aquifer, and purchasing additional direct reuse from the City of Borger.

Time Intended to Complete
The water conservation strategies should be implemented by 2010 with results of water savings noticed by 2020. The additional groundwater supply and the additional reuse will be needed by 2010.

Quantity, Reliability and Cost
There is a sufficient quantity of groundwater and reuse available for manufacturing use in Hutchinson County. The reliability of water conservation is high because each individual manufacturing facility is expected to implement strategies appropriate to their processes. There is no capital cost associated with the recommended water conservation strategies. The reliability of the groundwater supply is moderate because it depends on other Ogallala aquifer users. The reliability of additional direct reuse is high. The total capital cost for 24 new wells and additional reuse is $21,170,300.

Environmental Issues
No significant environmental impact is expected from 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
No significant impact on other water resources is expected for the recommended strategies.

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

Other Relevant Factors
There are no other identified relevant factors.

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.

4.5.2 Moore County Manufacturing
Location

County: Moore
River Basin: Canadian

The manufacturing shortages in Moore County range from 3,000 to 7,600 acre-feet per year over the planning period. The City of Cactus currently provides approximately 2,500 acre-feet of water for industrial use. The remainder of the demands is met with local groundwater wells. It is assumed that the city of Cactus will continue to provide industrial water at the same percentage it is currently providing. It is also assumed that a portion of Moore County manufacturing shortages are met with reuse from Dumas. The recommended strategies for meeting manufacturing shortages in Moore County include water conservation, overdrafting the Ogallala aquifer, and purchasing direct reuse water from Dumas.

Recommended Strategies

- Implement water conservation strategies
- Overdraft the Ogallala aquifer in Moore County with additional wells
- Purchase direct reuse from Dumas

Recommended Water Conservation Strategies

- System water audit
- Water waste reduction

Strategy Descriptions

Manufacturing water needs in Moore County are expected to be met by implementing water conservation strategies, overdrafting the Ogallala aquifer with new wells, and purchasing direct reuse from the City of Dumas. For this plan, it is assumed that 10 new wells will be drilled for those users with shortages.

Time Intended to Complete

The water conservation strategies should be implemented prior to 2010 with results of water savings noticed by 2010. The additional groundwater supply and the additional reuse will be needed by 2010.

Quantity, Reliability and Cost

There should be sufficient quantity of groundwater and reuse available for manufacturing use in Moore County. The reliability of water conservation is high because each individual manufacturing facility is expected to implement strategies appropriate to their processes. There is no capital cost associated with the recommended water conservation strategies. The reliability of the groundwater supply is moderate because it depends on other Ogallala aquifer users. The reliability of direct reuse is high. The total capital cost for the additional wells and reuse is $8,002,400.

Environmental Issues

No significant environmental impact is expected from 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. Water conservation is not expected to have impacts on water resources and other strategies. Direct reuse may decrease the amount of flow discharged into the watershed, but the amount of reuse recommended should not impact other water resources or strategies.

Impact on Agriculture and Natural Resources
The recommended strategies are not expected to have any significant impacts on agriculture or natural resources.

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

4.5.3 Potter County Manufacturing (Red Basin)

Location

County: Potter
River Basin: Canadian and Red

The current supplies for manufacturing in Potter County (Red Basin) include self supplied Ogallala water and water purchased from Amarillo. While Potter County is located partially in the Canadian Basin and Red Basin, only the portion in the Red Basin is expected to have shortages in this plan. Much of the water for manufacturing is currently supplied by the City of Amarillo via contracts to Tyson and ASARCO, Inc. Approximately 2,000 acre-feet per year of additional water supplies are expected to be needed by 2060. The recommended strategies include water conservation and additional water from Amarillo as Amarillo develops additional supplies.

Strategy Name
- Implement water conservation strategies
- Purchase additional water from Amarillo as Amarillo expands their supplies

Conservation Strategy Name
- System water audit
- Water waste reduction

Strategy Descriptions

Manufacturing water needs in Potter County (Red Basin) are expected to be met by implementing water conservation strategies and purchasing additional water from the City of Amarillo after Amarillo develops its Roberts County well field.

Time Intended to Complete

The water conservation strategies should be implemented prior to 2010 with results of water savings noticed by 2010. The additional supply from Amarillo is needed by 2040.

Quantity, Reliability and Cost

There should be sufficient quantity of water for manufacturing use in Potter County. The reliability of water conservation is high because each individual manufacturing facility is expected to implement strategies appropriate to their processes. There is no capital cost associated with the recommended water conservation strategies. The reliability of groundwater supply from Amarillo is moderate to high because it depends on other Ogallala aquifer users. There are no capital costs for the additional supply from Amarillo because the infrastructure is already in place.

Environmental Issues

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

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

The recommended strategies are not expected to have any significant impacts on agriculture or natural resources.

Other Relevant Factors

Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

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.

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 overdraft the Ogallala aquifer in Moore County with additional wells.

4.6.1 Moore County Steam Electric Power

Location

County: Moore
River Basin: Canadian

Recommended Strategy

- Overdraft the Ogallala aquifer with new wells

Recommended Water Conservation Strategies

The projected demands for steam electric power included water conservation when the demands were developed. Thus, no additional water conservation is recommended.

Strategy Description

The steam electric power shortages in Moore County will be met by overdrafting the Ogallala aquifer in Moore County with additional wells.

Time Intended to Complete

The recommended water management strategy should be implemented by 2010to meet the expected shortage.

Quantity, Reliability and Cost

The quantity of water should be sufficient. Reliability would be moderate, depending on other Ogallala water users. The capital cost for additional wells is $870,100.

Environmental Issues

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.

Impact on Water Resources and Other Management Strategies

There should be no impacts to water resources or other management strategies.

Impact on Agriculture and Natural Resources

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.

Other Relevant Factors
Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

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 have any impacts on water rights, contracts, or option agreements.

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

4.7 Irrigation Shortages

There are substantial irrigation shortages identified in the PWPA region due to limitations of the available supply of the Ogallala aquifer. By 2060, these shortages are projected to be 486,365 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, Hartley, Hutchinson, Moore, and Sherman Counties, which are the only counties in this Region showing water demands that cannot be met with existing supplies (see Table 4-4). It needs to be emphasized that nearly all of the water used for irrigated agriculture within this Region currently comes from groundwater. When a projected shortage indicates a negative amount, this is a demand which at this time cannot be met with currently available supplies. Hopefully, the use of irrigation management strategies and local groundwater rules will prolong the life of irrigated agriculture within this Region. The negative amounts of projected shortage 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 to this Region. The numerical groundwater model simulations indicate that there may be other counties, in addition to the five 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 five counties with identified shortages, the PWPA is encouraging irrigators of the Region to adopt the following water management strategies in all of the Region’s irrigated counties.

The agricultural water conservation strategies suggested include the use of the North Plains Evapotranspiration Network (NPET) to schedule irrigation, irrigation equipment efficiency improvements, implementation of conservation tillage methods and precipitation enhancement. A detailed evaluation of these strategies was performed by the Texas Agricultural Experiment Station and their report is included as Appendix Q.

Table 4-4: Irrigation Shortages Identified in the PWPA

County	Projected Need (acre-feet per year)					
	2010	2020	2030	2040	2050	2060
Dallam	-124,918	-149,794	-157,887	-144,732	-125,804	-119,181
Hartley	-16,286	-37,118	-104,394	-130,928	-142,803	-141,176
Hutchinson	-6,974	-14,728	-18,705	-24,269	-26,018	-30,431
Moore	-60,475	-77,157	-86,988	-84,649	-78,056	-77,491
Sherman	-84,506	-112,303	-127,348	-124,225	-116,123	-118,086

In the following section, an overview analysis of the agricultural water conservation strategies considered is presented. The analysis results are presented on a regional basis and include projected water saving, implementation cost, and potential impact on gross receipts for each strategy. Subsequent sections estimate the water savings on each of these strategies 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. A description of these strategies and the applicability to the identified irrigation shortages in the PWPA is presented in Section 4.8.

Other conservation strategies that were considered and are discussed in this section include changes in crop variety, changes in crop type and converting irrigated acreage to dryland farming. Each of these strategies were found to be less cost effective than the suggested strategies, but may be utilized by individual producers to meet water shortages. 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, the recommended irrigation strategies include the use of the NPET to schedule irrigation, irrigation equipment efficiency improvements, implementation of conservation tillage methods, and precipitation enhancement. A synopsis of the potential water savings associated with all seven strategies is presented in Section 4.8 for each county with an irrigation need.

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 10 meteorological stations in Region A and used to acquire localized crop weather data focusing on corn, sorghum, cotton, wheat, and soybeans (Comis, 2000). 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 to 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 (Marek et al., 1995).

Change in Crop Variety

Shifting from long season to short season corn and sorghum varieties is another water savings strategy. Water savings are generated by reducing the length of the growing season. However, lower yields are associated with short season varieties (Trimmer, 1994). Previous analysis by the Amarillo water team indicated that other major crops resulted in no water savings.

Irrigation Equipment Efficiency Improvements

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 drip 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 rest is lost to runoff, evaporation or deep percolation and the differences were used as a 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 could possibly 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 Region A 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 Region A 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.

In the Senate Bill 1 effort, implementation levels and schedules were developed for all strategies by the Agricultural Demands Subcommittee of the planning group. During the SB2 round of planning, these implementation levels have been modified based on actual results. Each of the strategies is presented in Table 4-6 with the revised water savings and implementation schedule per SB2.

Table 4-5: Possible Water Management Strategies for Reducing Irrigation Demands

Water Management Strategy	Assumed Annual Regional Water Savings (acre-feet/ac/yr)	Assumed Baseline Use Year 2010	Goal for Adoption 2020	Goal for Adoption 2030	Goal for Adoption 2040	Goal for Adoption 2050	Goal for Adoption 2060
Use of NPPET	0.083	20%	27.5%	35%	42.5%	50%	50%
Change in Crop Variety	0.341-corn 0.054-sorghum	40%	70%	70%	70%	70%	70%
Irrigation Equipment Changes	0.525	75%	95%	95%	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	0.08	0%	100%	100%	100%	100%	100%

The focus of this study was to revisit the strategies in a more detailed analysis. An effort was made to fully describe and document each strategy, refine the potential water savings, identify the cost of implementation and the potential impacts to the region from implementing the strategy.

Based on the research conducted, some of the assumptions on potential water savings and strategy implementation schedules were altered before the proposed strategy was evaluated. A summary of the changes that were made to the various strategies is given in Table 4-6.

Table 4-6: Changes to Senate Bill 1 Water Management Strategies.

Strategy	Change
Use of NPET	Water savings were reduced to 1 in/ac. Implementation was reduced to 10% in 2000 and increased 7½% per decade until it was assumed to level off at 50% after 2050.
Change in Crop Variety	The water savings from converting from long season corn and sorghum varieties to short season was specifically identified at 4.1 in/ac and .65 in/ac, respectively. The proposed implementation schedule for this strategy remained unchanged.
Irrigation Equipment Changes	In SB1, it was estimated in 2000 that 55% of the irrigation systems were efficient (LESA, LEPA and SDI). This was revised to 78.5%. The implementation schedule was altered to reflect the revised baseline. LEPA and SDI were projected to increase 2% and ½% every decade until the 95% level of efficient systems is reached. The calculated saving from this strategy was 6.3 inches per acre.
Change in Crop Type	Converting irrigated corn acreage to irrigated cotton, sorghum and soybean acreage equally as proposed in SB1 was again used and resulted in an estimated 8.3 inches per acre compared to the 5 inches per acre estimate in SB1. The proposed conversion of irrigated soybean and sorghum to irrigated wheat (SB1) was eliminated based on a lack of projected water savings. The proposed strategy implementation schedule remained the same.
Conservation Tillage Methods	Water savings from implementing conservation tillage was reduced from 2 to 1.75 inches per acre. The implementation schedule remained unchanged.
Precipitation Enhancement	Water savings estimates and implementation schedule remained unchanged from SB1.
Irrigated to Dryland Farming	The strategy of converting a portion of the marginally irrigated crops (wheat, sorghum and cotton) to dryland as proposed in SB1 remained unchanged. Estimated water saving per acre was 10 - 10.7 inches compared to 12 - 14 inches used in SB1.

LESA – low elevation spray application
LEPA – low elevation precision application
SDI – subsurface drip application

4.8.1 Methodology

Water savings, implementation cost and change in gross crop receipts were estimated for each proposed water management strategy identified in the Senate Bill 1 planning effort. All strategies were evaluated over a 60-year planning horizon as identified in the Senate Bill 2 planning effort using Farm Service Agency (FSA) irrigated acreage for the region as the base. 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 bourn by producers and/or the government. The change in gross crop receipts generated under the alternative strategies was estimated using five-year averages for yields and prices in the region. All costs were evaluated in current dollars.

4.8.2 Results

Cumulative water savings, implementation cost and direct regional impacts as expressed by the change in gross crop receipts for each of the water conservation strategies are presented in Table 4-7. The change in crop type was estimated to generate the largest amount of water savings, 8.7 million ac-ft, which was 8.3% of the total irrigation water pumped over the 60-year planning horizon. Implementing this strategy was expected to cost $46 million resulting in an average cost of $5.25 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 of $2.1 billion in gross crop receipts or $235.85 per ac-ft of water saved over the planning horizon.

Table 4-7: Estimated Water Savings and Costs Associated with Proposed Water Conservation Strategies in Region A

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	2,065,469	1.96	8,100	$3.92	+	+
Change in Crop Variety	6,658,309	6.32	-	-	-1,548,584	-$232.58
Irrigation Equipment Changes	4,124,398	3.91	169,608	$41.12	-	-
Change in Crop Type	8,709,995	8.26	46,000	$5.25	-2,054,000	-$235.85
Conservation Tillage Methods	2,135,882	2.03	1,098	$0.51	-	-
Precipitation Enhancement	4,105,680	3.89	25,800	$6.28	+	+
Irrigated to Dryland Farming	5,157,272	4.89	39,000	$7.54	-406,000	-$78.72

[1] +indicates an anticipated positive impact that was not quantified.

The change to shorter season corn and sorghum varieties yielded the second largest water savings of 6.7 million ac-ft or 6.3% of the total pumped. However, changing crop variety led to a reduction in yields that resulted in a loss in gross cash receipts of $1.5 billion or $232.58 per ac-ft of water saved.

Converting marginally irrigated land to dryland production yielded water savings of 5.2 million ac-ft or 4.9% of the total pumped. The estimated change in land values resulted in an implementation cost of 39 million dollars and a resultant cost of $7.54 per ac-ft of water saved. Loss in gross receipts was estimated to be $406 million or $78.72 per ac-ft of water saved.

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 4.1 million ac-ft (3.9% of total irrigation water pumped). Investment in these more efficient systems and reinvestment as they wore out resulted in an implementation cost of $170 million. This translates into a cost of $41.12 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, thus having a neutral impact on the regional economy.

The precipitation enhancement strategy was projected to save 4.1 million ac-ft under the assumption that increased rainfall would result in an equal reduction in pumping. The estimated implementation cost associated with this strategy was $25.8 million resulting in a cost of $6.28 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. No estimate of these positive externalities is provided.

Increasing the level of conservation tillage practices yielded water savings of 2.1 million ac-ft or 2.0% of total irrigation water pumped. The cost of the increased conservation tillage given the implementation schedule was estimated at $1,098,000 resulting in the lowest implementation cost per acre-foot of water saved ($0.51). Increasing conservation tillage acreage was assumed to have a neutral effect on gross crop receipts.

Increased use of the NPET to improve the efficiency of irrigation scheduling was estimated to save 2.1 million ac-ft or approximately 2.0% of total water pumped. Implementation costs were estimated at 8.1 million dollars resulting in the second lowest cost per ac-ft of water saved, $3.92. It should be noted that the water savings assumed a 1 in/ac 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 network 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.

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 136,884 ac-ft in 2010 (Table 4-8). This annual shortfall will increase to 169,459 ac-ft in 2030 before falling to 131,008 ac-ft by 2060. Changing Crop Type was the most effective water saving strategy when fully implemented in Dallam County reducing annual use by 43,388 ac-ft. The effectiveness of the remaining strategies once fully implemented ranked as follows: Change in Crop Variety (34,434 ac-ft), improvement in irrigation equipment (21,497 ac-ft), Precipitation Enhancement (11,288 ac-ft), Conversion to Dryland (10,415 ac-ft), Irrigation Scheduling (8,260 ac-ft) and Conservation Tillage (8,131 ac-ft).

Implementing all the strategies identified would not completely cover the projected irrigation deficits until 2060. Therefore, an improvement in the implementation level and/or schedule of the current strategies would be required to fully meet the irrigation needs or additional strategies need to enhance water conservation need to be developed.

Table 4-8: Dallam County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year).

		2010	2020	2030	2040	2050	2060
Projected Shortage		-124,918	-149,794	-157,887	-144,732	-125,804	-119,181
Projected Water Savings							
Water Saving Strategies	Change in Crop Type	21,694	43,388	43,388	43,388	43,388	43,388
	Change in Crop Variety	17,217	34,434	34,434	34,434	34,434	34,434
	Conservation Tillage	3,614	4,517	5,420	6,324	7,227	8,131
	Convert to Dry	3,472	6,943	10,415	10,415	10,415	10,415
	Irrigation Equipment	3,583	7,166	10,749	14,332	17,915	21,497
	PET Network	2,065	3,614	5,162	6,711	8,260	8,260
	Precipitation Enhancement	11,288	11,288	11,288	11,288	11,288	11,288
Total Potential Water Savings		62,933	111,350	120,856	126,892	132,927	137,413

4.8.4 Hartley County: Irrigation Shortages and Water Savings from Conservation Strategies

It is projected that Hartley County will have an irrigation shortage of 16,286 ac-ft in 2010 (Table 4-9). This annual shortfall will increase to 141,176 ac-ft in by 2060. Changing Crop Type was the most effective water saving strategy when fully implemented in Hartley County reducing annual use by 35,949 ac-ft. The effectiveness of the remaining strategies once fully implemented ranked as follows: Change in Crop Variety (27,145 ac-ft), Improvement in Irrigation Equipment (19,387 ac-ft), Conversion to Dryland (9,614 ac-ft), Precipitation Enhancement (9,342 ac-ft), Irrigation Scheduling (6,836 ac-ft) and Conservation Tillage (6,729 ac-ft). The total potential irrigation water savings are projected to be 115,000 acre-feet per year.

By 2030, irrigation conservation will not be able to meet the projected irrigation shortage. Water savings generated in the early decades may offset some of the projected shortfalls. Therefore, an improvement in the implementation level and/or schedule of the current strategies would be required to fully meet the irrigation needs or additional strategies would need to be developed to enhance water conservation.

Table 4-9: Hartley County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year).

		2010	2020	2030	2040	2050	2060
	Projected Shortage	-16,286	-37,118	-104,394	-130,928	-142,803	-141,176
	Projected Water Savings						
Water Saving Strategies	Change in Crop Type	17,974	35,949	35,949	35,949	35,949	35,949
	Change in Crop Variety	13,573	27,145	27,145	27,145	27,145	27,145
	Conservation Tillage	2,991	3,739	4,486	5,234	5,982	6,729
	Convert to Dry	3,205	6,409	9,614	9,614	9,614	9,614
	Irrigation Equipment	3,231	6,462	9,694	12,925	16,156	19,387
	PET Network	1,709	2,991	4,273	5,554	6,836	6,836
	Precipitation Enhancement	9,342	9,342	9,342	9,342	9,342	9,342
	Total Potential Water Savings	52,025	92,037	100,503	105,763	111,024	115,003

4.8.5 Hutchinson County: Irrigation Shortages and Water Savings from Conservation Strategies

It is projected that Hutchinson County will have an irrigation shortage of 6,974 ac-ft in 2010 (Table 4-10). This annual shortfall will increase to 30,431 ac-ft in 2060. Conversion to dryland was the most effective water saving strategy when fully implemented in Hutchinson County reducing annual use by 5,160 ac-ft. The effectiveness of the remaining strategies once fully implemented ranked as follows: Change in Crop Type (4,165 ac-ft), Improvement in Irrigation Equipment (4,239 ac-ft), Change in crop variety (3,086 ac-ft), Precipitation Enhancement (2,594 ac-ft), Irrigation Scheduling (2,043 ac-ft) and Conservation Tillage (2,011 ac-ft).

By 2040, irrigation conservation will not be able to meet the projected irrigation shortage. However, water savings generated in the early decades may offset some of the projected shortfalls. Improvements in the implementation level and/or schedule of the current strategies may be required to fully meet the irrigation demands.

Table 4-10: Hutchinson County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year).

		2010	2020	2030	2040	2050	2060
	Projected Shortage	-6974	-14,728	-18,705	-24,269	-26,018	-30,431
	Projected Water Savings						
Water Saving Strategies	Change in Crop Type	2,083	4,165	4,165	4,165	4,165	4,165
	Change in Crop Variety	1,543	3,086	3,086	3,086	3,086	3,086
	Conservation Tillage	894	1,117	1,341	1,564	1,788	2,011
	Convert to Dry	1,720	3,440	5,160	5,160	5,160	5,160
	Irrigation Equipment	707	1,413	2,120	2,826	3,533	4,239
	PET Network	511	894	1,277	1,660	2,043	2,043
	Precipitation Enhancement	2,594	2,594	2,594	2,594	2,594	2,594
	Total Potential Water Savings	10,052	16,709	19,743	21,055	22,369	23,298

4.8.6 Moore County: Irrigation Shortages and Water Savings from Conservation Strategies

It is projected that Moore County will have an irrigation shortage of 60,475 ac-ft in 2010 (Table 4-11). This annual shortfall will increase to 86,988 ac-ft in 2030 before decreasing to 77,491 in 2060. Changing Crop Type was the most effective water saving strategy when fully implemented in Moore County reducing annual use 23,131 ac-ft. The effectiveness of the remaining strategies once fully implemented ranked as follows: Change in Crop Variety (17,689 ac-ft), Improvement in Irrigation Equipment (12,111 ac-ft), Precipitation Enhancement (6,972 ac-ft), Conversion to Dryland (6,661 ac-ft), Irrigation Scheduling (5,102 ac-ft) and Conservation Tillage (5,022 ac-ft).

Implementing all the strategies identified would not completely cover the projected irrigation deficits for the county. Therefore, an improvement in the implementation level and/or schedule of the current strategies in the early decades would be required to fully meet the irrigation needs or additional strategies to enhance water conservation would need to be developed.

Table 4-11: Moore County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year).

		2010	2020	2030	2040	2050	2060
	Projected Shortage	-60,475	-77,157	-86,988	-84,649	-78,056	-77,491
	Projected Water Savings						
Water Saving Strategies	Change in Crop Type	11,565	23,131	23,131	23,131	23,131	23,131
	Change in Crop Variety	8,844	17,689	17,689	17,689	17,689	17,689
	Conservation Tillage	2,232	2,790	3,348	3,906	4,464	5,022
	Convert to Dry	2,220	4,441	6,661	6,661	6,661	6,661
	Irrigation Equipment	2,019	4,037	6,056	8,074	10,093	12,111
	PET Network	1,275	2,232	3,189	4,145	5,102	5,102
	Precipitation Enhancement	6,972	6,972	6,972	6,972	6,972	6,972
	Total Potential Water Savings	35,127	61,292	67,046	70,578	74,112	76,688

4.8.7 Sherman County: Irrigation Shortages and Water Savings from Conservation Strategies

It is projected that Sherman County will have an irrigation shortage of 84,506 ac-ft in 2010 (Table 4-12). This annual shortfall will increase to 127,348 ac-ft in 2030 before decreasing to 118,086 ac-ft in 2060. Changing Crop Type was the most effective water saving strategy when fully implemented in Sherman County reducing annual use by 25,810 ac-ft. The effectiveness of the remaining strategies once fully implemented ranked as follows: Improvement in Irrigation Equipment (19,765 ac-ft), Precipitation Enhancement (10,635 ac-ft), Conversion to Dryland (19,666 ac-ft), Change in Crop Variety (19,310 ac-ft), Irrigation Scheduling (7,782 ac-ft) and Conservation Tillage (7,660 ac-ft).

Implementing all the strategies identified would not completely cover the projected irrigation deficits. Therefore, an improvement in the implementation level and/or schedule of the current strategies would be required to fully meet the irrigation needs or additional strategies would need to be developed to enhance water conservation.

Table 4-12: Sherman County Projected Annual Irrigation Shortage and Water Savings by Strategy (acre-ft/year).

		2010	2020	2030	2040	2050	2060
	Projected Shortage	-84,506	-112,303	-127,348	-124,225	-116,123	-118,086
	Projected Water Savings						
Water Saving Strategies	Change in Crop Type	12,905	25,810	25,810	25,810	25,810	25,810
	Change in Crop Variety	9,655	19,310	19,310	19,310	19,310	19,310
	Conservation Tillage	3,405	4,256	5,107	5,958	6,809	7,660
	Convert to Dry	6,555	13,111	19,666	19,666	19,666	19,666
	Irrigation Equipment	3,294	6,588	9,883	13,177	16,471	19,765
	PET Network	1,945	3,405	4,864	6,323	7,782	7,782
	Precipitation Enhancement	10,635	10,635	10,635	10,635	10,635	10,635
	Total Potential Water Savings	48,394	83,115	95,275	100,879	106,483	110,628

4.8.8 Summary of Irrigation Conservation Strategies

Prioritizing and implementing the seven irrigation conservation strategies will depend on the individual irrigator and regional support of the strategy. The two strategies that yield the largest water savings, changing crop type and change in crop variety, are projected to generate a significant negative impact to the regional economy, -$235.85 and -$232.58 per ac-ft of water saved, respectively. The third leading water saving strategy, conversion to dryland, yields significant water savings, yet still has a negative impact to the regional economy of -$78.72 per ac-ft of water saved. Changing to more efficient irrigation systems comes with the highest estimated implementation cost of $41.12 per ac-ft of water saved. Conservation tillage is a proven water management strategy that is already widely adopted in the region; however, further adoption would result in significant water savings at the lowest implementation cost per acre-foot. Precipitation enhancement and irrigation scheduling appear to provide the potential of significant water savings while positively impacting the regional economy. However, of all the strategies considered, there is less documentation of the effectiveness of these strategies.

It is assumed that the recommended water conservation strategies will have a more thorough analysis prior to implementation. These analyses should include more detailed documentation of the selected strategies; a county level assessment of the water savings impacts; and a complete cost analysis of the strategy or strategies including required government expenditures and producer bourn costs. Completing these analyses will allow for development of an implementation plan of action that could maximize water savings given available funding for a specific strategy or combination of strategies on a county and regional basis.

It is also noted that 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.

4.8.9 Additional Irrigation Supply from Groundwater Wells

While the PWPG does not recommend new groundwater wells as a strategy to meet irrigation needs during the planning period, drilling new wells is an option for irrigation water users who require additional supplies. Rough cost estimates were developed to determine the costs of installing irrigation wells. Calculations assumed that a well costs $70 per foot; pumping equipment can be estimated at $80 per foot. Table 4-13 summarizes two scenarios: a pumping rate of less than and greater than 700 gallons per minute.

Table 4-13: Estimated Costs of Irrigation Wells in Region A

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	12 ¾	4-6	$26,250	$30,000	$56,250
Greater than 700	500	16	8	$35,000	$40,000	$75,000

4.9 Livestock Shortages

Livestock water shortages were identified for Dallam, Hartley, Moore, and Sherman counties. These shortages are the result of limited water supplies from the Ogallala in these counties and projected growth in concentrated animal feeding operations (CAFOs). The total water demand for livestock use within the region is expected to increase to 89,000 acre-feet by 2060, and CAFOs are expected to require roughly 82 percent of this total water use by 2060. Stock ponds and/or existing developed groundwater rights in the Ogallala will not be able to meet the projected shortages. Livestock producers will need to procure adequate water rights as the livestock demands increase.

It is assumed that projected livestock water shortages will be met in a similar manner as what has been observed over the last forty years as the CAFO industry has expanded in the region. Either new wells are drilled or nearby irrigated cropland is purchased (or water rights bought or leased) for its water and waste disposal. It is also possible that water allocated for irrigation use be transferred to livestock water users.

<u>Quantity, Reliability and Cost</u>

The estimated transfer of water is 26,300 acre-feet per year by 2060, which would be sufficient to meet the projected shortages. Reliability would be moderate, depending on other groundwater water users. Cost estimates were based on the development of multiple wells at capacities of 250 and 500 acre-feet per year. The total cost for all four counties is estimated at $11,324,000. This represents costs of $4.6 million for Dallam County, $724,000 for Hartley County, $1.6 million for Moore County and $4.4 million for Sherman County.

Environmental Issues
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.

Impact on Water Resources and Other Management Strategies
Assuming that water is voluntarily transferred from one use to another, there should be no additional impacts to water resources or other management strategies.

Impact on Agriculture and Natural Resources
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.

Other Relevant Factors
Other relevant factors that may affect the development of water rights include groundwater district rules affecting production limitations and property line setback requirements for locating wells.

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. Increased livestock activities could provide an economic benefit to the region.

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

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

4.10 Wholesale Water Providers

There are eight wholesale water providers located in the PWPA. Of these entities, four are projected to have shortages within the planning period.

4.10.1 Canadian River Municipal Water Authority

The Canadian River Municipal Water Authority (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 103,750 acre-feet per year in 2010, and decreases to 88,750 acre-feet per year by 2050. Current demands on CRMWA are estimated at approximately 104,000 acre-feet per year. Table 4-14 lists the demands by customer, current supplies, and recommended water management strategies for CRMWA. In addition to the current demands listed in Table 4-14, Lubbock has a recommended strategy to purchase additional water from CRMWA. This request is also included in Table 4-14.

Table 4-14: Summary of Demands, Supplies, and Recommended Strategies for CRMWA

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Lamesa	2,540	2,573	2,602	2,603	2,529	2,433
City of O'donnell	161	163	159	155	147	137
City of Pampa	3,300	3,273	3,182	3,058	2,871	2,689
City of Plainview	4,288	4,490	4,605	4,635	4,577	4,488
City of Levelland	2,310	2,362	2,369	2,322	2,216	2,107
City of Borger	3,000	3,000	3,000	3,000	3,000	3,000
City of Lubbock	41,123	41,123	41,123	41,123	41,123	41,123
City of Slaton	907	889	870	849	837	836
City of Tahoka	492	504	490	478	453	421
City of Amarillo	42,082	42,987	42,987	42,987	42,987	42,987
City of Brownfield	2,747	2,905	3,047	3,181	3,185	3,167
Steam Electric Power - Potter County (through Amarillo)	905	0	0	0	0	0
Total Demand	**103,855**	**104,269**	**104,434**	**104,391**	**103,925**	**103,388**
Special Requests from Customers						
City of Lubbock	6,000	6,000	6,000	6,000	6,000	6,000
	Current Water Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Lake Meredith	63,750	63,750	63,750	63,750	63,750	63,750
Roberts County Groundwater	40,000	40,000	35,000	30,000	25,000	25,000
Total Current Supply	**103,750**	**103,750**	**98,750**	**93,750**	**88,750**	**88,750**
Surplus or (Shortage)	**Shortage (AF/Y)**					
Current Customers	(105)	(519)	(5,684)	(10,641)	(15,175)	(14,638)
With Additional Requests	(6,105)	(6,519)	(11,684)	(16,641)	(21,175)	(20,638)
	Supply from Strategy (AF/Y)					
Recommended Strategies	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Expand Roberts Co. Well Field	31,659	31,659	31,659	31,659	31,659	31,659
Maintain Capacity of Existing Well Field	0	0	5,000	10,000	15,000	15,000
Total from Strategies	**31,659**	**31,659**	**36,659**	**41,659**	**46,659**	**46,659**

Recommended Strategies

- Expand Roberts County Well Field (Ogallala aquifer)
- Maintain current capacity of existing Roberts County well field

Strategy Descriptions

Due to continued lack of inflow for Lake Meredith, CRMWA is proceeding to expand their groundwater production and delivery capacity during the current and next planning cycle. For this plan there are two recommended water management strategies for CRMWA. The first water management strategy allows for CRMWA to secure additional groundwater rights in the vicinity of the Roberts County well field and utilize the full capacity of the existing transmission line. The additional quantity of water needed is 31,659 acre-feet per year to reach full capacity of the existing CRMWA transmission system of 71,659 acre-feet per year. This strategy is scheduled to be in operation by 2008. The second strategy recommends CRMWA expand its existing well-field to augment existing supplies by adding supplemental wells. This strategy will be needed when the existing well field can no longer support pumping at 40,000 acre-feet per year.

Based on information available to the members of CRMWA, landowners in the vicinity of the CRMWA Roberts County well field and/or transmission lines and are willing to sell water rights in sufficient quantities to implement this water management strategy. The existing Roberts County well field will experience water shortages due to groundwater district regulations and limited supply availability according to the groundwater model. The expansion of the CRMWA groundwater capacity will help offset this shortage.

Time Intended to Complete

The expansion of the Roberts County well field should be completed by 2008. Maintenance of the existing well field may be ongoing. However, additional wells may need to be drilled by 2030 to maintain the current supply.

Quantity, Reliability and Cost

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 71,659 acre-feet per year from Roberts County may be needed to meet future demands. During the next round of planning, CRMWA and its member cities will evaluate the need for additional groundwater supplies beyond those described above, and consider strategies for acquisition, development, and delivery as necessary. Any water management strategy will need to acquire an adequate quantity of groundwater water rights while complying with all applicable groundwater conservation district rules and honoring the Region A Policy Goal of 50/50 and no greater than 1.25% annual withdrawals of saturated thickness.

Reliability of Ogallala supplies is moderate to high. There are significant quantities of untapped water supplies in Roberts County, but the availability of this water also depends on other water users. The capital cost for the Roberts County well field expansion is $55,983,000. Costs to acquire additional water rights and infrastructure to maintain the capacity of the existing Roberts County well field is $23,415,000, making a total combined capital cost to CRMWA of $79,398,000.

Environmental Issues

The environmental issues associated with this water management strategy are for pipeline rights-of-way and sites for pumping plants and storage facilities. Since routes and sites can be selected to avoid sensitive wildlife habitat and cultural resources, there would be very little, if any, environmental issues of significant concern.

Impact on Water Resources and Other Management Strategies
The increased demands on the Ogallala will continue to deplete the storage in the aquifer. There are other users that may compete for groundwater supplies, but there is sufficient water in Roberts County to support these demands.

Impact on Agriculture and Natural Resources
The expansion of the Roberts County well field and maintenance of the existing well field are expected to have minimal impacts on the agriculture and other natural resources. A small amount of agricultural lands may be affected by the transmission system associated with the well field, depending on the final transmission route.

Other Relevant Factors
There are no other identified relevant factors.

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.

4.10.2 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 220,000 acres of water rights in Randall, Potter, Carson, Deaf Smith, Dallam, Hartley 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 55,392 acre-feet per year of potable water and 19,381 acre-feet of reuse supply. Potable water supplies are projected to decrease to 42,793 acre-feet per year by 2060, while reuse is expected is increase.

Table 4-15 lists the projected demands by customer, the current sources of supply available, and recommended water management strategies for Amarillo. The projected shortages are expected to begin in 2030 with a shortfall of 7,056 acre-feet per year and increasing up to 28,087 acre-feet per year by 2060.

Table 4-15: Summary of Demands, Supplies, and Recommended Strategies for 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**
	Current Water Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Ogallala - Randall County	630	630	630	630	630	630
Ogallala - Potter County	6,200	5,700	5,200	4,600	4,000	3,500
Ogallala - Carson County	7,000	6,700	6,300	5,800	5,300	4,600
Ogallala - Roberts County	17,543	17,560	14,945	12,329	10,155	10,155
Meredith (CRMWA)	23,894	23,894	23,894	23,894	23,894	23,894
Ogallala - Deaf Smith	125	125	100	100	50	14
Reuse Supply	19,381	23,241	24,658	26,262	27,865	31,969
Total Current Supply	**74,773**	**77,850**	**75,727**	**73,615**	**71,894**	**74,762**
Surplus or (Shortage)	**4,317**	**298**	**(7,056)**	**(15,026)**	**(22,870)**	**(28,087)**
	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
Additional Water from CRMWA	1,550	1,533	4,148	6,764	8,938	8,938
Potter County Well Field	0	0	8,000	18,210	18,210	18,000
Roberts County Well Field	0	0	0	0	0	10,420
Total from Strategies	**1,550**	**2,908**	**14,601**	**28,113**	**29,989**	**40,370**

Recommended Strategies

- Implement conservation strategies
- Develop Potter County Well Field (Ogallala aquifer)
- Purchase water from CRMWA under existing contract as CRMWA develops additional supplies
- Develop Roberts County Well Field (Ogallala aquifer)

Recommended Conservation Strategies

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

Strategy Descriptions

The recommended strategies include implementing conservation measures and developing the Potters and Roberts Counties well fields. Table 4-15 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 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 2 being developed by 2060.

Time Intended to Complete

Water conservation strategies should be in place by 2010 with water savings being noticed in 2020. The Potters County well field should be on-line by 2030. The Roberts County well field is scheduled for connection by 2040, with phase 2 implemented by 2060.

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 8,000 acre-feet per year of additional water will be obtained from the Potter County well field and 22,400 acre-feet per year from the Roberts County well field. Reliability of groundwater in Potters County is moderate to high, depending on competing interests. The capital costs for expanding the Potters County well field is $28,678,200. In Roberts County, the reliability of Ogallala supplies is moderate to high since there are large quantities of undeveloped supply in this county. The total capital cost for phase 1 and 2 of the Roberts County well field is $164,357,400.

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 Potters 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.

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.

4.10.3 City of Borger

The City of Borger provides water to customers in Hutchinson County, including TCW Supply, Inc. and Hutchinson County manufacturing. The City receives blended water from CRMWA and groundwater from the Ogallala aquifer. The City also sells treated wastewater to its manufacturing customers. Table 4-16 lists the projected demands and supplies for the City of Borger and its customers. Borger has sufficient supplies to meet its current demands.

Table 4-16: 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	2,500	2,500	2,500	2,500	2,500	2,500
County-other	56	57	57	55	52	49
TCW Supply	94	94	94	94	94	94
Total Demand	**5,002**	**5,035**	**5,002**	**4,923**	**4,794**	**4,682**
	Current Water Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Ogallala - Hutchinson Co.	2,397	2,226	2,066	1,970	1,870	1,713
Reuse	400	400	400	400	400	400
CRMWA:						
Lake Meredith	1,845	1,845	1,845	1,845	1,845	1,845
Ogallala - Roberts Co.	1,171	1,155	1,155	1,155	1,155	1,155
Total Current Supply	**5,813**	**5,626**	**5,466**	**5,370**	**5,270**	**5,113**
Surplus or (Shortage)	**811**	**591**	**464**	**447**	**476**	**431**

4.10.4 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 4-17 lists the projected demands by customer, current supplies, and recommended strategies for Cactus to meet the projected water needs.

Table 4-17: 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	3,653
Total Demand	**3,361**	**3,669**	**3,861**	**4,046**	**4,201**	**4,442**
	Current Water Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Ogallala - Moore County	2,161	1,908	1,660	1,522	1,431	1,311
Total Current Supply	**2,161**	**1,908**	**1,660**	**1,522**	**1,431**	**1,311**
Surplus or (Shortage)	**(1,200)**	**(1,761)**	**(2,201)**	**(2,524)**	**(2,770)**	**(3,131)**
	Supply from Strategy (AF/Y)					
Recommended Strategies	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Conservation	0	18	31	31	31	31
Overdraft Ogallala	1,337	1,786	2,189	2,589	2,816	3,142
Total from Strategies	**1,337**	**1,804**	**2,220**	**2,620**	**2,847**	**3,173**

<u>Recommended Strategies</u>

- Implement conservation strategies
- Overdraft the Ogallala aquifer in Moore County

<u>Recommended Conservation Strategies</u>

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

<u>Strategy Descriptions</u>

The recommended strategies for Cactus include implementing water conservation and overdrafting the Ogallala aquifer with 5 new wells. The amount of water supply associated with each of these strategies is shown in Table 4-17.

Time Intended to Complete

Water conservation strategies should be in place by 2010 with water savings being noticed in 2020. Cactus will need to begin overdrafting the Ogallala before 2010.

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 $5,430,700.

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, 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 $34,198,600 associated with their portion of the project.

4.10.5 City of Dumas

The City of Dumas is located in Moore County and is the largest member city of the Palo Duro River Authority (PDRA). Dumas has approximately 27,800 acre-feet of undeveloped groundwater rights that will be developed for use in the future. However, 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.

Table 4-18 shows the projected demands, current supplies, and recommended strategies to meet demands for the City of Dumas and its customers.

Table 4-18: Summary of Demands, Supplies, and Recommended Strategies for the City of Dumas

	Demands (AF/Y)					
Customers	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Dumas	2,734	2,962	3,163	3,322	3,419	3,478
Moore County - Other (3%)	21	29	38	45	50	52
Moore County - Manufacturing	0	0	0	0	0	0
Total Demand	**2,755**	**2,991**	**3,201**	**3,367**	**3,469**	**3,530**
	Current Water Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Ogallala - Moore County	1,719	1,516	1,323	1,207	1,120	988
Total Current Supply	**1,719**	**1,516**	**1,323**	**1,207**	**1,120**	**988**
Surplus or (Shortage)	**(1,036)**	**(1,475)**	**(1,878)**	**(2,160)**	**(2,349)**	**(2,542)**
	Supply from Strategy (AF/Y)					
Recommended Strategies	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Conservation	0	89	158	166	171	174
Overdraft Ogallala	1,100	1,500	1,778	2,061	2,229	2,371
Total from Strategies	**1,100**	**1,589**	**1,936**	**2,227**	**2,400**	**2,545**

Recommended Strategies

- Implement water conservation strategies
- Overdraft the Ogallala aquifer in Moore County with new wells

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 overdrafting the Ogallala aquifer with three 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. Dumas will need to begin overdrafting the Ogallala aquifer before 2010.

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 $6,887,900.

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 $23,234,000 associated with their portion of the project.

4.10.6 Greenbelt Municipal and Industrial Water Authority

Greenbelt Municipal and Industrial Water Authority (GM&IWA) owns and operates Greenbelt Reservoir on the Salt Fork of the Red River. The GM&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 GM&IWA.

The estimated safe yield from the reservoir is nearly 7,500 acre-feet per year, reducing to 6,635 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 M&IWA are shown in Table 4-19 and are not expected to exceed 5,000 acre-feet per year over the planning period. GM&IWA is not expected to have any water shortages during the planning period (2010-2060).

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	353	379	395	382	387	363
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	**4,543**	**4,554**	**4,567**	**4,515**	**4,495**	**4,341**
	Supply (AF/Y)					
Sources	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Greenbelt Reservoir	7,331	7,192	7,053	6,914	6,775	6,635
Surplus or (Shortage)	**2,788**	**2,638**	**2,486**	**2,399**	**2,280**	**2,294**

4.10.7 Mesa Water Inc.

Mesa Water, Inc. currently does not provide water to any customers. The group of land owners led by Boone Pickens currently holds 10 permits for groundwater withdrawals of up to 150,000 acre feet per year in Roberts County. The term permits are contingent on a signed contract within 5 years of authorization in January 2002.

4.10.8 Palo Duro River Authority

The Palo Duro River Authority (PDRA) currently does not provide water to any member city. The PDRA owns and operates the Palo Duro Reservoir in Hansford County, a potential future water supply source for cities in the Panhandle Region. The PDRA was authorized to serve Hansford and Moore Counties and the City of Stinnett. The lake was completed in 1991. The Palo Duro River Authority has six member cities that are interested in receiving water from the Palo Duro Reservoir. Three of these cities are projected to have water shortages over the planning period: Cactus, Dumas, and Sunray. The three remaining member cities, Gruver, Spearman and Stinnett, do not currently indicate needing additional supply. However, these cities 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	2.90	2,000
Dumas	1.78	1,000
Sunray	0.90	500
Unassigned	0.67	375
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 Senate Bill One purposes, the supply from the reservoir has been allocated to avoid exceeding the firm yield. However, the Palo Duro River Authority 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 $72,265,600. The cost included in Appendix E 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.

4.11 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 Panhandle Water Planning Region. 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.

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 Region A Policy Goals of 50/50 (no more than 50% depletion of aquifer storage in 50 years) and no greater than 1.25% annual withdrawals of the saturated thickness.

4.12 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 $161,970, with CRMWA paying $116,636, NRCS funding $40,274 and one landowner paying $5,060. 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 re-initiated in 2005, using EQIP funds which are still in place (about $323,740) and CRMWA funds ($92,000) which have been provided in the 2004/2005 budget year. Up to $300,000 has been provided in the CRMWA operating budget to pay for work in Texas and New Mexico in 2005, and the CRMWA Board of Directors has exhibited willingness to provide additional funding in future years to complete the program of spraying all salt cedar along the Canadian River upstream from Lake Meredith. In addition to the acreage already treated in New Mexico and under contract in Texas, about 1,150 acres remain to be treated in New Mexico and 2,050 acres not yet under contract in Texas. Funding to help pay for work on lands whose owners are ineligible for the federal cost shares is being sought. If state or federal funding for that part of the cost is not obtained, local (CRMWA) costs to complete treatment could amount to an additional $450,000 beyond the funds already committed. At the current rate of funding under the CRMWA operating budget, initial treatment would be complete in 2007.

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[1] Texas State Soil and Water Conservation Board, "Canadian River Watershed, Brush Control Planning, Assessment and Feasibility Study," December 2000.

4.13 Summary of Recommended Water Management Strategies

The recommended water management strategies in the PWPA include:

- Conservation,
- Developing new groundwater well fields in the Ogallala aquifer,
- Overdrafting the Ogallala in counties with limited supplies,
- Purchasing water from wholesale providers as they develop new strategies,
- Voluntary redistribution of water, and
- Reuse

Conservation is an important strategy in the region, as it is the only recommended strategy for the large irrigation deficits projected for the PWPA. Water savings of over 500,000 acre-feet per year from these strategies are projected for the region. This represents over 85% of the projected need in the PWPA. A list of the recommended conservation strategies and the recipients is shown in Table 4-21.

However, conservation alone cannot meet the entire irrigation shortage, or the other projected shortages. Continued reliance on groundwater from the Ogallala will be needed. Both CRMWA and Amarillo have plans to develop additional groundwater in Roberts County. Other 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. This strategy is recommended for needs in counties with potential sources of treated effluent. Summaries of the recommended strategies for water user groups and wholesale water providers in the PWPA are presented in Tables 4-22 and 4-23, respectively. Approximately 115,000 acre-feet per year of new supplies are recommended for the PWPA and wholesale providers, with an additional 26,300 acre-feet per year of water recommended for voluntary transfer from irrigation use to livestock use. Of the water developed by wholesale providers, some will be used to meet demands in Region O.

4.14 Socioeconomic Impact of Not Meeting Shortages

The socioeconomic impact analysis report, located in Appendix S, has been prepared by the Texas Water Development Board to meet the rules governing Regional Water Planning that require a social and economic impact analysis of not meeting regional water supply shortages. The report 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. Clarifications, Assumptions and Limitations of Analysis using the IMPLAN model can be found on page 14 of the *Socioeconomic Impacts of Unmet Water Needs in the Panhandle Water Planning Area Report* found in Appendix S.

Table 4-21: Summary of Water Savings from the Recommended Conservation Strategies
-Values in Acre-feet per Year-

Water User Group	County	Basin	2010	2020	2030	2040	2050	2060
Amarillo	Potter	Canadian	0	455	808	865	925	975
Amarillo	Potter	Red	0	325	575	615	660	700
Amarillo	Randall	Red	0	595	1,070	1,159	1,256	1,337
Cactus	Moore	Canadian	0	18	31	31	31	31
Canyon	Randall	Red	0	81	146	159	174	186
County-Other	Dallam	Canadian	0	6	10	10	10	10
County-Other	Hartley	Canadian	0	16	28	28	27	26
County-Other	Moore	Canadian	0	29	63	75	83	87
County-Other	Potter	Canadian	0	41	85	103	124	140
County-Other	Potter	Red	0	28	58	71	85	96
County-Other	Randall	Red	0	101	197	231	268	299
County-Other	Sherman	Canadian	0	7	12	13	13	13
Dalhart	Dallam	Canadian	0	43	74	75	74	70
Dalhart	Hartley	Canadian	0	21	36	36	36	34
Dumas	Moore	Canadian	0	89	158	166	171	174
Stratford	Sherman	Canadian	0	20	35	36	37	38
Sunray	Moore	Canadian	0	18	34	36	38	39
Manufacturing	Potter	Red	100	120	150	150	150	150
Manufacturing	Hutchinson	Canadian	0	500	1,000	1,000	1,000	1,000
Manufacturing	Moore	Canadian	236	254	446	469	489	522
Irrigation	Dallam	Canadian	62,932	11,349	120,856	126,891	132,926	137,413
Irrigation	Hartley	Canadian	52,025	92,037	100,503	105,763	111,024	115,003
Irrigation	Hutchinson	Canadian	10,051	16,710	19,743	21,056	22,369	23,299
Irrigation	Moore	Canadian	35,128	61,291	67,045	70,578	74,111	76,687
Irrigation	Randall	Red	13,465	21,685	28,046	30,077	31,904	33,323
Irrigation	Sherman	Canadian	48,394	83,113	95,273	100,878	106,482	110,627
TOTAL			**222,331**	**288,952**	**436,482**	**460,571**	**484,467**	**502,279**

Table 4-22: Summary of Supplies from the Recommended Strategies for Water User Groups

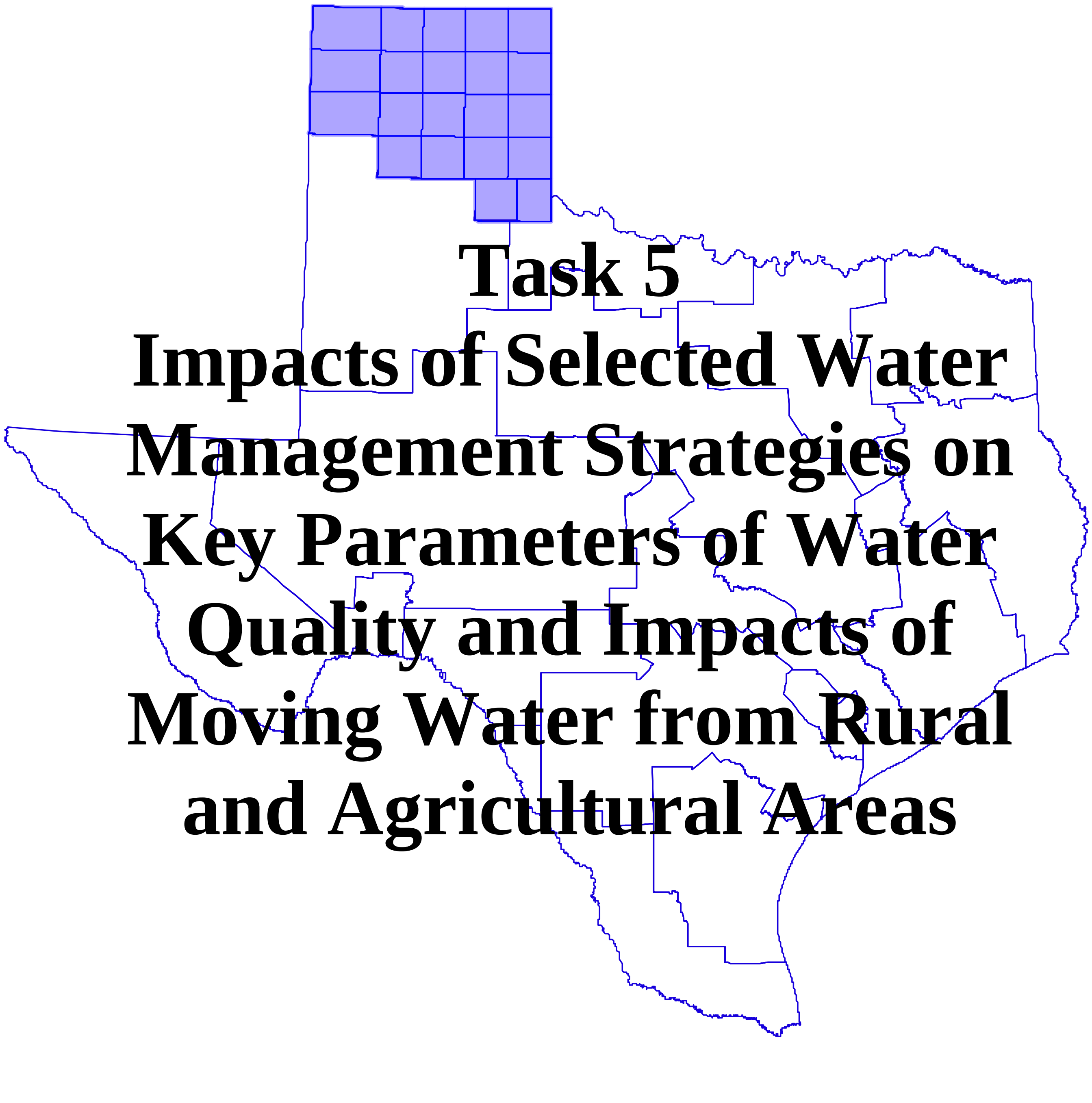
-Values in Acre-feet per Year-

Water User Group	County	Basin	Source Name	Source County	2010	2020	2030	2040	2050	2060
DRILL ADDITIONAL GROUNDWATER WELL										
County-Other	Potter	Canadian	Ogallala Aquifer	Potter	0	0	0	1,000	1,000	1,000
County-Other	Potter	Red	Ogallala Aquifer	Potter	0	600	600	600	1,100	1,100
County-Other	Randall	Red	Ogallala Aquifer	Randall	0	0	600	1,200	2,400	2,400
Manufacturing	Hutchinson	Canadian	Ogallala Aquifer	Hutchinson	2,500	5,000	10,600	10,600	14,200	14,200
OVERDRAFT AQUIFER										
Cactus	Moore	Canadian	Ogallala Aquifer	Moore	250	250	250	350	350	350
County-Other	Dallam	Canadian	Ogallala Aquifer	Dallam	150	150	150	150	150	150
County-Other	Hartley	Canadian	Ogallala Aquifer	Hartley	125	125	125	125	125	125
County-Other	Moore	Canadian	Ogallala Aquifer	Moore	800	800	1,300	1,300	1,600	1,600
County-Other	Sherman	Canadian	Ogallala Aquifer	Sherman	180	180	180	180	180	180
Dalhart	Dallam	Canadian	Ogallala Aquifer	Dallam	900	900	900	900	900	900
Dalhart	Hartley	Canadian	Ogallala Aquifer	Hartley	180	180	180	180	180	180
Dumas	Moore	Canadian	Ogallala Aquifer	Moore	1,092	1,486	1,756	2,032	2,195	2,334
Manufacturing	Moore	Canadian	Ogallala Aquifer	Moore	3,039	3,461	3,833	6,106	6,318	6,633
Steam Electric Power	Moore	Canadian	Ogallala Aquifer	Moore	200	200	200	200	200	200
Stratford	Sherman	Canadian	Ogallala Aquifer	Sherman	450	450	450	450	450	450
Sunray	Moore	Canadian	Ogallala Aquifer	Moore	550	550	550	550	550	550
PURCHASE FROM PROVIDER										
Canyon	Randall	Red	Ogallala Aquifer	Roberts	0	0	0	60	270	540
Manufacturing	Potter	Red	Ogallala Aquifer	Roberts				500	1,500	2,210
Manufacturing	Randall	Red	Ogallala Aquifer	Roberts				20	50	70
VOLUNTARY TRANSFER FROM OTHER USERS										
Livestock	Dallam	Canadian	Ogallala Aquifer	Dallam	4,800	9,100	10,200	10,800	10,900	11,300
Livestock	Hartley	Canadian	Ogallala Aquifer	Hartley	200	1,000	1,400	1,200	700	500
Livestock	Moore	Canadian	Ogallala Aquifer	Moore	1,300	2,200	2,800	3,200	3,500	3,900
Livestock	Sherman	Canadian	Ogallala Aquifer	Sherman	3,100	6,500	7,900	8,700	9,500	10,600
REUSE										
Manufacturing	Moore	Canadian	Direct Reuse	Moore	1,300	1,400	1,500	1,600	1,700	1,700
Manufacturing	Hutchinson	Canadian	Direct Reuse	Hutchinson	1,000	1,000	1,000	1,000	1,000	1,000

Table 4-23: Summary of Supplies from the Recommended Strategies for Wholesale Water Providers

-Values in Acre-feet per Year-

Wholesale Provider	Strategy	Source	Source County	2010	2020	2030	2040	2050	2060
Amarillo	Develop Potters Co. Well Field	Ogallala Aquifer	Potters			8,000	7,500	7,000	6,000
Amarillo	Develop Roberts Co. Well field	Ogallala Aquifer	Roberts	0	0	0	11,210	11,210	22,420
CRMWA	Expand Roberts Co. Well field	Ogallala Aquifer	Roberts	31,659	31,659	31,659	31,659	31,659	31,659
CRMWA	Maintain capacity of existing well field	Ogallala Aquifer	Roberts	0	0	5,000	10,000	15,000	15,000
PDRA	Develop transmission system	Palo Duro Reservoir	Reservoir	0	0	3,875	3,833	3,792	3,750
Cactus	Overdraft aquifer with expanded well field	Ogallala Aquifer	Moore	1,337	1,786	2,189	2,589	2,816	3,142
Dumas	Overdraft aquifer with expanded well field	Ogallala Aquifer	Moore	1,100	1,500	1,778	2,061	2,229	2,371



Task 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. The detailed water quality report can be found in Appendix P.

