4

4.2 Identification and Evaluation of Water Management Strategies

4.2.1 Evaluation Procedures

In accordance with TWDB rules, the Region F Water Planning Group has adopted a standard procedure for identifying potentially feasible strategies. This procedure classifies strategies using the TWDB's standard categories developed for regional water planning. These strategies categories include:

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

The Region F Water Planning Group did not consider water right cancellation to be a feasible strategy. Instead, Region F recommends that a water right holder consider selling water under their existing water right to the willing buyer.

Appendix 4C contains the procedures used to evaluate strategies and the results of the strategy evaluations.

4.2.2 Strategy Development

Water management strategies were developed for water user groups to meet projected needs in the context of their current supply sources, previous supply studies and available supply within the region. Much of the water supply in Region F is from groundwater, and several of the identified needs could be met by development of new groundwater supplies. Where site-specific data were available, this information was used. When specific well fields could not be identified, assumptions regarding well capacity, depth of well and associated costs were developed based on county and aquifer. In most cases new surface water supplies are not feasible because of the lack of unappropriated water in the upper Colorado Basin.

Water transmission lines were assumed to take the shortest route, following existing highways or roads where possible. Profiles were developed using USGS topographic maps. Pipes were sized to deliver peak-day flows within reasonable pressure and velocity ranges.

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.

In addition to the development of specific strategies to meet needs, there are other water management strategies that are general and could potentially increase water for all user groups. These include weather modification and brush control. A brief discussion of each of these general strategies and its applicability to Region F is included in Section 4.9.

In accordance with TWDB guidance, costs are reported using September 2008 prices and debt service is set at a 6 percent annual interest rate over 20 years except for reservoirs, which assumed a 6 percent annual interest rate over a period of 30 years. Cost estimates may be found in Appendix 4D.

4.2.3 Subordination of Downstream Senior Water Rights

The TWDB requires the use of the TCEQ Water Availability Models (WAM) for regional water planning. Most of the water rights in Region F are in the Colorado River Basin. Chapter 3 discusses the use of the WAM models for water supply estimates and the impacts to the available supplies in the upper Colorado River Basin. Table 3.2-2 in Chapter 3 shows that the Colorado WAM gives a very different assessment of water availability for many reservoirs in Region F than reported in previous studies. The primary difference between the supply analysis used in previous plans and the Colorado WAM is that previous plans did not assume that senior lower basin water rights would continuously make priority calls on Region F water rights. Other differences include a shorter period of hydrologic analysis, assumptions about channel losses, reservoir operation and the use of return flows.

Although the Colorado WAM does not give an accurate assessment of water supplies based on the way the basin has historically been operated, TWDB requires the regional water planning groups to use the WAM to determine supplies. Therefore several sources in Region F have no supply by definition, even though in practice their supply may be greater than indicated by the WAM. According to the WAM, the cities of Ballinger, Coleman, Junction, and Winters and their customers have no water supply. The Morgan Creek power plant has no supply to generate power. The cities of Big Spring, Bronte, Coahoma, Midland, Miles, Odessa, Robert Lee, San Angelo, Snyder and Stanton do not have sufficient water to meet current demands. The City of Brady, which recently built a new water treatment plant on Brady Creek Reservoir because its groundwater supplies exceed drinking water standards for radium, has no supply from that reservoir. Overall, the Colorado WAM shows shortages that are the result of modeling assumptions and regional water planning rules rather than the historical operation of the Colorado Basin. This would indicate Region F needs to immediately spend significant funds on new water supplies, when in reality the indicated water shortages are not justified. Conversely, the WAM model shows more water in Region K (Lower Colorado Basin) than may actually be available.

One way for the planning process to reserve water supplies for these communities and their customers is to assume that downstream senior water rights do not make priority calls on major

Region F municipal water rights, a process referred to as *subordination*. This assumption is similar to the methodology used to evaluate water supplies in previous water plans.

Because this strategy impacts water supplies outside of Region F, a joint modeling effort was conducted with the Lower Colorado Regional Water Planning Group (Region K) during the development of the 2006 regional water plans. The joint modeling had two major assumptions: 1) water rights in Region K do not make priority calls on specific upper basin water rights located in Regions F and Brazos G, and 2) these upper basin water rights do not make priority calls on each other. Only selected Region K water rights with a priority date before May 8, 1938, major reservoirs in Region F, and the City of Junction run-of-the-river right were subject to subordination. Table 4.2-1 contains a list of the water rights assumed to be participating in the subordination strategy. All other water rights were assumed to operate as originally modeled in the Colorado WAM. A detailed description of the joint modeling approach may be found in Appendix 4D of the 2006 Region F Water Plan.

Refinements to the subordination modeling were conducted for the Pecan Bayou watershed in 2009 as part of a special study conducted for Region F. A copy of the study is included in Appendix xxx. As discussed above the assumption that upper basin water rights do not make calls on each other is consistent with general operations in the basin, but it may not be appropriate for determining water supplies during drought in the Pecan Bayou watershed. The special study evaluated six different operating scenarios in the Pecan Bayou watershed, which includes Lake Brownwood, Lake Coleman, Hords Creek Reservoir and Lake Clyde. In addition, refinements to the naturalized flows in the Colorado WAM were made for Lake Coleman, Hords Creek Reservoir and Lake Clyde to better correlate with historical data.

Based on the findings of the special study for Pecan Bayou, all but one of the operating scenarios would provide sufficient supplies to meet the demands of the water rights holders. For planning purposes, Scenario 6 is selected for estimating the available supply from the Subordination Strategy. Scenario 6 assumes that the upstream reservoirs hold inflows that would have been passed to Lake Brownwood under strict priority analysis, with the exception that Lake Coleman would pass high flows when the capacity of Lake Brownwood is less than 50 percent full. For this analysis high flows were defined as the volume of water above the average monthly flow of 2,300 acre-feet per year. This scenario provides the maximum amount of total water supply in the basin while allowing Lake Brownwood to make priority calls at certain times during drought.

Since many of the reservoirs in the Colorado River Basin are experiencing significant drought conditions, a study was conducted as part of the 2006 Region F Water Plan to evaluate the impacts of recent drought on reservoir yields (considering hydrology through 2004). The yields presented in this section are the result of the findings of this study and have been adjusted to account for reduced yield due to drought conditions that have occurred since 1998, the last year simulated in the Colorado WAM. Many of the reservoirs are in drought of record conditions and new firm yields cannot be determined. The yields for the reservoirs in the Pecan Bayou watershed are based on the findings of the Pecan Bayou study and consider subordination of water rights in the Lower Colorado Region (Region K).

Two reservoirs providing water to the Brazos G planning region were included in the subordination analysis. Lake Clyde is located in Callahan County and provides water to the City of Clyde. Oak Creek Reservoir is located in Region F and supplies a small amount of water to water user groups within the region. However Oak Creek Reservoir is owned and operated by the City of Sweetwater, which is in the Brazos G Region. Both Clyde and Sweetwater have other sources of water in addition to the supplies in the Colorado Basin.

The subordination strategy modeling was conducted for regional water planning purposes only. By adopting this strategy, the Region F Water Planning Group does not imply that the water rights holders in Table 4.2-1 have agreed to relinquish the ability to make priority calls on junior water rights. The Region F Water Planning Group does not have the authority to create or enforce subordination agreements. Such agreements must be developed by the water rights holders themselves. Region F recommends and supports ongoing discussions on water rights issues in the Colorado Basin that may eventually lead to formal agreements that reserve water for Region F water rights.

Table 4.2-1
Major Water Rights Included in Subordination Analysis

Water Right Number	Region	Name of Water Right	Priority Date(s)
CA 1002	F	Lake Thomas	5/08/1946
CA 1009	F	Champion Creek Reservoir	4/08/1957
		Lake Colorado City	11/22/1948
CA 1008	F	Spence Reservoir	8/17/1964
CA 1031	F/G*	Oak Creek Reservoir	4/27/1949
CA 1072	F	Lake Ballinger	10/04/1946 4/7/1980
CA 1095	F	Lake Winters	12/18/1944
CA 1190	F	Fisher Reservoir	5/27/1949
CA 1318	F	Twin Buttes Reservoir	5/06/1959
CA 1319	F	Lake Nasworthy	3/11/1929
A 3866/P 3676	F	Ivie Reservoir	2/21/1978
CA 1705	F	Hords Creek Lake	3/23/1946
CA 1702	F	Lake Coleman	8/25/1958
CA 1660	G	Lake Clyde	2/02/1965
CA 1849	F	Brady Creek Reservoir	9/02/1959
CA 1570	F	Run-of-the river right City of Junction	5/17/1931 11/23/1964
CA 2454	F	Lake Brownwood	9/29/1925
CA 5434	K	Garwood	11/1/1900
CA 5476	K	Gulf Coast	12/1/1900
CA 5475	K	Lakeside	1/4/1901 9/2/1907
CA 5477	K	Pierce Ranch	9/1/1907
CA 5478	K	Lake Buchanan	3/29/1926 12/31/1929 3/7/1938
CA 5480	K	Lake LBJ	3/29/1926
CA 5479	K	Inks Lake	3/29/1926
CA 5482	K	Lake Travis	3/29/1926 03/07/1938
CA 5471	K	Lake Austin, Town Lake, Decker Lake et al.	6/30/1913 6/27/1914 12/31/1928

CA Certificate of Adjudication number
P Permit number
A Application number

* Oak Creek Reservoir is located in Region F but the supplies are primarily used in Brazos G.

The subordination analysis presented in this plan is only one possible scenario; others may need to be developed before implementation of this strategy.

Quantity, Reliability and Cost of Subordination

The subordination strategy shows additional supplies of 82,620 in 2010 and 74,728 in 2060. Figure 4.2-1 compares overall Region F surface water supplies and demands in the years 2010 and 2060, with and without the subordination strategy. Table 4.2-2 compares the 2010 and 2060 supplies for Region F water supply sources with and without the subordination strategy. Without the subordination strategy, in 2010 demand exceeds supply by 25,967 acre-feet per. With subordination, the region has a surplus supply of 56,653 acre-feet per year that can be used to meet other needs. By 2060, without subordination demand exceeds supply by 47,870 acre-feet per year. With subordination, the region has a surplus supply of 26,858 acre-feet per year that can be used to meet other needs.

Figure 4.2-1
Comparison of Supplies and Demands in Region F With and Without the Subordination Strategy

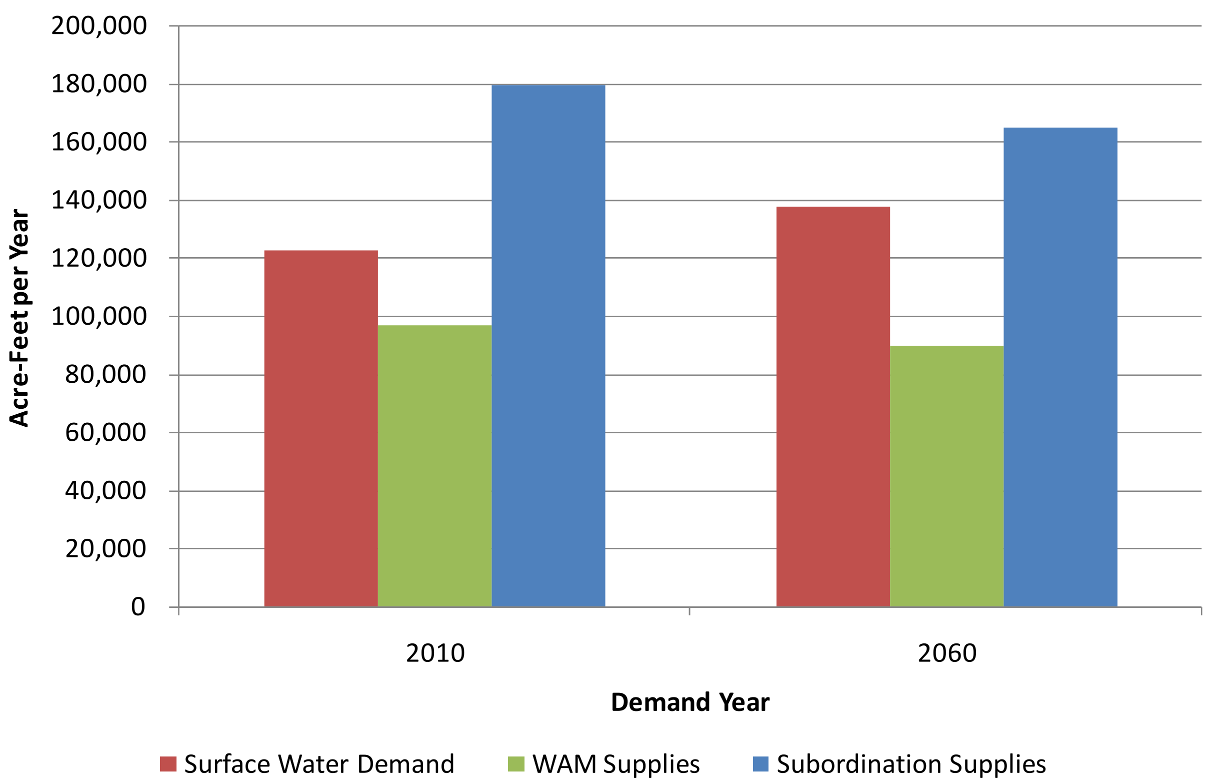


Table 4.2-2
Comparison of Region F Water Supplies with and Without Subordination
(Values in Acre-feet per Year)

Reservoir	2010 Supply WAM Run 3	2010 Supply Subord-ination	2060 Supply WAM Run 3	2060 Supply Subord-ination	Comments
Lake Colorado City	0	2,686	0	1,920	
Champion Creek Reservoir	0	2,337	0	2,220	
Colorado City/Champion System	*0*	*5,023*	*0*	*4,140*	
Oak Creek Reservoir	0	2,118	0	1,760	
Lake Ballinger	0	940	0	890	
Lake Winters	0	720	0	670	
Twin Buttes Reservoir/Lake Nasworthy	0	12,310	0	11,360	
O.C. Fisher Reservoir	0	3,862	0	3,270	
San Angelo System	*0*	*16,172*	*0*	*14,630*	
Hords Creek Reservoir	0	690	0	630	
Lake Coleman	0	5,760	0	5,340	
Coleman System	*0*	*6,450*	*0*	*5,970*	
Brady Creek Reservoir	0	2,170	0	2,220	
Lake Thomas	0	10,013	0	10,130	
Spence Reservoir (CRMWD system portion)	34	36,164	34	35,090	
Spence Reservoir (Non-system portion)	526	2,308	526	2,240	6% of safe yield
Spence Reservoir Total	*560*	*38,472*	*560*	*37,330*	
Ivie Reservoir (CRMWD system portion)	33,428	33,479	30,026	28,345	
Ivie Reservoir (Non-system portion)	32,922	32,973	29,574	27,915	49.62% of safe yield
Ivie Reservoir Total	*66,350*	*66,452*	*59,600*	*56,260*	
CRMWD Grand Total (Thomas, Spence & Ivie)	*66,910*	*114,937*	*60,160*	*103,720*	
Lake Brownwood	29,712	29,712	29,712	29,600	
City of Junction	0	1,000	0	1,000	

The reliability of this strategy is considered to be medium based on the uncertainty of implementing this strategy. The subordination strategy defined for the Region F Water Plan is for planning purposes. If an entity chooses to enter into a subordination agreement with a senior downstream water right holder, the details of the agreement (including costs, if any) will be between the participating parties. Therefore strategy costs will not be assessed for the subordination strategy. For planning purposes, capital and annual costs for the subordination strategy are assumed to be $0.

Environmental Issues Associated with Subordination

The WAM models assume a perfect application of the prior appropriations doctrine. A significant assumption in the model is that junior water rights routinely bypass water to meet the demands of downstream senior water rights and fill senior reservoir storage. If a downstream senior reservoir is less than full, all junior upstream rights are assumed to cease diverting and storing water until that reservoir is full, even if that reservoir does not need to be filled for that water right to meet its diversion targets. Currently in the Region F portion of the Colorado Basin, water rights divert and store inflows until downstream senior water rights make a priority call on upstream junior water rights. Many other assumptions are made in the Colorado WAM model that may be contrary to historical operation of the Colorado Basin in Region F.

Because many of the assumptions in the Colorado WAM are contrary to the actual operation of the upper portion of the basin, the model does not give a realistic assessment of stream flows in Region F. In the WAM a substantial amount of water is passed downstream to senior water rights that would not be passed based on historical operation. The subordination analysis better represents the actual operation of the basin. Therefore a comparison of flows with and without subordination is meaningless as an assessment of impacts on streamflow in the upper basin.

Environmental impacts should be based on an assessment of the actual conditions, not a simulation of a theoretical legal framework such as the WAM. Impacts should also be assessed for a change in actions. The subordination modeling approaches the actual operation of the upper basin. There is no change in operation or distinct action taken under this strategy. The actual impacts of implementing this strategy could occur during extreme drought when a downstream senior water right may elect to make a priority call on upstream junior water rights. Flows from priority releases could be used beneficially for environmental purposes in the intervening stream reaches before the water is diverted by the senior water right. Priority calls are largely based on the decision of individual water rights holders, making it difficult to quantify impacts. However, the potential environmental impacts are considered to be low to medium because this strategy, as modeled, assumes that operations in the basin continue as currently implemented. Existing species and habitats are established for current conditions, which are not proposed to change under this strategy.

Agricultural and Rural Issues Associated with Subordination

The water user groups impacted the most by the Colorado WAM are small rural towns such as Ballinger, Winters and Coleman, and the rural water supply corporations supplied by these towns. These towns have developed surface water supplies because groundwater supplies of sufficient quality and quantity are not available. This strategy reserves water for these rural communities.

Three Region F reservoirs included in the subordination strategy provide a significant amount of water for irrigation: the Twin Buttes Reservoir/Lake Nasworthy system and Lake Brownwood. Twin Buttes Reservoir uses a pool accounting system to divide water between the City of San Angelo and irrigation users. As long as water is in the irrigation pool, water is available for irrigation. Due to drought, no water has been in the irrigation pool since 1998. The total authorized diversion for the Twin Buttes/Nasworthy system is 54,000 acre-feet per year. The two reservoirs have no firm or safe yield in the Colorado WAM. With the subordination analysis the current safe yield of the Twin Buttes/Nasworthy system is 12,500 acre-feet per year. Historical water use from the reservoir has been as high as 40,000 acre-feet per year. The average recent use from the reservoir when irrigation supplies were available has been 29,000 acre-feet per year[2]. Therefore even with subordination there may not be sufficient water to meet both the needs of the City of San Angelo and irrigation demands.

The reliable supply from Lake Brownwood is the same with and without subordination. However, there is less water in storage with subordination which implies that there is less unpermitted yield available in the reservoir. The occurrence of drought conditions more severe than those encountered during the historical modeling period could impact supplies from this source.

Other Natural Resource Issues Associated with Subordination

None identified.

Significant Issues Affecting Feasibility of Subordination

Water supply in the Colorado Basin involves many complex legal and technical issues, as well as a variety of perspectives on these issues. There is also a long history associated with water supply development in the Colorado Basin. It is likely that a substantial study evaluating multiple subordination scenarios will be required before a full assessment of the feasibility of this strategy can be made. Legal opinions regarding the implementation of subordination agreements under Texas water law will be a large part of assessing the feasibility of the strategy.

Before assigning costs for this strategy a definitive assessment of the impacts on senior water right holders and the benefits to junior water rights holders must be determined. This assessment should take into account the existing agreements and the historical development of water supply in the basin. The analysis presented in this plan is not sufficient to make that determination.

Other Water Management Strategies Directly Affected by Subordination

All other strategies for this plan are based on water supplies with the subordination strategy in place. Table 4.3-1 is a partial list of Region F strategies potentially impacted by the subordination strategy. The amount of water needed from most of these strategies may be higher without the subordination strategy. Other strategies may be indirectly impacted. Changes to the assumptions made in the subordination strategy may have a significant impact on the amount of water needed from these strategies.

4.3 Municipal Needs

Implementation of the subordination strategy eliminates many of the needs shown in Tables 4.1-1, 4.1-2 and 4.1-3. However, there are seven municipal water user groups (WUGs) that do not have sufficient supplies even with the subordination strategy, including the cities of Ballinger, Bronte, Midland, Menard, San Angelo and Robert Lee,. Other municipal needs in Concho and McCulloch County are associated with the use of water from the Hickory aquifer, which exceeds drinking water standards for radionuclides in some areas. Several municipal water users are interested in developing additional water supplies or improved infrastructure to improve the overall reliability of their water supply. Section 4.8 discusses needs for Wholesale Water Providers, including the City of San Angelo and CRMWD.

Table 4.3-1
Partial List of Region F Water Management Strategies Potentially Impacted by the Subordination Strategy

Water User Group	County	Category	Description
Bronte	Coke	Other	Rehabilitate Oak Creek pipeline
Robert Lee	Coke	Desalination	Lake Spence RO
Robert Lee	Coke	Other	Expand WTP
Manufacturing	Kimble	New groundwater	Edwards-Trinity
Manufacturing	Kimble	Voluntary redistribution	Purchase or lease water rights
Midland	Midland	New groundwater	T-Bar Well Field
Midland	Midland	Voluntary redistribution	CRMWD
Ballinger	Runnels	Voluntary redistribution	Hords Creek Reservoir
Ballinger	Runnels	Voluntary redistribution	Obtain water from CRMWD system
San Angelo	Tom Green	New groundwater	McCulloch Well Field
San Angelo	Tom Green	Reuse	Municipal reuse
CRMWD	Various	New Groundwater	Winkler well field
CRMWD	Various	Reuse	Big Spring reuse
CRMWD	Various	Reuse	Midland/Odessa reuse
CRMWD	Various	Reuse	Snyder reuse

Over the planning period there may be additional water users that will need to upgrade their water supply systems or develop new supplies, but are not specifically identified in this plan. It is the intent of this plan to include all water systems that may demonstrate a need for water supply. This includes established water providers and new water supply corporations formed by individual users that may need to band together to provide a reliable water supply. In addition, Region F considers water supply projects that do not impact other water users but are needed to meet demands to meet regulatory requirements for consistency with the regional plan even though not specifically recommended in the plan.

4.3.1 City of Andrews

The City of Andrews obtains its water from city well fields in the Ogallala aquifer and purchased groundwater from University Lands. The City's contract with University Lands expires in 2033. It is assumed that the City will renew this contract for supplies through the planning period and this is a recommended strategy for the City of Andrews. Water from both the University Lands and the city well fields may provide sufficient supplies for the City of Andrews, but there are insufficient supplies to meet all needs within Andrews County. As a result there is competition for this water supply among other users. Also, the special study conducted for Region F on potential groundwater sources (Appendix xxx) indicated that the available supply from the Ogallala in southeast Andrews County may be less than estimated in this regional water plan. Only additional field data will be able to better define the available groundwater supplies in Andrews County. In addition to the quantity concerns, the city's supply exceeds drinking water standards for fluoride. The city is interested in desalination as a long-term strategy to improve the reliability and quality of their water supply.

Potentially Feasible Water Management Strategies for the City of Andrews

The following strategies have been identified as potentially feasible for the City of Andrews:

- Renew existing contract with University Lands for water from the Ogallala aquifer in Andrews County
- Develop and desalinate water from the Dockum aquifer in Andrews County
- Implement municipal water conservation

Desalination – Dockum Aquifer

The City of Andrews has identified the Dockum aquifer as a potential long-term source of water for the city. Use of this water would most likely require desalination to meet secondary drinking water standards. The project proposed by the city includes development of new wells into the Dockum located near the city's existing well field in northern Andrews County. This well field is located near an existing oil and gas field. Therefore, co-disposal of brine concentrate could help make this project more cost-effective. The proposed project could be developed in conjunction with the City of Seminole in Gaines County (Region O).

Additional information on the Dockum aquifer may be found in Section 3.1.5.

