El Paso County Water Authority
El Paso County Water Report
Draft Final

September 6, 2002

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Project 5633/1736A

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ac-ft	acre-feet
AWWA	American Water Works Association
BUREC	U.S. Bureau of Reclamation
CCP	Central Colorado Project
CDPHE	Colorado Department of Public Health and Environment
CSU	Colorado Springs Utilities
CWCB	Colorado Water Conservation Board
DNAPL	dense non-aqueous phase liquid
EIS	Environmental Impact Statement
EPCWA	El Paso County Water Authority
ESA	Endangered Species Act
Fry/Ark	Fryingpan-Arkansas Project
gpcd	gallons per capita per day
gpm	gallons per minute
gpm/ft	gallons per minute per foot of drawdown
ISDS	individual sewage disposal system
HOA	Homeowners' Association
MSL	mean sea level
NECO	National Energy Resources Company
NEPA	National Environmental Policy Act
O&M	operation and maintenance
PCE	tetrachloroethylene
PSOP	Preferred Storage Options Plan
SECWCD	Southeastern Colorado Water Delivery System
SEO	State Engineer's Office
SWDS	Southern Water Delivery System
TCE	trichloroethylene
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

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1.0 Water Provider Demands

The El Paso County Water Authority (EPCWA) has prepared this Water Report to assist its members in the formulation of current and future water policy to meet the needs of its customers. The EPCWA represents approximately 16 entities in El Paso County. These entities include the following: Cherokee Metropolitan District, City of Fountain, Colorado Centre Metropolitan District, Donala Water and Sanitation District, El Paso County, Forest Lakes Metropolitan District, Paint Brush Hills Metropolitan District, Security Water District, Stratmoor Hills Water and Sanitation District, Sunset Metropolitan District/Pikes Peak Water Company (part of Cherokee Metropolitan District), Town of Monument, Town of Palmer Lake, Triview Metropolitan District, Widefield Water and Sanitation District, Woodmoor Water and Sanitation District, and Woodmen Hills Metropolitan District. Whereas, approximately 16 other water providers, including the City of Colorado Springs Utilities (CSU), are not represented by the EPCWA, they have provided data for this study and are cooperating water providers to the EPCWA. The locations of these water providers within El Paso County are shown on Figure 1-1.

1.1 Evaluation Criteria

To evaluate water supply issues, it is necessary to first assess the historical, current, and future water demands of El Paso County water providers through the year 2020. These water demands will be used in the Water Report for (1) planning estimates for comparison to water supply, (2) estimating water shortfalls, (3) assessing water conservation and reuse potential, and (4) optimizing County water distribution infrastructure.

This evaluation updates and extends a study undertaken by the EPCWA in 1999 (GMS, Inc., 1999). Twenty-four water providers in El Paso County have provided data and information on their service areas, including the extent of current service and proposed future service area expansions. Only 13 of the water provider members of the EPCWA, along with another nine water providers, supplied data and information. The 11 additional water providers included the following: Academy Water and Sanitation District, Town of Calhan, Cascade Public Service Company, City of Manitou Springs Water Department, CSU, Park Forest Water District, Pioneer

Lookout Water District, Town of Ramah, Red Rock Valley Estates, Rock Creek Mesa Water District, and Sage Water Users Association. The locations of the service areas of the El Paso County water providers are shown for both current and proposed future areas on Figure 1-1.

Because no specific planning horizon was used during the 1999 water provider's inventory by GMS, Inc. (1999), specific data for the planning period through 2020 were not requested nor provided. As part of this task, we have extrapolated or interpolated data from the El Paso County water providers to estimate water demands for various years through the year 2020. No new data were collected for this phase. Those data and information provided by the EPCWA were used in forecasting the year 2020 water demands for both individual water providers and also for the County as a whole. These future individual water demand projections also included the CSU; however, future cumulative County water demands did not include the CSU. The demands also included estimates of current and future water demands for 25,000 people estimated by EPCWA to be on private wells and not associated with existing water providers.

The water demand projections given in this phase are considered to be preliminary and based only on data available at the time of report preparation. As new data and information become available, these water demand projections should be updated periodically.

1.2 Historical and Current Water Usage

Historical and current water usage for water providers in El Paso County are summarized in Table 1.1. Current usage figures are presented for the years 1995 through 1998. These were the water usage data available from the EPCWA (GMS, Inc., 1999). Several explanations of the historical water usage values in Table 1.1 are needed to fully understand the available data.

Academy Water and Sanitation District (AWSD) and the Town of Calhan have reported that they are 100-percent developed within their current boundaries. AWSD did not provide an indication of future build-out dates or future service area. Therefore, it was assumed that AWSD would not expand past its present service area or increase its present water demand. Because the Town of Calhan did provide an estimated future service area, future water demand projections were made for the Town (Section 1.3).

Colorado Centre Metropolitan District (Colorado Centre) partly lies within the City of Colorado Springs (City) and partly in El Paso County. The portion of Colorado Centre within the City was assumed to have its water demands included in the City water demands. Therefore, Table 1.1 only shows the historical water demands for that portion of Colorado Centre located in El Paso

County. Also, Triview Metropolitan District (Triview) is within the corporate limits of the Town of Monument; however, Triview is responsible for current and future water utility infrastructure and water supply.

Currently, the EPCWA estimates that there are 25,000 people in El Paso County who are served by individual wells for water supply. The exact locations and distribution of these people are unknown at this time as are their current water demands.

Current annual water demands in El Paso County, including the CSU, as summarized by the EPCWA, are estimated to be on the order of 89,600 acre-feet (ac-ft). Based upon a County population equivalent for this demand of approximately 457,000 (GMS, Inc., 1999), this gives a current unit water demand of approximately 175 gallons *per capita* per day (gpcd). Population equivalents for commercial and industrial water demand were provided by EPCWA (GMS, Inc, 1999).

Based on the data and information on current water usage and population equivalents supplied by the EPCWA (GMS, Inc., 1999), we have estimated the *per capita* water usage for each water provider in El Paso County. *Per capita* water usage ranged from 58 gpcd in Rock Creek Mesa Water District, which has only domestic taps, to 1,297 gpcd in Pioneer Lookout Water District, which serves only 67 people.

The historical and future water demands presented in this report represent the sum of domestic, commercial, and industrial water demands and includes irrigation of grass and landscaping. Typically, water demands in North America (Fair and Geyer, 1958; Metcalf & Eddy, Inc., 1972; McGhee, 1991) for various classes of water usage can be summarized as shown in the table below

Normal Water Demands

Usage Category	**Quantity (gpcd)**	
	Normal Range	**Average**
Domestic or residential	20-80	50
Commercial	10-130	20
Industrial	20-80	50
Public	5-20	10
Unaccounted for water	5-20	10
Totals	60-240	140

The above water usage and demand vary widely and are given for comparison only. Current water usage shown in Table 1.1 for El Paso County is used as the basis for future water demand projections in this report.

In addition to annual water demands, the EPCWA also asked County water providers to report peak day and peak week water demands (GMS, Inc., 1999). Of the 16 El Paso County water providers responding with data, the average peak day water demand was 2.57 times the average daily water demand, and the peak week water demand was 2.31 times the average weekly water demand. These values are within generally accepted ratios for the western United States.

The EPCWA also asked us to contact several public and private water providers, who were either not included in the GMS, Inc. (1999), report or were not originally contacted. These additional water providers included the following: Forest View Acres Water District, Cheyenne Creek Metropolitan Park and Water District, Forest Lakes Metropolitan District, Forest View Acres Water District, Garden Valley Water and Sanitation District, Park Forest Water District, Town of Ramah, Walden Community System, Westmoor Water and Sanitation District, and Woodmen Hills Metropolitan District. Of these additional water providers, data and information were available from Forest Lakes Metropolitan District, Park Forest Water District, and the Town of Ramah (Table 1-1).

1.3 Future Water Demands

Future water demands through the year 2020 were estimated for the existing water providers in El Paso County, based on estimated build-out dates, estimated annual water demand at build-out, and linear projections for those water providers whose build-out date was different than year 2020. Table 1.1 shows the estimated build-out date and estimated water demand at build-out as supplied by the El Paso County water providers (GMS, Inc., 1999). The build-out dates were not provided for some of the water providers. In these cases, we have assumed a build-out date. For both AWSD and Rock Creek Mesa Water District, we assumed a build-out date of 1998. For the Town of Calhan, we assumed that it is currently built-out but could expand to include additional service area as shown on Figure 1-1. We assumed that the CSU's build-out date was 2040, even though it may be later, as indicated in Table 1.1. For those water providers who did not give a build-out date, we assumed that they would have build-out in the year 2020. These providers included Colorado Center Metropolitan District, Manitou Springs Water Department, Town of Palmer Lake, Park Forest Water District, Pioneer Lookout Water District, Town of Ramah, and Sage Water Users Association.

For those El Paso County water providers whose build-out date occurs prior to 2020, we have maintained that date as the build-out date, but we carried the build-out date water demand as a constant demand to the year 2020. For those water providers whose build-out date is later than 2020, we assumed a linear rate of water demand increase from current demand to build-out demand, and we calculated the year 2020 water demand from this linear relationship.

In some cases, the water providers provided a build-out date but no estimated demand at build-out. For these cases, we estimated the year 2020 water demand from the historical demand using a linear relationship. Finally, for the estimated 25,000 people in El Paso County currently using their own wells, we estimated the year 2020 water demand by assuming no increase in the number of private well users in the County and applying a *per capita* water demand rate of 80 gpcd. The estimated annual water demand for 2020 by water provider, including the private well users, is shown in Table 1.1.

Figure 1-2 shows the current annual water usage and year 2020 annual water demand for the El Paso County water providers, as well as the individual well users group. Because the CSU is the largest current user (80 percent of current annual usage) and the largest projected year 2020 water demand provider (82 percent of year 2020 annual water demand excluding the individual well users), it was not included on Figure 1-2. It is interesting to note that individual well users have an annual water demand among the six highest projected for the year 2020 in El Paso County.

Based on the estimated annual water demands shown in Table 1.1, the County-wide year 2020 projected water demand is estimated to be approximately 163,300 ac-ft, compared to the current annual water usage of approximately 89,600 ac-ft. The estimated increase in El Paso County annual water demand is approximately 82 percent higher in year 2020 than the current annual water usage. This year 2020 value includes the CSU. Without the CSU, the year 2020 annual water demand will be approximately 32,300 ac-ft with the individual well users group and 30,000 ac-ft without the individual well users group (Table 1.2).

The future year 2020 projected annual water demands will not occur uniformly over the 20-year planning horizon. Because some water providers will be built-out prior to 2020 and others will still be growing, we have estimated the cumulative annual water demand from the year 2000 through the year 2020 as shown in Table 1.2 and graphically on Figure 1-3. Changes in annual water demand are non-linear, with larger increases for the first half of the planning horizon compared to the second half of the planning horizon. The annual distribution of water over the planning horizon does not include projected demands for the CSU. It does include, however, the projected constant annual water demand of the individual well users group. The annual water demand values shown in Table 1.2 will be used to identify water supply shortfalls and/or limitations, to assess potential synergistic projects with the CSU, and to optimize County water distribution infrastructure.

1.4 Conclusions

Based upon our analyses of existing historical, current, and future water demand data for water providers in El Paso County, we make the following conclusions:

1. A planning horizon through the year 2020 appears adequate for projection of future annual water demands for El Paso County.

2. Current annual water demands, based on El Paso County water providers, is on the order of 89,600 ac-ft.

3. Based on a current El Paso County population equivalent of 457,000, the *per capita* water usage is approximately 175 gpcd.

4. The current annual and *per capita* water demands of El Paso County water providers appear to be within typically accepted values for similar areas of North America and the western United States.

5. Peak day water demands average 2.6 times the average day demand; whereas, peak week water demands average 2.3 times the average week demand.

6. Future annual water demands for El Paso County in the year 2020 will be approximately 163,300 ac-ft with the CSU and 32,300 ac-ft without the CSU.

7. The year 2020 County-wide annual water demand includes approximately 2,240 ac-ft per year for individual well users in El Paso County.

8. The distribution of annual water demands for the 20-year planning horizon through the year 2020 is non-linear, with larger year-to-year increases in annual water demand between the years 2000 and 2010 and smaller year-to-year annual water demands between the years 2010 and 2020.

9. Based on the available data, the annual and *per capita* water demand projections given in this report should be periodically updated.

2.0 Inventory of County Aquifer Resources

Ground water provides much of the municipal water supplies in El Paso County. Ground water is available from many different sources; sedimentary bedrock formations, pre-Cambrian granites, and shallow alluvial aquifers associated with stream systems. The availability and reliability of ground water from these divergent sources is discussed in this section.

In the northern portion of El Paso County the principal aquifer resources are the sedimentary bedrock aquifers of the Denver Basin. There are four principal aquifers within the stratigraphic unit that is collectively referred to as the Denver Basin, the Dawson, the Denver, the Arapahoe and the Laramie-Fox Hills aquifers (Figure 2-1). In the southern portion of El Paso County, south of where the Denver Basin aquifers either subcrop or outcrop, the principal bedrock ground water resources are found in the Dakota/Cheyenne aquifers. Along the western edge of El Paso County, in the foothills of the Rocky Mountains, the principal bedrock ground water resources are found in the pre-Cambrian granitic rocks (Figure 2-1).

Throughout the county there are several major stream systems which flow over the Denver Basin, Dakota/Cheyenne and pre-Cambrian aquifers. Associated with these stream systems are alluvial deposits which carry significant volumes of water that are currently being used by El Paso County water providers. Some of the principal alluvial aquifer systems are associated with Fountain Creek, Monument Creek, Sand Creek, Black Squirrel Creek, and Jimmy Camp Creek.

In this section we will provide an inventory of the county aquifer resources and an initial assessment of the water supply reliability of the various sources into the future. Section 4.0, Identification of Water Supply Shortfalls and/or Limitations, will evaluate in more depth the reliability of currently-adjudicated water supplies of the County water providers as identified in Table 1.1.

2.1 Ground Water Inventory

The inventory of ground water resources in the County is based on available data in the public domain, principally the records at the State Engineer's Office (SEO) and the Denver Basin Rules Maps. The values generated in this inventory are based on the physical availability of water in each of the aquifer systems evaluated.

2.1.1 Denver Basin Aquifers

The Denver Basin, which underlies the northern portion of the County (Figure 2-1), is composed of five formations, four of which contain water-bearing aquifers. The formations of the Denver Basin are the stratigraphically-highest *Dawson Formation*, successively underlain by the *Denver Formation*, the *Arapahoe Formation*, the *Laramie Formation,* and the *Laramie-Fox Hills Sandstone*. The sandstone layers interbedded in each of these formations comprise the water-bearing units, or *aquifers,* of the formation. However, the Laramie Formation contains little, or no, water-bearing units and is, therefore, not considered one of the principal Denver Basin aquifers.

The formations of the Denver Basin that underlie the northern part of the County consist of a series of interbedded sandstones, siltstones, and shales. Generally, the sandstone layers are water-bearing, and are the units that produce water to wells, while the siltstones and shales yield little, or no, water to a well. Generally, the occurrence and the thicknesses of the water-bearing and non-water-bearing units of the Denver Basin will vary from location to location. Typical yields from Denver Basin wells in El Paso County are 50 to 150 gallons per minute (gpm) from Dawson aquifer wells, 50 to 100 gpm for Denver aquifer wells, 250 to 500 gpm for Arapahoe aquifer wells, and 150 to 300 gpm for Laramie-Fox Hills aquifer wells.