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.

On October 31, 2001, the U.S. Environmental Protection Agency (EPA) announced that the new arsenic maximum contaminant level (MCL) for drinking water would be 10 parts per billion (ppb) with a compliance date of January 23, 2006. Until recently, the MCL for arsenic allowed under the Safe Drinking Water Act was 50 ppb. Because of this impending new standard, a screening level of 10 ppb was used for this evaluation.

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
Lead	0.015	Action Level
Copper	1.3	Action Level

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 Subchapter F

Action Level- Copper and Lead have action levels as defined by 30 TAC 290.117

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 2002 State of Texas Water Quality Inventory (TCEQ, 2003), the principal water quality problems in the Canadian River Basin are elevated dissolved solids and bacteria; in the Red River Basin, the main contaminants of concern are 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. Seven segments in the PWPA were identified on the 2002 303(d) list. Constituents of concern and 303(d) listing of segments in the PWPA are shown in Table 5-2.

Table 5-2: 2002 303d Listed Segments in the PWPA

		Constituents of Concern				
Water Body	**Segment Number**	**bacteria**	**pH**	**mercury in walleye**	**dissolved oxygen**	**total dissolved solids**
Canadian River Basin						
Dixon Creek	0101A	X			X	
Lake Meredith	0102			X		
Rita Blanca Lake	0105	X	X			X
Palo Duro Reservoir	0199A				X	
Red River Basin						
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

Water Body	Segment Number	Constituents of Concern	Use Concern/Water Quality Concern	Potential Contaminant Sources
Canadian River Basin				
Canadian River below Lake Meredith	0101	Ammonia	Nutrient Enrichment Concern	Agriculture, Grazing-related sources
Dixon Creek	0101A	Bacteria		Unknown
Lake Meredith	0102	Chloride Sulfate Total Dissolved Solids	Public Water Supply Concern	Atmospheric Deposition Groundwater Loadings
Canadian River above Lake Meredith	0103	Bacteria	Contact Recreation Use Concern	Agriculture, Grazing-related sources
Wolf Creek	0104	Bacteria	Contact Recreation Use Concern	Unknown
Palo Duro Reservoir	0199A	Ammonia Nitrate/nitrite Orthophosphorus Total phosphorus	Nutrient Enrichment Concern	Unknown
Red River Basin				
Buck Creek	0207A	Bacteria		Unknown
Lake Tanglewood	0229A	Algal growth Nitrate/nitrite Orthophosphorus Total phosphorus	Nutrient Enrichment Concern Algal Growth Concern	Unknown
Upper Prairie Dog Town Fork of Red River	0229	Bacteria	Contact Recreation Use Concern Nutrient Enrichment Concern	Unknown
Sweetwater Creek	0229A	Bacteria		Unknown

*information available at http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/02twqi/02summaries.html

Table 5-3 shows stream segments within the PWPA that did not meet standards laid out in the 2002 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. There are no segments within the PWPA scheduled for TMDL development between 2001 and 2009.

The Draft 2004 303(d) list was created by the TCEQ on May 13, 2005. This list was examined, but has yet to be approved by the EPA.

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.

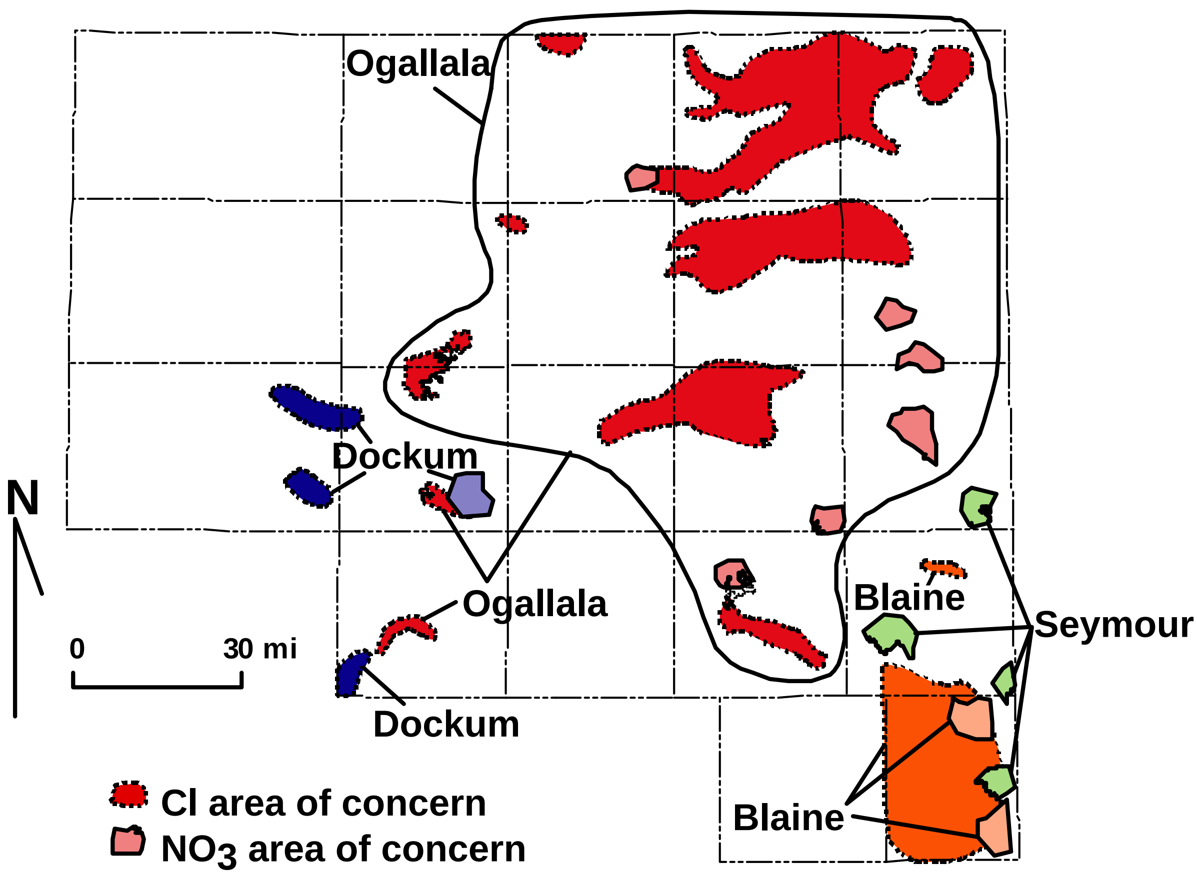
As of 2003, 116 reported or confirmed cases of groundwater contamination in the PWPA, 2.1 percent of the statewide total, were being investigated, monitored, or remediated by governmental agencies. Fuel hydrocarbons (gasoline, diesel, and kerosene) are the most frequently cited constituents in the PWPA. Potter, Hutchinson, Randall, and Carson Counties have roughly 60 percent 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 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 ~13 percent and the NO_3

area of concern covers ~2 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-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.

Figure 5-1: Areas of Concern within PWPA for Nitrates and Chlorides



5.2.2.1 Ogallala Aquifer

Areas of concern for Cl along the Canadian River and in Carson and Gray counties (Fig. 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 (Fig. 5-2) operated by:

- City of Perryton in Ochiltree County (Fig. 5-2),
- City of Pampa in Gray County (Fig. 5-2),
- City of Lefors in Gray County (Fig. 5-2), and
- Red River Authority in Donley County (Fig. 5-2).

Elevated Cl concentrations in most of the reported samples are less than the secondary MCL for dissolved chloride (Table 3-Appendix O).

The NO_3 areas of concern in the Ogallala aquifer include public-water-supply well fields operated by:

- City of McLean in Gray County (Fig. 5-2),
- City of Wheeler in Wheeler County (Fig. 5-2), and
- Red River Authority in Donley County, which well field also lies in the Cl area of concern (Fig. 5-2).

Some NO_3 concentrations in the reported samples exceed the MCL for dissolved NO_3.

Figure 5-2: Locations of Public Water-Supply Wells located in Areas of Concern

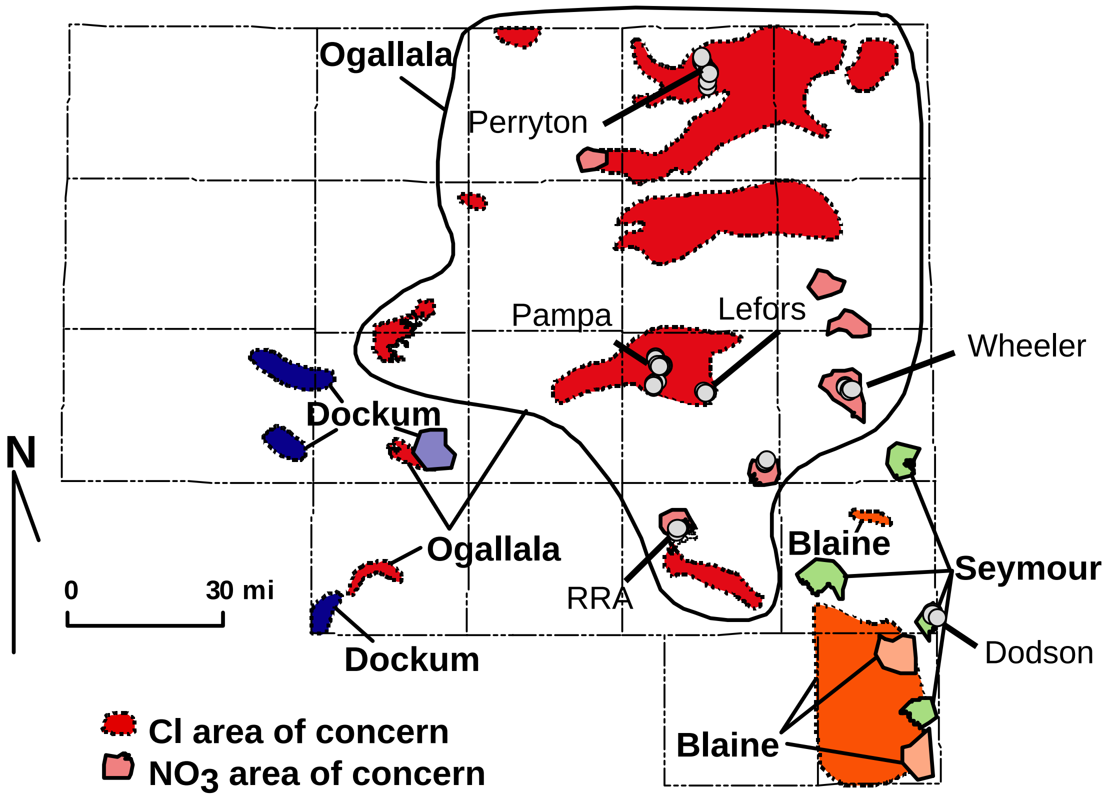


Table 5-4: List of public water supply well fields occurring in areas of concern for dissolved chloride and nitrate in groundwater

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

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.

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 (Figs. 8, 20) 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	Former Pantex Ordinance Plant	Amarillo	SVOC, Metals
4	Carson	RMD/CA	Pantex Plant (USDOE)	Hwy 60	Trichloroethylene, 1-2 Dichloroethane, Chromium
5	Carson	RMD/PST	Panhandle Butane & Oil Co Inc	Panhandle	Gasoline
6	Carson	Oil & Gas	Walt Poling vs. Unknown (Frank Sheehan)	Fritch	Drip gas or condensate
7	Childress	RMD/CA	TXDOT (Childress Maintenance Facility)	Childress	Chloroform
8	Childress	RMD/PST	Carrison Inc	Childress	Gasoline
9	Childress	RMD/PST	TXDOT	Childress	Gasoline
10	Childress	RMD/PST	Jimmy Bridges	Childress	Gasoline, Diesel
11	Childress	RMD/PST	Joe Tarrant Oil Co	Childress	Gasoline, Diesel
12	Childress	RMD/PST	Veta Marlene Havins	Childress	Gasoline, Diesel
13	Childress	RMD/PST	Anadarko Development Co	Childress	Unknown
14	Childress	RMD/PST	Geo Bitexplorationj Inc	Childress	Unknown
15	Childress	RMD/PST	RDJ Investments	Childress	Unknown
16	Dallam	RMD/VC	Burlington Northern Railroad	Childress	Chlorinated solvents
17	Dallam	RMD/PST	DB & E	Dalhart	Gasoline, Diesel
18	Dallam	RMD/PST	Dalhart Consumers Fuel Assoc	Dalhart	Unknown
19	Dallam	RMD/PST	Sam & Gerrie Putts Estate	Dalhart	Unknown
20	Dallam	RMD/PST	State LeadPerforming	Dalhart	Unknown

Number	County	Division	File name	Location	Contamination description
21	Gray	RMD/CA	Celenese Ltd	Pampa	Benzene, Acetone, MTBE
22	Gray	RMD/PST	Brock Crockett	Alanree	Gasoline
23	Gray	RMD/PST	FFP Operating Partners	Lefors	Gasoline
24	Gray	RMD/PST	Gray County	Lefors	Gasoline
25	Gray	Oil & Gas	Equilon Pipeline Co. (Lefors Station)	Lefors	BTEX
26	Gray	Oil & Gas	Ruby Gage Complaint	Pampa	Chloride
27	Hall	RMD/PST	OR Saye Enterprises	Memphis	Gasoline
28	Hall	RMD/PST	TXDOT	Memphis	Gasoline
29	Hall	RMD/PST	Allsups Petroleum Inc	Turkey	Unknown
30	Hall	RMD/PST	BCK Mcqueen Inc	Memphis	Unknown
31	Hemphill	RMD/PST	Ward Oil Co	Canadian	blank
32	Hemphill	RMD/PST	Allsups Petroleum Inc	Canadian	Gasoline
33	Hemphill	RMD/PST	Bob Ward	Canadian	Gasoline
34	Hemphill	RMD/PST	Brainard Cattle Co	Canadian	Gasoline
35	Hemphill	RMD/PST	Canadian Fuel Supply Inc	Canadian	Gasoline
36	Hemphill	RMD/PST	Small Business Administration	Canadian	Gasoline
37	Hemphill	RMD/PST	Nations Bank	Canadian	Gasoline, Kerosene
38	Hutchinson	RMD/CA	Agrium US Inc	Borger	Arsenic
39	Hutchinson	RMD/CA	Chevron Phillips Chemical Company LP (Philtex-Ryton Plant)	Borger	Hydrocarbons, Sulfolane, 1,4-Dichlorobenzene
40	Hutchinson	RMD/CA	Phillips 66 Co	Borger	Organics, Inorganics
41	Hutchinson	RMD/CA	Phillips Rubber Chemical Complex	Borger	Organics, Metals
42	Hutchinson	RMD/CA	Dowell Schlumberger Inc	Borger	TPH, VOCs
43	Hutchinson	RMD/PST	Allsups Petroleum Inc	Fritch	Gasoline
44	Hutchinson	RMD/PST	Charles Edwards	Borger	Gasoline

Number	County	Division	File name	Location	Contamination description
45	Hutchinson	RMD/PST	Claude P Robinson	Borger	Gasoline
46	Hutchinson	RMD/PST	Lewis Sargent	Stinnett	Gasoline
47	Hutchinson	RMD/PST	National Park Service	Sanford Marina	Gasoline
48	Hutchinson	RMD/PST	Ray Wright	Borger	Gasoline
49	Hutchinson	RMD/PST	Southwest Coca Cola	Borger	Gasoline
50	Hutchinson	RMD/PST	Phillips 66 Co	Borger	Kerosene
51	Hutchinson	RMD/PST	Dowell Schlumberger Inc	Borger	Waste oil
52	Hutchinson	Oil & Gas	Ranger Gathering Corp (Sanford Yard)	Sanford	Benzene & free phase HC
53	Hutchinson	Oil & Gas	El Paso Corp.	Sanford	Free phase HC & BTEX
54	Hutchinson	Oil & Gas	Phillips Petroleum Co (Patton Creek)	Borger	Hydrocarbons & SW
55	Moore	RMD/CA	Diamond Shamrock Refining Co (McKee)	Sunray	Benzene, LNAPL
56	Moore	RMD/PST	First State Bank of Dumas	Cactus	Gasoline, Diesel
57	Moore	RMD/PST	Jack Oldham Oil Co	Dumas	Gasoline, Diesel
58	Moore	RMD/SSDAT	Cactus Ordnance Works	12 mi N of Dumas	Bis(2-Ethylhexy)Phthlate
59	Moore	RMD/VC	Cactus Plant	Cactus	Nitrates, Metals
60	Moore	Oil & Gas	Colorado Interstate Gas (Bivins Sta)	Masterson	VOCs
61	Ochiltree	RMD/SC	City of Perryton Well 2	Perryton	Carbon tetrachloride, Nitrates
62	Potter	RMD/CA	Elements IS LTP Inc	Amarillo	Chromium
63	Potter	RMD/CA	Texaco Refining & Marketing Inc	Amarillo	Hydrocarbons
64	Potter	RMD/CA	Diamond Shamrock Refining Co	Amarillo	TPH, Benzene
65	Potter	RMD/PST	Petro Shopping	Amarillo	Diesel
66	Potter	RMD/PST	A to Z Tire	Amarillo	Gasoline

Number	County	Division	File name	Location	Contamination description
67	Potter	RMD/PST	ATEX Gas Bankruptcy & 101824	Amarillo	Gasoline
68	Potter	RMD/PST	Burlington Northern Railroad	Amarillo	Gasoline
69	Potter	RMD/PST	Chevron Products Co.	Amarillo	Gasoline
70	Potter	RMD/PST	City of Amarillo	Amarillo	Gasoline
71	Potter	RMD/PST	Diamond Shamrock Ref. & Mktg. Co.	Amarillo	Gasoline
72	Potter	RMD/PST	EZ Mart Stores	Amarillo	Gasoline
73	Potter	RMD/PST	EZ Mart Stores	Amarillo	Gasoline
74	Potter	RMD/PST	Glenda Scott	Amarillo	Gasoline
75	Potter	RMD/PST	Great Western Dist.	Amarillo	Gasoline
76	Potter	RMD/PST	J Lee Millingan, Inc.	Amarillo	Gasoline
77	Potter	RMD/PST	Kerr McGee Refining Corp.	Amarillo	Gasoline
78	Potter	RMD/PST	Macks Super Market	Amarillo	Gasoline
79	Potter	RMD/PST	Palo Duro Estate	Amarillo	Gasoline
80	Potter	RMD/PST	Scott & Co. Realtor	Amarillo	Gasoline
81	Potter	RMD/PST	Texaco Refining & Marketing Inc	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	Toot N Totum Food Stores	Amarillo	Gasoline
85	Potter	RMD/PST	Toot N Totum Food Stores	Amarillo	Gasoline
86	Potter	RMD/PST	Toot N Totum Food Stores	Amarillo	Gasoline
87	Potter	RMD/PST	Toot N Totum Food Stores	Amarillo	Gasoline
88	Potter	RMD/PST	W A Innes	Amarillo	Gasoline
89	Potter	RMD/PST	Northern O'Brien	Amarillo	Gasoline, Diesel
90	Potter	RMD/PST	Pro Am III Truck Stop	Amarillo	Gasoline, Diesel

Number	County	Division	File name	Location	Contamination description
91	Potter	WQD/WQAS	Southwestern Public Service Co	NE of Amarillo	Nitrate, Chloride, Sulfate
92	Potter	Oil & Gas	Williams Energy Service, Inc.	Pioneer Tank Battery #2	Free phase HC
93	Randall	RMD/CA	Valero Logistics	Palo Duor	Gasoline
94	Randall	RMD/PST	High Plains UWCD No. 1 Sampling Program	Well 11-09-806 (sample 381-2-4)	Atrazine
95	Randall	RMD/PST	Air Speed Oil Co.	Lake Tanglewood	Gasoline
96	Randall	RMD/PST	City of Canyon	Canyon	Gasoline
97	Randall	RMD/PST	Consumers Fuel Association	Canyon	Gasoline
98	Randall	RMD/PST	Donut Stop, Inc.	Canyon	Gasoline
99	Randall	RMD/PST	Estate of Annie Weaver	Canyon	Gasoline
100	Randall	RMD/PST	Exxon Mobile	Canyon	Gasoline
101	Randall	RMD/PST	Jack Sisemore Traveland	Amarillo	Gasoline
102	Randall	RMD/PST	Lagrone H. Odell	Canyon	Gasoline
103	Randall	RMD/PST	Weingarten Realty	Amarillo	Gasoline
104	Randall	RMD/PST	Sterling Gibson	Amarillo	Gasoline, Diesel
105	Randall	RMD/PST	BFI / Southwest	N of Canyon	MW-12: VOCs (Methlyene chloride)
106	Randall	RMD/PST	SJKR, Inc.	Canyon	Unknown
107	Randall	RMD/PST	Sun Country, Inc.	Canyon	Unknown
108	Randall	RMD/PST	Western Marketing	Canyon	Unknown
109	Roberts	RMD/PST	Bailey Oil Products, Co.	Miami	Gasoline
110	Roberts	RMD/PST	Environmental Impact	Miami	Gasoline
111	Roberts	RMD/PST	FFP Operating Partners	Miami	Gasoline
112	Sherman	RMD/PST	Olive Boston Estate	Stratford	Gasoline
113	Wheeler	RMD/PST	C&H Supply, Inc.	Shamrock	Gasoline
114	Wheeler	RMD/PST	Kelton ISD	Wheeler	Gasoline

Number	County	Division	File name	Location	Contamination description
115	Wheeler	RMD/PST	Royco Cantrell Corp.	Shamrock	Gasoline
116	Wheeler	RMD/PST	TXDOT	Wheeler	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 2005)

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 5.3. A brief summary is provided below. Similarly, specific groundwater quality issues were discussed in some detail in Section 5.4, and have been summarized as follows. Additionally, both groundwater and surface water quality is 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 NO_3 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 7 public water supply systems located within areas of concern for dissolved chloride and nitrates. The TCEQ groundwater contamination file contains 147 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 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 to verify and approve population and water use data. The survey also 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.

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.

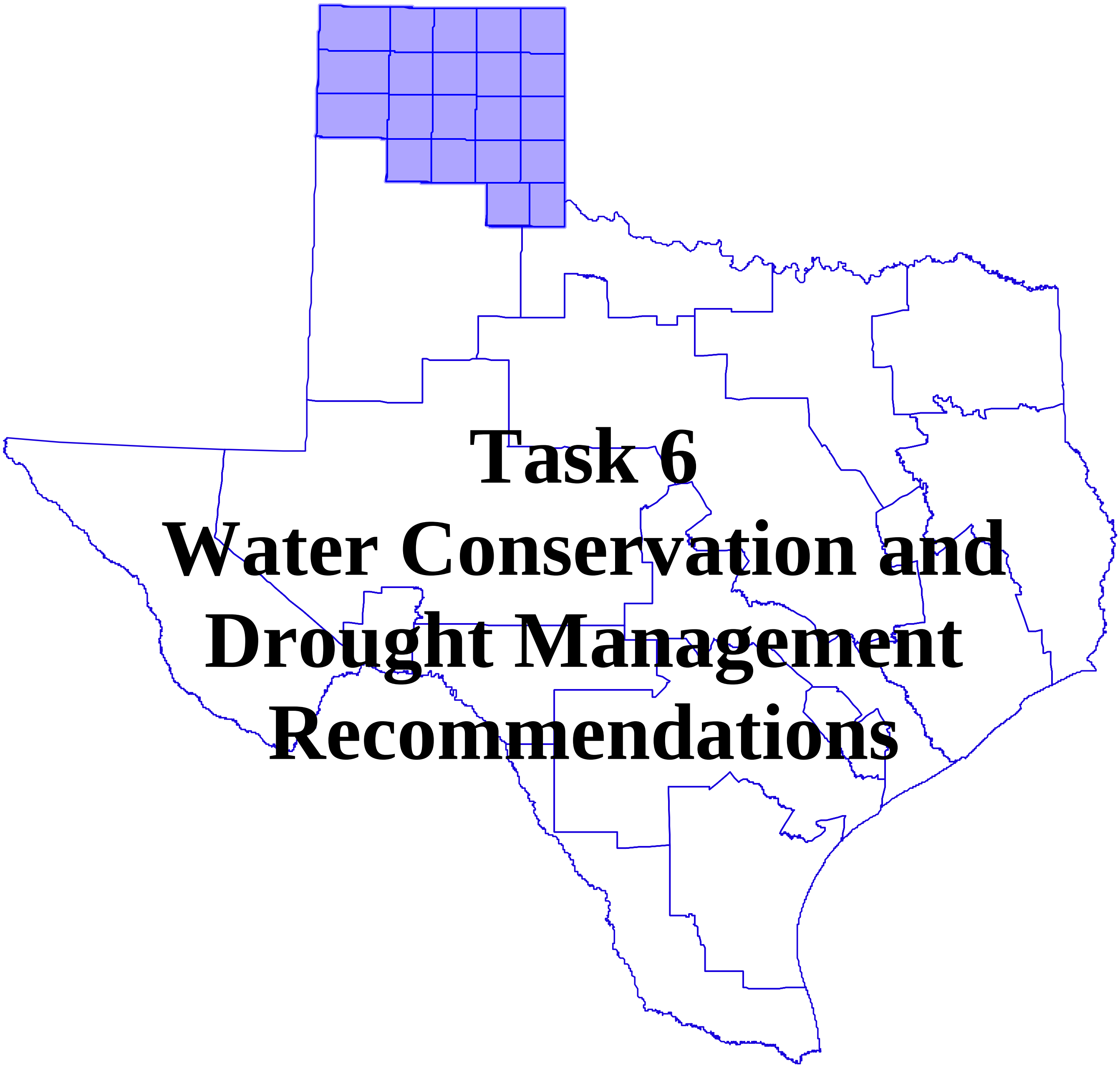
In addition to the problem with increase in runoff, urbanization also causes increased pollutant loads, including sediment, oil/grease/toxic chemicals from motor vehicles, pesticides/herbicides/fertilizers from gardens and lawns, viruses/bacteria/ nutrients from human and animal wastes including septic 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.

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 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. This complete report can be found in Appendix O.

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 PWPG recommended offsetting shortages for agricultural livestock water users with supplies allocated to irrigation. This voluntary transfer of water is based on priority of use within the agricultural sector. In most cases, this transfer of supply increases an already existing unmet demand for irrigation.



Task 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, under SB2 guidelines. 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 SB1 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. The Panhandle Water Planning Group chose to account conservation savings in the municipal sector for any new growth only. On a regional basis, this is less than a 1 percent reduction in municipal water use (less than 460 acre-feet per year) by year 2060. If the conservation savings through the Plumbing Code are applied to the full population, the reduction is approximately 6.5%, or 6,750 AFY, of the total municipal use in 2060. Additional municipal water savings may be expected as the Federal mandate for low flow clothes washing machines takes effect in 2007.

The PWPA 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% annual demand reduction in demand until the region reaches an average of 140 gpcd use. This demand management strategy will achieve this target sometime in the 2030 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 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.

SB1 requires 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 feels that water conservation is an excellent source of meeting future water demands.

Currently, only two 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 75 gpcd, both for County-Other water users, while the regional median is 169 and an average of 172 gpcd. Based on average GPCD use, a 1% annual decrease in municipal consumption would take nearly 20 years to reach the Conservation Taskforce 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 the industry as aquifers in the region continue to decline.

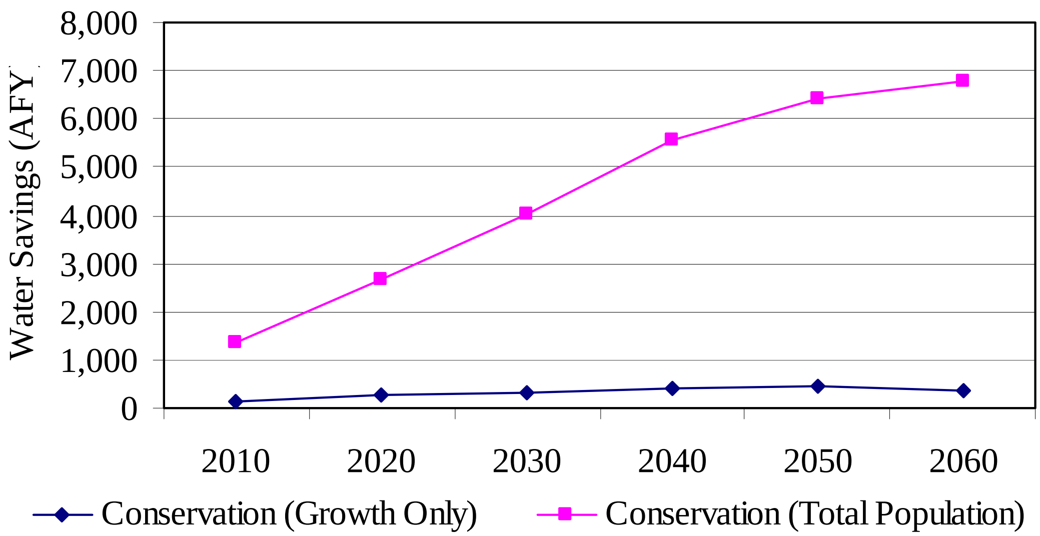


Figure 6-1: Municipal Conservation Savings Resulting from State Water-Efficient Plumbing Act (AFY)

Table 6-1 shows the 1980-2000 gallons per capita per day (gpcd) average for the recognized municipal user groups located in the Panhandle WPA. The statistical evaluation 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	20 year Average gpcd
Amarillo	201
Booker	240
Borger	144
Cactus	183
Canadian	182
Canyon	153
Childress	188
Clarendon	199
Claude	176
Dalhart	230
Dumas	164
Fritch	160
Groom	215
Gruver	248
High Texas Water Co.	99
Lake Tanglewood	144
Lefors	141
McLean	204
Memphis	159
Miami	210
Pampa	169
Panhandle	197
Perryton	207
Shamrock	142
Skellytown	154
Spearman	201
Stinnett	165
Stratford	258
Sunray	213
TCW Supply Co.	255
Texline*	334
Vega	217
Wellington	182
Wheeler	189
White Deer	137
REGIONAL STATISTICS (including County-Other)	
Average GPCD	172
Median GPCD	169
Highest GPCD	334
Lowest GPCD	75

* Texline supplies commercial water to a local fertilizer plant that was not historically metered separately.

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

6.2 Agricultural Conservation

Agricultural conservation savings provide for a significant amount of 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 canal lining and other improvements to agricultural water transmission systems (which in some cases now lose one-third to one-half of water pumped due to leaks, seepage, and evapotranspiration) can avoid substantial water loss, the biggest water savings in the agricultural sector in the foreseeable future will be achieved through 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.

The PWPA has contracted with Texas Agricultural Experiment Station and using local experts determined that the following conservation strategies 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, and (7)

Conversion from irrigated to dryland. Using these strategies, Table 6.3 shows the 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	911	1,150	1,389	1,628	1,867	2,030
Carson	7,593	9,641	11,688	13,735	15,783	17,224
Childress	803	1,014	1,224	1,435	1,645	1,796
Collingsworth	1,858	2,357	2,855	3,354	3,853	4,217
Dallam	21,104	27,177	33,249	39,322	45,395	49,895
Donley	1,545	1,960	2,376	2,792	3,207	3,509
Gray	2,213	2,789	3,365	3,941	4,517	4,910
Hall	1,691	2,123	2,555	2,988	3,420	3,726
Hansford	9,918	12,723	15,528	18,333	21,138	23,148
Hartley	18,540	23,909	29,278	34,646	40,015	44,034
Hemphill	86	107	127	148	168	181
Hutchinson	4,705	6,018	7,331	8,645	9,958	10,888
Lipscomb	1,027	1,313	1,600	1,886	2,173	2,383
Moore	12,914	16,480	20,045	23,610	27,176	29,764
Ochiltree	7,631	9,756	11,880	14,004	16,128	17,647
Oldham	365	469	573	677	781	856
Potter	487	632	777	923	1,068	1,178
Randall	7,478	9,509	11,539	13,570	15,600	17,021
Roberts	1,623	2,061	2,499	2,938	3,376	3,699
Sherman	19,260	24,883	30,506	36,129	41,752	45,904
Wheeler	741	928	1,116	1,304	1,492	1,620
TOTAL	122,492	156,998	191,503	226,008	260,513	285,630

Conservation for agricultural practices is summarized according to water management strategies. Assuming water savings is the primary criteria for prioritizing water conservation strategies, the strategies of changing crop variety and increased conservation tillage should be either dropped from consideration or assigned a low priority. Neither strategy generated significant water savings; in addition, the change in crop varieties was detrimental to gross crop receipts. It should be noted that the analysis of crop varieties is based on current available varieties. Research currently underway may provide improved varieties that are more water efficient with little negative effect on yield. If these improvements develop, the feasibility of this strategy would need to be reevaluated. Prioritizing the other five strategies will depend on the various decision variables, i.e., water savings, implementation costs and Regional impacts. The two strategies that yield the largest water savings, changing crop type and conversion to dryland, are projected to generate a significant negative impact to the Regional economy, -$235.85 and -$78.72 per ac-ft of water saved, respectively. The third leading water saving strategy, i.e., changing to more efficient irrigation systems, comes with the highest estimated implementation cost, $41.12 per ac-ft of water saved. The remaining strategies of precipitation enhancement and irrigation scheduling appear to provide the potential of significant water savings while positively impacting the Regional economy.

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. Recent 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 submitted to the Executive Director of the TCEQ by May 1, 2005.

In the PWPG area, 4 entities hold municipal or industrial rights in excess of 1,000 acre-feet per year and no entities have 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 PWPG area 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 C. 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. In addition, a TWDB questionnaire for GCD development of a groundwater management plan is also included.

The focus of the conservation activities for municipal water users in the PWPG 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 PWPG 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	

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 five GCDs in operation in the Panhandle Planning Area. Their management plan goals and objectives are summarized as follows:

6.4.1 Collingsworth County Underground Water Conservation District (CCUWCD)

The District was created in November 1986 and covers the whole of Collingsworth County. The District is dominated by agricultural production. About 55 percent of the District is rangeland, 40 percent is cropland and the rest is urban, transportation or water areas. According to District records, there are slightly more than 300 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 2000 still available by 2050. 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
- 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

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
- Use the Seymour aquifer Groundwater Availability Model (GAM) to run scenarios for predicting future water supplies
- Publicize groundwater conservation issues and the need for efficient use of groundwater through local media
- Establish a water level depiction program for landowner tax purposes
- Monitor selected flowmeters on wells
- Identify and address local irrigation practices which are wasteful of groundwater resources
- Establish a procedure for receiving and processing public complaints
- Initiate and implement a program to identify, locate and obtain closures of abandoned wells
- Develop a drought contingency plan

6.4.2 Hemphill County Underground Water Conservation District

The Hemphill County Underground Water Conservation District (HCUWC) was created in 1995 and a management plan was adopted in 1999. 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, and to control subsidence within the defined boundary of the District. The purpose of the District will be achieved through rules, education programs, District-provided services, and through mutual cooperation of local, state, and federal agencies. The District will issue water well permits, collect groundwater information, perform water quality analyses, and provide 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 objectives in order to meet the above goals.

- Provide prompt and timely processing of all applications of water well permits to provide for efficient use of water.
- 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.

6.4.3 North Plains Groundwater Conservation District No. 2

The North Plains Groundwater Conservation District No. 2 (NPGCD) was created in 1955. The District adopted a water management plan on August 18, 1998. 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:

- Provide prompt and timely processing of all applications for water well permits
- Maintain a well completion/equipment information database toy include each permitted well completed
- Maintain the most accurate and representative database of water level elevation information possible
- Provide accurate and timely depletion information to the landowners of the District
- Develop readily available up-to-date water quantity reports to the general public
- Respond to all requests for information
- Maintain a water quality observation well network to provide adequate information to determine any change in water quality within the District in time to seek remedial or corrective action
- Provide water quality analysis within the capabilities of the District
- Enforce the Rules of the District to conserve and protect the quantity and quality of the resource to the best of the District's ability through the powers provided in Chapter 36 of Texas Water Code
- Take appropriate action within powers of the District to protect quality of the groundwater
- Reduce the waste of water

- Take appropriate action within the powers of the District to address any natural resource issue which would have an impact on the use or availability of groundwater in the District
- Support research and demonstration projects which will help protect the groundwater quality, reduce waste, and promote efficient use of water
- Continue to encourage water conservation
- Provide current information to the residents of the District about water conservation and protection
- Inform people within and outside the District about the goals, programs, duties and responsibilities of the District
- Continue to provide public school education material to schools in the District
- Provide prompt field service to all water users

The District has outlined the following management objectives in order to achieve the above goals:

- Complete administrative review process, including County Committee review and schedule for Board consideration within 60 days of application date
- Review well log and registration information for accuracy and enter information into databases within 5 working days of the receipt
- Annually field visit each observation well and obtain a static water level measurement from at least 80 percent of the wells, review the readings for accuracy (revisit observation wells if necessary to resolve any inaccuracies) and enter observation well tabulations in the water level database
- Prepare necessary information, receive IRS approval and mail depletion information to landowners by December 31 each year
- Update current water quality reports within 30 days after new data has been tabulated
- Within 5 days from the time a specific request is made, provide the requested information
- Collect, analyze, verify and enter results in the District water quality database
- Respond to all water quality requests for analysis within the capabilities of the District
- Ensure that all Rules of the District are enforced fairly and equitably within the District
- Maintain a constant awareness of the activities that may be or may become a threat to the quality of the groundwater
- Begin investigation of all complaints involving waste of water within three days of receiving the complaint
- Maintain a constant awareness of natural resources issue which would have an impact on use or availability of the groundwater
- Annually consider all research and demonstration projects and make decisions regarding the District's participation
- Annually contact at least two cities within the District to encourage and help develop a well head protection plan for their public water supply wells
- Encourage the use of or conversion to more efficient application methods

6.4.4 The High Plains Underground Water Conservation District No. 1

The High Plains Underground Water Conservation District No. 1 (HPUWCD) created its water management plan on August 11, 1998. This plan will remain in effect for a period of ten years, unless a revised is approved. The District consists of both groundwater and surface water resources. The ground water resources include the Ogallala, Cretaceous and Dockum Aquifers and the surface water resources include Lake Meredith, Lake Mackenzie, River Lake and Lake Alan Henry (currently used for recreation, but intended as water supply source for Lubbock in 25-35 years) as well as numerous playa lakes. The HPUWCD has jurisdiction in the Panhandle WPA in Potter and Randall Counties. The District has outlined the following goals under the water management plan:

- Continue to implement management strategies to protect and enhance water quality and enhance the quality of useable quality ground water by encouraging the most efficient use
- Continue to implement programs to protect the quality of the aquifer and to control and prevent the waste of ground water
- Continue to implement management strategies that provide public information/education opportunities to assist in accomplishing the above 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
- Continue to provide laboratory services to residents
- 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 (PGCD) 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 Groundwater Conservation District adopted a water management plan on September 3, 2003. 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. Groundwater sources include the Ogallala aquifer and surface water sources include Lake Meredith and Lake Greenbelt. The PGCD 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
- Control and prevention of subsidence

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

6.5 Water Conservation Management Plans and Drought Contingency Plans

Because of the range of conditions that affected the more than 4,000 water utilities throughout the state in 1997, the Texas Legislature directed the TCEQ to adopt rules establishing common drought plan requirements for water suppliers. As a result, the TCEQ requires all wholesale public water suppliers, retail public water suppliers serving 3,300 connections or more, and irrigation districts to submit drought contingency plans. For all retail public water suppliers serving less than 3,300 connections, the drought contingency plans must be prepared and adopted no later than May 1, 2005, and 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, 2005.

Model drought contingency plans were developed for the PWPG and are included in Appendix C. 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. Plans were summarized and used to create model plans. 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 created a Drought Contingency Plan on April 10, 2001. 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 **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 **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 **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 adopted a Drought Contingency Plan by passing Ordinance No. O-015-99 on January 4, 2000, 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:** Continually falling treated water reservoir levels do not refill above 70 percent overnight and City personnel report this condition is likely to persist.
- **Moderate:** Continually falling treated water reservoir levels do not refill above 60 percent overnight and City personnel report this condition is likely to persist.
- **Severe:** Continually falling treated water reservoir levels do not refill above 50 percent overnight and City personnel report this condition is likely to persist.
- **Critical:** Continually falling treated water reservoir levels do not refill above 40 percent overnight and City personnel report this condition is likely to persist.
- **Emergency:** Major water line breaks, or pump or system failures occur **or** natural or man-made contamination of the water supply source occurs.

6.5.2.3 City of Canyon

Ordinance No. 730 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 Ordinance No. 1374 on February 12, 2002, resulting in the inclusion of a Drought Contingency Plan. 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.

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.

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
CRMWA		X
Lipsomb 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	

Drought trigger conditions for surface water supply are customarily related to reservoir levels. The Panhandle Water Planning Group 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 15, 2003. The triggering conditions are based on CRMWA's Reservoir Operation Model, as briefly described below.

- **Mild:** CRMWA's Reservoir Operation Model projections show a three year future supply in Lake Meredith.
- **Moderate:** CRMWA's Reservoir Operation Model projections show a two year future supply in Lake Meredith.
- **Severe:** CRMWA's Reservoir Operation Model projections show a 1.5 year future supply in Lake Meredith.
- **Emergency:** CRMWA determines that an equipment failure has caused the loss of capability to provide water service, or natural or man-made contamination of the water supply source.

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

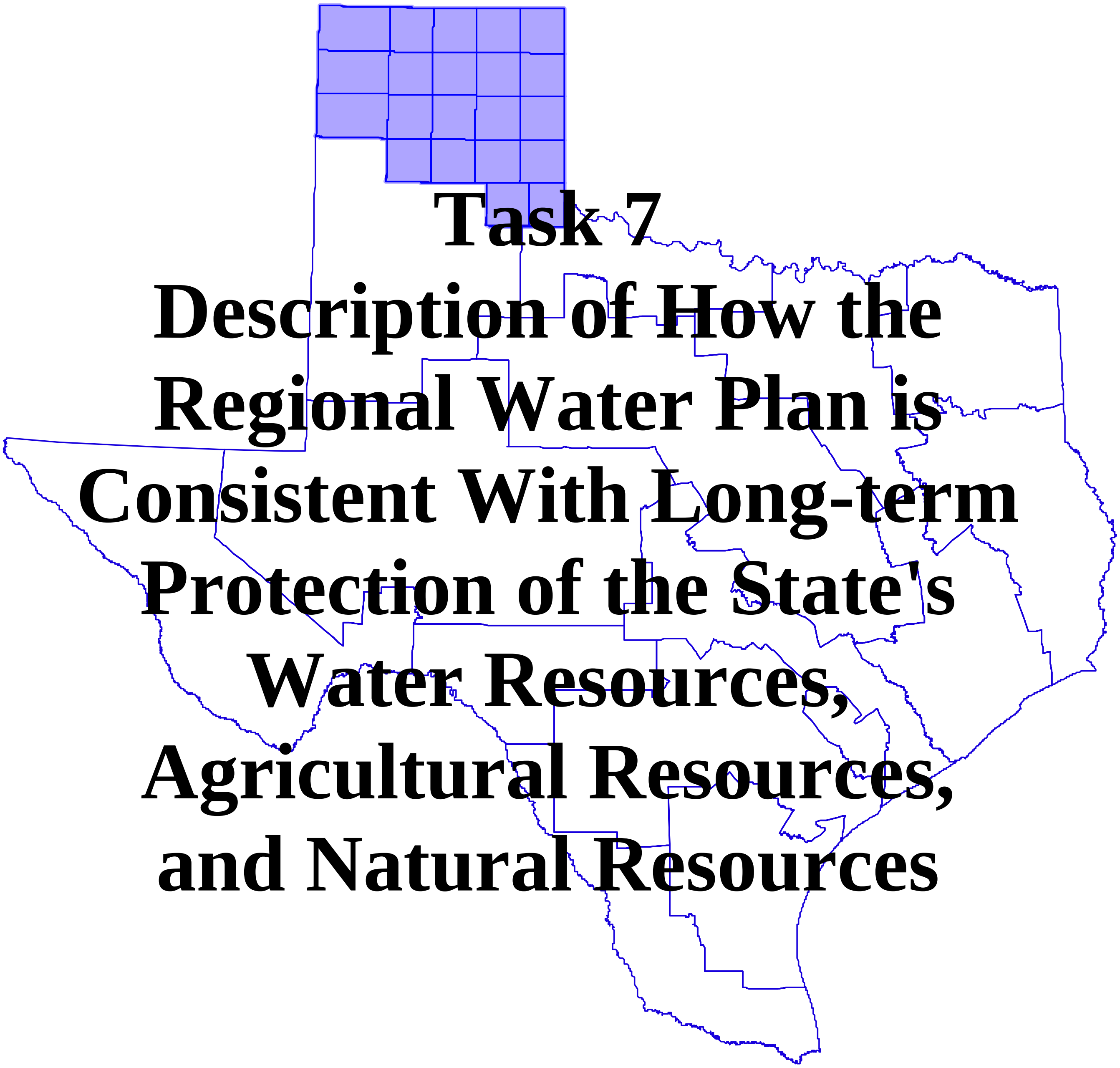
The TWDB provides a significant amount of information and services pertaining to water conservation that can be accessed at:

http://www.twdb.state.tx.us/assistance/conservation/consindex.asp .

Likewise, Water Conservation Tips were developed by the TCEQ's Clean Texas 2000.

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 C. 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. You can receive a print copy of a form from TCEQ by calling 512/239-4691 or by email to wras@tceq.state.tx.us.



Task 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 balanced meeting water shortages with good stewardship of the water, agricultural, and natural resources within the region. The PWPG recommended water conservation and demand reduction as the first strategy applied to meet every projected shortage. In the strategy selection process, the yield and environmental impact of projects were given greater consideration than the unit cost of water.

In this plan, existing in-basin or region supplies were fully utilized before any recommendations for new water supply projects or interbasin transfers were considered. Wastewater reuse is a recommended strategy to meet long-term power generation and industrial water needs and several other municipal options 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. This plan recommends using not more than 1.25% of annual saturated thickness within the aquifer as a management option for long-term sustainable management of the aquifers within the PWPA to meet local demands.

7.2 Water Resources within the Panhandle Water Planning Area

Water resources available by basin within Region A 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 2002 Census of Agriculture, Region A has approximately 1,523,839 acres of land in 2,762 farms. The number of farms has decreased in the period between 1978 and 2002. In the period between 1978 and 2002, the acres of harvested cropland have decreased by approximately 34 percent. In 2002, approximately 66 percent of the harvested cropland was contained in six counties (Carson, Dallam, Hansford, Hartley, Moore, and Sherman) on 973 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

7.4 Natural Resources within the Panhandle Water Planning Area

Region A 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 10 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

Region A contains over 103,000 acres of protected parks and public lands. The PWPA is home to Palo Duro Canyon State Park, approximately 16,400 acres located in Armstrong and Randall Counties. 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. Issues that are of concern for water supply in the PWPA include aquifer depletions due to pumping exceeding recharge; contamination of surface water and groundwater; and drought related shortages for both surface water and groundwater. Potential groundwater contamination 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; 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.

Table 7-1: Plan Consistency

RULE	RULE TASK
§357.5	**Guidelines for Development of Regional Water Plans**
§357.5(b)	Submittal of Plan on or before January 5, 2001and at least as frequently as every five years thereafter
§357.5(d)	Use of population and water demands. In developing regional water plans, RWPG shall use:
§357.5(d)(1)	State population and water demand projections in state water plan or adopted by the TWDB
§357.5(d)(2)	Population or water demand projection revisions adopted by the TWDB
§357.5(e)	Plan development. In developing regional water plans, RWPG shall:
§357.5(e)(1)	Ensure water management strategies are adjusted to provide appropriate environmental water needs, including instream flows and bays and estuaries inflows. Use environmental information from existing site-specific studies, state environmental planning criteria adopted by the TWDB.
§357.5(e)(2)	Provide water management strategies to be used during a drought of record
§357.5(e)(3)	Protect existing water rights, water contracts and option agreements
§357.5(e)(4)	Provide specific recommendations of water management strategies based upon identification, analysis and comparison of all water management strategies the RWPG determines to be potentially feasible, present for public comment.
	To determine the cost-effectiveness, the regional water planning groups will use the process described in §357.7(a)(8)(A)(i)
	To determine environmental sensitivity, the regional water planning groups shall use the process described in §357.7)a)(8)(A)(ii)
	Document the process by which the regional water planning group will list all possible water management strategies and identify water management strategies that are potentially feasible for meeting a need in the region.
	The regional water planning group shall present the process to the public for comment at the public meeting required by §357.12(a)(1).

RULE	**RULE TASK**
§357.5(e)(5)	Incorporate water conservation planning and drought contingency planning
	Water conservation and drought management strategies considered for each need should be evaluated as other WMS in Task 5. Must document why not selected if applicable. Conservation WMS for each WUG or WWP with new IBT. Model conservation and drought management plan. Chapter of conservation and drought management recommendations. (NOTE: IS OUR GUIDANCE CHANGING ON THIS PER VT?)
§357.5(e)(6)	Conduct planning to achieve efficient use of existing water supplies, explore opportunities for and benefits of developing regional water supply facilities or their management, coordinate actions of local and regional agencies, provide substantial public involvement, provide full dissemination of planning results
§357.5(e)(7)	For each source of water supply in the regional water planning area designated in accordance with §357.7(a)(3), identify:
§357.5(e)(7)(A)	Factors specific to each source of water supply to be considered in determining whether to initiate a drought response, and
§357.5(e)(7)(B)	Actions to be taken as part of the response, and
§357.5(e)(8)	Consider the effect of the regional water plan on navigation
§357.5(f)	Existing law. Each regional water planning group shall prepare its regional water plan to be consistent with all laws applicable to water use in the regional water planning area.
§357.5(g)	Special water resources
§357.5(h)	Protecting rights to special water resources
§357.5(i)	Consider emergency transfers of surface water
§357.5(j)	Simplified planning
§357.5(k)	Existing regional water planning efforts. In developing a regional water plan, consider the following:
§357.5(k)(1)	Consider existing plans and information, including:
§357.5(k)(1)(A)	Water conservation plans
§357.5(k)(1)(B)	Drought contingency plans
§357.5(k)(1)(C)	Information from water loss audits
§357.5(k)(1)(D)	Certified groundwater conservation district management plans
§357.5(k)(1)(E)	Publicly available plans of agricultural, municipal, manufacturing and commercial water users
§357.5(k)(1)(F)	Water management plans
§357.5(k)(1)(G)	Water availability requirements promulgated in accordance with TWC §35.019
§357.5(k)(1)(H)	Any other information available from existing local or regional water planning studies
§357.5(k)(2)	Existing programs and goals, including:
§357.5(k)(2)(A)	State Clean Rivers Program
§357.5(k)(2)(B)	Federal Clean Water Act
§357.5(k)(2)(C)	Other planning goals, including regionalization of water and wastewater services where appropriate

RULE	RULE TASK
§357.5(l)	Instream and bay and estuary flows. Consider environmental water needs including instream flows and bay and estuary inflows.
§357.7	**Regional Water Plan Development**
§357.7(a)	Prepare description of regional water planning area, including:
§357.7(a)(1)(A)	Major water providers
§357.7(a)(1)(B)	Current water use (for identified water use categories)
§357.7(a)(1)(C)	Identify water quality problems
§357.7(a)(1)(D)	Sources of groundwater and surface water including major springs
§357.7(a)(1)(E)	Major demand centers
§357.7(a)(1)(F)	Agricultural and natural resources
§357.7(a)(1)(G)	Social and Economic aspects
§357.7(a)(1)(H)	Assessment of current preparations for drought
§357.7(a)(1)(I)	Summary of existing regional water plans
§357.7(a)(1)(J)	Summary of recommendations in state water plan
§357.7(a)(1)(K)	Summary of local water plans
§357.7(a)(1)(L)	Identify threats to agricultural and natural resources due to water quantity or water quality problems related to water supply
§357.7(a)(1)(M)	Information compiled by the board from water loss audits performed by retail public utilities pursuant to §358.6
§357.7(a)(2)	Prepare presentation of current and projected population and water demands,
§357.7(a)(2)(A)	By:
§357.7(a)(2)(A)(i)	City for cities with populations greater than 500 people
§357.7(a)(2)(A)(ii)	Counties with less than 5 retail public utilities which provide more than 280 acre-ft per year for municipal use
§357.7(a)(2)(A)(iii)	Individual retail public utility or collective data for all retail public utilities that form a logical reporting unit for counties with more than 5 retail public utilities which provide more than 280 acre-ft per year for municipal use
§357.7(a)(2)(A)(iv)	Categories of water use, for each river basin
§357.7(a)(2)(B)	Wholesale water provider by category of water use, for each river basin. The wholesale water provider's current contractual obligations to supply water must be reported in addition to any demands projected for the wholesale water provider.
§357.7(a)(2)(C)	Include an adjustment to each municipal demand due to water savings from using plumbing fixtures identified in Chapter 372 of the Texas Health and Safety Code. The regional water planning group shall determine and report the extent to which such plumbing fixtures impact projected municipal water use using parameters approved by the executive administrator.
§357.7(a)(3)	Evaluation of adequacy of current water supplies legally and physically available to the regional water planning area for use during drought of record. Consider surface water and groundwater data from state water plan, existing water rights, contracts and option agreements, other planning and water supply studies and analysis of water supplies currently available. Firm yields for reservoirs.

RULE	RULE TASK
§357.7(a)(3)(A)	By:
§357.7(a)(3)(A)(i)	City for cities with populations greater than 500 people
§357.7(a)(3)(A)(ii)	Counties with less than 5 retail public utilities which provide more than 280 acre-ft per year for municipal use
§357.7(a)(3)(A)(iii)	Individual retail public utility or collective data for all retail public utilities that form a logical reporting unit for counties with more than 5 retail public utilities which provide more than 280 acre-ft per year for municipal use
§357.7(a)(3)(A)(iv)	Categories of water use, for each river basin
§357.7(a)(3)(B)	Wholesale water provider by category of water use, for each river basin. The wholesale water provider's current contractual obligations to supply water must be reported in addition to any demands projected for the wholesale water provider.
§357.7(a)(4)	Water supply and demand analysis comparing:
§357.7(a)(4)(A)	Water demands as developed in paragraph (2)(A) of this subsection with current water supplies available to the regional water planning area as developed in paragraph (3)(A) of this subsection to determine if water users identified in paragraph (2)(A) of this subsection in the regional water planning area will experience a surplus of supply or a need for additional supplies. The social and economic impact of not meeting these needs shall be evaluated by the regional water planning groups and reported by regional water planning area and river basin. The executive administrator shall provide available technical assistance to the regional water planning groups, upon request, on water supply and demand analysis, including methods to evaluate the social and economic impacts of not meeting needs. Other results report by:
§357.7(a)(4)(A)(i)	Cities with populations greater than 500 people
§357.7(a)(4)(A)(ii)	Counties with less than 5 retail public utilities which provide more than 280 acre-ft per year for municipal use
§357.7(a)(4)(A)(iii)	Individual retail public utility or collective data for all retail public utilities that form a logical reporting unit for counties with more than 5 retail public utilities which provide more than 280 acre-ft per year for municipal use
§357.7(a)(4)(A)(iv)	Categories of water use, for each river basin
§357.7(a)(4)(B)	Water demands as developed in paragraph (2)(B) of this subsection with current water supplies available to the wholesale water provider as developed in paragraph (3) of this subsection to determine if the wholesale water providers in the regional water planning area will experience a surplus of supply or a need for additional supplies. Results shall be reported, for each wholesale water provider by categories of water use, for each river basin. The executive administrator shall provide available technical assistance to the regional water planning groups, upon request, on water supply and demand analysis.
§357.7(a)(5)	Using identified water supply needs, provide water management strategies to be used during the drought of record to provide sufficient water supply to meet the identified needs

RULE	RULE TASK
§357.7(a)(5)(A)	Water management strategies shall be developed for:
§357.7(a)(5)(A)(i)	Cities with populations greater than 500 people
§357.7(a)(5)(A)(ii)	Counties with less than 5 retail public utilities which provide more than 280 acre-ft per year for municipal use
§357.7(a)(5)(A)(iii)	Individual retail public utility or collective data for all retail public utilities that form a logical reporting unit for counties with more than 5 retail public utilities which provide more than 280 acre-ft per year for municipal use
§357.7(a)(5)(A)(iv)	Categories of water use, for each river basin
§357.7(a)(5)(B)	Water demands as developed in paragraph (2)(B) of this subsection with current water supplies available to the wholesale water provider as developed in paragraph (3) of this subsection to determine if the wholesale water providers in the regional water planning area will experience a surplus of supply or a need for additional supplies. Results shall be reported, for each wholesale water provider by categories of water use, for each river basin. The executive administrator shall provide available technical assistance to the regional water planning groups, upon request, on water supply and demand analysis.
§357.7(a)(5)(C)	The plan to be used for water supply during drought of record shall meet all needs for the water use categories of municipal, manufacturing, irrigation, steam electric power generation, mining, and livestock watering except:
§357.7(a)(5)(C)(i)	Identify those needs for which no water management strategy is feasible, present full evaluation with reasons why no water management strategy is feasible
§357.7(a)(5)(C)(ii)	Where a political subdivision that provides water supply (other than water supply corporations, counties, or river authorities) does not participate in the regional water planning effort for needs located within its boundaries or extraterritorial jurisdiction. The regional water planning group shall establish terms of participation that shall be equitable and shall not unduly hinder participation.
§357.7(a)(6)	If desired by the RWPG, presentation of data in subdivisions of the reporting units required such as reporting irrigation for a county by splitting it into two or more reporting units
§357.7(a)(7)	Evaluation of all water management strategies the regional water planning group determines to be potentially feasible, including:
§357.7(a)(7)(A)	Water conservation practices:
§357.7(a)(7)(A)(i)	Impact on water needs
§357.7(a)(7)(A)(ii)	For each user group beyond the minimum requirements
§357.7(a)(7)(A)(iii)	For each water user group or wholesale water provider that is to obtain water from a proposed interbasin transfer, resulting in the highest practicable level of water conservation and efficiency achievable
§357.7(a)(7)(A)(iv)	Consider strategies to address any issues from water loss audits
§357.7(a)(7)((B)	Drought management measures including water demand management

RULE	RULE TASK
§357.7(a)(7)(C)	Reuse of wastewater
§357.7(a)(7)(D)	Expanded use of existing supplies
§357.7(a)(7)(E)	New supply development
§357.7(a)(7)(F)	Interbasin transfers
§357.7(a)(7)(G)	Other measures
§357.7(a)(8)	Evaluate all water management strategies the regional water planning group determines to be potentially feasible, including:
§357.7(a)(8)(A)	Quantitative reporting of:
§357.7(a)(8)(A)(i)	Quantity, reliability and cost of water delivered and treated for the end user's requirements, incorporating factors to be used in the calculation of infrastructure debt payments, present costs, and discounted present value costs provided by the executive administrator.
§357.7(a)(8)(A)(ii)	Environmental factors including effects on environmental water needs, wildlife habitat, cultural resources, and effect of upstream development on bays, estuaries and arms of the Gulf of Mexico.
§357.7(a)(8)(A)(iii)	Impacts on agricultural resources.
§357.7(a)(8)(B)	Impacts on other water resources of the state including other water management strategies and groundwater/surface water interrelationships.
§357.7(a)(8)(C)	For each threat to agricultural and natural resources identified, a discussion of how that threat will be addressed or affected by the water management strategies evaluated.
§357.7(a)(8)(D)	Any other factors as deemed relevant by the regional water planning group including recreational impacts;
§357.7(a)(8)(E)	Equitable comparison and consistent application of all water management strategies the regional water planning groups determine to be potentially feasible for each water supply need;
§357.7(a)(8)(F)	Consideration of the provisions in Texas Water Code §11.085(k)(1) for interbasin transfers of surface water. At a minimum, this consideration shall include a summation of water needs in the basin of origin and in the receiving basin, based on needs presented in the applicable approved regional water plan.
§357.7(a)(8)(G)	Consideration of third party social and economic impacts resulting from voluntary redistributions of water, including analysis of third-party impacts of moving water from rural and agricultural areas; and
§357.7(a)(8)(H)	Consideration of water pipelines and other facilities that can be used for water conveyance as described in subsection (a)(1)(M) of this section.
§357.7(a)(9)	Specific recommendations of water management strategies to meet the needs in sufficient detail to allow state agencies to make financial or regulatory decisions to determine the consistency of the proposed action before the state agency with an approved regional water plan. Strategies selected so that cost effective water management strategies which are consistent with long-term protection of the state's water resources, agricultural resources and natural resources are adopted.