Quantity, Reliability and Cost of Desalination

For the purposes of this plan it is assumed that a 1 mgd desalination plant delivering up to 950 acre-feet of water per year would be constructed in northern Andrews County near the city's existing well field. Delivery to the city would be through the existing pipeline. Disposal of brine reject would be through co-disposal with oil field brines at a near-by oil field. Because of the uncertainty involved with development of this source for municipal water use, the reliability of this source is considered to be moderate. Table 4.3-2 summarizes the expected costs for the project.

Table 4.3-2
Dockum Brackish Water Desalination Project for the City of Andrews

Supply from Strategy	**950 acre-feet per year**
Total Capital Costs (2008 Prices)	$ 6,717,000
Annual Costs	$ 1,105,000
Unit costs (before amortization)	$ 1,163 per acre-foot
	$ 3.57 per 1,000 gallons
Unit Costs (after amortization)	$ 546 per acre-foot
	$ 1.68 per 1,000 gallons

Environmental Issues Associated with Desalination

There is no surface expression of water from the Dockum aquifer in Andrews County. Therefore, it is unlikely that pumping from the Dockum will result in any alteration of terrestrial habitats. The conceptual design for the project uses existing deep well injection facilities for brine disposal. A properly designed and maintained facility should have minimal environmental impact. Well field development and construction of the treatment facility should have minimal environmental impact.

Agricultural and Rural Issues of Desalination

According to TWDB records, only a very small amount of water from the Dockum aquifer is currently used for mining and livestock in Andrews County. No competition is expected with municipal or irrigated agricultural water users. Therefore, agricultural and rural impacts are expected to be minimal.

Other Natural Resource Issues Associated with Desalination

None identified.

Significant Issues Affecting Feasibility

Additional studies will be required to determine the suitability of this source for municipal water supply.

Other Water Management Strategies Directly Affected by Desalination

None identified.

Water Conservation Savings by the City of Andrews

The City of Andrews provides water to its retail customers and sells water to several industrial and municipal customers. A review of the city's water losses indicate the total loss is about 13 percent, of which most is attributed to paper losses (under recording by meters, unauthorized use, etc.) Based on the city's estimated water use per person, water conservation is a potential strategy for the City of Andrews. Table 4-3.2 compares projected demands for the City of Andrews with no conservation, with the expected conservation due to plumbing code (the default projections used in regional water planning), and using Region F water conservation criteria (see Appendix 4G). Region F recognizes that it has no authority to implement, enforce or regulate water conservation practices. These water conservation practices are intended to be guidelines. Water conservation strategies determined and implemented by the City of Andrews supersede the recommendations in this plan and are considered to meet regulatory requirements for consistency with this plan.

Quantity, Reliability and Cost of Water Conservation

The Region F recommended conservation strategies reduce the demand of the City of Andrews by 509 acre-feet per year by 2060, about 13 percent of the expected demand without conservation. The reliability of this supply is considered to be medium because of the uncertainty involved in the potential for savings and the degree to which public participation is needed to realize savings. Site specific data regarding residential, commercial, industrial and other types of use would give a better estimate of the reliable supply from this strategy. Costs range from $628 per acre foot in 2010 to $185 per acre-foot in 2060.

Environmental Issues Associated with Water Conservation

There are no identified environmental issues associated with this strategy. This strategy may have a positive impact on the environment by reducing the quantity of water needed by the city to meet future demands.

Table 4.3-3

Estimated Water Conservation Savings for the City of Andrews

Per Capita Demand (gpcd)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	266	266	266	266	266	266	266
Plumbing Code	Projections	266	262	259	256	253	252	252
	Savings	0	4	7	10	13	14	14
Region F Estimate	Projections	266	255	244	238	234	231	230
	Savings (Region F practices)	0	11	22	28	32	35	36
	Savings (Total)	0	15	29	38	45	49	50
Water Demand (Ac-Ft/Yr)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	2,876	3,134	3,351	3,502	3,645	3,710	3,784
Plumbing Code	Projections	2,876	3,087	3,263	3,371	3,467	3,515	3,585
	Savings	0	47	88	131	178	195	199
Region F Estimate	Projections	2,876	3,003	3,072	3,131	3,202	3,228	3,275
	Savings (Region F practices)	0	84	191	240	265	287	310
	Savings (Total)	0	131	279	371	443	482	509
Costs								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Annual Costs			$52,743	$59,855	$59,813	$59,494	$57,936	$57,385
Cost per Acre-Foot [b]			$628	$313	$249	$225	$202	$185
Cost per 1,000 Gal [b]			$1.93	$0.96	$0.76	$0.69	$0.62	$0.57

a. Costs and savings based on information from TWDB *Report 362 Water Conservation Task Force Water Conservation Best Management Practices Guide*, November 2004.
b Costs for implementing recommended practices. Plumbing code savings not included in unit cost calculations.

Agricultural and Rural Issues Associated with Water Conservation

Due to the limited availability of water from the Ogallala aquifer in Andrews County, he City of Andrews competes with agriculture for water. Reducing the demand on the limited Ogallala resources in the county could have positive impacts on water availability for agriculture.

Other Natural Resource Issues Associated with Water Conservation

None identified.

Significant Issues Affecting Feasibility of with Water Conservation

This strategy is based on generic procedures and may not accurately reflect the actual costs or water savings that can be achieved by the City of Andrews. Site-specific data will be required for a better assessment of the potential for water conservation by the city. Technical and financial assistance by the state may be required to implement this strategy.

Other Water Management Strategies Directly Affected by Water Conservation

This may reduce the demand for water from other water management strategies.

4.3.2 City of Ballinger

Table 4.3-4 compares the current supply and projected demand for the City of Ballinger. Demands for the city (including municipal sales) are 1,068 acre-feet per year in 2010, increasing to 1,337 acre-feet in 2060. The city's primary sources of water are Lake Ballinger and Lake Moonen. These lakes have been heavily impacted by the recent drought. In 2003 the city completed a connection to the City of Abilene's pipeline from Ivie Reservoir and has a contract for emergency supplies from that source. This contract expired in 2008 and was not renewed. The City of Ballinger has since entered into a subcontract agreement with Millersview-Doole Water Supply Corporation (MDWSC) for water from CRMWD. This contract expires when the MDWSC contract expires in 2041. The city has also drilled several wells into a local unclassified aquifer, but has not been able to obtain a significant quantity of water from this source.

TWDB requires use of the TCEQ water availability models (WAM) to determine supplies in regional water planning[3]. Because these models are based on a perfect application of the prior appropriation system, the Colorado WAM shows essentially no yield for Lake Ballinger and Lake Moonen[4]. The reduced supplies are presented in Table 4.3-3. With implementation of a subordination strategy the current safe yield of Lakes Ballinger and Moonen is estimated to be

950 acre-feet per year. By 2060, the yield of the reservoir would decline to 890 acre-feet per year due to sedimentation. (Supplies from the subordination strategy are discussed in Section 4.2.3.) Current supplies from the CRMWD system are estimated between 244 and 373 acre-feet per year. Using the subordination strategy supplies, needs for the City of Ballinger are 439 acre-feet per year in 2060, or about 33 percent of total demand.

Potentially Feasible Water Management Strategies for the City of Ballinger

The following strategies have been identified as potentially feasible for the City of Ballinger:

- Subordination of downstream senior water rights
- Voluntary redistribution from Hords Creek Reservoir
- Voluntary redistribution from the CRMWD system (Spence and Ivie Reservoirs)
- Reuse
- Water Conservation

Table 4.3-4
Comparison of Supply and Demand for the City of Ballinger
(Values in Acre-Feet per Year)

Supply	2010	2020	2030	2040	2050	2060	Comments
Lake Ballinger/Moonen	0	0	0	0	0	0	WAM yield *
Ivie Reservoir	257	244	373	357	0	0	New contract through Millerview-Doole
Other aquifer	0	0	0	0	0	0	Assuming no reliable supply
Total	*257*	*244*	*373*	*357*	*0*	*0*	
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**Comments**
City of Ballinger	917	998	1,057	1,121	1,178	1,237	
Municipal sales	216	177	148	116	94	77	Rowena & N. Runnels WSC
Industrial Sales	9	10	11	12	13	15	
Total	*1,142*	*1,185*	*1,216*	*1,249*	*1,285*	*1,329*	
Subordination–Ballinger/Moonen	*940*	*930*	*920*	*910*	*900*	*890*	
Subordination - CRMWD system	*343*	*356*	*227*	*243*	*0*	*0*	
Surplus (Need)	*398*	*345*	*304*	*261*	*(385)*	*(439)*	

* Supplies from the Colorado WAM. With implementation of a subordination strategy, the 2010 supply from Lake Ballinger is estimated to be 940 acre-feet per year in 2010, declining to 890 acre-feet per year in 2060.

Although several strategies are technically feasible, the small quantity of water used by the city, the distance to other water sources, and the limited economic resources available to the community limit the number of strategies that can be implemented by the city.

Subordination of Downstream Senior Water Rights for the City of Ballinger

As previously discussed, TWDB requires the use of the TCEQ WAM for regional water planning. In the Colorado WAM, any water right in Region F with a priority date after 1926 has no firm supply. The priority dates for Lake Ballinger and Moonen are December 4, 1946 and April 7, 1980, so according to the WAM this reservoir has no reliable yield. The subordination strategy evaluates water supplies assuming the lower basin senior water rights do not make priority calls on major upstream water rights. This strategy also assumes that major water rights holders in Region F do not make priority calls on each other. The subordination strategy is discussed in detail in Section 4.2.3. Table 4.3-5 is a summary of the supply made available from Lakes Ballinger and Moonen from the subordination strategy.

Table 4.3-5
Impact of Subordination Strategy on Lakes Ballinger and Moonen [a]
(Values in acre-feet per year)

Reservoir	Priority Date	Permitted Diversion	2010 Supply WAM Run 3	2010 Supply with Subord-ination	2060 Supply WAM Run 3	2060 Supply with Subord-ination
Lake Ballinger/Moonen	10/04/1946 4/7/1980	1,000	0	940	0	890

a Water supply is defined as the safe yield of the reservoir. Safe yield reserves one year of supply in the reservoir.

In addition, the water supply from the CRMWD system that the city of Ballinger has contracted through Millersview-Doole is assumed to be made whole through the subordination strategy (600 acre-feet per year).

The modeling for the subordination strategy was developed for planning purposes only. By adopting this strategy, neither Region F nor the Lower Colorado Region stipulates that water rights holders will not make priority calls on junior water rights. A subordination agreement is not within the authority of the Region F Water Planning Group. Such an agreement must be developed by the water rights holders themselves, including the City of Ballinger and any other surface water sources considered by the city. Impacts of the subordination strategy are discussed in Section 4.2.3.

Voluntary Redistribution – Hords Creek Reservoir to Ballinger

The City of Coleman holds the water right for Hords Creek Reservoir, an 8,000 acre-foot reservoir in Coleman County. The reservoir is owned and operated by the Corps of Engineers. The City of Coleman has Certificate of Adjudication 14-1705A, authorizing storage of 7,959 acre-feet of water and diversion of 2,240 acre-feet of water per year for municipal and domestic purposes. The priority date of this right is March 23, 1946.

The City of Ballinger has discussed purchasing water from the City of Coleman and has completed a preliminary engineering feasibility report for this strategy. The proposed transmission line from Hords Creek would consist of 12 miles of 10-inch and 12-inch HDPE raw water transmission line, a pump station and a ground storage tank. The transmission line would tie into the City of Ballinger's existing 10-inch raw water line from the City of Abilene's Ivie pipeline to the city's treatment plant. The system is designed to deliver up to 800 acre-feet per year.[5] If implemented, the timing of this strategy would likely occur after the contract with MDWSC expires.

Quantity, Reliability and Cost for the Hords Creek Strategy

According to the Pecan Bayou study, Hords Creek Reservoir would have a safe yield of 650 acre-feet per year. Historical use from the reservoir averaged 750 acre-feet per year between 1956 and 1975, with significant reductions in diversions from the City of Coleman since 1975 (see Figure 4.3-1). During the last significant drought from 1997 through 2004, the City of Coleman diverted an average of 221 acre-feet per year. In 2003 water levels in the lake declined to a little more than one foot above the city's inlet structure at elevation 1878 feet msl. This indicates that the long-term reliable yield of Hords Creek Reservoir may be less than the 650 acre-feet per year estimated with the WAM.

Figure 4.3-1

Figure 4.3-1
Historical Water Use from Hords Creek Reservoir

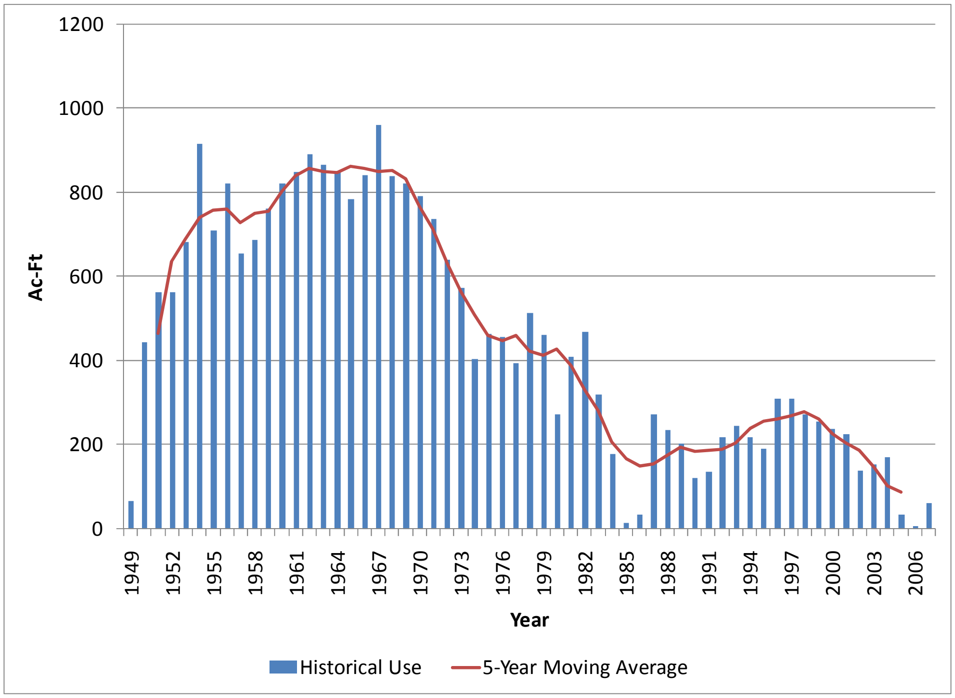
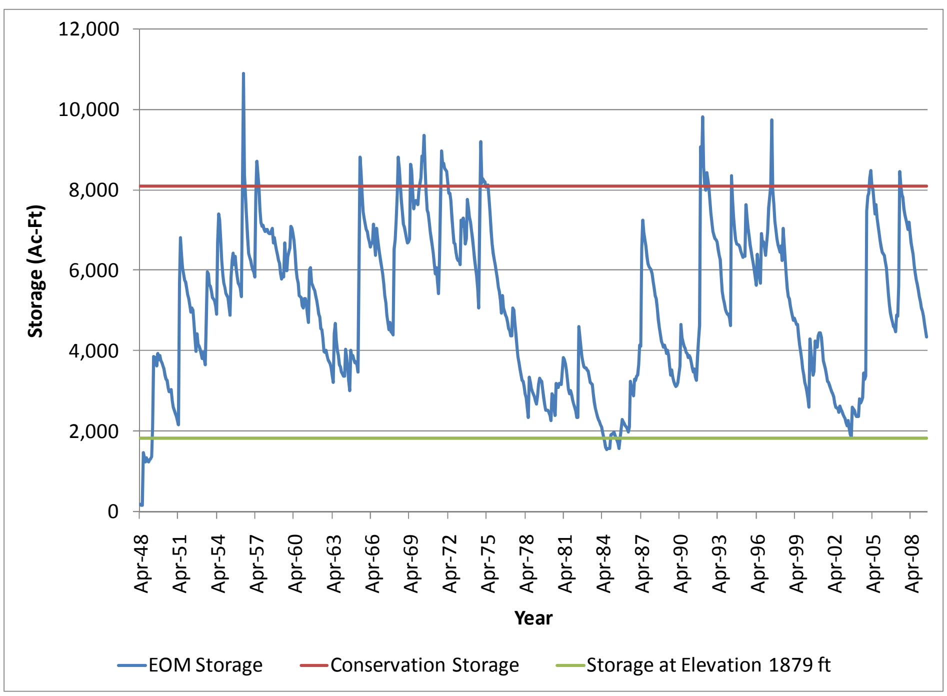


Figure 4.3-2
Historical Storage in Hords Creek Reservoir



Another factor impacting the reliability of Hords Creek Reservoir is the potential for a call by downstream water rights. According to the Colorado WAM, if the Colorado Basin is operated on a strict priority basis, Hords Creek Reservoir has no yield. Lake Brownwood, the first major reservoir downstream of Hords Creek, has a priority date of 1925. Other downstream senior water rights can make a priority call as well. Priority calls could significantly impact the yield of Hords Creek Reservoir.

The uncertainty regarding the reliable supply from the reservoir indicates that the reliability of this source may be low.

Total costs for this project may be found in Table 4.3-6. Detailed cost estimates may be found in Appendix 4D.

Table 4.3-6
Costs for Hords Creek Reservoir to Ballinger Pipeline

Supply from Strategy	220 acre-feet per year
Total Capital Costs (2008 Prices)	$ 8,445,000
Annual Costs	$ 898,500
Unit Costs (before amortization)	$ 4,084 per acre-foot
	$ 12.53 per 1,000 gallons
Unit Costs (after amortization)	$ 739 per acre-foot
	$ 2.27 per 1,000 gallons

Environmental Issues Associated with the Hords Creek Strategy

The proposed route is almost entirely along existing right-of-way, so the environmental impacts should be minimal. It can be assumed that the pipeline could be routed around sensitive environmental areas if needed.

Agricultural and Rural Issues Associated with the Hords Creek Strategy

The City of Ballinger supplies a large portion of the drinking water for rural Runnels County. Since the proposed project will make the city's water supply more reliable, it should have a positive impact on rural and agricultural interests in the area. Hords Creek Reservoir is used exclusively for drinking water, so the project will not be in conflict with existing agricultural water needs.

The City of Ballinger is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources and the surrounding rural area, potentially negating the positive impacts of a more reliable water supply.

Other Natural Resource Issues Associated with the Hords Creek Strategy

None identified.

Significant Issues Affecting Feasibility of the Hords Creek Strategy

There are several significant factors that impact the feasibility of this strategy:

- A subordination or some other form of agreement from downstream senior water rights holders may be necessary to ensure a reliable supply from this source.
- A contract must be negotiated with the City of Coleman to use the water.
- A new intake structure may be required if the City of Ballinger desires to withdraw more than 200 acre-feet per year during a drought period.
- An agreement may be necessary with the Corps of Engineers, particularly if the City of Ballinger desires to access storage below the existing City of Coleman intake structure.

Other Water Management Strategies Directly Affected by the Hords Creek Strategy

Other Ballinger strategies; City of Winters strategies.

Voluntary Redistribution – Purchase Water from CRMWD System

In 2003, the City of Ballinger completed a 10-mile pipeline to the Abilene pipeline from Ivie Reservoir to the City of Abilene. Ballinger and Abilene executed an emergency supply agreement to obtain water from this source when Lake Ballinger reaches approximately 13.7 percent of capacity. The contract expired in 2008 and was not renewed. Instead the City of Ballinger has subcontracted with Millersview-Doole Water Supply Corporation (MDWSC) for 600 acre-feet per year of water of the MDWSC contract with CRMWD for water from Lake Ivie. The MDWSC contract is for 1,100 acre-feet per year from the CRMWD system and expires in 2041. After the MDWSC contract expires, it is assumed that the city will contract directly with CRMWD for enough water to prevent shortages.

Quantity, Reliability and Cost of Water from the CRMWD System

For the purposes of this plan, it was assumed that the city would directly contract with CRMWD upon expiration of the contract with MDWSC for 600 acre-feet per year. Actual amounts will depend upon the city's projected needs and negotiations with CRMWD. The reliability of the water is considered to be high because sufficient reliable supplies are available from the Ivie Reservoir.

The cost of water is estimated to be $2.02 per 1,000 gallons, or $658 per acre-foot. The cost includes $1.47 per 1,000 gallons from the CRMWD system plus $0.55 per 1,000 gallons to cover the cost of pumping using the WCTMWD and City of Abilene pipelines. Actual costs would be negotiated between the contracting parties.

Environmental Issues Associated with Water from the CRMWD System

This strategy calls for water from an existing source using existing infrastructure which results in minimal impacts.

Agricultural and Rural Issues Associated with Water from the CRMWD System

The City of Ballinger supplies a large portion of the drinking water for rural Runnels County. Since this strategy will make the city's water supply more reliable, it should have a positive impact on rural and agricultural interests in the area.

Other Natural Resource Issues Associated with Water from the CRMWD System

None identified.

Significant Issues Affecting Feasibility of Water from the CRMWD System

This strategy depends on the success of the city negotiating agreements with CRMWD, WCTMWD and the City of Abilene. Actual quantities and costs will be determined through these negotiations.

This strategy relies on the WCTMWD pipeline from Ivie Reservoir to the City of Abilene to deliver water to Ballinger's tie-in to the water line. Therefore, obtaining water from this source may depend on whether the City of Abilene is currently using the pipeline for its own needs.

Other Water Management Strategies Directly Affected by Water from the CRMWD System

Other strategies for the City of Ballinger.

Reuse

Reuse has been identified as a feasible strategy for the City of Ballinger. The city currently holds a wastewater discharge permit for 0.48 MGD. This evaluation is based on a generalized direct reuse strategy developed for the Region F plan. This strategy assumes that a portion of the wastewater stream will be sent through membrane filtration and reverse osmosis (RO). The treated water will then be blended with raw water prior to treatment at the city's existing water treatment plant. It is assumed that the waste stream from the reuse facility will be permitted for discharge into a local stream. If this strategy is pursued, additional site-specific studies will be required to determine actual quantities of water available, costs and potential impacts.

Quantity, Reliability and Cost of Reuse

For the City of Ballinger, it is estimated that reuse could provide as much as 200,000 gallons per day of additional supply, or 220 acre-feet per year. This supply would be very reliable. Table 4.3-7 summarizes the costs for this strategy.

Table 4.3-7
Costs of Direct Reuse of Treated Effluent by the City of Ballinger

Supply from Strategy	220 acre-feet per year
Total Capital Costs (2008 Prices)	$ 2,567,000
Annual Costs	$ 324,000
Unit Costs (before amortization)	$ 1,473 per acre-foot
	$ 4.52 per 1,000 gallons
Unit Costs (after amortization)	$ 455 per acre-foot
	$ 1.39 per 1,000 gallons

Environmental Issues Associated with Reuse

The City of Ballinger currently discharges its wastewater, and it is assumed that the waste stream from the treatment facility will be combined with unused treated effluent and discharged in a similar manner. The potential impacts of this discharge on the receiving stream will need to be evaluated prior to implementation of this strategy. If the impacts are unacceptable, an alternative method of disposal may be required. Alternative disposal methods may significantly increase the cost of the project.

Reuse would result in a reduction in the quantity of water discharged by the city. An analysis of the impacts on the receiving stream will be required in the permitting process. However, because of the relatively small amount of flow reduction associated with this reuse project, the impact is not expected to be significant.

Agricultural and Rural Issues Associated with Reuse

The City of Ballinger supplies a large portion of the drinking water for rural Runnels County. Since the proposed project will make the city's water supply more reliable, it should have a positive impact on rural and agricultural interests in the area.

The City of Ballinger is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources and the surrounding rural area, potentially negating the positive impacts of a more reliable water supply.

Other Natural Resource Issues Associated with Reuse

None identified.

Significant Issues Affecting Feasibility of Reuse

Although direct reuse for potable consumption is technically feasible, at this time there are no operating facilities within the State of Texas. Adequate monitoring and oversight will be required to protect public health and safety. There may be public resistance to direct reuse of water.