Prior to 1973, appropriation of water from the Denver Basin aquifers was not based on overlying land ownership. With the passage of Senate Bill 213 in 1973, all water rights that were in place as of June 1, 1973 were classified as pre-Senate Bill 213 water rights. Since these water rights were not associated with overlying land ownership, the SEO grandfathered these rights by devising a methodology whereby a circle of appropriation would be constructed, with the well as the center of the circle, to define the overlying land that would be required for the vested appropriation for that well for 100 years.

With the advent of Senate Bill 213, subsequent adjudications of Denver Basin aquifer water were tied to land ownership, with all Denver Basin water being considered “nontributary,” i.e., there will be less than 0.1 percent impact to the streams of the state of Colorado as a result of 100 years of pumping at a well’s adjudicated rate. Under this presumption, all Denver Basin aquifer water could be used, and re-used, to extinction since its use does not materially affect any of the streams of the state.

With the passage of Senate Bill 5 in 1985, the legal impact of pumping of Denver Basin aquifer water on the state's stream system was modified. Nontributary water, as defined by Senate Bill 5, requires a replacement of 2 percent of the water pumped to compensate depletions to the stream systems, while a new water category, called "not-nontributary" water, was created for portions of the Denver Basin where the SEO believes that impacts to the stream are greater than 0.1 percent after 100 years of pumping. Therefore, under current law, there is a 2 percent replacement obligation for nontributary water and there is a requirement for an adjudicated augmentation plan prior to the use of any not-nontributary water, which would demonstrate that depletions to the stream system would be replaced by the user. For water withdrawn from not-nontributary aquifers within one mile of a stream contact, the actual depletions to the stream must be calculated and replaced as part of the augmentation plan. For areas beyond the one-mile contact, actual depletions would have to be calculated and replaced for the Dawson aquifer, while the Denver, Arapahoe, and Laramie-Fox Hills aquifers would require a 4 percent augmentation replacement.

The Senate Bill 5 Rules, as described above, do not apply to the Denver Basin aquifers inside designated basins. The Colorado Ground Water Commission has adopted rules for the withdrawal of ground water from the Denver Basin aquifers which are similar to the Senate Bill 5 rules, but differ in the application of replacement for tributary and not-nontributary ground water.

As part of Senate Bill 5, the SEO produced the Denver Basin Rules Maps, which delineate the areal extent of each of the Denver Basin aquifers, the tops and bottoms of each of the aquifers, the saturated thicknesses throughout the basin in each of the aquifers, and the line delineating nontributary from not-nontributary water. These Denver Basin Rules Maps have been used in evaluating water supply availability in El Paso County as part of this inventory of aquifer resources.

The Denver Basin Rules Maps show the lateral extent and the saturated thickness for each of the four principal Denver Basin aquifers, the Dawson, Denver, Arapahoe, and Laramie-Fox Hills. These Denver Basin Rules Maps have been used to estimate the overlying land area in each of the four principal aquifers, as well as the saturated thickness. We used the presumptive specific yield values identified in the Denver Basin Rules maps, which are as follows:

Aquifer	Specific Yield (dimensionless)
Dawson	0.20
Denver	0.17
Arapahoe	0.17
Laramie-Fox Hills	0.15

We then inventoried the total amount of Denver Basin aquifer water available in each of the four principal aquifers in El Paso County using the following formula:

Annual appropriation (ac-ft/yr) =

$$\{[\text{Land Area (ac)} \times \text{Specific Yield} \times \text{Saturated Thickness (ft)}] \div [100 \text{ years}]\}$$

The volume of water in storage is divided by 100 years to produce the Colorado statutory annual appropriable volumes. However, El Paso County has developed water supply standards (El Paso County Land Development Code, Chapter V, Section 49.5, November 20, 1986), which require a water supply for a 300-year period. It is our understanding that the 300-year rule would apply to any new inclusions to special districts within the County, but would not apply to any annexations to municipalities. Therefore, in evaluating the availability and reliability of Denver Basin aquifer water, the County's water supply standards will need to be applied on a site-specific basis.

The Denver Basin Rules Maps are used to estimate water supply availability under the current law (Senate Bill 85-5). However, there were pre-existing vested water rights in the Denver Basin prior to the passage of Senate Bill 5. Water rights that were established prior to June 1, 1973 are referred to as "pre-Senate 213" water rights, and we have separately accounted for these rights as pre-Senate Bill 213 rights, as they are not associated with overlying land. A summary of the water availability inventory for each of the four principal Denver Basin aquifers is presented in Appendix 2.1. The values presented therein are based on a 100-year supply calculation. To meet the County's 300-year supply rule, the average annual volumes available must be reduced to 1/3 of the values shown in Appendix 2.1.

Water availability is given by township and range, so the water availability can be estimated for various locations within the basin. In addition, the tables in Appendix 2.1 differentiate between nontributary versus not-nontributary water, as not-nontributary water requires an adjudicated augmentation plan prior to use.

As shown in Appendix 2.1, there is a potential total annual appropriable volume of over 667,000 ac-ft, which equates to 66 million ac-ft of potentially recoverable water in the four principal Denver Basin aquifers in El Paso County. However, because of the County's 300-year rule, and as discussed in the subsequent section 2.2.1, there are several factors which may limit the legal and physical ability of water providers to extract these volumes of water annually on a long-term basis from the Denver Basin aquifers beneath El Paso County.

Of the Denver Basin aquifer water identified in the inventory, approximately 69 percent is considered to be nontributary, while 31 percent is considered to not-nontributary. Therefore, of the over 667,000 ac-ft/yr that is potentially available, approximately 207,000 ac-ft/yr would have to be included in a Court-approved augmentation plan prior to its use.

While most not-nontributary aquifer pumping is augmented with either senior surface water rights or by leaving nontributary aquifer water in the ground, there is one known instance in El Paso County where a company (Northgate Company) is pumping nontributary water into local creek systems as a water credit for augmentation of "tributary" aquifer pumping (as defined in Northgate's augmentation plan decree.) A maximum of 23.2 ac-ft/yr will be pumped from nontributary aquifers to augment this "tributary" pumping. Where this is currently occurring, there is a depletion of both the nontributary and not-nontributary aquifers at a combined rate greater than actual consumption. However, this represents less than one ten-thousandth of one percent of the total Denver Basin resources available in El Paso County. If any of the return flows from the development recharge the uppermost Denver Basin aquifer, the impact would be even less.

Even with the potential limitations on use due to the 300-year rule and potential long-term reliability issues, the Denver Basin aquifers are currently the largest single source of ground water in the County.

2.1.2 Alluvial Aquifers

While the Denver Basin aquifers underlie approximately one-half of El Paso County land, alluvial aquifers are generally restricted to relatively small areas on either side of stream channels. The principal alluvial aquifers in the County are associated with Monument Creek, Sand Creek, Fountain Creek (including the Widefield aquifer), Jimmy Camp Creek, and Black Squirrel Creek. These streams are shown in Figure 2-l. Based on the thickness and hydraulic characteristics of the various alluvial aquifers, yields can be far-ranging, from as little as 50 gpm to over 1,000 gpm.

Stream alluvium is considered part of the stream channel under Colorado Water Law and, therefore, is considered to be a tributary water source, i.e., waters of the state. Being considered tributary water, alluvial aquifer water is subject to the Doctrine of Prior Appropriation under which Colorado Water Law operates. The doctrine of prior appropriation states “first in time, first in right.” In effect, this means that all water rights which are senior to a specific right have to be fully satisfied before the next right can take any water when the stream is operating under the administrative system.

The SEO operates a daily water call system, whereby a specific priority right is the calling right. Whenever there is a specific calling right, all rights at that date, or senior to that date, can divert water, while all rights junior to that date are not allowed to divert at all. When there is a free river condition, any adjudicated water right can divert at its adjudicated rate and/or volume.

The Arkansas River system almost never operates under free river conditions. For example, over the 29-year period from 1967 through 1995, water rights in Water District 10, which includes Monument and Fountain Creeks, were in priority a total of 156 days. This represents approximately 1.5 percent of the overall time frame (Table 2.1). Therefore, the river system is under call approximately 99 percent of the time.

Since the principal calling right in the Monument and Fountain Creek systems is March 1, 1910, or earlier, most alluvial wells are virtually always out of priority (unless a senior ditch right has been converted to use through an alluvial well). Therefore, the legal availability of alluvial water is closely tied to the adjudication of augmentation plans which allow the diversion of water through alluvial wells, even when the alluvial water right would otherwise not be in priority. Under the Amended Rules and Regulations for the Arkansas River (Amended Arkansas River Rules) (SEO, June 4, 1996), all alluvial well diversions have to operate under a Court-approved augmentation plan or a substitute water supply plan.

Augmentation plans allow alluvial wells to pump, with the depletion associated with this pumping replaced to the stream by a water right that would be in priority at the time of pumping. Typically, the depletions from alluvial pumping are made up by (a) reusable wastewater effluent returns, either from nontributary ground water or trans-basin diversions, or (b) from senior agricultural water rights that have been retired, with the historical depletion from these rights being left in the stream.

The one exception to this mode of operation relative to water rights administration is areas located within a designated basin. A designated basin is established because, by statutory definition, water in the basin is not, in its natural course, "available to and required for the fulfillment of decreed surface rights." There are three designated basins in El Paso County, the Upper Black Squirrel, the Kiowa-Bijou, and the Upper Big Sandy. The locations of these designated basins are shown in Figure 2-1. Therefore, being in a designated basin, water withdrawals from the alluvium in these areas are not subject to the water rights administration of the Arkansas River Basin. Instead, they are separately administered by the Colorado Ground Water Commission and, therefore, have a different reliability of use (from water rights outside the designated basin) based on their appropriation date. According to the SEO's office, these alluvial systems in El Paso County are fully appropriated and the only opportunity for ground water development in the designated basins is purchase of existing rights (Bill Fronczak, personal communication, June 28, 2000). Even then, there is evidence of declining water levels in the Upper Black Squirrel, which may indicate that a "mining" situation already exists. Exportation of water rights converted to municipal use is possible through approval from the Upper Black Squirrel Ground Water Management District and the Colorado Ground Water Commission.

In summary, alluvial aquifer water is an important source of water supply, as it can generally provide a high-volume, high-quality water. However, alluvial aquifer water rights cannot operate outside of an augmentation plan, which requires a supplemental supply to be secured to offset depletions associated with alluvial pumping. This is a significant hindrance to future expansion of alluvial water well development, as the availability of suitable augmentation sources is limited.

2.1.3 Pre-Cambrian Aquifer

A pre-Cambrian fractured crystalline rock aquifer occurs along the western edge of El Paso County, in the foothills of the Rocky Mountains. Ground water in this area occurs in fractures in the crystalline rocks and, due to the sporadic nature of the fracturing and the generally low permeability of the rock mass, this aquifer can only support the development of residential wells. According to records at the SEO, residential wells completed in the granitic rock in the western portion of El Paso County typically yield between 1 and 20 gallons per minute (gpm). There are some areas where yields are less than 1 gpm and can still support residential uses through installation of cisterns.

The ground water contained within the pre-Cambrian aquifer is considered to be a tributary water supply, as the fractures in the crystalline rock are periodically recharged through precipitation events and snowmelt runoff. As such, wells completed in the pre-Cambrian aquifer are subject to the state of Colorado's Doctrine of Prior Appropriation. While individual residential wells for plots prior to June 1, 1972 are exempt from the priority system, if larger production wells could be developed for commercial, industrial, or municipal purposes, they would be subject to the appropriation doctrine and would require an adjudicated plan for augmentation prior to use. Augmentation plans are also required for new lots that will be served by a household use only permit.

In summary, ground water from the pre-Cambrian aquifer in the western portion of El Paso County can only physically be developed in quantities that can support individual residential homes. Even if higher-producing pre-Cambrian wells could be developed, adjudicated augmentation plans would be necessary to utilize this water. In western El Paso County, there are few viable augmentation water sources to support large-scale development.

2.1.4 Hogback Aquifers

Sedimentary formations outcrop along the foothills in two areas, herein referred to as the Hogback Areas (Figure 2.1). These formations, which underlie the Denver Basin in the northern part of El Paso County, include the Manitou, Williams, and Leadville limestones, and, in addition, the Fountain Formation, Lyons Sandstone, Lykens Formation, Morrison Formation, and the Dakota Sandstone.

According to records at the SEO, ground water usage from the aquifers in these areas is currently limited. The permitted wells in these areas are primarily domestic and household wells, with reported yields less than 15 gpm. As with the pre-Cambrian crystalline aquifer further to the west, the ground water is considered to be tributary. Development of higher-producing wells would require adjudicated augmentation plans.

2.1.5 Pierre Shale and Dakota/Cheyenne Aquifers

Over much of the southern portion of El Paso County, the uppermost sedimentary bedrock aquifers are sands in the Pierre shale and the Dakota/Cheyenne sandstone formations. The Pierre shale outcrops at the surface and extends to depths of approximately 1000 feet. Locally, there are sand layers that have been developed for ground water production, primarily for stock wells and domestic uses. Typical well yields are reported to be less than 15 gpm.

The Pierre shale overlies the Dakota sandstone which, in turn, overlies the Cheyenne sandstone, and both consist of interbedded, fine-grained sandstones with beds of shale. The Dakota/Cheyenne aquifers are generally too deep to be considered for domestic wells in El Paso County and are not used if sands in the Pierre shale are present.

According to Rule 1 of the Amended Rules and Regulations for the Arkansas River (Amended Arkansas River Rules (SEO, June 4, 1996)), ground water diverted from the Cheyenne and Dakota aquifers is exempt from the regulations, but not from administration. While the Amended Arkansas River Rules are silent on the Pierre shale, we would assume that wells completed in the Pierre are also currently exempt. Therefore, existing Dakota and Cheyenne aquifer wells (and likely Pierre wells) would not be subject to the augmentation requirements that are outlined in the Amended Arkansas River Rules for other tributary water rights. It is the SEO's position that new Pierre/Dakota/Cheyenne wells are presumptively regarded as tributary unless proven to the SEO's satisfaction that they are nontributary.

Wells currently developed in the Pierre/Dakota/Cheyenne aquifers would be treated similarly to nontributary Denver Basin aquifers wells. However, given the status of ongoing litigation between Colorado and Kansas and the need to provide additional water at the state line, the continuing exemption of Pierre/Dakota/Cheyenne aquifer wells from the Amended Arkansas River Rules should be viewed with caution. It is possible that, in the future, these wells will again be administered as tributary water rights and require adjudicated augmentation plans.

In summary, Pierre shale wells may be suitable for individual residential homes in some areas in southeastern El Paso County. The Dakota/Cheyenne aquifers are used in areas outside El Paso County for small-scale, commercial, industrial, irrigation, or municipal purposes. However, there are few data that indicate these types of uses can be made in southeastern El Paso County. In addition, reliance on Pierre shale wells for non-exempt purposes should be viewed as potentially requiring augmentation in the future.

2.2 Water Supply Reliability

In many cases, the legal availability of water and physical availability of water are not the same. It is, therefore, important to compare "paper water" to actual "wet water." This comparison is an assessment of the reliability of water supplies on a long-term basis.

The following sections assess the long-term reliability of the ground water resources of the County that were described in the previous sections.

2.2.1 Denver Basin Aquifers

In Section 2.1.1, the procedure for the appropriation of Denver Basin water was described. This methodology calculates the volume of water in storage beneath a specific parcel of land, then divides that amount of water in storage by 100 to produce an annual appropriation which will, theoretically, have a life of 100 years. For new developments in El Paso County, the average annual volume would be calculated by dividing by 300. However, neither of these methodologies takes into account the movement of water into, and out of, the aquifer beneath a particular parcel of land.