RULE	RULE TASK
§357.7(a)(10)	Prepare regulatory, administrative or legislative recommendations.
§357.7(a)(11)	Include a chapter consolidating the water conservation and drought management recommendations of the regional water plan.
§357.7(a)(12)	Include a description of the major impacts of recommended water management strategies on key parameters of water quality identified by the regional water planning group as important to the use of the water resource and comparing conditions with the recommended water management strategies to current conditions using best available data.
§357.7(a)(13)	Include a chapter describing how the regional water plan is consistent with long-term protection of the state's water resources, agricultural resources, and natural resources as required in §357.14(2)(C) of this title (relating to Approval of Regional Water Plans by the Board); and
§357.7(a)(14)	Include a chapter describing the financing needed to implement the water management strategies recommended. Include how local governments, regional authorities, and other political subdivisions in the regional water planning area propose to pay for water management strategies identified in the regional water plan.
§357.7(b)	Specific recommendations of water management strategies to meet an identified need will not be shown as meeting the need for a political subdivision if the political subdivision to supply or to be provided water supplies objects to inclusion of the strategy for such political subdivision and specifies its reasons for such objection. This does not prevent the inclusion of the strategy to meet other needs.
§357.7(c)	The regional water planning group shall include in its regional water plan a model water conservation plan pursuant to Texas Water Code §11.1271.
§357.7(d)	The regional water planning group shall include in its regional water plan a model drought contingency plan pursuant to Texas Water Code §11.1272.
§357.7(e)	The executive administrator shall provide technical assistance within available resources to the regional water planning groups requesting such assistance in performing regional water planning activities and if requested, may facilitate resolution of conflicts within regional water planning areas.
§357.8	**Ecologically Unique River and Stream Segments**
§357.8(b)	A regional water planning group may recommend a river or stream segment as being of unique ecological value based upon the following criteria:
§357.8(b)(1)	**Biological function -** stream 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;
§357.8(b)(2)	**Hydrologic function -** stream segments which are fringed by habitats that perform valuable hydrologic functions relating to water quality, flood attenuation, flow stabilization, or groundwater recharge and discharge;

RULE	RULE TASK
§357.8(b)(3)	**Riparian conservation areas -** stream 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, or stream segments which are fringed by other areas managed for conservation purposes under a governmentally approved conservation plan;
§357.8(b)(4)	**High water quality/exceptional aquatic life/high aesthetic value -** stream 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
§357.8(b)(5)	**Threatened or endangered species/unique communities -** sites along streams where water development projects would have significant detrimental effects on state or federally listed threatened and endangered species, and sites along streams significant due to the presence of unique, exemplary, or unusually extensive natural communities.
§357.8(c)	For every river and stream segment that has been designated as a unique river or stream segment by the legislature, during a session that ends not less than one year before the required date of submittal of an adopted regional water plan to the board, or recommended as a unique river or stream segment in the regional water plan, the regional water planning group shall assess the impact of the regional water plan on these segments. The assessment shall be a quantitative analysis of the impact of the plan on the flows important to the river or stream segment, as determined by the regional water planning group, comparing current conditions to conditions with implementation of all recommended water management strategies. The assessment shall also describe the impact of the plan on the unique features cited in the region's recommendation of that segment.
§357.9	Unique Sites for Reservoir Construction. A regional water planning group 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:
§357.9(1)	Site-specific reservoir development is recommended as a specific water management strategy or in an alternative long-term scenario in an adopted regional water plan; or
§357.9(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:
§357.9(2)(A)	Reservoir development to provide water supply for the current planning period; or
§357.9(2)(B)	Where it might reasonably be needed to meet needs beyond the 50-year planning period.
§357.10	Format of information to be presented in regional water plans.

RULE	RULE TASK
§357.10(a)	Initially prepared and adopted regional water plans or amendments to approved regional water plans shall include:
§357.10(a)(1)	Technical report and data prepared in accordance with this chapter and the executive administrator's specifications.
§357.10(a)(2)	Include executive summary that documents the key regional water plan findings and recommendations.
§357.10(a)(3)	Prepare summaries of all written and oral comments, with a response by the RWPG explaining how the plan was revised or why changes were not warranted in response to written comments received.
§357.10(b)	Transfer copies of all data and reports to the TWDB in electronic format to the maximum extent possible.
§357.11	Adoption of regional water plans by regional water planning groups
§357.11(a)	RWPGs shall concurrently submit to the executive administrator and release to the public an initially prepared regional water plan prior to adoption. Plan submitted to the executive administrator must be in the specified electronic and paper format. RWPG must certify that the initially prepared plan is complete and adopted by the RWPG.
§357.11(b)	The RWPGs shall receive and consider comments from the TWDB, any federal or Texas state agency and the public.
§357.11(b)(1)	The executive administrator's written comments, which shall be provided to the regional water planning group within 120 days of receipt of the initially prepared plan
§357.11(b)(2)	Written comments received from any federal agency or Texas state agency, which the regional water planning groups shall accept for at least 120 days after the first public hearing notice is published pursuant to §357.12(a)(3) and (5) of this title.
§357.11(b)(3)	Any written or oral comments received from the public after the first public hearing notice is published pursuant to §357.12(a)(3) and (5) of this title until at least 60 days after the pubic hearing is held pursuant to §357.12(a)(3) and (4) of this title.
§357.11(c)	The regional water planning group shall submit in a timely manner to the executive administrator information on any known interregional conflict between regional water plans.
§357.11(d)	RWPG shall modify the regional water plan to incorporate board resolutions of interregional conflicts.
§357.11(e)	RWPG shall seek to resolve conflicts with other regional water planning groups and shall participate in any board sponsored efforts to resolve interregional conflicts.
§357.11(f)	A regional water planning group may amend an adopted regional water plan at any meeting, after giving notice according to §357.12 of this title and providing the public, the board, and other governmental entities 30 days to submit written or oral comments on the proposed amendment. A regional water planning group may propose amendments to an approved regional water plan by submitting proposed amendments to the board for its consideration and possible approval under the standards and procedures of this chapter.

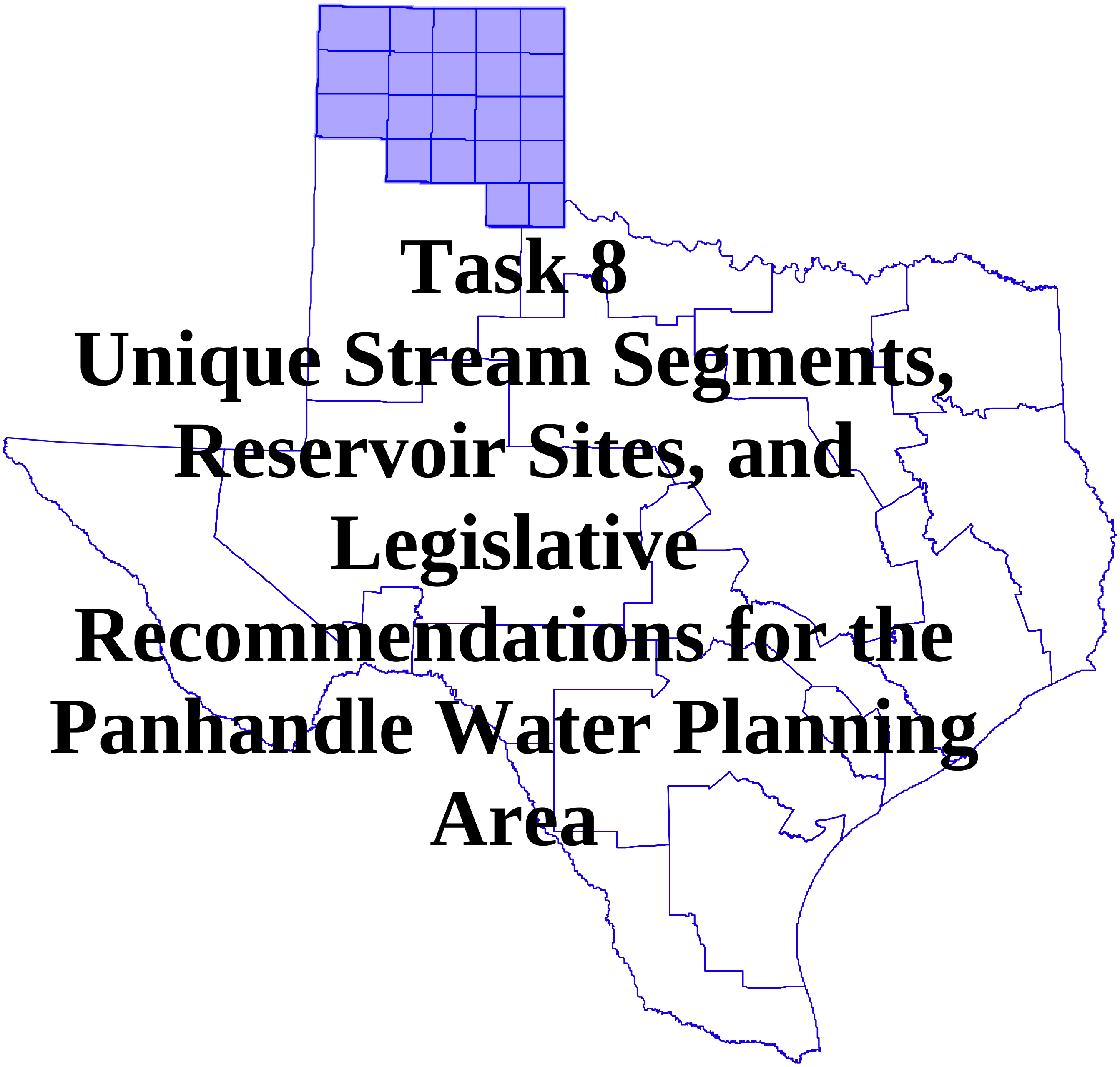
RULE	RULE TASK
§357.11(g)	A political subdivision in the regional water planning area may request a regional water planning group to consider specific changes to an adopted regional water plan based on changed conditions or new information. A regional water planning group must formally consider such a request within 180 days after its submittal and shall amend its adopted regional water plan if it determines an amendment is warranted. If the political subdivision is not satisfied with the regional water planning group's decision on the issue, it may file a petition with the executive administrator to request board review the decision and consider changing the approved regional water plan. The political subdivision shall send a copy of the petition to the chair of the affected regional water planning group.
§357.11(g)(1)	The petition must state:
§357.11(g)(1)(A)	The changed condition or new information that affects the approved regional water plan;
§357.11(g)(1)(B)	The specific sections and provisions of the approved regional water plan that are affected by the changed condition or new information;
§357.11(g)(1)(C)	The efforts made by the political subdivision to work with the regional water planning group to obtain an amendment;
§357.11(g)(1)(D)	The proposed amendment to the approved regional water plan.
§357.11(g)(2)	If the executive administrator determines that the changed condition or new information warrants a change in the approved regional water plan, the executive administrator shall request the regional water planning group to consider making the appropriate change and provide the reason in writing. The political subdivision that submitted the petition will receive notice of any action requested of the regional water planning group by the executive administrator. If the regional water planning group does not amend its plan consistent with the request within 90 days, the executive administrator will present the issue to the board for consideration at a public meeting. Before presenting the issue to the board, the executive administrator will provide the regional water planning group, the political subdivision submitting the petition, and any political subdivision determined by the executive administrator to be affected by the issue 30 days notice.
§357.12	Notice and Public Participation
§357.12(a)	RWGPs and any subregional water planning groups shall provide for public participation including:
§357.12(a)(1)	At least one public meeting prior to the preparation of the regional water plan pursuant to §357.6(a)(1) of this title held in some central location within the regional water planning area;
§357.12(a)(2)	Ongoing opportunities for public input during preparation of the regional water plan;
§357.12(a)(3)	A public hearing following adoption of an initially prepared regional water plan, to be held in a central location within the regional water planning area.
§357.12(a)(4)	A public hearing before adoption of an amendment to an adopted regional water plan, including amendments required by the board's resolution of interregional conflicts, to be held in a central location.

Rule	Rule Task
§357.12(a)(5)	Notice of the public meetings and public hearings required by paragraphs (1), (3), and (4) of this subsection shall be published in a newspaper of general circulation in each county located in whole or in part in the regional water planning area before the 30th day preceding the date of the public meeting or hearing and mailed to, at a minimum, the following:
§357.12(a)(5)(A)	Each mayor of a municipality with a population of 1,000 or more or which is a county seat that is located in whole or in part in the regional water planning area;
§357.12(a)(5)(B)	Each county judge of a county located in whole or in part in the regional water planning area;
§357.12(a)(5)(C)	Each special or general law district or river authority with responsibility to manage or supply water in the regional water planning area based upon lists of such water districts and river authorities obtained from TNRCC;
§357.12(a)(5)(D)	Each retail public utility, defined as a community water system, that serves any part of the regional water planning area or receives water from the regional water planning area based upon lists of such entities obtained from TNRCC; and
§357.12(a)(5)(E)	Each holder of record of a water right for the use of surface water the diversion of which occurs in the regional water planning area based upon lists of such water rights holders obtained from TNRCC; and
§357.12(a)(6)	Notice of the public meetings and public hearings shall include:
§357.12(a)(6)(A)	A date, time, and location of the public meeting or hearing;
§357.12(a)(6)(B)	A summary of the proposed action to be taken;
§357.12(a)(6)(C)	The name, telephone number, and address of the person to whom questions or requests for additional information may be submitted; and
§357.12(a)(6)(D)	Information that the regional water planning group will accept written and oral comments at the hearings required by paragraphs (3) and (4) of this subsection, and information on how the public may submit written comments separate from such hearings. The regional water planning group shall specify a deadline for submission of public written comments of not earlier than 30 days after the hearings required by paragraphs (3) and (4) of this subsection.
§357.12(b)	Make copies of the regional water plan available for public inspection at least one month before a required public hearing by providing a copy in at least one public library in each county and either the county courthouse's law library, the county clerk's office or some other accessible place within the county courthouse of each county having land in the regional water planning area and include locations of such copies in the notice for public hearing.
§357.12(c)	Regional water planning groups and regional water planning subgroups shall:
§357.12(c)(1)	Conduct all business in a meeting posted and held in accordance with the Texas Open Meetings Act with a copy of all materials presented or discussed available for public inspection prior to and following the meeting; and

Rule	Rule Task
§357.12(c)(2)	Provide notice of regional water planning group and subregional water planning meetings to persons who requested in writing receipt of such notice.
§357.12(d)	Regional water planning groups shall publish agendas, meeting notices, and current adopted initially prepared plans and adopted final regional water plans on the Internet. This requirement can be met by submitting the information, in the format specified by the executive administrator, to the board to be posted on the board's web site.
§358.3	**Guidelines**
§358.3(a)	The executive administrator shall prepare, develop, and formulate the state water plan and the board shall adopt a state water plan no later than January 5, 2002, and before the end of each successive five-year period after that date. The executive administrator shall identify the beginning of the 50-year planning period for the state and regional water plans. The executive administrator shall incorporate into the state water plan presented to the board those regional water plans approved by the board pursuant to Chapter 357 of this title (relating to Regional Water Planning Guidelines). The board shall, not less than 30 days before adoption or amendment of the state water plan, publish notice in the Texas Register of its intent to adopt a state water plan and shall mail notice to each regional water planning group. The board shall hold a hearing, after which it may adopt a water plan or amendments thereto.
§358.3(b)	Development of the state water plan and of regional water plans shall be guided by the following principles:
§358.3(b)(1)	Identification of those policies and actions that may be needed to meet Texas' near- and long-term water needs and preparation for and response to drought conditions, in order that sufficient water will be available at a reasonable cost to satisfy a reasonable projected use of water to ensure public health, safety and welfare, further economic development, and protect the agricultural and natural resources of the state;
§358.3(b)(2)	Decision-making that is open to and accountable to the public with decisions based on accurate, objective and reliable information with full dissemination of planning results;
§358.3(b)(3)	Consideration of the effect of policies or water management strategies on the public interest of the state, water supply and those entities involved in providing this supply throughout the entire state;
§358.3(b)(4)	Consideration of all water management strategies the board determines to be potentially feasible when developing plans to meet future water needs and to respond to drought so that cost effective water management strategies which are consistent with long-term protection of the state's water resources, agricultural resources, and natural resources are considered and approved;
§358.3(b)(5)	Consideration of opportunities that encourage and result in voluntary transfers of water resources, including but not limited to regional water banks, sales, leases, options, subordination agreements, and financing agreements;

Rule	Rule Task
§358.3(b)(6)	Consideration of a balance of economic, social, aesthetic, and ecological viability;
§358.3(b)(7)	For regional water planning areas without approved regional water plans or water providers for which revised plans are not developed through the regional water planning process, the use of information from the adopted state water plan and other completed studies that are sufficient for water planning shall represent the water supply plan for that area or water provider;
§358.3(b)(8)	The orderly development, management, and conservation of water resources;
§358.3(b)(9)	All surface waters are held in trust by the state, their use is subject to rights granted and administered by the commission and the use of surface water is governed by the prior appropriation doctrine, unless adjudicated otherwise.
§358.3(b)(10)	Protect existing water rights, water contracts and option agreements
§358.3(b)(11)	The use of groundwater in Texas is governed by the right of capture doctrine, unless such use is under the authority of a locally controlled groundwater management district.
§358.3(b)(12)	Consideration of recommendations of river and stream segments of unique ecological value to the legislature for potential protection;
§358.3(b)(13)	Consideration of recommendation of sites of unique value for the construction of reservoirs to the legislature for potential protection;
§358.3(b)(14)	Coordination of water planning and management activities of local, regional, state, and federal agencies;
§358.3(b)(15)	Designated water quality and related water uses as shown in the state water quality plan should be improved or maintained;
§358.3(b)(16)	Coordination of water planning and management activities of regional water planning groups to identify common needs and issues and achieve efficient use of water supplies, including the board and the neighboring regional water planning groups, working together to identify common needs, issues, and/or problems and working together to resolve conflicts in a fair, equitable, and efficient manner;
§358.3(b)(17)	Describe water management strategies identified in approved regional water plans to meet near-term needs in sufficient detail to allow a state agency making a financial or regulatory decision to determine if a proposed action before the state agency is consistent with an approved regional water plan;
§358.3(b)(18)	Evaluation of alternative water management strategies using environmental information resulting from site-specific studies, or in the absence of such information, using state environmental planning criteria adopted by the board for inclusion in the state water plan after coordinating with staff of the commission and the Texas Parks and Wildlife Department.
§358.3(b)(19)	Consideration of environmental water needs including instream flows and bay and estuary inflows;
§358.3(b)(20)	Planning consistent with all laws applicable to water use for the state and regional water planning area; and
§358.3(b)(21)	Inclusion of ongoing water development projects which have been issued a permit by the commission or predecessor agency.

Task 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.

More information regarding criteria set forth by TPWD can be found online at http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_issues/sigsegs/.

TPWD has compiled a listing of ecologically significant stream segments located in Region A. 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.

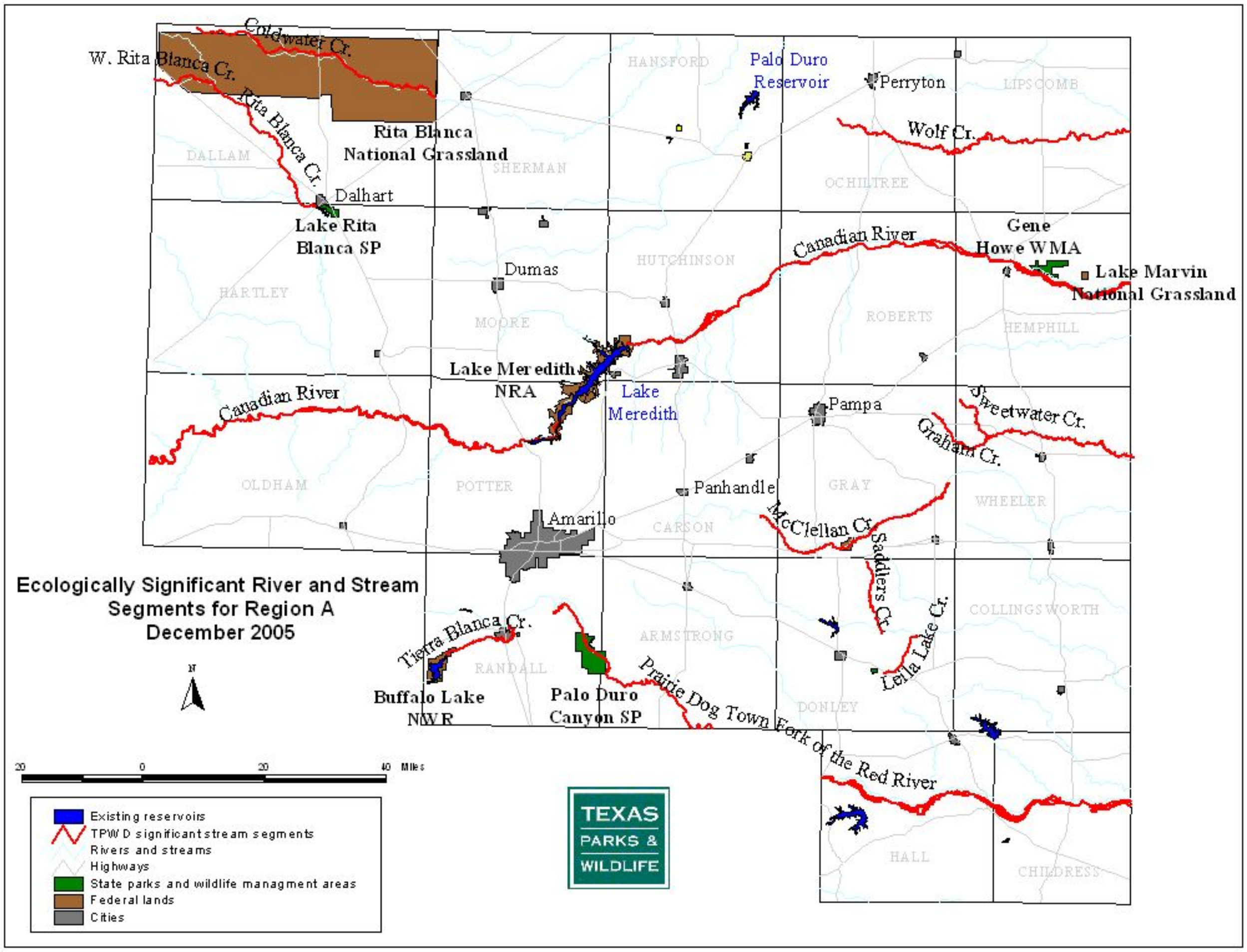


Figure 8-1: Ecologically Significant River and Stream Segments in Region A

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 Senate Bill One-sponsored 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 for the TWDB to consider.

8.3.1 Regulatory Issues

- *Continue to evaluate the rules governing reuse to encourage the use of wastewater effluent.* The current regulatory environment provides a number of barriers to encourage the reuse of wastewater effluent. TCEQ should re-evaluate the current rules and change the rules to provide and quantify incentives for municipalities, industries and agriculture to reuse wastewater effluent.

- *TWDB should modify the criteria used to evaluate the development of irrigation demands.* The PWPG believes that the development of irrigation demand numbers should be performed individually by each planning region using a state-approved methodology.
- *TWDB/TCEQ should evaluate the issue of groundwater rights vs. surface water rights.* The current rules and planning guidelines do not differentiate between handling surface water rights and groundwater rights. A surface water right is a renewable right that can be anticipated to be available every year. A groundwater right may not be necessarily available every year, especially in the case of the Ogallala aquifer which has limited effective annual recharge. The two types of rights also are treated differently under drought of record conditions and in drought management plan recommendations.
- TWDB should submit plans for and results of reservoir feasibility studies to the appropriate Compact Commission (Red River or Canadian River Compact Commission) for review.

8.3.2 Legislative Issues

- *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 Dockum, Rita Blanca, and Whitehorse aquifers.
- *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. It is recommended that the State sponsor programs to help implement these strategies and that the funding provided be specific to a region.
- *Manage groundwater resources through local groundwater conservation districts.* There remain certain areas of the Panhandle Water Planning Area, as well as other parts of the state, that are not within the boundaries of a groundwater district. In order to create an equal situation with regard to groundwater management, these areas should be included in a local district contained within the regional planning area.
- *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.
- *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.
- *Provide funding for expansion of the High Plains-PET network and integration into a statewide network.* 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 enhancement, expansion and/or cost sharing of operating costs of the High Plains-PET network and its integration into a statewide network. This would enable more farms to use the information provided by the network to schedule irrigations, thus using the water more efficiently.

- *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.
- *The PWPG requests that the State should require coordination between Regional Water Planning Groups and all State agencies, for example, regarding the development of the GAM and WAM models to ensure that the two models are not developed independently of or counter to each other.*

8.4 Recommendations for Future State Water Plans

- *TWDB should establish 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.
- *TWDB should improve the monitoring and quantification of small communities, county-other, manufacturing, and livestock operator water use to provide better information for planning purposes.*
- *TCEQ should be made 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.*
- *Clarification of the significance of designating unique reservoir sites and stream segments.* It is recommended that the purpose of designating a unique stream segment or reservoir site be defined before the next planning cycle. It is unclear what the implications are of such a designation.
- *Allow development of alternative near-term scenarios for systems that have less than 3,300 population.* Current planning rules require a single scenario be developed for meeting near-term needs. Since future permits must be consistent with the regional plan, a single State-approved scenario may hamper the ability of a community to make its own choice among viable sources of additional water supply.
- *Alternative definitions of the reliable supply from a reservoir.* The current water plan requires the use of firm yield as the definition of water availability in a reservoir. It is recommended that in future water plans the definition of supply from a reservoir match the owner's operational criteria or definition of supply. For example, a reservoir that is used for steam-electric power generation must maintain a minimum pool level in order to effectively dissipate heat. Another example is the case where

the water rights of a reservoir are less than the firm yield of the reservoir. In addition, many owners of reservoirs prefer to use the more conservative safe yield as the definition of reliable supply from their reservoirs to allow for more severe droughts than those experienced in the past.

- *Include reservoir sites in future water plans.* The PWPG proposes that the TWDB continue to include potentially feasible surface water supply projects in the Panhandle Water Planning Area, including, but not limited to, the potential Sweetwater Creek Reservoir site and the potential Lelia Lake Creek reservoir site. In addition, proposed flood control/aquifer recharge structures in the Red Deer Creek watershed should be included in future state water plans (PWPG Resolutions passed on February 29, 2000 and March 27, 2000).

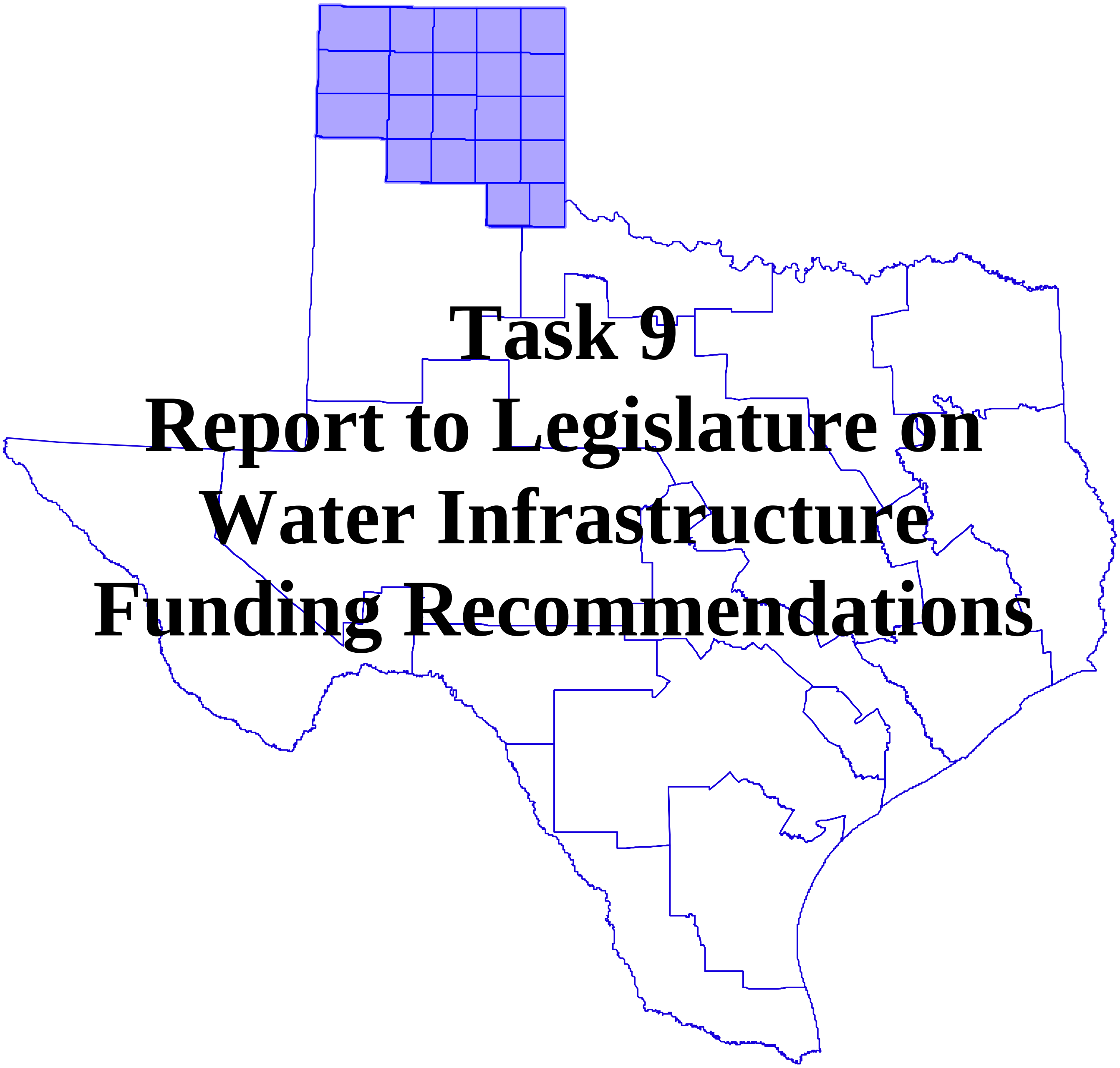
- *Clarification of relationship between drought contingency planning and regional water supply planning.* Historically drought contingency planning has not been part of regional water supply planning. It is not clear what role drought contingency planning has in the regional planning process. Also, since one of the goals of drought contingency planning is demand reduction, it is particularly difficult to analyze conservation strategies because conservation is already included in the demand projections.

- *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. For example, if irrigated acreage is converted to dryland production, there is no provision for developing an economic impact of implementing that water management strategy. A municipal example would be the effects of water/sewer rates charged to each homeowner if a water management strategy is developed to provide for projected future needs.

- *Salinity and brush control projects for the Canadian River and/or Red River Basin.* Although there have been salinity control projects recently implemented in the Canadian and Red River Basins, future State Water Plans should continue to plan for future salinity control projects and their funding to continue to improve water quality in the basins.

- *Interbasin/Intrabasin water transfers.* Future state water plans should provide for a detailed assessment of the potential for transporting water into the Panhandle Water Planning Area from outside regions as well as the potential for transferring groundwater from counties within the region with potentially developable supplies to counties which are showing significant deficits.

- *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.



Task 9
Report to Legislature on Water Infrastructure Funding Recommendations

9.1 Introduction

Senate Bill 2 requires that an Infrastructure Financing Report (IFR) be incorporated into the regional water planning process. In order to meet this requirement, each regional water planning group (RWPG) is required to examine the funding needed to implement the water management strategies and projects identified and recommended in the region's January 2006 water plan.

9.2 Objectives of the Infrastructure Financing Report

The objectives of the IFR are as follows:

- 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 Panhandle Water Planning Area, all municipal water user groups having water needs and recommended water management strategies in the regional plan with an associated cost were surveyed using the questionnaire provided by the TWDB. These surveys are included in this chapter. For individual cities, the survey was mailed to either mayor, city manager, or the utility manager. Surveys were mailed or faxed, along with supporting documentation that summarized the water management strategies included in the regional plan for that entity. Follow up phone contact was made with each political subdivision that did not respond by the due date.

9.4 Survey Responses

The Panhandle WPG mailed survey packages to multiple municipal water user groups and wholesale providers and received a nearly 90 percent response rate. Copies of the completed surveys and related documentation are included in this chapter. As shown in Table 9-1, the responses represent nearly all 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 $60,125,175 out of a total of $203,153,200 (30% of the total capital costs) would be paid from local cash reserves while $122,934,420 (61% of the total capital costs) would paid through bonds. Approximately $3,661,635 (1.8% of the total capital costs) would be financed through State Government programs or through Federal Government programs, and $543,070 (0.3% of the total capital costs) would be financed through other means, such as bank loans.

With respect to the role of the State in financing recommended water supply projects, the Panhandle Water Planning Group recommends that the Legislature provide adequate funding for the implementation of water management strategies in the plan.

Table 9-1: Municipal Water User Groups with Shortages

County	User Group	Basin	COST
Dallam, Hartley	Dalhart	Canadian	$3,029,500
Dallam	County-Other	Canadian	$870,100
Hartley	County-Other	Canadian	$870,100
Moore	Cactus	Canadian	$5,430,700
Moore	Dumas	Canadian	$6,887,900
Moore	Sunray	Canadian	$1,348,200
Moore	County-Other	Canadian	$3,396,800
Potter, Randall	Amarillo	Canadian, Red	$110,856,900
Potter	County-Other	Canadian, Red	$3,396,800
Randall	Canyon	Red	Amarillo Supply
Randall	County-Other	Canadian, Red	$5,136,800
Sherman	Stratford	Canadian	$984,300
Sherman	County-Other	Canadian	$870,100
Multiple	CRMWA	Canadian, Red	$60,075,000
Total			**$203,153,200**

Sample Survey to Obtain Infrastructure Financing Information from Political Subdivisions with Needs

Regional Water Planning Group ___________________________
Political Subdivision (WUG or WWP)________________________

Recommended Project/Strategy	*Implementation Date*	*Capital Cost to be paid by Political Subdivision*	*ID# from DBO7*
TOTAL COST OF CAPITAL IMPROVEMENTS		$	

Are you planning to implement the recommended projects/strategies?
YES NO
If 'no,' describe how you will meet your future water needs.

____
____

If 'yes', how do you plan to finance the proposed <u>total cost of capital improvements</u> identified by your Regional Water Planning Group?

Please indicate:
1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

ڤ %_________ Cash Reserves
ڤ %_________ Bonds
ڤ %_________ Bank Loans
ڤ %_________ Federal Government Programs
ڤ %_________ State Government Programs
ڤ %_________ Other____________________
% ________ *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.

____
____

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

____________________ ____________________ ____________________
Name Title Phone

Completed IFR Surveys for the Panhandle Water Planning Group

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Panhandle Water Planning Group (Region A)
Political Subdivision (WUG or WWP): City of Amarillo

Recommended Project/Strategy	***Implementation Date***	***Capital Cost to be paid by Political Subdivision***	***ID# from DBO7***
Develop Potter County Well Field (Ogallala)	2030	$28,678,200	
Develop Roberts County Well Field (Ogallala)	2050 ~~[illegible]~~	$82,178,700	
TOTAL COST OF CAPITAL IMPROVEMENTS		$110,856,900	

Are you planning to implement the recommended projects/strategies?
X ***YES*** ☐ ***NO***
If 'no,' describe how you will meet your future water needs.

____

____

If 'yes', how do you plan to finance the proposed total cost of capital improvements identified by your Regional Water Planning Group?

Please indicate:
1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

☐ %________ Cash Reserves
☒ % 100 Bonds
☐ %________ Bank Loans
☐ %________ Federal Government Programs
☐ %________ State Government Programs
☐ %________ Other____________________
%________ *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.

____

____

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

Name: ________ Title: Director of Utilities Phone: 806-378-9266

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Panhandle Water Planning Group (Region A)
Political Subdivision (WUG or WWP): City of Cactus

Recommended Project/Strategy	*Implementation Date*	*Capital Cost to be paid by Political Subdivision*	*ID# from DB07*
Additional wells	2010	$1,127,550	
Palo Duro	2010	$1,028 per acre foot	
Conservation	2010	$0	
TOTAL COST OF CAPITAL IMPROVEMENTS		$ 1,127,550	

Are you planning to implement the recommended projects/strategies?

☑ ***YES*** ☐ ***NO*** All wells

If 'no,' describe how you will meet your future water needs.

If 'yes', how do you plan to finance the proposed <u>total cost of capital improvements</u> identified by your Regional Water Planning Group?

Please indicate:

1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

- ☐ % 80 Cash Reserves
- ☐ % 10 Bonds
- ☐ % 10 Bank Loans
- ☐ % 0 Federal Government Programs
- ☐ % 0 State Government Programs
- ☐ % 0 Other__________
- % 100 *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.

NA

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

Name	Title	Phone
[signature]	City Manager	(806) 966-5458

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Panhandle Water Planning Group (Region A)
Political Subdivision (WUG or WWP):

Canadian River Municipal Water Authority (CRMWA)

Recommended Project/Strategy	***Implementation Date***	***Capital Cost to be paid by Political Subdivision***	***ID# from DB07***
Expand Roberts County Well Field (Ogallala)	2010	$43,000,000	
Replace Capacity of Roberts County Well Field (Ogallala)	2020	$17,075,000	
TOTAL COST OF CAPITAL IMPROVEMENTS		$60,075,000	

Are you planning to implement the recommended projects/strategies?
☐ ***YES*** ☐ ***NO***
If 'no,' describe how you will meet your future water needs.

Yes

If 'yes', how do you plan to finance the proposed total cost of capital improvements identified by your Regional Water Planning Group?

Please indicate:
1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

☐ %_____ Cash Reserves
☐ % 100 Bonds
☐ %_____ Bank Loans
☐ %_____ Federal Government Programs
☐ %_____ State Government Programs
☐ %_____ Other_____
% _____ *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

Kent Satterwhite (signature) — Name
Gen Mgr. — Title
806/865-3325 — Phone

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Panhandle Water Planning Group (Region A)
Political Subdivision (WUG or WWP): City of Amarillo

Recommended Project/Strategy	*Implementation Date*	*Capital Cost to be paid by Political Subdivision*	*ID# from DB07*
Additional wells	2050	$11,044,100	
Conservation	2010	$0	
TOTAL COST OF CAPITAL IMPROVEMENTS		$ 11,044,100	

Are you planning to implement the recommended projects/strategies?

☒ ***YES*** ☐ ***NO***

If 'no,' describe how you will meet your future water needs.

____

____

If 'yes', how do you plan to finance the proposed <u>total cost of capital improvements</u> identified by your Regional Water Planning Group?

Please indicate:

1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

☒ %__50__ Cash Reserves
☒ %__50__ Bonds
☐ %________ Bank Loans
☐ %________ Federal Government Programs
☐ %________ State Government Programs
☐ %________ Other________________
%________ *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.

____

____

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

Name	Title	Phone
Dan Coffey	Utilities Director	806-378-4266

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Panhandle Water Planning Group (Region A)
Political Subdivision (WUG or WWP): City of Dalhart

Recommended Project/Strategy	***Implementation Date***	***Capital Cost to be paid by Political Subdivision***	***ID# from DB07***
Additional wells	2010	$2,398,950	
Conservation	2010	$0	
TOTAL COST OF CAPITAL IMPROVEMENTS		$ $2,398,950	

Are you planning to implement the recommended projects/strategies?

☒ ***YES*** ☐ ***NO***

If 'no,' describe how you will meet your future water needs.

____

____

If 'yes', how do you plan to finance the proposed total cost of capital improvements identified by your Regional Water Planning Group?

Please indicate:

1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

- ☐ %__10__ Cash Reserves
- ☐ %______ Bonds
- ☐ %______ Bank Loans
- ☐ %______ Federal Government Programs
- ☐ %__90__ State Government Programs
- ☐ %______ Other______________
- %______ *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.

Low interest loans

____

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

[signature]	City Manager	806-244-5511
Name	Title	Phone

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Panhandle Water Planning Group (Region A)
Political Subdivision (WUG or WWP): City of Dumas

Recommended Project/Strategy	*Implementation Date*	*Capital Cost to be paid by Political Subdivision*	*ID# from DBO7*
Additional wells	2010	$7,363,900	
Palo Duro	2010	$1,028 per acre foot	
Conservation	2010	$0	
TOTAL COST OF CAPITAL IMPROVEMENTS		$ 7,363,900	

Are you planning to implement the recommended projects/strategies?

☑ ***YES*** ☑ ***NO*** ✱ See below

If 'no,' describe how you will meet your future water needs.

We plan to meet our future water needs through acquisition of additional water rights and additional well development. We have no plans to participate in any PDRA project and seriously question its viability.

If 'yes', how do you plan to finance the proposed <u>total cost of capital improvements</u> identified by your Regional Water Planning Group?

Please indicate:

1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

- ☐ %_____ Cash Reserves
- ☑ % 100 Bonds
- ☐ %_____ Bank Loans
- ☐ %_____ Federal Government Programs
- ☐ %_____ State Government Programs
- ☐ %_____ Other_____
- %_____ *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

Name	Title	Phone
Vince DiPizza	City Manager	806-935-4101

SURVEY TO OBTAIN INFRASTRUCTURE FINANCING INFORMATION FROM POLITICAL SUBDIVISIONS WITH NEEDS

Regional Water Planning Group : Panhandle Water Planning Group (Region A)
Political Subdivision (WUG or WWP): City of Stratford

Recommended Project/Strategy	*Implementation Date*	*Capital Cost to be paid by Political Subdivision*	*ID# from DBOT*
Additional wells	2010	$1,028,825	
Conservation	2010	$0	
TOTAL COST OF CAPITAL IMPROVEMENTS		$ 1,028,825	

Are you planning to implement the recommended projects/strategies?
x YES ☐ NO
If 'no,' describe how you will meet your future water needs.

____
____

If 'yes', how do you plan to finance the proposed total cost of capital improvements identified by your Regional Water Planning Group?

Please indicate:
1) Funding source(s)[1] by checking the corresponding box(es) and
2) Percent share of the total cost to be met by each funding source.

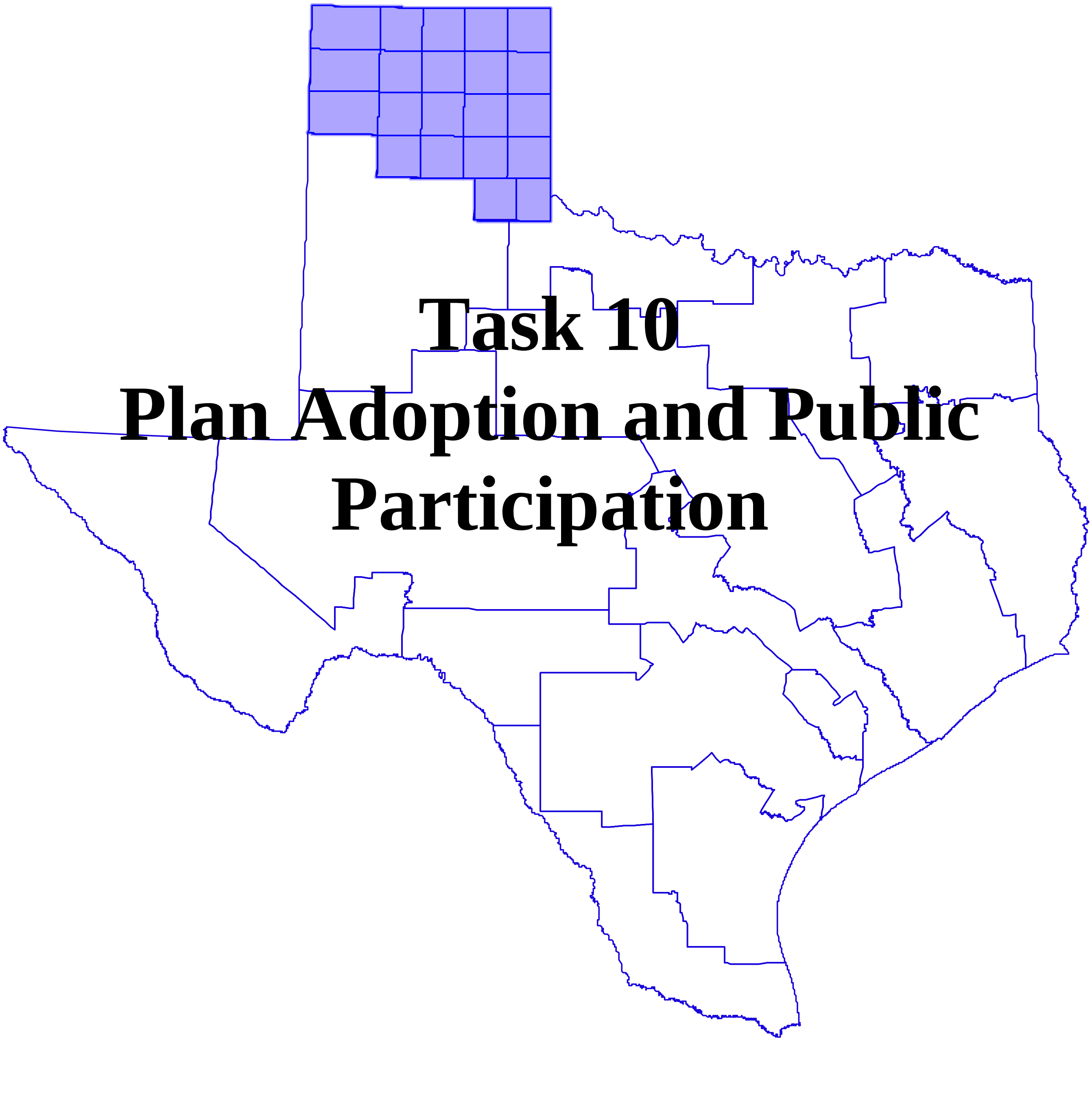
☐ %___5%___ Cash Reserves
☐ %_________ Bonds
☐ %_________ Bank Loans
☐ %_________ Federal Government Programs
☐ %___95%__ State Government Programs
☐ %_________ Other_______________
% __100%_ *TOTAL – (Sum should equal 100%)*

If state government programs are to be utilized for funding, indicate the programs and the provisions of those programs.
Stratford will seek Texas Water Development Board financing through the sale of Bonds.

[1]Funding source refers to the initial capital funds needed to construct or implement a project, not the means of paying off loans or bonds used for the construction or implementation.

Person Completing this Form:

Name	Title	Phone
[signature]	City Manager	806-366-5581



Task 10
Plan Adoption and Public Participation

10.1 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 Panhandle Water Planning Area's Regional Water Plan.

10.2 Panhandle Water Planning Group

The Panhandle Water Planning Group was created in accordance with and operates under the auspices of Senate Bill 1 (1997) and updated with Senate Bill 2 (2001). The enabling legislation and subsequent Texas Water Development Board 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 twenty-two 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 Panhandle Water Planning Group, their respective interest groups, and their principle county of interest. Table 10-2 lists the six former members of the Panhandle Water Planning Group 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
Dan Coffey	Municipalities	Potter/Randall
David Landis	Municipalities	Ochiltree
Bill Hallerberg	Industrial	Gray
Denise Jett	Industrial	Hutchinson
Ben Weinheimer	Agricultural	Region
Rudie Tate	Agricultural	Collingsworth
Janet Tregellas	Agricultural	Lipscomb
B.A. Donelson	Agricultural	Sherman
Dr. Nolan Clark	Environmental	Potter/Randall
Grady Skaggs	Environmental	Oldham
Inge Brady	Environmental	Potter/Randall
Rusty Gilmore	Small Business	Dallam
Gale Henslee	Electric Generating	Utility Region
Jim Derington	River Authorities	Hansford
Richard Bowers	Water Districts	Moore
C.E. Williams	Water Districts	Carson
John Williams	Water Districts	Hutchinson
Bobbie Kidd	Water Districts	Donley
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*
Therese Abraham	General Public	Hemphill
Dean Looper	General Public	Hemphill
Frank Simms	Agriculture	Carson
Robert Jacobson	Environmental	Oldham
Trish Neusch	Environmental	Potter
Michael Nelson	Industrial	Hutchinson

In addition to the 22 voting members, the PWPG has six ex-officio positions in accordance with the appropriate regulations governing the process and one additional ex-officio position established to ensure appropriate representation of regional interests. Table 10-3 lists the six ex-officio positions on the Panhandle Water Planning Group and their respective interests:

Table 10-3: Panhandle Water Planning Group Ex-Officio Positions

PWPG Member	*Ex-Officio Position*	*Interest Group*
Temple McKinnon	Texas Water Development Board	TWDB (Rules)
Steve Jones	Texas Department of Agriculture	TDA (Rules)
Bobbie Kidd (Voting Member)	Region B Liaison	Water Districts
Kent Satterwhite	Region O Liaison & 357.4G4	Water Districts
Mickey Black	USDA/NRCS	Agricultural
Charles Munger	Texas Parks & Wildlife Department	TPWD (Rules)

10.2.1 Panhandle Water Planning Group Public Information and Education Commitment

The Panhandle Water Planning Group (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, B.A. Donelson, Bill Hallerberg, Jim Derington, and Inge Brady. 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, the PWPG provided speakers to interest groups 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 as required by SB1 guidelines. Participation by the media was excellent throughout the process, with Planning Group representatives appearing on numerous media events. The PWPG also received routine press in all regional newspapers and regional radio stations provided public service announcements of relevant events.

- Electronic Communication – Web Access to Planning Information - The Panhandle Water Planning Group 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. In addition, the TWDB website is also a source of materials for PWPG data and reports.

- Public Information Meetings – The PWPG held all meetings in accordance with the open meetings act and encouraged public attendance at the meetings. Minutes of these meetings are available via the PWPG website.

- Symposiums and Forums – The PWPG has provided technical expertise to several symposiums and forums during the planning process. Included among these are the Ogallala Commons, Great Plains Symposium, Panhandle Plains Historical Museum Water Symposium and two Stakeholder Advisory Forums.

- Required Public Hearing – One formal hearing was conducted during the planning process to present and review the Initially Prepared Plan to the Region on August 9, 2005. An excess of 65 people were in attendance of this public hearing.

- Panhandle Water Planning Group Meetings – The Panhandle Water Planning Group conducted 25 meetings. While most meetings were held in Amarillo at the offices of the Panhandle Regional Planning Commission, meetings were also conducted in Bushland and Borger. Sub-groups of the PWPG met 44 times throughout the planning process. All meetings of the PWPG are conducted as open meetings and public attendance has been as high as 60 plus people at one time.

10.3 Public Participation Activities

Specific details on public participation activities conducted during the Regional Water Planning Process are summarized and detailed in this section.

10.3.1 Special Regional Water Planning Presentations

Special Regional Water Planning Presentations - The PWPG, through the direction and oversight of the Public Participation Committee, 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 reached all appropriate interests, presentations were tracked by category to ensure that the public outreach activities conducted achieved 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 within Region A. 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 Panhandle Water Planning Area 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 Senate Bill 1 was on municipal water use, the PWPG also undertook an effort to reach those entities with specific responsibility to provide water for municipal use.

10.3.2 Media Events and Coverage

Media Events: The PWPG made a commitment early in the planning process to enlist the support and interest of the local media. Overall, this effort was successful and yielded several excellent coverage items for the water planning process. The detail below lists several of the many media. 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 interviewed frequently in association with the regular meetings that were held.

D. Radio Coverage: Radio coverage of PWPG activities has been excellent. 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. Smaller newspapers throughout the region have also provided articles, publication notices, and features on water planning.

10.3.3 Electronic Outreach

Electronic Communications: The Panhandle Water Planning Group 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 Senate Bill 1, 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 entire 2005 Initially Prepared Plan, including public comments, references, appendices, and the Executive Summary. 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.

10.3.4 Formal Public Hearing and Advisory Forums
A Public Hearing and two Advisory Forums: The PWPG has conducted a public hearing and two advisory forums throughout the planning process. These meetings have been conducted at key milestones in the process and were designed to keep the region informed and to solicit input at important junctures in the plan from citizens and stakeholders.

A. Stakeholder Advisory Forum: The PWPG conducted two Stakeholder Advisory Forums as required by the TWDB to allow for the various stakeholders in the Northern Ogallala area to comment and discuss the Groundwater Availability Model (GAM).

B. Public Hearing: The Public Hearing was conducted to relay information regarding the Initially Prepared Regional Water Plan.

10.3.5 Surveys
Workshops and 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 and also to relay relevant information to various professional groups through workshops.

A. Surveys: Throughout the planning process, the PWPG conducted three surveys. The first, conducted during the preparation of Task 2, was designed to present to local water user groups a summary of their projected populations and water use demands. Surveys were prepared for each identified municipal water user group in the region and were hand-delivered to each individual user. The information obtained during this process was used to either validate pre-existing population and water demand data or to provide a reference to use in requesting revisions to individual municipal numbers where appropriate. The second survey conducted by the PWPG was during the process of preparing Task 3. The purpose of this survey was to identify the wholesale water providers and establish their populations and demands. The third survey conducted by the PWPG was targeted towards discussing water needs and the cost associated with meeting those needs as specified in Task 9 Infrastructure Finance Reports. The purpose of this survey was to provide all municipal use groups an opportunity to review and accept or modify the strategies proposed to meet future water needs.

10.4 Panhandle Water Planning Group Functions

Members of the PWPG have been quite active and very committed to the planning process. Through the course of the functions detailed below, Planning Group members have contributed approximately 1,800 non-reimbursed hours of time. In addition, PWPG members have traveled over 25,000 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 2,500) 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 27 members, three 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 X details functions conducted by the PWPG or their committees while Appendix Y details the commitment in terms of hours and miles traveled of the PWPG members.

10.4.1 Panhandle Water Planning Group Meetings

Through the 60 month planning process, the PWPG has conducted 25 formal, Planning Group meetings. Attendance at the meetings by the 27 member Panhandle Water Planning Group has been excellent, with appropriate quorums in attendance at all meetings. PWPG meetings have been conducted in Bushland, Borger and Amarillo, with the majority of the meetings being held in the office of the political subdivision, the Panhandle Regional Planning Commission. Frequency of PWPG meetings has averaged one per three months.

10.4.2 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 Model 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, 35 committee meetings have been held, for a frequency of approximately 1.71 per month.

Appendix Z contains a full listing of the PWPG committees and their membership.