The infrastructure associated with reuse requires on-going use of water from this source to make the project cost-effective. Reuse water should not be used on an as-needed basis.

The reuse strategy assumes that both the subordination and voluntary redistribution strategies have been implemented.

Other Water Management Strategies Directly Affected by Reuse

Other strategies for the City of Ballinger.

Water Conservation Savings by the City of Ballinger

Recent drought has severely impacted the City of Ballinger. As a result, the city has actively promoted water conservation and drought management. Table 4.3-8 compares projected demands for the City of Ballinger with no conservation, with the expected conservation due to plumbing code (the default projections used in regional water planning), and using Region F water conservation criteria (see Appendix 4G). Region F recognizes that it has no authority to implement, enforce or regulate water conservation practices. These water conservation practices are intended to be guidelines. Water conservation strategies determined and implemented by the

City of Ballinger supersede the recommendations in this plan and are considered to meet regulatory requirements for consistency with this plan.

Table 4.3-8
Estimated Water Conservation Saving for the City of Ballinger [a]

Per Capita Demand (gpcd)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	190	190	190	190	190	190	190
Plumbing Code	Projections	190	187	183	180	177	176	176
	Savings	0	3	7	10	13	14	14
Region F Estimate	Projections	190	180	167	162	158	156	155
	Savings (Region F practices)	0	7	16	18	19	20	21
	Savings (Total)	0	10	23	28	32	34	35
Water Demand (Ac-Ft/Yr)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	903	932	1,037	1,116	1,203	1,271	1,335
Plumbing Code	Projections	903	917	998	1,057	1,121	1,178	1,237
	Savings	0	15	39	59	82	93	98
Region F Estimate	Projections	903	884	910	950	1,002	1,047	1,093
	Savings (Region F practices)	0	33	88	107	119	131	144
	Savings (Total)	0	48	127	166	201	224	242
Costs								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Annual Costs			$21,067	$26,930	$27,563	$28,229	$28,386	$28,819
Cost per Acre-Foot [b]			$638	$306	$258	$237	$217	$200
Cost per 1,000 Gal [b]			$1.96	$0.94	$0.79	$0.73	$0.66	$0.61

a Costs and savings based on information from TWDB *Report 362 Water Conservation Task Force Water Conservation Best Management Practices Guide*, November 2004.
b Costs for implementing recommended practices. Plumbing code savings not included in unit cost calculations.

Quantity, Reliability and Cost of Water Conservation

The Region F recommended conservation strategies reduce the demand of the City of Ballinger by 242 acre-feet per year by 2060, about 18 percent of the expected demand without conservation. Actual experience during the recent drought indicates that the potential to save water may be even greater. The reliability of this supply is considered to be medium because of the uncertainty involved in the potential for savings and the degree to which public participation is needed to realize savings. Site specific data regarding residential, commercial, industrial and other types of use would give a better estimate of the reliable supply from this strategy. Costs range from $638 per acre foot in 2010 to $200 per acre-foot in 2060.

Environmental Issues Associated with Water Conservation

There are no identified environmental issues associated with this strategy. This strategy may have a positive impact on the environment by reducing the quantity of water needed by the city to meet future demands.

Agricultural and Rural Issues Associated with Water Conservation

The City of Ballinger is not in direct competition with agriculture for water, so there are no identified agricultural issues associated with this strategy.

The City of Ballinger is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources and the surrounding rural area. However, other less costly conservation strategies may be identified by the city that achieve similar results.

Other Natural Resource Issues Associated with Water Conservation

None identified.

Significant Issues Affecting Feasibility of with Water Conservation

This strategy is based on generic procedures and may not accurately reflect the actual costs or water savings that can be achieved by the City of Ballinger. Site-specific data will be required for a better assessment of the potential for water conservation by the city. Technical and financial assistance by the state may be required to implement this strategy.

The water conservation strategy assumes that both the subordination and voluntary redistribution strategies have been implemented.

Other Water Management Strategies Directly Affected by Water Conservation

Other Ballinger strategies may be impacted.

Drought Management

Region F has not identified drought strategies for the City of Ballinger other than those included in the city's water conservation and drought management plans.

Recommended Water Management Strategies for the City of Ballinger

The recommended strategies for the City of Ballinger are:

- Subordination of downstream water rights,
- Voluntary redistribution of water from Ivie Reservoir, and
- Water conservation.

Alternate strategies for the City of Ballinger include reuse and water form Hord's Creek Reservoir.

Table 4.3-9 compares expected demands for the City of Ballinger and its customers to water supplies with the strategies in place. Table 4.3-10 summarizes the annual costs of the recommended strategies.

Table 4.3-9
Recommended Water Management Strategies for the City of Ballinger
(Values in Acre-Feet per Year)

Supplies	2010	2020	2030	2040	2050	2060
Lake Ballinger	0	0	0	0	0	0
CRMWD System	257	244	373	357	0	0
Subordination of downstream water rights to Lake Ballinger	940	930	920	910	900	890
Subordination of downstream rights to CRMWD System	343	356	227	243	0	0
Voluntary redistribution - new contract for water from O.H. Ivie	0	0	0	0	600	600
Total	*1,540*	*1,530*	*1,520*	*1,510*	*1,500*	*1,490*
Conservation	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Potential savings*	33	88	107	119	131	144
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Ballinger	917	998	1,057	1,121	1,178	1,237
Municipal sales	216	177	148	116	94	77
Industrial Sales	9	10	11	12	13	15
Total	*1,142*	*1,185*	*1,216*	*1,249*	*1,285*	*1,329*
Surplus (Need) without conservation	*398*	*345*	*304*	*261*	*215*	*161*
Surplus (Need) with conservation	*431*	*433*	*411*	*380*	*346*	*305*

* Does not include plumbing code savings, which are already included in the water demand projections.

Table 4.3-10
Costs of Recommended Water Management Strategies for the City of Ballinger

Strategy	Capital Costs	Annual Costs					
		2010	2020	2030	2040	2050	2060
Voluntary redistribution – new contract for water from Ivie Reservoir	$0	$0	$0	$0	$0	$394,800	$394,800
Water Conservation	$0	$21,067	$26,930	$27,563	$28,229	$28,386	$28,819
Total	*$0*	*$21,067*	*$26,930*	*$27,563*	*$28,229*	*$423,186*	*$423,619*

4.3.3 City of Winters

Table 4.3-11 compares the supply and demand for the City of Winters. The maximum expected demand for the city (including outside sales) is 720 acre-feet per year in 2010. Although demand for the city is expected to grow over time, outside sales are expected to diminish as rural residents are annexed into the city, sales to Runnels County WSC are shifted to the City of Ballinger, and water conservation reduces per capita demand. The city's primary source of water is Lake Winters. Lake Winters has been heavily impacted by the recent drought. Without subordination to downstream water rights, the Colorado WAM shows no yield for the reservoir.

Table 4.3-11
Comparison of Supply and Demand for the City of Winters
(Values in Acre-Feet per Year)

Supply	2010	2020	2030	2040	2050	2060	Comments
Lake Winters	0	0	0	0	0	0	WAM yield *
Total	*0*	*0*	*0*	*0*	*0*	*0*	
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**Comments**
City of Winters	552	561	566	571	575	591	
Municipal sales	114	89	69	49	31	0	N. Runnels WSC, etc.
Industrial Sales	54	60	65	70	74	79	
Total	*720*	*710*	*700*	*690*	*680*	*670*	
Surplus (Need)	(720)	(710)	(700)	(690)	(680)	(670)	

* Supplies from the Colorado WAM. With implementation of a subordination strategy, the supply from Lake Winters is estimated to be 720 acre-feet per year in 2010, declining to 670 acre-feet per year in 2060.

Potentially Feasible Water Management Strategies for the City of Winters

The following strategies have been identified as potentially feasible for the City of Winters:

- Subordination of downstream senior water rights
- Reuse
- Water conservation
- Drought management

Although several strategies are technically feasible, the small quantity of water used by the city, the distance to other water sources, and the limited economic resources available to the community limit the number of strategies that can be implemented by the city.

Subordination of Downstream Senior Water Rights

TWDB requires the use of the TCEQ WAM for regional water planning. In the Colorado WAM, most reservoirs in Region F with a priority date after 1926 do not have a firm or safe yield. The priority date of Lake Winters is December 18, 1944, so the WAM shows no yield for the reservoir. This result is largely due to the assumptions used in the Colorado WAM.

In order to address water availability issues resulting from the Colorado WAM model, Region F and the Lower Colorado Region (Region K) participated in a joint modeling effort to evaluate a strategy in which lower basin senior water rights do not make priority calls on major upstream water rights. This strategy also assumes that major water rights in Region F do not make priority calls on each other. The subordination strategy is discussed in Section 4.2.3. Table 4.3-13 is a summary of the impacts of the subordination strategy on Lake Winters.

The joint modeling between the two regions was conducted for planning purposes only. Neither Region F nor the Lower Colorado Region mandates the adoption of this strategy by individual water right holders. A subordination agreement is not within the authority of the Region F Water Planning Group. Such an agreement must be developed by the water rights holders themselves, including the City of Winters.

Table 4.3-12
Impact of Subordination Strategy on Lake Winters [a]
(Values in acre-feet per year)

Reservoir	Priority Date	Permitted Diversion	2010 Supply WAM Run 3	2010 Supply with Subord-ination	2060 Supply WAM Run 3	2060 Supply with Subord-ination
Lake Winters	12/18/1944	1,360	0	720	0	670

a Water supply is defined as the safe yield of the reservoir. Safe yield reserves one year of supply in the reservoir.

Impacts of the subordination strategy are discussed in Section 4.2.3.

Reuse

Reuse has been identified as a feasible strategy for the City of Winters. The city currently holds a wastewater discharge permit for 0.49 MGD. Treated effluent is also authorized for irrigation. This evaluation is based on a generalized direct reuse strategy developed for the Region F plan. This strategy assumes that a portion of the wastewater stream will be sent through membrane filtration and reverse osmosis (RO). The treated water will then be blended with raw water prior to treatment at the city's existing water treatment plant. It is assumed that the waste stream from the reuse facility will be combined with the remaining treated effluent and discharge into a local stream or disposed of using land application. If this strategy is pursued, additional site-specific studies will be required to determine actual quantities of water available, costs and potential impacts.

Quantity, Reliability and Cost of Reuse by the City of Winters

For the City of Winters, it is estimated that reuse could provide as much as 100,000 gallons per day of additional supply, or 110 acre-feet per year. This supply would be very reliable. Table 4.3-13 summarizes the costs for this strategy.

Table 4.3-13
Direct Reuse of Treated Effluent by the City of Winters

Supply from Strategy	**110 acre-feet per year**
Total Capital Costs (2008 Prices)	$ 2,158,000
Annual Costs	$ 258,000
Unit Costs (before amortization)	$ 2,345 per acre-foot
	$ 7.20 per 1,000 gallons
Unit Costs (after amortization)	$ 636 per acre-foot
	$ 1.95 per 1,000 gallons

Environmental Issues Associated with Reuse by the City of Winters

The City of Winters currently discharges to a receiving stream and irrigates with its treated wastewater. This strategy assumes that reject from advanced treatment will be blended with the treated effluent that is not reused and disposed of in a similar manner. The potential impacts of this discharge on the receiving stream will need to be evaluated prior to implementation of this strategy. If the impacts are unacceptable, an alternative method of disposal may be required. Alternative disposal methods may significantly increase the cost of the project.

Agricultural and Rural Issues Associated with Reuse by the City of Winters

Reuse may make less water available for irrigation by diverting part of the treated effluent currently use for irrigation.

The City of Winters supplies a large portion of the drinking water for rural Runnels County. Since the proposed project will make the city's water supply more reliable, it should have a positive impact on rural and agricultural interests in the area

The City of Winters is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources and the surrounding rural area, potentially offsetting the positive impacts of a more reliable water supply.

Other Natural Resource Issues Associated with Reuse by the City of Winters

None identified.

Significant Issues Affecting Feasibility of Reuse by the City of Winters

Although direct reuse for potable consumption is technically feasible, at this time there are no operating facilities within the State of Texas. Adequate monitoring and oversight will be required to protect public health and safety. There may be public resistance to direct reuse of water.

The infrastructure associated with reuse requires on-going use of water from this source to make the project cost-effective. Reuse water should not be used on an as-needed basis.

Other Water Management Strategies Directly Affected by Reuse

Other strategies for the City of Winters may be impacted.

Water Conservation

Using the Region F suite of water conservation practices, it is estimated that the City of Winters can reduce water demand by as much as 20 percent. Additional information on Region F recommended water conservation practices may be found in Appendix 4G.

Region F recognizes that it has no authority to implement, enforce or regulate water conservation practices. The water conservation practices in this plan are guidelines. Region F considers water conservation strategies determined and implemented by the City of Winters to supersede the recommendations in this plan and meet regulatory requirements for consistency with this plan.

Quantity, Reliability and Cost of Water Conservation

Table 4.3-14 summarizes the estimated water savings and costs associated with the recommended Region F water conservation practices. Based on this evaluation, by 2060 up to 129 acre-feet of water per year could be saved, a reduction of almost 20 percent. The city's experience during the recent drought indicates that more water could potentially be saved. In 2006, the most recent year for which per capita water use data are available, the city had a per capita demand of 147 gpcd. The estimated per capita water demand in 2060 using the Region F criteria is 136 gpcd. The reliability of water conservation is considered to be medium due to the uncertainty of the long-term savings due to implementation of water conservation strategies.

Table 4.3-14
Estimated Water Conservation Savings for the City of Winters [a]

Per Capita Demand (gpcd)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	102	170	170	170	170	170	170
Plumbing Code	Projections	102	167	164	161	158	156	156
	Savings	0	3	6	9	12	14	14
Region F Estimate	Projections	170 [b]	161	148	143	139	137	136
	Savings (Region F Practices)	0	6	16	18	19	19	20
	Savings (Total)	0	9	22	27	31	33	34
Water Demand (Ac-Ft/Yr)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	548	562	582	597	614	627	644
Plumbing Code	Projections	548	552	561	566	571	575	591
	Savings	0	10	21	31	43	52	53
Region F Estimate	Projections	548	531	506	503	504	504	515
	Savings (Region F Practices)	0	21	55	63	67	71	76
	Savings (Total)	0	31	76	94	110	123	129
Costs [c]								
Annual Costs			$14,796	$19,808	$19,527	$19,265	$18,900	$18,843
Cost per Acre-Foot			$705	$360	$310	$288	$266	$248
Cost per 1,000 Gal			$2.16	$1.11	$0.95	$0.88	$0.82	$0.76

a Costs and water saving are based on data from TWDB *Report 362 Water Conservation Task Force Water Conservation Best Management Practices Guide*, November 2004.
b The City of Winters was under water use restriction in 2000. Base year 2000 demands were extrapolated from historical water use from 1995 to 1997.
c Costs for implementing Region F recommended practices. Costs of implementing plumbing code not included.

Environmental Issues Associated with Water Conservation

Most of the water used by the City of Winters is expected to come from Lake Winters. Conserved water will remain in the reservoir, so there will be little if any impact on instream flows and over-banking flows.

Agricultural and Rural Issues Associated with Water Conservation

Water conservation by the City of Winters will not make more water available for agriculture.

The City of Winters is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources and the surrounding rural area, potentially offsetting the positive impacts of water conservation.

Other Natural Resource Issues Associated with Water Conservation

None identified.

Significant Issues Affecting Feasibility of Water Conservation

This strategy is based on a generalized assessment of water conservation practices and may not accurately reflect the actual costs or water savings that can be achieved by the City of Winters. Site-specific data will be required for a better assessment of the potential for water conservation by the city. Technical assistance and funding by the state may be required to implement this strategy.

Other Water Management Strategies Directly Affected by Water Conservation

None identified.

Drought Management

The City of Winters has effectively used drought management to control demand during times of drought. Strategies are specified in the city's water conservation and drought contingency plan. Region F has not identified additional drought management strategies for the City of Winters.

Recommended Strategies for the City of Winters

Although subordination of downstream water rights will make sufficient supplies available to meet projected needs, the City of Winters may want to consider another strategy to increase the reliability of their water supply. While several strategies are feasible, all of the alternatives are costly and would strain the financial resources of the community. Region F recommends that the city consider reuse and water conservation as long-term alternatives to increase the reliability of the city's water supply. Table 4.3-15 is a comparison of supply to demand with the recommended strategies in place. Table 4.3-16 summarizes the expected costs for these strategies.

Table 4.3-15
Recommended Water Management Strategies for the City of Winters
(Values in Acre-Feet per Year)

Supplies	2010	2020	2030	2040	2050	2060
Lake Winters	0	0	0	0	0	0
Subordination of downstream water rights to Lake Winters	720	710	700	690	680	670
Direct Reuse	0	0	0	110	110	110
Total	720	710	700	800	790	780
Conservation	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Potential savings*	21	55	63	67	71	76
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Winters	552	561	566	571	575	591
Municipal sales	114	89	69	49	31	0
Industrial Sales	54	60	65	70	74	79
Total	720	710	700	690	680	670
Surplus (Need) without conservation	0	0	0	110	110	110
Surplus (Need) with conservation	21	55	63	177	181	186

* Does not include plumbing code savings, which are already included in the water demand projections.

Table 4.3-16
Costs of Recommended Water Management Strategies for the City of Winters

Strategy	Capital Costs	Annual Costs					
		2010	2020	2030	2040	2050	2060
Direct Reuse	$2,158,000	$0	$0	$0	$258,000	$258,000	$258,000
Water Conservation		$14,796	$19,808	$19,527	$19,265	$18,900	$18,843
Total	$2,158,000	$14,796	$19,808	$19,527	$277,265	$276,900	$276,843

4.3.4 City of Bronte

Table 4.3-17 compares the supply and demand for the City of Bronte. The city of Bronte is expected to have a maximum projected demand of about 274 acre-feet per year (in-city use plus municipal sales). The population of the city is expected to remain relatively stable over the next 50 years. Water demand projections decline over time due to conservation.

In the past the city relied exclusively on water from Oak Creek Reservoir, which was heavily impacted by the recent drought. As a result, the city developed a groundwater supply from ten wells in the vicinity of Oak Creek Reservoir. The groundwater is delivered to the city in the Oak Creek pipeline. The groundwater supply is from an unclassified aquifer and the reliability of the source is not well known. Collectively, the well field has a capacity of about 0.7 million gallons per day (MGD). For the purposes of this plan, it was assumed that this aquifer could produce up to 250 acre-feet per year in 2010 with 5 percent reductions each following decade.

Table 4.3-17
Comparison of Supply and Demand for the City of Bronte
(Values in Acre-Feet per Year)

Supply	2010	2020	2030	2040	2050	2060	Comments
Oak Creek Reservoir	0	0	0	0	0	0	WAM shows no yield
Other aquifer	250	238	226	215	204	194	
Total	*250*	*238*	*226*	*215*	*204*	*194*	
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**Comments**
City of Bronte	245	258	254	250	249	249	No outside sales
Total	*245*	*258*	*254*	*250*	*249*	*249*	
Surplus (Need)	*5*	*(20)*	*(28)*	*(35)*	*(45)*	*(55)*	

Without subordination to downstream water rights, Oak Creek Reservoir has no yield. Groundwater wells are sufficient for the near-term, but the long-term reliability of this source is unknown. While the city is currently using the infrastructure from Oak Creek Reservoir to move groundwater, the pipeline needs rehabilitation to more efficiently transport the water and reduce losses.

Potentially Feasible Water Management Strategies

The following potentially feasible strategies have been identified for the City of Bronte:

- Subordination of downstream water rights
- Reuse

- Rehabilitation of Oak Creek pipeline
- Water Conservation
- Drought Management

Brush control and precipitation enhancement are discussed in Section 4.9.

Although several strategies are technically feasible, the small quantity of water used by the city, the distance to other water sources, and the limited economic resources available to the community limit the strategies that can be implemented by the city.

Subordination of Downstream Senior Water Rights

TWDB requires the use of the TCEQ WAM for regional water planning. In the Colorado WAM, any water right in Region F with a priority date after 1926 has no firm supply. The priority date for Oak Creek Reservoir is April 27, 1949, so according to the WAM Oak Creek Reservoir has no yield. In order to address water availability issues in the Colorado Basin, Region F and the Lower Colorado Region (Region K) participated in a joint modeling effort to evaluate a strategy in which lower basin senior water rights do not make priority calls on major upstream water rights. This strategy also assumes that major water rights holders in Region F do not make priority calls on each other. The subordination strategy is discussed in detail in Section 4.2.2.

The joint modeling between the two regions was conducted for planning purposes only. By adopting this strategy, neither Region F nor the Lower Colorado Region stipulates that water rights will not make priority calls on junior water rights. A subordination agreement is not within the authority of the Region F Water Planning Group. Such an agreement must be developed by the water rights holders themselves. Oak Creek Reservoir is owned by the City of Sweetwater. For the purposes of this plan, it will be assumed that, with subordination, the City of Bronte will be able to obtain 129 acre-feet per year during drought from the reservoir.

Impacts of the subordination strategy are discussed in Section 4.2.3.

Reuse

Reuse has been identified as a feasible strategy for the City of Bronte. The city currently uses land application for disposal of treated effluent. This evaluation is based on a generalized direct reuse strategy developed for the Region F plan. This strategy assumes that a portion of the wastewater stream will be sent through membrane filtration and reverse osmosis (RO). The treated water will then be blended with raw water prior to treatment at the city's existing water treatment plant. It is assumed that the waste stream from the reuse facility will be combined with unused treated effluent and discharged into a local stream or use existing land application facilities. If this strategy is pursued, additional site-specific studies will be required to determine actual quantities of water available, costs and potential impacts.

Quantity, Reliability and Cost of Reuse

For the City of Bronte, it is estimated that reuse could provide as much as 100,000 gallons per day of additional supply, or 110 acre-feet per year. This supply would be very reliable. Table 4.3-18 summarizes the costs for this strategy.

Table 4.3-18
Direct Reuse of Treated Effluent by the City of Bronte

Supply from Strategy	110 acre-feet per year
Total Capital Costs (2008 Prices)	$ 2,158,000
Annual Costs	$ 258,000
Unit Costs (before amortization)	$ 2,345 per acre-foot
	$ 7.20 per 1,000 gallons
Unit Costs (after amortization)	$ 636 per acre-foot
	$ 1.95 per 1,000 gallons

Environmental Issues Associated with Reuse

The City of Bronte currently uses land application to dispose of treated effluent. This strategy assumes that the waste stream from the treatment facility will be blended with unused treated effluent and disposed of in a similar fashion. The potential impacts of land application may need to be evaluated prior to implementation of this strategy. If the impacts are unacceptable, an alternative method of disposal may be required. Alternative disposal methods may significantly increase the cost of the project.

Agricultural and Rural Issues Associated with Reuse

Less treated wastewater may be available for irrigation with implementation of this strategy.

The City of Bronte is a rural community. Like other water supply strategies, the high cost of this strategy may have an adverse impact on the limited financial resources of the city and the surrounding rural community.

Other Natural Resource Issues Associated with Reuse

None identified.

Significant Issues Affecting Feasibility of Reuse

Although direct reuse for potable consumption is technically feasible, at this time there are no such operating facilities within the State of Texas. Adequate monitoring and oversight will be required to protect public health and safety. There may be public resistance to direct reuse of water for municipal purposes.

The infrastructure associated with reuse requires on-going use of water from this source to make the project cost-effective. Reuse water should not be used on an as-needed basis.

Other Water Management Strategies Directly Affected by Reuse

Other strategies for the City of Bronte.

Rehabilitation of Oak Creek Pipeline

The City of Bronte has a 13-mile 8-inch and 10-inch pipeline to Oak Creek Reservoir. This pipeline is approximately 55 years old and in need of rehabilitation. The proposed strategy includes a new 50,000 gallon raw water ground storage tank.

Quantity, Reliability and Cost of Pipeline Rehabilitation

The pipeline has a capacity of 0.5 mgd and can deliver the city's projected demands. Table 4.3-19 is a summary of the expected costs of the project. To facilitate comparison with other strategies, the costs presented in this plan assume that the city will finance the entire project at one time. The city may elect to spread out the costs of the project over a longer period of time. Routine operation and maintenance costs are not included in the costs after the amortization period because these will not be new costs for the city.