Given that the Denver Basin aquifers are bowl-shaped, with the aquifers at higher elevations along the margins of the basin (as compared to the middle of the basin), the assumption of a 100-year aquifer life (or 300-year aquifer life) with no change in storage beneath a property, is not applicable, particularly along the basin margin (Figure 2-1).

In addition, the statutory methodology for determining appropriable volume assumes that all of the drainable water in storage beneath a parcel of land can be recovered using wells completed in each of the aquifers. This assumption has two serious practical limitations; namely, (a) the Denver Basin aquifers are interbedded with layers of water-bearing sands and non-water-bearing shales, which limits the ability to transmit water to wells due to low hydraulic gradients, even when the aquifers are fully saturated, and (b) as the aquifer gets dewatered, it is very difficult to drain the lowermost sands, as the hydraulic gradients between wells become de minimis. Because of these limitations, and the bowl-shaped nature of the basin, location within the basin can be extremely important to determinations of long-term reliability of Denver Basin aquifer water supplies.

We reviewed the hydrogeologic conditions of the Denver Basin aquifers in El Paso County and have conducted a preliminary assessment of water levels in these aquifers to evaluate current conditions, i.e., are water levels above, at, or below, the top of each of the aquifers at various locations within the County. Using these data, we have prepared a preliminary assessment of the reliability of water supplies in the Denver Basin aquifers which underlie much of the County.

Currently, water levels in each of the four principal Denver Basin aquifers are above the top of the aquifer in all but the outcrop areas, i.e., confined aquifer conditions. While depletions to the aquifers do not occur until water levels drop below the top of the aquifer, i.e., unconfined aquifer conditions, the hydraulic properties of the Denver Basin and the shape of this basin dictate that these depletions will not be everywhere equal.

Colorado Water Law does not require evaluation of the reliability of the water supplies from the nontributary/not-nontributary Denver Basin. Rather, its analysis is based on the static volume of water in storage beneath a property. This analysis assumes that water in storage will remain in storage, minus use on the property. However, water levels can change, even with no use on the property and, by statute, no one has the right to protect water levels, i.e., no injury to a water right can be claimed solely because of declining water levels. Because of this, evaluation of water supplies on a site-specific basis using a static analysis does not account for present and future pumping impacts within the Basin.

The County contains areas that are located at, or near, the outcrop of the Denver Basin aquifers, and areas that are located in the central portion of the Denver Basin (Figure 2-1). In addition, current Denver Basin water use is not evenly distributed. The northwestern portion of the County (Monument, Woodmoor, Triview, and Donala) has several major users, while other parts of the County have only limited use of the Denver Basin water. Therefore, a dynamic, as well as a static, analysis of water availability would be preferable to adequately address impacts of pumping on the longevity of the water supply in these areas of varying hydrogeologic characteristics. Effects such as (a) location of pumping in the Basin, (b) impacts caused by both current and future pumping of others in the Basin, (c) aquifer confinement and hydraulic control, and (d) relative elevation differences can be assessed to preliminarily evaluate reliability.

In our preliminary assessment of Denver Basin water supplies in El Paso County, we used three sets of existing data, (a) geologic maps covering the County, (b) water well records, and (c) contour maps showing the elevations of the tops and bases of the Denver Basin formations. The general surface geology was compiled from U.S. Geological Survey maps of the Colorado Springs/Castle Rock area (Trimball and Machette, 1979b). Subsurface geologic interpretations were compiled from maps published by the Colorado

Division of Water Resources State Engineer's Office (SEO) for each of the Denver Basin bedrock aquifers (Van Slyke, et. al., 1988a, 1988b, 1988c, and 1988d). Hydrogeologic information was obtained from published water level data from the SEO (Colorado Division of Water Resources, 1995).

While the geologic structure of the Denver Basin is relatively consistent, there are distinct differences in the Basin hydrogeology depending on the location within the Basin. The basin is bowl-shaped, with the deepest, and thickest, portion located to the north, in Douglas County. The edge arcs through the northern part of El Paso County, as shown in Figure 2-1. For purposes of this report, we will refer to the edge of the Denver Basin as the *Margin Zone*, and the deeper portion of the Denver Basin as the *Central Basin.*

The reason that we differentiated the Margin Zone of the Denver Basin from the Central Basin is the bowl-shaped nature of the Basin, i.e., the elevations of the aquifers in the Central Basin are much lower than the elevations along the margin of the Basin. For example, the base of the Arapahoe aquifer near the center in Douglas County is approximately 4,150 feet above mean sea level (ft MSL), while the base of the Arapahoe aquifer at the margin near Colorado Springs is approximately 6,400 ft MSL (2,300 ft higher). This fact alone plays a significant role in the water supply reliability in areas of the Margin Zone, i.e., pumping at 4,150 ft MSL impacts wells at 6,400 ft MSL more than the reverse.

Under normal development, pumping in the Central Basin can dewater the sands in the Margin Zone. This is due, in part, to the interbedded nature of the Denver Basin formations, whereby sandstone units near the base of the aquifer will remain confined even when the upper sands become unconfined. Because of this, any pumping in the Basin will reduce heads across the basin in the confined aquifers. Therefore, pumping in the Central Basin exerts a measure of hydraulic control over water supplies in the Margin Zone, causing further reductions in water availability. Therefore, a delineation of that part of the County at risk from this scenario must be identified. As additional data are collected, this area must be revised, as necessary.

We have preliminarily defined the Margin Zone as the area where the nearly flat-lying Denver Basin aquifers found to the east are upturned against the mountains, aquifer water levels have currently declined below the top of the aquifer, and/or the aquifers are generally at higher elevations relative to the Central Basin (as shown in the two cross-sections in Figures 2-2 and 2-3).

In the Margin Zone, each of the four Denver Basin aquifers becomes truncated by either faulting or erosion, and the ability to produce water reliably becomes limited. However, the delineation of a "margin zone" is difficult to predict, as there are not sufficient data available and there does not appear to be a single mapable change that can be followed from one end of the County to the other. We used several criteria in our evaluation to establish the Margin Zone as the area in the Denver Basin where water supply availability would likely be limited, and long-term reliability would be questionable due to the location at a relatively high elevation compared to the Central Basin.

Therefore, for the purpose of defining water supply reliability, we have delineated the Margin Zone by the following characteristics:

- Water levels that have declined to at least the top of the aquifer
- Increase in aquifer base elevation that makes the aquifers susceptible to impacts from others pumping at lower elevations in the Basin
- Truncation of one or more of the Denver Basin aquifers by erosion
- Lack of recharge to the aquifers along the subcrop/outcrop areas

We have reviewed the water level data from well completion reports on file with the SEO, and these published water level data indicate that the potentiometric surfaces for each of the Denver Basin aquifers do not change commensurate with the increase in the elevation of the aquifers approaching the mountains. As a result, water levels converge with the tops of the aquifers in the Margin Zone and, in some instances, are currently below the top of the aquifers. Our delineation in Figure 2-4 is based on a limited set of water level data for the Arapahoe aquifer. The Arapahoe aquifer was used in this evaluation since it is the most prolific Denver Basin aquifer, and the most utilized.

To exacerbate the current reduction in water availability in the Margin Zone, the higher elevations of these aquifers relative to the same aquifers in the Central Basin will result in declining water levels as the Central Basin is developed. The SEO has been tracking water levels over the last several decades in each of the four aquifers at a select set of wells located primarily in the Central Basin (Colorado Division of Water Resources, 1995). These data indicate that there has been a rapid rate of decline in the elevations of the potentiometric surfaces in the Central Basin. The Arapahoe aquifer shows the most widespread declines in elevations.

The combination of large production wells and lower elevations in the Central Basin will produce ground water gradients from the higher-elevation locations in the Margin Zone to the Central Basin. This applies to all large production wells completed in the Central Basin, whether they are located inside or outside of the County. This will increase flow out of the Margin Zone, which will result in decreasing the longevity of water supplies along the higher-elevation Margin Zone.

The degree to which the longevity of the water supplies will be decreased due to the change in gradients resulting from the development of large production municipal wells in the Central Basin is related to the degree of confinement and hydraulic connection between the two zones and their relative elevations. In areas of the Margin Zone where aquifer hydraulic characteristics are good and the sandstone layers are regional in nature, extending from the Margin Zone into the Central Basin, aquifer longevity will be decreased the most. This is because pumping in the Central Basin would have a good hydraulic connection to the higher-elevation sandstone layers in the Margin Zone. Therefore, Central Basin pumping can dewater the Margin

Zone through the hydraulic control from pumping in the Central Basin, as described above.

In other areas in the Margin Zone that have poor aquifer hydraulic characteristics, and the sandstone layers are more localized, the effects on aquifer longevity can be less. This is because the hydraulic connection between pumping in the Central Basin and the higher-elevation sandstone layers in the Margin Zone would be less pronounced.

We believe that aquifer longevity is an issue in the Margin Zone, as it is likely that long-term reliability cannot be achieved due to the elevation issue. This puts water users in the Margin Zone at risk, as water development in the Central Basin will impact individual well production rates and, ultimately, longevity.

Secondary to the issue of decreased longevity due to the Margin Zone being at a relatively high elevation compared to the Central Basin, the geology in the Margin Zone reduces water availability. As the sedimentary formations in the Denver Basin rise approaching the edge of the basin, the uppermost layers have been removed by erosion. With the reduction in the number of aquifers, there is a corresponding reduction in the water available in this zone.

The factors described above indicate that the Central Basin is generally capable of providing water supplies that provide long-term reliability, while the Margin Zone may not provide long-term reliability. At the current time, most of the EPCWA member municipal Denver Basin wells are in the Central Basin, and not in the Margin Zone (Figure 2-4), although, as mentioned previously, use of the Denver Basin aquifers in El Paso County is relatively concentrated in the Monument area. This will affect long-term reliability due to interference effects.

Because of the concentration of Denver Basin aquifer pumping in the northern portion of El Paso County, even though there is significant water supply availability, the need for additional wells may occur sooner than in other areas of the Basin. This would be related to well interference effects caused by multiple wells pumping in the same aquifer in close proximity to each other. These potential impacts will be evaluated in the next section dealing with water supply shortfalls and limitations of the municipal water supplies in El Paso County.

Water quality can also play a role in the long-term reliability of Denver Basin aquifer water supplies. Naturally-occurring iron in some of the Denver Basin formations has already led to significant treatment requirements to reduce iron concentrations to acceptable levels. This situation will likely be exacerbated as water levels decline into the aquifer and air is allowed to react with the iron to cause further well and aquifer water quality problems. In the Laramie-Fox Hills aquifer, dissolved methane and hydrogen sulfide gasses in addition to high total dissolved solids have led many municipal water suppliers to avoid use of the Laramie-Fox Hills aquifer because of the low water quality coupled with the high cost of well development in this aquifer (for wells in excess of 2,000 feet deep) and the relatively low production rates that are realized from Laramie-Fox Hills aquifer wells.

In addition to the physical limitations related to reliability of Denver Basin aquifer water supplies, there are also legal limitations relative to reliability. Under Senate Bill 5, a new definition for Denver Basin water was created, "not-nontributary water." Not-nontributary water requires that an adjudicated augmentation plan be in place prior to its use, which not only demonstrates the replacement of depletions during the pumping period, but also requires the replacement of post-pumping depletions. While depletions which occur during pumping are typically augmented through return flows to the stream from wastewater discharges and, therefore, have little impact on the overall operation of a municipal water supply, post-pumping depletion augmentation can cause significant water supply issues, both currently and in the future. For example, currently-acceptable augmentation water supply sources to make up post-pumping depletions would include (a) in-basin senior water rights, (b) trans-basin water rights, or (c) the reservation of some nontributary water in the Denver Basin aquifers that would then not be available as part of a municipal water supplier's portfolio. Procurement of an augmentation supply source can cause a significant financial burden to secure the suitable augmentation water supply source and/or it can diminish the currently-available nontributary water supply remaining in the other Denver Basin aquifers. Therefore, reliance upon not-nontributary water needs to take these factors into account.

A portion of El Paso County lies within designated basins (Figure 2-1). While Denver Basin aquifer water in the designated basins might be available for use in other parts of the County using a satellite well field, i.e., a well field remote from its place of use, this water cannot be exported from the designated basin without approval from the local management district, if it exists, or, in the absence of a local district, the Colorado Ground Water Commission. Therefore, there are potential limitations on the use of Denver Basin water within the designated basin.

Even outside the designated basin, the use of Denver Basin aquifer water requires ownership of the overlying land or consent of the landowner to use the underlying Denver Basin aquifer water. The presence of deemed consent areas and/or pre-Senate Bill 213 wells can affect water availability beneath properties, as well. Therefore, construction of any satellite Denver Basin aquifer well field at a location remote from the municipal water supply entities' boundaries would require ownership of the overlying land or the consent of the landowner to use the water and an evaluation of prior vested rights.

In conclusion, the Denver Basin aquifers represent a very large ground water resource. However, location within the basin, use within specific areas, the amount of not-nontributary water versus nontributary water, the degree of layering in each aquifer, water quality, and the legal ownership of the water all play key roles in assessing the long-term reliability of Denver Basin aquifer supplies. In all cases, the Denver Basin aquifers represent a finite water supply, one that is not replenished on an average annual basis as are the tributary water supply sources in the County. Of the four hydrogeologic zones that underlie the County, as described in our analysis, the Central Basin provides the largest water supply availability, but has some issues related to long-term, reliable water supplies.

2.2.2 Alluvial Aquifers

Ground water resources developed from alluvial aquifers in the County are subject to Colorado's Doctrine of Prior Appropriation and also to the Amended Arkansas River Rules (SEO, June 4, 1996). Under Colorado Law, alluvial well water rights that have relatively junior priorities generally have to be supported by an adjudicated augmentation plan. In the Arkansas River Basin in El Paso County, all ground water withdrawals from Fountain Creek have to be fully augmented regardless of priority date. The long-term reliability of alluvial ground water resources is tied to the priority date of the right, either directly (if the alluvial well is a change in point of diversion of a senior water right) or indirectly (if the alluvial well can only operate when the augmentation water supply source is in priority).

Since alluvial water rights with a priority date junior to March 1, 1910 would be in priority approximately 1 percent of the time, there are virtually no new depletions occurring to the alluvial system, except at times of very high flow. In fact, under the Amended Arkansas River Rules, no new depletions will occur (at least on Fountain Creek), as all alluvial well withdrawals have to be augmented. Therefore, depletions to the alluvial system are principally related to senior surface water rights that reduce flows in the streams. For alluvial wells, augmentation plans are carefully crafted not only to replace the depletions caused by the alluvial pumping, but also to identify the location and timing of these depletions, so that no injury occurs to other vested water rights.

In the Upper Black Squirrel Designated Basin, only exempt permits are currently being issued, and there are virtually no new depletions to the ground water system that are not pre-1965 rights (when the designated basin was formed (Bill Fronczak, personal communication, June 28,2000)). Currently, the pre-1965 rights are allowed to divert without administration. Water level data in parts of the Upper Black Squirrel appear to be declining with time. Therefore, we would judge that the reliability of alluvial water in the Upper Black Squirrel would need to be made on a case-by-case basis, depending upon location and an evaluation of potential future administrative procedures.

An example of managing limited water supplies is the Widefield Aquifer Management Plan, which is based on a model of the Widefield aquifer using a dry year yield analysis from the 1960s. These data have then been used to divide the physical capacity of the aquifer among the users (CSU, Stratmoor Hills, Security, Widefield, and El Paso County Parks). To manage the Widefield aquifer, one-month, four-month, and annual limits are placed on users. The total annual allocation is 7,955 ac-ft over a 5-mile reach, including other users that may represent 1,000 to 2,000 ac-ft/yr additional use. This implies a firm annual yield in the Widefield aquifer of 1,800 to 2,000 ac-ft/yr/mi.