10.4.3 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.

10.5 Plan Adoption Process

Plan Adoption: In accordance with Senate Bill 1 and 2 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 August 9, 2005. 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 150 direct mail notices were sent to interested parties, interest groups, agencies, individuals, water rights holders, etc. 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 public libraries or alternate locations in each of the 21 counties. In addition, full posting requirements regarding Secretary of State, County Clerk, and all interested parties were conducted. Attendance at the Hearing totaled over 60 individuals. Oral comments were received at the hearing and written comments were received through Monday, October 10, 2005.

10.5.2 Initially Prepared Plan Adoption

IPP Adoption: The PWPG conducted a formal Planning Group meeting prior to the Public Hearing on June 16, 2005. 25 of the 27 Planning Group members were in attendance and the IPP was given unanimous approval for submission to the Texas Water Development Board.

10.5.3 Response to Comments

Response to Comments: Overall, the PWPG received 121 comments regarding the IPP. Comments were broken out on a line-item basis and distributed to the PWPG. The PWPG carefully considered the comments and proposed responses at the meeting held on

October 27 and December 1, 2005. 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 submitted 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 AA.

10.5.4 Final Regional Water Plan Adoption

The PWPG adopted the final Regional Water Plan for the Panhandle Water Planning Area on December 16, 2005 and approved the same for submission to the TWDB. The Plan was adopted by a unanimous vote.

10.6 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 over $62,000 of the needed $63,000. This equates to over a 98% success rate in raising the needed funds. The PWPG believes this is a strong indicator of the 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 V contains a full listing of the entities and organizations who voluntarily contributed to the Regional Planning Process.

10.7 Conclusion

The Panhandle Water Planning Group 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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APPENDIX A

TWDB DB07 Summary Tables

POPULATION PROJECTIONS FOR REGION A WATER USERS

wug_name	wug_basin	wug_county	P2000	P2010	P2020	P2030	P2040	P2050	P2060
AMARILLO	CANADIAN	POTTER	58,287	62,656	67,364	71,767	76,781	82,253	86,738
AMARILLO	RED	POTTER	41,546	44,660	48,016	51,155	54,729	58,629	61,826
AMARILLO	RED	RANDALL	73,794	80,688	88,117	95,065	102,976	111,611	118,760
BOOKER	CANADIAN	LIPSCOMB	1,306	1,318	1,345	1,305	1,267	1,250	1,189
BOOKER	CANADIAN	OCHILTREE	9	9	9	9	9	9	9
BORGER	CANADIAN	HUTCHINSON	14,302	14,580	14,780	14,574	14,096	13,314	12,641
CACTUS	CANADIAN	MOORE	2,538	2,600	3,000	3,000	3,000	3,000	3,000
CANADIAN	CANADIAN	HEMPHILL	2,233	2,330	2,340	2,262	2,178	2,120	2,015
CANYON	RED	RANDALL	12,875	14,227	15,684	17,047	18,599	20,293	21,695
CHILDRESS	RED	CHILDRESS	6,778	6,918	7,033	7,132	7,167	7,170	6,987
CLARENDON	RED	DONLEY	1,974	1,974	1,974	1,974	1,974	1,974	1,974
CLAUDE	RED	ARMSTRONG	1,313	1,327	1,369	1,322	1,268	1,255	1,219
COUNTY-OTHER	RED	ARMSTRONG	835	844	871	841	806	798	775
COUNTY-OTHER	CANADIAN	CARSON	337	338	342	340	328	299	271
COUNTY-OTHER	RED	CARSON	841	844	853	846	819	744	676
COUNTY-OTHER	RED	CHILDRESS	910	929	944	958	962	963	938
COUNTY-OTHER	RED	COLLINGSWORTH	931	895	898	842	766	709	613
COUNTY-OTHER	CANADIAN	DALLAM	1,063	1,170	1,262	1,320	1,334	1,306	1,245
COUNTY-OTHER	RED	DONLEY	1,854	1,790	1,720	1,562	1,401	1,264	1,052
COUNTY-OTHER	CANADIAN	GRAY	2,382	2,321	2,304	2,239	2,151	2,020	1,892
COUNTY-OTHER	RED	GRAY	1,086	1,058	1,050	1,020	981	921	863
COUNTY-OTHER	RED	HALL	1,303	1,267	1,358	1,416	1,368	1,388	1,303
COUNTY-OTHER	CANADIAN	HANSFORD	1,186	1,388	1,663	1,898	2,152	2,301	2,433
COUNTY-OTHER	CANADIAN	HARTLEY	2,948	3,033	3,135	3,189	3,208	3,168	3,006
COUNTY-OTHER	CANADIAN	HEMPHILL	781	814	818	791	762	741	705
COUNTY-OTHER	RED	HEMPHILL	337	352	353	341	329	320	304
COUNTY-OTHER	CANADIAN	HUTCHINSON	303	308	314	310	299	283	268
COUNTY-OTHER	CANADIAN	LIPSCOMB	1,751	1,766	1,804	1,749	1,699	1,675	1,595
COUNTY-OTHER	CANADIAN	MOORE	1,877	3,307	4,534	5,970	7,110	7,805	8,223
COUNTY-OTHER	CANADIAN	OCHILTREE	1,223	1,223	1,223	1,223	1,223	1,223	1,223
COUNTY-OTHER	CANADIAN	OLDHAM	970	1,031	1,053	979	862	749	606
COUNTY-OTHER	RED	OLDHAM	279	296	303	281	248	216	174
COUNTY-OTHER	CANADIAN	POTTER	8,133	12,019	16,206	20,121	24,578	29,444	33,433
COUNTY-OTHER	RED	POTTER	5,580	8,245	11,117	13,803	16,862	20,200	22,936
COUNTY-OTHER	CANADIAN	RANDALL	54	70	87	101	119	137	153
COUNTY-OTHER	RED	RANDALL	16,729	21,376	26,384	31,068	36,401	42,222	47,041

POPULATION PROJECTIONS FOR REGION A WATER USERS

wug_name	wug_basin	wug_county	P2000	P2010	P2020	P2030	P2040	P2050	P2060
COUNTY-OTHER	CANADIAN	ROBERTS	280	293	302	271	227	197	177
COUNTY-OTHER	RED	ROBERTS	19	20	20	18	15	13	12
COUNTY-OTHER	CANADIAN	SHERMAN	1,195	1,297	1,405	1,447	1,490	1,528	1,547
COUNTY-OTHER	RED	WHEELER	1,877	1,795	1,796	1,785	1,805	1,799	1,766
DALHART	CANADIAN	DALLAM	4,648	5,118	5,518	5,770	5,833	5,711	5,447
DALHART	CANADIAN	HARTLEY	2,589	2,664	2,754	2,800	2,818	2,782	2,640
DUMAS	CANADIAN	MOORE	13,747	14,884	16,123	17,216	18,084	18,613	18,931
FRITCH	CANADIAN	HUTCHINSON	2,226	2,269	2,300	2,268	2,194	2,072	1,968
FRITCH	CANADIAN	MOORE	9	21	34	45	54	59	62
GROOM	RED	CARSON	587	589	595	591	572	520	472
GRUVER	CANADIAN	HANSFORD	1,162	1,169	1,178	1,186	1,195	1,200	1,204
HAPPY	RED	RANDALL	35	66	100	132	168	207	239
HI TEXAS WATER CO	CANADIAN	CARSON	492	494	499	495	479	435	395
HI TEXAS WATER CO	CANADIAN	HUTCHINSON	3,020	3,079	3,121	3,077	2,976	2,811	2,669
LAKE TANGLEWOOD	RED	RANDALL	825	993	1,174	1,344	1,537	1,748	1,923
LEFORS	RED	GRAY	559	545	540	525	505	474	444
MCLEAN	RED	GRAY	830	809	802	780	750	704	659
MEMPHIS	RED	HALL	2,479	2,483	2,474	2,468	2,473	2,471	2,480
MIAMI	CANADIAN	ROBERTS	588	617	633	568	477	412	372
PAMPA	CANADIAN	GRAY	17,887	17,430	17,292	16,807	16,155	15,167	14,206
PANHANDLE	RED	CARSON	2,589	2,599	2,626	2,605	2,521	2,291	2,081
PERRYTON	CANADIAN	OCHILTREE	7,774	8,453	9,208	9,769	10,148	10,334	10,571
SHAMROCK	RED	WHEELER	2,029	1,963	1,963	1,954	1,970	1,966	1,941
SKELLYTOWN	CANADIAN	CARSON	610	612	619	614	594	540	490
SPEARMAN	CANADIAN	HANSFORD	3,021	3,142	3,307	3,448	3,601	3,690	3,769
STINNETT	CANADIAN	HUTCHINSON	1,936	1,974	2,001	1,973	1,908	1,802	1,711
STRATFORD	CANADIAN	SHERMAN	1,991	2,172	2,365	2,439	2,515	2,582	2,617
SUNRAY	CANADIAN	MOORE	1,950	2,237	2,550	2,826	3,045	3,178	3,258
TCW SUPPLY INC	CANADIAN	HUTCHINSON	2,070	2,110	2,139	2,109	2,040	1,927	1,830
TEXLINE	CANADIAN	DALLAM	511	563	607	634	641	628	599
VEGA	CANADIAN	OLDHAM	936	995	1,017	944	832	724	584
WELLINGTON	RED	COLLINGSWORTH	2,275	2,239	2,241	2,187	2,114	2,058	1,965
WHEELER	RED	WHEELER	1,378	1,374	1,374	1,373	1,374	1,374	1,373
WHITE DEER	CANADIAN	CARSON	393	395	399	395	383	348	316
WHITE DEER	RED	CARSON	667	670	677	671	649	590	536

WATER DEMANDS FOR WATER USER GROUPS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WD_2010	WD_2020	WD_2030	WD_2040	WD_2050	WD_2060
AMARILLO	CANADIAN	POTTER	14,107	15,167	16,158	17,287	18,519	19,529
AMARILLO	RED	POTTER	10,055	10,811	11,517	12,322	13,200	13,920
AMARILLO	RED	RANDALL	18,167	19,839	21,404	23,185	25,129	26,739
BOOKER	CANADIAN	LIPSCOMB	354	362	351	341	336	320
BOOKER	CANADIAN	OCHILTREE	2	2	2	2	2	2
BORGER	CANADIAN	HUTCHINSON	2,352	2,384	2,351	2,274	2,148	2,039
CACTUS	CANADIAN	MOORE	533	615	615	615	615	615
CANADIAN	CANADIAN	HEMPHILL	475	477	461	444	432	411
CANYON	RED	RANDALL	2,438	2,688	2,922	3,188	3,478	3,718
CHILDRESS	RED	CHILDRESS	1,457	1,481	1,502	1,509	1,510	1,471
CLARENDON	RED	DONLEY	440	440	440	440	440	440
CLAUDE	RED	ARMSTRONG	262	270	261	250	247	240
COUNTY-OTHER	RED	ARMSTRONG	109	112	108	104	103	100
COUNTY-OTHER	CANADIAN	CARSON	73	74	74	71	65	59
COUNTY-OTHER	RED	CARSON	183	185	184	178	162	147
COUNTY-OTHER	RED	CHILDRESS	196	199	202	203	203	198
COUNTY-OTHER	RED	COLLINGSWORTH	234	234	220	200	185	160
COUNTY-OTHER	CANADIAN	DALLAM	181	195	204	206	202	192
COUNTY-OTHER	RED	DONLEY	219	210	191	171	154	128
COUNTY-OTHER	CANADIAN	GRAY	351	348	339	325	305	286
COUNTY-OTHER	RED	GRAY	160	159	154	148	139	131
COUNTY-OTHER	RED	HALL	353	379	395	382	387	363
COUNTY-OTHER	CANADIAN	HANSFORD	266	319	364	412	441	466
COUNTY-OTHER	CANADIAN	HARTLEY	523	541	550	553	546	519
COUNTY-OTHER	CANADIAN	HEMPHILL	110	111	107	103	100	96
COUNTY-OTHER	RED	HEMPHILL	48	48	46	45	43	41
COUNTY-OTHER	CANADIAN	HUTCHINSON	56	57	57	55	52	49
COUNTY-OTHER	CANADIAN	LIPSCOMB	394	402	390	379	373	356
COUNTY-OTHER	CANADIAN	MOORE	700	960	1,264	1,505	1,652	1,741
COUNTY-OTHER	CANADIAN	OCHILTREE	181	181	181	181	181	181
COUNTY-OTHER	CANADIAN	OLDHAM	135	138	128	113	98	79
COUNTY-OTHER	RED	OLDHAM	39	40	37	33	28	23
COUNTY-OTHER	CANADIAN	POTTER	1,010	1,361	1,690	2,065	2,474	2,809
COUNTY-OTHER	RED	POTTER	693	934	1,160	1,417	1,697	1,927
COUNTY-OTHER	CANADIAN	RANDALL	9	11	13	15	17	19

WATER DEMANDS FOR WATER USER GROUPS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WD_2010	WD_2020	WD_2030	WD_2040	WD_2050	WD_2060
COUNTY-OTHER	RED	RANDALL	2,706	3,340	3,932	4,608	5,344	5,954
COUNTY-OTHER	CANADIAN	ROBERTS	41	42	38	32	28	25
COUNTY-OTHER	RED	ROBERTS	3	3	3	2	2	2
COUNTY-OTHER	CANADIAN	SHERMAN	218	236	243	250	257	260
COUNTY-OTHER	RED	WHEELER	277	278	276	279	278	273
DALHART	CANADIAN	DALLAM	1,319	1,422	1,487	1,503	1,471	1,403
DALHART	CANADIAN	HARTLEY	686	710	721	726	717	680
DUMAS	CANADIAN	MOORE	2,734	2,962	3,163	3,322	3,419	3,478
FRITCH	CANADIAN	HUTCHINSON	407	412	406	393	371	353
FRITCH	CANADIAN	MOORE	4	6	8	10	11	11
GROOM	RED	CARSON	142	143	142	138	125	114
GRUVER	CANADIAN	HANSFORD	325	327	329	332	333	334
HAPPY	RED	RANDALL	11	17	22	27	33	38
HI TEXAS WATER CO	CANADIAN	CARSON	55	55	55	53	48	44
HI TEXAS WATER CO	CANADIAN	HUTCHINSON	341	346	341	330	312	296
IRRIGATION	RED	ARMSTRONG	10,280	10,017	9,490	8,435	7,381	6,854
IRRIGATION	CANADIAN	CARSON	30,371	29,592	28,035	24,920	21,805	20,247
IRRIGATION	RED	CARSON	64,541	62,886	59,576	52,956	46,337	43,027
IRRIGATION	RED	CHILDRESS	10,046	9,789	9,273	8,243	7,213	6,698
IRRIGATION	RED	COLLINGSWORTH	24,967	24,327	23,046	20,486	17,925	16,645
IRRIGATION	CANADIAN	DALLAM	312,463	304,452	288,428	256,380	224,333	208,309
IRRIGATION	RED	DONLEY	20,493	19,968	18,917	16,815	14,713	13,662
IRRIGATION	CANADIAN	GRAY	5,470	5,330	5,049	4,488	3,927	3,647
IRRIGATION	RED	GRAY	19,392	18,894	17,900	15,911	13,923	12,929
IRRIGATION	RED	HALL	20,269	19,749	18,710	16,631	14,552	13,513
IRRIGATION	CANADIAN	HANSFORD	134,929	131,470	124,550	110,711	96,872	89,953
IRRIGATION	CANADIAN	HARTLEY	281,783	274,557	260,107	231,206	202,306	187,855
IRRIGATION	CANADIAN	HEMPHILL	790	764	733	699	671	639
IRRIGATION	RED	HEMPHILL	2,847	2,732	2,621	2,513	2,399	2,290
IRRIGATION	CANADIAN	HUTCHINSON	61,628	60,048	56,887	50,567	44,246	41,085
IRRIGATION	CANADIAN	LIPSCOMB	14,419	14,049	13,310	11,831	10,352	9,613
IRRIGATION	CANADIAN	MOORE	176,079	171,564	162,535	144,475	126,416	117,386
IRRIGATION	CANADIAN	OCHILTREE	101,615	99,009	93,798	83,376	72,954	67,743
IRRIGATION	CANADIAN	OLDHAM	1,579	1,538	1,457	1,295	1,133	1,053
IRRIGATION	RED	OLDHAM	3,513	3,424	3,243	2,883	2,523	2,342

WATER DEMANDS FOR WATER USER GROUPS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WD_2010	WD_2020	WD_2030	WD_2040	WD_2050	WD_2060
IRRIGATION	CANADIAN	POTTER	3,928	3,826	3,625	3,222	2,820	2,618
IRRIGATION	RED	POTTER	3,881	3,782	3,583	3,185	2,786	2,588
IRRIGATION	CANADIAN	RANDALL	292	280	269	258	246	235
IRRIGATION	RED	RANDALL	28,874	27,749	26,624	25,499	24,374	23,249
IRRIGATION	CANADIAN	ROBERTS	19,639	19,135	18,128	16,114	14,099	13,093
IRRIGATION	RED	ROBERTS	2,679	2,611	2,473	2,198	1,924	1,786
IRRIGATION	CANADIAN	SHERMAN	287,336	279,968	265,233	235,763	206,292	191,557
IRRIGATION	RED	WHEELER	8,127	7,919	7,502	6,668	5,835	5,418
LAKE TANGLEWOOD	RED	RANDALL	160	189	217	248	282	310
LEFORS	RED	GRAY	86	85	83	80	75	70
LIVESTOCK	RED	ARMSTRONG	612	645	673	703	734	768
LIVESTOCK	CANADIAN	CARSON	447	473	493	514	536	560
LIVESTOCK	RED	CARSON	569	601	627	654	683	712
LIVESTOCK	RED	CHILDRESS	292	348	353	359	366	372
LIVESTOCK	RED	COLLINGSWORTH	592	656	672	688	705	723
LIVESTOCK	CANADIAN	DALLAM	12,287	18,390	18,614	18,851	19,102	19,369
LIVESTOCK	RED	DONLEY	1,206	1,283	1,332	1,385	1,440	1,500
LIVESTOCK	CANADIAN	GRAY	306	348	363	378	402	412
LIVESTOCK	RED	GRAY	1,877	2,137	2,226	2,322	2,469	2,530
LIVESTOCK	RED	HALL	300	302	305	309	311	316
LIVESTOCK	CANADIAN	HANSFORD	4,744	5,218	5,509	5,817	6,144	6,490
LIVESTOCK	CANADIAN	HARTLEY	7,088	10,236	10,506	10,792	11,096	11,418
LIVESTOCK	CANADIAN	HEMPHILL	964	1,068	1,114	1,163	1,216	1,271
LIVESTOCK	RED	HEMPHILL	671	743	775	809	845	884
LIVESTOCK	CANADIAN	HUTCHINSON	814	1,018	1,051	1,086	1,123	1,163
LIVESTOCK	CANADIAN	LIPSCOMB	831	958	976	996	1,016	1,037
LIVESTOCK	CANADIAN	MOORE	4,172	5,379	5,575	5,783	6,004	6,283
LIVESTOCK	CANADIAN	OCHILTREE	4,538	4,787	4,938	5,098	5,268	5,450
LIVESTOCK	CANADIAN	OLDHAM	2,011	2,146	2,241	2,338	2,441	2,551
LIVESTOCK	RED	OLDHAM	105	112	117	122	128	134
LIVESTOCK	CANADIAN	POTTER	468	490	512	534	557	582
LIVESTOCK	RED	POTTER	35	37	38	40	42	44
LIVESTOCK	CANADIAN	RANDALL	31	34	36	38	40	43
LIVESTOCK	RED	RANDALL	3,142	3,455	3,647	3,850	4,066	4,295
LIVESTOCK	CANADIAN	ROBERTS	591	609	630	651	673	697

WATER DEMANDS FOR WATER USER GROUPS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WD_2010	WD_2020	WD_2030	WD_2040	WD_2050	WD_2060
LIVESTOCK	RED	ROBERTS	18	19	19	20	21	21
LIVESTOCK	CANADIAN	SHERMAN	10,880	16,701	16,903	17,118	17,347	17,589
LIVESTOCK	RED	WHEELER	1,645	1,793	1,852	1,915	1,982	2,053
MANUFACTURING	RED	CARSON	591	669	735	797	849	920
MANUFACTURING	CANADIAN	GRAY	4,264	4,383	4,451	4,497	4,515	4,334
MANUFACTURING	CANADIAN	HANSFORD	49	52	54	56	58	62
MANUFACTURING	CANADIAN	HARTLEY	5	5	5	5	5	5
MANUFACTURING	RED	HEMPHILL	1	1	1	1	1	1
MANUFACTURING	CANADIAN	HUTCHINSON	23,659	25,482	26,969	28,399	29,640	31,708
MANUFACTURING	CANADIAN	LIPSCOMB	89	95	100	104	108	116
MANUFACTURING	CANADIAN	MOORE	7,879	8,450	8,914	9,371	9,773	10,436
MANUFACTURING	CANADIAN	POTTER	1,058	1,164	1,254	1,341	1,417	1,521
MANUFACTURING	RED	POTTER	5,730	6,304	6,789	7,263	7,673	8,236
MANUFACTURING	RED	RANDALL	605	670	726	778	821	892
MCLEAN	RED	GRAY	185	183	178	171	161	151
MEMPHIS	RED	HALL	442	441	440	440	440	442
MIAMI	CANADIAN	ROBERTS	145	149	134	112	97	88
MINING	RED	ARMSTRONG	13	12	12	12	12	12
MINING	CANADIAN	CARSON	975	942	929	918	907	893
MINING	RED	CARSON	486	470	464	458	453	446
MINING	RED	CHILDRESS	17	16	16	16	16	16
MINING	RED	DONLEY	15	14	14	14	14	14
MINING	CANADIAN	GRAY	85	88	89	90	91	93
MINING	RED	GRAY	1,844	1,911	1,939	1,966	1,992	2,025
MINING	RED	HALL	15	14	14	14	14	14
MINING	CANADIAN	HANSFORD	543	533	529	525	521	516
MINING	CANADIAN	HUTCHINSON	398	393	394	395	396	396
MINING	CANADIAN	LIPSCOMB	6	6	6	6	6	6
MINING	CANADIAN	MOORE	1,733	1,716	1,709	1,703	1,697	1,689
MINING	CANADIAN	OCHILTREE	198	213	220	226	232	240
MINING	CANADIAN	OLDHAM	151	156	159	162	164	167
MINING	RED	OLDHAM	177	185	188	190	193	197
MINING	CANADIAN	POTTER	212	236	252	268	285	297
MINING	RED	POTTER	117	131	140	149	157	165
MINING	CANADIAN	RANDALL	2	3	3	3	3	3

WATER DEMANDS FOR WATER USER GROUPS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WD_2010	WD_2020	WD_2030	WD_2040	WD_2050	WD_2060
MINING	RED	RANDALL	16	16	17	18	19	20
MINING	CANADIAN	ROBERTS	1	1	1	1	1	1
MINING	RED	ROBERTS	5	5	5	5	5	5
MINING	CANADIAN	SHERMAN	17	16	16	16	16	16
MINING	RED	WHEELER	89	85	83	82	81	79
PAMPA	CANADIAN	GRAY	3,300	3,273	3,182	3,058	2,871	2,689
PANHANDLE	RED	CARSON	574	579	575	556	506	459
PERRYTON	CANADIAN	OCHILTREE	1,960	2,135	2,265	2,353	2,396	2,451
SHAMROCK	RED	WHEELER	312	312	311	313	313	309
SKELLYTOWN	CANADIAN	CARSON	106	107	106	102	93	85
SPEARMAN	CANADIAN	HANSFORD	707	745	776	811	831	849
STEAM ELECTRIC POWER	CANADIAN	MOORE	200	200	200	200	200	213
STEAM ELECTRIC POWER	CANADIAN	POTTER	22,432	25,387	26,804	28,408	30,011	34,115
STINNETT	CANADIAN	HUTCHINSON	365	370	365	353	333	316
STRATFORD	CANADIAN	SHERMAN	628	683	705	727	746	756
SUNRAY	CANADIAN	MOORE	534	608	674	727	758	777
TCW SUPPLY INC	CANADIAN	HUTCHINSON	603	611	602	583	550	523
TEXLINE	CANADIAN	DALLAM	211	227	237	240	235	224
VEGA	CANADIAN	OLDHAM	242	247	229	202	176	142
WELLINGTON	RED	COLLINGSWORTH	456	457	446	431	420	401
WHEELER	RED	WHEELER	291	291	291	291	291	291
WHITE DEER	CANADIAN	CARSON	61	61	61	59	53	48
WHITE DEER	RED	CARSON	103	104	103	100	91	82

CURRENT WATER SUPPLIES TO WATER USER GROUPS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	so_name	so_basin	so_county	WS2010	WS2020	WS2030	WS2040	WS2050	WS2060
AMARILLO	CANADIAN	POTTER	MEREDITH LAKE	CANADIAN	RESERVOIR	5,165	5,098	4,888	4,867	5,070	5,100
AMARILLO	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	CARSON	930	934	906	884	850	737
AMARILLO	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	POTTER	3,720	3,420	3,120	2,760	2,400	2,100
AMARILLO	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	ROBERTS	5,731	5,813	4,920	4,037	3,308	3,295
AMARILLO	RED	POTTER	MEREDITH LAKE	CANADIAN	RESERVOIR	3,681	3,634	3,484	3,469	3,614	3,635
AMARILLO	RED	POTTER	OGALLALA AQUIFER	CANADIAN	ROBERTS	4,084	4,143	3,507	2,877	2,358	2,349
AMARILLO	RED	POTTER	OGALLALA AQUIFER	RED	CARSON	835	824	790	757	717	623
AMARILLO	RED	POTTER	OGALLALA AQUIFER	RED	POTTER	2,480	2,280	2,080	1,840	1,600	1,400
AMARILLO	RED	RANDALL	MEREDITH LAKE	CANADIAN	RESERVOIR	6,651	6,668	6,476	6,528	6,879	6,983
AMARILLO	RED	RANDALL	OGALLALA AQUIFER	CANADIAN	ROBERTS	7,379	7,604	6,518	5,413	4,488	4,511
AMARILLO	RED	RANDALL	OGALLALA AQUIFER	RED	CARSON	5,235	4,942	4,603	4,159	3,732	3,239
AMARILLO	RED	RANDALL	OGALLALA AQUIFER	RED	RANDALL	630	630	630	630	630	630
AMARILLO	RED	RANDALL	OGALLALA AQUIFER	RED	DEAF SMITH	125	125	100	100	50	14
BOOKER	CANADIAN	LIPSCOMB	OGALLALA AQUIFER	CANADIAN	LIPSCOMB	1,500	1,500	1,500	1,500	1,500	1,500
BOOKER	CANADIAN	OCHILTREE	OGALLALA AQUIFER	CANADIAN	OCHILTREE	10	10	10	10	10	10
BORGER	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	2,247	2,075	1,915	1,821	1,724	1,570
BORGER	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	ROBERTS	916	900	900	900	900	900
CACTUS	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	MOORE	420	390	353	331	311	277
CANADIAN	CANADIAN	HEMPHILL	OGALLALA AQUIFER	CANADIAN	HEMPHILL	2,450	2,450	2,450	2,450	2,450	2,450
CANYON	RED	RANDALL	MEREDITH LAKE	CANADIAN	RESERVOIR	1,000	1,000	1,000	942	829	765
CANYON	RED	RANDALL	OGALLALA AQUIFER	RED	RANDALL	2,300	2,300	2,300	2,300	2,300	2,300
CHILDRESS	RED	CHILDRESS	GREENBELT LAKE	RED	RESERVOIR	1,457	1,481	1,502	1,509	1,510	1,471
CLARENDON	RED	DONLEY	GREENBELT LAKE	RED	RESERVOIR	440	440	440	440	440	440
CLAUDE	RED	ARMSTRONG	OGALLALA AQUIFER	RED	ARMSTRONG	711	711	711	711	711	711
COUNTY-OTHER	RED	ARMSTRONG	OGALLALA AQUIFER	RED	ARMSTRONG	400	400	400	400	400	400
COUNTY-OTHER	CANADIAN	CARSON	OGALLALA AQUIFER	CANADIAN	CARSON	249	237	228	225	208	185
COUNTY-OTHER	RED	CARSON	OGALLALA AQUIFER	RED	CARSON	215	205	197	194	180	160
COUNTY-OTHER	RED	CHILDRESS	GREENBELT LAKE	RED	RESERVOIR	196	199	202	203	203	198
COUNTY-OTHER	RED	CHILDRESS	SEYMOUR AQUIFER	RED	CHILDRESS	20	20	20	20	20	20
COUNTY-OTHER	RED	COLLINGSWORTH	SEYMOUR AQUIFER	RED	COLLINGSWORTH	158	158	158	158	158	158
COUNTY-OTHER	RED	COLLINGSWORTH	BLAINE AQUIFER	RED	COLLINGSWORTH	83	83	83	83	83	83
COUNTY-OTHER	RED	COLLINGSWORTH	OTHER AQUIFER	RED	COLLINGSWORTH	6	6	6	6	6	6
COUNTY-OTHER	CANADIAN	DALLAM	OGALLALA AQUIFER	CANADIAN	DALLAM	73	66	61	58	57	52
COUNTY-OTHER	RED	DONLEY	GREENBELT LAKE	RED	RESERVOIR	219	210	191	171	154	128
COUNTY-OTHER	RED	DONLEY	OGALLALA AQUIFER	RED	DONLEY	180	180	180	180	180	180
COUNTY-OTHER	CANADIAN	GRAY	OGALLALA AQUIFER	CANADIAN	GRAY	432	432	432	432	432	432
COUNTY-OTHER	RED	GRAY	OGALLALA AQUIFER	RED	GRAY	197	197	197	197	197	197
COUNTY-OTHER	RED	HALL	GREENBELT LAKE	RED	RESERVOIR	152	152	152	152	152	152
COUNTY-OTHER	RED	HALL	OGALLALA AQUIFER	RED	DONLEY	85	85	85	85	85	85
COUNTY-OTHER	RED	HALL	SEYMOUR AQUIFER	RED	HALL	192	192	192	192	192	192
COUNTY-OTHER	CANADIAN	HANSFORD	OGALLALA AQUIFER	CANADIAN	HANSFORD	413	424	440	487	535	554
COUNTY-OTHER	CANADIAN	HARTLEY	OGALLALA AQUIFER	CANADIAN	HARTLEY	434	417	408	429	452	421
COUNTY-OTHER	CANADIAN	HEMPHILL	OGALLALA AQUIFER	CANADIAN	HEMPHILL	132	132	132	132	132	132
COUNTY-OTHER	RED	HEMPHILL	OGALLALA AQUIFER	RED	HEMPHILL	90	90	90	90	90	90
COUNTY-OTHER	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	56	57	57	55	52	49
COUNTY-OTHER	CANADIAN	LIPSCOMB	OGALLALA AQUIFER	CANADIAN	LIPSCOMB	473	473	473	473	473	473
COUNTY-OTHER	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	MOORE	205	190	172	161	152	136
COUNTY-OTHER	CANADIAN	OCHILTREE	OGALLALA AQUIFER	CANADIAN	OCHILTREE	386	406	429	474	523	550
COUNTY-OTHER	CANADIAN	OLDHAM	DOCKUM AQUIFER	CANADIAN	OLDHAM	384	384	384	384	384	384

CURRENT WATER SUPPLIES TO WATER USER GROUPS IN REGION A

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wug_name	wug_basin	wug_county	so_name	so_basin	so_county	WS2010	WS2020	WS2030	WS2040	WS2050	WS2060
COUNTY-OTHER	CANADIAN	OLDHAM	OGALLALA AQUIFER	CANADIAN	OLDHAM	160	160	160	160	160	160
COUNTY-OTHER	RED	OLDHAM	OGALLALA AQUIFER	RED	OLDHAM	46	46	45	44	44	44
COUNTY-OTHER	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	POTTER	1,200	1,200	1,200	1,200	1,200	1,200
COUNTY-OTHER	CANADIAN	POTTER	DOCKUM AQUIFER	CANADIAN	POTTER	566	566	566	566	566	566
COUNTY-OTHER	RED	POTTER	OGALLALA AQUIFER	RED	POTTER	831	831	831	831	831	831
COUNTY-OTHER	CANADIAN	RANDALL	MEREDITH LAKE	CANADIAN	RESERVOIR	25	25	25	24	21	19
COUNTY-OTHER	RED	RANDALL	OGALLALA AQUIFER	RED	RANDALL	2,982	3,250	3,250	3,250	3,250	3,250
COUNTY-OTHER	RED	RANDALL	DOCKUM AQUIFER	RED	RANDALL	85	85	85	85	85	85
COUNTY-OTHER	CANADIAN	ROBERTS	OGALLALA AQUIFER	CANADIAN	ROBERTS	60	60	60	60	60	60
COUNTY-OTHER	RED	ROBERTS	OGALLALA AQUIFER	RED	ROBERTS	5	5	5	5	5	5
COUNTY-OTHER	CANADIAN	SHERMAN	OGALLALA AQUIFER	CANADIAN	SHERMAN	154	142	127	119	113	100
COUNTY-OTHER	RED	WHEELER	SEYMOUR AQUIFER	RED	WHEELER	21	21	21	21	21	21
COUNTY-OTHER	RED	WHEELER	OGALLALA AQUIFER	RED	WHEELER	348	348	348	348	348	348
COUNTY-OTHER	RED	WHEELER	BLAINE AQUIFER	RED	WHEELER	15	15	15	15	15	15
COUNTY-OTHER	RED	WHEELER	OTHER AQUIFER	RED	WHEELER	22	22	22	22	22	22
DALHART	CANADIAN	DALLAM	OGALLALA AQUIFER	CANADIAN	DALLAM	717	645	593	570	557	512
DALHART	CANADIAN	HARTLEY	OGALLALA AQUIFER	CANADIAN	HARTLEY	569	547	534	563	592	552
DUMAS	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	HARTLEY	162	119	100	99	120	171
DUMAS	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	MOORE	1,706	1,501	1,307	1,191	1,104	973
FRITCH	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	587	545	506	482	458	419
FRITCH	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	4	6	8	10	11	11
GROOM	RED	CARSON	OGALLALA AQUIFER	RED	CARSON	166	158	152	150	139	124
GRUVER	CANADIAN	HANSFORD	OGALLALA AQUIFER	CANADIAN	HANSFORD	607	622	646	714	784	813
HAPPY	RED	RANDALL	OTHER AQUIFER	RED	RANDALL	40	40	37	35	35	35
HAPPY	RED	RANDALL	DOCKUM AQUIFER	RED	RANDALL	50	50	50	50	50	50
HI TEXAS WATER COMPAN	CANADIAN	CARSON	OGALLALA AQUIFER	CANADIAN	CARSON	100	100	100	100	100	100
HI TEXAS WATER COMPAN	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	400	400	400	400	400	400
IRRIGATION	RED	ARMSTRONG	OGALLALA AQUIFER	RED	ARMSTRONG	15,000	15,000	15,000	15,000	15,000	15,000
IRRIGATION	CANADIAN	CARSON	OGALLALA AQUIFER	CANADIAN	CARSON	40,000	40,000	40,000	40,000	40,000	40,000
IRRIGATION	CANADIAN	CARSON	DIRECT REUSE	CANADIAN	CARSON	4	3	3	3	3	3
IRRIGATION	RED	CARSON	OGALLALA AQUIFER	RED	CARSON	84,600	77,800	71,300	65,250	58,490	53,340
IRRIGATION	RED	CARSON	DIRECT REUSE	RED	CARSON	10	10	10	10	10	10
IRRIGATION	RED	CARSON	RED RUN-OF-RIVER	RED	CARSON	300	300	300	300	300	300
IRRIGATION	RED	CHILDRESS	BLAINE AQUIFER	RED	CHILDRESS	8,993	8,993	8,993	8,993	8,993	8,993
IRRIGATION	RED	CHILDRESS	OTHER AQUIFER	RED	CHILDRESS	62	62	62	62	62	62
IRRIGATION	RED	CHILDRESS	SEYMOUR AQUIFER	RED	CHILDRESS	1,200	1,200	1,200	1,200	1,200	1,200
IRRIGATION	RED	CHILDRESS	DIRECT REUSE	RED	CHILDRESS	120	117	117	118	120	120
IRRIGATION	RED	CHILDRESS	RED RUN-OF-RIVER	RED	CHILDRESS	28	28	28	28	28	28
IRRIGATION	RED	COLLINGSWORTH	RED RUN-OF-RIVER	RED	COLLINGSWORTH	798	798	798	798	798	798
IRRIGATION	RED	COLLINGSWORTH	SEYMOUR AQUIFER	RED	COLLINGSWORTH	18,721	18,221	17,221	17,221	17,221	17,221
IRRIGATION	RED	COLLINGSWORTH	BLAINE AQUIFER	RED	COLLINGSWORTH	10,579	10,579	10,579	10,579	10,579	10,579
IRRIGATION	RED	COLLINGSWORTH	OGALLALA AQUIFER	RED	COLLINGSWORTH	1,021	1,020	1,019	1,018	1,017	1,016
IRRIGATION	RED	COLLINGSWORTH	DIRECT REUSE	RED	COLLINGSWORTH	300	300	300	300	300	300
IRRIGATION	CANADIAN	DALLAM	RITA BLANCA AQUIFER	CANADIAN	DALLAM	5,096	5,096	5,096	5,096	5,096	5,096
IRRIGATION	CANADIAN	DALLAM	OGALLALA AQUIFER	CANADIAN	DALLAM	175,213	142,335	118,230	99,355	86,248	76,847
IRRIGATION	CANADIAN	DALLAM	DOCKUM AQUIFER	CANADIAN	DALLAM	6,806	6,806	6,806	6,806	6,806	6,806
IRRIGATION	CANADIAN	DALLAM	DIRECT REUSE	CANADIAN	DALLAM	430	421	409	391	379	379
IRRIGATION	RED	DONLEY	OGALLALA AQUIFER	RED	DONLEY	34,220	32,433	29,935	25,999	22,313	20,381
IRRIGATION	RED	DONLEY	RED RUN-OF-RIVER	RED	DONLEY	195	195	195	195	195	195

CURRENT WATER SUPPLIES TO WATER USER GROUPS IN REGION A

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wug_name	wug_basin	wug_county	so_name	so_basin	so_county	WS2010	WS2020	WS2030	WS2040	WS2050	WS2060
IRRIGATION	CANADIAN	GRAY	OGALLALA AQUIFER	CANADIAN	GRAY	7,701	7,332	7,010	6,524	6,026	5,764
IRRIGATION	CANADIAN	GRAY	DIRECT REUSE	CANADIAN	GRAY	1,672	1,654	1,423	1,383	1,346	1,346
IRRIGATION	CANADIAN	GRAY	CANADIAN RUN-OF-RIVER	CANADIAN	GRAY	1	1	1	1	1	1
IRRIGATION	RED	GRAY	OGALLALA AQUIFER	RED	GRAY	25,783	24,546	23,468	21,841	20,172	19,296
IRRIGATION	RED	GRAY	DIRECT REUSE	RED	GRAY	230	225	192	185	179	179
IRRIGATION	RED	GRAY	RED RUN-OF-RIVER	RED	GRAY	33	33	33	33	33	33
IRRIGATION	RED	HALL	SEYMOUR AQUIFER	RED	HALL	20,272	19,772	18,774	18,774	18,774	18,774
IRRIGATION	RED	HALL	DIRECT REUSE	RED	HALL	7	6	6	6	5	5
IRRIGATION	RED	HALL	RED RUN-OF-RIVER	RED	HALL	59	59	59	59	59	59
IRRIGATION	CANADIAN	HANSFORD	CANADIAN RUN-OF-RIVER	CANADIAN	HANSFORD	150	149	147	146	144	144
IRRIGATION	CANADIAN	HANSFORD	OGALLALA AQUIFER	CANADIAN	HANSFORD	247,173	230,371	214,354	199,083	185,395	173,589
IRRIGATION	CANADIAN	HANSFORD	CANADIAN RUN-OF-RIVER	CANADIAN	HANSFORD	22	22	22	22	22	22
IRRIGATION	CANADIAN	HARTLEY	OGALLALA AQUIFER	CANADIAN	HARTLEY	265,497	237,439	155,713	100,278	59,503	46,679
IRRIGATION	CANADIAN	HEMPHILL	OGALLALA AQUIFER	CANADIAN	HEMPHILL	1,977	1,880	1,830	1,776	1,718	1,662
IRRIGATION	RED	HEMPHILL	OGALLALA AQUIFER	RED	HEMPHILL	6,213	5,908	5,749	5,582	5,400	5,221
IRRIGATION	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	54,558	45,224	38,086	26,202	18,132	10,558
IRRIGATION	CANADIAN	HUTCHINSON	CANADIAN RUN-OF-RIVER	CANADIAN	HUTCHINSON	96	96	96	96	96	96
IRRIGATION	CANADIAN	LIPSCOMB	CANADIAN RUN-OF-RIVER	CANADIAN	LIPSCOMB	66	66	66	66	66	66
IRRIGATION	CANADIAN	LIPSCOMB	OGALLALA AQUIFER	CANADIAN	LIPSCOMB	30,000	30,000	30,000	30,000	30,000	30,000
IRRIGATION	CANADIAN	LIPSCOMB	DIRECT REUSE	CANADIAN	LIPSCOMB	34	34	34	34	34	34
IRRIGATION	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	MOORE	100,950	79,708	61,607	47,555	37,469	30,292
IRRIGATION	CANADIAN	MOORE	DOCKUM AQUIFER	CANADIAN	MOORE	14,100	14,100	13,300	11,600	10,200	8,900
IRRIGATION	CANADIAN	MOORE	CANADIAN RUN-OF-RIVER	CANADIAN	MOORE	7	7	7	7	7	7
IRRIGATION	CANADIAN	MOORE	DIRECT REUSE	CANADIAN	MOORE	547	592	633	664	684	696
IRRIGATION	CANADIAN	OCHILTREE	OGALLALA AQUIFER	CANADIAN	OCHILTREE	130,000	128,424	121,765	115,359	109,565	104,683
IRRIGATION	CANADIAN	OLDHAM	DOCKUM AQUIFER	CANADIAN	OLDHAM	562	562	562	562	562	562
IRRIGATION	CANADIAN	OLDHAM	OGALLALA AQUIFER	CANADIAN	OLDHAM	20,439	19,549	18,901	17,691	16,872	16,181
IRRIGATION	RED	OLDHAM	OGALLALA AQUIFER	RED	OLDHAM	3,607	3,450	3,335	3,122	2,977	2,856
IRRIGATION	CANADIAN	POTTER	CANADIAN RUN-OF-RIVER	CANADIAN	POTTER	327	326	325	324	322	322
IRRIGATION	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	POTTER	12,231	8,328	6,539	4,374	2,857	1,672
IRRIGATION	CANADIAN	POTTER	DIRECT REUSE	RED	RANDALL	700	700	700	700	700	700
IRRIGATION	RED	POTTER	RED RUN-OF-RIVER	RED	POTTER	1,359	1,359	1,358	1,358	1,357	1,357
IRRIGATION	RED	POTTER	OGALLALA AQUIFER	RED	POTTER	3,251	2,214	1,738	1,163	759	445
IRRIGATION	RED	POTTER	DIRECT REUSE	RED	RANDALL	750	750	750	750	750	786
IRRIGATION	CANADIAN	RANDALL	OGALLALA AQUIFER	CANADIAN	RANDALL	280	270	260	250	240	230
IRRIGATION	CANADIAN	RANDALL	DIRECT REUSE	CANADIAN	RANDALL	16	16	16	16	16	16
IRRIGATION	RED	RANDALL	RED RUN-OF-RIVER	RED	RANDALL	634	630	627	624	621	621
IRRIGATION	RED	RANDALL	OGALLALA AQUIFER	RED	RANDALL	50,215	41,651	36,191	29,521	28,083	25,176
IRRIGATION	RED	RANDALL	DIRECT REUSE	RED	RANDALL	1,450	1,450	1,450	1,450	1,450	1,450
IRRIGATION	RED	RANDALL	RED RUN-OF-RIVER	RED	RANDALL	175	175	175	175	175	175
IRRIGATION	CANADIAN	ROBERTS	OGALLALA AQUIFER	CANADIAN	ROBERTS	23,850	22,619	21,167	18,821	16,585	15,339
IRRIGATION	CANADIAN	ROBERTS	CANADIAN RUN-OF-RIVER	CANADIAN	ROBERTS	72	72	72	72	72	72
IRRIGATION	RED	ROBERTS	OGALLALA AQUIFER	RED	ROBERTS	3,992	3,786	3,528	3,153	2,781	2,573
IRRIGATION	CANADIAN	SHERMAN	CANADIAN RUN-OF-RIVER	CANADIAN	SHERMAN	406	405	404	402	400	400
IRRIGATION	CANADIAN	SHERMAN	OGALLALA AQUIFER	CANADIAN	SHERMAN	202,392	167,228	137,449	111,104	89,737	73,039
IRRIGATION	CANADIAN	SHERMAN	CANADIAN RUN-OF-RIVER	CANADIAN	SHERMAN	32	32	32	32	32	32
IRRIGATION	RED	WHEELER	SEYMOUR AQUIFER	RED	WHEELER	38	38	38	38	38	38
IRRIGATION	RED	WHEELER	OGALLALA AQUIFER	RED	WHEELER	12,203	12,061	11,876	11,504	11,079	10,771
IRRIGATION	RED	WHEELER	BLAINE AQUIFER	RED	WHEELER	15	15	15	15	15	15

CURRENT WATER SUPPLIES TO WATER USER GROUPS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	so_name	so_basin	so_county	WS2010	WS2020	WS2030	WS2040	WS2050	WS2060
IRRIGATION	RED	WHEELER	OTHER AQUIFER	RED	WHEELER	280	280	280	280	280	280
IRRIGATION	RED	WHEELER	DIRECT REUSE	RED	WHEELER	16	15	15	15	14	14
IRRIGATION	RED	WHEELER	RED RUN-OF-RIVER	RED	WHEELER	580	580	580	580	580	580
LAKE TANGLEWOOD	RED	RANDALL	OGALLALA AQUIFER	RED	RANDALL	535	666	783	840	840	840
LEFORS	RED	GRAY	OGALLALA AQUIFER	RED	GRAY	509	509	509	509	509	509
LIVESTOCK	RED	ARMSTRONG	LIVESTOCK LOCAL SUPPLY	RED	ARMSTRONG	121	121	121	121	121	121
LIVESTOCK	RED	ARMSTRONG	OGALLALA AQUIFER	RED	ARMSTRONG	844	845	916	997	1,162	1,361
LIVESTOCK	RED	ARMSTRONG	OTHER AQUIFER	RED	ARMSTRONG	102	102	102	102	102	102
LIVESTOCK	CANADIAN	CARSON	LIVESTOCK LOCAL SUPPLY	CANADIAN	CARSON	125	125	125	125	125	125
LIVESTOCK	CANADIAN	CARSON	OGALLALA AQUIFER	CANADIAN	CARSON	587	599	613	662	712	739
LIVESTOCK	RED	CARSON	LIVESTOCK LOCAL SUPPLY	RED	CARSON	159	159	159	159	159	159
LIVESTOCK	RED	CARSON	OGALLALA AQUIFER	RED	CARSON	662	676	691	747	803	833
LIVESTOCK	RED	CHILDRESS	LIVESTOCK LOCAL SUPPLY	RED	CHILDRESS	300	300	300	300	300	300
LIVESTOCK	RED	CHILDRESS	SEYMOUR AQUIFER	RED	CHILDRESS	100	100	100	100	100	100
LIVESTOCK	RED	COLLINGSWORTH	LIVESTOCK LOCAL SUPPLY	RED	COLLINGSWORTH	750	750	750	750	750	750
LIVESTOCK	RED	COLLINGSWORTH	SEYMOUR AQUIFER	RED	COLLINGSWORTH	26	26	26	26	26	26
LIVESTOCK	RED	COLLINGSWORTH	BLAINE AQUIFER	RED	COLLINGSWORTH	36	36	36	36	36	36
LIVESTOCK	RED	COLLINGSWORTH	OTHER AQUIFER	RED	COLLINGSWORTH	24	24	24	24	24	24
LIVESTOCK	RED	COLLINGSWORTH	OGALLALA AQUIFER	RED	COLLINGSWORTH	23	23	23	23	23	23
LIVESTOCK	CANADIAN	DALLAM	LIVESTOCK LOCAL SUPPLY	CANADIAN	DALLAM	741	741	741	741	741	741
LIVESTOCK	CANADIAN	DALLAM	RITA BLANCA AQUIFER	CANADIAN	DALLAM	73	73	73	73	73	73
LIVESTOCK	CANADIAN	DALLAM	OGALLALA AQUIFER	CANADIAN	DALLAM	6,698	8,564	7,622	7,342	7,438	7,274
LIVESTOCK	RED	DONLEY	LIVESTOCK LOCAL SUPPLY	RED	DONLEY	1,225	1,225	1,225	1,225	1,225	1,225
LIVESTOCK	RED	DONLEY	OTHER AQUIFER	RED	DONLEY	71	71	71	71	71	71
LIVESTOCK	RED	DONLEY	OGALLALA AQUIFER	RED	DONLEY	403	417	422	428	437	448
LIVESTOCK	CANADIAN	GRAY	LIVESTOCK LOCAL SUPPLY	CANADIAN	GRAY	732	732	732	732	732	732
LIVESTOCK	CANADIAN	GRAY	OGALLALA AQUIFER	CANADIAN	GRAY	100	100	100	100	100	100
LIVESTOCK	RED	GRAY	LIVESTOCK LOCAL SUPPLY	RED	GRAY	2,000	2,000	2,000	2,000	2,000	2,000
LIVESTOCK	RED	GRAY	OGALLALA AQUIFER	RED	GRAY	1,400	1,700	1,700	1,800	2,000	2,100
LIVESTOCK	RED	HALL	LIVESTOCK LOCAL SUPPLY	RED	HALL	301	301	301	301	301	301
LIVESTOCK	RED	HALL	SEYMOUR AQUIFER	RED	HALL	28	28	26	26	26	26
LIVESTOCK	RED	HALL	OTHER AQUIFER	RED	HALL	18	18	18	18	18	18
LIVESTOCK	CANADIAN	HANSFORD	LIVESTOCK LOCAL SUPPLY	CANADIAN	HANSFORD	2,464	2,464	2,464	2,464	2,464	2,464
LIVESTOCK	CANADIAN	HANSFORD	OGALLALA AQUIFER	CANADIAN	HANSFORD	4,177	4,826	5,241	6,029	7,043	7,769
LIVESTOCK	CANADIAN	HARTLEY	LIVESTOCK LOCAL SUPPLY	CANADIAN	HARTLEY	1,702	1,702	1,702	1,702	1,702	1,702
LIVESTOCK	CANADIAN	HARTLEY	OGALLALA AQUIFER	CANADIAN	HARTLEY	4,071	6,383	6,257	6,747	7,565	8,135
LIVESTOCK	CANADIAN	HARTLEY	DOCKUM AQUIFER	CANADIAN	HARTLEY	1,161	1,161	1,161	1,161	1,161	1,161
LIVESTOCK	CANADIAN	HEMPHILL	LIVESTOCK LOCAL SUPPLY	CANADIAN	HEMPHILL	524	524	524	524	524	524
LIVESTOCK	CANADIAN	HEMPHILL	OGALLALA AQUIFER	CANADIAN	HEMPHILL	812	993	1,092	1,199	1,313	1,437
LIVESTOCK	RED	HEMPHILL	LIVESTOCK LOCAL SUPPLY	RED	HEMPHILL	364	364	364	364	364	364
LIVESTOCK	RED	HEMPHILL	OGALLALA AQUIFER	RED	HEMPHILL	638	780	858	942	1,032	1,129
LIVESTOCK	CANADIAN	HUTCHINSON	LIVESTOCK LOCAL SUPPLY	CANADIAN	HUTCHINSON	493	493	493	493	493	493
LIVESTOCK	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	474	712	713	748	799	821
LIVESTOCK	CANADIAN	LIPSCOMB	LIVESTOCK LOCAL SUPPLY	CANADIAN	LIPSCOMB	657	657	657	657	657	657
LIVESTOCK	CANADIAN	LIPSCOMB	OGALLALA AQUIFER	CANADIAN	LIPSCOMB	2,610	4,553	5,042	5,936	7,053	7,948
LIVESTOCK	CANADIAN	MOORE	LIVESTOCK LOCAL SUPPLY	CANADIAN	MOORE	981	981	981	981	981	981
LIVESTOCK	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	MOORE	1,989	2,226	1,896	1,719	1,619	1,480
LIVESTOCK	CANADIAN	OCHILTREE	LIVESTOCK LOCAL SUPPLY	CANADIAN	OCHILTREE	2,506	2,506	2,506	2,506	2,506	2,506
LIVESTOCK	CANADIAN	OCHILTREE	OGALLALA AQUIFER	CANADIAN	OCHILTREE	4,517	4,931	5,262	5,977	6,913	7,582

CURRENT WATER SUPPLIES TO WATER USER GROUPS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	so_name	so_basin	so_county	WS2010	WS2020	WS2030	WS2040	WS2050	WS2060
LIVESTOCK	CANADIAN	OLDHAM	LIVESTOCK LOCAL SUPPLY	CANADIAN	OLDHAM	1,187	1,187	1,187	1,187	1,187	1,187
LIVESTOCK	CANADIAN	OLDHAM	DOCKUM AQUIFER	CANADIAN	OLDHAM	180	180	180	180	180	180
LIVESTOCK	CANADIAN	OLDHAM	OGALLALA AQUIFER	CANADIAN	OLDHAM	1,379	1,633	1,868	2,183	2,631	2,993
LIVESTOCK	RED	OLDHAM	LIVESTOCK LOCAL SUPPLY	RED	OLDHAM	62	62	62	62	62	62
LIVESTOCK	RED	OLDHAM	OGALLALA AQUIFER	RED	OLDHAM	487	576	659	770	928	1,056
LIVESTOCK	CANADIAN	POTTER	LIVESTOCK LOCAL SUPPLY	CANADIAN	POTTER	480	480	480	480	480	480
LIVESTOCK	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	POTTER	1,565	1,176	1,079	991	986	784
LIVESTOCK	CANADIAN	POTTER	DOCKUM AQUIFER	CANADIAN	POTTER	13	13	13	13	13	13
LIVESTOCK	RED	POTTER	LIVESTOCK LOCAL SUPPLY	RED	POTTER	36	36	36	36	36	36
LIVESTOCK	RED	POTTER	OGALLALA AQUIFER	RED	POTTER	416	313	287	263	262	208
LIVESTOCK	CANADIAN	RANDALL	LIVESTOCK LOCAL SUPPLY	CANADIAN	RANDALL	5	5	5	5	5	5
LIVESTOCK	CANADIAN	RANDALL	OGALLALA AQUIFER	CANADIAN	RANDALL	40	40	40	40	40	40
LIVESTOCK	RED	RANDALL	LIVESTOCK LOCAL SUPPLY	RED	RANDALL	511	511	511	511	511	511
LIVESTOCK	RED	RANDALL	OGALLALA AQUIFER	RED	RANDALL	4,995	4,910	4,802	4,443	4,779	4,865
LIVESTOCK	RED	RANDALL	DOCKUM AQUIFER	RED	RANDALL	230	230	230	230	230	230
LIVESTOCK	CANADIAN	ROBERTS	LIVESTOCK LOCAL SUPPLY	CANADIAN	ROBERTS	500	500	500	500	500	500
LIVESTOCK	CANADIAN	ROBERTS	OGALLALA AQUIFER	CANADIAN	ROBERTS	231	231	233	239	245	249
LIVESTOCK	RED	ROBERTS	LIVESTOCK LOCAL SUPPLY	RED	ROBERTS	15	15	15	15	15	15
LIVESTOCK	RED	ROBERTS	OGALLALA AQUIFER	RED	ROBERTS	22	22	22	23	24	25
LIVESTOCK	CANADIAN	SHERMAN	LIVESTOCK LOCAL SUPPLY	CANADIAN	SHERMAN	699	699	699	699	699	699
LIVESTOCK	CANADIAN	SHERMAN	OGALLALA AQUIFER	CANADIAN	SHERMAN	7,162	9,549	8,388	7,728	7,233	6,431
LIVESTOCK	RED	WHEELER	LIVESTOCK LOCAL SUPPLY	RED	WHEELER	1,561	1,561	1,561	1,561	1,561	1,561
LIVESTOCK	RED	WHEELER	SEYMOUR AQUIFER	RED	WHEELER	29	29	29	29	29	29
LIVESTOCK	RED	WHEELER	OGALLALA AQUIFER	RED	WHEELER	1,886	2,022	2,374	3,370	4,644	5,896
LIVESTOCK	RED	WHEELER	BLAINE AQUIFER	RED	WHEELER	19	19	19	19	19	19
LIVESTOCK	RED	WHEELER	OTHER AQUIFER	RED	WHEELER	29	29	29	29	29	29
MANUFACTURING	RED	CARSON	OGALLALA AQUIFER	RED	CARSON	706	756	802	889	963	1,024
MANUFACTURING	CANADIAN	GRAY	OGALLALA AQUIFER	CANADIAN	GRAY	4,768	4,794	4,875	5,193	5,555	5,532
MANUFACTURING	CANADIAN	HANSFORD	OGALLALA AQUIFER	CANADIAN	HANSFORD	90	91	93	101	111	120
MANUFACTURING	CANADIAN	HARTLEY	OGALLALA AQUIFER	CANADIAN	HARTLEY	5	5	5	5	5	5
MANUFACTURING	RED	HEMPHILL	OGALLALA AQUIFER	RED	HEMPHILL	1	1	1	1	1	1
MANUFACTURING	CANADIAN	HUTCHINSON	MEREDITH LAKE	CANADIAN	RESERVOIR	1,845	1,845	1,845	1,845	1,845	1,845
MANUFACTURING	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	18,859	18,037	17,826	15,630	14,640	13,277
MANUFACTURING	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	ROBERTS	255	255	255	255	255	255
MANUFACTURING	CANADIAN	HUTCHINSON	DIRECT REUSE	CANADIAN	HUTCHINSON	400	400	400	400	400	400
MANUFACTURING	CANADIAN	LIPSCOMB	OGALLALA AQUIFER	CANADIAN	LIPSCOMB	120	120	120	120	120	120
MANUFACTURING	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	MOORE	4,851	4,201	3,581	3,242	3,038	2,809
MANUFACTURING	CANADIAN	POTTER	MEREDITH LAKE	CANADIAN	RESERVOIR	514	622	665	726	775	949
MANUFACTURING	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	POTTER	544	542	589	615	642	572
MANUFACTURING	RED	POTTER	MEREDITH LAKE	CANADIAN	RESERVOIR	6,002	6,547	7,056	7,055	6,456	6,213
MANUFACTURING	RED	POTTER	OGALLALA AQUIFER	RED	POTTER	145	144	157	164	171	152
MANUFACTURING	RED	RANDALL	MEREDITH LAKE	CANADIAN	RESERVOIR	300	300	300	283	250	230
MANUFACTURING	RED	RANDALL	OGALLALA AQUIFER	RED	RANDALL	498	480	475	616	643	662
MCLEAN	RED	GRAY	OGALLALA AQUIFER	RED	GRAY	463	463	463	463	463	463
MEMPHIS	RED	HALL	GREENBELT LAKE	RED	RESERVOIR	100	100	100	100	100	100
MEMPHIS	RED	HALL	OGALLALA AQUIFER	RED	DONLEY	505	505	505	505	505	505
MIAMI	CANADIAN	ROBERTS	OGALLALA AQUIFER	CANADIAN	ROBERTS	541	541	541	541	541	541
MINING	RED	ARMSTRONG	OGALLALA AQUIFER	RED	ARMSTRONG	82	56	52	53	58	64
MINING	CANADIAN	CARSON	OGALLALA AQUIFER	CANADIAN	CARSON	1,173	1,071	1,021	1,031	1,036	1,001