Table 4.3-19
Rehabilitation of Pipeline from Oak Creek Reservoir to Bronte

Supply from Strategy	**0 acre-feet per year**
Total Capital Costs (2008 Prices)	$ 1,955,000
Annual Costs	$ 391,000
Unit Costs	Not applicable

Environmental Issues Associated with Pipeline Rehabilitation

Environmental impacts are expected to be minimal because this is rehabilitation of an existing project.

Agricultural and Rural Issues Associated with Pipeline Rehabilitation

Rehabilitation may temporarily impact agricultural activities.

Other Natural Resource Issues Associated with Pipeline Rehabilitation

None identified.

Significant Issues Affecting Feasibility of Pipeline Rehabilitation

The most significant factor affecting rehabilitation of the pipeline is funding of the project. The city plans to use block grants to implement this strategy.

Other Water Management Strategies Directly Affected by Pipeline Rehabilitation

None identified.

Water Conservation

The City of Bronte has actively promoted water conservation and drought management during the recent drought. Peak demands have been reduced from as much as 760,000 gallons per day to about 600,000 gallons per day. The city uses mail outs, newspaper articles, public education and word-of-mouth to distribute information on water conservation. Several sample xeriscape projects have been implemented in the city with assistance from Texas A&M University. School education programs targeting grades 5 and 6 are used as well.

Table 4.3-20 compares projected demands for the City of Bronte with no conservation, with the expected conservation due to plumbing code (the default projections used in regional water planning), and using Region F water conservation criteria (see Appendix 4G).

Quantity, Reliability and Cost of Water Conservation

Using the Region F criteria, conservation can reduce the demand for the City of Bronte by 68 acre-feet per year, about 25 percent of the expected demand for the city without conservation. The reliability of this supply is considered to be medium because of the uncertainty involved in the analysis used to calculate the savings. Site specific data regarding residential, commercial, industrial and other types of use would give a better estimate of the reliable supply from this strategy. Table 4.3-20 summarizes the estimated costs of implementing the Region F conservation practices. Costs range from over $334 per acre foot in 2010 to $188 per acre-foot in 2060.

Environmental Issues Associated with Water Conservation

There are no identified environmental issues associated with this strategy. This strategy may have a positive impact on the environment by reducing the quantity of water needed by the city to meet future demands.

Agricultural and Rural Issues Associated with Water Conservation

The City of Bronte is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources. However, the city may identify other less costly conservation strategies that achieve similar results.

Other Natural Resource Issues Associated With Water Conservation

None identified.

Significant Issues Affecting Feasibility of Water Conservation

This strategy is based on generic procedures and may not accurately reflect the actual costs or water savings that can be achieved by the City of Bronte. Site-specific data will be required for a better assessment of the potential for water conservation by the city. Technical and financial assistance by the state may be required to implement this strategy.

Other Water Management Strategies Directly Affected by Water Conservation

If water conservation is successful in reducing water demand, other water management strategies may be delayed or become unnecessary.

Table 4.3-20
Estimated Water Conservation Savings for the City of Bronte [a]

Per Capita Demand (gpcd)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	192	208	208	208	208	208	208
Plumbing Code	Projections	192	205	202	199	196	195	195
	Savings	0	3	6	9	12	13	13
Region F Estimate	Projections	208 [b]	192	167	161	158	156	155
	Savings (Region F practices)	0	13	35	38	38	39	40
	Savings (Total)	0	16	41	47	50	52	53
Water Demand (Ac-Ft/Yr)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	251	248	266	266	266	266	266
Plumbing Code	Projections	251	245	258	254	250	249	249
	Savings	0	3	8	12	16	17	17
Region F Estimate	Projections	251	229	213	206	202	199	198
	Savings (Region F practices)	0	16	45	48	48	50	51
	Savings (Total)	0	19	53	60	64	67	68
Costs [c]								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Annual Costs			$5,340	$10,440	$10,196	$9,958	$9,725	$9,580
Cost per Acre-Foot			$334	$232	$212	$207	$195	$188
Cost per 1,000 Gal			$1.03	$0.71	$0.65	$0.64	$0.60	$0.58

a Costs and savings based on information from TWDB *Report 362 Water Conservation Task Force Water Conservation Best Management Practices Guide*, November 2004.
b The City of Bronte was under restrictions in 2000. Base year 2000 demands were extrapolated from historical water use between 1997 and 1999.
c Costs for implementing recommended practices. Costs of implementing plumbing code savings not included in cost calculations.

Drought Management

Region F has not identified specific drought management strategies for the City of Bronte. Drought management will be conducted through the city’s drought contingency plan.

Recommended Strategies for the City of Bronte

The recommended strategies for the City of Bronte are: 1) subordination of downstream water rights, 2) rehabilitation of the Oak Creek pipeline and 3) water conservation. Table 4.3-21 compares expected demands for the City of Bronte to water supplies with the strategies in place. Table 4.3-22 summarizes the annual costs of the recommended strategies.

Table 4.3-21
Recommended Water Management Strategies for the City of Bronte
(Values in Acre-Feet per Year)

Supplies	2010	2020	2030	2040	2050	2060
Oak Creek Reservoir	0	0	0	0	0	0
Subordination/Pipeline Rehab	129	129	129	129	129	129
Existing Water Wells	250	238	226	215	204	194
Total	379	367	355	344	333	323
Conservation	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Potential savings*	16	45	48	48	50	51
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Bronte	*245*	*258*	*254*	*250*	*249*	*249*
Surplus (Need) without conservation	134	109	101	94	84	74
Surplus (Need) with conservation	*150*	*154*	*149*	*142*	*134*	*125*

* Does not include plumbing code savings, which are already included in the water demand projections.

Table 4.3-22
Costs of Recommended Water Management Strategies for the City of Bronte

Strategy *	Capital Costs	Annual Costs					
		2010	2020	2030	2040	2050	2060
Rehabilitation of the Oak Creek pipeline	$1,955,000	$34,100	$34,100	$ 0	$ 0	$ 0	$ 0
Water Conservation	$ 0	$5,340	$11,687	$11,443	$10,298	$10,065	$9,920
Total	*$1,955,000*	*$39,440*	*$45,787*	*$11,443*	*$10,298*	*$10,065*	*$9,920*

4.3.5 City of Robert Lee

Table 4.3-23 compares the supply and demand for the City of Robert Lee. The City of Robert Lee is expected to have a maximum projected demand of about 420 acre-feet per year, including municipal sales. The city has three sources of water: E.V. Spence Reservoir (owned and operated by CRMWD), Mountain Creek Reservoir (owned by the Upper Colorado River Authority and operated by the city) and a small run-of-the-river right on the Colorado River. Although Spence Reservoir has adequate supplies for the city, the water has historically been high in chlorides, dissolved solids and sulfates. Mountain Creek Reservoir, which is a very small reservoir, is an important supply source for Robert Lee when supplies are available because it has better water quality. The WAM shows a small reliable supply from the city's run-of-the-river right, but in practice this supply is not reliable and is used infrequently.

The city uses a floating pump in both Spence Reservoir and a pump and intake structure in Mountain Creek Reservoir. The intake in Mountain Creek Reservoir limits the ability of the city to obtain water when the reservoir is low. In addition, the city has been under restrictions because their water treatment plant was near capacity. An additional 0.5 mgd of capacity would be desirable to prevent overloading of the treatment plant.

Table 4.3-23
Comparison of Supply and Demand for the City of Robert Lee
(Values in Acre-Feet per Year)

Supply	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**Comments**
Colorado River	7	7	7	7	7	7	Underflow right
Mountain Creek Reservoir	0	0	0	0	0	0	No WAM yield
Spence Reservoir	333	296	435	403	384	357	Supply changes as other CRMWD contracts expire
Total	*340*	*303*	*442*	*410*	*391*	*364*	
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**Comments**
City of Robert Lee	351	346	342	338	336	336	
Municipal Sales	105	97	95	92	91	91	Coke Co WSC et al.
Total	*456*	*443*	*437*	*430*	*427*	*427*	
Surplus (Need)	(116)	(140)	5	(20)	(36)	(63)	

Potentially Feasible Water Management Strategies

The following potentially feasible water management strategies have been identified for the City of Robert Lee:

- Subordination of downstream water rights
- Reuse

- Desalination of Spence Reservoir water
- New floating pump in Mountain Creek Reservoir
- Expansion of water treatment plant and storage facilities
- Water Conservation
- Drought Management

Brush control and precipitation enhancement are discussed in Section 4.9.

Although several strategies are technically feasible, the small quantity of water used by the city, the distance to other water sources, and the limited economic resources available to the community limit the number of strategies that can be implemented by the city.

Subordination of Downstream Senior Water Rights

TWDB requires the use of the TCEQ WAM for regional water planning. In the Colorado WAM, any water right in Region F with a priority date after 1926 has little or no firm supply. The priority date of Mountain Creek Reservoir is December 16, 1949 and the priority date of Spence Reservoir is August 17, 1964. According to the WAM, Mountain Creek Reservoir has no yield and Spence Reservoir has a safe yield of 560 acre-feet per year.

In order to address water availability issues in the Colorado Basin, Region F and the Lower Colorado Region (Region K) participated in a joint modeling effort to evaluate a strategy in which lower basin senior water rights do not make priority calls on major upstream water rights. This strategy also assumes that major water rights holders in Region F do not make priority calls on each other. The subordination strategy is discussed in detail in Section 4.2.3.

The joint modeling between the two regions was conducted for planning purposes only. By adopting this strategy, neither Region F nor the Lower Colorado Region stipulates that water rights will not make priority calls on junior water rights. A subordination agreement is not within the authority of the Region F Water Planning Group. Such an agreement must be developed by the water rights holders themselves. Mountain Creek Reservoir is owned by the Upper Colorado River Authority, and Spence Reservoir is owned by CRMWD. For the purposes of this plan, it will be assumed that Mountain Creek Reservoir will be overdrafted during normal to wet years and will have no supply during drought. With subordination, the City of Robert Lee should be able to obtain sufficient water from Spence Reservoir to meet projected demands.

Impacts of the subordination strategy are discussed in Section 4.2.3.

Reuse

Reuse has been identified as a feasible strategy for the City of Robert Lee. The city is currently authorized to both discharge and irrigate with treated effluent. This evaluation is based on a generalized direct reuse strategy developed for the Region F plan. This strategy assumes that a portion of the wastewater stream will be sent through membrane filtration and reverse osmosis (RO). The treated water will then be blended with raw water either in Spence Reservoir or Mountain Creek Reservoir prior to treatment at the city's existing water treatment plant. It is assumed that the waste stream from the reuse facility will be permitted for discharge along with unused treated effluent into a local stream or for land application. If this strategy is pursued, additional site-specific studies will be required to determine actual quantities of water available, costs and potential impacts.

Quantity, Reliability and Cost of Reuse

For the City of Robert Lee, it is estimated that reuse could provide as much as 100,000 gallons per day of additional supply, which is about 25 percent of the maximum expected demand for the city and its customers. This supply is considered very reliable. Table 4.3-24 summarizes of the costs for this strategy.

Environmental Issues Associated with Reuse

This strategy assumes that the City of Robert Lee will discharge the waste stream from treatment along with the remaining treated effluent or use existing land application facilities. The potential impacts of discharge will need to be evaluated prior to implementation of this strategy. If the impacts are unacceptable, an alternative method of disposal may be required, which may significantly increase the cost of the project.

Because of the relatively small amount of treated effluent currently discharged by the city, the strategy is not expected to have a significant impact on the volume of instream flows or over-bank flows. The strategy will have no impact on the Colorado estuary or Matagorda Bay.

Table 4.3-24
Direct Reuse of Treated Effluent for the City of Robert Lee

Supply from Strategy	110 acre-feet per year
Total Capital Costs (2008 Prices)	$ 2,158,000
Annual Costs	$ 258,000
Unit Costs (before amortization)	$ 2,345 per acre-foot
	$ 7.20 per 1,000 gallons
Unit Costs (after amortization)	$ 636 per acre-foot
	$ 1.95 per 1,000 gallons

Agricultural and Rural Issues Associated with Reuse

Reuse of treated wastewater currently used for land application may make less water available for irrigated agriculture.

The City of Robert Lee is a rural community. Like other water supply strategies, the high cost of this strategy may have an adverse impact on the limited financial resources of the city and the surrounding rural community.

Other Natural Resource Issues Associated with Reuse

None identified.

Significant Issues Affecting Feasibility of Reuse

Although direct reuse for potable consumption is technically feasible, at this time there are no operating facilities within the State of Texas. Adequate monitoring and oversight will be required to protect public health and safety. There may be public resistance to direct reuse of water.

Another significant issue is the on-going use of water from this strategy. The operating costs of the project are relatively high. On-going maintenance and operation of the plant are necessary for the project to be cost-effective. If this project is implemented, it should be considered an integral part of the city's supply and not used on an as-needed basis.

Other Water Management Strategies Directly Affected by Reuse

Other strategies for the City of Robert Lee.

Desalination of Spence Reservoir Water

The city currently obtains 75 percent or more of its water from Spence Reservoir. Historically, water from Spence Reservoir has been high in chlorides, sulfates and dissolved solids. Although water quality has improved with recent inflows, the city may need to consider advanced treatment of Spence water to improve the water quality available to its citizens.

Quantity, Reliability and Cost of Spence Reservoir Desalination

For the purposes of this plan, this strategy assumes that the city would construct an intake structure in Lake Spence to replace its existing floating pump and a reverse osmosis (RO) facility capable of producing up to 1.0 mgd of treated water. This would give the city sufficient capacity to meet most of its projected demand from Spence Reservoir. The reliability of the water is considered to be high. Table 4.3-25 contains a cost summary for this strategy.

Table 4.3-25
Desalination of Spence Reservoir Water by the City of Robert Lee

Supply from Strategy	500 acre-feet per year
Total Capital Costs (2008 Prices)	$ 8,309,000
Annual Costs	$ 891,500
Unit Costs (before amortization)	$ 1,783 per acre-foot
	$ 5.47 per 1,000 gallons
Unit Costs (after amortization)	$ 335 per acre-foot
	$ 1.03 per 1,000 gallons

Environmental Issues Associated with Spence Reservoir Desalination

Many surface water sources in this portion of the Colorado Basin have high dissolved solids and most aquatic communities are adapted to these conditions. This strategy assumes that the reject from the RO process will be discharged into Spence Reservoir, the Colorado River or disposed using land application. If this strategy is pursued, additional studies may be required to evaluate potential impacts of reject disposal. If other methods of disposal are required, costs may be significantly higher.

Spence Reservoir has never spilled, so this project is not expected to have significant impacts on instream flows or over-bank flows. There will be no impact on bays and estuaries.

Agricultural and Rural Issues Associated with Spence Reservoir Desalination

No agricultural issues have been identified for this strategy.

The City of Robert Lee is a rural community. Like other water supply strategies, the high cost of this strategy may have an adverse impact on the limited financial resources of the city and the surrounding rural community.

Other Natural Resource Issues Associated with Spence Reservoir Desalination

None identified.

Significant Issues Affecting Feasibility of Spence Reservoir Desalination

The costs for implementing this strategy will be significant, and financing the project will be an issue for the City of Robert Lee.

Feasibility is also dependent upon the city's ability to dispose of brine reject by discharge or land application. If deep well injection or other methods are required, the costs of the project could be significantly higher. If this option is pursued, additional studies may be required to address the disposal issue.

Other Water Management Strategies Directly Affected by Spence Reservoir Desalination

Other strategies for the City of Robert Lee.

Floating Pump in Mountain Creek Reservoir

The existing intake structure in Mountain Creek Reservoir makes it difficult for the city to take water when the reservoir is 10 to 15 feet below conservation. A new floating pump could allow the city access to more water during dry periods.

Quantity, Reliability and Cost of Floating Pump

For the purposes of this plan, this strategy assumes that the city would install a new floating pump with a capacity of 1.0 mgd and 1,000 feet of 12-inch piping. This would give the city sufficient capacity to meet most of its demand from Mountain Creek Reservoir when water is available. The reliability of the water is low because supplies from this source are typically unavailable during drought. However, the water quality of this source is typically better than Spence Reservoir. The city uses Mountain Creek Reservoir to supply about 25 percent of its water. Table 4.3-26 contains a cost summary for this strategy. Although the intake has more capacity than shown, the actual amount of reliable supply made available is low, increasing the unit cost of the project.

Table 4.3-26
New Floating Pump in Mountain Creek Reservoir for the City of Robert Lee

Supply from Strategy	50 acre-feet per year
Total Capital Costs (2008 Prices)	$ 995,520
Annual Costs	$ 106,500
Unit Costs (before amortization)	$ 2,130 per acre-foot
	$ 6.54 per 1,000 gallons
Unit Costs (after amortization)	$ 390 per acre-foot
	$ 1.20 per 1,000 gallons

Environmental Issues Associated with Floating Pump

The impact of this strategy is expected to be minimal.

Agricultural and Rural Issues Associated with Floating Pump

The City of Robert Lee is a rural community. Like other water supply strategies, the high cost of this strategy may have an adverse impact on the community's limited financial resources.

Other Natural Resource Issues Associated with Floating Pump

None identified.

Significant Issues Affecting Feasibility of Floating Pump

The most significant issues associated with this project are financing for the new facilities.

Another issue is the available supply from the project. Although the project will allow additional water to be used from the reservoir, there are less than 200 acre-feet of storage that the city cannot access. The supply from this storage is not reliable and may not be sufficient to justify the cost of the project.

Other Water Management Strategies Directly Affected by Floating Pump

Lake Spence RO project, other strategies for Robert Lee.

Infrastructure Expansion - Water Treatment Plant and Storage Facility

Infrastructure improvements include a 0.5 mgd expansion of the city's water treatment plant, a new 100,000 gallon treated water storage tank for the city, and improvements to allow the city to simultaneously treat water from both Spence and Mountain Creek Reservoirs.

Quantity, Reliability and Cost of Infrastructure Expansion

The expansions would increase the reliability of existing supplies and make approximately 200 acre-feet per year of additional average production available to the city. Table 4.3-27 shows the estimated costs for these improvements.

Table 4.3-27
0.5 MGD Water Treatment Plant Expansion for the City of Robert Lee

Supply from Strategy	**0 acre-feet per year**
Total Capital Costs (2008 Prices)	$ 3,327,000
Annual Costs	$ 277,000
Unit Costs	Not applicable

Improvements to existing infrastructure are not evaluated for impacts. Although this strategy will increase the reliability of the Robert Lee water system, it may not sufficiently reduce chlorides and TDS to meet secondary drinking water standards (see Desalination of Spence Reservoir Water).

Water Conservation

In recent years the City of Robert Lee has been under water use restrictions primarily due to infrastructure limitations. Table 4.3-28 compares projected demands for the city without conservation, with the expected conservation due to the implementation of the plumbing code (the default projections used in regional water planning), and with Region F water conservation criteria (see Appendix 4G).

Quantity, Reliability and Cost of Water Conservation

Using the Region F criteria, conservation can reduce the demand for the City of Robert Lee by 66 acre-feet per year, about 19 percent of the expected demand for the city without conservation. The reliability of this supply is considered to be medium because of the uncertainty involved in the analysis used to calculate the savings. Site specific data would give a better estimate of the reliable supply from this strategy. Costs range from $356 per acre-foot in 2010 to $199 per acre-foot in 2060.

Table 4.3-28
Estimated Water Conservation for the City of Robert Lee [a]

Per Capita Demand (gpcd)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	278	278	278	278	278	278	278
Plumbing Code	Projections	278	276	272	269	266	264	264
	Savings	0	2	6	9	12	14	14
Region F Estimate	Projections	278	263	240	232	228	225	224
	Savings (Region F practices)	0	13	32	37	38	39	40
	Savings (Total)	0	15	38	46	50	53	54
Water Demand (Ac-Ft/Yr)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	365	354	354	354	354	354	354
Plumbing Code	Projections	365	351	346	342	338	336	336
	Savings	0	3	8	12	16	18	18
Region F Estimate	Projections	365	335	306	298	293	290	288
	Savings (Region F practices)	0	16	40	44	45	46	48
	Savings (Total)	0	19	48	56	61	64	66
Costs [b]								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Annual Costs			$5,696	$10,422	$10,177	$9,940	$9,708	$9,565
Cost per Acre-Foot			$356	$261	$231	$221	$211	$199
Cost per 1,000 Gal			$1.09	$0.80	$0.71	$0.68	$0.65	$0.61

a Costs and savings based on information from TWDB *Report 362 Water Conservation Task Force Water Conservation Best Management Practices Guide*, November 2004.
b Costs for implementing recommended practices. Costs of implementing plumbing code savings not included in cost calculations.

Drought Management

The City of Robert Lee has a water conservation and drought contingency plan. Region F has not identified any additional drought management strategies for the city.

Recommended Strategies for the City of Robert Lee

The recommended strategies for the City of Robert Lee are:

- Subordination of downstream water rights
- Expansion of water treatment plant and storage facilities
- Water Conservation

Table 4.3-29 is a comparison of supplies to demands with strategies in place, and Table 4.3-30 summarizes the costs of the strategies.

The recommended strategies may not sufficiently address treated water quality for the city. As an alternative or supplement to the water treatment plant expansion, the city may wish to consider RO treatment of Spence Reservoir water. Region F considers RO treatment to meet regulatory requirements for consistency with this plan, but the strategy is not recommended because of the cost of the project and the uncertainty involved with disposal of the brine reject.

Recommended Alternative Strategies for the City of Robert Lee

The recommended alternative strategy for the City of Robert Lee is:

- Desalination of Spence Reservoir water

Table 4.3-29
Recommended Water Management Strategies for the City of Robert Lee
(Values in Acre-Feet per Year)

Supplies	2010	2020	2030	2040	2050	2060
Colorado River	7	7	7	7	7	7
Mountain Creek Reservoir	0	0	0	0	0	0
Spence Reservoir	333	296	435	403	384	357
Infrastructure Expansion	0	0	0	0	0	0
Subordination	123	147	2	27	43	70
Total	*463*	*450*	*444*	*437*	*434*	*434*
Conservation	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Potential savings [b]	16	40	44	45	46	48
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Robert Lee	351	346	342	338	336	336
Municipal Sales	105	97	95	92	91	91
Total	*456*	*443*	*437*	*430*	*427*	*427*
Surplus (Need) without conservation	*7*	*7*	*7*	*7*	*7*	*7*
Surplus (Need) with conservation	*23*	*47*	*51*	*52*	*53*	*55*

a The infrastructure expansion increases the reliability of existing supplies but does not make additional water available.

b Does not include plumbing code savings, which are already included in the water demand projections.

Table 4.3-30
Costs of Recommended Water Management Strategies for the City of Robert Lee

Strategy	Capital Costs	Annual Costs					
		2010	2020	2030	2040	2050	2060
Infrastructure expansion	$2,482,500	$259,000	$259,000	$43,000	$43,000	$43,000	$43,000
Water Conservation		$5,696	$10,422	$10,177	$9,940	$9,708	$9,565
Total	*$2,482,500*	*$264,696*	*$269,422*	*$53,177*	*$52,940*	*$52,708*	*$52,565*

Note: The subordination strategy will be implemented by CRWMD. Therefore no costs for this strategy are associated with the City of Robert Lee.

4.3.6 City of Menard

The city of Menard has several wells near the banks of the San Saba River that produce water from the San Saba River Alluvium. Reduced flows in the San Saba River during a severe drought have the potential to reduce the city's available supply. Under drought-of-record conditions Menard may experience small shortages. For the purposes of this plan, supplies for the City of Menard are considered to be surface water. However, recent actions by state agencies have re-classified the city's supply as groundwater.