By using a dry year yield analysis, a firm yield of the Widefield aquifer can be estimated and the users are limited to these values to preserve the renewability of this system. However, this yield will continue to be refined as each of the entities reaches their target capacity (Gary Thompson, personal communication, June 19,2000).

With these uses in mind, the principal legal issues related to reliability of alluvial aquifer water supplies are (a) the percent of time the water right is in priority (if operating under its own priority) and (b) whether the junior well water rights have a permanent augmentation source versus a contractual augmentation source, e.g., a contract with CSU to provide reusable return flows for augmentation.

Table 2.1 illustrates the percent of time that specific water right priorities would be allowed to divert under their own priority. As Table 2.1 shows, unless a water right has a priority date of 1887, or earlier, it would generally be unreliable except in wet years.

There are several ways to secure an augmentation water supply source, including (a) conversion of senior agricultural consumptive use credits that would result in the dry-up of irrigated land with the water being left in the stream, (b) use of trans-basin flows or reusable return flows, or (c) use of other entities' reusable return flows as augmentation credits. The purchase of any of these rights by an entity seeking augmentation water supply sources would provide for ongoing augmentation credit. However, some augmentation plans are structured based on water obtained by contract with a fixed contract duration. In these instances, it is possible that the augmentation water supply source would not be available in perpetuity and would, therefore, limit the reliability of these junior alluvial water rights.

In addition to legal issues related to reliability, there is the physical supply issue. While alluvial aquifer water is renewable, the physical supply at any given time is limited by the hydrologic cycle. During wet cycles, there are abundant water supplies for all users, while during dry cycles, water supplies can be limiting, even with a reliable augmentation source. A good example of this is the Widefield Aquifer Management Plan, which is based on a dry year yield analysis. This is prudent planning, as the model then estimates a minimum "firm yield" upon which the water providers can rely.

To illustrate the large potential flow variation, monthly flow in May in Monument Creek (at Station 7104000) can vary from 12.7 cfs (780 ac-ft) to 399 cfs (24,530 ac-ft), and averages 98.5 cfs (6,056 ac-ft). Likewise, Fountain Creek (at Station 7106000) averages 240 cfs (14,755 ac-ft) in May, but can range from 9.8 cfs (600 ac-ft) to 1,602 cfs (98,490 ac-ft) (Appendix 3-2). Since surface flows directly recharge the alluvial aquifers, the dramatic changes in runoff from year to year, and even seasonally within a year, can affect the alluvial aquifer's capacity to yield water.

In summary, alluvial aquifer ground water sources constitute a very important water resource in the County and, due to the renewable nature of this water, have a high reliability factor as long as there is a secure augmentation water supply source and there is sufficient water supply availability.

2.2.3 Pre-Cambrian Aquifer

The pre-Cambrian aquifer along the western margins of El Paso County is considered a tributary water resource, in that this system is periodically recharged through rainfall and snowmelt runoff events. Given the relatively low demands on the pre-Cambrian aquifer, as it principally serves individual residential homes, the current long-term reliability of this water supply system is good. However, with additional development in the foothills, this water supply could become more strained in the future.

One of the principal issues regarding water use from the pre-Cambrian aquifer in western El Paso County is related to water quality, as individual homes are not only provided water from individual wells, but dispose of their wastewater through individual septic tanks and leach fields, commonly referred to as "individual sewage disposal systems" (ISDSs). When ISDSs are discharging into the same aquifer system as is being used for potable water supplies, there is the potential for degradation in water quality over time. To minimize this potential, maximum housing densities of one home to 5 to 10 acres would seem prudent.

In summary, use of the pre-Cambrian aquifer to supply individual residential wells is likely adequate in terms of long-term reliability from a quantity standpoint, but water quality issues can potentially create instances where the water supply might be adequate, but the water quality is not. Therefore, future additional development in the pre-Cambrian aquifer needs to be monitored, and kept to minimum densities, if possible, so that long-term reliability does not become a question of quality versus quantity.

2.2.4 Hogback Aquifers

Since the Hogback aquifers are typically used for residential wells, there are very few data available regarding the long-term reliability of these aquifers.

Similar to the pre-Cambrian aquifer, the Hogback aquifers are considered to be tributary water supply sources and, therefore, receive recharge annually from renewable water supplies, i.e., streams flowing through the area, precipitation recharge, and snowmelt runoff. Therefore, as long as use of these aquifers continues to be related to individual residential homes, it is likely that these aquifers will continue to provide a reliable water supply. However, if these homes are also served by ISDSs, there could be potential water quality issues similar to that described above for the pre-Cambrian aquifer.

2.2.5 Pierre/Dakota/Cheyenne Aquifers

There are very few data regarding the Pierre shale aquifer with respect to long-term reliability. This formation consists primarily of shale with few sand lenses. Therefore, the Pierre shale aquifer is currently being used only for individual residential wells. Therefore, available production and water level change data are very limited.

The data that we do have on the Pierre shale aquifer in the County indicate that water levels are currently above the top of the formation, indicative of fully saturated conditions in the aquifer. It is likely that the aquifer will continue to provide reliable water supplies for the limited uses described above, but other larger-scale development of water supplies from this aquifer could result in rapid dewatering of the system.

In summary, the long-term reliability of the Pierre shale aquifer is unknown. It is judged that continued small-scale development of the Pierre shale aquifer can be supported on a long-term, reliable basis, while large-scale development of water supplies for purposes such as municipal water supply could not be supported on a long-term basis.

The Dakota/Cheyenne aquifers may also be capable of providing reliable supplies for residential wells, but the depth of the aquifers in southeastern El Paso County make it economically impractical to develop at this time. Yields are likely too low to justify the cost to drill Dakota/Cheyenne wells for irrigation, small-scale commercial, or municipal use.

2.3 Conclusions

Based on our inventory of County aquifer resources, we would offer the following conclusions:

1. Denver Basin aquifers comprise a major ground water resource in northern El Paso County. There is over 667,000 ac-ft/yr available for appropriation based on a 100-year statutory life.

2. Not-nontributary water within the Denver Basin system potentially reduces the overall water supply availability, as not-nontributary water has to be augmented both during the pumping period and the post-pumping period.

3. While El Paso County's 300-year rule may extend the life of the Denver Basin aquifers to some extent, it does limit the availability of Denver Basin ground water resources to be used currently for central water supplies outside incorporated areas.

4. Denver Basin aquifer reliability is highly dependent upon location within the Basin, with some areas already considered to be unreliable as long-term water supply sources.

5. Concentrated areas of use of Denver Basin water, notably in the northern portion of the County, will also affect long-term reliability.

6. Water quality may also play a major role in the long-term reliability of the Denver Basin aquifers.

7. Alluvial aquifers associated with the stream systems which transect El Paso County represent a major water supply source for County water purveyors.

8. Most alluvial aquifer well water rights are relatively junior in nature, and can only operate under an adjudicated augmentation plan.

9. Long-term reliability of alluvial aquifer water is good, given the renewable aspect of this supply.

10. The legal long-term reliability of alluvial aquifer water rights is principally tied to the augmentation water supply source. For alluvial water rights that are tied to renewable water supply sources available in perpetuity, long-term reliability is very good. For alluvial aquifer water rights that are tied to contractual agreements, long-term reliability is directly related to the term of the contract and its renewability clauses.

11. Water from the pre-Cambrian aquifer in western El Paso County is limited in quantity and is only capable of supporting individual residential homes. Continued development of this water resource may create the attendant problem of degradation in water quality.

12. Water supply in the Pierre shale aquifer is relatively limited and can be used mostly for individual residential wells, while water supplies in the Dakota/Cheyenne aquifers are too deep to economically develop for residential wells. In other areas outside El Paso County, the Dakota/Cheyenne is used for small-scale irrigation, commercial, and municipal uses. However, it is unknown if the Dakota/Cheyenne aquifers in El Paso County can support these uses.

13. The long-term reliability of the Pierre shale aquifer or the Dakota/Cheyenne aquifers is unknown due to a limited data base from these aquifer systems. However, it is judged that future development on a similar scale to what is currently being developed in the Pierre shale aquifer can be sustained on a long-term basis, while any large-scale development of Pierre shale aquifer water beyond residential use would likely result in a long-term reliability problem. The Dakota/Cheyenne aquifers likely

can not be developed economically, given the expected low yield from the aquifers and the depth to the aquifers.

3.0 Inventory of County Surface Water Resources

Virtually all of El Paso County is located within the Arkansas River Basin, with the exception of a small portion of northern El Paso County that is located within the South Platte River drainage basin. The principal stream systems currently being used for irrigation and municipal water supplies are Fountain Creek, Monument Creek, Jimmy Camp Creek, Sand Creek, and Upper Black Squirrel Creek (Figure 2-1).

Generally, the surface waters in each of these stream systems is governed by the Colorado Doctrine of Prior Appropriation. In the Arkansas River Basin, there is the additional regulation under the Amended Arkansas River Rules. While the Amended Arkansas River Rules apply only to the diversion of tributary ground water, the requirements of the Amended Arkansas River Rules has impacts on ongoing use of surface water resources, e.g., use of the consumptive use credits from senior surface water ditch rights as the augmentation source for diversion of tributary ground water.

Since Colorado is a "first in time, first in right" state, the legal availability of water based on priority date is well established, given that the first rights in the basin date back to the 1870s. This section of the inventory of County surface water resources describes the legal framework which determines surface water availability and also evaluates what potential surface water resources may be available to satisfy some municipal water demands as part of this County Water Master Plan.

3.1 Current Legal Framework

Water rights within the Arkansas River Basin are administered on a daily basis using the priority date system. When the river is under call, a specific right is the "calling right." The priority date of this calling right determines which water rights within the basin can divert and which water rights have to cease diversion. For example, if the calling right is the winter storage right, with a priority date of March 1, 1910, all water rights with priorities after March 1, 1910 have to cease diversions, while all water rights with priority dates prior to March 1, 1910 can continue to divert at their adjudicated rates and volumes.

A line diagram showing the surface water diversion rights on Monument and Fountain Creeks is presented in Appendix 3-1. This line diagram was prepared by the Colorado Division of Water Resources and is used by the Water Commissioners to administer water rights in District 10 (Monument and Fountain Creeks). In the "first in time, first in right" priority system, it does not matter where the water right is located relative to its ability to divert water. For example, water rights located in the headwaters of either Monument Creek or Fountain Creek do not have any preference in diversion of water if their priority date is junior to water rights located further downstream. Therefore, on the line diagram, the right to divert is related to the priority number shown, and not necessarily the location of the water right in the drainage basin.

Colorado's priority system, administered from the main stem of the Arkansas River, does not apply within the designated basins located in El Paso County (Figure 2-1). Water rights within the designated basins are administered within their own separate priority system by the Colorado Ground Water Commission. However, the designated basins were created because water in the basin, in its natural course, would not be available to fulfill decreed surface water rights within the rest of the Arkansas River Basin. This implies that there are few reliable surface water supplies within the designated basins for appropriation. In fact, all of the water rights within the designated basins in El Paso County are related to the diversion of alluvial ground water and/or Denver Basin aquifer water, and not to surface water diversions. Therefore, there is little, or no, reliable yields available from surface flows in the designated basins.

3.2 Legal Availability of Water

As stated above, the legal availability of surface water supplies is related to the priority date of the water right. Therefore, we have evaluated the daily call records in the Arkansas River Basin, specifically for Water District 10, to assess the percent of time that specific priority dates can divert water. Table 2.1 shows a summary of specific call dates and the percent of time that these rights have been in priority based on Water Commissioner records from 1967 to 1995. These specific call dates were used, as they represent the majority of the calling rights over this period of time.

As shown in Table 2.1, a priority date of 1874, or earlier, essentially will be in priority all of the time (100 percent). Likewise, a priority date of 1884 will be in priority 97 percent of the time. However, by just three years later (1887), the reliability of the right is reduced from 97 percent to 78 percent of the time in priority. Adding another three years, for a priority date in 1890, the in-priority status drops to 50 percent of the time. Thereafter, decreed surface water rights are in priority generally only during wet years, or wet periods of time.

Free river conditions exist approximately 1.5 percent of the time, generally during periods of very high flows, e.g., the springtime runoff period in 1995, when significant flooding was occurring in the Arkansas River Valley. The lack of free river conditions indicates that there is virtually no opportunity to develop new surface water rights in the Arkansas River Basin that would provide a reliable yield.

According to the District 10 Water Commissioner's records, the total surface water diverted in calendar year 1998 from the Fountain/Monument Creek system is approximately 57,000 ac-ft. To some degree, this water use would include the return flows of water rights upstream and, therefore, would not represent all virgin water diversions from the Monument/Fountain Creek system, i.e., first use water and not return flows from previous uses.

Appendix 3-2 presents selected discharge data for two gaging stations on Monument Creek and two gaging stations on Fountain Creek, one at the upstream end of each reach and one at the downstream end of the reach. As Table A3-2.1 indicates, the average annual yield of Monument Creek at the downstream end is 22,876 ac-ft/yr, while the average annual yield from Fountain Creek downstream of Fountain, Colorado, is 78,899 ac-ft/yr. When compared to the current water usage in District 10 of approximately 57,000 ac-ft/yr, a significant portion of the flows developed in Monument and Fountain Creeks is being utilized in-basin compared to the flow being passed to the main stem of the Arkansas River to satisfy senior water rights.

Historically, most of the surface water rights in Monument Creek and Fountain Creek have been related to irrigation practices. As such, the pattern of use is only during the irrigation season (typically from April through October), with very minimal year-round use.

To make irrigation season water rights available on a more continuous basis or to regulate flows better to meet peak day demands, reservoir storage can be used to regulate flows for subsequent use. Table 3.1 summarizes the currently-operating reservoirs, based on the District 10 Water Commissioner's records for 1998. The overall active storage capacity in District 10 is approximately 70,000 ac-ft, based on 1998 records.

In summary, virtually all of the surface water rights in El Paso County were originally decreed for irrigation purposes. Many of these water rights have since been converted to municipal use through a change of use proceeding in Water Court and are being used by water providers for a portion of its municipal water demands. There are also many currently-operating reservoirs within El Paso County which potentially could be used for the storage and regulation of direct flow water rights (Table 3.1). The following section describes how the existing surface water rights and reservoirs can potentially be used to increase water supply availability for municipal use.

3.3 Potential Expansion of Water Availability for Municipal Use

Since most of the historical surface water rights in El Paso County are related to irrigation use, a change of water right is necessary to convert these rights to municipal use. In a change of water right proceeding in Water Court, the historic consumptive use associated with the right is determined, and that volume is then available for the change of use. The remaining water, the return flow from irrigation use, is not available and must continue to be returned to the stream system, or simply left in the stream system without use.

There have been many irrigation water rights that have been converted to municipal use in El Paso County to date. One of the largest is shares in the Fountain Mutual Irrigation Company, which owns both direct flow and storage rights. We have contacted the Assistant District 10 Water Commissioner, Mr. Rich Snyder, relative to the shares in the Fountain Mutual Irrigation Company (personal communication, June 21, 2000). According to Mr. Snyder, approximately two-thirds of the shares in the Fountain Mutual Irrigation Company are currently being used for irrigation, while the other third of the shares have been converted to use as augmentation water sources.

Mr. Gary Steen with Fountain Mutual (personal communication, June 26, 2000) indicates additional irrigation shares may be available as development continues to encroach on the historically-irrigated areas. While some of the remaining 4000+ shares that are still in irrigation use are not used regularly, Fountain Mutual continues to divert its full allotment, which helps preserve the shares in an active status. The conversion for one share of Fountain Mutual water has been well established in Water Court at a consumptive use of 0.7 ac-ft/yr.