CURRENT WATER SUPPLIES TO WATER USER GROUPS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	so_name	so_basin	so_county	WS2010	WS2020	WS2030	WS2040	WS2050	WS2060
MINING	RED	CARSON	OGALLALA AQUIFER	RED	CARSON	500	500	500	500	500	500
MINING	RED	CHILDRESS	OTHER LOCAL SUPPLY	RED	CHILDRESS	21	21	21	21	21	21
MINING	RED	DONLEY	OGALLALA AQUIFER	RED	DONLEY	50	45	44	43	42	42
MINING	CANADIAN	GRAY	OGALLALA AQUIFER	CANADIAN	GRAY	125	125	125	125	125	125
MINING	RED	GRAY	OGALLALA AQUIFER	RED	GRAY	2,500	2,500	2,500	2,500	2,500	2,500
MINING	RED	HALL	OTHER AQUIFER	RED	HALL	22	22	22	22	22	22
MINING	CANADIAN	HANSFORD	OGALLALA AQUIFER	CANADIAN	HANSFORD	995	934	910	944	997	996
MINING	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	593	536	506	501	505	487
MINING	CANADIAN	LIPSCOMB	OGALLALA AQUIFER	CANADIAN	LIPSCOMB	90	91	95	105	118	125
MINING	CANADIAN	MOORE	OTHER LOCAL SUPPLY	CANADIAN	MOORE	1,658	1,658	1,658	1,658	1,658	1,658
MINING	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	MOORE	77	59	51	46	43	39
MINING	CANADIAN	OCHILTREE	OGALLALA AQUIFER	CANADIAN	OCHILTREE	440	460	476	521	581	618
MINING	CANADIAN	OLDHAM	DOCKUM AQUIFER	CANADIAN	OLDHAM	283	283	283	283	283	283
MINING	CANADIAN	OLDHAM	OGALLALA AQUIFER	CANADIAN	OLDHAM	3	3	3	3	3	3
MINING	RED	OLDHAM	OGALLALA AQUIFER	RED	OLDHAM	232	237	246	263	291	306
MINING	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	POTTER	550	550	550	550	550	550
MINING	RED	POTTER	OGALLALA AQUIFER	RED	POTTER	150	150	150	150	160	165
MINING	CANADIAN	RANDALL	OGALLALA AQUIFER	CANADIAN	RANDALL	3	3	3	3	3	3
MINING	RED	RANDALL	OGALLALA AQUIFER	RED	RANDALL	16	16	17	18	19	20
MINING	CANADIAN	ROBERTS	OGALLALA AQUIFER	CANADIAN	ROBERTS	2	2	2	2	2	2
MINING	RED	ROBERTS	OGALLALA AQUIFER	RED	ROBERTS	25	25	25	25	25	25
MINING	CANADIAN	SHERMAN	OGALLALA AQUIFER	CANADIAN	SHERMAN	32	30	28	28	27	26
MINING	RED	WHEELER	OGALLALA AQUIFER	RED	WHEELER	145	145	145	145	145	145
PAMPA	CANADIAN	GRAY	MEREDITH LAKE	CANADIAN	RESERVOIR	4,566	4,566	4,566	4,566	4,566	4,566
PAMPA	CANADIAN	GRAY	OGALLALA AQUIFER	CANADIAN	GRAY	2,670	2,670	2,670	2,670	2,670	2,670
PANHANDLE	RED	CARSON	OGALLALA AQUIFER	RED	CARSON	672	641	615	608	562	501
PERRYTON	CANADIAN	OCHILTREE	OGALLALA AQUIFER	CANADIAN	OCHILTREE	3,790	3,790	3,790	3,790	3,790	3,790
SHAMROCK	RED	WHEELER	OGALLALA AQUIFER	RED	WHEELER	1,490	1,490	1,490	1,490	1,490	1,490
SKELLYTOWN	CANADIAN	CARSON	OGALLALA AQUIFER	CANADIAN	CARSON	357	341	327	323	299	266
SPEARMAN	CANADIAN	HANSFORD	OGALLALA AQUIFER	CANADIAN	HANSFORD	1,357	1,391	1,442	1,595	1,693	1,693
STEAM ELECTRIC POWER	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	MOORE	125	101	83	72	64	59
STEAM ELECTRIC POWER	CANADIAN	POTTER	MEREDITH LAKE	CANADIAN	RESERVOIR	556	0	0	0	0	0
STEAM ELECTRIC POWER	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	POTTER	2,146	2,146	2,146	2,146	2,146	2,146
STEAM ELECTRIC POWER	CANADIAN	POTTER	OGALLALA AQUIFER	CANADIAN	ROBERTS	349	0	0	0	0	0
STEAM ELECTRIC POWER	CANADIAN	POTTER	DIRECT REUSE	CANADIAN	POTTER	19,381	23,241	24,658	26,262	27,865	31,969
STINNETT	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	594	552	512	488	463	425
STRATFORD	CANADIAN	SHERMAN	OGALLALA AQUIFER	CANADIAN	SHERMAN	441	406	363	340	322	286
SUNRAY	CANADIAN	MOORE	OGALLALA AQUIFER	CANADIAN	MOORE	333	308	279	260	245	217
TCW SUPPLY INC	CANADIAN	HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	787	730	678	646	613	562
TEXLINE	CANADIAN	DALLAM	RITA BLANCA AQUIFER	CANADIAN	DALLAM	250	250	250	250	250	250
VEGA	CANADIAN	OLDHAM	OGALLALA AQUIFER	CANADIAN	OLDHAM	529	529	529	529	529	529
WELLINGTON	RED	COLLINGSWORTH	SEYMOUR AQUIFER	RED	COLLINGSWORTH	466	466	466	466	466	466
WHEELER	RED	WHEELER	OGALLALA AQUIFER	RED	WHEELER	981	981	981	981	981	981
WHITE DEER	CANADIAN	CARSON	OGALLALA AQUIFER	CANADIAN	CARSON	250	238	229	226	209	186
WHITE DEER	RED	CARSON	OGALLALA AQUIFER	RED	CARSON	120	115	110	109	101	90

PROJECTED WATER SURPLUS OR SHORTAGE FOR WUGS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WNS2010	WNS2020	WNS2030	WNS2040	WNS2050	WNS2060
AMARILLO	CANADIAN	POTTER	1,439	98	-2,324	-4,739	-6,891	-8,297
AMARILLO	RED	POTTER	1,025	70	-1,656	-3,379	-4,911	-5,913
AMARILLO	RED	RANDALL	1,853	130	-3,077	-6,355	-9,350	-11,362
BOOKER	CANADIAN	LIPSCOMB	1,146	1,138	1,149	1,159	1,164	1,180
BOOKER	CANADIAN	OCHILTREE	8	8	8	8	8	8
BORGER	CANADIAN	HUTCHINSON	811	591	464	447	476	431
CACTUS	CANADIAN	MOORE	-113	-225	-262	-284	-304	-338
CANADIAN	CANADIAN	HEMPHILL	1,975	1,973	1,989	2,006	2,018	2,039
CANYON	RED	RANDALL	862	612	378	54	-349	-653
CHILDRESS	RED	CHILDRESS	0	0	0	0	0	0
CLARENDON	RED	DONLEY	0	0	0	0	0	0
CLAUDE	RED	ARMSTRONG	449	441	450	461	464	471
COUNTY-OTHER	RED	ARMSTRONG	291	288	292	296	297	300
COUNTY-OTHER	CANADIAN	CARSON	176	163	154	154	143	126
COUNTY-OTHER	RED	CARSON	32	20	13	16	18	13
COUNTY-OTHER	RED	CHILDRESS	20	20	20	20	20	20
COUNTY-OTHER	RED	COLLINGSWORTH	13	13	27	47	62	87
COUNTY-OTHER	CANADIAN	DALLAM	-108	-129	-143	-148	-145	-140
COUNTY-OTHER	RED	DONLEY	180	180	180	180	180	180
COUNTY-OTHER	CANADIAN	GRAY	81	84	93	107	127	146
COUNTY-OTHER	RED	GRAY	37	38	43	49	58	66
COUNTY-OTHER	RED	HALL	76	50	34	47	42	66
COUNTY-OTHER	CANADIAN	HANSFORD	147	105	76	75	94	88
COUNTY-OTHER	CANADIAN	HARTLEY	-89	-124	-142	-124	-94	-98
COUNTY-OTHER	CANADIAN	HEMPHILL	22	21	25	29	32	36
COUNTY-OTHER	RED	HEMPHILL	42	42	44	45	47	49
COUNTY-OTHER	CANADIAN	HUTCHINSON	0	0	0	0	0	0
COUNTY-OTHER	CANADIAN	LIPSCOMB	79	71	83	94	100	117
COUNTY-OTHER	CANADIAN	MOORE	-495	-770	-1,092	-1,344	-1,500	-1,605
COUNTY-OTHER	CANADIAN	OCHILTREE	205	225	248	293	342	369
COUNTY-OTHER	CANADIAN	OLDHAM	409	406	416	431	446	465
COUNTY-OTHER	RED	OLDHAM	7	6	8	11	16	21
COUNTY-OTHER	CANADIAN	POTTER	756	405	76	-299	-708	-1,043
COUNTY-OTHER	RED	POTTER	138	-103	-329	-586	-866	-1,096
COUNTY-OTHER	CANADIAN	RANDALL	16	14	12	9	4	0

PROJECTED WATER SURPLUS OR SHORTAGE FOR WUGS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WNS2010	WNS2020	WNS2030	WNS2040	WNS2050	WNS2060
COUNTY-OTHER	RED	RANDALL	361	-5	-597	-1,273	-2,009	-2,619
COUNTY-OTHER	CANADIAN	ROBERTS	19	18	22	28	32	35
COUNTY-OTHER	RED	ROBERTS	2	2	2	3	3	3
COUNTY-OTHER	CANADIAN	SHERMAN	-64	-94	-116	-131	-144	-160
COUNTY-OTHER	RED	WHEELER	129	128	130	127	128	133
DALHART	CANADIAN	DALLAM	-602	-777	-894	-933	-914	-891
DALHART	CANADIAN	HARTLEY	-117	-163	-187	-163	-125	-128
DUMAS	CANADIAN	MOORE	-866	-1,342	-1,756	-2,032	-2,195	-2,334
FRITCH	CANADIAN	HUTCHINSON	180	133	100	89	87	66
FRITCH	CANADIAN	MOORE	0	0	0	0	0	0
GROOM	RED	CARSON	24	15	10	12	14	10
GRUVER	CANADIAN	HANSFORD	282	295	317	382	451	479
HAPPY	RED	RANDALL	79	73	65	58	52	47
HI TEXAS WATER CO	CANADIAN	CARSON	45	45	45	47	52	56
HI TEXAS WATER CO	CANADIAN	HUTCHINSON	59	54	59	70	88	104
IRRIGATION	RED	ARMSTRONG	4,720	4,983	5,510	6,565	7,619	8,146
IRRIGATION	CANADIAN	CARSON	9,633	10,411	11,968	15,083	18,198	19,756
IRRIGATION	RED	CARSON	20,369	15,224	12,034	12,604	12,463	10,623
IRRIGATION	RED	CHILDRESS	357	611	1,127	2,158	3,190	3,705
IRRIGATION	RED	COLLINGSWORTH	6,452	6,591	6,871	9,430	11,990	13,269
IRRIGATION	CANADIAN	DALLAM	-124,918	-149,794	-157,887	-144,732	-125,804	-119,181
IRRIGATION	RED	DONLEY	13,922	12,660	11,213	9,379	7,795	6,914
IRRIGATION	CANADIAN	GRAY	3,904	3,657	3,385	3,420	3,446	3,464
IRRIGATION	RED	GRAY	6,654	5,910	5,793	6,148	6,461	6,579
IRRIGATION	RED	HALL	69	88	129	2,208	4,286	5,325
IRRIGATION	CANADIAN	HANSFORD	112,416	99,072	89,973	88,540	88,689	83,802
IRRIGATION	CANADIAN	HARTLEY	-16,286	-37,118	-104,394	-130,928	-142,803	-141,176
IRRIGATION	CANADIAN	HEMPHILL	1,187	1,116	1,097	1,077	1,047	1,023
IRRIGATION	RED	HEMPHILL	3,366	3,176	3,128	3,069	3,001	2,931
IRRIGATION	CANADIAN	HUTCHINSON	-6,974	-14,728	-18,705	-24,269	-26,018	-30,431
IRRIGATION	CANADIAN	LIPSCOMB	15,681	16,051	16,790	18,269	19,748	20,487
IRRIGATION	CANADIAN	MOORE	-60,475	-77,157	-86,988	-84,649	-78,056	-77,491
IRRIGATION	CANADIAN	OCHILTREE	28,385	29,415	27,967	31,983	36,611	36,940
IRRIGATION	CANADIAN	OLDHAM	19,422	18,573	18,006	16,958	16,301	15,690
IRRIGATION	RED	OLDHAM	94	26	92	239	454	514

PROJECTED WATER SURPLUS OR SHORTAGE FOR WUGS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WNS2010	WNS2020	WNS2030	WNS2040	WNS2050	WNS2060
IRRIGATION	CANADIAN	POTTER	9,330	5,528	3,939	2,176	1,059	76
IRRIGATION	RED	POTTER	1,479	541	263	86	80	0
IRRIGATION	CANADIAN	RANDALL	4	6	7	8	10	11
IRRIGATION	RED	RANDALL	23,600	16,157	11,819	6,271	5,955	4,173
IRRIGATION	CANADIAN	ROBERTS	4,283	3,556	3,111	2,779	2,558	2,318
IRRIGATION	RED	ROBERTS	1,313	1,175	1,055	955	857	787
IRRIGATION	CANADIAN	SHERMAN	-84,506	-112,303	-127,348	-124,225	-116,123	-118,086
IRRIGATION	RED	WHEELER	5,005	5,070	5,302	5,764	6,171	6,280
LAKE TANGLEWOOD	RED	RANDALL	375	477	566	592	558	530
LEFORS	RED	GRAY	423	424	426	429	434	439
LIVESTOCK	RED	ARMSTRONG	455	423	466	517	651	816
LIVESTOCK	CANADIAN	CARSON	265	251	245	273	301	304
LIVESTOCK	RED	CARSON	252	234	223	252	279	280
LIVESTOCK	RED	CHILDRESS	108	52	47	41	34	28
LIVESTOCK	RED	COLLINGSWORTH	267	203	187	171	154	136
LIVESTOCK	CANADIAN	DALLAM	-4,775	-9,012	-10,178	-10,695	-10,850	-11,281
LIVESTOCK	RED	DONLEY	493	430	386	339	293	244
LIVESTOCK	CANADIAN	GRAY	526	484	469	454	430	420
LIVESTOCK	RED	GRAY	1,523	1,563	1,474	1,478	1,531	1,570
LIVESTOCK	RED	HALL	47	45	40	36	34	29
LIVESTOCK	CANADIAN	HANSFORD	1,897	2,072	2,196	2,676	3,363	3,743
LIVESTOCK	CANADIAN	HARTLEY	-154	-990	-1,386	-1,182	-668	-420
LIVESTOCK	CANADIAN	HEMPHILL	372	449	502	560	621	690
LIVESTOCK	RED	HEMPHILL	331	401	447	497	551	609
LIVESTOCK	CANADIAN	HUTCHINSON	153	187	155	155	169	151
LIVESTOCK	CANADIAN	LIPSCOMB	2,436	4,252	4,723	5,597	6,694	7,568
LIVESTOCK	CANADIAN	MOORE	-1,202	-2,172	-2,698	-3,083	-3,404	-3,822
LIVESTOCK	CANADIAN	OCHILTREE	2,485	2,650	2,830	3,385	4,151	4,638
LIVESTOCK	CANADIAN	OLDHAM	735	854	994	1,212	1,557	1,809
LIVESTOCK	RED	OLDHAM	444	526	604	710	862	984
LIVESTOCK	CANADIAN	POTTER	1,590	1,179	1,060	950	922	695
LIVESTOCK	RED	POTTER	417	312	285	259	256	200
LIVESTOCK	CANADIAN	RANDALL	14	11	9	7	5	2
LIVESTOCK	RED	RANDALL	2,594	2,196	1,896	1,334	1,454	1,311
LIVESTOCK	CANADIAN	ROBERTS	140	122	103	88	72	52

PROJECTED WATER SURPLUS OR SHORTAGE FOR WUGS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WNS2010	WNS2020	WNS2030	WNS2040	WNS2050	WNS2060
LIVESTOCK	RED	ROBERTS	19	18	18	18	18	19
LIVESTOCK	CANADIAN	SHERMAN	-3,019	-6,453	-7,816	-8,691	-9,415	-10,459
LIVESTOCK	RED	WHEELER	1,879	1,867	2,160	3,093	4,300	5,481
MANUFACTURING	RED	CARSON	115	87	67	92	114	104
MANUFACTURING	CANADIAN	GRAY	504	411	424	696	1,040	1,198
MANUFACTURING	CANADIAN	HANSFORD	41	39	39	45	53	58
MANUFACTURING	CANADIAN	HARTLEY	0	0	0	0	0	0
MANUFACTURING	RED	HEMPHILL	0	0	0	0	0	0
MANUFACTURING	CANADIAN	HUTCHINSON	-2,300	-4,945	-6,643	-10,269	-12,500	-15,931
MANUFACTURING	CANADIAN	LIPSCOMB	31	25	20	16	12	4
MANUFACTURING	CANADIAN	MOORE	-3,028	-4,249	-5,333	-6,129	-6,735	-7,627
MANUFACTURING	CANADIAN	POTTER	0	0	0	0	0	0
MANUFACTURING	RED	POTTER	417	387	424	-44	-1,046	-1,871
MANUFACTURING	RED	RANDALL	193	110	49	121	72	0
MCLEAN	RED	GRAY	278	280	285	292	302	312
MEMPHIS	RED	HALL	163	164	165	165	165	163
MIAMI	CANADIAN	ROBERTS	396	392	407	429	444	453
MINING	RED	ARMSTRONG	69	44	40	41	46	52
MINING	CANADIAN	CARSON	198	129	92	113	129	108
MINING	RED	CARSON	14	30	36	42	47	54
MINING	RED	CHILDRESS	4	5	5	5	5	5
MINING	RED	DONLEY	35	31	30	29	28	28
MINING	CANADIAN	GRAY	40	37	36	35	34	32
MINING	RED	GRAY	656	589	561	534	508	475
MINING	RED	HALL	7	8	8	8	8	8
MINING	CANADIAN	HANSFORD	452	401	381	419	476	480
MINING	CANADIAN	HUTCHINSON	195	143	112	106	109	91
MINING	CANADIAN	LIPSCOMB	84	85	89	99	112	119
MINING	CANADIAN	MOORE	2	1	0	1	4	8
MINING	CANADIAN	OCHILTREE	242	247	256	295	349	378
MINING	CANADIAN	OLDHAM	135	130	127	124	122	119
MINING	RED	OLDHAM	55	52	58	73	98	109
MINING	CANADIAN	POTTER	338	314	298	282	265	253
MINING	RED	POTTER	33	19	10	1	3	0
MINING	CANADIAN	RANDALL	1	0	0	0	0	0

PROJECTED WATER SURPLUS OR SHORTAGE FOR WUGS IN REGION A

-Values in ac-ft/yr-

wug_name	wug_basin	wug_county	WNS2010	WNS2020	WNS2030	WNS2040	WNS2050	WNS2060
MINING	RED	RANDALL	0	0	0	0	0	0
MINING	CANADIAN	ROBERTS	1	1	1	1	1	1
MINING	RED	ROBERTS	20	20	20	20	20	20
MINING	CANADIAN	SHERMAN	15	14	12	12	11	10
MINING	RED	WHEELER	56	60	62	63	64	66
PAMPA	CANADIAN	GRAY	3,936	3,963	4,054	4,178	4,365	4,547
PANHANDLE	RED	CARSON	98	62	40	52	56	42
PERRYTON	CANADIAN	OCHILTREE	1,830	1,655	1,525	1,437	1,394	1,339
SHAMROCK	RED	WHEELER	1,178	1,178	1,179	1,177	1,177	1,181
SKELLYTOWN	CANADIAN	CARSON	251	234	221	221	206	181
SPEARMAN	CANADIAN	HANSFORD	650	646	666	784	862	844
STEAM ELECTRIC POWER	CANADIAN	MOORE	-75	-99	-117	-128	-136	-154
STEAM ELECTRIC POWER	CANADIAN	POTTER	0	0	0	0	0	0
STINNETT	CANADIAN	HUTCHINSON	229	182	147	135	130	109
STRATFORD	CANADIAN	SHERMAN	-187	-277	-342	-387	-424	-470
SUNRAY	CANADIAN	MOORE	-201	-300	-395	-467	-513	-560
TCW SUPPLY INC	CANADIAN	HUTCHINSON	184	119	76	63	63	39
TEXLINE	CANADIAN	DALLAM	39	23	13	10	15	26
VEGA	CANADIAN	OLDHAM	287	282	300	327	353	387
WELLINGTON	RED	COLLINGSWORTH	10	9	20	35	46	65
WHEELER	RED	WHEELER	690	690	690	690	690	690
WHITE DEER	CANADIAN	CARSON	189	177	168	167	156	138
WHITE DEER	RED	CARSON	17	11	7	9	10	8

RECOMMENDED WATER MANAGEMENT STRATEGIES FOR WUGS IN REGION A

-Values in ac-ft/yr-

WUG_Name	WUG_County	WUG_Basin	Project_Name	SOURCE	SO_County	SO_Basin	SELLER_NAME	SS2010	SS2020	SS2030	SS2040	SS2050	SS2060
AMARILLO	POTTER	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	POTTER	CANADIAN		0	455	808	865	925	975
AMARILLO	POTTER	CANADIAN	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN		0	0	0	3,517	3,100	6,870
AMARILLO	POTTER	CANADIAN	CRMWA EXPAND GROUNDWATER	OGALLALA AQUIFER	ROBERTS	CANADIAN	CRMWA	517	507	1,366	2,215	2,912	2,900
AMARILLO	POTTER	CANADIAN	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	POTTER	CANADIAN		0	0	2,600	2,500	2,300	2,000
AMARILLO	POTTER	RED	MUNICIPAL CONSERVATION	CONSERVATION	POTTER	RED		0	325	575	615	660	700
AMARILLO	POTTER	RED	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN		0	0	0	2,501	2,100	3,940
AMARILLO	POTTER	RED	CRMWA EXPAND GROUNDWATER	OGALLALA AQUIFER	ROBERTS	CANADIAN	CRMWA	368	362	973	1,578	2,071	2,061
AMARILLO	POTTER	RED	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	POTTER	CANADIAN		0	0	1,900	1,800	1,700	1,500
AMARILLO	RANDALL	RED	MUNICIPAL CONSERVATION	CONSERVATION	RANDALL	RED		0	595	1,070	1,159	1,256	1,337
AMARILLO	RANDALL	RED	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN		0	0	0	4,612	4,190	8,790
AMARILLO	RANDALL	RED	CRMWA EXPAND GROUNDWATER	OGALLALA AQUIFER	ROBERTS	CANADIAN	CRMWA	665	664	1,809	2,970	3,951	3,971
AMARILLO	RANDALL	RED	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	POTTER	CANADIAN		0	0	3,500	3,200	3,000	2,500
CACTUS	MOORE	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	MOORE	CANADIAN		0	18	31	31	31	31
CACTUS	MOORE	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN		250	250	250	350	350	350
CANYON	RANDALL	RED	MUNICIPAL CONSERVATION	CONSERVATION	RANDALL	RED		0	81	146	159	174	186
CANYON	RANDALL	RED	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	0	0	0	60	270	540
COUNTY-OTHER	DALLAM	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	DALLAM	CANADIAN		0	6	10	10	10	10
COUNTY-OTHER	DALLAM	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	DALLAM	CANADIAN		150	150	150	150	150	150
COUNTY-OTHER	HARTLEY	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	HARTLEY	CANADIAN		0	16	28	28	27	26
COUNTY-OTHER	HARTLEY	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	HARTLEY	CANADIAN		125	125	125	125	125	125
COUNTY-OTHER	MOORE	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	MOORE	CANADIAN		0	29	63	75	83	87
COUNTY-OTHER	MOORE	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN		800	800	1,300	1,300	1,600	1,600
COUNTY-OTHER	POTTER	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	POTTER	CANADIAN		0	41	85	103	124	140
COUNTY-OTHER	POTTER	CANADIAN	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	POTTER	CANADIAN		0	0	0	1,000	1,000	1,000
COUNTY-OTHER	POTTER	RED	MUNICIPAL CONSERVATION	CONSERVATION	POTTER	RED		0	28	58	71	85	96
COUNTY-OTHER	POTTER	RED	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	POTTER	RED		0	600	600	600	1,100	1,100
COUNTY-OTHER	RANDALL	RED	MUNICIPAL CONSERVATION	CONSERVATION	RANDALL	RED		0	101	197	231	268	299
COUNTY-OTHER	RANDALL	RED	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	RANDALL	RED		0	0	600	1,200	2,400	2,400
COUNTY-OTHER	RANDALL	RED	CRMWA EXPAND GROUNDWATER	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	0	0	0	1	4	6
COUNTY-OTHER	SHERMAN	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	SHERMAN	CANADIAN		0	7	12	13	13	13
COUNTY-OTHER	SHERMAN	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	SHERMAN	CANADIAN		180	180	180	180	180	180
DALHART	DALLAM	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	DALLAM	CANADIAN		0	43	74	75	74	70
DALHART	DALLAM	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	DALLAM	CANADIAN		900	900	900	900	900	900
DALHART	HARTLEY	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	HARTLEY	CANADIAN		0	21	36	36	36	34
DALHART	HARTLEY	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	HARTLEY	CANADIAN		180	180	180	180	180	180
DUMAS	MOORE	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	MOORE	CANADIAN		0	89	158	166	171	174
DUMAS	MOORE	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN		1,092	1,486	1,756	2,032	2,195	2,334
IRRIGATION	ARMSTRONG	RED	IRRIGATION CONSERVATION	CONSERVATION	ARMSTRONG	RED		911	1,150	1,389	1,628	1,867	2,030
IRRIGATION	CARSON	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	CARSON	CANADIAN		3,569	4,531	5,493	6,456	7,418	8,095
IRRIGATION	CARSON	RED	IRRIGATION CONSERVATION	CONSERVATION	CARSON	RED		4,024	5,109	6,195	7,280	8,365	9,129
IRRIGATION	CHILDRESS	RED	IRRIGATION CONSERVATION	CONSERVATION	CHILDRESS	RED		803	1,014	1,224	1,435	1,645	1,796
IRRIGATION	COLLINGSWORTH	RED	IRRIGATION CONSERVATION	CONSERVATION	COLLINGSWORTH	RED		1,858	2,357	2,855	3,354	3,853	4,217
IRRIGATION	DALLAM	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	DALLAM	CANADIAN		20,550	26,585	32,619	38,655	44,690	49,176
IRRIGATION	DONLEY	RED	IRRIGATION CONSERVATION	CONSERVATION	DONLEY	RED		1,545	1,960	2,376	2,792	3,207	3,509
IRRIGATION	GRAY	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	GRAY	CANADIAN		509	642	774	907	1,039	1,129
IRRIGATION	GRAY	RED	IRRIGATION CONSERVATION	CONSERVATION	GRAY	RED		1,704	2,148	2,591	3,035	3,478	3,780
IRRIGATION	HALL	RED	IRRIGATION CONSERVATION	CONSERVATION	HALL	RED		1,691	2,123	2,555	2,988	3,420	3,726
IRRIGATION	HANSFORD	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	HANSFORD	CANADIAN		9,918	12,723	15,528	18,333	21,138	23,148
IRRIGATION	HARTLEY	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	HARTLEY	CANADIAN		17,273	22,534	27,795	33,055	38,316	42,294
IRRIGATION	HEMPHILL	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	HEMPHILL	CANADIAN		38	47	56	65	74	80
IRRIGATION	HEMPHILL	RED	IRRIGATION CONSERVATION	CONSERVATION	HEMPHILL	RED		48	60	71	83	94	101
IRRIGATION	HUTCHINSON	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	HUTCHINSON	CANADIAN		4,706	6,018	7,332	8,644	9,958	10,887
IRRIGATION	LIPSCOMB	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	LIPSCOMB	CANADIAN		1,027	1,313	1,600	1,886	2,173	2,383
IRRIGATION	MOORE	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	MOORE	CANADIAN		12,498	16,031	19,566	23,097	26,631	29,207
IRRIGATION	OCHILTREE	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	OCHILTREE	CANADIAN		7,631	9,756	11,880	14,004	16,128	17,647
IRRIGATION	OLDHAM	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	OLDHAM	CANADIAN		314	403	493	582	672	736
IRRIGATION	OLDHAM	RED	IRRIGATION CONSERVATION	CONSERVATION	OLDHAM	RED		51	66	80	95	109	120

RECOMMENDED WATER MANAGEMENT STRATEGIES FOR WUGS IN REGION A

-Values in ac-ft/yr-

WUG_Name	WUG_County	WUG_Basin	Project_Name	SOURCE	SO_County	SO_Basin	SELLER_NAME	SS2010	SS2020	SS2030	SS2040	SS2050	SS2060
IRRIGATION	POTTER	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	POTTER	CANADIAN		385	500	614	729	843	930
IRRIGATION	POTTER	RED	IRRIGATION CONSERVATION	CONSERVATION	POTTER	RED		102	133	163	194	224	247
IRRIGATION	RANDALL	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	RANDALL	CANADIAN		0	0	0	0	0	0
IRRIGATION	RANDALL	RED	IRRIGATION CONSERVATION	CONSERVATION	RANDALL	RED		7,478	9,509	11,539	13,570	15,600	17,021
IRRIGATION	ROBERTS	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	ROBERTS	CANADIAN		1,558	1,978	2,399	2,820	3,241	3,551
IRRIGATION	ROBERTS	RED	IRRIGATION CONSERVATION	CONSERVATION	ROBERTS	RED		65	82	100	118	135	148
IRRIGATION	SHERMAN	CANADIAN	IRRIGATION CONSERVATION	CONSERVATION	SHERMAN	CANADIAN		19,279	24,884	30,489	36,093	41,697	45,842
IRRIGATION	WHEELER	RED	IRRIGATION CONSERVATION	CONSERVATION	WHEELER	RED		741	928	1,116	1,304	1,492	1,620
LIVESTOCK	DALLAM	CANADIAN	VOLUNTARY TRANSFER FROM OTHER USERS	OGALLALA AQUIFER	DALLAM	CANADIAN		4,800	9,100	10,200	10,800	10,900	11,300
LIVESTOCK	HARTLEY	CANADIAN	VOLUNTARY TRANSFER FROM OTHER USERS	OGALLALA AQUIFER	HARTLEY	CANADIAN		200	1,000	1,400	1,200	700	500
LIVESTOCK	MOORE	CANADIAN	VOLUNTARY TRANSFER FROM OTHER USERS	OGALLALA AQUIFER	MOORE	CANADIAN		1,300	2,200	2,800	3,200	3,500	3,900
LIVESTOCK	SHERMAN	CANADIAN	VOLUNTARY TRANSFER FROM OTHER USERS	OGALLALA AQUIFER	SHERMAN	CANADIAN		3,100	6,500	7,900	8,700	9,500	10,600
MANUFACTURING	HUTCHINSON	CANADIAN	MANUFACTURING CONSERVATION	CONSERVATION	HUTCHINSON	CANADIAN		0	500	1,000	1,000	1,000	1,000
MANUFACTURING	HUTCHINSON	CANADIAN	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	HUTCHINSON	CANADIAN		2,500	5,000	10,600	10,600	14,200	14,200
MANUFACTURING	HUTCHINSON	CANADIAN	REUSE	DIRECT REUSE	HUTCHINSON	CANADIAN	BORGER	1,000	1,000	1,000	1,000	1,000	1,000
MANUFACTURING	MOORE	CANADIAN	MANUFACTURING CONSERVATION	CONSERVATION	MOORE	CANADIAN		236	254	446	469	489	522
MANUFACTURING	MOORE	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN		3,039	3,461	3,833	6,106	6,318	6,633
MANUFACTURING	MOORE	CANADIAN	REUSE	DIRECT REUSE	MOORE	CANADIAN	DUMAS	1,300	1,400	1,500	1,600	1,700	1,700
MANUFACTURING	POTTER	RED	MANUFACTURING CONSERVATION	CONSERVATION	POTTER	RED		100	120	150	150	150	150
MANUFACTURING	POTTER	RED	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	0	0	0	500	1,500	2,210
MANUFACTURING	RANDALL	RED	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	0	0	0	20	50	70
STEAM ELECTRIC POWER	MOORE	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN		200	200	200	200	200	200
STRATFORD	SHERMAN	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	SHERMAN	CANADIAN		0	20	35	36	37	38
STRATFORD	SHERMAN	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	SHERMAN	CANADIAN		450	450	450	450	450	450
SUNRAY	MOORE	CANADIAN	MUNICIPAL CONSERVATION	CONSERVATION	MOORE	CANADIAN		0	18	34	36	38	39
SUNRAY	MOORE	CANADIAN	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN		550	550	550	550	550	550

WHOLESALE WATER PROVIDER DEMANDS

-Values in ac-ft/yr-

Wholesale Provider	Recipient_name	Cust_Reg	WD2010	WD2020	WD2030	WD2040	WD2050	WD2060
AMARILLO CITY OF	AMARILLO	A	10,055	10,811	11,517	12,322	13,200	13,920
AMARILLO CITY OF	AMARILLO	A	14,107	15,167	16,158	17,287	18,519	19,529
AMARILLO CITY OF	AMARILLO	A	18,167	19,839	21,404	23,185	25,129	26,739
AMARILLO CITY OF	CANYON	A	1,000	1,000	1,000	1,000	1,000	1,000
AMARILLO CITY OF	MANUFACTURING-RANDALL	A	300	300	300	300	300	300
AMARILLO CITY OF	MANUFACTURING-POTTER	A	6,516	7,169	7,721	8,260	8,726	9,367
AMARILLO CITY OF	STEAM ELECTRIC POWER	A	20,286	23,241	24,658	26,262	27,865	31,969
AMARILLO CITY OF	TEXAS PARKS & WILDLIFE DEPT	A	25	25	25	25	25	25
BORGER CITY OF	BORGER	A	2,352	2,384	2,351	2,274	2,148	2,039
BORGER CITY OF	COUNTY-OTHER-HUTCHINSON	A	56	57	57	55	52	49
BORGER CITY OF	MANUFACTURING	A	2,500	2,500	2,500	2,500	2,500	2,500
BORGER CITY OF	TCW SUPPLY INC.	A	94	94	94	94	94	94
CACTUS CITY OF	CITY OF CACTUS	A	533	615	615	615	615	615
CACTUS CITY OF	MOORE COUNTY MANUFACTURING	A	2,758	2,958	3,120	3,280	3,421	3,653
CACTUS CITY OF	MOORE COUNTY-OTHER	A	70	96	126	151	165	174
CRMWA	BORGER	A	3,000	3,000	3,000	3,000	3,000	3,000
CRMWA	BROWNFIELD	O	2,747	2,905	3,047	3,181	3,185	3,167
CRMWA	CITY OF AMARILLO	A	42,987	42,987	42,987	42,987	42,987	42,987
CRMWA	LAMESA	O	2,540	2,573	2,602	2,603	2,529	2,433
CRMWA	LEVELLAND	O	2,310	2,362	2,369	2,322	2,216	2,107
CRMWA	LUBBOCK	O	41,123	41,123	41,123	41,123	41,123	41,123
CRMWA	ODONNELL	O	144	146	142	138	130	121
CRMWA	ODONNELL	O	17	17	17	17	16	16
CRMWA	PAMPA	A	3,300	3,273	3,182	3,058	2,871	2,689
CRMWA	PLAINVIEW	O	4,288	4,490	4,605	4,635	4,577	4,488
CRMWA	SLATON	O	907	889	870	849	837	836
CRMWA	TAHOKA	O	492	504	490	478	453	421
DUMAS CITY OF	CITY OF DUMAS	A	2,734	2,962	3,163	3,322	3,419	3,478
DUMAS CITY OF	MOORE COUNTY-OTHER	A	21	29	38	45	50	52
GREENBELT M&IWA	CHILDRESS	A	1,457	1,481	1,502	1,509	1,510	1,471
GREENBELT M&IWA	CHILLICOTHE	B	61	55	53	51	50	49
GREENBELT M&IWA	CLARENDON	A	440	440	440	440	440	440
GREENBELT M&IWA	COUNTY-OTHER-CHILDRESS	A	196	199	202	203	203	198
GREENBELT M&IWA	COUNTY-OTHER-DONLEY	A	219	210	191	171	154	128
GREENBELT M&IWA	COUNTY-OTHER-HALL	A	353	379	395	382	387	363
GREENBELT M&IWA	COUNTY-OTHER FOARD	B	68	68	68	68	68	68
GREENBELT M&IWA	COUNTY-OTHER HARDEMAN	B	210	210	210	210	210	210

WHOLESALE WATER PROVIDER DEMANDS

-Values in ac-ft/yr-

Wholesale Provider	Recipient_name	Cust_Reg	WD2010	WD2020	WD2030	WD2040	WD2050	WD2060
GREENBELT M&IWA	COUNTY-OTHER WILBARGER	B	6	6	6	6	6	6
GREENBELT M&IWA	CROWELL	B	332	317	302	289	280	269
GREENBELT M&IWA	GREENBELT M&IWA	A	0	0	0	0	0	0
GREENBELT M&IWA	MANUFACTURING - HARDEMAN	B	449	478	509	542	576	576
GREENBELT M&IWA	MEMPHIS	A	100	100	100	100	100	100
GREENBELT M&IWA	QUANAH	B	652	612	589	544	511	463

WHOLESALE WATER PROVIDER SUPPLY

-Values in ac-ft/yr-

Wholesale Provider	Recipient_name	Source	so_basin	so_county	WPS2010	WPS2020	WPS2030	WPS2040	WPS2050	WPS2060
AMARILLO CITY OF	AMARILLO	MEREDITH LAKE	CANADIAN	RESERVOIR	3,681	3,634	3,484	3,469	3,614	3,635
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	CANADIAN	ROBERTS	4,084	4,143	3,507	2,877	2,358	2,349
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	RED	CARSON	835	824	790	757	717	623
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	RED	POTTER	2,480	2,280	2,080	1,840	1,600	1,400
AMARILLO CITY OF	AMARILLO	MEREDITH LAKE	CANADIAN	RESERVOIR	5,165	5,098	4,888	4,867	5,070	5,100
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	CANADIAN	CARSON	930	934	906	884	850	737
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	CANADIAN	POTTER	3,720	3,420	3,120	2,760	2,400	2,100
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	CANADIAN	ROBERTS	5,731	5,813	4,920	4,037	3,308	3,295
AMARILLO CITY OF	AMARILLO	MEREDITH LAKE	CANADIAN	RESERVOIR	6,651	6,668	6,476	6,528	6,879	6,983
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	CANADIAN	ROBERTS	7,379	7,604	6,518	5,413	4,488	4,511
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	RED	CARSON	5,236	4,942	4,603	4,159	3,732	3,239
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	RED	RANDALL	630	630	630	630	630	630
AMARILLO CITY OF	AMARILLO	OGALLALA AQUIFER	RED	DEAF SMITH	125	125	100	100	50	14
AMARILLO CITY OF	CANYON	MEREDITH LAKE	CANADIAN	RESERVOIR	1,000	1,000	1,000	942	829	765
AMARILLO CITY OF	MANUFACTURING-RANDALL	MEREDITH LAKE	CANADIAN	RESERVOIR	300	300	300	283	250	230
AMARILLO CITY OF	MANUFACTURING-POTTER	MEREDITH LAKE	CANADIAN	RESERVOIR	6,516	7,169	7,721	7,781	7,231	7,162
AMARILLO CITY OF	STEAM ELECTRIC POWER	MEREDITH LAKE	CANADIAN	RESERVOIR	556	0	0	0	0	0
AMARILLO CITY OF	STEAM ELECTRIC POWER	OGALLALA AQUIFER	CANADIAN	ROBERTS	349	0	0	0	0	0
AMARILLO CITY OF	STEAM ELECTRIC POWER	DIRECT REUSE	CANADIAN	POTTER	19,381	23,241	24,658	26,262	27,865	31,969
AMARILLO CITY OF	TEXAS PARKS & WILDLIFE DEPT	MEREDITH LAKE	CANADIAN	RESERVOIR	25	25	25	24	21	19
BORGER CITY OF	BORGER	MEREDITH LAKE	CANADIAN	RESERVOIR	0	0	0	0	0	0
BORGER CITY OF	BORGER	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	2,247	2,075	1,915	1,821	1,724	1,570
BORGER CITY OF	BORGER	OGALLALA AQUIFER	CANADIAN	ROBERTS	916	900	900	900	900	900
BORGER CITY OF	COUNTY-OTHER-HUTCHINSON	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	56	57	57	55	52	49
BORGER CITY OF	MANUFACTURING	MEREDITH LAKE	CANADIAN	RESERVOIR	1,845	1,845	1,845	1,845	1,845	1,845
BORGER CITY OF	MANUFACTURING	OGALLALA AQUIFER	CANADIAN	ROBERTS	255	255	255	255	255	255
BORGER CITY OF	MANUFACTURING	DIRECT REUSE	CANADIAN	HUTCHINSON	400	400	400	400	400	400
BORGER CITY OF	TCW SUPPLY INC.	OGALLALA AQUIFER	CANADIAN	HUTCHINSON	94	94	94	94	94	94
CACTUS CITY OF	CITY OF CACTUS	OGALLALA AQUIFER	CANADIAN	MOORE	420	390	353	331	311	277
CACTUS CITY OF	MOORE COUNTY MANUFACTURING	OGALLALA AQUIFER	CANADIAN	MOORE	1,719	1,497	1,288	1,174	1,103	1,020
CACTUS CITY OF	MOORE COUNTY-OTHER	OGALLALA AQUIFER	CANADIAN	MOORE	22	21	19	18	17	15
CRMWA	BORGER	MEREDITH LAKE	CANADIAN	RESERVOIR	1,845	1,845	1,845	1,845	1,845	1,845
CRMWA	BORGER	OGALLALA AQUIFER	CANADIAN	ROBERTS	1,155	1,155	1,155	1,155	1,155	1,155
CRMWA	BROWNFIELD	MEREDITH LAKE	CANADIAN	RESERVOIR	1,670	1,670	1,670	1,670	1,670	1,670
CRMWA	BROWNFIELD	OGALLALA AQUIFER	CANADIAN	ROBERTS	879	879	879	879	879	879
CRMWA	CITY OF AMARILLO	MEREDITH LAKE	CANADIAN	RESERVOIR	23,894	23,894	23,894	23,894	23,894	23,894
CRMWA	CITY OF AMARILLO	OGALLALA AQUIFER	CANADIAN	ROBERTS	17,543	17,560	14,945	12,329	10,155	10,155
CRMWA	LAMESA	MEREDITH LAKE	CANADIAN	RESERVOIR	1,656	1,656	1,656	1,656	1,656	1,656
CRMWA	LAMESA	OGALLALA AQUIFER	CANADIAN	ROBERTS	872	872	872	872	672	672
CRMWA	LEVELLAND	MEREDITH LAKE	CANADIAN	RESERVOIR	2,120	2,120	2,120	2,120	2,120	2,120
CRMWA	LEVELLAND	OGALLALA AQUIFER	CANADIAN	ROBERTS	1,116	1,116	1,116	1,116	688	688
CRMWA	LUBBOCK	MEREDITH LAKE	CANADIAN	RESERVOIR	22,808	22,679	22,550	22,423	22,295	22,244
CRMWA	LUBBOCK	OGALLALA AQUIFER	CANADIAN	ROBERTS	16,018	16,017	13,632	11,248	10,065	10,065
CRMWA	ODONNELL	MEREDITH LAKE	CANADIAN	RESERVOIR	173	173	173	173	173	173
CRMWA	ODONNELL	OGALLALA AQUIFER	CANADIAN	ROBERTS	91	91	91	91	61	61
CRMWA	ODONNELL	MEREDITH LAKE	CANADIAN	RESERVOIR	38	38	38	38	38	38
CRMWA	ODONNELL	OGALLALA AQUIFER	CANADIAN	ROBERTS	20	20	20	20	20	20
CRMWA	PAMPA	MEREDITH LAKE	CANADIAN	RESERVOIR	4,566	4,566	4,566	4,566	4,566	4,566

WHOLESALE WATER PROVIDER SUPPLY

-Values in ac-ft/yr-

Wholesale Provider	Recipient_name	Source	so_basin	so_county	WPS2010	WPS2020	WPS2030	WPS2040	WPS2050	WPS2060
CRMWA	PLAINVIEW	MEREDITH LAKE	CANADIAN	RESERVOIR	2,805	2,805	2,805	2,805	2,805	2,805
CRMWA	PLAINVIEW	OGALLALA AQUIFER	CANADIAN	ROBERTS	1,476	1,476	1,476	1,476	1,076	1,076
CRMWA	SLATON	MEREDITH LAKE	CANADIAN	RESERVOIR	739	739	739	739	739	739
CRMWA	SLATON	OGALLALA AQUIFER	CANADIAN	ROBERTS	630	630	630	630	150	150
CRMWA	TAHOKA	MEREDITH LAKE	CANADIAN	RESERVOIR	350	350	350	350	350	350
CRMWA	TAHOKA	OGALLALA AQUIFER	CANADIAN	ROBERTS	184	184	184	184	110	110
DUMAS CITY OF	CITY OF DUMAS	OGALLALA AQUIFER	CANADIAN	HARTLEY	162	119	100	99	120	171
DUMAS CITY OF	CITY OF DUMAS	OGALLALA AQUIFER	CANADIAN	MOORE	1,706	1,501	1,307	1,191	1,104	973
DUMAS CITY OF	MOORE COUNTY-OTHER	OGALLALA AQUIFER	CANADIAN	MOORE	13	15	16	16	16	15
GREENBELT M&IWA	CHILDRESS	GREENBELT LAKE	RED	RESERVOIR	1,457	1,481	1,502	1,509	1,510	1,471
GREENBELT M&IWA	CHILLICOTHE	GREENBELT LAKE	RED	RESERVOIR	61	55	53	51	50	49
GREENBELT M&IWA	CLARENDON	GREENBELT LAKE	RED	RESERVOIR	440	440	440	440	440	440
GREENBELT M&IWA	COUNTY-OTHER-CHILDRESS	GREENBELT LAKE	RED	RESERVOIR	196	199	202	203	203	198
GREENBELT M&IWA	COUNTY-OTHER-DONLEY	GREENBELT LAKE	RED	RESERVOIR	219	210	191	171	154	128
GREENBELT M&IWA	COUNTY-OTHER-HALL	GREENBELT LAKE	RED	RESERVOIR	353	379	395	382	387	363
GREENBELT M&IWA	COUNTY-OTHER FOARD	GREENBELT LAKE	RED	RESERVOIR	68	68	68	68	68	68
GREENBELT M&IWA	COUNTY-OTHER HARDEMAN	GREENBELT LAKE	RED	RESERVOIR	210	210	210	210	210	210
GREENBELT M&IWA	COUNTY-OTHER WILBARGER	GREENBELT LAKE	RED	RESERVOIR	6	6	6	6	6	6
GREENBELT M&IWA	CROWELL	GREENBELT LAKE	RED	RESERVOIR	332	317	302	289	280	269
GREENBELT M&IWA	GREENBELT M&IWA	GREENBELT LAKE	RED	RESERVOIR	2,788	2,637	2,486	2,399	2,280	2,294
GREENBELT M&IWA	MANUFACTURING - HARDEMAN	GREENBELT LAKE	RED	RESERVOIR	449	478	509	542	576	576
GREENBELT M&IWA	MEMPHIS	GREENBELT LAKE	RED	RESERVOIR	100	100	100	100	100	100
GREENBELT M&IWA	QUANAH	GREENBELT LAKE	RED	RESERVOIR	652	612	589	544	511	463

RECOMMENDED STRATEGIES FOR WHOLESALE WATER PROVIDERS

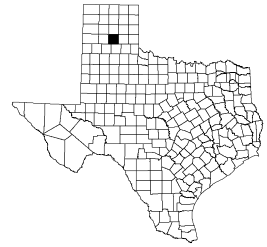
-Values in ac-ft/yr-

Wholesale Provider	Project_name	Source	So_county	So_basin	Recipient_name	ss2010	ss2020	ss2030	ss2040	ss2050	ss2060
AMARILLO CITY OF	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	368	362	973	1,578	2,071	2,061
AMARILLO CITY OF	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	517	507	1,366	2,215	2,912	2,900
AMARILLO CITY OF	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	665	664	1,809	2,970	3,951	3,971
AMARILLO CITY OF	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	TEXAS PARKS & WILDLIFE DEPT	0	0	0	1	4	6
AMARILLO CITY OF	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	POTTER	CANADIAN	AMARILLO	0	0	1,900	1,800	1,700	1,500
AMARILLO CITY OF	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	POTTER	CANADIAN	AMARILLO	0	0	2,600	2,500	2,300	2,000
AMARILLO CITY OF	DRILL ADDITIONAL GROUNDWATER WELL	OGALLALA AQUIFER	POTTER	CANADIAN	AMARILLO	0	0	3,500	3,200	3,000	2,500
AMARILLO CITY OF	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	0	0	0	2,501	2,100	3,940
AMARILLO CITY OF	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	0	0	0	3,517	3,100	6,870
AMARILLO CITY OF	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN	AMARILLO	0	0	0	4,612	4,190	8,790
AMARILLO CITY OF	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN	CANYON	0	0	0	60	270	540
AMARILLO CITY OF	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN	MANUFACTURING	0	0	0	20	50	70
AMARILLO CITY OF	ROBERTS COUNTY WELL FIELD	OGALLALA AQUIFER	ROBERTS	CANADIAN	MANUFACTURING	0	0	0	500	1,500	2,210
AMARILLO CITY OF	MUNICIPAL CONSERVATION	CONSERVATION	POTTER	RED	AMARILLO	0	325	575	615	660	700
AMARILLO CITY OF	MUNICIPAL CONSERVATION	CONSERVATION	POTTER	CANADIAN	AMARILLO	0	455	808	865	925	975
AMARILLO CITY OF	MUNICIPAL CONSERVATION	CONSERVATION	RANDALL	RED	AMARILLO	0	595	1,070	1,159	1,256	1,337
CACTUS CITY OF	MUNICIPAL CONSERVATION	CONSERVATION	MOORE	CANADIAN	CITY OF CACTUS	0	18	31	31	31	31
CACTUS CITY OF	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN	CITY OF CACTUS	250	250	250	350	350	350
CACTUS CITY OF	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN	MOORE COUNTY MANUFACTURING	1,039	1,461	1,832	2,106	2,318	2,633
CACTUS CITY OF	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN	MOORE COUNTY-OTHER	48	75	107	133	148	159
CRMWA	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	BROWNFIELD	650	650	650	650	650	650
CRMWA	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	CITY OF AMARILLO	1,550	1,533	4,148	6,764	8,938	8,938
CRMWA	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	CRMWA- FUTURE	13,598	13,615	16,000	18,384	21,210	21,210
CRMWA	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	LAMESA	250	250	250	250	250	250
CRMWA	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	LUBBOCK	14,911	14,911	14,911	14,911	14,911	14,911
CRMWA	CRMWA EXPAND GROUNDWATER SUPPLY	OGALLALA AQUIFER	ROBERTS	CANADIAN	PLAINVIEW	700	700	700	700	700	700
DUMAS CITY OF	MUNICIPAL CONSERVATION	CONSERVATION	MOORE	CANADIAN	CITY OF DUMAS	0	89	158	166	171	174
DUMAS CITY OF	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN	CITY OF DUMAS	1,092	1,486	1,756	2,032	2,195	2,334
DUMAS CITY OF	OVERDRAFT AQUIFER	OGALLALA AQUIFER	MOORE	CANADIAN	MOORE COUNTY-OTHER	8	14	22	29	34	37
PALO DURO RA	PALO DURO RESERVOIR	PALO DURO LAKE	RESERVOIR	CANADIAN	CITY OF CACTUS- FUTURE	0	0	2,000	2,000	1,542	1,500
PALO DURO RA	PALO DURO RESERVOIR	PALO DURO LAKE	RESERVOIR	CANADIAN	CITY OF DUMAS- FUTURE	0	0	1,000	1,000	1,500	1,500
PALO DURO RA	PALO DURO RESERVOIR	PALO DURO LAKE	RESERVOIR	CANADIAN	GRUVER- FUTURE	0	0	120	100	50	50
PALO DURO RA	PALO DURO RESERVOIR	PALO DURO LAKE	RESERVOIR	CANADIAN	SPEARMAN- FUTURE	0	0	150	150	150	150
PALO DURO RA	PALO DURO RESERVOIR	PALO DURO LAKE	RESERVOIR	CANADIAN	STINNET- FUTURE	0	0	105	83	50	50
PALO DURO RA	PALO DURO RESERVOIR	PALO DURO LAKE	RESERVOIR	CANADIAN	SUNRAY- FUTURE	0	0	500	500	500	500

APPENDIX B

Water Management Strategies
County Summaries

Panhandle Water Planning Group
Armstrong County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Armstrong County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

<u>Claude</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>County-Other</u>

- Current supply is water from the Ogallala and Whitehorse aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Irrigation</u>

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Livestock</u>

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Manufacturing</u>

- There are no demands in this category

<u>Mining</u>

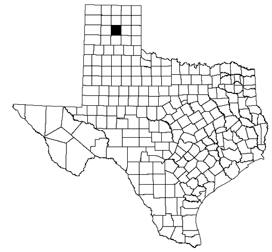
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric Power

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Claude	Ogallala aquifer	No	None
County-Other	Ogallala and Whitehorse aquifers	No	None
Irrigation	Ogallala and Dockum/Rita Blanca aquifers	No	None
Livestock	Ogallala and Dockum/Rita Blanca aquifers and local supply (stock ponds)	No	None
Manufacturing	None	---	---
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Carson County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Carson County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. The analysis of supplies includes the City of Amarillo withdrawing water from Carson County for use elsewhere in the region. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

County-Other

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Groom

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Hi Texas Water Company

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Irrigation

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Mining

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Panhandle

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Skellytown

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric

- There are no demands in this category

White Deer

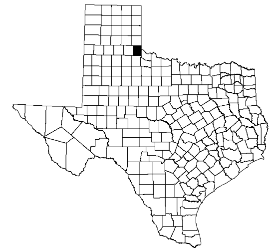
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
County-Other	Ogallala aquifer	No	None
Groom	Ogallala aquifer	No	None
Hi Texas Water Co	Ogallala aquifer	No	None
Irrigation	Ogallala and Dockum/Rita Blanca aquifers	No	None
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer	No	None
Mining	Ogallala aquifer	No	None
Panhandle	Ogallala aquifer	No	None
Skellytown	Ogallala aquifer	No	None
Steam Electric	None	----	----
White Deer	Ogallala aquifer	No	None

Panhandle Water Planning Group

Childress County

Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Childress County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

<u>Childress</u>

- Current supply is water from the Blaine and Seymour aquifers and Greenbelt Reservoir
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>County-Other</u>

- Current supply is water from the Blaine and Seymour aquifers and Greenbelt Reservoir
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Irrigation</u>

- Current supply is water from the Blaine, Seymour and Whitehorse aquifers and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Livestock</u>

- Current supply is water from the Blaine and Seymour aquifers and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Manufacturing</u>

- There are no demands in this category

<u>Mining</u>

- Current supply is water from the Blaine and Seymour aquifers and local supply

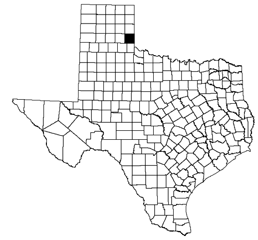
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Steam Electric Power</u>

- There are no demands in this category

Water User Group	**Current Supplies**	**Shortage**	**Proposed Water Management Strategies**
Childress	Blaine and Seymour aquifers and Greenbelt Reservoir	No	None
County-Other	Blaine and Seymour aquifers and Greenbelt Reservoir	No	None
Irrigation	Blaine, Seymour and Whitehorse aquifers and reuse	No	None
Livestock	Blaine and Seymour aquifers and local supply (stock ponds)	No	None
Manufacturing	None	---	---
Mining	Blaine and Seymour aquifers and local supply	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Collingsworth County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Collingsworth County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

Wellington

- Current supply is water from the Ogallala, Blaine and Seymour aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

County-Other

- Current supply is water from the Ogallala, Blaine, Seymour and Whitehorse aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Irrigation

- Current supply is water from the Ogallala, Blaine and Seymour aquifers and local supply
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala, Blaine, Seymour and Whitehorse aquifers and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- There are no demands in this category

Mining

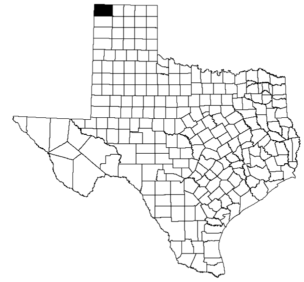
- There are no demands in this category

Steam Electric Power

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Wellington	Ogallala, Blaine and Seymour aquifers	No	None
County-Other	Ogallala, Blaine, Seymour and Whitehorse aquifers	No	None
Irrigation	Ogallala, Blaine and Seymour aquifers and local supply	No	None
Livestock	Ogallala, Blaine, Seymour and Whitehorse aquifers and local supply (stock ponds)	No	None
Manufacturing	None	---	---
Mining	None	---	---
Steam Electric	None	---	---

Panhandle Water Planning Group
Dallam County
Strategy Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Dallam County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. Strategies have been suggested for all water user groups that have a projected shortage. Following the narrative is a table summarizing this information.