Table 4.3-31 compares the supply and demand for the city. (Supplies are based on the Colorado WAM, which may not give an accurate picture of the city's particular method of obtaining water supply. Based on historical data, the Colorado WAM supply appears to be somewhat conservative and more water may actually be available to the city.) The projected population of the city is expected to remain fairly stable over the planning period, so demands are expected to decline over time due to conservation. The projected need for Menard is 70 acre-feet per year in 2010, decreasing to 54 acre-feet per year by 2060. During the recent drought the city relied on water conservation and drought management to prevent shortages. Although this strategy proved successful, the city desires to increase the reliability of its supplies by developing a groundwater source. The city is currently considering developing a well in the Hickory aquifer. In addition the city is interested in developing a direct reuse project for irrigation of a municipal golf course.

Table 4.3-31
Comparison of Supply and Demand for the City of Menard
(Values in Acre-Feet per Year)

Supply	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
San Saba River	304	304	304	304	304	304
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Menard	354	353	347	341	339	339
Municipal sales	20	21	20	20	19	19
Total	*374*	*374*	*367*	*361*	*358*	*358*
Surplus (Need)	*(70)*	*(70)*	*(63)*	*(57)*	*(54)*	*(54)*

Potentially Feasible Strategies

Potentially feasible strategies for the City of Menard include:

- Water conservation
- Drought management
- New groundwater development
- Aquifer storage and recovery.
- Voluntary redistribution – San Saba Off-Channel Reservoir

Although several strategies are technically feasible, the small quantity of water used by the city, the distance from other water supply sources, and the limited economic resources available to the community limits the number of strategies that could be implemented by the city.

Water Conservation

Using the Region F suite of water conservation practices, it is estimated that the City of Menard can reduce water demand by as much as 17 percent. Additional information on Region F recommended water conservation practices may be found in Appendix 4G.

Region F recognizes that it has no authority to implement, enforce or regulate water conservation practices. The water conservation practices in this plan are guidelines. Region F considers water conservation strategies determined and implemented by the City of Menard to supersede the recommendations in this plan and to meet regulatory requirements for consistency with this plan.

Quantity, Reliability and Cost of Water Conservation

Table 4.3-32 summarizes the estimated water savings and costs associated with the recommended Region F water conservation practices. Based on this evaluation, by 2060 up to 61 acre-feet of water per year could be saved, a reduction of almost 17 percent. The estimated reductions compare favorably with actual reductions in demand experienced by the city during the recent drought. The estimated per capita water demand in 2030 using the Region F criteria is 161 gpcd. In 2006, the most recent year for which per capita water use data are available, the city had a per capita demand of 144 gpcd. The reliability of water conservation is considered to be medium due to the uncertainty of the long-term savings from implementation of water conservation strategies.

Environmental Issues Associated with Water Conservation

Water conserved by the City of Menard will most likely be made available for irrigation or livestock purposes in the area. Some of the saved water may contribute to environmental flow needs. Other impacts are expected to be minimal.

Table 4.3-32
Estimated Water Conservation Savings for the City of Menard [a]

Per Capita Demand (gpcd)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	185	185	185	185	185	185	185
Plumbing Code	Projections	185	181	178	175	172	171	171
	Savings	0	4	7	10	13	14	14
Region F Estimate	Projections	185	176	166	161	157	155	154
	Savings (Region F Practices)	0	5	12	14	15	16	17
	Savings (Total)	0	9	19	24	28	30	31
Water Demand (Ac-Ft/Yr)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	343	362	367	367	367	367	367
Plumbing Code	Projections	343	354	353	347	341	339	339
	Savings	0	8	14	20	26	28	28
Region F Estimate	Projections	343	344	329	319	311	307	306
	Savings (Region F Practices)	0	10	24	28	30	32	33
	Savings (Total)	0	18	38	48	56	60	61
Costs [b]								
Annual Costs			$8,755	$13,526	$13,146	$12,776	$12,414	$12,190
Cost per Acre-Foot			$876	$564	$470	$426	$388	$369
Cost per 1,000 Gal			$2.69	$1.73	$1.44	$1.31	$1.19	$1.13

a Costs and water saving are based on data from TWDB *Report 362 Water Conservation Task Force Water Conservation Best Management Practices Guide*, November 2004.
b Costs for implementing Region F recommended practices. Costs of implementing plumbing code not included.

Agricultural and Rural Issues Associated with Water Conservation

Water from the San Saba River is also used for irrigation purposes. Some of the conserved water may become available for irrigation needs.

The City of Menard is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources.

Other Natural Resource Issues Associated with Water Conservation

None identified.

Significant Issues Affecting Feasibility of Water Conservation

This strategy is based on a generalized assessment of water conservation practices and may not accurately reflect the actual costs or water savings that can be achieved by the City of Menard. Site-specific data will be required for a better assessment of the potential for water conservation by the city. Technical assistance and funding by the state may be required to implement this strategy.

Other Water Management Strategies Directly Affected by Water Conservation

None identified.

Drought Management

The City of Menard has effectively used drought management to control demand during times of drought. Strategies are specified in the city's water conservation and drought contingency plan. Region F has not identified additional drought management strategies for the City of Menard.

New Groundwater Development - Hickory Aquifer

The City of Menard has been actively seeking a groundwater source to back up its current supplies. Yields from the Edwards-Trinity Plateau aquifer tend to be low in Menard County and the city has been unsuccessful in locating an adequate supply from that source. An alternative is the Hickory aquifer, which underlies the city at a depth of approximately 3,500 ft. The city is planning to drill a well near its existing storage tanks. In this portion of the aquifer, dissolved solids may be above 1,000 mg/l. Also, much of the water from the Hickory aquifer exceeds drinking water standards for radionuclides. For the purposes of this plan, this strategy assumes that water from the Hickory can meet primary drinking water standards if blended with the city's existing water supply. However, advanced treatment may be required to meet standards, significantly increasing the cost of this strategy.

Quantity, Reliability and Cost of Hickory Aquifer Well

The proposed well will produce water from the down-dip portion of the Hickory aquifer. Faulting may have caused this portion of the aquifer to be compartmentalized and isolated from the recharge zone. Therefore, most of the supply is expected to come from water in storage. The total thickness of the Hickory formation is approximately 500 feet. Although no wells are available in the immediate area of the city, based on other users of the aquifer, such as the City of Brady, there should be sufficient supplies to meet the city's long-term water supply needs. Reliability is medium because water quality may impact the usefulness of the supply. Table 4.3-33 summarizes the estimated costs of the project.

Table 4.3-33
Costs for New Hickory Water Well for the City of Menard

Supply from Strategy	160 acre-feet per year
Total Capital Costs (2008 Prices)	$ 1,684,000
Annual Costs	$ 233,000
Unit Costs (before amortization)	$ 1,456 per acre-foot
	$ 4.47 per 1,000 gallons
Unit Costs (after amortization)	$ 538 per acre-foot
	$ 1.65 per 1,000 gallons

Environmental Issues Associated with Hickory Aquifer Well

The proposed well will produce water from the down-dip portion of the Hickory aquifer. Because of the over 3,000 feet of overburden, there is no interconnectedness with the land surface and, therefore, there would be no impact on springs or surface water sources. Subsidence would also not be a factor due to the depth of the source and the competency of the overburden. Therefore environmental impacts are expected to be minimal unless the water requires advanced treatment. If advanced treatment is required to use the aquifer, impacts may be higher depending on the method used to dispose of the reject from the treatment process.

Based on the available data, it is unlikely that pumping limits other than those already imposed by the Hickory Underground Water Conservation District will be required to protect the environment.

Agricultural and Rural Issues Associated with Hickory Aquifer Well

Currently, only a very small amount of water from the Hickory is used for irrigation in Menard County. Because of the relatively small amount of water from this strategy, there are no expected impacts on irrigated agriculture.

The City of Menard is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources.

Other Natural Resource Issues Associated with Hickory Aquifer Well

None identified.

Significant Issues Affecting Feasibility of Hickory Aquifer Well

Much of the water from the Hickory aquifer has radium levels that exceed the maximum contaminant level (MCL) for drinking water. Water in this portion of the Hickory aquifer may be high in dissolved solids as well. The water may require special treatment, blending or some other process to meet standards. A test well will be required to determine if water quality will limit the use of this source. Both financing the test program and development of the well will be an issue for the City of Menard.

Other Water Management Strategies Directly Affected by Hickory Aquifer Well

Aquifer storage and recovery by the City of Menard.

Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) may work well with development of a Hickory aquifer well. It is possible that the Hickory aquifer can be used to store water during the winter months for use during peak summer months. Additional supplies may be held longer for use during times of drought. During extreme droughts, the native water in the Hickory formation may be used to supplement the stored water. This strategy may mitigate any water quality issues associated with the Hickory.

Quantity, Reliability and Cost of ASR

Treated surface water would be injected into the Hickory aquifer during winter months at approximately the same rate that groundwater can be withdrawn from the aquifer. Because of the depth of this aquifer, there are no other Hickory wells in the area. Therefore, water placed in this reservoir would be relatively protected from unauthorized withdrawals. Assuming that the water would be withdrawn within the following few months, a return of approximately 80 to 90 percent can be anticipated. The cost of modifying an existing water well into an ASR injection and retrieval well is slight. The major cost is incorporated into the drilling and construction of the well (see New Groundwater Development - Hickory aquifer above). Additional cost will be required in the permitting phase of the project.

Since more water is made available by this strategy than the Hickory well by itself, the unit costs of the strategy are lower. Table 4.3-34 is a summary of the expected costs of the project.

Table 4.3-34
Costs for Aquifer Storage and Recovery by the City of Menard

Supply from Strategy	240 acre-feet per year
Total Capital Costs (2008 Prices)	$ 1,752,000
Annual Costs	$ 305,000
Unit Costs (before amortization)	$ 1,271 per acre-foot
	$ 3.90 per 1,000 gallons
Unit Costs (after amortization)	$ 633 per acre-foot
	$ 1.94 per 1,000 gallons

Environmental Issues Associated with ASR

This strategy relies on using diversions made under an existing water right and does not represent a significant variation in diversions on an annual basis. Seasonally, this strategy will most likely result in slightly higher diversions in the winter, potentially reducing diversions during the summer. As a result, this strategy should have a positive impact on water quality and environmental water needs because of reduced diversions during the summer months. Therefore instream bypass, diversion limits and other operational factors should not be needed. This strategy should have little or no impact on over-banking flows.

Agricultural and Rural Issues Associated with ASR

Menard is a rural community, and implementation of this and other strategies represents a significant financial drain on the community.

The potential to reduce diversions during the summer may have a positive impact on irrigated agriculture in the Menard area.

Other Natural Resource Issues Associated with ASR

None identified.

Significant Issues Affecting Feasibility of ASR

The suitability of the Hickory aquifer in this area for ASR has not been firmly established. Further studies will be required to evaluate aquifer characteristics. Injection of water into the subsurface will likely require a Class V permit from TCEQ. Also as stated above, the project could have a significant financial impact on the rural community. The price to extract injected water from the proposed Hickory ASR project could be costly given the 3,500 foot well depth and possible deep static water level.

Other Water Management Strategies Directly Affected by ASR

New well in the Hickory aquifer.

San Saba Off-Channel Reservoir

Previous studies have evaluated an off-channel reservoir on the San Saba River in McCulloch County. For this plan, the off-channel reservoir would be located near the City of Menard with a yield of approximately 500 acre-feet per year. The conceptual design for the project includes a channel weir and pump station, an off channel reservoir with 1,550 acre-feet of storage, a new water treatment plant, and a pipeline from the reservoir to the treatment plant.

There is little unappropriated water available in the San Saba River. If constructed, the reservoir would most likely need to be permitted under the existing City of Menard water right or as an upstream diversion under the LCRA water rights for the Highland Lakes, or both.

Quantity, Reliability and Cost of Off-Channel Reservoir

The project has been designed to yield 500 acre-feet per year. Water was stored in the reservoir at a 1926 priority date, the same priority date as the Highland Lakes, limited by bypass requirements based on the Consensus Method. The reliability of the project is expected to be high. Table 4.3-35 summarizes the costs for this strategy.

Environmental Issues Associated with Off-Channel Reservoir

A specific location for the off-channel reservoir has not been determined. Before this strategy could be pursued, a site selection study would need to be performed, in addition to other studies to identify and quantify potential environmental impacts associated with the project. For the purposes of this analysis, it is assumed that a site could be selected that would have

Table 4.3-35
San Saba Off-Channel Reservoir - City of Menard

Supply from Strategy	500 acre-feet per year
Total Capital Costs (2008 Prices)	$ 24,520,000
Annual Costs	$ 2,517,000
Unit Costs (before amortization)	$ 5,034 per acre-foot
	$ 15.45 per 1,000 gallons
Unit Costs (after amortization)	$ 758 per acre-foot
	$ 2.33 per 1,000 gallons

acceptable impacts. It can be assumed that the impacts of reservoir construction would be greater than the other feasible strategies for the City of Menard.

In accordance with TWDB guidelines, this analysis assumes that the consensus environmental bypass apply to diversions from the San Saba River. Other bypass requirements may change the yield and cost of the project.

Agricultural and Rural Issues Associated with Off-Channel Reservoir

Menard is a rural community, and implementation of this and other strategies represents a significant financial drain on the community.

Other Natural Resource Issues Associated with Off-Channel Reservoir

None identified.

Significant Issues Affecting Feasibility of Off-Channel Reservoir

There is not enough unappropriated water in this reach for a new water right. One possibility for implementation of this project would be as an upstream diversion of the Lower Colorado River Authority water rights in the Highland Lakes. The existing City of Menard water right may be used as well. An agreement with LCRA would be necessary to implement this project. Diversion with a priority date junior to 1926 could significantly impact the feasibility of this project.

The analyses presented in this plan were developed for screening purposes only. Additional studies will be required if this strategy is pursued. The cost and feasibility of this project may change significantly based upon a more detailed analysis.

Other Water Management Strategies Directly Affected by Off-Channel Reservoir

Other City of Menard strategies.

Recommended Strategies for the City of Menard

Region F recommends the following strategies for the City of Menard:

- New groundwater development from the Hickory aquifer
- Water conservation

Recommended Alternative Strategies for the City of Menard

Region F recommends the following alternative strategy for the City of Menard:

- ASR with new well in the Hickory aquifer

If possible, the city should explore the possibility of using the Hickory aquifer for ASR when developing the Hickory well. If the city elects to pursue ASR, Region F will consider this option to meet regulatory requirements for consistency with this plan. Table 4.3-36 compares supply to demand with the recommended strategies. Table 4.3-37 summarizes the capital and annual costs associated with these strategies.

Table 4.3-36
Comparison of Supply and Demand with Recommended Water Management Strategies
City of Menard
(Values in Acre-Feet per Year)

Supplies	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
San Saba River	304	304	304	304	304	304
New Hickory well	160	160	160	160	160	160
Total	*464*	*464*	*464*	*464*	*464*	*464*
Conservation	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Potential savings	*10*	*24*	*28*	*30*	*32*	*33*
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Menard	354	353	347	341	339	339
Municipal Sales	20	21	20	20	19	19
Total	*374*	*374*	*367*	*361*	*358*	*358*

Surplus (Need) without Conservation	*90*	*90*	*97*	*103*	*106*	*106*
Surplus (Need) with Conservation	*100*	*114*	*125*	*133*	*138*	*139*

Table 4.3-37
Costs of Recommended Strategies for the City of Menard

Strategy	Capital Costs	2010	2020	2030	2040	2050	2060
New Hickory well	$1,684,000	$233,000	$233,000	$86,000	$86,000	$86,000	$86,000
Water Conservation *	$0	$8,755	$13,526	$13,146	$12,776	$12,414	$12,190
Total	*$1,684,000*	*$241,755*	*$246,526*	*$99,146*	*$98,776*	*$98,414*	*$98,190*

* Costs for water conservation are for Region F practices only. Costs of implementing plumbing code savings not included.

4.3.7 City of Midland

The City of Midland currently uses three sources of water:

- The 1966 Contract with CRMWD, which can provide water from any source in the CRMWD system (Ivie, Spence, Thomas or groundwater sources). The amount of water from this contract increases from 16,624 acre-feet per year in 2010 to 18,257 acre-feet per year in 2020. The contract will expire in 2026.
- The CRMWD Ivie Contract for water from Ivie Reservoir. The contract is currently set at 15,000 acre-feet per year. The contract also has a clause allowing the contract to be reduced to 16.54 percent of the safe yield of the reservoir. For the purposes of this analysis, we have assumed that the amount of water available to Midland over the planning period will be limited to 16.54 percent of the safe yield of Ivie Reservoir based on the Region F assessment of water availability.
- Paul Davis Well Field in Martin and Andrews Counties, which provides an average of 4,722 acre-feet per year from the Ogallala aquifer. The city expects the well field to be depleted by about 2035.

The city also owns an undeveloped well field in Winkler County, known as the T-Bar Ranch. The McMillan Well Field in Midland County was used for aquifer storage and recovery for many years, but has remained idle recently due to elevated concentrations of perchlorate in the water.

TWDB requires use of the TCEQ water availability models (WAM) to determine supplies in regional water planning. Because these models are based on a perfect application of the prior appropriation system, the Colorado WAM[6] shows substantially less water for Region F than previous assessments of water availability. As a result, supplies from CRMWD have been uniformly decreased for all users. The reduced supplies for the City of Midland are presented in Table 4.3-38.

Table 4.3-38 compares the available supplies to the projected demands for the City of Midland and its current customers. The city provides a small amount of water to industrial users and to municipal customers outside of the city. Demands for the city are expected to increase from about 29,000 acre-feet per year in 2010 to over 32,000 acre-feet per year by 2060.

Based on the Region F analysis, the city may experience short-term needs by 2010. These needs are the result of the water supply analysis using the Colorado WAM and can be met by CRMWD supplies, assuming subordination of downstream senior water rights. Beginning in 2030 the city may experience significant needs if supplies from the 1966 Contract are no longer available. Needs increase in 2040 when water from the Paul Davis Well Field is no longer available.

Potentially Feasible Water Management Strategies for the City of Midland

Three potentially feasible strategies have been identified for the city:

- *New Groundwater* - development of the T-Bar Well Field in Winkler county
- *Voluntary Redistribution* - purchase water from the CRMWD system
- *Water Conservation* – implementation of water conservation management practices to reduce demand

Region F has identified several other feasible strategies for the City of Midland, including subordination of downstream senior water rights, reuse, co-development of groundwater in the Pecos Valley aquifer with CRMWD's Winkler well field, desalination and aquifer storage and recovery. For the purposes of this plan it was assumed that these strategies would be implemented by CRMWD or in conjunction with CRMWD. These strategies are discussed in

Section 4.8.1 regarding strategies for CRMWD. Other feasible strategies are considered less likely to be implemented over the planning period.

Table 4.3-38
Comparison of Current Supplies to Projected Demands for the City of Midland
(Values in Acre-Feet per Year)

Supplies	2010	2020	2030	2040	2050	2060
CRMWD 1966 Contract [a,b]	12,136	12,202	0	0	0	0
Ivie Contract [c]	10,925	10,669	10,473	10,246	10,021	9,795
Paul Davis Well Field [d]	4,722	4,722	4,722	0	0	0
Total Supplies	*27,783*	*27,593*	*15,195*	*10,246*	*10,021*	*9,795*
Demands	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Midland	28,939	30,056	30,804	31,246	31,631	32,112
Outside Sales	49	52	55	58	60	63
Total Demand	*28,988*	*30,108*	*30,859*	*31,304*	*31,691*	*32,175*
Surplus (Need)	*(1,205)*	*(2,515)*	*(15,664)*	*(21,058)*	*(21,670)*	*(22,380)*

a Actual contract amounts for the 1966 Contract are 16,624 acre-feet per year in 2010 and 18,257 acre-feet per year in 2020. Surface water supplies for all CRMWD customers have been reduced to reflect lower supplies from the CRMWD system from the Colorado WAM. With implementation of the subordination strategy, supplies from the 1966 Contract will be increased to current levels because of the additional supply available from the system.

b The 1966 Contract will expire in 2026.

c The Ivie Contract amount has been reduced to 16.54 percent of the safe yield of the reservoir using the Colorado WAM. Currently, the contract is set at 15,000 acre-feet per year. CRMWD has the option to reduce this contract if the safe yield of Ivie Reservoir has been reduced because of sedimentation, drought or other conditions.

d The Paul Davis Well Field is expected to be depleted by 2035.

T-Bar Well Field

In 1965 the city of Midland purchased the T-Bar Well Field, which consists of approximately 20,230 acres in northwestern Winkler County and northeastern Loving County. Based on previous studies, the City of Midland estimates that there is approximately 650,000 acre-feet of available water in storage in the Pecos Valley aquifer from this field. The city expects the well field to have a life of approximately 60 years. The annual recharge is estimated at approximately 6,600 acre-feet per year. The city is planning to use this well field during high demand periods. The proposed design capacity is 20 MGD[7]. To develop this well field, it is assumed that 43 wells will be installed and a 70-mile transmission line will be constructed. Costs are based on a draft study re-evaluating supplies from this source[8].

It is possible that this well field could be developed in conjunction with CRMWD resources in Winkler County.

Quantity, Reliability and Cost of T-Bar Well Field

The T-Bar Well Field could provide as much as 40 percent of the city's demand in 2060. The reliability is high over the planning period, since there is available supply from storage in the Pecos Valley aquifer in Winkler County and annual recharge is approximately half of the proposed annual supply. Expected costs for the project may be found in Table 4.3-39. More detailed cost estimates may be found in Appendix 4D.

Table 4.3-39
Costs for T-Bar Well Field - City of Midland

Supply from Strategy	13,600 acre-feet per year
Total Capital Costs (2008 Prices)	$ 168,756,000
Annual Costs	$ 19,384,500
Unit costs (before amortization)	$ 1,425 per acre-foot
	$ 4.37 per 1,000 gallons
Unit Costs (after amortization)	$ 343 per acre-foot
	$ 1.05 per 1,000 gallons

Environmental Issues Associated with T-Bar Well Field

There is no flowing surface water in Winkler County, so development of the T-Bar Well Field is expected to have no impact on environmental water needs. Development of the well field and construction of the 70-mile pipeline are expected to have minimal impact on wildlife habitats or cultural resources. It is assumed that the 70-mile pipeline can be routed to minimize or eliminate impact on potentially sensitive areas if needed. Once the pipeline route has been chosen, the potential for environmental impacts will need further investigation.

No subsidence or bay and estuary impacts are expected with well field development.

Agricultural and Rural Issues Associated with T-Bar Well Field

This strategy should have minimal effects on agriculture since the water rights are already owned by the city and there is little agriculture in the area. The right of way for the transmission line may temporarily affect a small amount of agricultural acreage during construction.

Other Natural Resource Issues Associated with T-Bar Well Field

There is adequate supply in the Pecos Valley aquifer in Winkler County to support the proposed well field. Since the proposed well field is located in a geological trough, pumping of groundwater should have minimal impacts on the aquifer outside of the well field.

Significant Issues Affecting Feasibility of T-Bar Well Field

The most significant obstacle for implementation of this strategy will be financing the project. The cost of the project represents a significant financial commitment by the city. Other issues include possible water quality concerns, including the potential for perchlorate and arsenic concentrations that may exceed drinking water standards. Additional treatment of the water may be required if standards cannot be met by blending with other sources. Also, elevated chloride and TDS levels may be present in some or all of the future wells.

Other Water Management Strategies Directly Affected by T-Bar Well Field

There are no other identified management strategies that will be affected.

Voluntary Redistribution – Purchase Water from CRMWD

Additional water should be available from the CRMWD system to meet potential long-term needs for the city. Sources of water include existing CRMWD reservoirs and groundwater sources, as well as future sources such as reuse, desalination, aquifer storage and recovery or new groundwater sources. Actual sources of water, quantity and costs will be determined by negotiation between the two parties.

Quantity, Reliability and Cost of Purchasing Water from CRMWD

For the purposes of this plan, it will be assumed that Midland will renew its 1966 Contract at 8.45 percent of the total yield of the existing CRMWD system. Supplies are set at 10,000 acre-feet per year in 2030, declining to 9,400 acre-feet per year in 2060. Costs are assumed to be $479 per acre-foot ($1.47 per 1,000 gallons), the same as the current CRMWD system rate. The actual amount and cost of water depends on negotiations between the two parties. The reliability is considered to be high due to the multiple sources in the CRMWD system. No new infrastructure will be required to implement this strategy.