We also questioned Mr. Snyder regarding other potential irrigation water rights that may be for sale for use for augmentation purposes. Mr. Snyder indicated that the Chillcotte Ditch, located on Fountain Creek, has, in the past, sold shares for use in augmentation plans, but that he is not currently aware of any shares in the Chillcotte Ditch being available for a change of use at this time. It is also known that the Monument Ditch, located in the headwaters of Monument Creek, is for sale for potential municipal use or use within an augmentation plan.

We reviewed the 1998 annual water diversion summary for District 10 with Mr. Snyder to identify large irrigation water rights and to query Mr. Snyder regarding the potential availability of these irrigation rights for conversion to municipal use and/or augmentation. The large irrigation rights include the Burke Ditch, the Dr. Rogers Ditch, the Gale Ditch, the Greenview Ditch, the Iron and Irvine Ditch, the Liston and Love (South) Ditch, the Lytle Spring and Ditch, the Merriam Rock Creek Ditch, the North Catamount Creek Ditch, the Owen and Hall Ditch, the Ripley Ditch, the South Catamount Creek Ditch, the Talcott and Cotton Ditch, the Womack Ditch, and the Wood Valley Ditch. Many of these ditches are currently operated by CSU or by Fort Carson, and would not be available for conversion to municipal use or use as an augmentation water supply source. The remaining ditches are currently being used for operating farms and ranches, and to the best of Mr. Snyder's knowledge, are not available for sale at this time (personal communication, June 21, 2000). Therefore, from a direct flow right standpoint, the principal source of additional senior surface water rights in District 10 is the Fountain Mutual Irrigation Company, with some possibility that augmentation water could be obtained from the Chillcotte Ditch.

In addition to the historic irrigation rights that have been developed on Fountain and Monument Creeks, there is a major trans-basin diversion project, the Frying Pan-Arkansas Project (Fry-Ark). According to Mr. Tom Simpson of the Southeastern Colorado Water Conservancy District (SECWCD) (personal communication, June 22, 2000), the Fountain Valley Authority can receive up to 20,100 ac-ft/yr of Fry-Ark water, with the Authority members having the right to first use and the SECWCD retaining dominion and control to the reusable return flows. However, each member of the Fountain Valley Authority has the right of first refusal on the reusable return flows. Four of the Fountain Valley Authority members are also members of the EPCWA (Security, Fountain, Widefield, and Stratmoor Hills), with the remaining member being CSU. Based on the current status of Fry-Ark water, it is unlikely that any of the reusable return flows, or first-use water, would be available to provide supplemental municipal supplies for EPCWA members.

Another possible avenue for expanding the water availability for municipal use is to maximize re-use under existing augmentation plans. Agricultural rights which have been converted to municipal use, trans-basin diversions, and return flows from use of nontributary and not-nontributary water can be re-used under Court-approved augmentation plans. While re-use can be accomplished through the use of alluvial wells, in many instances surface storage can improve the utility of maximizing re-use.

According to Mr. Snyder, the existing reservoir systems within El Paso County may have additional storage capacity available that could assist in a more efficient use of available water supplies, including reusable water. According to Mr. Snyder, the Woodmoor Reservoir (capacity of 936 ac-ft) could be for sale, although it is currently under restrictions from a dam safety standpoint. Monument Dam is currently undergoing rehabilitation and potentially will be used in the future as a terminal storage facility. Bristlecone Reservoir and Pinon Reservoir also may have surplus storage capacity for regulating direct flow rights. In addition, CSU operates several reservoirs with significant storage capacity. As part of the approach to pursuing synergistic water supply projects with CSU, discussion can include the potential for providing some storage capacity to other County water providers.

In summary, there are no significant surface water resources available at this time which could potentially increase municipal yields, and it is unknown if there is water storage capacity which could be used to regulate available direct flow rights. However, we believe that meetings to discuss cooperative actions with CSU can potentially flesh out some of these possibilities.

3.4 Conclusions

Based on our inventory of County surface water resources, we would offer the following conclusions:

1. Based on the currently-adjudicated water rights in the Fountain Creek/Monument Creek drainage basin, these basins are fully appropriated.

2. Water right priorities junior to 1887 would not be reliable as direct flow rights, while a water right priority of 1890 could provide reliable yields with attendant storage capacity.

3. Fountain Mutual shares may potentially be available for a change of water right to be used as augmentation sources. Other possible sources may be the Chillcotte Ditch and Monument Ditch.

4. There are existing storage facilities that potentially have storage space available to regulate direct flow rights.

5. Optimization of re-usable return flows will help extend muncipal water supply availability.

6. Fry-Ark water is fully subscribed and the only likely scenario for use of Fry-Ark water would be through reusable return flows from CSU.

7. CSU controls a large segment of available storage capacity and reusable return flows and synergistic approaches to cooperative projects should be explored.

4.0 Identification of Water Supply Shortfalls and/or Limitations

In Section 1.0, the water demands for the EPCWA members to a planning horizon of 2020 were estimated (Tables 1.1 and 1.2). To compare water supply availability to these estimated 2020 demands, we have reviewed the pertinent Water Court decrees for each of the EPCWA members. This review of the pertinent decrees was an overview to estimate overall water supply availability. A detailed analysis of each decree for each member provider was beyond the scope of this work. Therefore, in estimating water supply availabilities in some of the complex augmentation plans, we necessarily used simplifying assumptions. A summary of the general types of water rights held by each of the member providers is shown in Table 4.1, while our estimation of water supply availability from our interpretation of the Water Court decrees is presented in Table 4.2.

Comparing the water supply availability numbers shown in Table 4.2 to the estimated 2020 demands shown in Table 1.2 indicates that each of the EPCWA water providers has adequate water supplies to meet the 2020 demands (with the exception of Colorado Centre). However, based on our knowledge of water supply sources available to these water providers, we have evaluated potential physical water supply and water quality shortfalls and/or limitations.

4.1 Water Supply Sources Available

In interviews conducted with the Northern Water Providers (Academy, Donala, Forest Lakes, Monument, Palmer Lake, Triview, and Woodmoor) on October 5, 2000 and with the Southern Water Providers (Cherokee, Fountain, Stratmoor Hills, and Widefield) on October 25, 2000, we were able to identify four distinct groups which have common water supply sources. These four groups include:

1. Denver Basin aquifer water users (Academy, Donala, Forest Lakes, Monument, Palmer Lake, Park Forest, Triview, and Woodmoor).

2. Upper Black Squirrel water users in the designated basin (Paint Brush Hills, Cherokee, Sunset, and Woodmen Hills).

3. Fry/Ark water and Widefield aquifer water users (Fountain, Stratmoor Hills, Security, and Widefield).

4. Monument and Fountain Creek well and surface water users (Colorado Centre, Monument, Palmer Lake, Woodmoor).

Because each of these water providers has distinct water issues related to both availability and reliability, we will address each group separately.

4.2 Evaluation of Northern Providers Using Denver Basin Water

When the water supply availability for each of the Northern Water Providers (Academy, Donala, Forest Lakes, Monument, Palmer Lake, Park Forest, Triview, and Woodmoor) are compared to the estimated 2020 demands, it appears that there is a net surplus of water supply availability for these providers (Tables 1.2 and 4.2). However, there are a number of factors which make this relatively simplistic comparison deceptively optimistic.

It is known that the water supplies from the Denver Basin aquifers are finite in nature because water is being extracted at a rate faster than water is being recharged into the system, i.e., the system is being mined. This is resulting in water levels declining in each of the four principal bedrock aquifers, which result in a declining water supply for each of the EPCWA member providers that use Denver Basin aquifer water.

To exacerbate this condition, the municipal users in Northern El Paso County are clustered in a fairly small area, which creates hydraulic interference effects among the various users, resulting in increased drawdowns in the users' wells. This interference effect is also compounded by the fact that this fairly small area is located in close proximity to the outcrop of the Denver Basin aquifers. Therefore, to the west of all of the Northern El Paso County Denver Basin users is a no-flow boundary, which will further increase drawdown at municipal production wells as a result of pumping. Therefore, all other things being equal, an isolated well in the middle of the basin will produce more flow instantaneously and into the future than a well on the edge of the basin near other wells.

Another issue with Denver Basin aquifer use in Northern El Paso County is that a large portion of the water supply availability in the Denver Basin aquifers is associated with the Laramie-Fox Hills aquifer. Overall, the Laramie-Fox Hills aquifer water is approximately 30 percent of the total Denver Basin aquifer water (Appendix 2-1). Given the high cost to drill Laramie-Fox Hills aquifer wells to depths in excess of 2,500 feet, the low expected yield per well and the relatively poor water quality makes the Laramie-Fox Hills aquifer a relatively unattractive aquifer to develop for economical municipal water supplies.

While the decreed water supply availability for the Northern El Paso County Water Providers using Denver Basin aquifer water appears adequate, we have conducted an analytical model to evaluate drawdown effects due to the close proximity of municipal production wells to each other and due to the close proximity of the aquifer outcrops to the pumping centers. We have then also estimated the additional area that would be required to space these municipal production wells to minimize drawdown interference effects, i.e., reduce drawdown interference effects by three-quarters. The following section describes the results of the analytical modeling exercise.

4.2.1 Analytical Model

To evaluate the hydraulic interference from the placement of municipal production wells in close proximity to other production wells, we used the analytical model QUICKFLOW to simulate pumping effects over time. We simulated the Arapahoe aquifer, as it is the most heavily used aquifer. Therefore, we would expect the greatest effect due to interference between pumping wells and interference effects related to the location of the western edge of the basin to the production wells is simulated. Our simulations assumed 20 years of pumping, consistent with the planning horizon to the year 2020.

Our initial simulation used the adjudicated locations of Arapahoe aquifer wells for each of the Northern Water Providers and each of these wells was run separately to evaluate drawdown effects with no interference from adjacent production wells. We then simulated all of the wells pumping at their adjudicated volumes for 20 years to estimate the change in drawdown as a result of interference effects related to the proximity of the production wells to each other. The results of these simulations indicated that drawdown increased by approximately 35 to 150 percent (55 to 224 feet) as a result of multiple production wells being operated in the Arapahoe aquifer in close proximity to each other.

We then conducted similar simulations by imposing the no-flow boundary to the west of these Arapahoe aquifer production wells to simulate the western edge of the Denver Basin aquifer. In these simulations, the drawdown increased by up to 70 percent (86 feet) as a result of the impact of the no-flow boundary and a total of 35 to 155 percent (74 to 225 feet) as a result of the combination of wells pumping in proximity to each other near a no-flow boundary.

We then used the analytical model to simulate how much the production wells would need to be spaced to minimize drawdown interference effects, both from proximity of the well pumping and proximity to the no-flow boundary. The criterion used for minimizing interference was to reduce drawdown interference effects by 75 percent. To accomplish both objectives, we increased well spacings to the east (away from the no-flow boundary). The results of these simulations indicate that significant additional land would be required to minimize drawdown effects. In the original simulations, the adjudicated well locations are contained within an approximate 20 square-mile area, while in our modified simulations, we had to use a surface area of approximately 80 square miles. To accomplish this, it would be required that additional land with associated Denver Basin aquifer water rights be obtained adjacent to the current Town/District lands so that a satellite well field could be developed.

However, the preceding analysis was based on confined aquifer conditions. As water levels drop to below the top of the aquifer, semi-confined aquifer conditions will exist, i.e., the upper sands will be unconfined while the lower sands remain confined.

We conducted a second analysis under semi-confined conditions (storage coefficient equals 0.005). This analysis indicated that the primary interference effects for existing wells is their spacing. Current, and adjudicated, wells are clustered in a small area and spacing is not optimized. To meet the drawdown criterion described above, new wells would need more spacing and the 20 square-mile area currently used would need to be expanded to approximately 35 square miles. To accomplish this, it would be required that additional land with associated Denver Basin aquifer water rights be obtained adjacent to the current Town/District lands so a satellite well field could be developed.

Specific capacity is a measure of a well's ability to produce per unit of drawdown. In our simulations of the Northern El Paso County Water Providers' wells at their adjudicated locations, specific capacities were in the range of 0.3 to 0.5 gallons per minute per foot of drawdown (gpm/ft). When the wells were spread out over a larger area, as described above, the specific capacities of the wells increased to 0.5 to 0.7 gpm/ft. This increase (40 to 70 percent) is a result of less interference between wells and moving away from the edge of the basin.

The results of these model simulations indicate that there are significant issues related to the continuing use of Denver Basin aquifer water to provide municipal demands for the Northern EPCWA Water Providers. The model simulations indicate that there are significant interference effects related to the concentrated pumping of Denver Basin water along the I-25 corridor in Northern El Paso County. The simple analytical model used to evaluate drawdown interference effects does not take into account two other significant factors which will also greatly affect the future reliability of producing water from the Denver Basin aquifers because the detail of such a model is beyond this scope of work.

First, in addition to the drawdown effect simulated in the analytical model, regional water levels in all of the Denver Basin aquifers are declining, some by as much as 10-20 feet per year. This will further reduce water supply availability, as aquifer hydraulic characteristics decline as the hydraulic head of the aquifers decline.

Second, to exacerbate this issue, the Denver Basin aquifers are comprised of a very layered system that will have significant impacts on water supply production per well (as described in Section 2.2.1). The effects of layering in the aquifer will result in the need for many supplemental wells to be installed to maintain aquifer production. Given the interference effects that have been estimated by the analytical model for the adjudicated well locations, the addition of many supplemental wells within this same area will only further exacerbate drawdown conditions during pumping.

Therefore, while the water supply availability identified in the Water Court decrees would indicate a surplus of water, we believe there are potentially significant water supply availability limitations. While in the near term the ability to provide peak day demands is the issue, in the longer term the ability just to meet average annual demands becomes the dominant issue. Ways to address this issue include water re-use, water conservation, development of satellite well fields, regionalization of water supply systems, and/or development of new, renewable water supplies. These issues will be discussed in subsequent sections.

4.3 Evaluation of Upper Black Squirrel Water Providers

Paint Brush Hills and Woodmen Hills currently produce Denver Basin water from within the Upper Black Squirrel Designated Basin. Cherokee currently produces alluvial water associated with Upper Black Squirrel Creek, also within the designated basin. In addition, Cherokee also provides service for Sunset and sells supplemental water for use at Woodmen Hills. Based on a comparison of the year 2020 demands for each of these water supply entities compared to the adjudicated water supplies available (Tables 1.2 and 4.2), there appears to be sufficient water supply availability to meet year 2020 demands.

Paint Brush Hills and Woodmen Hills are located in the central portion of the Denver Basin (Figure 2.4) and are generally separated from other areas of high-intensity Denver Basin aquifer pumping. Based on Paint Brush Hills' and Woodmen Hills' locations in the Denver Basin and relative to other large municipal pumpers, we believe it is likely that both water supply entities have an adequate water supply to meet year 2020 demands.

The shallow alluvial deposits of the Upper Black Squirrel Basin have been the target of significant studies related to their potential longevity. Both the Colorado State Engineer's Office and the U.S. Geological Survey have evaluated underflow in the Upper Black Squirrel alluvium and charted water level declines over time. Estimates of aquifer longevity have ranged from exhaustion of the useful life of the alluvial aquifer by the year 2000 (Erker and Romero, 1967) to the useful life being extended to approximately 2030 to 2035 (Office of the State Engineer, 1993). While there are significant differences in the expected useful life of the Upper Black Squirrel alluvial aquifer, there is agreement that water levels are declining and that the alluvial aquifer is being mined at the current time.