<u>Dalhart</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells and implementation of conservation measures.

<u>Texline</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>County-Other</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells and implementation of conservation measures.

<u>Irrigation</u>

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers and reuse
- Projected demands will exceed current supplies in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include NPET, improved irrigation equipment, conservation tillage, and precipitation enhancement.

<u>Livestock</u>

- Current supply is water from the Ogallala aquifer and local supply (stock ponds)
- Projected demands will exceed current supplies in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include voluntary transfer from other users, conservation, and drilling additional wells.

Manufacturing

- There are no demands in this category

Mining

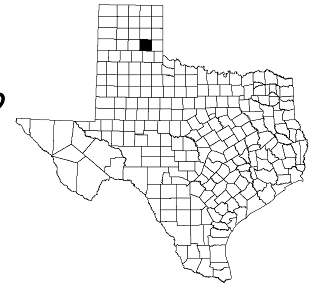
- There are no demands in this category

Steam Electric

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Dalhart	Ogallala aquifer	Yes	New wells, Conservation
Texline	Ogallala aquifer	No	None
County-Other	Ogallala aquifer	Yes	New wells, Conservation
Irrigation	Ogallala and Dockum/Rita Blanca aquifers and reuse	Yes	NPET, conservation tillage, improved irrigation equipment, precipitation enhancement
Livestock	Ogallala aquifer and local supply (stock ponds)	Yes	New wells, voluntary transfer from other users
Manufacturing	None	---	---
Mining	None	---	---
Steam Electric	None	---	---

Panhandle Water Planning Group
Donley County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Donley County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

<u>Clarendon</u>

- Current supply is water from the Ogallala aquifer and Greenbelt reservoir
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>County-Other</u>

- Current supply is water from the Ogallala aquifer and Greenbelt reservoir
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Irrigation</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Livestock</u>

- Current supply is water from the Ogallala and Whitehorse aquifers and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Manufacturing</u>

- There are no demands in this category

<u>Mining</u>

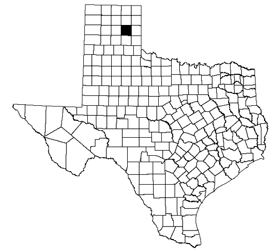
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric Power

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Clarendon	Ogallala aquifer and Greenbelt reservoir	No	None
County-Other	Ogallala aquifer and Greenbelt reservoir	No	None
Irrigation	Ogallala aquifer	No	None
Livestock	Ogallala and Whitehorse aquifers and local supply (stock ponds)	No	None
Manufacturing	None	---	---
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Gray County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Gray County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

<u>Lefors</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>McLean</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Pampa</u>

- Current supply is water from the Ogallala aquifer and CRMWA system
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>County-Other</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Irrigation</u>

- Current supply is water from the Ogallala aquifer and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- There are no demands in this category

Mining

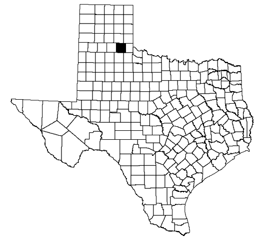
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Lefors	Ogallala aquifer	No	None
McLean	Ogallala aquifer	No	None
Pampa	Ogallala aquifer and CRMWA system	No	None
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala and reuse	No	None
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	None	No	None
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Hall County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Hall County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

Memphis

- Current supply is water from the Blaine and Seymour aquifers and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

County-Other

- Current supply is water from the Blaine and Seymour aquifers and Greenbelt reservoir
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Irrigation

- Current supply is water from the Blaine and Seymour aquifers and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Blaine, Seymour, Whitehorse and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- There are no demands in this category

Mining (Shortage less than 10AFY)

- Current supply is water from the Blaine and Seymour aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric

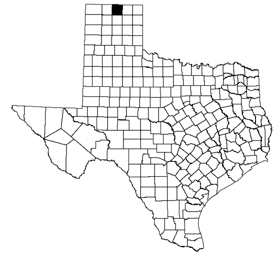
- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Memphis	Blaine & Seymour aquifers and Greenbelt reservoir	No	None
County-Other	Blaine & Seymour aquifers and Greenbelt reservoir	No	None
Irrigation	Blaine & Seymour aquifers and reuse	No	None
Livestock	Blaine, Seymour, Whitehorse and local supply (stock ponds)	No	None
Manufacturing	None	---	---
Mining	Blaine, and Seymour aquifers	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group

Hansford County

Supply/Demand Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Hansford County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

Gruver

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Spearman

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

County-Other

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Irrigation

- Current supply is water from the Ogallala aquifer, local supply and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds and irrigation)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Mining

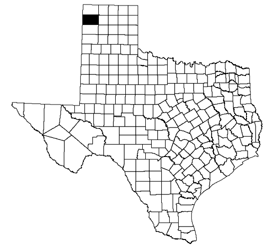
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Gruver	Ogallala aquifer	No	None
Spearman	Ogallala aquifer	No	None
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer, local supply and reuse	No	None
Livestock	Ogallala aquifer and local supply (stock ponds and irrigation)	No	None
Manufacturing	Ogallala aquifer	No	None
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Hartley County
Strategy Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Hartley County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. Strategies have been suggested for all water user groups that have a projected shortage, including the ones with a shortage of less than 10 AFY.

Dalhart

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2020
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells and implementation of conservation measures.

County-Other

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells and implementation of conservation measures.

Irrigation

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers and reuse
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include NPET, improved irrigation equipment, conservation tillage and precipitation enhancement.

Livestock

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers and local supply (stock ponds)
- Projected demands will exceed current supplies starting in 2030
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include voluntary transfer from other users.

Manufacturing

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Mining

- There are no demands in this category

Steam Electric

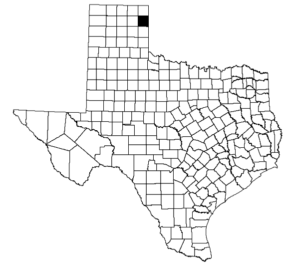
- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Dalhart	Ogallala aquifer	Yes	New wells, Conservation
County-Other	Ogallala aquifer	Yes	New wells, Conservation
Irrigation	Ogallala and Dockum/Rita Blanca aquifers and reuse	Yes	NPET, Improved Irrigation Equipment, Conservation Tillage, Precipitation Enhancement
Livestock	Ogallala and Dockum/Rita Blanca aquifers and local supply (stock ponds)	Yes	Voluntary Transfer From Other Users
Manufacturing	Ogallala aquifer	No	None
Mining	None	---	---
Steam Electric	None	---	---

Panhandle Water Planning Group

Hemphill County

Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Hemphill County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

Canadian

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

County-Other

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Irrigation

- Current supply is water from the Ogallala aquifer and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Mining

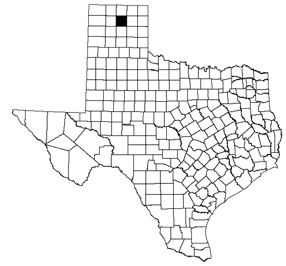
- There are no demands in this category

Steam Electric Power

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Canadian	Ogallala aquifer	No	None
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer and reuse	No	None
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer	No	None
Mining	None	---	---
Steam Electric	None	---	---

Panhandle Water Planning Group
Hutchinson County
Strategy Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Hutchinson County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. Strategies have been suggested for all water user groups that have a projected shortage.

<u>Borger</u>

- Current supply is water from the Ogallala aquifer and CRMWA system
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Fritch</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Hi Texas Water Company</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Stinnett</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>TCW Supply Inc.</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Irrigation</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include NPET, improved irrigation equipment, conservation tillage and precipitation enhancement.

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- Current supply is water from the Ogallala aquifer and the CRMWA system
- Projected demands will exceed current supplies starting in 2030
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells and reuse.

Mining

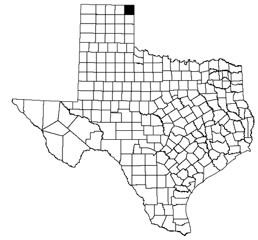
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Borger	Ogallala aquifer and CRMWA system	No	None
Fritch	Ogallala aquifer	No	None
Hi Texas Water Company	Ogallala aquifer	No	None
Stinnett	Ogallala aquifer	No	None
TCW Supply Inc.	Ogallala aquifer	No	None
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer, local supply and reuse	Yes	NPET, Improved Irrigation Equipment, Conservation Tillage, Precipitation Enhancement
Livestock	Ogallala aquifer and local supply (stock ponds and irrigation)	No	None
Manufacturing	Ogallala aquifer	Yes	New wells, reuse
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Lipscomb County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Lipscomb County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

Booker

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

County-Other

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Irrigation

- Current supply is water from the Ogallala aquifer, local supply and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds and irrigation)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Mining

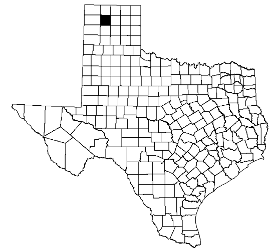
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric Power

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Booker	Ogallala aquifer	No	None
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer, local supply and reuse	No	None
Livestock	Ogallala aquifer and local supply (stock ponds and irrigation)	No	None
Manufacturing	Ogallala aquifer	No	None
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Moore County
Strategy Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Moore County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. Strategies have been suggested for all water user groups that have a projected shortage. Following the narrative is a table summarizing this information.

Cactus

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells, and implementation of conservation measures.

County-Other

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells and implementation of conservation measures.

Dumas

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells, and implementation of conservation measures.

Irrigation

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include NPET, conservation tillage, improved irrigation equipment, and precipitation enhancement.

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds)
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include drilling additional wells and voluntary transfer water from other users.

Manufacturing

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells, conservation, and reuse

Mining

- Current supply is water from the Ogallala aquifer and local supply
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric Power

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells, conservation, and reuse.

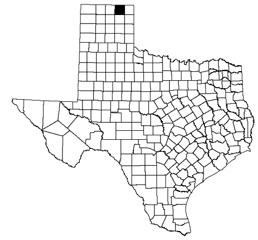
Sunray

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells, and implementation of conservation measures.

Water User Group	**Current Supplies**	**Shortage**	**Proposed Water Management Strategies**

Cactus	Ogallala aquifer	Yes	New wells, Conservation
Dumas	Ogallala aquifer	Yes	New wells, Conservation
Sunray	Ogallala aquifer	Yes	New wells, Conservation
County-Other	Ogallala aquifer	Yes	New wells, Conservation
Irrigation	Ogallala and Dockum/Rita Blanca aquifers	Yes	NPET, conservation tillage, improved irrigation equipment, precipitation enhancement
Livestock	Ogallala aquifer and local supply (stock ponds)	Yes	New wells, Voluntary Transfer From Other Users
Manufacturing	Ogallala aquifer	Yes	New wells, Reuse
Mining	Ogallala aquifer and local supply	No	None
Steam Electric	Ogallala aquifer	Yes	New wells, reuse

Panhandle Water Planning Group
Ochiltree County
Supply/Demand Summary



The following narrative describes the source/source(s) of current water supply for water user groups in Ochiltree County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

Perryton
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

County-Other

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Irrigation

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing
- There are no demands in this category

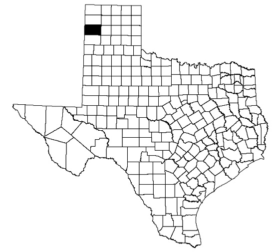
Mining
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric Power

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Perryton	Ogallala aquifer	No	None
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer	No	None
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	None	---	---
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Oldham County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Oldham County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

Vega

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

County-Other

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Irrigation

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- There are no demands in this category

Mining

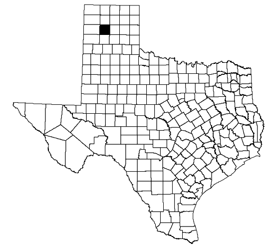
- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric Power

- There are no demands in this category

Water User Group	**Current Supplies**	**Shortage**	**Proposed Water Management Strategies**
Vega	Ogallala aquifer	No	None
County-Other	Ogallala and Dockum/Rita Blanca aquifers	No	None
Irrigation	Ogallala and Dockum/Rita Blanca aquifers	No	None
Livestock	Ogallala and Dockum/Rita Blanca aquifers and local supply (stock ponds)	No	None
Manufacturing	None	---	---
Mining	Ogallala and Dockum/Rita Blanca aquifers	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Potter County
Strategy Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Potter County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. Strategies have been suggested for all water user groups that have a projected shortage. Following the narrative is a table summarizing this information.

<u>Amarillo</u>

- Current supply is water from the Ogallala aquifer and the CRMWA system
- Projected demands will exceed current supplies starting in 2030.
- Shortages occur in the Red River basin.
- The recommended water management strategies to meet shortages include the installation of new wells, CRMWA well field expansion, and implementation of conservation measures.

<u>County-Other</u>

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers
- Projected demands will exceed current supplies starting in 2010
- Shortages occurs in the Canadian and Red River basins
- The recommended water management strategies to meet shortages include the installation of new wells and implementation of conservation measures.

<u>Irrigation</u>

- Current supply is water from the Ogallala aquifer, local supply and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Livestock</u>

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers and local supply (stock ponds and irrigation)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Manufacturing</u>

- Current supply is water from the Ogallala aquifer and the CRMWA system
- Projected demands will exceed current supplies starting in 2030 in Canadian River basin and in 2050 in the Red River basin
- Shortage occurs in the Canadian and Red River basins

- The recommended water management strategies to meet shortages include the installation of new wells.

Mining

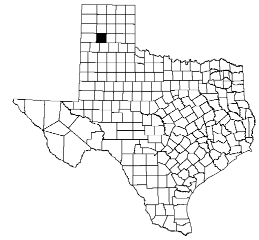
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended.

Steam Electric Power

- Current supply is water from the Ogallala aquifer, the CRMWA system and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended.

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Amarillo	CRMWA system Ogallala aquifer	Yes	New wells, CRMWA, Conservation
County-Other	Ogallala and Dockum/Rita Blanca aquifers	Yes	New wells, Conservation
Irrigation	Ogallala aquifer, local supply and reuse	No	None
Livestock	Ogallala and Dockum/Rita Blanca aquifers and local supply (stock ponds and irrigation)	No	None
Manufacturing	Ogallala aquifer & CRMWA system	Yes	New wells
Mining	Ogallala aquifer	No	None
Steam Electric	Ogallala aquifer, CRMWA system and reuse	No	None

Panhandle Water Planning Group
Randall County
Strategy Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Randall County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. Strategies have been suggested for all water user groups that have a projected shortage, including the ones with a shortage of less than 10 AFY. Following the narrative is a table summarizing this information.

Amarillo

- Current supply is water from the Ogallala aquifer and CRMWA system
- Projected demands will exceed current supplies starting in 2030.
- Shortages occur in the Red River basin.
- The recommended water management strategies to meet shortages include the installation of new wells, CRMWA well field expansion, and implementation of conservation measures.

Canyon

- Current supply is water from the Ogallala aquifer and CRMWA system
- Projected demands will exceed current supplies starting in 2050.
- Shortages occur in the Red River basin.
- The recommended water management strategies to meet shortages include purchasing water from Amarillo & CRMWA and implementation of conservation measures.

Lake Tanglewood

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

County-Other

- Current supply is water from the Ogallala and Dockum/Rita Blanca aquifers and the CRMWA system in the Canadian River basin and from the Ogallala and Dockum/Rita Blanca aquifers in the Red River basin
- Projected demands will exceed current supplies starting in 2010 in the Red River basin and in 2020 in the Canadian River basin
- Shortages occurs in the Canadian and Red River basins
- The recommended water management strategies to meet shortages include the installation of new wells and implementation of conservation measures.

Irrigation

- Current supply is water from the Ogallala aquifer, local supply and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds) in the Canadian River basin and from the Ogallala and Dockum/Rita Blanca aquifers and local supply (irrigation and stock ponds) in the Red River basin
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- Current supply is water from the Ogallala aquifer and the CRMWA system
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Mining

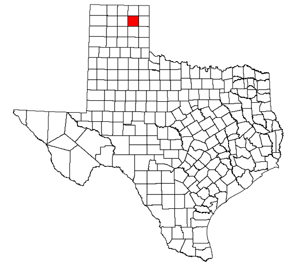
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Amarillo	Ogallala aquifer and CRMWA system	Yes	New wells, CRMWA, Conservation
Canyon	Ogallala aquifer and CRMWA system	Yes	Amarillo & CRMWA, Conservation
Lake Tanglewood	Ogallala aquifer	No	None
County-Other	Ogallala & Dockum/Rita Blanca aquifers and CRMWA system	Yes	New wells, Conservation
Irrigation	Ogallala aquifer, local supply and reuse	No	None
Livestock	Ogallala & Dockum/Rita Blanca aquifers and local supply (stock ponds)	No	None
Manufacturing	Ogallala aquifer & CRMWA system	No	None
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Roberts County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Roberts County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. The analysis of supplies includes CRMWA withdrawing water from Roberts County for use elsewhere in the region. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

Miami

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

County-Other

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Irrigation

- Current supply is water from the Ogallala aquifer and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Livestock

- Current supply is water from the Ogallala aquifer and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- There are no demands in this category

Mining

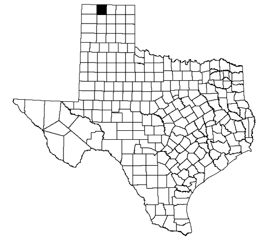
- Current supply is water from the Ogallala and aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric Power

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Miami	Ogallala aquifer	No	None
County-Other	Ogallala aquifer	No	None
Irrigation	Ogallala aquifer and reuse	No	None
Livestock	Ogallala aquifer and local supply (stock ponds)	No	None
Manufacturing	None	---	---
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Sherman County
Strategy Summary



The following narrative describes the source(s) of current water supply and recommended water management strategies for water user groups in Sherman County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. Strategies have been suggested for all water user groups that have a projected shortage. Following the narrative is a table summarizing this information.

<u>Stratford</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells and implementation of conservation measures.

<u>County-Other</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include the installation of new wells and implementation of conservation measures.

<u>Irrigation</u>

- Current supply is water from the Ogallala aquifer and local supply
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include NPET, improved irrigation equipment, conservation tillage and precipitation enhancement.

<u>Livestock</u>

- Current supply is water from the Ogallala aquifer and local supply (irrigation and stock ponds)
- Projected demands will exceed current supplies starting in 2010
- Shortage occurs in the Canadian River basin
- The recommended water management strategies to meet shortages include voluntary transfer from other users.

Manufacturing

- There are no demands in this category

Mining

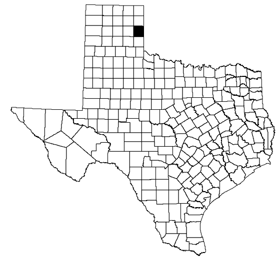
- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric

- There are no demands in this category

Water User Group	Current Supplies	Shortage	Proposed Water Management Strategies
Stratford	Ogallala aquifer	Yes	New wells, Conservation
County-Other	Ogallala aquifer	Yes	New wells, Conservation
Irrigation	Ogallala aquifer & local supply	Yes	NPET, Improved Irrigation Equipment, Conservation Tillage, Precipitation Enhancement
Livestock	Ogallala aquifer and local supply (irrigation and stock ponds)	Yes	Voluntary Transfer From Other Users, Conservation
Manufacturing	None	---	---
Mining	Ogallala aquifer	No	None
Steam Electric	None	---	---

Panhandle Water Planning Group
Wheeler County
Supply/Demand Summary



The following narrative describes the source(s) of current water supply for water user groups in Wheeler County. All groundwater supplies are shown to be 1.25% of annual allocation of saturated thickness in the respective aquifer. There are no projected shortages and therefore no strategies were identified. Following the narrative is a table summarizing this information.

<u>Shamrock</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Wheeler</u>

- Current supply is water from the Ogallala aquifer
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>County-Other</u>

- Current supply is water from the Ogallala, Blaine, Seymour and Whitehorse aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Irrigation</u>

- Current supply is water from the Ogallala, Blaine, Seymour, Whitehorse aquifers and reuse
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

<u>Livestock</u>

- Current supply is water from the Ogallala, Blaine, Seymour and Whitehorse aquifers and local supply (stock ponds)
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Manufacturing

- There are no demands in this category

Mining

- Current supply is water from the Ogallala and Blaine aquifers
- Projected demands will *not* exceed current supplies by 2060
- There are no projected shortages
- Currently, no strategies are recommended

Steam Electric Power

- There are no demands in this category

Water User Group	**Current Supplies**	**Shortage**	**Proposed Water Management Strategies**
Shamrock	Ogallala aquifer	No	None
Wheeler	Ogallala aquifer	No	None
County-Other	Ogallala, Blaine, Seymour and Whitehorse aquifers	No	None
Irrigation	Ogallala, Blaine, Seymour, Whitehorse aquifers and reuse	No	None
Livestock	Ogallala, Blaine, Seymour, Whitehorse aquifers and local supply (stock ponds)	No	None
Manufacturing	None	---	---
Mining	Ogallala and Blaine aquifers	No	None
Steam Electric	None	---	---

APPENDIX D (ADDENDA)

GAM Run 05-10

GAM run 05-10

by Richard Smith and Robert Mace
Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0877
March 3, 2005

REQUESTOR:

Mr. Stefan Schuster with Freese and Nichols, Inc. on behalf of the Panhandle Regional Water Planning Group

DESCRIPTION OF REQUEST:

Mr. Schuster requested that we compare the groundwater volumes between GAM Run 04-13 (Smith, 2004) and GAM Run 05-09 (Smith, 2005). GAM Run 04-13 involved calculating the groundwater in storage in the Ogallala aquifer for each county-basin area in the Panhandle Regional Water Planning Area assuming a 1.25 percent annual depletion from the base year of 1998 from 2000 through 2060 with average recharge (1.25% analysis). GAM Run 05-09 involved running the Groundwater Availability Model (GAM) for the northern part of the Ogallala aquifer from 2000 to 2060 using estimates of groundwater demands from the Panhandle Regional Water Planning Group for their 2006 regional water plan (GAM run).

METHODS:

We extracted the volumes from the 1.25% analysis and the GAM run and created a table to compare the numbers.

PARAMETERS AND ASSUMPTIONS:

- See GAM Run 04-13 and GAM Run 05-09 for the parameters and assumptions used in the source data for this analysis.

RESULTS:

Table 1 shows the groundwater volumes from the 1.25% analysis and the GAM run for the appropriate counties in the Panhandle Regional Water Planning Area. The volumes between the 1.25% analysis and the GAM run are similar for all but two counties in 2000. These volumes should be similar since the 1.25% analysis and the GAM run start with the same aquifer conditions. The volumes for Oldham and Randall counties do not agree because the GAM run does not include the entire county whereas the 1.25% analysis does.

After 2000, the volumes between the 1.25% analysis and the GAM run diverge. This is because the 1.25% analysis assumes that pumping will equal 1.25 percent of the current volume while the GAM run is based on actual projected demands.

The table can be used to see if the projected demands as expressed in the GAM violate the 1.25% analysis. This happens if the volume projected by the GAM is less than the volume projected by the 1.25% analysis. This occurs in Armstrong County (2000), Dallam County (2000 to 2060), Moore County (2010 to 2060), and Sherman County (2020 to 2060). The violation in Armstrong County can probably be disregarded because the difference only shows up in 2000 and is probably due to differences in starting volumes in the analysis. Note that the GAM run may include less pumpage than initially assigned because the aquifer cannot support the pumpage and begins to go dry. This occurs in Dallam, Moore, and Sherman counties as well as others (see GAM Run 05-09).

REFERENCES:

Smith, R., 2004, GAM Run 04-13: Texas Water Development Board, 7 p.
Smith, R., 2005, GAM Run 05-09: Texas Water Development Board, 14 p.

Table 1. Comparison between volumes of remaining groundwater using the 1.25% concept and using the GAM.

County	1.25% 2000 (acre-feet)	GAM 2000 (acre-feet)	1.25% 2010 (acre-feet)	GAM 2010 (acre-feet)	1.25% 2020 (acre-feet)	GAM 2020 (acre-feet)	1.25% 2030 (acre-feet)	GAM 2030 (acre-feet)	1.25% 2040 (acre-feet)	GAM 2040 (acre-feet)
Armstrong	3,680,000	3,610,000	3,290,000	3,540,000	2,950,000	3,480,000	2,650,000	3,420,000	2,380,000	3,370,000
Carson	13,300,000	13,500,000	11,800,000	12,500,000	10,500,000	11,600,000	9,360,000	10,700,000	8,330,000	9,980,000
Collingsworth	72,700	74,000	66,500	73,900	61,000	73,800	56,200	73,700	51,900	73,600
Dallam	15,500,000	14,700,000	13,800,000	12,300,000	12,400,000	10,300,000	11,200,000	9,090,000	10,000,000	7,790,000
Donley	5,200,000	5,290,000	4,720,000	5,130,000	4,300,000	4,990,000	3,930,000	4,860,000	3,600,000	4,740,000
Gray	11,200,000	11,400,000	10,000,000	11,100,000	9,010,000	10,800,000	8,100,000	10,500,000	7,300,000	10,300,000
Hansford	18,200,000	18,500,000	16,200,000	17,300,000	14,300,000	16,200,000	12,700,000	15,200,000	11,300,000	14,200,000
Hartley	20,300,000	20,500,000	18,100,000	18,300,000	16,100,000	16,300,000	14,300,000	14,700,000	12,800,000	13,600,000
Hemphill	13,300,000	13,700,000	12,000,000	13,700,000	10,900,000	13,600,000	9,890,000	13,600,000	9,020,000	13,500,000
Hutchinson	9,480,000	9,590,000	8,510,000	8,900,000	7,650,000	8,220,000	6,890,000	7,610,000	6,230,000	7,080,000
Lipscomb	18,300,000	18,600,000	16,300,000	18,500,000	14,600,000	18,400,000	13,000,000	18,300,000	11,700,000	18,200,000
Moore	10,500,000	10,500,000	9,370,000	8,750,000	8,340,000	7,060,000	7,420,000	5,560,000	6,620,000	4,400,000
Ochiltree	18,700,000	19,100,000	16,600,000	18,200,000	14,700,000	17,400,000	13,000,000	16,600,000	11,600,000	15,900,000
Oldham*	2,580,000	444,000	2,310,000	436,000	2,080,000	431,000	1,870,000	425,000	1,690,000	419,000
Potter	2,790,000	2,790,000	2,490,000	2,680,000	2,230,000	2,530,000	2,000,000	2,410,000	1,800,000	2,340,000
Randall*	6,230,000	1,560,000	5,730,000	1,450,000	5,290,000	1,360,000	4,900,000	1,280,000	4,560,000	1,220,000
Roberts	23,400,000	23,900,000	20,800,000	23,400,000	18,600,000	22,800,000	16,600,000	22,300,000	14,900,000	21,900,000
Sherman	16,600,000	17,300,000	14,700,000	15,000,000	13,000,000	12,700,000	11,600,000	10,100,000	10,300,000	8,590,000
Wheeler	6,540,000	6,650,000	6,000,000	6,600,000	5,520,000	6,550,000	5,090,000	6,510,000	4,720,000	6,480,000

* - The GAM numbers for Oldham and Randall counties do not include the entire county while to 1.25% analysis numbers do. The GAM numbers only include the parts of the counties that are included in the GAM for the northern part of the Ogallala aquifer.

- Volumes that are underlined represent cases where the volume from the GAM run is less than the volume from the 1.25% analysis.
- Values are rounded to three significant figures.

Table 1. Continued.

County	1.25% 2050 (acre-feet)	GAM 2050 (acre-feet)	1.25% 2060 (acre-feet)	GAM 2060 (acre-feet)
Armstrong	2,140,000	3,320,000	1,930,000	3,280,000
Carson	7,420,000	9,320,000	6,620,000	8,730,000
Collingsworth	48,200	73,500	44,900	73,400
Dallam	9,050,000	6,890,000	8,190,000	6,210,000
Donley	3,310,000	4,650,000	3,050,000	4,570,000
Gray	6,600,000	10,000,000	5,970,000	9,810,000
Hansford	10,000,000	13,300,000	8,900,000	12,500,000
Hartley	11,500,000	13,000,000	10,300,000	12,500,000
Hemphill	8,250,000	13,500,000	7,570,000	13,500,000
Hutchinson	5,640,000	6,660,000	5,130,000	6,310,000
Lipscomb	10,500,000	18,100,000	9,450,000	18,000,000
Moore	5,910,000	3,570,000	5,280,000	2,970,000
Ochiltree	10,300,000	15,300,000	9,160,000	14,700,000
Oldham*	1,530,000	415,000	1,390,000	411,000
Potter	1,620,000	2,260,000	1,460,000	2,190,000
Randall*	4,250,000	1,170,000	3,990,000	1,130,000
Roberts	13,400,000	21,400,000	12,000,000	20,800,000
Sherman	9,120,000	7,040,000	8,120,000	5,490,000
Wheeler	4,390,000	6,450,000	4,100,000	6,430,000

APPENDIX E

Water Management Strategies Cost Estimates

Table E-1
City of Amarillo
Develop Potters County Well Field (Ogallala Aquifer)

Owner: City of Amarillo
Quantity: 8,000 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	600	gpm	15	Ea.	$320,000	$4,800,000
Connection to Pump Station			15	Ea.	$100,000	$1,500,000
Storage Tank	1,500,000	Gal	1	Ea.	$355,000	$355,000
Engineering and Contingencies (35% for well field)						$2,329,300
Subtotal for Wellfield and Treatment						**$8,984,300**
Transmission System						
Pipeline - Transmission Main	30	inch	105,600	LF	$86	$9,081,600
Pump Station	1,000	HP	2	LS	$2,400,000	$4,800,000
Easement - Rural	20	Feet	48	AC	$500	$24,000
Engineering and Contingencies (30% for pipelines, 35% for other items)						$4,404,500
Subtotal for Transmission						**$18,310,100**
TOTAL CONSTRUCTION COST						**$27,294,400**
Interest During Construction				**(12 months)**		**$1,137,400**
Permitting and Mitigation						**$246,400**
Groundwater Rights/ Purchase						**$0**
TOTAL CAPITAL COST						**$28,678,200**
Annual Costs						
Debt Service (6 percent for 20 years)						$2,500,300
Electricity						$88,600
Water Treatment ($0.15 per 1,000 gal)						$391,000
Operation and Maintenance						$452,700
Total Annual Cost						**$3,432,600**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$429**
Water Cost ($ per 1,000 gallons)						**$1.32**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$117**
Water Cost ($ per 1,000 gallons)						**$0.36**

Table E-2
City of Amarillo
Develop Roberts County Well Field (Ogallala Aquifer)

Owner: City of Amarillo
Quantity: 11,210 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	800	gpm	15	Ea.	$320,000	$4,800,000
Connection to Pump Station			15	Ea.	$100,000	$1,500,000
Storage Tank	2,500,000	Gal	1	Ea.	$510,000	$510,000
Engineering and Contingencies (35% for well field)						$2,383,500
Subtotal for Wellfield and Treatment						**$9,193,500**
Transmission System						
Pipeline - Transmission Main	36	inch	401,280	LF	$114	$45,745,900
Pump Station	2,000	HP	2	LS	$3,500,000	$7,000,000
Easement - Rural	20	Feet	184	AC	$500	$92,000
Engineering and Contingencies (30% for pipelines, 35% for other items)						$16,173,800
Subtotal for Transmission						**$69,011,700**
TOTAL CONSTRUCTION COST						**$78,205,200**
Interest During Construction				**(12 months)**		**$3,258,800**
Permitting and Mitigation						**$714,700**
Groundwater Rights/ Purchase						**$0**
TOTAL CAPITAL COST						**$82,178,700**
Annual Costs						
Debt Service (6 percent for 30 years)						$5,970,200
Electricity						$251,100
Water Treatment ($0.15 per 1,000 gal)						$547,900
Operation and Maintenance						$963,300
Total Annual Cost						**$7,732,500**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$690**
Water Cost ($ per 1,000 gallons)						**$2.12**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$157**
Water Cost ($ per 1,000 gallons)						**$0.48**

Table E-3
Canadian River Municipal Water Authority
Expand Roberts County Well Field (Ogallala Aquifer)

Owner: Canadian River Municipal Water Authority
Quantity: 31,659 AF/Y

Capital Costs	**Cost**
Water Rights	$23,000,000
Collection Pipeline(s)	$1,800,000
Well Field(s) and Wells	$18,200,000
Total Capital Cost	**$43,000,000**
Engineering, Legal Costs and Contingencies (30% for pipelines & 35% for all other)	$6,910,000
Interest During Construction (3 years @ 4 percent)	$6,073,000
Total Project Cost	**$55,983,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$4,067,000
Pipeline and Well Operation and Maintenance	$473,000
Pumping Energy Costs (35,391,000 kWh @ $0.072/kWh)	$2,547,600
Total Annual Cost	**$7,087,600**
Unit Cost	
Annual Cost of Water ($ per acft)	$224
Annual Cost of Water ($ per 1,000 gallons)	$0.69

Table E-4
Canadian River Municipal Water Authority
Replace Capacity of Roberts County Well Field (Ogallala Aquifer) in 2030

Owner: Canadian River Municipal Water Authority
Quantity: 15,000 AF/Y

Capital Costs	**Cost**
Water Rights	$6,075,000
Collection Pipeline(s)	$1,000,000
Well Field(s) and Wells	$10,000,000
Total Capital Cost	**$17,075,000**
Engineering, Legal Costs and Contingencies (30% for pipelines & 35% for all other)	$3,800,000
Interest During Construction (3 years @ 4 percent)	$2,540,000
Total Project Cost	**$23,415,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$1,701,000
Pipeline and Well Operation and Maintenance	$260,000
Pumping Energy Costs (35,391,000 kWh @ $0.072/kWh)	$1,207,200
Total Annual Cost	**$3,168,200**
Unit Cost	
Annual Cost of Water ($ per acft)	$211
Annual Cost of Water ($ per 1,000 gallons)	$0.65

Table E-5
City of Cactus
Overdraft Ogallala Aquifer with New Wells

Owner: City of Cactus
Quantity: 3,200 AF/Y

Capital Costs	**Size**		**Quantity**	**Unit**	**Unit Price**	**Cost**
Wellfield and Treatment						
Wells	700	gpm	5	Ea.	$300,000	$1,500,000
Connection to Pump Station			5	Ea.	$100,000	$500,000
Storage Tank (Closed)	700,000	Gal	1	Ea.	$203,000	$203,000
Engineering and Contingencies (35% for well field)						$771,100
Subtotal for Wellfield and Treatment						**$2,974,100**
Transmission System						
Pipeline - Transmission Main	20	inch	7,920	LF	$51	$403,900
Pump Station	100	HP	1	LS	$620,000	$620,000
Easement - Rural	20	Feet	4	AC	$500	$1,800
Engineering and Contingencies (30% for pipelines, 35% for other items)						$338,200
Subtotal for Transmission						**$1,363,900**
TOTAL CONSTRUCTION COST						**$4,338,000**
Interest During Construction				**(6 months)**		**$94,000**
Permitting and Mitigation						**$38,700**
Groundwater Rights/ Purchase						**$960,000**
TOTAL CAPITAL COST						**$5,430,700**
Annual Costs						
Debt Service (6 percent for 20 years)						$473,500
Electricity (Transmission)						$18,300
Water Treatment ($0.15 per 1,000 gal)						$156,400
Operation and Maintenance						$89,500
Total Annual Cost						**$737,700**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$231**
Water Cost ($ per 1,000 gallons)						**$0.71**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$83**
Water Cost ($ per 1,000 gallons)						**$0.25**

Table E-6
City of Dalhart (Dallam County)
Overdraft Ogallala Aquifer in Dallam County with New Wells

Owner: City of Dalhart
Quantity: 900 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	500	gpm	2	Ea.	$162,500	$325,000
Connection to Pump Station			2	Ea.	$100,000	$200,000
Storage Tank (Closed)	200,000	Gal	1	Ea.	$91,700	$91,700
Engineering and Contingencies (35% for well field)						$215,800
Subtotal for Wellfield and Treatment						**$832,500**
Transmission System						
Pipeline - Transmission Main	20	inch	10,560	LF	$51	$538,600
Pump Station	25	HP	1	LS	$250,000	$250,000
Easement - Rural	20	Feet	5	AC	$500	$2,400
Engineering and Contingencies (30% for pipelines, 35% for other items)						$249,100
Subtotal for Transmission						**$1,040,100**
TOTAL CONSTRUCTION COST						**$1,872,600**
Interest During Construction				**(6 months)**		**$40,600**
Permitting and Mitigation						**$16,900**
Groundwater Rights/ Purchase						**$270,000**
TOTAL CAPITAL COST						**$2,200,100**
Annual Costs						
Debt Service (6 percent for 20 years)						$191,800
Electricity (Transmission)						$4,700
Water Treatment ($0.15 per 1,000 gal)						$44,000
Operation and Maintenance						$32,500
Total Annual Cost						**$273,000**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$303**
Water Cost ($ per 1,000 gallons)						**$0.93**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$90**
Water Cost ($ per 1,000 gallons)						**$0.28**

Table E-7
City of Dalhart (Hartley County)
Overdraft Ogallala Aquifer in Hartley County with New Wells

Owner: City of Dalhart
Quantity: 180 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	200	gpm	1	Ea.	$162,500	$162,500
Connection to Pump Station			1	Ea.	$100,000	$100,000
Storage Tank (Closed)	50,000	Gal	1	Ea.	$40,000	$40,000
Engineering and Contingencies (35% for well field)						$105,900
Subtotal for Wellfield and Treatment						**$408,400**
Transmission System						
Pipeline - Transmission Main	8	inch	10,560	LF	$20	$211,200
Pump Station	5	HP	1	LS	$50,000	$50,000
Easement - Rural	15	Feet	4	AC	$500	$1,800
Engineering and Contingencies (30% for pipelines, 35% for other items)						$80,900
Subtotal for Transmission						**$343,900**
TOTAL CONSTRUCTION COST						**$752,300**
Interest During Construction				**(6 months)**		**$16,300**
Permitting and Mitigation						**$6,800**
Groundwater Rights/ Purchase						**$54,000**
TOTAL CAPITAL COST						**$829,400**
Annual Costs						
Debt Service (6 percent for 20 years)						$72,300
Electricity (Transmission)						$1,000
Water Treatment ($0.15 per 1,000 gal)						$8,800
Operation and Maintenance						$13,100
Total Annual Cost						**$95,200**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$529**
Water Cost ($ per 1,000 gallons)						**$1.62**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$127**
Water Cost ($ per 1,000 gallons)						**$0.39**

Table E-8
City of Dumas
Overdraft Ogallala Aquifer with New Wells

Owner: City of Dumas
Quantity: 2,300 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	800	gpm	3	Ea.	$280,000	$840,000
Connection to Pump Station			3	Ea.	$100,000	$300,000
Storage Tank	500,000	Gal	1	Ea.	$155,000	$155,000
Engineering and Contingencies (35% for well field)						$453,300
Subtotal for Wellfield and Treatment						**$1,748,300**
Transmission System						
Pipeline - Rural	18	inch	52,800	LF	$42	$2,217,600
Pump Station	200	HP	1	LS	$930,000	$930,000
Easement - Rural	20	Feet	24	AC	$500	$12,100
Engineering and Contingencies (30% for pipelines, 35% for other items)						$990,800
Subtotal for Transmission						**$4,150,500**
TOTAL CONSTRUCTION COST						**$5,898,800**
Interest During Construction				**(12 months)**		**$245,800**
Permitting and Mitigation						**$53,300**
Groundwater Rights/ Purchase						**$690,000**
TOTAL CAPITAL COST						**$6,887,900**
Annual Costs						
Debt Service (6 percent for 20 years)						$600,500
Electricity (Transmission)						$13,900
Water Treatment ($0.15 per 1,000 gal)						$112,400
Operation and Maintenance						$93,400
Total Annual Cost						**$820,200**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$357**
Water Cost ($ per 1,000 gallons)						**$1.09**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$96**
Water Cost ($ per 1,000 gallons)						**$0.29**

Table E-9
City of Stratford
Overdraft Ogallala Aquifer with New Wells

Owner: City of Stratford
Quantity: 450 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	600	gpm	1	Ea.	$162,500	$162,500
Connection to Pump Station			1	Ea.	$100,000	$100,000
Storage Tank (Closed)	100,000	Gal	1	Ea.	$75,000	$75,000
Engineering and Contingencies (35% for well field)						$118,100
Subtotal for Wellfield and Treatment						**$455,600**
Transmission System						
Pipeline - Rural	10	inch	5,280	LF	$24	$126,700
Pump Station	15	HP	1	LS	$150,000	$150,000
Easement - Rural	20	Feet	2	AC	$500	$1,200
Engineering and Contingencies (30% for pipelines, 35% for other items)						$90,500
Subtotal for Transmission						**$368,400**
TOTAL CONSTRUCTION COST						**$824,000**
Interest During Construction				**(6 months)**		**$17,900**
Permitting and Mitigation						**$7,400**
Groundwater Rights/ Purchase						**$135,000**
TOTAL CAPITAL COST						**$984,300**
Annual Costs						
Debt Service (6 percent for 20 years)						$85,800
Electricity (Transmission)						$2,500
Water Treatment ($0.15 per 1,000 gal)						$22,000
Operation and Maintenance						$16,100
Total Annual Cost						**$126,400**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$281**
Water Cost ($ per 1,000 gallons)						**$0.86**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$90**
Water Cost ($ per 1,000 gallons)						**$0.28**

Table E-10
City of Sunray
Overdraft Ogallala with New Groundwater Wells

Owner: City of Sunray
Quantity: 550 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	700	gpm	1	Ea.	$162,500	$162,500
Connection to Pump Station			1	Ea.	$100,000	$100,000
Storage Tank (Closed)	125,000	Gal	1	Ea.	$315,000	$315,000
Engineering and Contingencies (35% for well field)						$202,100
Subtotal for Wellfield and Treatment						**$779,600**
Transmission System						
Pipeline - Rural	10	inch	5,280	LF	$24	$126,700
Pump Station	15	HP	1	LS	$150,000	$150,000
Easement - Rural	20	Feet	2	AC	$500	$1,200
Engineering and Contingencies (30% for pipelines, 35% for other items)						$90,500
Subtotal for Transmission						**$368,400**
TOTAL CONSTRUCTION COST						**$1,148,000**
Interest During Construction				**(6 months)**		**$24,900**
Permitting and Mitigation						**$10,300**
Groundwater Rights/ Purchase						**$165,000**
TOTAL CAPITAL COST						**$1,348,200**
Annual Costs						
Debt Service (6 percent for 20 years)						$117,500
Electricity (Transmission)						$1,600
Water Treatment ($0.15 per 1,000 gal)						$26,900
Operation and Maintenance						$23,300
Total Annual Cost						**$169,300**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$308**
Water Cost ($ per 1,000 gallons)						**$0.94**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$94**
Water Cost ($ per 1,000 gallons)						**$0.29**

Table E-11
County-Other WUGs with Needs less than 200 ac-ft/yr
Install New Groundwater Well

Owner: County-Other
Quantity: 200 AF/Y

Capital Costs	**Size**		**Quantity**	**Unit**	**Unit Price**	**Cost**
Wellfield and Treatment						
Wells	300	gpm	1	Ea.	$137,500	$137,500
Connection to Pump Station			1	Ea.	$100,000	$100,000
Storage Tank (Closed)	50,000	Gal	1	Ea.	$40,000	$40,000
Engineering and Contingencies (35% for well field)						$97,100
Subtotal for Wellfield and Treatment						**$374,600**
Transmission System						
Pipeline - Rural	8	inch	10,560	LF	$20	$211,200
Pump Station	10	HP	1	LS	$100,000	$100,000
Easement - Rural	15	Feet	4	AC	$500	$1,800
Engineering and Contingencies (30% for pipelines, 35% for other items)						$98,400
Subtotal for Transmission						**$411,400**
TOTAL CONSTRUCTION COST						**$786,000**
Interest During Construction				**(6 months)**		**$17,000**
Permitting and Mitigation						**$7,100**
Groundwater Rights/ Purchase						**$60,000**
TOTAL CAPITAL COST						**$870,100**
Annual Costs						
Debt Service (6 percent for 20 years)						$75,900
Electricity (Transmission)						$1,100
Water Treatment ($0.15 per 1,000 gal)						$9,800
Operation and Maintenance						$13,800
Total Annual Cost						**$100,600**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$503**
Water Cost ($ per 1,000 gallons)						**$1.54**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$124**
Water Cost ($ per 1,000 gallons)						**$0.38**

Table E-12
County-Other WUGs with Needs around 600 ac-ft/yr
Install New Groundwater Wells

Owner: County-Other
Quantity: 600 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	400	gpm	2	Ea.	$150,000	$300,000
Connection to Pump Station			2	Ea.	$100,000	$200,000
Storage Tank (Closed)	120,000	Gal	1	Ea.	$80,000	$80,000
Engineering and Contingencies (35% for well field)						$203,000
Subtotal for Wellfield and Treatment						**$783,000**
Transmission System						
Pipeline - Rural	10	inch	10,560	LF	$24	$253,400
Pump Station	25	HP	1	LS	$250,000	$250,000
Easement - Rural	20	Feet	5	AC	$500	$2,400
Engineering and Contingencies (30% for pipelines, 35% for other items)						$163,500
Subtotal for Transmission						**$669,300**
TOTAL CONSTRUCTION COST						**$1,452,300**
Interest During Construction				**(12 months)**		**$60,500**
Permitting and Mitigation						**$13,000**
Groundwater Rights/ Purchase						**$180,000**
TOTAL CAPITAL COST						**$1,705,800**
Annual Costs						
Debt Service (6 percent for 20 years)						$148,700
Electricity (Transmission)						$3,700
Water Treatment ($0.15 per 1,000 gal)						$29,300
Operation and Maintenance						$27,900
Total Annual Cost						**$209,600**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$349**
Water Cost ($ per 1,000 gallons)						**$1.07**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$102**
Water Cost ($ per 1,000 gallons)						**$0.31**

Table E-13
County-Other WUGs with Needs around 1,000 ac-ft/yr
Install New Groundwater Wells

Owner: County-Other
Quantity: 1,000 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	600	gpm	2	Ea.	$162,500	$325,000
Connection to Pump Station			2	Ea.	$100,000	$200,000
Storage Tank (Closed)	200,000	Gal	1	Ea.	$91,700	$91,700
Engineering and Contingencies (35% for well field)						$215,800
Subtotal for Wellfield and Treatment						**$832,500**
Transmission System						
Pipeline - Rural	14	inch	10,560	LF	$32	$337,900
Pump Station	50	HP	1	LS	$400,000	$400,000
Easement - Rural	20	Feet	5	AC	$500	$2,400
Engineering and Contingencies (30% for pipelines, 35% for other items)						$241,400
Subtotal for Transmission						**$981,700**
TOTAL CONSTRUCTION COST						**$1,814,200**
Interest During Construction				**(12 months)**		**$75,600**
Permitting and Mitigation						**$16,300**
Groundwater Rights/ Purchase						**$300,000**
TOTAL CAPITAL COST						**$2,206,100**
Annual Costs						
Debt Service (6 percent for 20 years)						$192,300
Electricity (Transmission)						$5,600
Water Treatment ($0.15 per 1,000 gal)						$48,900
Operation and Maintenance						$34,600
Total Annual Cost						**$281,400**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$281**
Water Cost ($ per 1,000 gallons)						**$0.86**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$89**
Water Cost ($ per 1,000 gallons)						**$0.27**

Table E-14
County-Other WUGs with Needs around 2,000 ac-ft/yr
Install New Groundwater Wells

Owner: County-Other
Quantity: 2,000 AF/Y

Capital Costs	**Size**		**Quantity**	**Unit**	**Unit Price**	**Cost**
Wellfield and Treatment						
Wells	800	gpm	3	Ea.	$200,000	$600,000
Connection to Pump Station			3	Ea.	$100,000	$300,000
Storage Tank (Closed)	400,000	Gal	1	Ea.	$133,000	$133,000
Engineering and Contingencies (35% for well field)						$361,600
Subtotal for Wellfield and Treatment						**$1,394,600**
Transmission System						
Pipeline - Rural	18	inch	10,560	LF	$42	$443,500
Pump Station	75	HP	1	LS	$510,000	$510,000
Easement - Rural	20	Feet	5	AC	$500	$2,400
Engineering and Contingencies (30% for pipelines, 35% for other items)						$311,600
Subtotal for Transmission						**$1,267,500**
TOTAL CONSTRUCTION COST						**$2,662,100**
Interest During Construction				**(12 months)**		**$110,900**
Permitting and Mitigation						**$23,800**
Groundwater Rights/ Purchase						**$600,000**
TOTAL CAPITAL COST						**$3,396,800**
Annual Costs						
Debt Service (6 percent for 20 years)						$296,100
Electricity (Transmission)						$11,200
Water Treatment ($0.15 per 1,000 gal)						$97,800
Operation and Maintenance						$51,600
Total Annual Cost						**$456,700**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$228**
Water Cost ($ per 1,000 gallons)						**$0.70**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$80**
Water Cost ($ per 1,000 gallons)						**$0.25**

Table E-15

Armstrong

Strategy	Annual Costs						
	2010	2020	2030	2040	2050	2060	Capital Cost
Change Crop Type	0	0	0	0	0	0	58,560
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	917	1,147	1,376	1,606	1,835	2,064	0
Convert to Dry	0	0	0	0	0	0	492,229
Irrigation Equipment	917	1,835	2,752	4,587	5,505	6,422	1,161,030
PET Network	1,018	1,018	1,018	1,018	1,018	1,018	4,886
Precipitation Enhancement	3,257	3,257	3,257	3,257	3,257	3,257	14,659
Total	6,110	7,257	8,404	10,468	11,615	12,762	1,731,363

Carson

Strategy	Annual Costs						
	2010	2020	2030	2040	2050	2060	Capital Cost
Change Crop Type	0	0	0	0	0	0	1,277,280
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	7,272	9,091	10,909	12,727	14,545	16,363	0
Convert to Dry	0	0	0	0	0	0	3,169,335
Irrigation Equipment	7,272	14,545	21,817	36,362	43,635	50,907	9,203,009
PET Network	8,069	8,069	8,069	8,069	8,069	8,069	38,731
Precipitation Enhancement	25,820	25,820	25,820	25,820	25,820	25,820	116,192
Total	48,434	57,525	66,615	82,978	92,069	101,159	13,804,547

Childress

Strategy	Annual Costs						
	2010	2020	2030	2040	2050	2060	Capital Cost
Change Crop Type	0	0	0	0	0	0	0
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	723	904	1,085	1,265	1,446	1,627	0
Convert to Dry	0	0	0	0	0	0	385,613
Irrigation Equipment	723	1,446	2,169	3,615	4,338	5,061	914,929
PET Network	802	802	802	802	802	802	3,850
Precipitation Enhancement	2,567	2,567	2,567	2,567	2,567	2,567	11,551
Total	4,815	5,719	6,623	8,249	9,153	10,057	1,315,943

Collingsworth

Strategy	Annual Costs						
	2010	2020	2030	2040	2050	2060	Capital Cost
Change Crop Type	0	0	0	0	0	0	2,400
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	1,609	2,012	2,414	2,816	3,219	3,621	0
Convert to Dry	0	0	0	0	0	0	320,483
Irrigation Equipment	1,609	3,219	4,828	8,047	9,657	11,266	2,036,666
PET Network	1,786	1,786	1,786	1,786	1,786	1,786	8,571
Precipitation Enhancement	5,714	5,714	5,714	5,714	5,714	5,714	25,714
Total	10,719	12,730	14,742	18,363	20,375	22,387	2,393,834

Table E-15, Continued

Dallam

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	13,355,920
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	18,870	23,588	28,306	33,023	37,741	42,459	0
Convert to Dry	0	0	0	0	0	0	3,902,876
Irrigation Equipment	18,870	37,741	56,611	94,352	113,223	132,093	23,879,837
PET Network	20,937	20,937	20,937	20,937	20,937	20,937	100,498
Precipitation Enhancement	66,999	66,999	66,999	66,999	66,999	66,999	301,493
Total	125,676	149,264	172,853	215,311	238,899	262,487	41,540,625

Donley

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	97,280
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	1,370	1,713	2,055	2,398	2,740	3,083	0
Convert to Dry	0	0	0	0	0	0	496,031
Irrigation Equipment	1,370	2,740	4,110	6,850	8,221	9,591	1,733,809
PET Network	1,520	1,520	1,520	1,520	1,520	1,520	7,297
Precipitation Enhancement	4,864	4,864	4,864	4,864	4,864	4,864	21,890
Total	9,125	10,837	12,550	15,633	17,345	19,058	2,356,308

Gray

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	501,440
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	2,206	2,757	3,309	3,860	4,411	4,963	0
Convert to Dry	0	0	0	0	0	0	866,726
Irrigation Equipment	2,206	4,411	6,617	11,028	13,234	15,440	2,791,198
PET Network	2,447	2,447	2,447	2,447	2,447	2,447	11,747
Precipitation Enhancement	7,831	7,831	7,831	7,831	7,831	7,831	35,240
Total	14,690	17,447	20,204	25,167	27,924	30,681	4,206,351

Hall

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	0
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	1,516	1,895	2,274	2,653	3,032	3,411	0
Convert to Dry	0	0	0	0	0	0	656,321
Irrigation Equipment	1,516	3,032	4,548	7,579	9,095	10,611	1,918,314
PET Network	1,682	1,682	1,682	1,682	1,682	1,682	8,073
Precipitation Enhancement	5,382	5,382	5,382	5,382	5,382	5,382	24,220
Total	10,096	11,991	13,886	17,296	19,191	21,086	2,606,928

Table E-15, Continued

Hansford

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	2,533,440
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	9,535	11,918	14,302	16,686	19,069	21,453	0
Convert to Dry	0	0	0	0	0	0	4,202,543
Irrigation Equipment	9,535	19,069	28,604	47,673	57,208	66,742	12,065,674
PET Network	10,579	10,579	10,579	10,579	10,579	10,579	50,778
Precipitation Enhancement	33,852	33,852	33,852	33,852	33,852	33,852	152,334
Total	63,500	75,418	87,337	108,789	120,708	132,626	19,004,769

Hartley

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	10,483,280
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	16,202	20,252	24,302	28,353	32,403	36,454	0
Convert to Dry	0	0	0	0	0	0	3,558,360
Irrigation Equipment	16,202	32,403	48,605	81,008	97,210	113,412	20,502,572
PET Network	17,976	17,976	17,976	17,976	17,976	17,976	86,285
Precipitation Enhancement	57,523	57,523	57,523	57,523	57,523	57,523	258,854
Total	107,902	128,154	148,406	184,860	205,112	225,364	34,889,351