Impacts of Purchasing Water from CRMWD

Contract renewal strategies are not evaluated for quantified environmental impacts. Because this is a renewal of an existing contract, all impacts are expected to be low. This strategy should not affect any other water management strategies.

Water Conservation

The City of Midland has developed and is currently implementing a comprehensive water conservation program, including public education on indoor and outdoor water conservation. The city has completed a demonstration project at a city park that includes water conserving landscaping and irrigation practices. The City of Midland is currently focusing on their largest water user, the Midland Independent School District. The city is subsidizing the cost to install sprinkler systems at the schools with centralized control for each of the systems. Projected savings from this project is 369,000 gallons per day in the summer months. Midland also is investigating the feasibility of using reuse water for landscape irrigation to a local college. In addition, the city's wastewater may be used in a proposed reuse project sponsored by CRMWD.

Quantity, Reliability and Cost of Water Conservation

Since most of the city's water conservation effort begun after 2000 (basis year for water demands), the default Region F suite of water conservation practices and the city's irrigation strategy were used to evaluate the potential water savings and costs of implementation. Table 4.3-40 compares projected demands for the City of Midland with no conservation, with the expected conservation due to plumbing code (the default projections used in regional water planning), and using Region F water conservation criteria (see Appendix 4G).

The reliability of this supply is considered to be medium because of the uncertainty involved in the analysis used to calculate the savings.

Table 4.3-40
Estimated Water Conservation Savings by the City of Midland [a]

Per Capita Demand (gpcd)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	262	262	262	262	262	262	262
Plumbing Code	Projections	262	258	254	251	248	247	247
	Savings	0	4	8	11	14	15	15
Region F Estimate [a]	Projections	262	246	232	226	222	220	219
	Savings	0	16	30	36	40	42	43
Water Demand (Ac-Ft/Yr)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	27,879	29,388	31,003	32,154	33,010	33,552	34,062
Plumbing Code	Projections	27,879	28,939	30,056	30,804	31,246	31,631	32,112
	Savings	0	449	947	1,350	1,764	1,921	1,950
Region F Estimate	Projections	27,879	27,595	27,440	27,743	27,985	28,174	28,449
	Savings (Region F practices)	0	1,344	2,616	3,061	3,261	3,457	3,663
	Savings (Total)	0	1,793	3,563	4,411	5,025	5,378	5,613
Costs								
Annual Costs			$602,091	$521,355	$517,031	$507,177	$492,061	$484,787
Cost per Acre-Foot [b]			$448	$199	$169	$156	$142	$132
Cost per 1,000 Gal [b]			$1.37	$0.61	$0.52	$0.48	$0.44	$0.41

a Costs and savings based on information from TWDB *Report 362 Water Conservation Task Force Water Conservation Best Management Practices Guide*, November 2004 and communication with Midland..
b Costs for implementing recommended Region F practices. Plumbing code savings not included in unit cost calculations.

Region F recognizes that it has no authority to implement, enforce or regulate water conservation practices. These water conservation practices are intended only as guidelines. Region F considers water conservation strategies determined and implemented by the City of Midland to supersede the recommendations in this plan and to meet regulatory requirements for consistency with this plan.

Environmental Issues Associated with Water Conservation

There are no identified environmental issues associated with this strategy. This strategy may have a positive impact on the environment by reducing the quantity of water needed by the city to meet future demands.

Agricultural and Rural Issues Associated with Water Conservation

The City of Midland is not in direct competition with agriculture for water, so there are no identified agricultural issues associated with this strategy.

Other Natural Resource Issues Associated with Water Conservation

None identified.

Significant Issues Affecting Feasibility of Water Conservation

This strategy is based on a generic assessment of water conservation practices and may not accurately reflect the actual costs or water savings that can be achieved by the City of Midland. Site-specific data will be required for a better assessment of the potential for water conservation by the city. Technical assistance by the state may be required to implement this strategy.

Other Water Management Strategies Directly Affected by Water Conservation

The timing and quantity of other recommended strategies for the City of Midland could be impacted by successful implementation of water conservation.

Drought Management

The current Midland Drought Contingency Plan, the CRMWD Drought Contingency Plan and subsequent revisions of these plans determine drought management for the City of Midland. No other drought management strategies have been identified.

Recommended Strategies for the City of Midland

Table 4.3-41 compares demands to the supplies from the recommended water management strategies for the City of Midland. These include:

- Subordination,
- New groundwater development of the T-Bar Well Field,
- Voluntary redistribution from the CRMWD system and
- Municipal water conservation

Although Table 4.3-49 includes adjustments to supplies from subordination, the strategy would be implemented by CRMWD. A discussion of this strategy is included in Section 4.2.3. Note that water conservation may delay implementation or reduce the amount of water needed from other strategies. Because both the renewal of the 1966 Contract and the T-Bar Well Field are long-term strategies, the city can monitor demand reductions due to conservation and adjust the timing and supply from each project as needed before implementation of those strategies. Table 4.3-42 is a breakdown of expected costs for these strategies. Costs for subordination, which will be implemented by CRMWD, are not included in Table 4.3-42.

Table 4.3-41
Recommended Water Management Strategies for the City of Midland
(Values in Acre-Feet per Year)

Supplies	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
CRMWD 1966 Contract	12,136	12,202	0	0	0	0
Ivie Contract	10,925	10,669	10,473	10,246	10,021	9,795
Subordination Strategy [a]	4,656	6,113	-156	-266	-378	-490
Paul Davis Well Field	4,722	4,722	4,722	0	0	0
T-Bar Well Field	0	0	13,600	13,600	13,600	13,600
Voluntary Redistribution (purchase from CRMWD)	0	0	10,000	9,800	9,600	9,400
Total Supplies	32,439	33,706	38,639	33,380	32,843	32,305
Conservation	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Potential Savings [b]	930	2,320	2,903	3,110	3,310	3,521
Demands	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Midland	28,939	30,056	30,804	31,246	31,631	32,112
Outside Sales	49	52	55	58	60	63
Total Demand	*28,988*	*30,108*	*30,859*	*31,304*	*31,691*	*32,175*
Surplus (Need) without Conservation	*3,451*	*3,598*	*7,780*	*2,076*	*1,152*	*130*
Surplus (Need) with Conservation	*4,381*	*5,918*	*10,683*	*5,186*	*4,462*	*3,651*

a With implementation of the subordination strategy, near-term supplies are increased. Subordination decreases long-term supplies because of the reduced yield in Ivie Reservoir. See memorandum on subordination strategy for more detailed information.
b Does not include plumbing code savings, which are already included in the water demand projections.

Table 4.3-42
Costs of Water Management Strategies for the City of Midland

Strategy	Capital Cost	Annual Costs					
		2010	2020	2030	2040	2050	2060
T-Bar Well Field	$168,756,000			$19,384,500	$19,384,500	$4,664,800	$4,664,800
Voluntary Redistribution				$4,790,000	$4,694,200	$4,598,400	$4,502,600
Conservation		$602,091	$521,355	$517,031	$507,177	$492,061	$484,787
Total	*$168,756,000*	*$602,091*	*$521,355*	*$24,691,531*	*$24,585,877*	*$9,755,261*	*$9,652,187*

4.3.8 City of Coleman

Table 4.3-43 compares the supply and demand for the City of Coleman. The maximum expected demand for the city (including outside sales) is 1,542 acre-feet per year in 2010. Demand declines to 1,474 acre-feet in 2060 due to water conservation. Lake Coleman is the city's primary source of water. The city also obtains a small amount of supply from Hords Creek Reservoir. Without subordination to downstream water rights, the Colorado WAM shows no yield for either reservoir. .

Table 4.3-43
Comparison of Supply and Demand for the City of Coleman
(Values in Acre-Feet per Year)

Supply	2010	2020	2030	2040	2050	2060	Comments
Lake Coleman	0	0	0	0	0	0	WAM yield *
Hords Creek Reservoir	0	0	0	0	0	0	WAM yield *
Total	*0*	*0*	*0*	*0*	*0*	*0*	
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**Comments**
City of Coleman	1,285	1,269	1,252	1,235	1,223	1,223	
Municipal sales	251	253	250	244	243	245	Coleman Co WSC, etc.
Manufacturing Sales	6	6	6	6	6	6	
Total	*1,542*	*1,528*	*1,508*	*1,485*	*1,472*	*1,474*	
Surplus (Need)	*(1,542)*	*(1,528)*	*(1,508)*	*(1,485)*	*(1,472)*	*(1,474)*	

* Supplies from the Colorado WAM. With implementation of a subordination strategy, the combined supply from Lake Coleman and Hords Creek Reservoir is estimated to be 6,450 acre-feet per year in 2010, declining to 5,970 acre-feet per year in 2060.

Potentially Feasible Water Management Strategies

With subordination of downstream water rights, the City of Coleman has sufficient supply. Therefore other water management strategies, except for water conservation, are not necessary.

Subordination of Downstream Senior Water Rights

TWDB requires the use of the TCEQ WAM for regional water planning. In the Colorado WAM, most reservoirs in Region F with a priority date after 1926 do not have a firm or safe yield. The priority dates of Lake Coleman and Hords Creek Reservoir are August 25, 1958 and March 23, 1946, respectively, so the reservoirs have no yield. This result is largely due to the assumptions used in the Colorado WAM.

In order to address water availability issues resulting from the Colorado WAM model, Region F and the Lower Colorado Region (Region K) participated in a joint modeling effort to evaluate a strategy in which lower basin senior water rights do not make priority calls on major upstream water rights. This strategy also assumes that major water rights in Region F do not make priority calls on each other. Subsequent to the joint modeling effort, Region F conducted a study on the Pecan Bayou watershed to identify possible operating scenarios in this watershed. (A copy of this study is included in Appendix xx.) One scenario was selected for planning purposes, which is the basis of the water supplies for the subordination scenario in the Pecan Bayou watershed. The subordination strategy is described in Section 4.2.3. Table 4.3-44 is a summary of the impacts of the subordination strategy on the city's raw water supplies. Available supplies are limited by the city's existing infrastructure to 2,200 acre-feet per year.

Table 4.3-44
Impact of Subordination Strategy on City of Coleman Water Supplies [a]
(Values in acre-feet per year)

Reservoir	Priority Date	Permitted Diversion	2010 Supply WAM Run 3	2010 Supply with Subord-ination	2060 Supply WAM Run 3	2060 Supply with Subord-ination
Lake Coleman	8/25/1958	9,000	0	5,760	0	5,340
Hords Creek Reservoir	3/23/1946	2,240	0	690	0	630
Total [b]		*11,240*	*0*	*6,450*	*0*	*5,970*

a Water supply is defined as the safe yield of the reservoir.
b Actual supplies are limited to 2,200 acre-feet per year by treatment plant and delivery capacity.

The subordination modeling was conducted for planning purposes only. Neither Region F nor the Lower Colorado Region mandates the adoption of this strategy by individual water right holders. A subordination agreement is not within the authority of the Region F Water Planning

Group. Such an agreement must be developed by the water rights holders themselves, including the City of Coleman and Brown County WID.

Impacts of the subordination strategy are discussed in Section 4.2.3.

Water Conservation

Using the Region F suite of water conservation practices, it is estimated that the City of Coleman can reduce water demand by as much as 14 percent. Additional information on Region F recommended water conservation practices may be found in Appendix 4G

Region F recognizes that it has no authority to implement, enforce or regulate water conservation practices. The water conservation practices in this plan are guidelines. Region F considers water conservation strategies determined and implemented by the City of Coleman to supersede the recommendations in this plan and to meet regulatory requirements for consistency with this plan.

Quantity, Reliability and Cost of Water Conservation

Table 4.3-45 summarizes the estimated water savings and costs associated with the recommended Region F water conservation practices. Based on this evaluation, by 2060 up to 187 acre-feet of water per year could be saved, a reduction of more than 14 percent. Experience during the recent drought indicates that there may be even more opportunity for savings. The city has been under restrictions for much of the period since the year 2000 because of low lake levels. In 2006, the most recent year for which per capita water use data are available, the city had a per capita demand of 203 gpcd. The estimated per capita water demand in 2060 using the Region F criteria is 196 gpcd. The reliability of water conservation is considered to be medium due to the uncertainty of the long-term savings due to implementation of water conservation strategies.

Environmental Issues Associated with Water Conservation

Water conserved by the City of Coleman will most likely remain in Lake Coleman and Hords Creek Reservoir. Because these reservoirs spill infrequently, it is unlikely that conservation will contribute to environmental flow needs or increase over-bank flows. Other impacts are expected to be minimal.

Agricultural and Rural Issues Associated with Water Conservation

No agricultural issues have been identified for this strategy.

The City of Coleman is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources.

Other Natural Resource Issues Associated with Water Conservation

None identified.

Significant Issues Affecting Feasibility of Water Conservation

This strategy is based on a generalized assessment of water conservation practices and may not accurately reflect the actual costs or water savings that can be achieved by the City of Coleman. Site-specific data will be required for a better assessment of the potential for water conservation by the city. Technical assistance and funding by the state may be required to implement this strategy.

Other Water Management Strategies Directly Affected by Water Conservation

None identified.

Drought Management

The City of Coleman has effectively used drought management to control demand during times of drought. Strategies are specified in the city's water conservation and drought contingency plan. Region F has not identified additional drought management strategies for the City of Coleman.

Table 4.3-45
Estimated Water Conservation Savings by the City of Coleman [a]

Per Capita Demand (gpcd)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	177	229	229	229	229	229	229
Plumbing Code	Projections	177	226	223	220	217	215	215
	Savings	0	3	6	9	12	14	14
Region F Estimate	Projections	229 [b]	220	210	204	200	197	196
	Savings (Region F Practices)	0	6	13	16	17	18	19
	Savings (Total)	0	9	19	25	29	32	33
Water Demand (Ac-Ft/Yr)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	1,315	1,302	1,303	1,303	1,303	1,303	1,303
Plumbing Code	Projections	1,315	1,285	1,269	1,252	1,235	1,223	1,223
	Savings	0	17	34	51	68	80	80
Region F Estimate	Projections	1,315	1,252	1,194	1,162	1,140	1,122	1,116
	Savings (Region F Practices)	0	33	75	90	95	101	107
	Savings (Total)	0	50	109	141	163	181	187
Costs [c]								
Annual Costs			$8,719	$13,409	$13,337	$13,306	$13,246	$13,217
Cost per Acre-Foot			$264	$179	$148	$140	$131	$124
Cost per 1,000 Gal			$0.81	$0.55	$0.45	$0.43	$0.40	$0.38

a Costs and water saving are based on data from TWDB *Report 362 Water Conservation Task Force Water Conservation Best Management Practices Guide*, November 2004.
b The City of Coleman was under water use restriction in 2000. Base year 2000 demands were extrapolated from historical water use between 1995 and 1999.
c Costs for implementing Region F recommended practices. Costs of implementing plumbing code not included.

Recommended Strategies for the City of Coleman

Region F recommends water conservation and subordination of downstream water rights for the City of Coleman. Table 4.3-46 is a comparison of supply to demand with the recommended strategies in place. Table 4.3-47 summarizes the expected costs for these strategies.

Table 4.3-46
Recommended Water Management Strategies for the City of Coleman
(Values in Acre-Feet per Year)

Supplies	2010	2020	2030	2040	2050	2060
Lake Coleman	0	0	0	0	0	0
Hords Creek Reservoir	0	0	0	0	0	0
Subordination of downstream water rights [a]	2,200	2,200	2,200	2,200	2,200	2,200
Total	*2,200*	*2,200*	*2,200*	*2,200*	*2,200*	*2,200*
Conservation	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Potential savings [b]	33	75	90	95	101	107
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Coleman	1,285	1,269	1,252	1,235	1,223	1,223
Municipal sales	251	253	250	244	243	245
Manufacturing Sales	6	6	6	6	6	6
Total	*1,542*	*1,528*	*1,508*	*1,485*	*1,472*	*1,474*
Surplus (Need) without conservation	*658*	*672*	*692*	*715*	*728*	*726*
Surplus (Need) with conservation	*691*	*747*	*782*	*810*	*829*	*833*

a Limited by treatment and delivery capacity. The combined supply from Lake Coleman and Hords Creek Reservoir is estimated to be 6,450 acre-feet per year in 2010, declining to 5,970 acre-feet per year in 2060.
b Does not include plumbing code savings, which are already included in the water demand projections.

Table 4.3-47
Costs of Recommended Water Management Strategies for the City of Coleman

Strategy	Capital Costs	Annual Costs					
		2010	2020	2030	2040	2050	2060
Water Conservation		$8,719	$13,409	$13,337	$13,306	$13,246	$13,217
Total	*$0*	*$8,719*	*$13,409*	*$13,337*	*$13,306*	*$13,246*	*$13,217*

4.3.9 City of Brady

Table 4.3-48 compares the supply and demand for the City of Brady. The maximum expected demand for the city (including outside sales) is 2,108 acre-feet per year in 2020. Demand declines to 1,967 acre-feet in 2060 due to water conservation. The city obtains water from groundwater wells in the Hickory aquifer and surface water from Brady Creek Reservoir. To address water quality concerns, the city has constructed a 3.0 MGD filtration treatment plant for water from Brady Creek Reservoir. For purposes of this plan it is assumed that the City of

Brady obtains about 60 percent of its water from Brady Creek Reservoir and the remainder from groundwater. However, without subordination to downstream water rights, the Colorado WAM shows no yield for Brady Creek Reservoir, leaving the city with an unmet need.

Table 4.3-48
Comparison of Supply and Demand for the City of Brady
(Values in Acre-Feet per Year)

Supply	2010	2020	2030	2040	2050	2060	Comments
Brady Creek Reservoir	0	0	0	0	0	0	WAM yield *
Hickory aquifer	1,009	1,009	1,009	1,009	1,009	1,009	Half of maximum demand
Total	*1,009*	*1,009*	*1,009*	*1,009*	*1,009*	*1,009*	
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**Comments**
City of Brady	1,879	1,893	1,874	1,854	1,842	1,842	
Manufacturing Sales	125	125	125	125	125	125	
Total	*2,004*	*2,018*	*1,999*	*1,979*	*1,967*	*1,967*	
Surplus (Need)	*(995)*	*(1,009)*	*(990)*	*(970)*	*(958)*	*(958)*	

* Supplies from the Colorado WAM. With implementation of a subordination strategy, the supply from Brady Creek Reservoir is 2,170 acre-feet per year.

Potentially Feasible Water Management Strategies for the City of Brady

With subordination of downstream water rights, the City of Brady has excess supply. Therefore other water management strategies, except for water conservation, are not necessary.

Subordination of Downstream Senior Water Rights

TWDB requires the use of the TCEQ WAM for regional water planning. In the Colorado WAM, most reservoirs in Region F with a priority date after 1926 do not have a firm or safe yield. The priority date of Brady Creek Reservoir is September 2, 1959, so the reservoir has no yield. This result is largely due to the assumptions used in the Colorado WAM.

In order to address water availability issues resulting from the Colorado WAM model, Region F and the Lower Colorado Region (Region K) participated in a joint modeling effort to evaluate a strategy in which lower basin senior water rights do not make priority calls on major upstream water rights. This strategy also assumes that major water rights in Region F do not make priority calls on each other. The subordination strategy is discussed in Section 4.2.3. Table 4.3-49 is a summary of the impacts of the subordination strategy on the city's raw water supplies. The actual supply from the reservoir will be limited by the capacity of the new water treatment plant. For the purposes of this plan, the amount of water available from the reservoir is assumed to be 1,350 acre-feet per year.

Table 4.3-49
Impact of Subordination Strategy on City of Brady Water Supplies [a]
(Values in acre-feet per year)

Reservoir	Priority Date	Permitted Diversion	2010 Supply WAM Run 3	2010 Supply with Subord-ination	2060 Supply WAM Run 3	2060 Supply with Subord-ination
Brady Creek Reservoir	9/02/1959	3,500	0	2,170	0	2,170 [b]

a Water supply is defined as the safe yield of the reservoir. Actual supply to Brady is limited by treatment capacity.
b Although capacity of the reservoir is somewhat less in 2060, the safe yield is the same because fewer downstream senior water rights call on water from the reservoir.

The joint modeling between the two regions was conducted for planning purposes only. Neither Region F nor the Lower Colorado Region mandates the adoption of the subordination strategy by individual water right holders. A subordination agreement is not within the authority of the Region F Water Planning Group. Such an agreement must be developed by the water rights holders themselves, including the City of Brady.

Impacts of the subordination strategy are discussed in Section 4.2.3.

Water Conservation

Using the Region F suite of water conservation practices, it is estimated that the City of Brady can reduce water demand by as much as 17 percent. Additional information on Region F recommended water conservation practices may be found in Appendix 4G.

Region F recognizes that it has no authority to implement, enforce or regulate water conservation practices. The water conservation practices in this plan are guidelines. Region F considers water conservation strategies determined and implemented by the City of Brady to supersede the recommendations in this plan and to meet regulatory requirements for consistency with this plan.

Quantity, Reliability and Cost of Water Conservation

Table 4.3-50 summarizes the estimated water savings and costs associated with the recommended Region F water conservation practices. Based on this evaluation, by 2060 up to 328 acre-feet of water per year could be saved, a reduction of almost 17 percent. The city's experience during the recent drought indicates that more water could potentially be saved. In 2006, the most recent year for which per capita water use data are available, the city had a per capita demand of 236 gpcd. The estimated per capita water demand in 2060 using the Region F criteria is 251 gpcd. The reliability of water conservation is considered to be medium due to the uncertainty of the long-term savings due to implementation of water conservation strategies.

Environmental Issues Associated with Water Conservation

Most of the water used by the City of Brady is expected to come from Brady Creek Reservoir. Conserved water will remain in the reservoir, so there will be little if any impact on instream flows and over-banking flows.

Agricultural and Rural Issues Associated with Water Conservation

No agricultural issues have been identified for this strategy.

The City of Brady is a rural community. Like other water supply strategies, the cost of this strategy may have an adverse impact on the community's limited financial resources.

Other Natural Resource Issues Associated with Water Conservation

None identified.

Significant Issues Affecting Feasibility of Water Conservation

This strategy is based on a generalized assessment of water conservation practices and may not accurately reflect the actual costs or water savings that can be achieved by the City of Brady. Site-specific data will be required for a better assessment of the potential for water conservation by the city. Technical assistance and funding by the state may be required to implement this strategy.

Table 4.3-50
Estimated Water Conservation Savings by the City of Brady [a]

Per Capita Demand (gpcd)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	303	303	303	303	303	303	303
Plumbing Code	Projections	303	300	297	294	291	289	289
	Savings	0	3	6	9	12	14	14
Region F Estimate	Projections	303	287	267	260	256	253	251
	Savings (Region F Practices)	0	13	30	34	35	36	38
	Savings (Total)	0	16	36	43	47	50	52
Water Demand (Ac-Ft/Yr)								
		2000	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
No Conservation	Projections	1,875	1,898	1,931	1,931	1,931	1,931	1,931
Plumbing Code	Projections	1,875	1,879	1,893	1,874	1,854	1,842	1,842
	Savings	0	19	38	57	77	89	89
Region F Estimate	Projections	1,875	1,802	1,701	1,660	1,632	1,612	1,603
	Savings (Region F Practices)	0	77	192	214	222	230	239
	Savings (Total)	0	96	230	271	299	319	328
Costs [c]								
Annual Costs			$26,992	$31,776	$31,695	$31,660	$31,593	$31,561
Cost per Acre-Foot			$351	$166	$148	$143	$137	$132
Cost per 1,000 Gal			$1.08	$0.51	$0.45	$0.44	$0.42	$0.41

a Costs and water saving are based on data from TWDB *Report 362 Water Conservation Task Force Water Conservation Best Management Practices Guide*, November 2004.
b The City of Brady was under water use restriction in 2000. Base year 2000 demands were extrapolated from historical water use from 1997 to 1999.
c Costs for implementing Region F recommended practices. Costs of implementing plumbing code not included.