Cherokee estimates a future increase in demand of approximately 900 ac-ft to meet the year 2020 demands (Table 1.2). With water levels currently declining, this could affect the longevity of the Upper Black Squirrel alluvial aquifer if these additional demands are met from this source. It is our understanding from the Southern El Paso County Group Workshop held on October 25, 2000 that Cherokee is currently investigating the possibility of recharging return flows from their wastewater treatment plant back to the Upper Black Squirrel alluvium using rapid infiltration basins. This would help to offset some of the depletions that are currently occurring in the alluvial aquifer and may help extend the useful life of the aquifer. It is also our understanding the Cherokee is currently inter-tied with CSU for emergency water supply and can potentially increase this supply should alluvial well production continue to decline in the future.

It appears that the Denver Basin aquifer water supplies for Paint Brush Hills and Woodmen Hills in the Upper Black Squirrel Designated Basin should be reliable through the planning horizon of the year 2020, based on their locations within the basin and their proximity to other municipal users of Denver Basin aquifers. While the Upper Black Squirrel alluvial aquifer is currently being mined, as evidenced by a trend of declining water levels, it appears that Cherokee has options available to it to either reduce the depletion rate of the alluvial aquifer by recharging and/or by using alternative water supplies. Potential options for Cherokee to inter-tie with some of the other Southern EPCWA Water Providers will be evaluated, along with potential water re-use and water conservation efforts.

4.4 Evaluation of Southern Providers Using Fry/Ark Water and Widefield Aquifer

Several EPCWA water providers (Fountain, Stratmoor Hills, Security, and Widefield) obtain their primary water supply from trans-basin diversions associated with the Fry/Ark Project and in-basin water associated with Fountain Creek in the Widefield aquifer. Both water supplies are renewable in nature, with the Fry/Ark water also having the additional benefit of being fully consumable since it is trans-basin water. Generally, these entities use the Fry/Ark water and water pumped from the Widefield aquifer as their primary source of water and have purchased senior water rights in the Arkansas River Basin to augment depletions associated with pumping from the Widefield aquifer.

When the estimated annual water demands at the year 2020 are compared to the adjudicated water supplies available for each of these entities, there appears to be adequate water to meet year 2020 demands (Tables 1.2 and 4.2).

It is our understanding that the Fry/Ark Project produces water of a very high quality that is suitable for all municipal purposes. In addition, return flows from the first use of this trans-basin water can be used as an augmentation source. Therefore, the Fry/Ark water being used by the EPCWA water providers is an excellent base water supply.

Ground water pumped from the Widefield aquifer is subject to augmentation, as the water rights associated with the Widefield aquifer wells are junior to other rights in the Arkansas River Basin. However, each of the water supply entities using the Widefield aquifer have secured adequate augmentation sources to offset depletions associated with pumping from the Widefield aquifer. Therefore, from a legal perspective, continued future pumping from the Widefield aquifer is protected. However, there are still two issues potentially associated with production from the Widefield aquifer.

First, the Widefield Aquifer Management Plan, which estimates annual production, was based on a computer model of the Widefield aquifer. As described in Section 2.2.2, the model estimated a firm annual yield of 1,800 to 2,000 ac-ft/yr per mile. However, to date, the Widefield aquifer has not been pumped near the capacities simulated in the Widefield Aquifer Management Plan model. Therefore, it is possible that, in the future, allocations to the Widefield aquifer may need to be refined, with potentially less production capacity available for EPCWA water providers.

Second, there are potential water quality issues in the Widefield aquifer. Information obtained in the October 25, 2000 workshop indicates that nitrate contamination, likely from Eagle Picher and irrigation return flows, is causing water quality concerns (concentrations near the drinking water standard of 10 mg/L). The areal extent of the nitrate concentrations in the Widefield aquifer do not seem to be well understood at this time. While Widefield aquifer water can be blended with Fry/Ark water to reduce nitrate concentrations, depending upon the areal extent and concentrations which could affect the Widefield aquifer in the future, this could become a water supply concern. In addition, Schlage Lock is currently attempting to remediate a ground water contamination issue associated with tetrachloroethylene (PCE) and trichloroethylene (TCE). Obviously, the presence of chlorinated hydrocarbons in a municipal drinking water system is a water quality concern. Currently, both Eagle Picher and Schlage Lock are working with the Colorado Department of Public Health and Environment (CDPHE) to implement acceptable remedial action plans.

In general, for the entities using Fry/Ark water and the Widefield aquifer, the water supplies appear to be very reliable and of high quality. However, future increased use in the Widefield aquifer could cause changes in the estimates of reliable yield from the aquifer, and these reduced yields could also exacerbate water quality concerns related to nitrate contamination. As with all of the EPCWA water providers, we will evaluate water savings related to water re-use and water conservation, while carryover storage in Pueblo Reservoir may be the best hedge against potential future problems in the Widefield aquifer. These issues will be addressed in the regionalization studies.

4.5 Evaluation of Providers Using Monument and Fountain Creek Surface Water and Wells

One EPCWA water provider (Colorado Centre) derives its primary water supply from Fountain Creek through alluvial wells. Since these wells are relatively junior in priority, Colorado Centre also has purchased senior water rights to augment depletions associated with the pumping of these alluvial wells. Currently, Colorado Centre can produce up to 600 ac-ft/yr from these alluvial wells. When the currently-available water supply is compared to the projected 2020 demands for Colorado Centre, there appears to be an approximate 400 ac-ft/yr shortfall (Tables 1.2 and 4.2). However, the estimated future water demands for Colorado Centre were based on growth of the district. According to Mr. Al Testa, future growth will not occur unless developers bring adequate water with them to supply the water demands that were estimated for year 2020 (Al Testa, personal communication, January 23, 2001).

Given the renewability aspect of alluvial water in Fountain Creek, it is likely that these rights will provide a reliable water supply into the future. While no water quality concerns have been expressed, all shallow, unconsolidated aquifers are subject to potential contamination issues due to recharge occurring in the immediate vicinity of alluvial production wells.

Three EPCWA water providers use water from Monument Creek (Monument, Palmer Lake, and Woodmoor), either from alluvial wells or surface diversions. Given the renewability aspect of alluvial water associated with Monument Creek, these water rights should provide a dependable supply. We are aware of water quality issues in the Monument Creek alluvial aquifer that likely will require significant treatment of this water.

In summary, it appears that Colorado Centre has adequate water to provide up to 600 ac-ft/yr of supplies. To be able to met year 2020 demands, additional water supplies need to be secured. Monument, Palmer Lake, and Woodmoor have adequate water supplies without the Monument Creek water. However, use of these renewable supplies will help lessen demand on the Denver Basin aquifers. Water re-use and water conservation can help to increase service and regionalization plans will include Colorado Centre in evaluating potential additional sources of water.

4.6 Recommendations for Evaluation of Issues

There are several issues that have been identified relative to water supply availability to the year 2020 planning horizon which will be addressed in subsequent sections. These issues include:

1. Evaluation of regionalization plans for the Northern EPCWA Water Providers to make more efficient use of available Denver Basin aquifer water supplies.

2. Evaluation of Denver Basin satellite well fields to minimize the impact of interference among wells and proximity of production wells to the outcrop of the Denver Basin aquifers.

3. Evaluation of regionalization plans for the Southern EPCWA members to address issues such as potential limitations on productivity in the Widefield aquifer and water quality issues.

4. Evaluation of water re-use to increase first use water supplies.

5. Evaluation of water conservation efforts to reduce overall water use per tap.

5.0 Water Conservation

Although there are water supply shortfall issues, as described in Section 4.0, one of the means to reduce water usage of existing users is to implement water conservation measures. These measures can take the form of voluntary in-house water conservation measures and voluntary landscaping irrigation measures. There are also mandatory means to encourage water conversation, such as tiered pricing schedules and, ultimately, water rationing. Means available for encouraging and/or requiring water conservation are described below.

5.1 In-House Water Conservation Measures

Typically, in-house water use is less than one half of the overall annual residential demand. However, there are several water conversation measures that can be implemented in the home to reduce these in-house demands.

The 1992 Energy Policy and Conservation Act has served to set limits on water consumed in new homes. The principal means to accomplish this is through the use of low flow shower heads, toilets and bathroom and kitchen faucets. Water savings over older, conventional fixtures can be as much as 25 to 50 percent.

It has been estimated that a family of four wastes up to 40 gallons per day waiting for hot water to get to a fixture. This is principally related to the distance from the hot water heater to the point of use in having to move the water already in the pipes through the fixture prior to obtaining hot water. Two potential water saving devices that can remedy this problem are rapid-delivery hot water kits and point-of-use electric water heaters. Both are designed to get hot water to a fixture in a very short period of time, thus minimizing the loss of water while the fixture is running.

While these water conservation measures are voluntary (although some are required in new home construction), we would recommend that EPCWA members provide education regarding these water conservation measures and encourage their use within your water service areas. The U.S. Environmental Protection Agency (USEPA) and American Water Works Association (AWWA), and other organizations produce information related to water conservation that can be provided to your customers, to educate the public regarding water conservation. Some examples of information available on the Internet are presented in Appendix 5-1.

5.2 Landscaping Water Conservation Measures

Over half, and at times as much as 70%, of the annual residential demand is associated with outside irrigation of landscaped areas. Therefore, the use of water conservation measures in selecting landscape materials and providing efficient irrigation of these landscaped areas can result in significant water savings.

There are several techniques that can be applied to produce water-efficient landscaping. If a lawn is to be maintained, the following steps can be taken to reduce water consumption:

1. Maintain a lawn height of 2-1/2 to 3 inches to reduce the loss of moisture to evaporation;

2. Avoid planting grass in areas that are difficult to irrigate, e.g., steep slopes and isolated strips along sidewalks and driveways;

3. Aerate clay soils at least annually to help the soil retain moisture;

4. Water in several short sessions rather than one long session. This will allow the lawn to better absorb moisture and will also promote deeper root growth. A lawn with deep roots requires less water and is more resistant to drought and disease.

Significant water savings can also be realized through the use of xeriscaping, which is a type of landscaping that conserves water through efficient planning and design. For example, plants with similar usage are clustered so that, where irrigation is needed, it can be concentrated in a smaller area. In addition, soil preparation prior to planting, and mulching after planting, allows for good root development, allows better infiltration of water and helps to retain soil moisture.

For any type of landscaping, efficient irrigation is the key to conserving water use. From a hardware perspective, it is important to (a) match sprinkler head types so that the watering rate is uniform, (b) sprinkler heads are designed to operate with head-to-head coverage, (c) the precipitation rate of the sprinkler does not exceed the soil's infiltration rate, e.g., the precipitation rate needs to be lower for clay soils than for sandy soils, (d) the sprinklers operate within their design pressure rating for maximum efficiency, (e) there should be no overspray on the sidewalks, driveways, streets, etc., (f) there should be no obstructions in the spray path of the sprinklers, (g) adjustable station run times should be used so that irrigation can be adjusted for various types of vegetation and soil types and (h) the system should have a rain sensor so that stations can be shut off when it rains.

From an irrigation standpoint, water saving techniques for landscape irrigating include (a) watering before 8:00 a.m. or after 6:00 p.m. and avoiding irrigation on windy days, (b) watering in several short sessions rather than one long one and (c) only water when the grass requires it. Installation of soil moisture sensors will assist in evaluating when irrigation is necessary.

For gardens, trees and shrubs, it is recommended that drip irrigation systems be installed for the most efficient watering of these types of vegetation.

5.3 Water Pricing

While the previous sections have talked about potential voluntary means to conserve water, both in-house and through landscape irrigation, water pricing is the most effective mandatory means to realize significant water savings.

Tiered water prices are the most common means to encourage water conservation. As more water is used at a tap, the price continues to rise so that with each incremental increase in use, the cost of the water becomes more significant. A study for a municipal water supplier in Douglas County indicated that, over a 12-year period after the implementation of a tiered water pricing schedule, water use per tap was reduced by almost 40%.

We have conducted a survey of each of the EPCWA members to obtain current water pricing schedules. The data obtained from that survey are presented in Table 5.1. Of the 11 member entities surveyed, 8 currently have a tiered pricing schedule. All of the member entities have a base fee that they charge on a monthly basis, as well as a unit price for water. The base fees range from \$3.00 per month to \$28.00 per month, while the unit price of water varies from a low of \$0.30 per thousand gallons to a high of \$5.99 per thousand gallons (Table 5.1). We would recommend that those entities that are not currently using a tiered pricing schedule consider implementing a tiered pricing schedule as a water conservation measure.

We would also recommend that the EPCWA members track water use with time so that you not only have a handle on the water use per tap, but also how that water use changes with time.

5.4 Water Rationing

Water rationing is the most severe approach to water conservation efforts and is typically only implemented when available water supplies are so limited as to jeopardize the ability to provide in-house water demands to existing customers. While it is a severe measure to conserve water, water rationing is becoming more common in all parts of the United States. Water rationing in

Florida has become necessary due to a prolonged drought, and rationing in states such as Texas, Arizona and California has been routine over recent years. Even states not normally associated with a shortage of water, such as Pennsylvania, have experienced recent water rationing necessities.

Globally, water rationing is also being implemented more frequently, with current water rationing in Cameroon and Malaysia.

Because of the many factors that have been described previously in this water master plan, there is the distinct possibility of the need for future water rationing by EPCWA members.

We would recommend that each water supply entity consider formulating a water shortage emergency plan that would set forth policies to be followed in the event of a water shortage emergency. The plan could be set up in successive phases, with the initial phases being related to 3-day watering schedules. Subsequent phases, which would represent more significant water emergency conditions, could include restrictions on watering to certain times of the day, a fine for water on non-authorized days or times and limitations on the total amount of irrigated landscaping per home.

While, hopefully, water rationing will not be required either currently or in the future, an establishment of a policy to meet with contingency demonstrates prudent water management.

5.5 Recommendations

As El Paso County and other parts of the Front Range grow in population, demands on the limited water resources will continue to grow. It is important that the water resources available will be used as efficiently as possible. Water conservation should be encouraged for all residents so that voluntary water conservation measures, in conjunction with tiered pricing can prevent having to go to more draconian measures, such as water rationing, to be able to provide your customers with reliable water supplies.

6.0 Water Reuse

There are several categories of water within the State of Colorado that are legally available to be reused after the initial use. These waters include the not-nontributary and nontributary waters of the Denver Basin, transbasin water, i.e. water that has been legally transferred from one drainage basin to another drainage basin, and in-basin tributary water rights that have been through a change of use proceeding in Water Court that quantifies the historic consumptive use of the right, and therefore, the historic depletion to the stream system.

The way that these waters can be legally reused is through an adjudicated augmentation plan. The following sections describe the general principles of augmentation plans, followed by a discussion of specific augmentation plans that are currently in place for EPCWA member water suppliers.

6.1 Augmentation Plans

An augmentation plan is a judicially-approved plan which allows water rights that would otherwise be out of priority to continue to divert based on the depletions associated with this out-of-priority pumping being replaced to the affected stream system. Therefore, an augmentation plan provides the procedures for allowing junior water rights to divert while keeping the stream system whole for the benefit of senior water right appropriators. A schematic showing generally how an augmentation plan would work in a residential community is shown in Figure 6-1.

As shown in Figure 6-1, when reusable water is input to a municipal distribution system, it is used to meet municipal in-house and landscaping demands. However, not all of the reusable water delivered to residential homes is consumed. A portion of this water exits the home as wastewater flow to be delivered to a wastewater treatment plant (Figure 6-1). Once this wastewater has been treated, it is released to the stream system where it provides additional stream flow above the stream's native flow because the water is non-native to that stream system (or has historically been depleted from that stream system). Under Colorado Water Law, there is no requirement of any water supply entity to provide additional flow to a stream above the amount of native flow. Therefore, this water can be extracted in an equivalent volume from either the stream system, or shallow alluvial wells associated with the stream system, so that the stream flow is maintained at its native flow. This water can then be recycled into the municipal distribution system, which is the concept of reusable water (Figure 6-1).