Hemphill

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	0
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	95	119	143	167	191	215	0
Convert to Dry	0	0	0	0	0	0	59,085
Irrigation Equipment	95	191	286	477	573	668	120,820
PET Network	106	106	106	106	106	106	508
Precipitation Enhancement	339	339	339	339	339	339	1,525
Total	636	755	875	1,089	1,209	1,328	181,939

Hutchinson

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	1,152,080
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	4,597	5,746	6,895	8,045	9,194	10,343	0
Convert to Dry	0	0	0	0	0	0	2,078,115
Irrigation Equipment	4,597	9,194	13,791	22,984	27,581	32,178	5,817,202
PET Network	5,100	5,100	5,100	5,100	5,100	5,100	24,482
Precipitation Enhancement	16,321	16,321	16,321	16,321	16,321	16,321	73,445
Total	30,615	36,361	42,107	52,450	58,197	63,943	9,145,324

Table E-15, Continued

Lipscomb

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	396,480
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	918	1,148	1,377	1,607	1,836	2,066	0
Convert to Dry	0	0	0	0	0	0	230,100
Irrigation Equipment	918	1,836	2,754	4,590	5,508	6,427	1,161,789
PET Network	1,019	1,019	1,019	1,019	1,019	1,019	4,889
Precipitation Enhancement	3,260	3,260	3,260	3,260	3,260	3,260	14,668
Total	6,114	7,262	8,410	10,475	11,623	12,770	1,807,926

Moore

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	6,699,120
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	11,723	14,653	17,584	20,515	23,445	26,376	0
Convert to Dry	0	0	0	0	0	0	3,010,556
Irrigation Equipment	11,723	23,445	35,168	58,613	70,336	82,059	14,834,568
PET Network	13,006	13,006	13,006	13,006	13,006	13,006	62,431
Precipitation Enhancement	41,621	41,621	41,621	41,621	41,621	41,621	187,293
Total	78,072	92,726	107,379	133,755	148,408	163,062	24,793,968

Ochiltree

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	1,250,080
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	7,270	9,087	10,905	12,722	14,539	16,357	0
Convert to Dry	0	0	0	0	0	0	3,158,708
Irrigation Equipment	7,270	14,539	21,809	36,348	43,618	50,888	9,199,497
PET Network	8,066	8,066	8,066	8,066	8,066	8,066	38,716
Precipitation Enhancement	25,811	25,811	25,811	25,811	25,811	25,811	116,148
Total	48,416	57,503	66,590	82,947	92,034	101,121	13,763,148

Oldham

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	0
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	346	432	518	605	691	777	0
Convert to Dry	0	0	0	0	0	0	205,140
Irrigation Equipment	346	691	1,037	1,728	2,073	2,419	437,249
PET Network	383	383	383	383	383	383	1,840
Precipitation Enhancement	1,227	1,227	1,227	1,227	1,227	1,227	5,520
Total	2,301	2,733	3,165	3,942	4,374	4,806	649,749

Table E-15, Continued

Potter

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	27,760
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	421	527	632	737	842	948	0
Convert to Dry	0	0	0	0	0	0	183,251
Irrigation Equipment	421	842	1,264	2,106	2,527	2,948	533,013
PET Network	467	467	467	467	467	467	2,243
Precipitation Enhancement	1,495	1,495	1,495	1,495	1,495	1,495	6,730
Total	2,805	3,332	3,858	4,806	5,332	5,859	752,997

Randall

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	368,240
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	7,320	9,150	10,979	12,809	14,639	16,469	0
Convert to Dry	0	0	0	0	0	0	4,524,536
Irrigation Equipment	7,320	14,639	21,959	36,598	43,918	51,237	9,262,707
PET Network	8,121	8,121	8,121	8,121	8,121	8,121	38,982
Precipitation Enhancement	25,988	25,988	25,988	25,988	25,988	25,988	116,946
Total	48,748	57,898	67,047	83,517	92,666	101,816	14,311,411

Roberts

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	157,680
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	1,383	1,729	2,075	2,421	2,766	3,112	0
Convert to Dry	0	0	0	0	0	0	325,504
Irrigation Equipment	1,383	2,766	4,149	6,916	8,299	9,682	1,750,324
PET Network	1,535	1,535	1,535	1,535	1,535	1,535	7,366
Precipitation Enhancement	4,911	4,911	4,911	4,911	4,911	4,911	22,099
Total	9,212	10,941	12,670	15,782	17,511	19,240	2,262,972

Sherman

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	7,339,280
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	17,651	22,064	26,477	30,889	35,302	39,715	0
Convert to Dry	0	0	0	0	0	0	6,662,614
Irrigation Equipment	17,651	35,302	52,953	88,255	105,906	123,557	22,336,701
PET Network	19,584	19,584	19,584	19,584	19,584	19,584	94,003
Precipitation Enhancement	62,669	62,669	62,669	62,669	62,669	62,669	282,010
Total	117,555	139,619	161,683	201,397	223,461	245,525	36,714,609

Table E-15, Continued

Wheeler

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	0	0	0	0	0	0	30,000
Change Crop Variety	0	0	0	0	0	0	0
Conservation Tillage	718	897	1,077	1,256	1,436	1,615	0
Convert to Dry	0	0	0	0	0	0	386,246
Irrigation Equipment	718	1,436	2,154	3,589	4,307	5,025	908,475
PET Network	797	797	797	797	797	797	3,823
Precipitation Enhancement	2,549	2,549	2,549	2,549	2,549	2,549	11,470
Total	4,781	5,679	6,576	8,191	9,089	9,986	1,340,015

Total

Strategy	Annual Costs						Capital Cost
	2010	2020	2030	2040	2050	2060	
Change Crop Type	$0	$0	$0	$0	$0	$0	$45,730,320
Change Crop Variety	$0	$0	$0	$0	$0	$0	$0
Conservation Tillage	$112,662	$140,827	$168,993	$197,158	$225,324	$253,489	$0
Convert to Dry	$0	$0	$0	$0	$0	$0	$38,874,371
Irrigation Equipment	$112,662	$225,324	$337,986	$563,310	$675,971	$788,633	$142,569,385
PET Network	$125,000	$125,000	$125,000	$125,000	$125,000	$125,000	$600,000
Precipitation Enhancement	$400,000	$400,000	$400,000	$400,000	$400,000	$400,000	$1,800,000
Total	$750,324	$891,151	$1,031,979	$1,285,468	$1,426,295	$1,567,123	$229,574,076

Table E-16
Manufacturing WUGs with Needs of Approximately 1,000 ac-ft/yr
Purchase Direct Reuse

Owner: Manufacturing
Quantity: 1,000 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Transmission System						
Pipeline - Rural	12	inch	10,560	LF	$28	$295,700
Pump Station	30	HP	1	LS	$280,000	$280,000
Easement - Rural	20	Feet	5	AC	$500	$2,500
Engineering and Contingencies (30% for pipleines, 35% for other items)						$186,700
Subtotal for Transmission						**$764,900**
TOTAL CONSTRUCTION COST						**$764,900**
Interest During Construction				**(6 months)**		**$16,600**
Permitting and Mitigation						**$6,900**
TOTAL CAPITAL COST						**$788,400**
Annual Costs						
Debt Service (6 percent for 20 years)						$68,700
Electricity (Transmission)						$3,700
Water Purchase ($0.15 per 1,000 gal)						$48,900
Operation and Maintenance						$11,900
Total Annual Cost						**$133,200**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$133**
Water Cost ($ per 1,000 gallons)						**$0.41**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$65**
Water Cost ($ per 1,000 gallons)						**$0.20**

Table E-17
Manufacturing WUGs with Needs of Approximately 1,700 ac-ft/yr
Purchase Direct Reuse

Owner: Manufacturing
Quantity: 1,700 AF/Y

Capital Costs	Size	Quantity	Unit	Unit Price	Cost
Transmission System					
Pipeline - Rural	16 inch	10,560	LF	$37	$390,700
Pump Station	45 HP	1	LS	$370,000	$370,000
Easement - Rural	20 Feet	5	AC	$500	$2,500
Engineering and Contingencies (30% for pipleines, 35% for other items)					$246,700
Subtotal for Transmission					**$1,009,900**
TOTAL CONSTRUCTION COST					**$1,009,900**
Interest During Construction			**(6 months)**		**$21,900**
Permitting and Mitigation					**$9,100**
TOTAL CAPITAL COST					**$1,040,900**
Annual Costs					
Debt Service (6 percent for 20 years)					$90,800
Electricity (Transmission)					$5,500
Water Purchase ($0.15 per 1,000 gal)					$83,100
Operation and Maintenance					$15,800
Total Annual Cost					**$195,200**
UNIT COSTS (Until Amortized)					
Water Cost ($ per ac-ft)					**$115**
Water Cost ($ per 1,000 gallons)					**$0.35**
UNIT COSTS (After Amortization)					
Water Cost ($ per ac-ft)					**$61**
Water Cost ($ per 1,000 gallons)					**$0.19**

Table E-18
Manufacturing WUGs with Needs of Approximately 2,000 ac-ft/yr
Install Additional Groundwater Wells in Ogallala Aquifer

Owner: Manufacturing
Quantity: 2,000 AF/Y

Item	Size		Quantity	Unit	Unit Price	Cost
Capital Costs						
Wellfield and Treatment						
Wells	700	gpm	3	Ea.	$140,000	$420,000
Connection to Pump Station			3	Ea.	$100,000	$300,000
Storage Tank (Closed)	400,000	Gal	1	Ea.	$145,000	$145,000
Engineering and Contingencies (35% for well field)						$302,800
Subtotal for Wellfield and Treatment						**$1,167,800**
Transmission System						
Pipeline - Rural	18	inch	10,560	LF	$42	$443,500
Pump Station	50	HP	1	LS	$400,000	$400,000
Easement - Rural	20	Feet	5	AC	$500	$2,500
Engineering and Contingencies (30% for pipleines, 35% for other items)						$273,100
Subtotal for Transmission						**$1,119,100**
TOTAL CONSTRUCTION COST						**$2,286,900**
Interest During Construction				**(6 months)**		**$49,600**
Permitting and Mitigation						**$20,500**
Groundwater Rights/ Purchase						**$600,000**
TOTAL CAPITAL COST						**$2,957,000**
Annual Costs						
Debt Service (6 percent for 20 years)						$257,800
Electricity (Transmission)						$6,100
Water Treatment ($0.15 per 1,000 gal)						$97,800
Operation and Maintenance						$43,300
Total Annual Cost						**$405,000**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$203**
Water Cost ($ per 1,000 gallons)						**$0.62**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$74**
Water Cost ($ per 1,000 gallons)						**$0.23**

Table E-19
Manufacturing WUGs with Needs of Approximately 2,500 ac-ft/yr
Install Additional Groundwater Wells in Ogallala Aquifer

Owner: Manufacturing
Quantity: 2,500 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	700	gpm	4	Ea.	$140,000	$560,000
Connection to Pump Station			4	Ea.	$100,000	$400,000
Storage Tank (Closed)	500,000	Gal	1	Ea.	$155,000	$155,000
Engineering and Contingencies (35% for well field)						$390,300
Subtotal for Wellfield and Treatment						**$1,505,300**
Transmission System						
Pipeline - Rural	18	inch	10,560	LF	$42	$443,500
Pump Station	75	HP	1	LS	$510,000	$510,000
Easement - Rural	20	Feet	5	AC	$500	$2,500
Engineering and Contingencies (30% for pipleines, 35% for other items)						$311,600
Subtotal for Transmission						**$1,267,600**
TOTAL CONSTRUCTION COST						**$2,772,900**
Interest During Construction				**(6 months)**		**$60,100**
Permitting and Mitigation						**$24,800**
Groundwater Rights/ Purchase						**$750,000**
TOTAL CAPITAL COST						**$3,607,800**
Annual Costs						
Debt Service (6 percent for 20 years)						$314,500
Electricity (Transmission)						$8,500
Water Treatment ($0.15 per 1,000 gal)						$122,200
Operation and Maintenance						$54,100
Total Annual Cost						**$499,300**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$200**
Water Cost ($ per 1,000 gallons)						**$0.61**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$74**
Water Cost ($ per 1,000 gallons)						**$0.23**

Table E-20
Manufacturing WUGs with Needs of Approximately 3,600 ac-ft/yr
Install Additional Groundwater Wells in Ogallala Aquifer

Owner:	Manufacturing	
Quantity:	3,600	AF/Y

Item	Size		Quantity	Unit	Unit Price	Cost
Capital Costs						
Wellfield and Treatment						
Wells	700	gpm	6	Ea.	$140,000	$840,000
Connection to Pump Station			6	Ea.	$100,000	$600,000
Storage Tank (Closed)	700,000	Gal	1	Ea.	$203,000	$203,000
Engineering and Contingencies (35% for well field)						$575,100
Subtotal for Wellfield and Treatment						**$2,218,100**
Transmission System						
Pipeline - Rural	20	inch	10,560	LF	$51	$538,600
Pump Station	100	HP	1	LS	$620,000	$620,000
Easement - Rural	20	Feet	5	AC	$500	$2,500
Engineering and Contingencies (30% for pipleines, 35% for other items)						$378,600
Subtotal for Transmission						**$1,539,700**
TOTAL CONSTRUCTION COST						**$3,757,800**
Interest During Construction				**(6 months)**		**$81,400**
Permitting and Mitigation						**$33,600**
Groundwater Rights/ Purchase						**$1,080,000**
TOTAL CAPITAL COST						**$4,952,800**
Annual Costs						
Debt Service (6 percent for 20 years)						$431,800
Electricity (Transmission)						$12,600
Water Treatment ($0.15 per 1,000 gal)						$176,000
Operation and Maintenance						$74,400
Total Annual Cost						**$694,800**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$193**
Water Cost ($ per 1,000 gallons)						**$0.59**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$73**
Water Cost ($ per 1,000 gallons)						**$0.22**

Table E-21
Manufacturing WUGs with Needs of Approximately 5,600 ac-ft/yr
Install Additional Groundwater Wells in Ogallala Aquifer

Owner: Manufacturing
Quantity: 5,600 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	800	gpm	8	Ea.	$140,000	$1,120,000
Connection to Pump Station			8	Ea.	$100,000	$800,000
Storage Tank (Closed)	1,250,000	Gal	1	Ea.	$393,500	$393,500
Engineering and Contingencies (35% for well field)						$809,700
Subtotal for Wellfield and Treatment						**$3,123,200**
Transmission System						
Pipeline - Rural	24	inch	10,560	LF	$66	$697,000
Pump Station	150	HP	1	LS	$775,000	$775,000
Easement - Rural	20	Feet	5	AC	$500	$2,500
Engineering and Contingencies (30% for pipleines, 35% for other items)						$480,400
Subtotal for Transmission						**$1,954,900**
TOTAL CONSTRUCTION COST						**$5,078,100**
Interest During Construction				**(6 months)**		**$110,000**
Permitting and Mitigation						**$45,400**
Groundwater Rights/ Purchase						**$1,680,000**
TOTAL CAPITAL COST						**$6,913,500**
Annual Costs						
Debt Service (6 percent for 20 years)						$602,800
Electricity (Transmission)						$19,600
Water Treatment ($0.15 per 1,000 gal)						$273,700
Operation and Maintenance						$101,100
Total Annual Cost						**$997,200**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$178**
Water Cost ($ per 1,000 gallons)						**$0.55**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$70**
Water Cost ($ per 1,000 gallons)						**$0.22**

Table E-22
Steam Electric Power WUGs with Needs less than 200 ac-ft/yr
Install New Groundwater Well

Owner: Steam Electric Power
Quantity: 200 AF/Y

Capital Costs	**Size**		**Quantity**	**Unit**	**Unit Price**	**Cost**
Wellfield and Treatment						
Wells	300	gpm	1	Ea.	$137,500	$137,500
Connection to Pump Station			1	Ea.	$100,000	$100,000
Storage Tank (Closed)	50,000	Gal	1	Ea.	$40,000	$40,000
Engineering and Contingencies (35% for well field)						$97,100
Subtotal for Wellfield and Treatment						**$374,600**
Transmission System						
Pipeline - Rural	8	inch	10,560	LF	$20	$211,200
Pump Station	10	HP	1	LS	$100,000	$100,000
Easement - Rural	15	Feet	4	AC	$500	$1,800
Engineering and Contingencies (30% for pipelines, 35% for other items)						$98,400
Subtotal for Transmission						**$411,400**
TOTAL CONSTRUCTION COST						**$786,000**
Interest During Construction				**(6 months)**		**$17,000**
Permitting and Mitigation						**$7,100**
Groundwater Rights/ Purchase						**$60,000**
TOTAL CAPITAL COST						**$870,100**
Annual Costs						
Debt Service (6 percent for 20 years)						$75,900
Electricity (Transmission)						$1,100
Water Treatment ($0.15 per 1,000 gal)						$9,800
Operation and Maintenance						$13,800
Total Annual Cost						**$100,600**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$503**
Water Cost ($ per 1,000 gallons)						**$1.54**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$124**
Water Cost ($ per 1,000 gallons)						**$0.38**

Table E-23
Connecting to Palo Duro Reservoir

Owner:	Palo Duro River Authority	
Quantity:	Cactus	2,265
	Dumas	1,760
	Sunray	370
	Gruver	146
	Spearman	331
	Stinnet	157
	Total	5,029

		Quantity	Units	1995 Dollars	Unit Price	Cost
Water Treatment Plant						
9 MGD Conventional Treatment Plant		1	LS		$14,300,000	$14,300,000
Engineering and Contingencies (35%)						$5,005,000
Subtotal for Water Treatment Plant						**$19,305,000**

	Construction	Capital
Cactus	$6,440,600	$8,694,800
Dumas	$5,005,800	$6,757,800
Sunray	$1,052,200	$1,420,400
Gruver	$414,500	$559,600
Spearman	$940,600	$1,269,800
Stinnet	$446,400	$602,600
check total	$14,300,100	$19,305,000

		Quantity	Units	1995 Dollars	Unit Price	Cost
Pipeline System Components						
24" line from Res. to WTP		9,000	LF		$66	$594,000
24" line from WTP to Spearman		51,000	LF		$66	$3,366,000
Crossings		1	LS	$75,000		$88,000
Connection to Spearman		1	LS	$10,000		$11,700
ROW	20	23	AC		$500	$11,500
Engineering and Contingencies (30%)						$1,217,900
Pipeline Subtotal at Spearman						**$5,289,100**

	Construction	Capital	Electricity ($)
Cactus	$1,783,500	$2,382,200	$11,600
Dumas	$1,386,200	$1,851,500	$9,000
Sunray	$291,400	$389,200	$1,900
Gruver	$114,800	$153,300	$700
Spearman	$260,500	$347,900	$1,700
Stinnet	$123,600	$165,100	$800
check total	$3,960,000	$5,289,200	$25,700

Table E-23, Continued

		Quantity	Units	1995 Dollars	Unit Price	Cost
8" line from Spearman to Gruver		71,300	LF		$20	$1,426,000
Crossings		1	LS	$65,000		$76,200
Connection to Gruver		1	LS	$10,000		$11,700
ROW	15	25	AC		$500	$12,500
Engineering and Contingencies (30%)						$454,200
Pipeline Subtotal at Gruver						**$1,980,600**

	Construction	Capital	Electricity ($)
Cactus	$0	$0	$0
Dumas	$0	$0	$0
Sunray	$0	$0	$0
Gruver	$1,426,000	$1,980,600	$300
Spearman	$0	$0	$0
Stinnet	$0	$0	$0
check total	$1,426,000	$1,980,600	$300

		Quantity	Units	1995 Dollars	Unit Price	Cost
24" line from Spearman to Stinnet		133,500	LF		$66	$8,811,000
Crossings		1	LS	$125,000		$146,600
ROW	20	61	AC		$500	$30,500
Engineering and Contingencies (30%)						$2,687,300
Pipeline Subtotal at Stinnet						**$11,675,400**

	Construction	Capital	Electricity ($)
Cactus	$4,383,800	$5,808,900	$19,400
Dumas	$3,407,200	$4,514,900	$15,100
Sunray	$716,200	$949,000	$3,200
Gruver	$0	$0	$0
Spearman	$0	$0	$0
Stinnet	$303,800	$402,600	$1,300
check total	$8,811,000	$11,675,400	$39,000

		Quantity	Units	1995 Dollars	Unit Price	Cost
8" line Stinnet Spur		83,350	LF		$20	$1,667,000
Crossings		1	LS	$200,000		$234,600
Connection to Stinnet		1	LS	$10,000		$11,700
ROW	20	38	AC		$500	$19,000
Engineering and Contingencies (30%)						$574,000
Pipeline Subtotal at Stinnet						**$2,506,300**

	Construction	Capital	Electricity ($)
Cactus	$0	$0	$0
Dumas	$0	$0	$0
Sunray	$0	$0	$0
Gruver	$0	$0	$0
Spearman	$0	$0	$0
Stinnet	$1,667,000	$2,506,300	$500
check total	$1,667,000	$2,506,300	$500

Table E-23, Continued

		Quantity	Units	1995 Dollars	Unit Price	Cost
24" line from Stinnet Spur to Dumas		122,800	LF		$66	$8,104,800
Crossings		1	LS	$115,000		$134,900
Connection to Dumas		1	LS	$10,000		$11,700
ROW	20	56	AC		$500	$28,000
Engineering and Contingencies (30%)						$2,475,400
Pipeline Subtotal at Dumas						**$10,754,800**

	Construction	Capital	Electricity ($)
Cactus	$4,176,500	$5,542,000	$17,200
Dumas	$3,246,100	$4,307,400	$13,300
Sunray	$682,300	$905,400	$2,800
Gruver	$0	$0	$0
Spearman	$0	$0	$0
Stinnet	$0	$0	$0
check total	$8,104,900	$10,754,800	$33,300

		Quantity	Units	1995 Dollars	Unit Price	Cost
8" line Sunray Spur		28,000	LF		$20	$560,000
Crossings		1	LS	$85,000		$99,700
Pressure Reducing Valve		1	EA	$20,000		$23,500
Connection to Sunray		1	LS	$10,000		$11,700
ROW	15	10	AC		$500	$5,000
Engineering and Contingencies (30%)						$208,500
Pipeline Subtotal at Sunray						**$348,400**

	Construction	Capital	Electricity ($)
Cactus	0	$0	$0
Dumas	0	$0	$0
Sunray	$560,000	$348,400	$1,500
Gruver	0	$0	$0
Spearman	0	$0	$0
Stinnet	0	$0	$0
check total	$560,000	$348,400	$1,500

		Quantity	Units	1995 Dollars	Unit Price	Cost
18" line from Dumas to Cactus		67,150	LF		$42	$2,820,300
Crossings		1	LS	$165,000		$193,600
Connection to Cactus		1	LS	$10,000		$11,700
ROW	20	31	AC		$500	$15,500
Engineering and Contingencies (30%)						$907,700
Pipeline Subtotal at Sunray						**$3,948,800**

Table E-23, Continued

	Construction	Capital	Electricity ($)
Cactus	$2,820,300	$3,948,800	$11,800
Dumas	0	$0	$0
Sunray	0	$0	$0
Gruver	0	$0	$0
Spearman	0	$0	$0
Stinnet	0	$0	$0
check total	$2,820,300	$3,948,800	$11,800

Pump Station Components	**Quantity**	**Units**	**1995 Dollars**	**Unit Price**	**Cost**
9 MGD PS at intake	250	HP			$1,065,000
9 MGD PS at WTP	250	HP			$1,065,000
9 MGD PS at Spearman	400	HP			$1,500,000
8.12 MGD at Stinnet Spur	400	HP			$1,500,000
4.04 MGD at Dumas	100	HP			$620,000
Engineering and Contingencies (35%)					$2,012,500
Pump Station Subtotal					**$7,762,500**

Construction Costs	9 MGD PS at intake	9 MGD PS at WTP	9 MGD PS at Spearman	8.12 MGD at Stinnet Spur	4.04 MGD at Dumas	
Cactus	$479,700	$479,700	$675,600	$746,300	$348,900	
Dumas	$372,800	$372,800	$525,100	$580,000	$271,100	
Sunray	$78,400	$78,400	$110,400	$121,900	$0	
Gruver	$30,900	$30,900	$43,500	$0	$0	
Spearman	$70,100	$70,100	$98,700	$0	$0	
Stinnet	$33,200	$33,200	$46,800	$51,700	$0	
check total	$1,065,100	$1,065,100	$1,500,100	$1,499,900	$620,000	$5,750,200

Capital Costs	9 MGD PS at intake	9 MGD PS at WTP	9 MGD PS at Spearman	8.12 MGD at Stinnet Spur	4.04 MGD at Dumas	
Cactus	$647,500	$647,500	$912,000	$1,007,500	$471,000	
Dumas	$503,300	$503,300	$708,900	$783,100	$366,000	
Sunray	$105,800	$105,800	$149,000	$164,600	$0	
Gruver	$41,700	$41,700	$58,700	$0	$0	
Spearman	$94,600	$94,600	$133,200	$0	$0	
Stinnet	$44,900	$44,900	$63,200	$69,800	$0	
check total	$1,437,800	$1,437,800	$2,025,000	$2,025,000	$837,000	$7,762,600

Ground Storage Tanks	**Quantity**	**Units**	**1995 Dollars**	**Unit Price**	**Cost**
3 MG at WTP	1	LS	$1,200,000	$589,000	$589,000
3 MG at Spearman	1	LS	$1,200,000	$589,000	$589,000
2.5 MG at Stinnet Spur	1	LS	$1,000,000	$510,000	$510,000
1.5 MG at Dumas	1	LS	$600,000	$355,000	$355,000
Engineering and Contingencies (35%)					$715,100
Pump Station Subtotal					**$2,758,100**

Table E-23, Continued

Construction Costs	3 MG at WTP	3 MG at Spearman	2.5 MG at Stinnet Spur	1.5 MG at Dumas	
Cactus	$265,300	$265,300	$253,700	$199,700	
Dumas	$206,200	$206,200	$197,200	$155,300	
Sunray	$43,300	$43,300	$41,500	$0	
Gruver	$17,100	$17,100	$0	$0	
Spearman	$38,700	$38,700	$0	$0	
Stinnet	$18,400	$18,400	$17,600	$0	
check total	$589,000	$589,000	$510,000	$355,000	$2,043,000

Capital Costs	3 MG at WTP	3 MG at Spearman	2.5 MG at Stinnet Spur	1.5 MG at Dumas	
Cactus	$358,100	$358,100	$342,600	$269,700	
Dumas	$278,300	$278,300	$266,200	$209,600	
Sunray	$58,500	$58,500	$56,000	$0	
Gruver	$23,000	$23,000	$0	$0	
Spearman	$52,300	$52,300	$0	$0	
Stinnet	$24,800	$24,800	$23,700	$0	
check total	$795,000	$795,000	$688,500	$479,300	$2,757,800

TOTAL CONSTRUCTION COST	
Cactus	$31,390,700
Dumas	$21,328,600
Sunray	$4,710,600
Gruver	$2,881,600
Spearman	$2,044,700
Stinnet	$3,972,700
check total	$66,328,900

Interest During Construction (24 month)	
Cactus	$2,563,700
Dumas	$1,741,900
Sunray	$384,700
Gruver	$235,300
Spearman	$167,000
Stinnet	$324,500
check total	$5,417,100

Permitting and Mitigation	
Cactus	$244,200
Dumas	$163,500
Sunray	$41,100
Gruver	$24,000
Spearman	$15,700
Stinnet	$31,100
check total	$519,600

Table E-23, Continued

TOTAL CAPITAL COST

Cactus	$34,198,600
Dumas	$23,234,000
Sunray	$5,136,400
Gruver	$3,140,900
Spearman	$2,227,400
Stinnet	$4,328,300
check total	$72,265,600

Annual Costs - Cactus	**Cost**
Debt Service (6 percent for 20 years)	$2,981,600
Electricity	$60,000
Price to Purchase Water ($0.15 per 1,000 gal)	$110,700
Operation and Maintenance	$385,500
Total Annual Cost	$3,537,800
UNIT COSTS (Until Amortized)	
Water Cost ($ per ac-ft)	$1,562
Water Cost ($ per 1,000 gallons)	$4.79
UNIT COSTS (After Amortization)	
Water Cost ($ per ac-ft)	$246
Water Cost ($ per 1,000 gallons)	$0.75

Annual Costs - Dumas	**Cost**
Debt Service (6 percent for 20 years)	$2,025,600
Electricity	$37,400
Price to Purchase Water ($0.15 per 1,000 gal)	$86,000
Operation and Maintenance	$277,700
Total Annual Cost	$2,426,700
UNIT COSTS (Until Amortized)	
Water Cost ($ per ac-ft)	$1,379
Water Cost ($ per 1,000 gallons)	$4.23
UNIT COSTS (After Amortization)	
Water Cost ($ per ac-ft)	$228
Water Cost ($ per 1,000 gallons)	$0.70

Table E-23, Continued

Annual Costs - Sunray	Cost
Debt Service (6 percent for 20 years)	$447,800
Electricity	$9,400
Price to Purchase Water ($0.15 per 1,000 gal)	$18,100
Operation and Maintenance	$61,700
Total Annual Cost	$537,000
UNIT COSTS (Until Amortized)	
Water Cost ($ per ac-ft)	$1,451
Water Cost ($ per 1,000 gallons)	$4.45
UNIT COSTS (After Amortization)	
Water Cost ($ per ac-ft)	$241
Water Cost ($ per 1,000 gallons)	$0.74

Annual Costs - Gruver	Cost
Debt Service (6 percent for 20 years)	$273,800
Electricity	$1,000
Price to Purchase Water ($0.15 per 1,000 gal)	$7,100
Operation and Maintenance	$29,300
Total Annual Cost	$311,200
UNIT COSTS (Until Amortized)	
Water Cost ($ per ac-ft)	2131.506849
Water Cost ($ per 1,000 gallons)	$6.54
UNIT COSTS (After Amortization)	
Water Cost ($ per ac-ft)	$256
Water Cost ($ per 1,000 gallons)	$0.79

Annual Costs - Spearman	Cost
Debt Service (6 percent for 20 years)	$194,200
Electricity	$1,700
Price to Purchase Water ($0.15 per 1,000 gal)	$16,200
Operation and Maintenance	$34,000
Total Annual Cost	$246,100
UNIT COSTS (Until Amortized)	
Water Cost ($ per ac-ft)	743.5045317
Water Cost ($ per 1,000 gallons)	$2.28
UNIT COSTS (After Amortization)	
Water Cost ($ per ac-ft)	$157
Water Cost ($ per 1,000 gallons)	$0.48

Table E-23, Continued

Annual Costs - Stinnet	Cost
Debt Service (6 percent for 20 years)	$377,400
Electricity	$2,600
Price to Purchase Water ($0.15 per 1,000 gal)	$7,700
Operation and Maintenance	$37,600
Total Annual Cost	$425,300
UNIT COSTS (Until Amortized)	
Water Cost ($ per ac-ft)	$2,708.92
Water Cost ($ per 1,000 gallons)	$8.31
UNIT COSTS (After Amortization)	
Water Cost ($ per ac-ft)	$305
Water Cost ($ per 1,000 gallons)	$0.94

Table E-24
Livestock WUGs with Needs of 250 ac-ft/yr
Install Additional Groundwater Wells in Ogallala Aquifer

Owner: Unknown
Quantity: 250 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	300	gpm	1	Ea.	$97,500	$97,500
Storage (stock ponds or troughs)	30,000	AF	1	Ea.	$20,000	$20,000
Engineering and Contingencies (35%)						$41,100
Subtotal for Wellfield and Treatment						**$158,600**
TOTAL CONSTRUCTION COST						**$158,600**
Interest During Construction				**(6 months)**		**$3,400**
TOTAL CAPITAL COST						**$162,000**
Annual Costs						
Debt Service (6 percent for 20 years)						$14,100
Operation and Maintenance						$3,500
Total Annual Cost						**$17,600**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$70**
Water Cost ($ per 1,000 gallons)						**$0.22**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$14**
Water Cost ($ per 1,000 gallons)						**$0.04**

Table E-25
Livestock WUGs with Needs of 500 ac-ft/yr
Install Additional Groundwater Wells in Ogallala Aquifer

Owner: Unknown
Quantity: 500 AF/Y

Capital Costs	Size		Quantity	Unit	Unit Price	Cost
Wellfield and Treatment						
Wells	600	gpm	1	Ea.	$115,000	$115,000
Storage (stock ponds or troughs)	50,000	AF	1	Ea.	$30,000	$30,000
Engineering and Contingencies (35%)						$50,800
Subtotal for Wellfield and Treatment						**$195,800**
TOTAL CONSTRUCTION COST						**$195,800**
Interest During Construction				**(6 months)**		**$4,200**
TOTAL CAPITAL COST						**$200,000**
Annual Costs						
Debt Service (6 percent for 20 years)						$17,400
Operation and Maintenance						$4,400
Total Annual Cost						**$21,800**
UNIT COSTS (Until Amortized)						
Water Cost ($ per ac-ft)						**$44**
Water Cost ($ per 1,000 gallons)						**$0.13**
UNIT COSTS (After Amortization)						
Water Cost ($ per ac-ft)						**$9**
Water Cost ($ per 1,000 gallons)						**$0.03**

APPENDIX W (ADDENDA)

Vulnerability Assessment for Lake Meredith
And Lake Palo Duro

Modified Canadian River WAM
- Run 8 -

Monthly Results

		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
	Year	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Jan-40	1940		494,917		59,702		0		0
Feb-40	1940		490,733		59,702		7,986		84
Mar-40	1940		478,687		58,682		270		122
Apr-40	1940		465,914		57,754		63		270
May-40	1940		478,807		57,526		0		8,896
Jun-40	1940		467,541		56,797		3,351		3,227
Jul-40	1940		447,476		54,768		0		0
Aug-40	1940		443,923		54,119		0		572
Sep-40	1940		438,210		53,218		0		1,036
Oct-40	1940		424,060		51,983		21		0
Nov-40	1940		430,148		51,796		5,541		251
Dec-40	1940		424,393		51,416		3,364		109
Jan-41	1941		419,684		51,233		4,386		181
Feb-41	1941		416,050		51,086		8,874		297
Mar-41	1941		410,926		50,765		9,353		266
Apr-41	1941		401,734		50,186		7,549		259
May-41	1941		500,000		50,425		380,787		2,821
Jun-41	1941		500,000		50,098		519,941		873
Jul-41	1941		500,000		49,632		359,548		896
Aug-41	1941		500,000		48,900		198,069		489
Sep-41	1941		500,000		48,228		428,294		15
Oct-41	1941		500,000		49,421		623,571		436
Nov-41	1941		500,000		49,003		71,693		355
Dec-41	1941		500,000		48,639		29,501		291
Jan-42	1942		500,000		48,336		18,758		367
Feb-42	1942		500,000		47,987		7,910		257
Mar-42	1942		499,594		47,413		14,853		430
Apr-42	1942		500,000		47,336		345,565		1,200
May-42	1942		500,000		46,348		217,449		348
Jun-42	1942		500,000		46,038		104,011		2,347
Jul-42	1942		500,000		44,747		8,906		430
Aug-42	1942		500,000		44,002		10,767		13
Sep-42	1942		500,000		43,342		262,463		0
Oct-42	1942		500,000		48,829		82,919		1,093
Nov-42	1942		500,000		49,196		5,359		157
Dec-42	1942		497,530		49,434		1,180		325
Jan-43	1943		500,000		51,081		21,150		323
Feb-43	1943		492,540		50,848		2,816		186
Mar-43	1943		482,345		50,302		2,399		194
Apr-43	1943		471,273		49,697		616		323
May-43	1943		458,451		49,245		6,690		142
Jun-43	1943		441,834		48,084		552		0
Jul-43	1943		452,438		48,357		0		1,431
Aug-43	1943		433,515		46,986		0		0
Sep-43	1943		417,782		45,903		0		0
Oct-43	1943		404,642		44,967		0		0

		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
	Year	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Nov-43	1943		395,599		44,455		0		0
Dec-43	1943		393,913		44,777		1,267		0
Jan-44	1944		399,491		46,145		11,772		599
Feb-44	1944		397,947		46,561		5,268		355
Mar-44	1944		389,255		46,050		1,062		340
Apr-44	1944		381,198		45,837		1,375		451
May-44	1944		392,236		48,226		5,971		2,580
Jun-44	1944		410,987		50,335		5,897		87
Jul-44	1944		421,967		51,697		8,499		1,015
Aug-44	1944		430,379		51,268		0		0
Sep-44	1944		460,747		53,263		5,647		0
Oct-44	1944		451,844		53,088		4,353		0
Nov-44	1944		443,334		52,735		713		2
Dec-44	1944		450,309		54,833		18,513		202
Jan-45	1945		453,540		56,186		12,840		321
Feb-45	1945		447,519		56,209		3,255		318
Mar-45	1945		437,926		55,768		3,572		372
Apr-45	1945		427,193		55,305		996		145
May-45	1945		410,562		53,952		113		58
Jun-45	1945		396,272		52,758		0		302
Jul-45	1945		379,511		51,692		0		190
Aug-45	1945		387,789		51,106		694		381
Sep-45	1945		378,642		52,754		0		0
Oct-45	1945		378,083		52,726		2,347		61
Nov-45	1945		367,770		52,000		0		26
Dec-45	1945		359,144		51,634		90		120
Jan-46	1946		351,862		51,247		2,193		150
Feb-46	1946		344,298		50,931		1,115		196
Mar-46	1946		333,926		50,227		0		212
Apr-46	1946		321,517		49,547		0		106
May-46	1946		309,408		48,819		6,191		537
Jun-46	1946		301,377		47,672		8,591		69
Jul-46	1946		282,795		46,739		0		3,757
Aug-46	1946		277,599		46,344		1,996		0
Sep-46	1946		321,650		49,525		33,833		107
Oct-46	1946		466,956		59,702		118,734		36,263
Nov-46	1946		464,373		59,702		1,050		1,230
Dec-46	1946		459,606		59,472		7,904		544
Jan-47	1947		456,280		59,174		12,369		573
Feb-47	1947		447,746		58,702		1,264		421
Mar-47	1947		442,652		58,227		10,557		676
Apr-47	1947		436,386		57,814		11,158		603
May-47	1947		460,857		57,836		19,740		707
Jun-47	1947		448,269		59,352		4,898		21,352
Jul-47	1947		441,558		58,052		0		2,437
Aug-47	1947		423,941		56,675		0		325
Sep-47	1947		406,364		54,972		0		0

	Year	Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
		TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Oct-47	1947		394,254		54,324		0		0
Nov-47	1947		385,857		53,886		0		143
Dec-47	1947		379,054		53,756		0		301
Jan-48	1948	493,084	372,730	60,682	53,545	626	268	14	281
Feb-48	1948	493,504	370,706	60,776	53,658	4,527	2,554	28	533
Mar-48	1948	491,903	367,531	60,378	53,220	9,904	9,433	41	738
Apr-48	1948	478,258	354,069	59,345	52,112	223	0	39	260
May-48	1948	470,982	345,759	58,634	51,461	2,518	0	283	160
Jun-48	1948	500,000	423,366	58,451	50,907	125,978	45,565	277	472
Jul-48	1948	490,503	409,369	57,444	50,078	3,617	0	589	185
Aug-48	1948	500,000	441,039	57,945	50,181	54,432	24,966	1,303	533
Sep-48	1948	484,409	425,275	57,065	48,964	312	75	30	53
Oct-48	1948	473,429	414,747	56,338	48,206	674	0	3	34
Nov-48	1948	470,768	412,465	56,686	48,289	3,344	2,682	672	345
Dec-48	1948	461,637	402,219	56,304	47,559	523	220	38	318
Jan-49	1949	453,806	396,121	55,686	47,428	539	83	29	190
Feb-49	1949	451,325	390,980	55,678	47,203	5,148	3,918	36	424
Mar-49	1949	444,040	382,448	55,359	46,672	917	706	60	465
Apr-49	1949	442,233	374,483	54,778	46,172	3,612	0	79	365
May-49	1949	500,000	484,167	60,074	50,305	185,406	111,763	6,195	1,395
Jun-49	1949	500,000	500,000	60,148	50,189	109,882	105,088	519	569
Jul-49	1949	500,000	500,000	59,735	49,730	69,069	40,418	356	4,048
Aug-49	1949	500,000	500,000	59,017	49,087	28,521	14,633	472	46
Sep-49	1949	500,000	500,000	58,199	48,246	13,772	0	24	36
Oct-49	1949	490,387	490,900	57,931	47,877	923	951	401	83
Nov-49	1949	482,852	482,506	57,400	47,247	1,076	0	67	244
Dec-49	1949	474,624	474,848	56,858	46,995	403	595	87	358
Jan-50	1950	467,998	467,388	56,316	46,481	3,281	2,626	48	304
Feb-50	1950	459,878	460,146	55,975	46,131	214	1,870	64	364
Mar-50	1950	447,351	449,105	54,990	45,373	323	0	82	328
Apr-50	1950	433,737	437,808	53,652	44,627	1,011	0	71	322
May-50	1950	415,931	424,993	52,271	43,810	492	2,583	73	215
Jun-50	1950	441,075	442,794	52,534	44,196	14,708	0	1,789	70
Jul-50	1950	500,000	500,000	60,143	51,655	184,662	143,869	10,053	20,429
Aug-50	1950	500,000	500,000	60,900	57,316	69,855	59,227	8,905	6,280
Sep-50	1950	500,000	500,000	60,900	59,702	101,638	97,272	11,469	12,680
Oct-50	1950	493,918	493,755	60,299	58,969	3,141	0	519	2,467
Nov-50	1950	484,750	484,164	59,936	58,380	374	56	225	409
Dec-50	1950	479,072	476,788	59,817	57,932	5,724	4,965	241	498
Jan-51	1951	475,060	473,273	59,683	57,857	8,555	7,473	239	504
Feb-51	1951	474,519	471,014	59,746	57,671	11,916	10,373	229	543
Mar-51	1951	466,073	462,565	59,402	57,091	4,551	3,604	189	522
Apr-51	1951	453,250	450,348	58,622	56,250	1,304	789	198	477
May-51	1951	500,000	500,000	60,900	59,702	154,608	116,452	33,904	19,497
Jun-51	1951	500,000	500,000	60,740	59,533	52,864	49,896	863	1,249
Jul-51	1951	500,000	500,000	59,572	57,898	21,395	17,610	260	241
Aug-51	1951	486,436	480,878	58,524	55,888	1,773	0	99	1,414

		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
	Year	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Sep-51	1951	470,959	463,428	57,306	54,048	732	3,681	32	0
Oct-51	1951	460,075	448,911	56,568	52,747	367	831	30	7
Nov-51	1951	453,103	442,342	56,332	52,147	951	5,079	90	199
Dec-51	1951	445,101	434,170	56,137	51,673	320	1,763	84	270
Jan-52	1952	438,179	426,787	55,775	51,209	336	2,166	82	262
Feb-52	1952	430,166	418,329	55,571	50,687	247	762	103	288
Mar-52	1952	421,381	408,116	55,310	50,105	317	205	96	458
Apr-52	1952	414,696	399,996	58,505	53,355	1,460	0	5,696	342
May-52	1952	400,749	386,948	57,449	52,451	775	0	145	152
Jun-52	1952	379,626	369,103	55,165	50,663	547	0	28	3
Jul-52	1952	372,727	355,288	53,488	49,129	6,210	0	53	663
Aug-52	1952	386,673	345,781	52,843	48,256	12,574	0	1,437	94
Sep-52	1952	372,038	329,670	51,445	46,519	1,507	0	4	0
Oct-52	1952	358,807	313,779	50,531	44,967	264	0	0	0
Nov-52	1952	350,427	303,913	50,127	44,269	288	0	6	0
Dec-52	1952	343,775	296,159	49,996	43,911	353	893	53	15
Jan-53	1953	338,940	290,393	49,757	43,436	7,291	6,435	40	261
Feb-53	1953	331,050	282,971	49,343	42,980	1,929	1,508	36	202
Mar-53	1953	319,910	271,936	48,640	42,080	654	524	77	207
Apr-53	1953	304,800	258,491	47,584	41,002	245	0	27	136
May-53	1953	287,981	242,646	46,476	39,742	239	0	26	78
Jun-53	1953	265,637	226,749	45,480	39,096	5,303	4,983	1,390	4
Jul-53	1953	284,274	237,457	57,180	50,486	32,196	21,740	18,211	292
Aug-53	1953	316,280	244,006	56,328	49,559	29,463	15,632	534	0
Sep-53	1953	297,708	226,023	54,585	47,666	747	0	52	0
Oct-53	1953	302,237	228,684	54,806	47,413	17,439	14,674	803	0
Nov-53	1953	295,751	220,646	54,628	46,909	3,049	2,416	110	0
Dec-53	1953	289,415	214,806	54,505	46,833	1,299	730	86	35
Jan-54	1954	283,012	211,102	54,145	46,563	3,342	7,372	70	232
Feb-54	1954	273,257	204,385	53,463	45,904	301	4,634	46	137
Mar-54	1954	262,494	196,017	52,748	45,182	324	2,700	47	135
Apr-54	1954	250,152	189,259	51,562	44,451	1,139	3,928	90	163
May-54	1954	284,843	231,603	51,162	44,496	18,335	26,970	185	294
Jun-54	1954	264,193	216,378	59,303	53,151	792	0	14,701	103
Jul-54	1954	279,496	234,119	58,931	52,825	14,385	0	2,045	0
Aug-54	1954	274,948	228,899	58,110	52,357	6,201	0	1,456	127
Sep-54	1954	256,117	213,425	56,151	50,731	723	0	39	0
Oct-54	1954	307,080	223,642	60,422	54,902	24,237	0	7,086	0
Nov-54	1954	297,057	214,881	59,775	54,203	453	0	176	0
Dec-54	1954	287,889	206,498	59,347	53,728	294	0	200	0
Jan-55	1955	281,683	200,598	59,197	53,582	1,612	1,077	203	8
Feb-55	1955	274,430	193,912	58,896	53,255	344	742	110	87
Mar-55	1955	262,655	184,299	57,964	52,417	251	0	77	138
Apr-55	1955	281,070	199,498	60,900	58,093	13,658	0	9,943	141
May-55	1955	358,714	262,347	60,900	59,702	79,786	83,393	19,536	9,466
Jun-55	1955	366,029	277,401	60,168	59,133	26,265	32,985	507	5,842
Jul-55	1955	370,418	271,843	59,738	58,940	10,299	2,771	2,356	1,787

	Year	Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
		TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Aug-55	1955	375,396	268,027	60,900	59,702	9,078	0	3,631	336
Sep-55	1955	377,989	262,222	60,339	58,885	5,599	0	50	0
Oct-55	1955	367,768	253,404	59,370	57,802	1,324	0	5	0
Nov-55	1955	357,911	244,193	58,717	57,020	308	0	0	49
Dec-55	1955	349,960	235,968	58,362	56,532	349	0	0	181
Jan-56	1956	342,751	229,412	58,076	56,157	439	0	23	279
Feb-56	1956	336,098	224,656	58,061	55,993	2,139	2,548	85	296
Mar-56	1956	323,041	214,359	57,097	55,165	392	0	144	265
Apr-56	1956	307,237	202,006	55,730	53,888	275	0	17	182
May-56	1956	324,834	224,569	54,710	53,416	29,063	18,591	953	751
Jun-56	1956	309,730	214,250	53,046	52,127	2,682	14,443	405	318
Jul-56	1956	314,998	202,633	53,139	52,112	9,484	0	1,820	681
Aug-56	1956	298,403	187,029	53,411	52,307	1,500	0	2,481	455
Sep-56	1956	279,477	172,485	51,722	50,624	195	0	0	0
Oct-56	1956	265,570	161,613	50,656	49,542	206	0	7	0
Nov-56	1956	255,891	153,336	50,091	48,903	250	0	24	3
Dec-56	1956	247,518	145,601	49,733	48,458	310	0	42	127
Jan-57	1957	241,695	139,172	49,663	48,275	267	0	59	286
Feb-57	1957	234,781	133,162	49,287	47,997	824	615	39	286
Mar-57	1957	230,366	129,559	49,556	48,273	6,572	5,699	136	803
Apr-57	1957	232,986	130,977	51,856	50,674	15,992	12,833	3,964	550
May-57	1957	288,693	184,569	58,316	57,428	77,271	68,053	9,259	1,198
Jun-57	1957	309,651	208,897	58,361	57,635	14,742	3,910	1,568	3,914
Jul-57	1957	301,662	191,839	57,784	57,176	5,127	1,233	1,881	286
Aug-57	1957	386,072	252,245	57,521	57,280	38,786	742	1,313	2,770
Sep-57	1957	385,178	247,269	56,690	56,464	4,860	1,976	82	0
Oct-57	1957	394,296	252,406	56,403	56,229	7,180	0	32	81
Nov-57	1957	389,315	248,049	56,296	56,099	827	3,209	93	231
Dec-57	1957	381,256	240,358	55,892	55,586	1,895	1,296	69	288
Jan-58	1958	378,415	237,798	55,815	55,569	6,028	4,881	90	316
Feb-58	1958	375,060	234,858	55,664	55,428	3,535	2,374	99	273
Mar-58	1958	379,984	238,260	55,830	55,632	8,912	5,753	89	384
Apr-58	1958	377,071	235,885	55,515	55,437	3,058	2,303	344	415
May-58	1958	424,304	239,673	54,679	55,023	23,186	0	12	317
Jun-58	1958	453,110	244,398	53,764	54,491	21,561	11,801	831	43
Jul-58	1958	500,000	425,005	60,900	59,702	230,261	92,439	14,718	690
Aug-58	1958	500,000	469,592	60,900	59,702	51,386	8,940	1,793	6,940
Sep-58	1958	500,000	500,000	60,003	59,088	58,764	25,049	330	250
Oct-58	1958	489,084	489,105	59,207	58,178	924	0	55	117
Nov-58	1958	481,112	481,475	58,803	57,745	644	0	95	289
Dec-58	1958	475,119	475,182	58,728	57,593	834	0	168	271
Jan-59	1959	469,454	469,074	58,587	57,429	1,426	976	258	562
Feb-59	1959	463,616	462,494	58,362	57,109	839	0	100	440
Mar-59	1959	451,845	451,655	57,666	56,358	270	0	114	363
Apr-59	1959	439,480	439,848	56,848	55,614	887	757	108	332
May-59	1959	435,690	438,695	56,399	55,579	4,265	13,472	109	667
Jun-59	1959	434,171	438,332	55,168	54,724	6,638	0	469	591

		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
	Year	**TCEQ**	**Region A Model**	**TCEQ**	**Region A Model**	**TCEQ**	**Region A Model**	**TCEQ**	**Region A Model**
Jul-59	1959	442,851	446,750	58,159	57,610	9,110	8,512	5,292	3,741
Aug-59	1959	496,105	469,308	57,387	57,121	27,625	0	736	210
Sep-59	1959	481,842	457,093	56,234	55,974	1,413	1,075	88	0
Oct-59	1959	477,303	450,828	56,126	55,739	1,785	0	64	0
Nov-59	1959	468,704	442,413	55,780	55,305	327	419	66	78
Dec-59	1959	494,837	463,359	56,403	56,041	23,764	15,593	765	173
Jan-60	1960	500,000	469,712	56,512	56,114	22,841	17,195	120	148
Feb-60	1960	500,000	474,087	56,549	56,200	17,487	11,545	118	401
Mar-60	1960	494,561	470,144	55,961	55,772	3,957	2,214	82	297
Apr-60	1960	479,485	457,582	54,894	54,776	394	0	24	231
May-60	1960	463,777	444,138	53,806	54,067	269	0	60	83
Jun-60	1960	500,000	500,000	54,264	54,800	93,675	43,758	2,020	291
Jul-60	1960	500,000	500,000	54,588	55,278	215,915	210,045	1,513	19
Aug-60	1960	500,000	500,000	53,649	54,373	97,520	89,422	242	6
Sep-60	1960	500,000	500,000	60,900	59,702	20,788	17,696	17,630	1,290
Oct-60	1960	500,000	500,000	60,900	59,702	56,461	71,886	14,388	2,620
Nov-60	1960	492,472	492,468	60,537	59,302	1,275	943	348	201
Dec-60	1960	496,560	490,645	60,631	59,322	4,168	0	239	223
Jan-61	1961	493,013	486,130	60,398	59,238	1,597	447	194	177
Feb-61	1961	495,697	486,961	60,281	59,152	3,925	0	121	267
Mar-61	1961	500,000	500,000	60,281	59,177	17,572	15,255	177	464
Apr-61	1961	497,090	494,375	59,276	58,232	4,764	239	32	388
May-61	1961	486,408	483,030	58,807	58,056	2,741	0	771	742
Jun-61	1961	477,272	479,639	58,779	58,291	1,794	18,205	1,372	606
Jul-61	1961	493,535	485,014	60,900	59,702	12,390	0	6,270	233
Aug-61	1961	493,627	482,482	60,076	58,895	6,678	0	164	7
Sep-61	1961	500,000	492,730	59,234	58,017	16,596	0	143	0
Oct-61	1961	491,178	482,049	58,617	57,257	1,592	0	59	12
Nov-61	1961	497,839	487,941	58,723	57,367	4,936	1,653	207	174
Dec-61	1961	492,921	486,070	58,732	57,111	1,457	12,207	154	230
Jan-62	1962	488,877	484,615	58,512	57,114	1,454	6,145	96	285
Feb-62	1962	481,963	477,233	58,029	56,684	1,260	3,002	52	253
Mar-62	1962	471,071	466,822	57,211	55,967	977	0	54	287
Apr-62	1962	459,949	456,746	56,432	55,305	880	2,407	59	316
May-62	1962	441,220	441,028	54,954	54,133	737	0	115	118
Jun-62	1962	441,260	440,078	54,930	54,330	5,519	0	330	2,040
Jul-62	1962	460,527	437,087	55,130	54,544	12,221	0	1,398	1,302
Aug-62	1962	471,719	454,267	54,670	54,191	10,794	27,082	1,044	262
Sep-62	1962	466,487	446,383	54,432	53,985	2,672	0	291	56
Oct-62	1962	456,616	435,705	53,802	53,224	814	0	5	118
Nov-62	1962	449,100	427,729	53,464	52,805	605	0	56	218
Dec-62	1962	442,687	422,242	53,286	52,616	829	1,595	86	235
Jan-63	1963	436,275	416,926	53,148	52,519	397	899	60	136
Feb-63	1963	428,603	411,630	52,682	52,201	552	3,168	59	245
Mar-63	1963	415,846	400,626	51,681	51,185	463	260	8	255
Apr-63	1963	398,588	385,728	50,231	49,945	290	0	8	190
May-63	1963	387,050	377,648	50,640	50,400	2,230	0	1,858	160

	Year	Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
		TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Jun-63	1963	400,619	392,442	52,161	52,198	12,046	0	4,116	557
Jul-63	1963	391,565	385,366	51,901	52,156	5,158	0	2,065	601
Aug-63	1963	390,177	387,500	50,606	51,175	7,325	0	406	10
Sep-63	1963	388,439	387,446	54,910	55,487	5,087	0	7,414	526
Oct-63	1963	374,364	375,052	53,898	54,417	294	0	181	0
Nov-63	1963	364,963	365,625	53,404	53,801	279	0	95	8
Dec-63	1963	358,283	359,077	53,256	53,671	346	0	77	140
Jan-64	1964	349,330	353,532	52,851	53,594	338	697	100	147
Feb-64	1964	346,798	352,641	52,948	53,796	1,262	4,928	311	164
Mar-64	1964	335,948	343,543	52,205	53,081	385	0	41	216
Apr-64	1964	318,919	329,557	50,815	51,764	215	0	55	159
May-64	1964	303,789	316,872	49,752	50,960	589	0	28	47
Jun-64	1964	285,636	304,344	48,723	50,217	309	7,409	771	80
Jul-64	1964	262,464	285,417	46,941	48,517	217	0	37	0
Aug-64	1964	245,188	271,416	45,477	47,197	1,190	0	0	0
Sep-64	1964	257,396	281,714	44,531	46,318	10,541	0	0	0
Oct-64	1964	245,086	270,100	43,694	45,409	322	0	0	0
Nov-64	1964	239,459	264,637	43,888	45,429	495	2,226	0	0
Dec-64	1964	232,826	258,941	43,787	45,313	252	3,957	0	0
Jan-65	1965	225,990	254,132	43,570	45,122	213	5,114	0	0
Feb-65	1965	219,195	248,109	43,358	44,913	190	2,227	0	0
Mar-65	1965	211,652	242,673	43,068	44,668	268	3,818	18	0
Apr-65	1965	197,656	231,349	42,061	43,741	153	70	18	0
May-65	1965	205,412	243,296	51,169	52,830	8,103	6,845	13,952	7,649
Jun-65	1965	386,550	448,488	60,900	59,702	72,680	64,070	82,752	45,574
Jul-65	1965	379,539	445,642	60,676	59,604	5,542	756	2,006	1,093
Aug-65	1965	385,748	454,286	60,900	59,702	9,048	5,576	3,804	2,069
Sep-65	1965	384,381	440,219	60,397	59,215	4,955	818	445	235
Oct-65	1965	414,069	451,612	60,900	59,702	15,808	3,148	1,998	1,098
Nov-65	1965	414,183	450,545	60,372	59,147	4,258	1,290	156	86
Dec-65	1965	408,378	445,594	60,418	59,075	955	2,059	189	103
Jan-66	1966	403,028	440,336	60,114	58,977	5,007	1,350	23	13
Feb-66	1966	400,038	437,571	59,996	59,061	3,970	3,496	33	18
Mar-66	1966	388,982	427,619	59,051	58,068	852	862	133	57
Apr-66	1966	375,232	413,251	58,020	57,183	241	256	114	31
May-66	1966	357,236	395,185	56,521	55,999	343	0	78	11
Jun-66	1966	351,075	391,778	57,292	56,840	4,180	313	3,317	1,795
Jul-66	1966	339,823	380,479	57,066	56,441	3,188	2,891	1,208	638
Aug-66	1966	353,381	389,288	56,771	56,175	9,732	2,243	245	102
Sep-66	1966	346,534	383,746	56,957	56,257	2,414	4,040	874	480
Oct-66	1966	333,473	372,154	56,005	55,196	265	0	26	14
Nov-66	1966	323,620	362,228	55,382	54,329	298	0	33	18
Dec-66	1966	315,536	354,567	55,071	54,083	343	641	34	19
Jan-67	1967	308,051	347,263	54,606	53,883	638	2,513	30	17
Feb-67	1967	300,123	339,962	54,128	53,488	373	1,345	32	17
Mar-67	1967	287,102	328,152	53,175	52,540	304	630	188	87
Apr-67	1967	287,202	331,318	52,748	52,200	5,579	2,270	943	487