Other Water Management Strategies Directly Affected by Water Conservation

None identified.

Drought Management

The City of Brady has effectively used drought management to control demand during times of drought. Strategies are specified in the city's water conservation and drought contingency plan. Region F has not identified additional drought management strategies for the City of Brady.

Recommended Strategies for the City of Brady

Region F recommends water conservation and subordination of downstream water rights for the City of Brady. Since the new treatment plant is under construction, a strategy is not necessary. Table 4.3-51 is a comparison of supply to demand with the recommended strategies in place. Table 4.3-52 summarizes the expected costs for these strategies.

Table 4.3-51
Recommended Water Management Strategies for the City of Brady
(Values in Acre-Feet per Year)

Supplies	2010	2020	2030	2040	2050	2060
Brady Creek Reservoir	0	0	0	0	0	0
Hickory aquifer	1,009	1,009	1,009	1,009	1,009	1,009
Subordination of downstream water rights [a]	1,350	1,350	1,350	1,350	1,350	1,350
Total	*2,359*	*2,359*	*2,359*	*2,359*	*2,359*	*2,359*
Conservation	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Potential savings [b]	77	192	214	222	230	239
Demand	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
City of Brady	1,879	1,893	1,874	1,854	1,842	1,842
Manufacturing Sales	125	125	125	125	125	125
Total	*2,004*	*2,018*	*1,999*	*1,979*	*1,967*	*1,967*
Surplus (Need) without conservation	*355*	*341*	*360*	*380*	*392*	*392*
Surplus (Need) with conservation	*432*	*533*	*574*	*602*	*622*	*631*

a Limited by treatment and delivery capacity of the water treatment plant.
b Does not include plumbing code savings, which are already included in the water demand projections.

Table 4.3-52
Costs of Recommended Water Management Strategies for the City of Brady

Strategy	Capital Costs	Annual Costs					
		2010	2020	2030	2040	2050	2060
Water Conservation		$26,992	$31,776	$31,695	$31,660	$31,593	$31,561
Total	*$0*	*$26,992*	*$31,776*	*$31,695*	*$31,660*	*$31,593*	*$31,561*

4.3.10 Strategies for Hickory Aquifer Users

Among the needs identified in previous regional water plans was a water shortage resulting from new EPA regulations limiting the permissible amount of radionuclides in drinking water. Some of the Hickory aquifer wells produce water with radionuclide concentrations that exceed the maximum concentration limits (MCLs) for drinking water. Water suppliers currently relying on these wells will need to implement water management strategies that will allow them to continue to serve their customers. The following sections describe these water suppliers, the regulatory framework, and the potential water management strategies.

In the 2001 Region F Plan, water management strategies were evaluated for public water suppliers that were using the Hickory aquifer as a major or as a sole water source. This included public water supplies in McCulloch and Concho Counties, and in portions of Runnels and Tom Green Counties. Treatment to remove radionuclides was considered infeasible due to a lack of options for disposal of treatment residuals. In the 2001 Region F plan, the lack of treatment alternatives effectively eliminated the consideration of the Hickory aquifer as a primary drinking water source after the year 2010. A regional approach to obtaining alternative water supplies was considered in the 2001 Region F plan, but all of the identified strategies were expensive and the smaller communities affected by the radionuclides rule did not opt for a regional strategy.

Further evaluation of water management strategies for Hickory aquifer users was undertaken for the 2006 *Region F Regional Water Plan*. Each of the affected public water suppliers was contacted in order to update the status of each regarding Hickory aquifer usage. Since the 2001 plan, TCEQ has implemented a regular testing program of Hickory aquifer users, providing additional water quality data for each system. The current status of drinking water and waste disposal regulations as related to radionuclides was investigated. For selected water suppliers, specific water management strategies were identified and evaluated.

These strategies were reviewed and updated based on current activities of Hickory water users and updates to the regulations. This section presents these findings. A description of the Hickory aquifer may be found in Chapter 3 of this plan.

Hickory Aquifer Water User Groups

The municipal wells in Region F with radionuclide levels exceeding drinking water limits are located in Concho and McCulloch Counties. Nine public water suppliers currently rely on the Hickory aquifer as a supply source. The demands for City of Brady, the Millersview-Doole Water Supply Corporation (MDWSC), the City of Eden and the Richland Special Utility District (Richland SUD) are listed in Table 4.3-53. These four entities are classified as Water User Groups (WUGs). The remaining Hickory water suppliers are Rochelle WSC, Lakeland Services, Inc., the City of Melvin, Lohn WSC and Live Oak Hills Subdivision. The demands for these small water suppliers are aggregated as McCulloch County Other. The demand for this category is underestimated because the approved TWDB population projections for the County Other category are low. In addition there are other potential future users of the Hickory aquifer, including the City of Menard.

Table 4.3-53
Hickory Water Suppliers

Public Water System	**Average Annual Demand** (acre-feet per year)
City of Brady	1,009
Millersview-Doole WSC	524
City of Eden	572
Richland SUD	207 [a]
McCulloch County Other	12 [b]

a TWDB approved projections are 113 acre-feet per year. However, TWDB projections do not include water used for livestock or other purposes. Richland SUD expects demands to be closer to 207 acre-feet per year.
b Demands for McCulloch County Other are underestimated because TWDB approved population projections for this category are low.

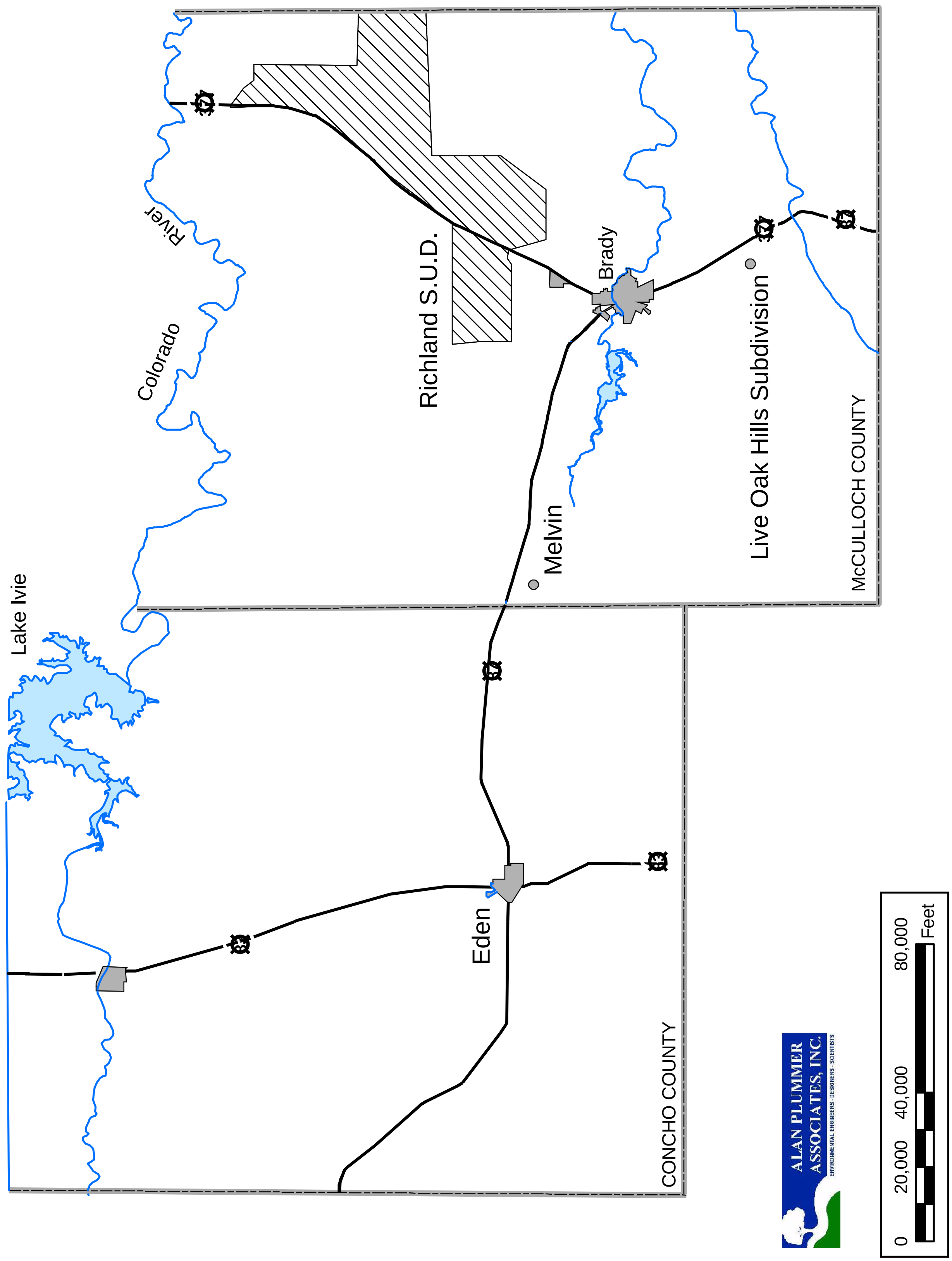
Two of the larger Hickory water suppliers, the City of Brady and MDWSC, have both recently implemented strategies that enable them to reduce their reliance on Hickory water and comply with the MCLs for radionuclides. The City of Brady has constructed a 3.0 MGD plant utilizing microfiltration and reverse osmosis (RO) to treat water from the Brady Creek Reservoir and blend it with groundwater from the Hickory aquifer such that the MCLs for radionuclides are not exceeded. The plant will initially operate at 1.5 MGD.[9] Lakeland Services, Inc. is supplied by the City of Brady.[10] MDWSC is constructing a 3.0 MGD plant that will treat water from Lake Ivie, using treatment processes similar to those at the Brady plant and will blend treated surface water with Hickory groundwater. The construction of the Lake Ivie treatment plant should be complete and operational by 2010. The City of Eden has obtained funding to construct a reverse osmosis water treatment facility to treat Hickory Aquifer water. The treated water will comply with the MCL for radionuclides.

Several of the water suppliers expect to be able to comply with the radionuclides rule without having to treat the Hickory groundwater. Rochelle WSC recently began utilizing a new Hickory well that does not have levels of radionuclides that exceed the drinking water limits. They expect to rely on the new well and reduce or eliminate use of the older well. Lohn WSC also reports radionuclides levels that are under the drinking water standard.[11]

The communities that will continue to utilize the Hickory aquifer as a sole or major source of water serve a combined population of less than 10,000 persons. These communities include Richland SUD, the City of Melvin and Live Oak Hills Subdivision. Due to the long transmission distances required, these communities have not opted to join with a larger service provider. Figure 4.3-3 shows the locations of these water suppliers.

Radionuclides and the Hickory Aquifer Users

Communities that continue to rely on Hickory aquifer water wells where radionuclide concentrations exceed the drinking water standards will soon be required to comply with the EPA/TCEQ rules. EPA is concerned that the radionuclides pose a health threat when routinely ingested over a long period of time. The original rules implementing the Safe Water Drinking Act contained maximum concentration limits (MCLs) for radionuclides, but, until recently, the limits were not enforced and water suppliers were not required to treat for radionuclides. In December 2000, EPA published the Radionuclides Rule, retaining the MCLs for combined radium-226 and radium-228, gross alpha particle radioactivity, and beta particle and photon activity. The rule also regulates uranium for the first time.[12] In December 2004, TCEQ amended its rules to implement the EPA radionuclides rule as part of the state's drinking water program (TAC Rule §290.108).[13] The federal and state MCLs for radionuclides are listed in Table 4.3-54. Compliance determinations are based on a running average annual MCL. In some areas,



ALAN PLUMMER ASSOCIATES, INC.
ENVIRONMENTAL ENGINEERS · DESIGNERS · SCIENTISTS

Area of Evaluation for Hickory Users	FN JOB NO
	FILE
	DATE July 22, 2005
	SCALE
	DESIGNED CCL
	DRAFTED

FIGURE 4.3-3

Hickory aquifer water contains radium and gross alpha particle activity. Neither beta/photon emitters nor uranium have been shown to be a problem in the Hickory aquifer.

Table 4.3-54
MCLs for Regulated Radionuclide Contaminants

Contaminant	MCL
Beta/photon emitters	4 mrem/yr
Gross alpha particle activity	15 pCi/L
Combined radium-226/228	5 pCi/L
Uranium	30 μg/L

EPA expects the implementation of the radionuclides rule to reduce the risk of cancer for affected citizens. Many of the Hickory aquifer users in Region F, however, question the assertion that their drinking water increases cancer risk. Anecdotally, residents compare themselves to populations in other areas and see no cause for alarm, in spite of having used Hickory groundwater for their entire lives. A cluster cancer investigation was conducted by the Texas Cancer Registry of the Texas Department of Health (TDH), analyzing incidence and mortality data from the early 1990's through 2001 over a four-county area of Hickory groundwater consumption.[14] The study showed that cancer incidence and mortality in the area were within ranges comparable to the rest of the state. The Texas Radiation Advisory Board has also expressed concern that the EPA rules are unwarranted and unsupported by epidemiological public health data. They describe the rules as relying on models of health impacts which have not been validated.[15]

The affected communities in Region F are also greatly concerned about the costs of compliance with the radionuclides rule. EPA estimates that the 795 water systems nationwide affected by the radionuclides rule will incur a combined annual cost of $81 million to comply with the rules, an average of about $100,000 per system.[16] TCEQ also included cost estimates in the publication of its rules, estimating that large water systems would face increases of less than $3 per household per month, while typical small water systems, serving less than 10,000 persons, would have to charge customers between $4 and $9 extra per month to comply with the radionuclide standard.[17] TCEQ is continuing to study the potential economic impacts on small communities struggling to comply with the December 2004 TCEQ drinking water amendments, and is funding a comprehensive study of drinking water compliance issues and costs for small communities.[18]

Potentially Feasible Water Management Strategies

As previously described, three water suppliers in Region F currently have no expectation of being able to develop a water source where the radionuclide levels are under the drinking water MCLs. Richland SUD serves a rural area encompassing 330 miles of transmission lines serving 382 households and a population of 764. The City of Melvin has a population of 155 on 127 meter connections. Live Oak Hills Subdivision serves a population of 75 and has 33 connections.

Richland SUD provides water to a relatively small number of rural customers spread over a large area. The system has over 330 miles of pipeline. Most of the water provided by the system is used for livestock. According to representatives of Richland SUD, only 0.5 percent of the water supplied by the system is actually used for potable purposes[19]. The system losses are relatively high, averaging 32 percent for the year 2004.[20] Losses include water used for flushing as required by TCEQ. In order to recoup production expenses, Richland SUD needs to charge customers $1.47 for every dollar spent to produce water. Also, Richland SUD does not operate, or have access to, a wastewater treatment system to handle the residuals that would be generated by some treatment processes. Lastly, the Richland SUD wells have some of the highest reported radium levels in the area. The higher concentrations in the raw water would result in higher radium concentrations in the treatment residuals than would be expected from other Hickory aquifer users. Thus, Richland SUD has a number of characteristics that limit the feasibility of implementing a treatment system for removal of radionuclides.

The City of Melvin and the Live Oak Hills Subdivision are both very small communities that do not have the financial resources or staffing to implement water treatment systems. Annual income for water services at Live Oak Hills Subdivision is only about $5,000 per year.[21] Like Richland SUD, these communities also do not operate wastewater collection and treatment systems. Thus, disposal of liquid residuals from water treatment processes would require considerable expense and permitting effort.

Water management strategies have been identified and evaluated for each of these four water suppliers. Other communities who may later find that their source water exceeds the MCLs for radionuclides should be able to implement similar strategies. The strategies that were evaluated include well replacement, advanced treatment processes, specialty media treatment options, treatment at point-of-entry or point-of-use, several configurations of bottled water options, and a no-action alternative. The well replacement strategy is necessary to sustain the water supply currently provided by a well that is beyond its service life. The other types of strategies identified for the Hickory aquifer users represent very different responses to the EPA/TCEQ radionuclides rule. The first type of strategy is to comply by treating all of the water supply for the water supplier (advanced treatment alternatives). The second option involves treating all or a portion of the water supply at the point where water reaches the customer (point-of-entry/point-of-use alternative). In the third strategy, the water supplier treats only the portion of its water supply that is used for human consumption or imports enough water to ensure a sufficient drinking water supply (bottled water alternative). The last strategy would include a decision by the water supplier to simply not comply with the radionuclides rule (no-action alternative). These alternatives are described in further detail in the following sections.

Well Replacement

The first recommended strategy is replacement of existing Hickory wells owned by the City of Eden and Richland SUD. The City of Eden needs to replace the city's older Hickory wells to ensure a continued adequate supply for the city. The proposed well is estimated at a depth of 4,200 feet, with an estimated maximum production of 300 gpm and an average of 200 gpm. Operation and maintenance costs are based on average production rates.

Richland SUD has been investigating areas of the Hickory aquifer that may have lower radionuclide concentrations. If a low-radium location can be found, Richland SUD will convert most of its supply to the replacement well.

Quantity, Reliability and Cost of Well Replacement

A replacement Hickory aquifer well could provide up to 322 acre-feet of water per year. This source is considered very reliable. Table 4.3-55 summarizes the expected costs for the City of Eden and Table 4.3-56 summarizes the expected costs for Richland SUD.

Table 4.3-55
Costs for Replacement Hickory Well for the City of Eden

Supply from Strategy	323 acre-feet per year
Total Capital Costs	$ 1,800,000
Annual Costs	$ 359,000
Additional Unit Costs (before amortization)	$ 1,113 per acre-foot
	$ 3.42 per 1,000 gallons
Additional Unit Costs (after amortization)	$ 626 per acre-foot
	$ 1.92 per 1,000 gallons

Table 4.3-56
Costs for Replacement Hickory Well for Richland SUD

Supply from Strategy	113 acre-feet per year
Total Capital Costs	$ 1,700,979
Annual Costs	$ 224,000
Additional Unit Costs (before amortization)	$ 1,982 per acre-foot
	$ 6.08 per 1,000 gallons
Additional Unit Costs (after amortization)	$ 673 per acre-foot
	$ 2.06 per 1,000 gallons

Environmental Issues Associated with Well Replacement

The proposed wells will produce water from the down-dip portion of the Hickory aquifer. Because of the over 4,000 feet of overburden, there is no interconnectedness with the land surface and, therefore, there would be no impact on springs or surface water sources. Subsidence would also not be a factor due to the depth of the source and the competency of the overburden. Therefore environmental impacts are expected to be minimal.

Based on the available data, it is unlikely that pumping limits other than those already imposed by the Hickory Underground Water Conservation District will be required to protect the environment.

Agricultural and Rural Issues Associated with Well Replacement

Currently, no water from the Hickory aquifer is used for irrigation in Concho County. The new well will allow the City of Eden to continue furnishing financial, educational, medical, public safety, and agricultural services. Without these services, agriculture will suffer an increase in cost of doing business, a decrease in productivity, and loss of services that contribute to its overall well-being and safety. As a rural community, drilling a new well represents a significant burden on the public and private economic resources.

Although the Hickory aquifer is used for irrigation in McCulloch County, it is likely that the replacement well for Richland SUD will be located in an area downdip of the agricultural users. Richland SUD provides drinking water to rural residents in McCulloch County, as well as much of the water used for livestock in the area. Therefore, it this strategy should have a positive impact on the rural areas of the county.

Other Natural Resource Issues Associated with Well Replacement

Because these wells will replace existing wells, aquifer withdrawals are not expected to significantly exceed current levels.

Significant Issues Affecting Feasibility of Well Replacement

The primary issue affecting feasibility is funding of the replacement wells. As small communities, the City of Eden and Richland SUD have limited resources available for infrastructure improvements. Furthermore, in order to receive funding the City of Eden may need to agree to treat the water to remove radionuclides. The combined costs of advanced treatment plus new wells could raise the average monthly bill per household in the City of Eden to as much as $65.00 per month. To fund both the well and treatment facility will expend public and private money needed for other services such as education, community health, public safety, streets, wastewater treatment, and recreation. The city is classified as economically disadvantaged.

Other Water Management Strategies Directly Affected by Well Replacement

Other strategies for the City of Eden and Richland SUD will be dependent on the production levels and the radium concentrations in the new wells.

Advanced Treatment Alternatives

Several treatment technologies effectively remove radionuclides from water. Radium and gross alpha particle activity are the two radionuclide contaminants that are of concern in the Hickory aquifer wells. Gross alpha particle activity is an indirect measure for radionuclides, measuring the alpha radiation generated by source contaminants. EPA recommends cation exchange (CAX), reverse osmosis (RO), and specialty media as effective technologies for radium removal for small communities. For removal of gross alpha particle activity, the recommended EPA “best available technology” is limited to RO. However, one EPA expert has stated that if radium is the generator of the gross alpha particle activity, then effective radium removal will also reduce the gross alpha particle activity.[22] For well sources where gross alpha particle activity exceeds the MCL, pilot tests would have to be conducted to assess the effectiveness of treatment processes other than RO.

CAX and RO are both considered advanced treatment processes, beyond what has been historically required to enable a water supplier to produce water that complies with the MCLs. CAX is commonly used to remove the hardness minerals, calcium and magnesium, but will also effectively remove radium. RO involves forcing the water under pressure through very fine membranes that prevent passage of contaminants. Both processes produce a brine waste stream, though their characteristics vary. RO typically produces a continuous waste stream consisting of about 15-25 percent of the influent flow quantity. CAX resins must be periodically regenerated, and therefore the waste stream is typically both saline and highly concentrated. The waste stream typically constitutes approximately 5-15 percent of the influent flow. It should also be noted that radium adsorption sites on the CAX resins are not easily regenerated, reducing the ion exchange capacity of the media over time, and ultimately increasing the frequency of resin replacement. However, because radium concentrations are typically very small (10^{-8} mg/L or less) in terms of the amount of mass present, this effect is not pronounced.

Brine with radium concentrations exceeding 60 pCi/L of either radium-226 or radium-228 may require handling as a low-level radioactive waste and may not be discharged to the environment.[23] Therefore, CAX and RO treatment are only cost-effective in situations where there is a waste stream that the brine can be blended into, such that radium concentrations do not exceed the stated discharge limits. Discharges to a sanitary sewer system may not have radium concentrations exceeding 600 pCi/L and must not adversely affect the ability of the wastewater treatment plant to meet its effluent limits.

Specialty Media Treatment Systems

Specialty media are designed to preferentially remove particular contaminants. Media that specifically target radium are not as sensitive to competing contaminants as standard media, thus enabling longer use before replacement is required. The disadvantage of a longer life cycle is that radium may build up to high concentration levels before the media replacement is needed, requiring operational precautions for workers who routinely inspect and maintain the water supply system. Specialty media are much more expensive than standard filtration or CAX media. A spent medium typically must be disposed as a low-level radioactive waste.

One specialty media considered for implementation in Region F has been developed and licensed by Water Remediation Technologies, LLC (WRT). The WRT system has been shown to effectively reduce both radium and gross alpha particle activity by capturing the radium on the media. TWDB funded a pilot test of the WRT system for Richland SUD from December 2003 to April 2004. From this study, Richland SUD concluded that the WRT system will successfully treat the water from Richland's well to EPA drinking water standards.[14] WRT would maintain ownership of its system and would be responsible for media replacement and disposal. The company is currently seeking to license an injection well in west Texas, where they would be able to dispose of the spent media in a slurried form.[24]

Quantity, Reliability and Cost of Specialty Media Systems

WRT has provided a proposal to Richland SUD to treat water at a cost of $0.85 per 1,000 gallons. Costs for other specialty media systems are assumed to be similar. At a cost of $0.85 per 1000 gallons, Richland SUD would need to charge about $1.25 per 1000 gallons sold, because of the high transmission losses. In addition to the WRT fees, Richland SUD would be required to provide a facility to house the WRT equipment, connection of the treatment facility Richland SUD's distribution system, and the electricity required to power the equipment.[25] The proposed WRT system would be sized to provide radium removal for all of the water pumped from Richland SUD's existing well. The projected costs are shown in Table 4.3-57.

