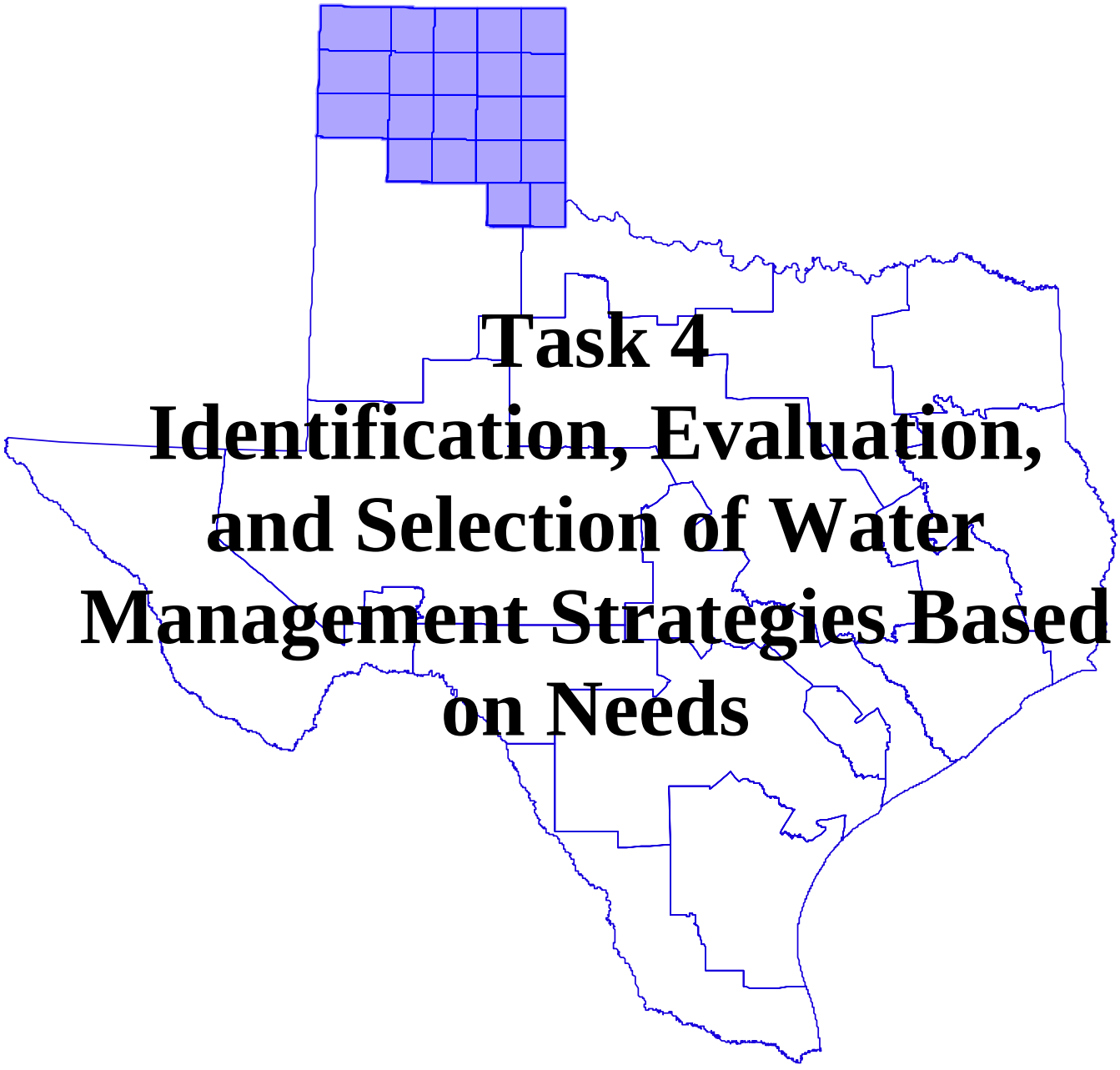

Task 4
Identification, Evaluation, and Selection of Water Management Strategies Based on Needs

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

Insert table. T:\Region A\Final Report\Chapter 4\Table 4-2.xls

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

Location

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

Location

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

Location

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

Use of North Plains Evapotranspiration Network (NPET)

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.

Quantity, Reliability and Cost

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 on 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 on 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 on 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**

Recommended Strategies

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

Recommended Conservation Strategies

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

Strategy Descriptions

The recommended strategies for Cactus include implementing water conservation and 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 on 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 on 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.

[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