By recycling this reusable water back into the municipal water supply system, it lessens the need for “first-use” water from its original source, whether that is nontributary Denver Basin aquifer water, transbasin water or historical consumptive use water. In this way, reuse maximizes the efficiency of municipal water supply systems.

Figure 6-2 shows how reusable water can increase the efficiency of a municipal water supply system. The example shown in Figure 6-2 is 100 ac-ft of first-use water that is fully consumable is used to meet residential demands. Assuming in-house demand is 45 percent and landscape irrigation is 55 percent of annual demand, and in-house consumptive use is 10 percent, irrigation consumptive use is 85 percent and treatment plant losses are 5 percent, the amount of reuse and number of successive uses can be estimated. Through multiple uses, an additional 86 ac-ft of water can be produced by exchange, which significantly reduces the demand on first-use water, such as Denver Basin aquifer water. Figure 6-2 shows that the demand on reusable water can be reduced to almost half with the full reuse provisions allowed by Colorado Water Law. This example clearly shows the benefit of an augmentation plan and how the most efficient use of reusable water can be realized.

The use of an augmentation plan to fully utilize reusable water can result in significant cost and water savings. While the type of augmentation plan described above helps minimize the first use of reusable water, there is another type of augmentation that allows junior tributary wells to continue to pump when they would otherwise be out of priority. For this type of augmentation, junior tributary wells continue to pump and any depletions that occur while these wells are out of priority are simply augmented to the stream system by water rights that are senior enough to continue to be in priority. In this case, the stream system is kept whole, yet the pumping of junior tributary wells carries only a first-use right, with all return flows having to remain in the stream system after first use.

The following section describes EPCWA member augmentation plans that are currently in place and operating.

6.2 Description of Member Augmentation Plans

As summarized in Table 4.1, there are 13 EPCWA member water providers and, of these water providers, 11 have adjudicated augmentation plans. The two water providers that do not have adjudicated augmentation plans (Cherokee and Paint Brush Hills) are located within the Upper Black Squirrel Designated Basin.

The EPCWA water supply entities generally fall within the two categories of augmentation plans described above, i.e., augmentation for the reuse of nontributary Denver Basin aquifer water and augmentation to replace depletions associated with pumping junior tributary wells when they would otherwise be out of priority. Table 6.1 presents a summary of the augmentation plans for each of the EPCWA member water providers. The following is a brief description of each of these member augmentation plans.

Colorado Centre Metropolitan District operates a number of junior tributary wells in the Fountain Creek alluvial aquifer. Colorado Centre is allowed to operate these junior alluvial wells when they would otherwise be out of priority by augmenting Fountain Creek with water rights associated with the Fountain Mutual Irrigation Company, as well as being able to store augmentation water rights in the Janitel Farms Reservoir #1. Since Colorado Centre's junior tributary wells can only produce first-use water, the augmentation plan in Case No. 86CW31 only provides for reuse relative to successive uses related to the historical consumptive use component of the augmentation sources. Donala Water and Sanitation District operates Denver Basin aquifer wells in all four principal aquifers. Part of this water is considered to be not-nontributary and has to be augmented. Donala's augmentation plan in Case No. 97CW61 augments the pumping of not-nontributary Denver Basin wells through reusable return flows that pass through Donala's wastewater treatment plant and through the reservation of Laramie-Fox Hills water to meet post-pumping depletions.

Forest Lakes has an adjudicated augmentation plan in Case No. 84CW19 but is not currently operating under this augmentation plan, as the Forest Lakes development has not been initiated. When operational, the augmentation plan proposes to operate two storage reservoirs, as well as several junior tributary wells and surface diversion points on both Beaver Creek and Monument Creek. Depletions associated with these water rights will be augmented with reusable wastewater return flows from the pumping of Denver Basin nontributary wells, with effluent return flows from CSU and by releases of stored water from the two storage reservoirs. Forest Lakes nontributary Denver Basin ground water is fully reusable.

The City of Fountain obtains its water supply from shallow alluvial wells completed in the Fountain Creek and Jimmy Camp Creek alluvial aquifers. Since these wells are relative junior in nature, Fountain's augmentation plan in Case No. 85CW110 uses senior direct flow rights associated with the Fountain Mutual Irrigation Company and storage rights associated with Big Johnson Reservoir to augment depletions associated with the shallow alluvial well. In addition, the City of Fountain has a contractual right to the delivery of 2,000 ac-ft of Friark Project water, which is fully reusable.

The Town of Monument obtains its principal water supplies from the nontributary Denver Basin aquifers, which do not require any augmentation. However, Monument also operates shallow Monument Creek alluvial aquifer wells to produce water under their junior priorities and to pump nontributary return flows. Monument's augmentation plan in Case No. 83CW10 augments depletions associated with use of its junior tributary wells with both nontributary Denver Basin reusable return flows and with five senior surface water ditch rights on Beaver Creek, a tributary to Monument Creek. All of Monument's Denver Basin aquifer water rights that are currently adjudicated are fully reusable, minus the 2 percent replacement requirement.

The Town of Palmer Lake primarily obtains its water supply from nontributary Denver Basin aquifer wells and from Monument Creek. While Palmer Lake's Denver Basin aquifer water rights are nontributary and do not have to be augmented, Palmer Lake, in its augmentation plan in Case No. 87CW069, proposes to divert surface water at two locations on Monument Creek as well as extract water from the Monument Creek alluvium through an alluvial well. Palmer Lake also proposes to store water in Glen Park Reservoir. Depletions associated with out-of-priority diversions and storage from Monument Creek will be augmented by reusable return flows from the first use of Palmer Lake's Denver Basin nontributary water rights. All of Palmer Lake's Denver Basin water rights are fully consumable, subject to the 2 percent relinquishment requirement.

The Security Water and Sanitation District obtains its principal water supply from the Widefield aquifer, which is tributary to Fountain Creek. Security also has the right to use up to 1,646 ac-ft of Friark Project water, which is fully reusable. Security's alluvial aquifer wells are augmented with return flows from the Friark Project water, senior direct flow and storage rights associated with the Fountain Mutual Irrigation Company and with senior surface rights associated with the Tread well and Lamb Ditch #4.

The Stratmoor Hills Water District obtains its primary water supply from alluvial wells completed in the Widefield aquifer, tributary to Fountain Creek and from Friark Project water. Under Stratmoor Hills augmentation plan in Case No. 91CW24, depletions associated with pumping of the Widefield aquifer wells are augmented with senior direct flow rights associated with the Fountain Mutual Irrigation Company, direct flow rights from the Laughlin Ditch #10 and #17, with CSU return flows obtained by contract and with reusable return flows from Friark

Project water. Stratmoor Hills allocation of 601 ac-ft per year from the Friark Project is fully consumable water.

The Triview Metropolitan District obtains its principal water supplies from the Denver Basin. While most of this water is considered nontributary, and therefore, does not require augmentation, Triview does have some not-nontributary Denver Basin aquifer water which has to be augmented (Denver aquifer). It is proposed in Triview's augmentation plan in Case No. 93CW134 that the 4 percent augmentation requirement of the Denver aquifer water be made through reusable return flows from the use of nontributary Denver Basin aquifer water. In addition, Triview will reserve Denver Basin water to meet post-pumping depletion requirements. All of Triview's Denver Basin aquifer water is fully reusable, with the exception of the 4 percent augmentation requirements and 2 percent relinquishment requirements.

The Widefield Water and Sanitation District obtains its principal water supplies from wells completed in the Widefield aquifer, tributary to Fountain Creek, and from the Jimmy Camp Creek alluvial aquifer. In addition, Widefield has the right to take delivery of 1,500 ac-ft per year of Friark Project water, which is fully reusable. In Widefield's augmentation plan in Case No. 86CW116, depletions associated with out-of-priority pumping of its alluvial aquifer wells will be augmented to the stream through senior direct flow rights associated with the Fountain Mutual Irrigation Company and through reusable return flows of Friark Project water.

The Woodmoor Water and Sanitation District obtains its principal water supplies from the Denver Basin aquifers. While a majority of this water is nontributary, and therefore, does not require augmentation, Woodmoor has some not-nontributary Dawson, Denver and Arapahoe aquifer water, as well as "tributary" Dawson water. Woodmoor, in its augmentation plan in Case No. 87CW067, proposes to augment depletions associated with not-nontributary and "tributary" pumping with reusable return flows from first-use Denver Basin aquifer water and with potential direct release of Denver Basin aquifer water into the effective stream systems. Woodmoor also proposes to reserve Denver Basin aquifer water for meeting post-pumping depletions

Woodmoor also proposes to operate several shallow alluvial wells in Dirty Woman Creek, a tributary to Monument Creek. Since these wells would be junior in priority, out-of-priority depletions would be augmented with reusable return flows from Denver Basin aquifer pumping. All of Woodmoor's Denver Basin aquifer water rights are fully reusable, with the exception of the augmentation requirements associated with the not-nontributary and "tributary" water.

As this review of the EPCWA member water providers' augmentation plan shows, there is a considerable reusable component associated with all of these water supplies. If this reuse component can be maximized, there can be a substantial reduction in the need for first-use water, which will benefit all of these water supply systems.

6.3 Conclusions

Water reuse is a very important component of an efficient water supply system and each of the member water providers has a substantial portion of its overall water supply that is fully, or partially, reusable. These reusability aspects will be further evaluated in the assessment of ways to optimize county water distribution infrastructure (Section 7.0).

7.0 Optimum County Water Distribution Infrastructure

This County water distribution infrastructure evaluation considers the significant factors associated with use of the Denver Basin aquifers, local alluvial aquifers, and renewable water from surface water sources. In this alternatives assessment, the Denver Basin water supply alternatives should be considered to be interim measures available up to the year 2020. The renewable water supply alternatives are preferred for the long term, after the year 2020. This section provides the costs of infrastructure needs for members of the EPCWA for alternative scenarios up to a master meter interface point. The infrastructure does not include water distribution within the various districts. Fourteen alternative infrastructure scenarios have been considered to move water within El Paso County.

7.1 County Water Provider Demands

Section 1.0 provides estimates of the Year 2000 and future water demands for EPCWA members and other water providers through the Year 2020, which is the end of the planning horizon for this Water Report. A summary of the Year 2020 water demands in acre-feet per year (ac-ft/yr) for water providers in El Paso County is provided in Table 1.1. These demands were used to select and cost alternative County infrastructure scenarios. Some of the EPCWA water providers have ultimate buildout horizons after the Year 2020. For these water providers we have estimated their Year 2020 water demands as shown in Table 1.1.

7.2 Alternative Infrastructure Identification

Infrastructure alternatives were identified by EPCWA members during two one-day workshops. Because of the differences between water supply sources within El Paso County, the workshops were divided into water providers from the Northern portion of El Paso County and water providers from the Southern portion of the County. The Northern Water Provider group included Academy Water and Sanitation District, Donala Water and Sanitation District, Forest Lakes Metropolitan District, Paint Brush Hills Metropolitan District, Town of Monument, Town of Palmer Lake, Triview Metropolitan District, Woodmen Hills Metropolitan District, and Woodmoor Water and Sanitation District. Paint Brush Hills and Woodmen Hills Metropolitan Districts did not participate in the workshop. These Northern Water Providers met on October 5, 2000 to discuss possible alternatives which would benefit both individual providers, as well as coordinated, looped, emergency or non-emergency, interconnected water supply systems. Meeting minutes of the EPCWA Northern Water Provider workshop are in Appendix 7-1.

The Southern Water Provider group included Cherokee Metropolitan District, City of Fountain, Colorado Centre Metropolitan District, Security Water and Sanitation District, Stratmoor Hills Water District, and Widefield Water and Sanitation District. Security Water District and Colorado Centre Metropolitan District did not participate in the workshop. The Southern Water Providers met on October 25, 2000 to discuss possible alternatives which would benefit them as individual water providers, as well as collectively. Meeting minutes of the EPCWA Southern Water Provider workshop are in Appendix 7-2.

7.2.1 Northern Water Providers

At the October 5, 2000 workshop, the Northern Water Providers generally agreed that several actions were necessary for future water supply needs. These needs included water reuse, renewable water supplies, and a looped and shared infrastructure system. The group also agreed that existing private well users should be connected to a future water infrastructure system.

Based on the workshop, the following general alternative water infrastructure sub-systems were developed for inclusion in larger alternatives: (1) water reuse via treated wastewater return flows using an existing (Bristlecone) or new reservoir within Forest Lakes Metropolitan District; (2) a satellite Denver Basin well field; (3) a large new reservoir within the Forest Lakes Metropolitan District, most likely on Beaver Creek; and (4) renewable water from a southern source, assumed to be stored in the proposed Jimmy Camp Reservoir. For each of these sub-systems, it was assumed that water treatment would be necessary at each source, or a regional water treatment plant could be constructed at a single location, most likely in the Forest Lakes Metropolitan District. While individual source water treatment would require more than one water treatment plant for most alternatives, it was assumed that if the alternatives were constructed in phases, multiple water treatment facilities might be required in any case.

7.2.2 Southern Water Providers

At the October 25, 2000 workshop, the Southern Water Providers indicated that they, with the exception of Cherokee Metropolitan District, are already interconnected among themselves and also with CSU. The Southern Water Providers, with the exception of Cherokee, also have renewable water in the form of water rights in Pueblo Reservoir and receive Fry/Ark project water. These entities pump water from the Widefield alluvial aquifer which is a renewable supply. Cherokee Metropolitan District pumps water from the alluvial aquifer in the Black Squirrel Designated Basin, a renewable water source. Thus, the Southern Water Providers have renewable water but may need new raw water storage to provide redundancy.

The main issue with the Southern Water Providers is related to the water quality in the Black Squirrel designated basin (high nitrates) and in the Widefield aquifer (chlorinated hydrocarbons and nitrate from past and current industrial activities). Based on the workshop, alternatives for the Southern Water Providers will include: (1) continued wellhead treatment and monitoring of alluvial aquifer water, and (2) fully utilizing return flows to reduce costs.

7.3 Infrastructure Analyses for Northern Water Providers

Fourteen alternatives were formulated for the Northern Water Providers as summarized in Table 7.1. These alternatives include meeting Year 2020 water demands using a satellite well field with reuse (Alternatives 1A through 1E), meeting Year 2020 water demands using Jimmy Camp Reservoir with reuse (Alternatives 2A through 2C and 3A), meeting year 2020 demands from a new reservoir in Forest Lakes Metropolitan District with reuse (Alternatives 4A and 4B), and providing water to approximately 14,500 people in El Paso County who are on private wells (Alternatives 5A, 5B, and 5C). These infrastructure alternatives are shown schematically on Figures 7-1 through 7-7.

7.3.1 Assumptions

General assumptions related to the selection and evaluation of alternatives for the Northern Water Providers are given in Table 7.2. These assumptions are in addition to specific assumptions related to how the infrastructure was sized and costed. Water reuse quantities were assumed to be approximately 50 percent of the total water demand. This assumption is based on the discussion in Section 6.0 "Water Reuse." We assumed that for a given residential, fully-consumable water demand unit, 45 percent is for in-house use and 55 percent is for irrigation use. We also assumed 10 percent consumptive use of the in-house demand and 85 percent consumptive use of the irrigation demand. Thus, approximately 49 percent of the water demand is available for reuse. For assessment of the various alternatives, we assumed that 50 percent of the total demand would be available for reuse.