		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
	Year	**TCEQ**	**Region A Model**	**TCEQ**	**Region A Model**	**TCEQ**	**Region A Model**	**TCEQ**	**Region A Model**
May-67	1967	274,568	320,687	51,521	51,410	1,034	10,165	133	40
Jun-67	1967	290,293	336,038	60,900	59,702	11,545	6,251	15,424	8,433
Jul-67	1967	373,404	396,401	60,900	59,702	36,977	12,533	10,064	5,497
Aug-67	1967	376,582	396,449	60,900	59,702	7,426	1,751	5,108	2,766
Sep-67	1967	375,069	391,978	60,264	59,082	5,225	1,129	404	220
Oct-67	1967	379,070	390,852	59,188	57,875	7,344	560	154	85
Nov-67	1967	376,845	385,711	59,052	57,592	2,361	322	279	153
Dec-67	1967	372,991	383,247	58,757	57,370	1,900	1,993	76	41
Jan-68	1968	372,208	382,683	58,406	57,453	8,258	3,825	79	43
Feb-68	1968	368,950	378,978	58,121	57,448	5,705	2,520	58	33
Mar-68	1968	360,239	371,047	57,348	56,801	5,859	2,415	74	35
Apr-68	1968	347,151	357,297	56,302	55,897	3,098	0	72	30
May-68	1968	349,235	357,565	57,443	57,202	10,114	7,014	2,068	1,129
Jun-68	1968	341,660	357,835	58,218	58,015	11,570	17,743	2,629	1,436
Jul-68	1968	336,655	357,101	59,354	59,421	5,467	2,226	3,993	2,175
Aug-68	1968	334,895	358,904	60,900	59,702	6,053	1,913	7,102	3,872
Sep-68	1968	318,555	344,277	60,015	58,825	524	0	745	400
Oct-68	1968	314,999	343,335	60,900	59,702	17,815	20,212	22,349	12,285
Nov-68	1968	308,339	335,767	60,900	59,702	432	1,157	494	271
Dec-68	1968	301,425	328,807	60,868	59,702	207	1,677	180	99
Jan-69	1969	295,160	322,192	60,667	59,583	404	3,638	21	12
Feb-69	1969	290,843	319,730	60,394	59,570	1,078	4,755	6	3
Mar-69	1969	284,623	316,878	60,029	59,524	1,242	7,532	49	22
Apr-69	1969	270,345	304,183	59,018	58,618	96	1,076	28	6
May-69	1969	291,115	334,285	58,838	58,644	12,415	28,478	605	324
Jun-69	1969	351,203	369,481	57,850	57,967	28,641	12,850	194	99
Jul-69	1969	369,422	380,339	57,244	56,855	14,570	1,928	318	163
Aug-69	1969	380,495	387,997	58,486	58,110	11,175	3,114	3,610	1,974
Sep-69	1969	471,517	447,379	60,900	59,702	39,321	9,171	8,262	4,512
Oct-69	1969	485,929	454,732	60,494	59,293	8,958	2,002	60	34
Nov-69	1969	480,712	451,190	59,940	58,779	1,808	1,698	6	3
Dec-69	1969	475,215	446,780	59,645	58,673	1,171	3,275	63	35
Jan-70	1970	468,814	443,284	58,955	58,476	4,557	2,067	16	9
Feb-70	1970	461,615	435,646	58,419	58,044	3,982	1,898	16	9
Mar-70	1970	452,146	429,217	57,586	57,797	1,136	3,459	53	41
Apr-70	1970	467,057	446,705	57,660	58,105	11,113	5,427	1,353	756
May-70	1970	448,087	428,850	55,898	56,737	976	0	35	37
Jun-70	1970	429,536	409,928	57,470	57,982	536	0	3,791	2,121
Jul-70	1970	415,141	392,530	57,021	57,396	2,494	0	1,159	662
Aug-70	1970	417,750	389,578	56,922	56,992	7,508	393	1,071	581
Sep-70	1970	410,220	385,684	55,923	56,003	3,410	12,372	113	73
Oct-70	1970	404,132	378,340	55,595	55,599	1,681	223	245	135
Nov-70	1970	397,139	370,288	55,350	55,368	756	665	232	128
Dec-70	1970	387,764	362,495	54,867	55,162	402	1,724	112	62
Jan-71	1971	380,045	356,560	54,340	54,673	3,510	2,143	41	23
Feb-71	1971	375,393	351,276	54,027	54,424	5,334	3,795	21	12
Mar-71	1971	363,742	340,214	53,223	53,661	324	2,281	93	76

		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
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Apr-71	1971	350,887	327,302	52,247	52,764	662	478	145	91
May-71	1971	342,187	319,673	51,827	52,633	3,706	272	1,254	698
Jun-71	1971	343,454	323,955	59,094	59,702	7,862	10,869	12,185	6,704
Jul-71	1971	360,460	338,069	60,900	59,702	13,813	6,291	6,018	3,302
Aug-71	1971	386,778	353,742	60,606	59,518	16,875	3,210	1,342	758
Sep-71	1971	392,696	361,660	60,842	59,702	6,427	8,039	1,299	740
Oct-71	1971	386,229	359,467	60,585	59,411	1,667	13,064	422	232
Nov-71	1971	413,191	386,359	60,900	59,702	49,570	40,761	20,038	11,015
Dec-71	1971	411,628	389,471	60,900	59,702	6,994	23,406	311	172
Jan-72	1972	407,698	388,701	60,644	59,350	1,514	13,821	57	32
Feb-72	1972	401,129	383,407	60,258	58,739	760	6,146	36	21
Mar-72	1972	387,348	371,212	59,055	57,654	366	1,487	33	81
Apr-72	1972	371,339	355,370	58,394	57,208	270	285	812	582
May-72	1972	362,475	347,599	59,044	58,416	2,148	2,203	1,983	1,117
Jun-72	1972	356,702	342,359	60,858	59,702	3,352	1,103	4,166	2,320
Jul-72	1972	416,477	395,259	60,900	59,702	30,268	4,924	5,217	2,970
Aug-72	1972	452,594	423,759	60,900	59,702	20,989	5,041	2,668	1,555
Sep-72	1972	497,174	442,449	60,681	59,460	22,995	2,429	773	454
Oct-72	1972	500,000	447,398	60,360	59,108	8,641	654	302	191
Nov-72	1972	496,783	444,507	60,679	59,395	1,154	1,033	102	82
Dec-72	1972	490,348	439,653	60,473	58,973	762	1,017	31	42
Jan-73	1973	486,143	435,601	60,361	58,843	2,650	1,304	25	14
Feb-73	1973	481,844	430,962	60,253	58,615	3,476	2,925	74	40
Mar-73	1973	489,844	440,436	60,900	59,702	17,817	22,775	3,551	2,002
Apr-73	1973	494,910	448,130	60,900	59,702	5,593	26,018	2,072	1,270
May-73	1973	480,366	434,364	60,900	59,702	597	2,666	2,032	1,168
Jun-73	1973	460,665	415,094	59,547	58,504	164	0	46	164
Jul-73	1973	456,778	411,865	58,956	58,104	5,552	1,195	369	291
Aug-73	1973	448,591	402,403	58,286	57,360	4,520	182	962	583
Sep-73	1973	437,457	390,741	58,549	57,752	367	0	984	583
Oct-73	1973	424,670	379,011	57,778	57,044	232	0	159	126
Nov-73	1973	416,158	369,537	57,663	56,808	253	0	390	215
Dec-73	1973	398,884	362,210	56,098	56,389	368	797	73	40
Jan-74	1974	382,691	357,422	54,410	55,991	590	1,333	0	0
Feb-74	1974	367,314	349,492	52,848	55,135	377	2,067	0	0
Mar-74	1974	362,536	350,139	52,626	55,006	2,240	15,539	523	352
Apr-74	1974	347,891	335,060	51,900	54,157	129	1,325	375	322
May-74	1974	335,979	326,857	50,323	53,261	2,839	705	106	131
Jun-74	1974	320,069	314,019	49,596	52,665	1,680	473	930	542
Jul-74	1974	296,214	295,962	47,466	50,694	1,000	0	18	91
Aug-74	1974	332,655	336,832	48,110	51,543	18,767	3,771	1,735	1,009
Sep-74	1974	337,298	343,477	47,367	51,153	7,116	1,062	23	51
Oct-74	1974	363,533	373,764	47,007	50,886	13,617	3,399	110	97
Nov-74	1974	358,113	368,476	46,716	50,578	1,418	1,488	139	77
Dec-74	1974	350,855	363,437	46,366	50,355	787	1,171	0	0
Jan-75	1975	344,526	360,894	45,835	50,287	1,451	3,714	0	0
Feb-75	1975	339,701	360,146	45,473	50,212	1,421	4,680	0	0

	Year	Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
		TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Mar-75	1975	331,174	352,316	44,964	49,872	741	2,859	10	99
Apr-75	1975	320,813	343,097	44,303	49,234	1,118	2,562	68	71
May-75	1975	309,848	332,220	46,712	52,070	977	4,365	4,442	2,521
Jun-75	1975	326,393	351,180	46,677	52,167	11,798	4,620	1,047	644
Jul-75	1975	330,788	357,594	52,860	58,449	6,935	4,572	9,990	5,574
Aug-75	1975	324,323	350,670	54,559	59,702	3,817	2,569	3,973	2,228
Sep-75	1975	314,077	338,518	54,390	59,431	524	0	440	283
Oct-75	1975	302,197	325,808	53,639	58,231	337	0	226	175
Nov-75	1975	295,002	318,336	53,849	58,418	208	588	279	154
Dec-75	1975	287,264	310,700	53,691	58,057	171	1,347	99	54
Jan-76	1976	277,990	303,377	53,084	57,488	285	2,089	19	11
Feb-76	1976	268,514	294,460	52,429	56,635	296	1,666	2	1
Mar-76	1976	257,315	285,419	51,625	55,758	351	3,022	18	45
Apr-76	1976	247,096	276,587	52,128	56,314	864	3,263	1,569	874
May-76	1976	239,688	270,086	51,813	56,313	2,571	3,571	671	384
Jun-76	1976	222,771	256,160	50,252	55,015	1,265	342	234	130
Jul-76	1976	205,782	242,729	48,766	53,574	1,474	0	188	108
Aug-76	1976	200,033	241,476	47,170	52,033	5,107	468	26	42
Sep-76	1976	239,326	289,306	46,703	51,486	19,846	4,101	82	64
Oct-76	1976	231,907	281,939	46,168	50,822	1,397	407	6	16
Nov-76	1976	223,296	275,195	45,682	50,349	410	864	13	7
Dec-76	1976	216,336	268,117	45,508	49,830	341	1,089	0	0
Jan-77	1977	211,474	260,305	45,431	49,620	634	0	0	0
Feb-77	1977	206,896	253,970	45,317	49,059	636	2,308	0	0
Mar-77	1977	194,888	242,372	44,452	48,123	115	1,290	10	38
Apr-77	1977	194,151	242,204	44,017	47,941	3,501	5,449	232	140
May-77	1977	202,622	255,555	45,837	50,045	42,125	49,302	3,342	1,852
Jun-77	1977	188,390	248,008	45,254	49,603	1,723	15,173	1,301	720
Jul-77	1977	175,797	233,586	44,538	48,771	2,858	0	1,084	603
Aug-77	1977	213,242	264,788	45,896	50,393	19,609	6,609	3,124	1,744
Sep-77	1977	226,165	274,322	45,020	49,413	10,749	3,081	47	43
Oct-77	1977	213,416	262,638	44,224	48,503	63	69	0	13
Nov-77	1977	204,504	253,599	43,883	47,879	71	850	0	0
Dec-77	1977	195,225	244,919	43,472	47,361	83	1,036	0	0
Jan-78	1978	189,393	238,291	43,373	47,190	157	1,133	0	0
Feb-78	1978	185,703	232,733	43,386	47,082	5,354	4,438	0	0
Mar-78	1978	176,118	223,665	42,806	46,336	3,790	2,747	10	38
Apr-78	1978	160,802	210,527	41,865	45,230	2,009	1,563	18	15
May-78	1978	176,955	228,693	45,440	48,923	30,839	26,451	5,142	2,817
Jun-78	1978	212,796	267,017	49,386	53,162	41,336	34,235	7,305	4,055
Jul-78	1978	189,960	248,309	47,301	51,340	624	0	22	170
Aug-78	1978	171,680	234,705	49,914	54,179	898	887	6,206	3,583
Sep-78	1978	174,055	241,328	49,469	53,975	6,674	4,051	1,000	725
Oct-78	1978	167,940	237,680	48,415	53,167	3,016	625	0	170
Nov-78	1978	161,343	231,889	48,245	53,045	398	977	0	57
Dec-78	1978	151,910	224,701	47,715	52,577	188	1,736	0	0
Jan-79	1979	146,546	219,330	47,784	52,612	1,791	4,778	0	121

		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
	Year	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Feb-79	1979	140,136	212,927	47,814	52,598	262	2,762	0	186
Mar-79	1979	131,431	206,853	47,869	52,745	216	9,046	12	442
Apr-79	1979	118,769	196,228	47,291	52,422	141	1,845	20	294
May-79	1979	109,314	192,875	58,693	59,702	675	17,177	1,063	9,099
Jun-79	1979	114,174	203,179	58,633	59,702	7,188	10,128	207	1,030
Jul-79	1979	96,220	186,976	59,430	59,702	147	1,842	1,276	1,724
Aug-79	1979	95,066	185,372	58,738	59,194	5,874	669	130	558
Sep-79	1979	82,192	172,972	57,595	58,252	776	0	20	292
Oct-79	1979	70,660	162,530	57,021	57,346	69	0	143	0
Nov-79	1979	67,477	155,813	56,821	57,121	2,019	1,758	229	68
Dec-79	1979	60,611	148,554	56,889	57,013	404	1,742	364	65
Jan-80	1980	59,660	145,917	57,286	57,270	2,023	3,365	418	133
Feb-80	1980	67,758	146,075	57,519	57,248	5,573	4,563	397	237
Mar-80	1980	62,420	141,545	57,787	57,133	989	3,957	496	162
Apr-80	1980	51,481	133,329	60,900	59,702	424	5,868	6,464	199
May-80	1980	57,513	144,120	60,900	59,702	6,319	13,869	4,519	756
Jun-80	1980	48,632	137,616	60,782	59,702	2,637	1,152	1,626	169
Jul-80	1980	24,911	120,098	58,291	57,443	28	0	403	0
Aug-80	1980	12,889	110,498	56,601	55,847	2,322	0	197	170
Sep-80	1980	231	100,499	55,240	54,559	982	0	115	109
Oct-80	1980	-4,690	90,166	54,314	53,629	36	0	146	0
Nov-80	1980	-6,424	82,853	54,010	53,339	83	0	191	0
Dec-80	1980	-6,762	76,827	53,944	53,203	448	837	233	0
Jan-81	1981	-8,075	70,954	53,738	53,012	234	1,402	231	0
Feb-81	1981	-9,447	63,894	53,552	52,598	124	1,172	199	0
Mar-81	1981	-10,329	57,708	53,451	52,533	337	3,179	283	17
Apr-81	1981	-14,684	47,189	52,507	51,694	87	33	254	30
May-81	1981	-15,569	37,611	51,684	51,206	1,088	3,213	167	30
Jun-81	1981	-3,471	47,039	50,184	49,816	7,387	6,341	94	30
Jul-81	1981	0	46,963	49,036	48,863	5,374	703	61	48
Aug-81	1981	163,538	181,133	48,287	48,181	68,763	10,662	100	115
Sep-81	1981	199,685	210,467	47,661	47,445	19,035	3,131	55	0
Oct-81	1981	198,102	210,191	47,247	47,222	2,926	3,324	52	0
Nov-81	1981	193,175	206,639	47,228	47,085	1,039	3,537	105	0
Dec-81	1981	188,637	201,236	47,321	46,751	799	2,417	84	0
Jan-82	1982	184,434	194,894	47,395	46,452	658	2,331	72	0
Feb-82	1982	181,482	189,284	47,674	46,198	2,681	4,011	96	0
Mar-82	1982	173,517	181,494	47,277	45,536	5,073	3,938	150	17
Apr-82	1982	160,801	170,396	46,476	44,902	1,814	1,577	160	30
May-82	1982	153,344	166,220	46,205	45,030	4,960	10,113	407	3,873
Jun-82	1982	188,789	193,866	47,285	46,254	17,912	15,439	1,594	2,171
Jul-82	1982	249,948	226,828	46,547	45,598	29,288	4,833	259	39
Aug-82	1982	268,217	220,163	45,235	44,381	14,449	2,730	95	43
Sep-82	1982	274,363	213,700	44,085	43,284	8,657	523	48	8
Oct-82	1982	284,412	209,607	43,436	42,563	8,915	437	74	10
Nov-82	1982	292,053	203,506	42,940	42,239	6,907	922	73	0
Dec-82	1982	296,285	202,891	43,018	42,182	4,037	2,247	119	0

		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
	Year	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Jan-83	1983	299,161	201,271	43,111	42,118	5,698	2,575	134	0
Feb-83	1983	306,077	203,981	43,379	42,261	10,271	5,705	196	0
Mar-83	1983	306,719	203,983	43,472	42,153	11,603	8,375	288	17
Apr-83	1983	300,034	195,879	43,148	41,791	7,308	4,919	295	30
May-83	1983	290,139	186,796	42,622	41,595	5,965	3,681	264	30
Jun-83	1983	286,761	184,636	42,621	41,891	17,370	22,203	757	30
Jul-83	1983	261,991	167,040	40,971	40,344	25	0	205	30
Aug-83	1983	240,890	151,146	39,437	38,890	22	0	58	30
Sep-83	1983	222,275	137,253	38,221	37,802	27	0	51	0
Oct-83	1983	212,746	128,623	37,837	37,429	164	303	48	0
Nov-83	1983	204,064	120,959	37,580	37,064	126	0	69	0
Dec-83	1983	194,428	114,091	37,285	37,005	52	0	70	0
Jan-84	1984	186,873	108,931	36,970	36,881	3,673	3,880	123	0
Feb-84	1984	179,324	102,795	36,725	36,391	2,298	2,591	104	0
Mar-84	1984	172,887	96,313	36,658	36,336	3,406	3,196	134	17
Apr-84	1984	165,121	89,970	36,385	36,001	4,864	3,835	263	30
May-84	1984	150,986	78,576	35,614	35,420	1,311	1,663	153	30
Jun-84	1984	139,151	70,199	34,959	35,115	4,505	1,866	694	30
Jul-84	1984	118,383	56,033	33,717	34,033	594	0	204	30
Aug-84	1984	116,868	58,867	32,797	33,153	5,357	635	57	30
Sep-84	1984	100,980	47,294	31,834	32,144	238	0	20	0
Oct-84	1984	99,354	46,369	31,786	32,006	2,578	1,157	49	0
Nov-84	1984	92,786	42,159	31,441	31,701	1,088	1,645	56	0
Dec-84	1984	89,556	40,205	31,400	31,820	5,301	3,740	167	0
Jan-85	1985	84,844	37,149	31,258	31,865	3,586	3,128	200	0
Feb-85	1985	81,324	34,115	31,381	32,006	5,943	4,031	217	0
Mar-85	1985	80,844	33,980	31,397	31,962	10,801	8,305	287	17
Apr-85	1985	74,023	28,747	31,600	32,176	8,808	7,390	756	30
May-85	1985	68,272	26,321	31,618	32,387	6,523	7,015	771	30
Jun-85	1985	56,084	18,891	31,016	31,903	1,341	3,461	223	30
Jul-85	1985	36,195	4,716	29,951	30,876	158	0	211	30
Aug-85	1985	20,892	0	29,023	30,041	759	139	111	30
Sep-85	1985	31,147	12,577	28,905	29,887	8,360	1,601	40	1,613
Oct-85	1985	38,632	23,311	28,882	29,881	5,854	10,496	53	1,275
Nov-85	1985	33,353	19,567	28,760	29,822	2,731	3,391	144	0
Dec-85	1985	26,933	15,035	28,587	29,970	3,967	3,589	164	0
Jan-86	1986	21,315	10,385	28,305	29,587	4,860	3,639	53	0
Feb-86	1986	19,513	8,771	28,117	29,251	5,373	3,873	52	0
Mar-86	1986	10,916	2,406	27,614	28,621	3,510	2,582	110	17
Apr-86	1986	0	0	27,028	28,097	588	806	96	30
May-86	1986	-2,580	-843	26,298	27,635	522	941	71	30
Jun-86	1986	0	1,136	25,819	27,192	8,513	3,669	96	30
Jul-86	1986	-8,248	-1,025	24,820	26,211	336	1,037	132	30
Aug-86	1986	0	2,713	24,552	25,971	5,714	2,783	320	30
Sep-86	1986	12,190	19,409	24,191	25,797	9,682	3,057	386	0
Oct-86	1986	10,711	18,681	24,224	25,984	4,567	3,145	411	0
Nov-86	1986	17,847	24,557	24,477	26,240	13,879	5,754	327	0

	Year	Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
		TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Dec-86	1986	14,930	20,748	24,884	26,446	4,348	4,003	339	0
Jan-87	1987	13,997	17,808	25,433	26,836	6,741	4,885	512	0
Feb-87	1987	13,507	14,964	25,993	27,205	7,193	4,993	436	0
Mar-87	1987	11,895	13,959	26,673	27,993	11,789	7,599	967	17
Apr-87	1987	12,224	4,915	26,785	28,150	7,657	2,798	854	30
May-87	1987	59,465	62,171	27,704	29,311	22,487	7,356	1,149	269
Jun-87	1987	77,151	72,788	28,080	29,806	11,469	9,346	885	30
Jul-87	1987	70,098	59,674	27,556	29,232	4,837	3,388	562	31
Aug-87	1987	75,309	68,383	26,927	28,636	7,902	1,722	158	30
Sep-87	1987	76,837	71,740	27,059	28,693	4,536	4,364	271	0
Oct-87	1987	68,586	64,933	26,867	28,340	793	2,289	171	0
Nov-87	1987	61,569	59,020	26,840	28,296	1,457	2,120	256	0
Dec-87	1987	58,473	55,010	27,136	28,568	3,038	3,717	372	0
Jan-88	1988	58,200	54,526	27,509	28,907	8,056	8,143	440	0
Feb-88	1988	54,156	50,023	27,861	29,084	4,782	4,565	491	0
Mar-88	1988	55,785	53,929	28,720	30,205	12,700	13,342	1,265	17
Apr-88	1988	54,992	56,307	29,870	31,443	9,000	12,876	1,525	30
May-88	1988	69,889	76,719	30,656	32,449	10,661	9,789	1,526	30
Jun-88	1988	85,333	100,224	30,230	32,192	12,262	9,673	552	30
Jul-88	1988	104,101	125,339	29,880	31,790	13,414	8,443	249	30
Aug-88	1988	94,177	117,846	29,039	31,069	2,096	1,194	88	30
Sep-88	1988	120,150	148,631	28,785	30,881	14,706	4,493	140	0
Oct-88	1988	111,765	141,464	28,470	30,530	1,238	1,373	196	0
Nov-88	1988	111,709	133,430	28,280	30,220	3,616	1,273	206	0
Dec-88	1988	108,190	129,048	28,466	30,031	1,271	2,219	240	0
Jan-89	1989	104,886	124,561	28,700	29,939	2,144	2,612	257	0
Feb-89	1989	101,989	119,869	29,021	30,134	1,885	2,607	306	0
Mar-89	1989	94,253	112,260	28,827	29,783	3,968	3,167	287	17
Apr-89	1989	81,523	101,925	28,161	29,306	3,153	1,891	217	30
May-89	1989	88,040	111,092	33,227	35,066	17,173	12,501	5,565	5,262
Jun-89	1989	100,474	128,909	35,025	37,063	9,051	15,663	1,897	30
Jul-89	1989	89,359	121,715	34,670	36,804	2,888	3,107	741	39
Aug-89	1989	94,974	129,950	34,460	36,661	7,793	3,359	447	39
Sep-89	1989	93,427	130,992	34,053	36,229	4,702	1,899	206	153
Oct-89	1989	83,212	122,326	33,573	35,565	705	917	222	9
Nov-89	1989	89,470	120,593	33,233	34,976	6,462	1,779	228	0
Dec-89	1989	82,869	116,266	33,176	34,952	783	2,077	271	0
Jan-90	1990	80,296	114,175	33,337	35,119	5,445	4,455	344	0
Feb-90	1990	79,668	114,155	33,509	35,417	6,905	5,647	403	0
Mar-90	1990	76,237	111,321	33,805	35,879	7,088	6,469	642	17
Apr-90	1990	68,672	104,713	34,087	36,196	1,137	5,056	611	3,122
May-90	1990	55,605	94,795	34,100	36,460	692	4,045	781	30
Jun-90	1990	36,226	79,775	33,091	35,392	27	944	334	30
Jul-90	1990	20,184	66,706	32,195	34,425	646	0	134	30
Aug-90	1990	6,688	55,760	31,176	33,422	913	0	135	30
Sep-90	1990	16,458	68,811	30,740	32,908	8,575	1,319	75	0
Oct-90	1990	9,718	63,970	30,217	32,418	1,819	892	61	0

	Year	Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
		TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Nov-90	1990	5,760	61,037	29,994	32,252	1,749	1,324	93	0
Dec-90	1990	0	55,656	29,818	32,221	683	1,125	171	0
Jan-91	1991	0	54,631	29,702	32,218	1,755	2,400	222	0
Feb-91	1991	-923	48,907	29,578	31,997	590	1,935	237	0
Mar-91	1991	-3,731	40,674	29,304	31,557	303	1,949	242	0
Apr-91	1991	-7,684	31,091	28,769	30,898	428	1,432	224	0
May-91	1991	0	34,447	28,519	30,638	5,122	2,711	229	0
Jun-91	1991	0	38,223	31,394	30,094	4,664	8,829	258	2,480
Jul-91	1991	8,721	50,946	30,500	29,132	9,172	3,247	87	0
Aug-91	1991	29,794	75,982	29,541	28,087	13,932	3,338	36	0
Sep-91	1991	27,962	65,386	28,853	27,398	4,626	497	43	0
Oct-91	1991	23,085	57,551	28,253	26,669	2,745	169	37	0
Nov-91	1991	20,528	53,743	28,442	26,518	1,011	2,110	55	0
Dec-91	1991	25,596	54,938	28,776	26,494	3,383	5,732	123	0
Jan-92	1992	31,705	58,564	28,875	26,556	4,390	6,277	207	0
Feb-92	1992	28,776	54,969	28,937	26,318	930	3,790	149	0
Mar-92	1992	20,953	48,216	28,547	26,022	545	3,031	216	0
Apr-92	1992	12,432	42,099	28,186	25,933	498	6,773	348	0
May-92	1992	5,230	37,005	27,579	25,693	1,775	3,590	124	0
Jun-92	1992	41,567	78,673	31,562	25,851	17,849	12,101	264	327
Jul-92	1992	37,278	77,579	31,051	25,621	4,735	2,390	477	0
Aug-92	1992	41,918	83,348	30,732	25,329	6,344	1,586	124	438
Sep-92	1992	30,957	75,555	29,795	24,519	1,786	301	69	0
Oct-92	1992	19,113	65,818	29,132	23,956	192	0	93	20
Nov-92	1992	13,922	59,709	29,073	23,798	525	1,001	71	0
Dec-92	1992	8,466	56,934	28,809	23,856	1,072	3,921	264	0
Jan-93	1993	3,278	54,397	28,680	24,036	865	4,719	299	0
Feb-93	1993	0	52,106	28,732	24,351	957	5,275	518	0
Mar-93	1993	0	47,590	28,460	25,188	842	5,669	1,171	0
Apr-93	1993	-2,032	40,012	28,062	26,386	520	5,053	1,655	0
May-93	1993	-2,876	32,311	31,259	27,479	900	4,714	1,516	0
Jun-93	1993	3,923	41,038	32,044	27,380	7,149	4,609	517	231
Jul-93	1993	1,894	39,207	35,990	31,980	4,971	1,556	5,268	0
Aug-93	1993	1,505	35,227	35,138	31,311	5,641	549	364	331
Sep-93	1993	18,875	39,007	34,927	30,592	11,292	847	140	0
Oct-93	1993	10,925	32,309	34,419	30,079	1,074	297	180	0
Nov-93	1993	4,643	26,339	34,249	29,805	609	865	164	0
Dec-93	1993	0	20,218	34,376	29,770	499	1,218	264	0
Jan-94	1994	0	14,156	34,459	29,720	422	1,740	291	0
Feb-94	1994	0	8,853	34,499	29,757	393	1,723	336	0
Mar-94	1994	-535	3,507	34,422	29,685	873	2,766	466	0
Apr-94	1994	-1,932	0	34,116	29,445	808	3,680	293	0
May-94	1994	20,160	5,482	34,678	29,312	13,286	3,533	390	263
Jun-94	1994	30,368	4,676	34,235	28,484	10,237	1,943	229	0
Jul-94	1994	50,632	9,302	33,403	27,541	13,662	1,045	35	0
Aug-94	1994	49,237	0	32,882	26,693	5,479	0	29	0
Sep-94	1994	51,403	0	32,203	25,965	6,227	0	43	0

	Year	Storage Lake Meredith TCEQ	Storage Lake Meredith Region A Model	Storage Palo Duro TCEQ	Storage Palo Duro Region A Model	Reg Flow Can Riv near Can TCEQ	Reg Flow Can Riv near Can Region A Model	Reg Flow Colwater Creek TCEQ	Reg Flow Colwater Creek Region A Model
Oct-94	1994	76,208	28,801	31,811	25,465	13,478	3,917	45	0
Nov-94	1994	70,346	24,944	31,762	25,074	754	0	46	0
Dec-94	1994	64,425	19,808	31,677	24,877	627	2,737	57	0
Jan-95	1995	61,020	15,940	31,696	24,968	660	2,609	98	0
Feb-95	1995	56,457	10,054	31,702	25,073	500	2,179	111	0
Mar-95	1995	48,329	3,781	31,384	24,737	466	2,919	183	0
Apr-95	1995	38,802	0	31,030	24,441	573	2,716	167	0
May-95	1995	38,003	53	32,207	24,561	2,817	6,249	192	0
Jun-95	1995	48,698	5,272	34,134	26,425	8,779	15,265	2,243	0
Jul-95	1995	55,852	5,989	35,456	26,241	8,833	1,921	410	0
Aug-95	1995	78,545	15,750	34,477	25,598	14,958	2,539	112	77
Sep-95	1995	99,819	25,379	34,191	25,360	12,576	2,104	58	71
Oct-95	1995	98,396	25,046	33,557	24,784	4,175	2,858	74	0
Nov-95	1995	90,648	20,662	33,080	24,328	783	1,634	76	0
Dec-95	1995	85,110	15,784	32,980	24,082	700	1,972	144	0
Jan-96	1996	79,416	11,430	32,823	23,912	586	2,286	175	0
Feb-96	1996	73,752	5,436	32,673	23,650	490	2,127	152	0
Mar-96	1996	63,693	0	32,199	23,242	218	2,062	174	0
Apr-96	1996	49,081	-2,709	31,253	22,560	100	1,333	145	0
May-96	1996	36,079	-2,792	30,354	22,244	1,143	2,634	67	0
Jun-96	1996	41,362	5,313	31,236	21,770	7,074	3,650	31	101
Jul-96	1996	81,053	44,264	35,690	23,071	20,044	8,590	1,523	10
Aug-96	1996	111,829	69,917	36,483	24,400	16,481	7,512	1,495	266
Sep-96	1996	130,689	78,986	60,900	57,007	10,500	6,239	30,344	35
Oct-96	1996	124,808	75,103	60,208	58,634	1,922	3,002	2,474	0
Nov-96	1996	120,533	71,926	60,900	59,702	1,173	3,895	1,698	0
Dec-96	1996	116,150	68,678	60,773	59,702	1,537	5,195	1,414	0
Jan-97	1997	112,315	65,108	60,616	59,702	2,889	4,140	989	0
Feb-97	1997	110,508	62,014	60,592	59,702	9,017	5,486	963	0
Mar-97	1997	100,873	55,010	59,653	59,059	3,223	3,960	780	0
Apr-97	1997	119,240	71,504	60,900	59,702	36,617	27,590	2,343	0
May-97	1997	118,718	71,458	60,548	59,702	18,303	13,839	2,430	3
Jun-97	1997	121,575	82,877	59,808	59,702	5,812	6,273	1,596	0
Jul-97	1997	123,422	73,510	58,714	58,478	7,156	1,341	296	1
Aug-97	1997	140,241	83,067	58,124	57,999	11,196	4,502	254	160
Sep-97	1997	137,826	73,516	57,408	57,207	4,236	1,706	166	0
Oct-97	1997	131,655	68,634	56,833	56,600	1,650	1,759	219	0
Nov-97	1997	125,812	64,306	56,424	56,347	843	2,348	286	0
Dec-97	1997	123,609	61,997	56,464	56,892	5,209	5,599	487	0
Jan-98	1998	123,494	61,942	56,618	57,268	9,934	7,213	877	0
Feb-98	1998	122,610	60,469	56,946	57,780	7,703	6,382	851	0
Mar-98	1998	126,994	63,856	58,213	58,907	17,178	12,142	1,679	0
Apr-98	1998	117,014	56,786	58,304	59,068	712	5,701	1,215	0
May-98	1998	104,177	47,256	57,656	58,644	545	4,201	776	0
Jun-98	1998	85,988	33,060	56,720	56,558	22	238	158	0
Jul-98	1998	68,345	19,557	56,395	56,530	21	0	1,197	0
Aug-98	1998	59,535	13,452	55,454	55,469	2,268	1,146	121	0

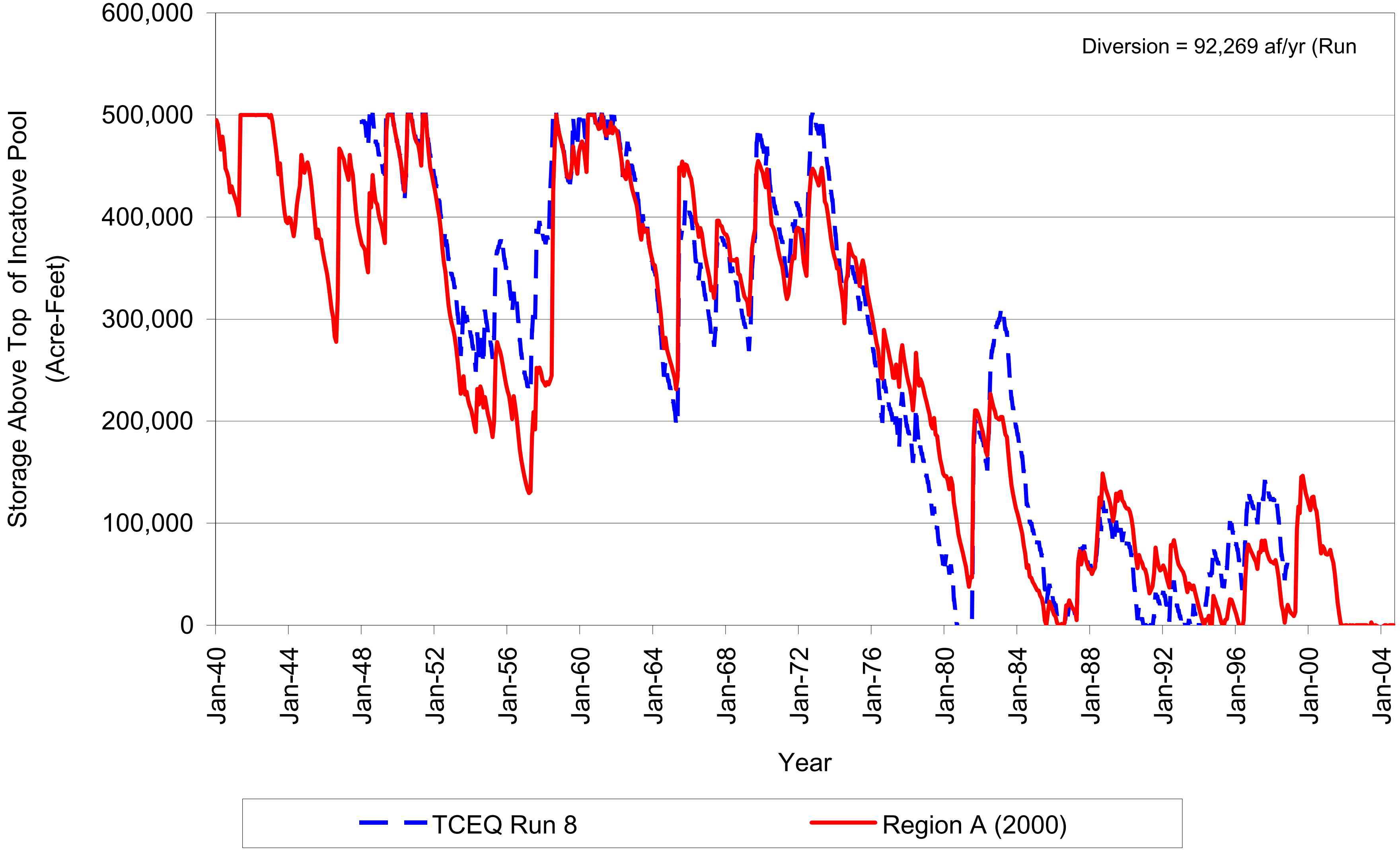
		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
	Year	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Sep-98	1998	46,002	2,520	54,282	54,082	268	0	66	0
Oct-98	1998	56,958	12,745	57,645	54,012	6,477	2,467	158	229
Nov-98	1998	60,581	19,996	60,900	54,068	4,501	7,940	412	189
Dec-98	1998	53,076	15,561	59,798	54,113	8,072	3,779	378	0
Jan-99	1999		12,165		54,465		4,019		0
Feb-99	1999		10,762		54,651		6,504		0
Mar-99	1999		9,022		55,260		9,453		0
Apr-99	1999		12,981		59,702		13,710		0
May-99	1999		93,729		59,702		14,952		0
Jun-99	1999		116,153		58,963		3,612		0
Jul-99	1999		109,871		57,447		4,580		0
Aug-99	1999		145,237		56,270		1,474		0
Sep-99	1999		146,332		55,425		1,017		0
Oct-99	1999		137,115		54,505		1,183		0
Nov-99	1999		129,030		53,469		0		0
Dec-99	1999		123,749		52,594		2,600		0
Jan-00	2000		118,079		52,067		2,162		0
Feb-00	2000		112,806		51,369		0		0
Mar-00	2000		125,342		51,225		0		0
Apr-00	2000		126,065		50,260		4,548		0
May-00	2000		115,612		49,159		4,015		0
Jun-00	2000		111,760		51,656		5,002		0
Jul-00	2000		99,659		50,187		1,960		0
Aug-00	2000		83,891		48,310		0		9
Sep-00	2000		70,448		46,591		0		0
Oct-00	2000		77,497		46,631		0		0
Nov-00	2000		75,109		46,179		3,805		0
Dec-00	2000		69,964		45,804		1,793		0
Jan-01	2001		69,107		45,567		5,199		0
Feb-01	2001		69,788		45,418		7,642		0
Mar-01	2001		73,880		45,290		10,105		0
Apr-01	2001		66,714		44,469		8,247		0
May-01	2001		61,339		44,214		7,676		0
Jun-01	2001		50,068		42,757		3,330		0
Jul-01	2001		35,002		41,042		1,551		0
Aug-01	2001		22,214		40,015		0		0
Sep-01	2001		11,174		39,082		0		0
Oct-01	2001		1,831		38,110		0		0
Nov-01	2001		0		37,899		1,137		0
Dec-01	2001		-876		37,908		0		0
Jan-02	2002		0		37,654		2,707		0
Feb-02	2002		0		37,594		2,902		0
Mar-02	2002		-1,467		37,374		1,917		0
Apr-02	2002		0		36,577		2,296		0
May-02	2002		-172		35,693		9,099		0
Jun-02	2002		0		35,503		1,847		0
Jul-02	2002		-946		34,545		3,681		0

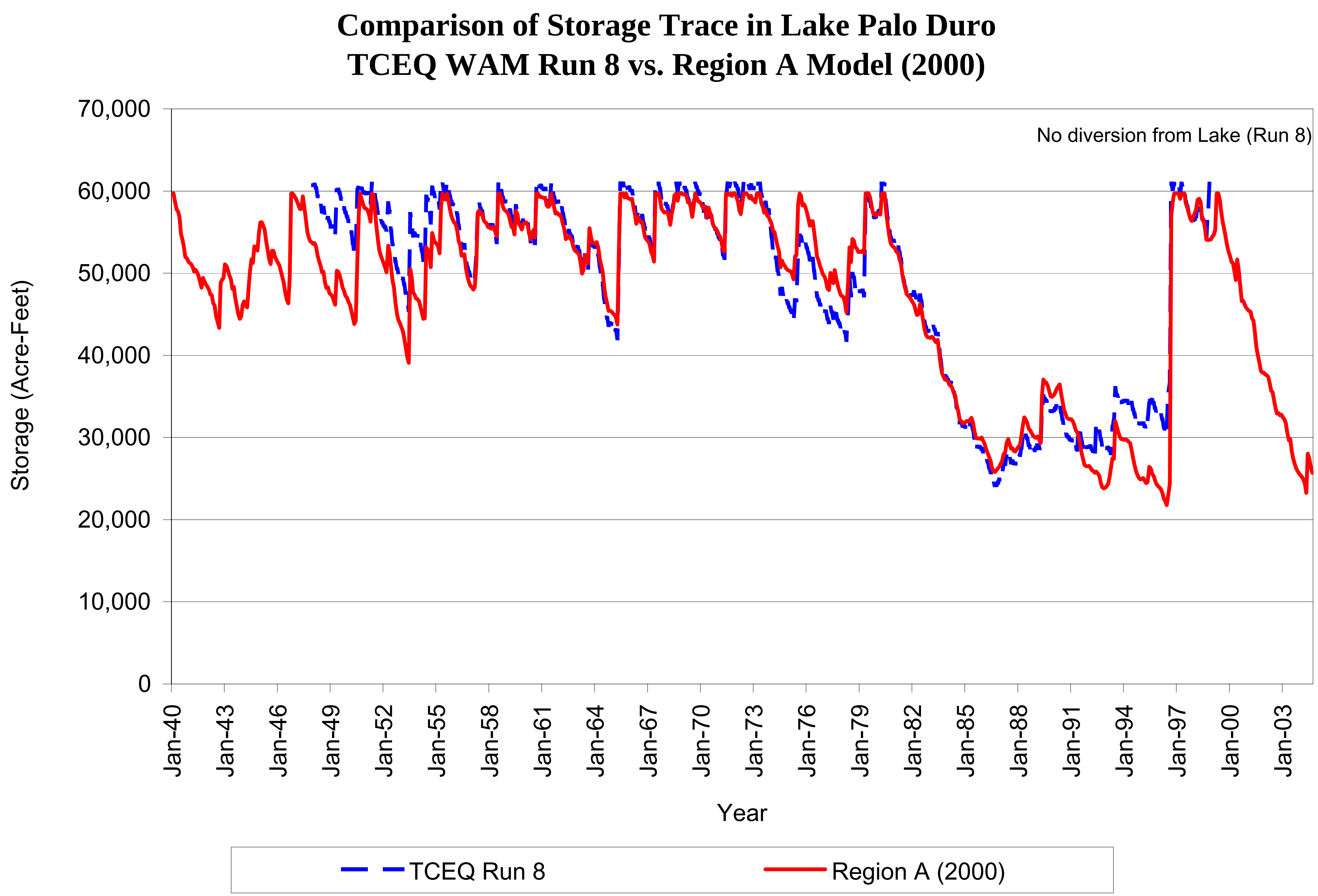
		Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
	Year	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Aug-02	2002		0		33,629		0		0
Sep-02	2002		0		32,916		6,626		0
Oct-02	2002		0		32,974		0		0
Nov-02	2002		0		32,699		2,720		0
Dec-02	2002		0		32,773		6,674		0
Jan-03	2003		0		32,466		4,409		0
Feb-03	2003		0		32,224		3,302		0
Mar-03	2003		0		31,786		4,050		0
Apr-03	2003		-1,850		30,650		4,735		0
May-03	2003		-4,002		29,648		3,013		0
Jun-03	2003		2,733		29,796		1,002		0
Jul-03	2003		0		28,337		3,692		0
Aug-03	2003		-3,156		27,439		241		0
Sep-03	2003		0		26,823		0		0
Oct-03	2003		-718		26,284		1,991		0
Nov-03	2003		-1,742		25,930		691		0
Dec-03	2003		-2,336		25,601		1,474		0
Jan-04	2004		-2,213		25,379		2,301		0
Feb-04	2004		-1,087		25,206		2,424		0
Mar-04	2004		0		24,853		6,133		0
Apr-04	2004		0		24,373		6,204		0
May-04	2004		-2,033		23,254		3,558		0
Jun-04	2004		0		28,019		8,297		288
Jul-04	2004		0		27,351		3,081		32
Aug-04	2004		0		26,334		0		0
Sep-04	2004		0		25,688		3,078		0

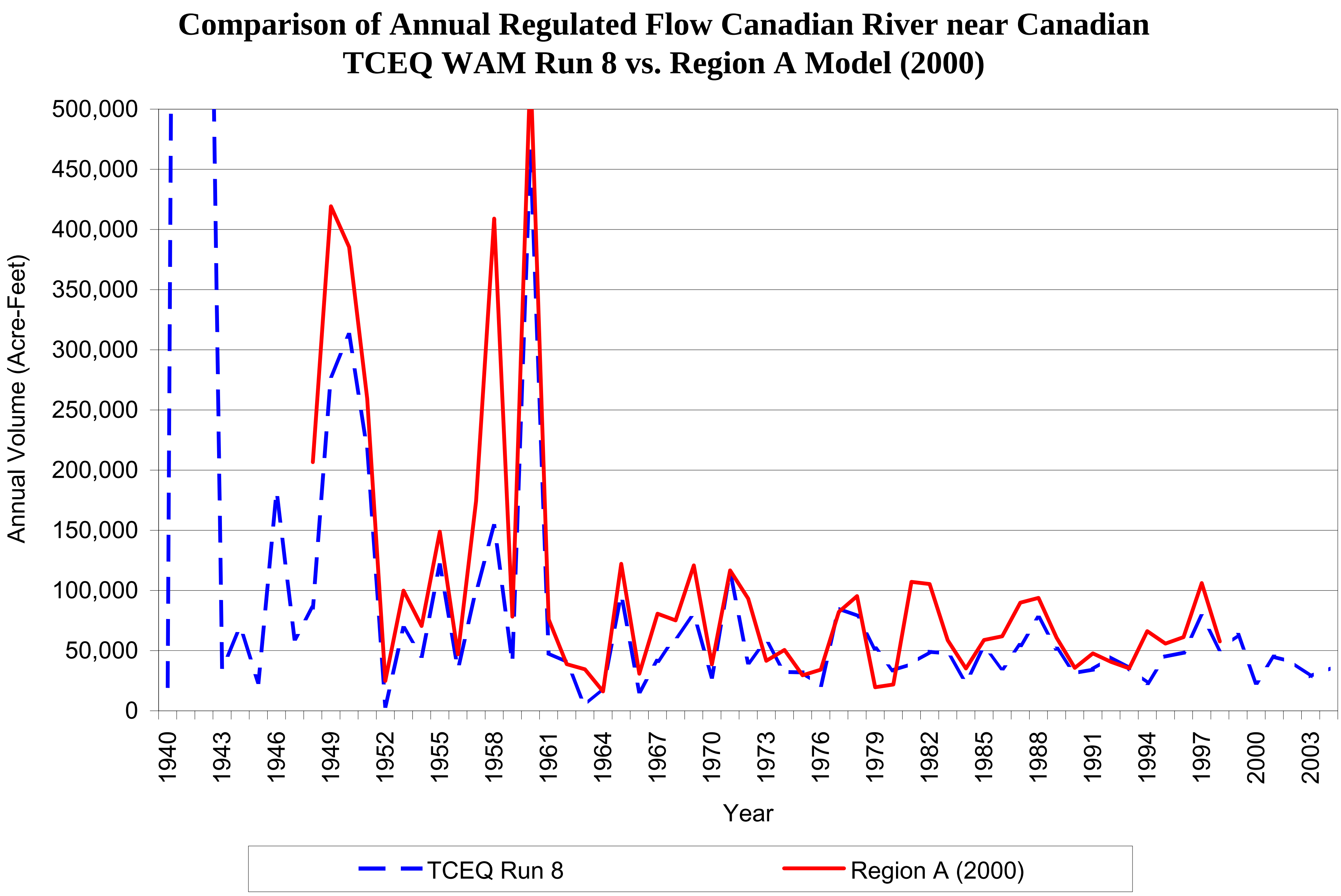
	Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
Year	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
Annual Results								
1940						20,595		14,567
1941						2,641,565		7,180
1942						1,080,141		6,967
1943						35,490		2,599
1944						69,070		5,629
1945						23,905		2,294
1946						181,608		43,170
1947						59,986		27,537
1948					206,679	85,762	3,316	3,909
1949					419,266	278,154	8,324	8,224
1950					385,421	312,468	33,538	44,367
1951					259,335	217,550	36,215	24,921
1952					24,878	4,026	7,702	2,275
1953					99,854	68,643	21,392	1,214
1954					70,525	45,603	26,141	1,192
1955					148,872	120,968	36,418	18,035
1956					46,934	35,582	5,999	3,358
1957					174,342	99,564	18,493	10,691
1958					409,090	153,539	18,622	10,305
1959					78,349	40,804	8,170	7,157
1960					534,750	464,703	36,784	5,809
1961					76,041	48,005	9,663	3,301
1962					38,760	40,231	3,586	5,489
1963					34,467	4,328	16,347	2,827
1964					16,116	19,218	1,344	812
1965					122,172	95,790	105,336	57,907
1966					30,834	16,091	6,117	3,194
1967					80,705	41,462	32,832	17,842
1968					75,102	60,702	39,842	21,807
1969					120,881	79,515	13,220	7,187
1970					38,552	28,229	8,197	4,614
1971					116,744	114,610	43,169	23,821
1972					93,220	40,141	16,181	9,445
1973					41,587	57,863	10,735	6,497
1974					50,559	32,334	3,958	2,670
1975					29,497	31,876	20,572	11,803
1976					34,205	20,882	2,826	1,683
1977					82,164	85,165	9,140	5,153
1978					95,283	78,841	19,702	11,630
1979					19,562	51,747	3,464	13,880
1980					21,863	33,611	15,204	1,936
1981					107,192	39,112	1,686	269
1982					105,350	49,099	3,145	6,190
1983					58,631	47,760	2,435	164
1984					35,214	24,207	2,024	164
1985					58,831	52,545	3,177	3,052

	Storage Lake Meredith		Storage Palo Duro		Reg Flow Can Riv near Can		Reg Flow Colwater Creek	
Year	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model	TCEQ	Region A Model
1986					61,892	35,287	2,392	164
1987					89,898	54,576	6,593	405
1988					93,802	77,382	6,918	164
1989					60,707	51,580	10,643	5,578
1990					35,678	31,275	3,782	3,256
1991					47,729	34,348	1,794	2,480
1992					40,641	44,762	2,404	785
1993					35,318	35,371	12,056	562
1994					66,244	23,083	2,261	263
1995					55,819	44,964	3,868	148
1996					61,267	48,526	39,690	412
1997					106,150	78,544	10,809	164
1998					57,699	51,207	7,887	418
1999						63,105		0
2000						23,286		9
2001						44,886		0
2002						40,469		0
2003						28,599		0
2004						35,075		319

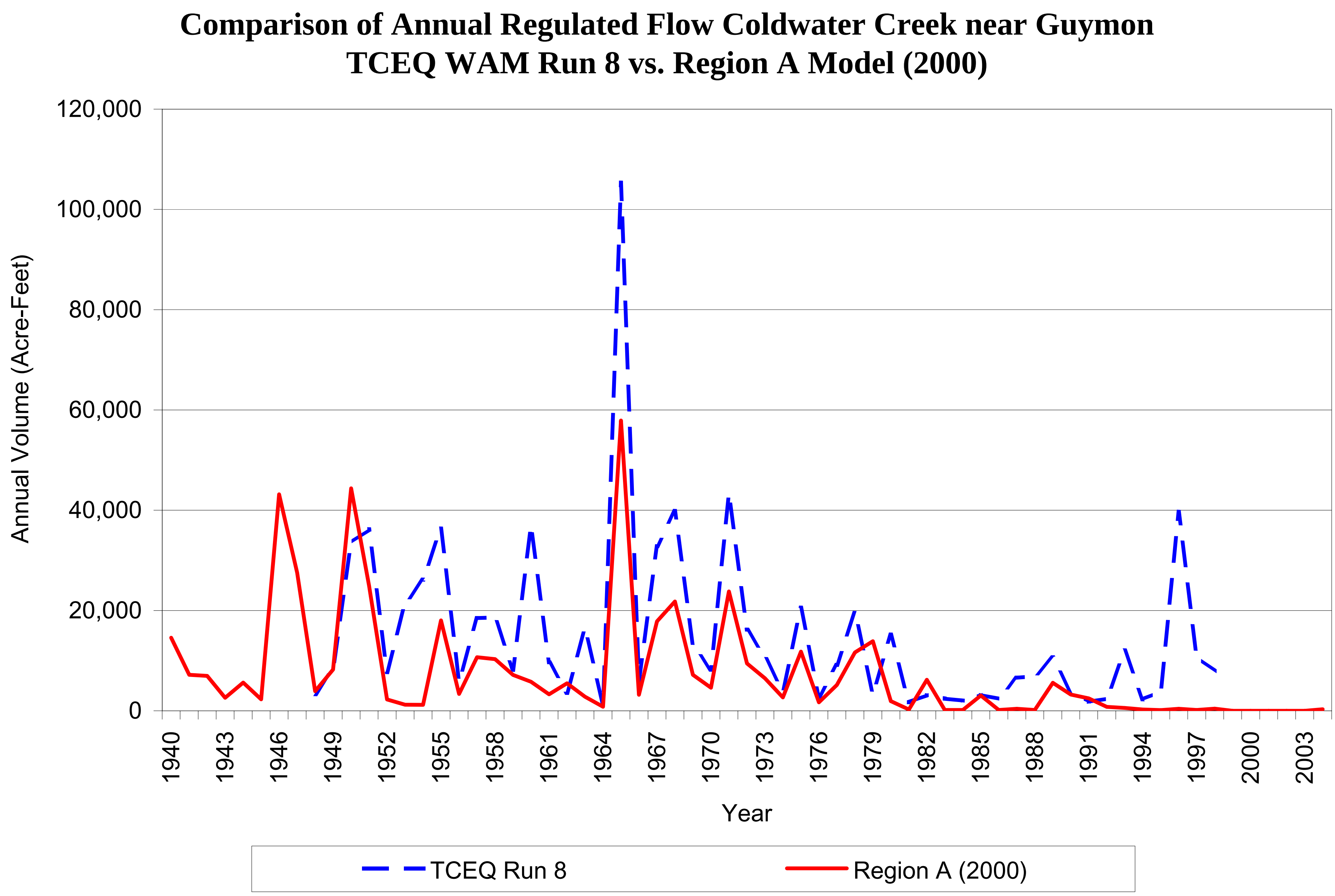
Comparison of Storage Trace in Lake Meredith
TCEQ WAM Run 8 vs. Region A Model (2000)




Comparison of Storage Trace in Lake Palo Duro
TCEQ WAM Run 8 vs. Region A Model (2000)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Storage (Acre-Feet)
No diversion from Lake (Run 8)
Jan-40
Jan-43
Jan-46
Jan-49
Jan-52
Jan-55
Jan-58
Jan-61
Jan-64
Jan-67
Jan-70
Jan-73
Jan-76
Jan-79
Jan-82
Jan-85
Jan-88
Jan-91
Jan-94
Jan-97
Jan-00
Jan-03
Year
TCEQ Run 8
Region A (2000)



Comparison of Annual Regulated Flow Canadian River near Canadian
TCEQ WAM Run 8 vs. Region A Model (2000)
Annual Volume (Acre-Feet)
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1940
1943
1946
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
Year
TCEQ Run 8
Region A (2000)


Comparison of Annual Regulated Flow Coldwater Creek near Guymon
TCEQ WAM Run 8 vs. Region A Model (2000)
Annual Volume (Acre-Feet)
120,000
100,000
80,000
60,000
40,000
20,000
0
1940
1943
1946
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
Year
TCEQ Run 8
Region A (2000)