Table 4.3-57
Specialty Media Treatment System for Richland SUD

Supply from Strategy	113 acre-feet per year
Total Capital Costs	$80,400
Annual Costs for Treatment	$93,800
Unit Costs to be added to Water Rates	$892 per acre-foot
	$2.74 per 1,000 gallons

WRT could also be implemented at Melvin's well, but the per-unit cost is likely to be higher than at Richland because there are a number of fixed costs associated with the system that would not scale down for the lower production at Melvin. The City of Melvin has only about 10 percent of the demand at Richland SUD. Based on an assumption that the per-unit cost would be twice as high for Melvin as compared to Richland SUD, the annual cost for Melvin to implement a specialized media technology is $35,000, or about $24 per residential connection per month.

Environmental Issues Associated with Specialty Media Systems

This treatment technology results in a build-up of radium concentrations in the media over the course of its useful life. Accidental release of the highly concentrated radium to the environment is possible if security systems fail or if there is an accident during transport of the spent media to a regulated disposal site.

Agricultural and Rural Issues Associated with Specialty Media Systems

Richland SUD and the City of Melvin are located in a rural area and their customers include ranchers and seasonal hunters. The expense of specialty media treatment may cause some customers to revert to the use of stock ponds or shallow wells for household and livestock water increasing the potential for human and livestock diseases.

Other Natural Resource Issues Associated with Specialty Media Systems

None identified.

Significant Issues Affecting Feasibility of Specialty Media Systems

Suppliers of specialty media, such as WRT, typically require a long-term contract and a minimum guaranteed payment from communities. For rural areas that do not anticipate significant growth in the future, the communities could be legally obligated to pay for more water treatment than they need. Loss of revenues as users conserve water because of high water costs is another concern. Additionally, communities are concerned about the feasibility of providing adequate security and worker safety for the treatment system. The increased costs to customers may result in a decrease in water sales, potentially causing financial difficulties for the community's water system.

Other Water Management Strategies Directly Affected by Specialty Media Systems

The long-term contracts required for implementation of specialty media could inhibit the flexibility of communities to implement more cost-effective strategies that may become available in the future.

Point-of-Entry/Point-of-Use Alternatives

Because of the expense of advanced treatment, EPA allows an option for small community water suppliers to implement point-of-entry or point-of-use treatment for its customers. Point-of-entry (POE) refers to treatment of the water supply for a residence or business at the point where the water enters. The most typical example of this is home water softeners. Point-of-use (POU) devices are most often installed under a kitchen sink and treat only the water at the kitchen tap. EPA rules require that the water supplier own, maintain, inspect and test all of the POE/POU devices within its system. One hundred percent customer participation is required.[26] The POE/POU strategy has several pitfalls. The most obvious obstacle to a POU/POE strategy is the private property access required for a WUG to fulfill the EPA requirements. Maintenance and testing at levels acceptable to the EPA and TCEQ represent a significant investment in time and personnel for small systems. TCEQ has indicated that each home needs to be tested at least once every three years.[12] The TDH Laboratory lists the current fees for drinking water 226 and 228 radium tests at $66 and $94 respectively.[27]

Quantity, Reliability and Cost of POE/POU

EPA has strict guidelines for implementation of POE/POU options, aimed at ensuring reliable treatment of drinking water for all customers. POE/POU strategies do not affect the reliability of the quantity of water, but these systems may not provide the reliability of water quality that an advanced treatment system provides.

For Richland SUD, the City of Melvin and Live Oak Hills Subdivision, POE/POU options are potential strategies for complying with the radionuclides rule. POE/POU treatment provides an acceptable means of handling treatment residuals because single-family septic systems are exempt from the regulations applicable to disposal of radionuclide waste products.

The EPA has developed a small system cost calculator[28] with their report using standard costs developed from the case studies included in *Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems*[29]. The calculator can be set to reflect the size of a system, the treatment type, and the contaminant of interest. Technologies in this calculator are limited to those identified by EPA for treatment of the contaminant by small systems.

One of the issues facing rural systems in Region F is the treatment of radionuclides. Treatment options for radium 226 and radium 228 include ion exchange, reverse osmosis and lime softening. However, the EPA cost calculator only has options for reverse osmosis for POU applications and cation exchange for POE applications. Three entities facing radium compliance issues, Richland SUD, the City of Melvin, and Live Oak Hills, were selected as examples using the EPA cost calculator.

Using the EPA created small system cost calculator for Richland SUD, the City of Melvin, and Live Oak Hills subdivision, the costs for POU treatment were estimated. Table 4.3-58 shows results for RO POU for these three entities, and Table 4.3-59 shows the same information for POE treatment using cation exchange. Each table shows the number of connections for each system, the cost per connection, total capital costs, the annual operation and maintenance costs and the total annual costs including the capital costs annualized over 10 years.

Table 4.3-58
Total Costs for POU Treatment using Reverse Osmosis

Entity	# Connections	$/Connection	$/1,000 gal	Total Capital Costs	Annual O&M Costs	Total Annual Costs
Richland SUD	382	$378.64	$4.56	$379,757	$90,571	$144,640
City of Melvin	127	$381.26	$4.59	$126,676	$30,385	$48,420
Live Oak Hills Subdivision	33	$402.40	$4.85	$34,928	$8,306	$13,279

Table 4.3-59
Total Costs for POE Treatment

Entity	# Connections	$/Connection	$/1,000 gal	Total Capital Costs	Annual O&M Costs	Annual Costs
Richland SUD	382	$403.45	$4.86	$595,684	$69,307	$154,119
City of Melvin	127	$239.25	$4.89	$198,463	$23,315	$51,572
Live Oak Hills Subdivision	33	$428.48	$5.16	$53,876	$6,469	$14,140

POE costs are higher than the cost of POU treatment. This is because POE treatment treats all water used in a building, while POU focuses primarily on water used for human consumption.

Table 4.3-60 compares the operation and maintenance costs for POU RO treatment to the annual budget for treatment provided by these entities in the Rural Systems Study survey. In every case the current budget is significantly less than the estimated costs for POE/POU treatment.

Table 4.3-60
Cost Comparison of Current Treatment to POU

Entity	Current Annual Costs	Annual O&M Costs (POU)
Richland SUD	$10,489	$90,571
City of Melvin	$5,000	$30,385
Live Oak Hills Subdivision	$300	$8,306

In its response to the Rural Systems Study survey, Richland SUD indicated the potential of using the Water Remediation Technology (WRT) removal system, a centralized system for treating Radium 226 and 228 at the water treatment facility. The WRT removal system will cost about $0.78/1000 gallons per year or $39,000 per year. The WRT treatment strategy is half the cost for operating and maintaining a POU system.

Environmental Issues Associated with POE/POU

The potential groundwater impacts of long-term disposal of naturally occurring radionuclides through septic systems have not been studied.

Agricultural and Rural Issues Associated with POE/POU

POE/POU systems that would require periodic access to private property are unlikely to be acceptable to residents in rural areas such as are served by Richland SUD, the City of Melvin and Live Oak Hills Subdivision. The high costs associated with POE/POU systems would impose an economic burden on these rural communities.

Other Natural Resource Issues Associated with POE/POU

None Identified

Significant Issues Affecting Feasibility of POE/POU

POU/POE options cannot be recommended as a strategy because of access, cost, and liability uncertainties. The strategy requires full participation by all customers of a water system. NRWA is recommending that EPA modify the regulations for POE/POU to make the implementation of these strategies more economical for small communities.[22]

Other Water Management Strategies Directly Affected by POE/POU

The implementation of POE/POU strategies requires a large initial investment that would likely preclude adoption of an advanced treatment or bottled water strategy.

Bottled Water Alternatives

Another water management strategy considered for Region F Hickory aquifer users is bottled water. Although not presently allowed by EPA as a compliance option, bottled water is allowed on a "temporary basis" to avoid "unreasonable health risks". Some cities in Texas have provided bottled water in cases where the water supply concentrations of fluoride or nitrates exceed levels considered safe for certain segments of the population. These systems have been set up under bilateral compliance agreements, meaning that the water suppliers are not considered to be in compliance with regulations, but have implemented a temporarily acceptable alternative strategy. Regulators from several states are currently lobbying EPA for inclusion of a bottled water compliance option. This option may be limited to home delivery of bottled water.[12]

A different approach to provision of bottled water is supplying drinking water at a central location for customer self-bottling. The City of Andrews has used a bottled water strategy for the past 12 years to supply customers with drinking water that has been treated to remove fluorides. The treatment equipment is installed in a building, but the tap is external and is thus always accessible to customers. Citizens bring their own 1- to 5-gallon containers to refill and are allowed up to 10 gallons per day. Andrews supplies an average of 1,000 gpd of bottled water to its customers.[30] Water suppliers lacking the personnel or expertise to set up treatment facilities could contract for water brought by truck or distributed at commercial water kiosks.

Bottled water strategies would be implemented only as a temporary option, pending the following future developments:

- More definitive rules regarding disposal options for radionuclide treatment residuals: The EPA and TCEQ regulations and guidance for disposal of residuals from radionuclide drinking water treatment processes remains unclear. A new EPA guidance document is due to be published later this year.
- Development of less expensive technologies for radium removal
- Further study by EPA and TCEQ of treatment options and associated costs for small community compliance with the drinking water standards. TCEQ currently has a study underway addressing these issues.
- Possible modification of the EPA rules regarding POE/POU and/or bottled water options, as has been suggested by the NRWA.

Hopefully, these future changes will enable small communities to move forward with more certainty in making the large investments that are likely to be required to enable long-term compliance with the drinking water standards.

Quantity, Reliability and Costs of Bottled Water Alternative for Richland SUD, Melvin and Live Oak Hills

Because of the high costs and uncertain regulatory implications of alternative strategies, the recommended temporary strategy for Richland SUD, along with the City of Melvin, and Live Oak Hills Subdivision, is to set up a self-service bottled water supply point within the City of Brady where customers of these utilities can obtain tap water that meets the MCLs. Each supplier would decide whether or not to implement this strategy, but costs can be reduced by implementing a cooperative system. The customers of these three utilities typically make trips to

Brady at least weekly for shopping or other business and could obtain water during those trips. One possible location for delivery is the office of the Hickory Underground Water Conservation District No. 1 (HUWCD). It is also possible that an arrangement could be made for citizens to obtain water at other locations in Brady. The estimated costs associated with this strategy include $10,000 in annual administrative costs, plus $1,200 per year for purchase of water from the City of Brady. Some initial expenses for plumbing reconfiguration may also be incurred. Combined expenses for the system would be distributed among the three utilities relative to the expected water usage. The estimated system costs are summarized in Table 4.3-61.

Table 4.3-61
Bottled Water System Costs for Richland SUD, Melvin and Live Oak Hills

Supply from Strategy	0.5 acre-feet per year
Annual Costs	$13,400
Unit Costs to be added to Water Rates	$26,800 per acre-foot
	$82 per 1,000 gallons

Environmental Issues of Bottled Water Alternatives

Impacts of small scale bottled water treatment systems are expected to be minimal.

Agricultural and Rural Issues Associated with Bottled Water Alternatives

Self-serve bottled water will not be as convenient for rural customers as for urban customers. However, as rural communities that serve the area, the low cost of implementation could reserve public and private funds for other uses such as improving educational and medical facilities, providing public safety such as fire protection, and promoting economic development leading to an increase of products and services needed in agriculture and rural communities..

Other Natural Resource Issues Associated with Bottled Water Alternatives

None identified.

Significant Issues Affecting Feasibility of Bottled Water Alternatives

The TCEQ regulatory procedures for setting up a bottled water system as a means of providing low-radium water to customers have not yet been established. The specific requirements for this type of system remain uncertain.

Other Water Management Strategies Directly Affected by Bottled Water Alternatives

Bottled water systems would be set up as a temporary strategy, allowing water suppliers to remain flexible regarding future options. Technology developments, regulatory changes, and availability of funding may change in future years to make other strategies more feasible for these small water suppliers.

No-Action Alternative

Another approach considered for the Hickory aquifer users is a "no action" alternative. This alternative does not bring the water supplier into compliance with TCEQ drinking water rules. However, representatives of some of the supplier utilizing the Hickory aquifer have expressed concern that the questionable health benefits of compliance with the radionuclides rule do not justify the high costs that their customers will be forced to bear. In fact, some have argued that the significant increase in water cost resulting from the implementation of any alternative to reduce radionuclides may force some of their customers to revert to using stock ponds or shallow wells that have a greater likelihood of containing pollutants that pose a serious health risk.

A cluster cancer investigation was conducted by the Texas Cancer Registry of the Texas Department of Health and found that the cancer incidence and mortality in the area were within ranges comparable to the rest of the state[31]. The Texas Radiation Advisory Board also expressed concern that the EPA rules are unsupported by epidemiological public health data[32]. Additional information may be found in Appendix 4J.

Environmental Issues of No Action Alternative

The no-action alternative would have no environmental impacts that differ from current practices. Furthermore, any environmental consequences of disposal of concentrated brine reject will be eliminated.

Agricultural and Rural Issues Associated with No Action Alternative

The lack of compliance with drinking water regulations could have negative impacts on the economic development in this area. It may be difficult for the area to attract new industries if the water supply does not meet drinking water standards. On the other hand, the adverse impact of the high cost of advanced treatment will tie up the area's limited financial resources that could be used for other purposes such as improving educational and medical facilities, providing public safety such as fire protection, and promoting economic development leading to an increase of products and services needed in agriculture and rural communities..

Other Natural Resources Issues Associated with No Action Alternative

None identified.

Significant Issues Affecting Feasibility of No Action Alternative

Water suppliers choosing a no-action alternative would face fines or penalties, or other legal action. Private-action lawsuits are also possible. There could be repercussions for funding of state or federal projects.

Other Water Management Strategies Affected by No Action Alternative

The no-action alternative is only a response to the radionuclides rule and does not impact water management strategies that may be necessary to increase or to ensure water supplies.

Hickory Strategy Summary

Potential water management strategies considered for Hickory aquifer users are listed in Table 4.3-62. Table 4.3-64 provides a summary of the issues associated with each type of strategy.

Table 4.3-62
Strategy Evaluation Matrix for Hickory Aquifer Users

Strategy	Eden	Richland SUD	Melvin	Live Oak Hills
Cation Exchange (CAX)				
Reverse Osmosis (RO)	X			
Specialized Media (e.g. WRT)		X	X	
POE/POU (CAX)		X	X	X
Bottled Water – Central Location		X	X	X
No Action		X	X	X

Recommended Strategies for Hickory Aquifer Users

For each of these four water suppliers, the potential water management strategies involve significant uncertainties regarding costs and regulations. Regulatory uncertainty about disposal options for treatment residuals and the potential economic impact of treatment on rural Texas continue to inhibit implementation of compliance strategies. The more innovative options of

POE/POU do not yet have clearly defined requirements for operation, maintenance and testing. Although EPA is being lobbied to include bottled water as a compliance strategy, this option has not yet been defined in that manner. The current regulatory environment is not conducive to the implementation of strategies that would allow these small community water systems to comply with the radionuclides rule. Thus, the bottled water strategies are recommended as a temporary measure until conditions improve such that other options become more economically feasible and involve less regulatory uncertainty. Table 4.3-63 summarizes the costs of the recommended strategies for each Hickory aquifer user.

Table 4.3-63
Costs of Recommended Strategies for Hickory Aquifer Users

Richland SUD

Strategy	Capital Costs*	2010	2020	2030	2040	2050	2060
Point of Use (POU) RO	$379,757	$144,640	$144,640	$144,640	$144,640	$144,640	$144,640
Point of Entry (POE) (CAX)	$595,684	$154,119	$154,119	$154,119	$154,119	$154,119	$154,119
Bottled water system	$2,388	$9,552	$9,552	$9,552	$9,552	$9,552	$9,552
Low Radium well	$ 1,700,979	$ 224,000	$ 224,000	$76,050	$76,050	$76,050	$76,050
Total	*$977,829*	*$308,311*	*$308,311*	*$384,361*	*$384,361*	*$384,361*	*$384,361*

City of Melvin

Strategy	Capital Costs*	2010	2020	2030	2040	2050	2060
Point of Use (POU) RO	$126,676	$48,420	$48,420	$48,420	$48,420	$48,420	$48,420
Point of Entry (POE) (CAX)	$198,463	$51,572	$51,572	$51,572	$51,572	$51,572	$51,572
Bottled water system	$0	$2,400	$2,400	$2,400	$2,400	$2,400	$2,400
Total	*$325,139*	*$102,392*	*$102,392*	*$102,392*	*$102,392*	*$102,392*	*$102,392*

Live Oak Hills Subdivision

Strategy	Capital Costs*	2010	2020	2030	2040	2050	2060
Point of Use (POU) RO	$34,928	$13,279	$13,279	$13,279	$13,279	$13,279	$13,279
Point of Entry (POE) (CAX)	$53,876	$14,140	$14,140	$14,140	$14,140	$14,140	$14,140
Bottled water system	$0	$1,400	$1,400	$1,400	$1,400	$1,400	$1,400
Total	*$88,804*	*$28,819*	*$28,819*	*$28,819*	*$28,819*	*$28,819*	*$28,819*

* Capital costs are assigned to Richland SUD for the purposes of this plan. Actual costs will be shared by program participants.

Table 4.3-64
Potential Strategies for Hickory Aquifer Users

Type of WMS	Primary Advantages	Primary Disadvantages	Disposal Issues	Other Regulatory Issues
Cation Exchange (CAX)	Provides high level of treatment for radium.	System requires regular backwashing/regeneration. Sodium supply is a constant expense. Ion exchange media must also periodically be replaced.	Brine could be considered low-level radioactive waste unless there is a waste stream to blend the brine into. Potential long-term liability risks.	State needs to address low-level radioactive waste rules to accommodate disposal of treatment residuals in Texas.
Reverse Osmosis (RO)	Provides high level of treatment for radium and gross alpha.	Membranes have to be monitored and periodically cleaned or replaced and 15-25% of water is wasted as brine. High level of operator training is required to properly operate and maintain the system.	Brine could be considered low-level radioactive waste unless there is a waste stream to blend the brine into. Potential long-term liability risks.	State needs to address low-level radioactive waste rules to accommodate disposal of treatment residuals in Texas.
Specialized Media (e.g. WRT Z-88)	No liquid residual requiring disposal, requires little operation/maintenance from the water supplier.	Water supplier is reliant on commercial supplier to maintain and operate. Radium concentrations in the media require precautions re: worker safety and could also expose water supplier to liability risks.	There is no viable disposal option within Texas at this time. WRT is seeking to permit an injection well within Texas. Disposal costs will be higher if the well can't be permitted.	State needs to address low-level radioactive waste rules to accommodate disposal of treatment residuals in Texas.
POE (CAX)	Smaller CAX systems are simpler to operate and maintain than central systems. Water supplier operators could maintain systems that are located in accessible areas outside the customers' homes.	The water supplier must own the system and 100% of customers must agree to participate. Property access by the water supplier operator is required for maintenance and inspection. A contract must be set up between the water supplier and the homeowner to allow the necessary access. Each system has to be tested once every 3 years.	Single-family septic systems are exempt from rules regarding disposal of radionuclides.	Maintenance and inspection intervals have not yet been determined by TCEQ. Radium testing cost would be prohibitive; no adequate substitute test has yet been approved by TCEQ.
POU (RO)	Only a portion of the water supply has to be treated. Home RO systems are less expensive and easier to install and maintain than POE CAX.	Water supplier must own the system and 100% of customers must agree to participate. Access to interior of customers' homes for maintenance and inspection is required. A contract must be set up between the water supplier and the homeowner to allow the necessary access. Each system has to be tested once every 3 years.	Single-family septic systems are exempt from rules regarding disposal of radionuclides.	Maintenance and inspection intervals have not yet been determined by TCEQ. Radium testing costs would be prohibitive; no adequate substitute test has yet been approved by TCEQ.
Bottled Water (delivered)	Convenient supply of drinking water for customers.	Delivery is extremely expensive and typically requires use of 3- to 5-gallon containers that may be too heavy for some customers to handle. Water supplier would be dependent on a commercial water supplier or would have to implement treatment, bottling and delivery themselves.	None if imported by a commercial supplier. Septic system could possibly accommodate disposal of residuals from CAX or RO processes, if there is a sufficient waste stream to blend the brine into.	EPA has not approved bottled water as a compliance option, but TCEQ believes delivery might be viewed the same as POU from a regulatory standpoint. A water supplier that is bottling water for delivery will have to comply with the regulations that govern the bottled water industry.
Bottled Water (central location)	Provides customers a drinking water supply, without the added expense of home delivery or the maintenance access issues of POE or POU.	Customers bear the inconvenience of obtaining drinking water from a central location. Abuse is possible from non-customers taking water or from customers taking too much water. Round-the-clock accessibility to bottled water may be required.	Water suppliers have to dispose of brine residuals in a sanitary sewer system or a septic system. Septic system could possibly accommodate disposal of residuals from CAX or RO processes, if there is a sufficient waste stream to blend the brine into. Drinking water supply could be tanked in from a nearby city.	EPA has not approved bottled water as a compliance option. This option has only been allowed under bilateral compliance agreements.
No Action	Avoids high costs of compliance that could impose an economic hardship on customers. Avoids liability issues of concentrating radium via treatment process.	Customers continue to be supplied with drinking water that exceeds EPA standards. Water supplier could potentially bear liability if health concerns are later validated.	None	Water supplier would face fines and penalties, or other legal action. Private-action lawsuits are also possible. There could be potential repercussions for funding of state or federal projects.

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[7] Kay Snyder, City of Midland. Personal communication.

[8] PSC draft report. Reference needed.

[9] Phone conversation with Rufus Beam, City of Brady, 1/21/05.

[10] Phone conversation with Aubrey Bierman, President of Lakeland Services, Inc., 6/6/05.

[11] Verbal information provided at Regional Planning Meeting, 2/05.

[12] US Environmental Protection Agency Radionuclides Rule, 66 FR 76708-76753, Volume 65, No. 236, December 7, 2000.

[13] Texas Commission on Environmental Quality, Chapter 290 – Public Drinking Water, Rule Project No. 2004-038-290-WT, adopted December 1, 2004.

[14] Summary of Investigation Into the Occurrence of Cancer; Concho, McCulloch, San Saba, and Tom Green Counties, Texas, 1990-1998, prepared by Texas Department of Health, December 15, 2000.

[15] Letter to Robert J. Huston, Chairman of Texas Natural Resource Conservation Commission, from Michael Ford, C.H.P., Vice Chair of the Texas Radiation Advisory Board, dated May 6, 2002.

[16] US Environmental Protection Agency Radionuclides Rule: A Quick Reference Guide, EPA 816-F-01-003, June 2001.

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[18] Meeting with Tony Bennett, Water Supply Division, Texas Commission on Environmental Quality, 02/04/05.

[19] Letter from Mr. Ken Bull of Richland SUD to Jon Albright, Freese and Nichols, Inc., July 25, 2005.

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[24] Phone conversation with Ron Dollar of Water Remediation Technology, LLC on 1/20/05.

[25] WRT Proposal letter to Mr. August Pope, Richland Springs SUD, dated July 8, 2004.

[26] US Environmental Protection Agency, Office of Ground Water and Drinking Water, "Radionuclides in Drinking Water: A Small Entity Compliance Guide", February 2002.

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[29] United States Environmental Protection Agency: *Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems,* EPA 815-R-06-010, April 2006

[30] Phone conversation with David Sanders, Director of Utilities, City of Andrews, 1/31/05.

[31] Texas Department of Health: *Summary of an Investigation into the Occurrence of Cancer Concho, McCulloch, San Saba, and Tom Green Counties, Texas 1990-1998*, December 15, 2000.

[32] Michael Ford, Vice Chair of the Texas Radiation Advisory Board, letter to Robert J. Huston, Chairman, Texas Natural Resource Conservation commission, May 6, 2002.