Another important assumption in assessing the costs of various alternatives is that the cost of obtaining future renewable and non-renewable water rights was not included. Renewable (surface water or alluvial ground water) water rights may cost between $3,000 and $10,000 per ac-ft; whereas, non-renewable Denver Basin water rights may cost between $1,500 and $3,000 per ac-ft. Also, the costs of constructing the storage reservoirs used in the renewable and reuse water alternatives and the cost of getting renewable and reuse water to these reservoirs was not included. This was because no planning level cost estimates were available for a typical water storage reservoir storing renewable water, whether this water is stored in Jimmy Camp Reservoir or in a new Forest Lakes reservoir. Storage reservoirs would be common to many of the renewable and reuse water alternatives.

The alternative costs include the pumping and transport of water from the renewable or non-renewable sources to a given water provider. The costs did not include the water distribution system within a given water provider's service area. Assumptions related to the sizing and costing of specific infrastructure sub-systems are presented as part of Appendix 7-3 "Description of Calculation Factors for Computer Program 'COST'."

7.3.2 Physical Features

In Alternative 1A (Figure 7-1), the Northern Water Providers continue to pump their individual wells at existing rates (2,410 ac-ft/yr). A regional water pumping, treatment, and conveyance system from a satellite well field located at the intersection of Colorado Highway 105 and U.S. Highway 83 would supply 2,551 ac-ft/yr; whereas water reuse from an individual Northern Water Provider's wastewater treatment plant effluent would supply 2,480 ac-ft/yr, or approximately 33 percent of the total 2020 demand. This total supply of 7,441 ac-ft/yr would meet the estimated 2020 demand for Donala, Forest Lakes, Monument, Palmer Lake, Triview, and Woodmoor. For this alternative, two regional water treatment plants are proposed, one each at the satellite well field and the reuse reservoir in Forest Lakes Metropolitan District.

Potential satellite well fields that could supply water from Denver Basin aquifers for the Northern Water Providers include: (1) the Younger Ranch, which has approximately 5,000 ac-ft of Denver Basin decreed water (99CW214); (2) the Shamrock Ranch, which has 2,241 ac-ft of Denver Basin water; (3) the Shamrock East Ranch, which has 1,276 ac-ft of Denver Basin water; and (4) the Bar X Ranch, which has 3,888 ac-ft of Denver Basin water.

Alternative 1B (Figure 7-1) is similar to Alternative 1A except that the Northern Water Providers would cease pumping their individual wells and derive both existing and future demands from a satellite well field (4,961 ac-ft/yr). This scenario would likely only happen if Denver Basin aquifer well production within the water provider's service area declined so significantly that it would no longer be practical to use the existing well systems. Water reuse of 2,480 ac-ft/yr would still come from a reuse reservoir in Forest Lakes Metropolitan District. This total supply of 7,441 ac-ft/yr, of which approximately 33 percent is renewable water, would meet the estimated 2020 demand for the Northern Water Providers. As with Alternative 1A, two water treatment plants are proposed, one each at the satellite well field and the reuse reservoir.

Alternatives 1C, 1D, and 1E (Figure 7-2) are similar to Alternatives 1A and 1B, except that in each a single regional water treatment plant is proposed in Forest Lakes Metropolitan District to treat both satellite well field and reuse water. Alternative 1C is different from Alternative 1A in that only non-winter reuse water (1,860 ac-ft/yr instead of 2,480 ac-ft/yr) is available due to lack of adequate reservoir storage. Thus, only 25 percent of the total 7,441 ac-ft/yr of 2020 demand is renewable water for Alternative 1C, with the remaining 2020 demand of 3,171 ac-ft/yr coming from a satellite well field, but treated at the regional water treatment plant in Forest Lakes. Alternative 1D is identical to Alternative 1A, except that all water is treated at a single regional water treatment plant. Alternative 1E is identical to Alternative 1B, except that all water is treated at a single regional water treatment plant in Forest Lakes Metropolitan District. Both Alternatives 1D and 1E result in 33 percent of the 2020 demand of 7,441 ac-ft/yr coming from renewable water.

In Alternative 2A (Figure 7-3), the Northern Water Providers continue to pump their individual wells at existing rates (2,410 ac-ft/yr). A regional water pumping, treatment, and conveyance system from a new Jimmy Camp storage reservoir would supply 2,551 ac-ft/yr; while water reuse from a Forest Lakes reservoir would supply 2,480 ac-ft/yr. This total supply of 7,441 ac-ft/yr would meet the 2020 demand for Donala, Forest Lakes, Monument, Palmer Lake, Triview, and Woodmoor. For this alternative, two regional treatment plants, one each at Jimmy Camp Reservoir and the Forest Lakes reservoir, would be needed. This alternative provides 5,031 ac-ft/yr of renewable water, or approximately 68 percent of the estimated 2020 demand for the Northern Water Providers.

In Alternatives 2B and 2C (Figure 7-4), a single regional water treatment plant in Forest Lakes Metropolitan District is assumed. For Alternative 2B, approximately 68 percent of the 2020 demand is from renewable water; whereas for Alternative 2C, 100 percent of the 2020 demand is from renewable water.

Alternative 3A (Figure 7-5, Sheets 1 and 2) is similar to Alternative 2A except that the Northern Water Providers would cease pumping their individual wells and derive both existing and future demands from Jimmy Camp Reservoir (4,961 ac-ft/yr). Water reuse of 2,480 ac-ft/yr would still come from a reuse water storage reservoir in Forest Lakes Metropolitan District for Donala, Forest Lakes, Monument, Palmer Lake, Triview, and Woodmoor. An additional 2020 demand of 1,152 ac-ft/yr from Jimmy Camp Reservoir, without reuse, would be provided for Paint Brush Hills, Park Forest, and Woodmen Hills. For this alternative, two regional treatment plants, one each at Jimmy Camp Reservoir and the reuse reservoir, would be needed. This alternative provides a renewable water supply for 100 percent of the estimated 2020 demand (8,593 ac-ft/yr) for the above water providers.

In Alternative 4A (Figure 7-6), the Northern Water Providers continue to pump their individual wells at existing rates (2,410 ac-ft/yr). A regional water pumping, treatment, and conveyance system from a new storage reservoir on Beaver Creek in the Forest Lakes Metropolitan District would supply 2,551 ac-ft/yr; while water reuse water from the same reservoir would supply 2,480 ac-ft/yr. This total supply of 7,441 ac-ft/yr would meet the estimated 2020 demand for Donala, Forest Lakes, Monument, Palmer Lake, Triview, and Woodmoor. For this alternative, one regional treatment plant in Forest Lakes is proposed for both the reservoir and reuse water. This alternative provides 5,031 ac-ft/yr of renewable water, or approximately 68 percent of the estimated 2020 demand for the Northern Water Providers.

Alternative 4B (Figure 7-6) is similar to Alternative 4A except that the Northern Water Providers would cease pumping their individual wells and derive both existing and future demands from a new storage reservoir on Beaver Creek in the Forest Lakes Metropolitan District (4,961 ac-ft/yr). Water reuse of 2,480 ac-ft/yr would still come from the Forest Lakes reservoir. This total supply of 7,441 ac-ft/yr would meet the estimated 2020 demand for the Northern Water Providers. As with Alternative 4A, one water treatment plant is proposed. This alternative provides a renewable water supply for 100 percent of the estimated 2020 demand for the Northern Water Providers.

It should be noted that Alternatives 4A and 4B would also serve as infrastructure if renewable water were available from Rampart Reservoir. This assumes that minimal infrastructure would be required at Rampart Reservoir to divert water north to the Beaver Creek watershed and ultimately into a new reservoir in the Forest Lakes Metropolitan District.

For Alternatives 5A, 5B, and 5C (Figure 7-7), the number of individual well users was estimated from SEO well records for Townships 11 and 12 South and Ranges 65, 66, and 67 West. A total of 4,541 wells were identified in this area with well concentrations of up to 184 wells per square mile. It is estimated that these wells could account for as many as 14,530 people, if it is assumed there are 3.2 people per well. The centroid of these well concentrations is a point on the section line between Sections 4 and 5, T. 12S., R. 65W and between Sections 32 and 33 of T. 11S., R. 65W. (Figure 7-7). Assuming 80 gpcd for each well user, it is estimated that the annual Year 2020 demand for 14,530 people is approximately 1,300 ac-ft.

It was assumed that this annual demand could be provided from the proposed satellite well field (Alternative 5A), from Jimmy Camp Reservoir (Alternative 5B) or from a new Forest Lakes reservoir (Alternative 5C). For each of these alternatives, a water treatment plant would be required to provide treated water to the demand centroid location. Alternatives 5B and 5C provide a renewable water supply for 100 percent of the 2020 demand for 14,530 individual well users. Further evaluation of alternative private well user systems is provided in Section 8 of this report.

7.3.3 Capital and O&M Costs

The computer program COST (Appendix 7-3) was used to assess the capital and operation and maintenance (O&M) costs of each alternative. These costs form the basis for recommendations related to County water infrastructure projects to the Year 2020. The rationale for using this computer program is that each alternative was treated equally relative to other alternatives.

Several cost factors were common to each alternative. These factors are presented in the following table and were part of the input to the COST program.

Program COST Input Variables Common to Alternatives

Variable	Value Used on COST
Cost of electricity	0.070 $/kwh
Pump efficiency	0.70 (decimal)
Hazen-Williams friction coefficient	135
Escalation cost factor	1.0
Pipe length factor	1.15
Maximum water flow factor	1.5
Price per acre of land	$500.00
Annual interest rate	0.05 (decimal)
Annual insurance rate	0.01 (decimal)
Tax rate	0.0025 (decimal)
Number of years in amortization period	20

Appendix 7-4 contains summaries of capital costs and annual O&M costs by alternative for each of the Northern Water Providers included in the analyses. The alternative cost summaries were developed from individual alternative components such as water treatment, optimal transmission pipe costs, Denver Basin well costs, and other components by water provider, as shown in Appendix 7-5. The component costs in Appendix 7-5 can be combined for each individual Northern Water Provider to assess the capital and O&M costs for additional alternatives not specifically addressed in this report.

Capital costs include construction costs, depreciable capital costs, and non-depreciable capital costs. Construction costs include wells, pumps, interwell pipe, transmission pipe, booster stations, terminal storage, and water treatment. Depreciable capital costs include interest during construction, startup costs, and owner's general expense. Non-depreciable capital costs include land costs and working capital. The definitions of these costs and the factors used to calculate them are given in Appendix 7-3.

Table 7.3 summarizes the capital and annual O&M costs for each of the infrastructure alternatives. The capital costs ranged from $8.092 million for Alternative 5C, associated with providing 1,300 ac-ft/yr of water to private well users, to $82.192 million for Alternative 3A, a renewable water supply of 8,593 ac-ft/yr from Jimmy Camp Reservoir for nine Northern Water Providers. Other alternatives had capital costs falling between these two. While these capital costs may appear high by today's standards, water, especially renewable water, will become increasingly expensive in the future as population grows and water supplies dwindle in El Paso County.

Several infrastructure alternatives are directly comparable if it is kept in mind that water rights acquisition and reservoir construction costs were not included in the capital costs. These costs were not included because no planning level cost estimates were available for reservoirs storing renewable water, whether it is stored in Jimmy Camp Reservoir or in a new Forest Lakes reservoir. These two reservoirs would be common to many of the renewable water alternatives.

Alternatives 1A, 1C, 1D, 2A, 2B, and 4A all assume that the Northern Water Providers will continue to pump their individual wells at existing rates (2,410 ac-ft/yr), but that future year 2020 demand will be from reuse (1,860 or 2,480 ac-ft/yr) and from either a new satellite well field, or new surface reservoirs (2,551 or 3,171 ac-ft/yr). Comparing the capital and O&M costs for these three alternatives, as shown in Table 7.3, indicates that for the same quantities of future water demand for the Northern Water Providers, the cost of transporting water is less expensive if a nearby surface reservoir is used. Such a reservoir would be in the Forest Lakes subdivision. While it may be less expensive to use a satellite well field (capital cost of approximately $31 million), this water supply is judged to be only an interim solution (say up to the Year 2020);

whereas, the fully renewable supply obtained from the reservoirs (either $12 or $53 million, respectively) is a long-term reliable source.

Alternatives 1B and 4B are comparable and similar to Alternatives 1A, 2A, and 4A, except that the Northern Water Providers cease pumping their individual wells. While the capital and operating costs for these two alternatives (either $46.544 or 21.285 million, respectively) indicate that a water supply closer to the respective water providing entities may be less expensive, it should be kept in mind that costs for acquisition of water rights and reservoir construction are not included. Alternatives 1B and 1E also are comparable and show the difference in two versus one water treatment plant. The capital and O&M costs for two water treatment plants (Alternative 1B) is $46.544 million versus the capital and O&M costs for a single water treatment plant of $55.461 million. The difference is, while treatment plant costs benefit from an economy of scale, more and larger pipelines are needed to move the raw water from the satellite well field to the regional treatment plant and then redistribute the treated water to each water provider. Therefore, a system of smaller, but separate water conveyance pipelines, including booster stations and terminal storage tanks, may be less expensive than a single large water conveyance system.

Alternatives 5A, 5B, and 5C compare the capital and O&M costs of transporting water to a demand center for 14,530 of the estimated 25,000 private well users in the northern portion of El Paso County. Water transport from a satellite well field ($11.806 million capital cost for an interim solution) or from new surface reservoirs ($9.137 or $8.092 million capital cost for a long-term solution), indicate that a nearby surface reservoir may be a reasonable long-term solution if storage can be obtained on a cost-sharing basis. Again, it must be understood that the costs of water rights and reservoir construction are not included in the infrastructure costs.

Capital and annual O&M costs were allocated among the individual water providers according to the percentage of the annual demand of each provider. Figure 7-8 shows the approximate percentages of construction and annual O&M costs allocated to the Northern Water Providers for Alternatives 1, 2, and 4. Figure 7-9 shows the allocations for Alternative 3A.

7.3.4 Annual Costs

Table 7.4 gives total annual costs, unit costs per acre-foot of water, and unit costs per 1,000 gallons ($/1,000 gal) for each alternative. Total annual costs are calculated as the sum of annual O&M costs, plus depreciable capital costs times a fixed charge rate for interest, insurance and taxes, plus non-depreciable capital costs times the annual interest rate. The annual costs represent the costs for each water provider to service the debt on construction cost, land cost, and working capital, plus annual O&M cost. Total annual unit costs for the alternatives range from $2.77 to $6.06/1,000 gal.

As with the capital and O&M costs, annual costs for various alternatives are comparable. Annual unit costs for Alternatives 1A through 1E indicate that using a satellite well field to meet year 2020 demands would cost between $4.19 and $4.51/1000 gal. Surface reservoir supply sources (Alternatives 2A through 2C, 3A, and 4A and 4B) would cost between $2.77 and $5.85/1000 gal. These unit costs do not include the cost of water rights and reservoir construction. For fully renewable water supply alternatives (Alternatives 2C, 3A, and 4B) the annual costs range from $2.77 to $5.16/1000 gal, assuming no costs for water rights or reservoir construction. Figure 7-10 graphically compares the unit costs in $/1,000 gal for each alternative.

7.3.5 Phasing of Infrastructure Construction

Infrastructure construction phasing could reduce the cost burden on the Northern Water Providers, especially when a reuse system or new water supply from a satellite well field is part of a selected alternative. Wells could be drilled as needed to supply new demand. Pipelines, however, are usually constructed only once. Therefore, the final design size pipeline would be constructed initially.

Reuse components should be constructed first to take advantage of the water currently discharged from existing Denver Basin pumping. A key component of this reuse system would be use of the existing Bristlecone Reservoir, an expanded Bristlecone Reservoir, or a new reservoir, along with a water treatment plant, in the Forest Lakes Metropolitan District. As future demand approaches existing Denver Basin pumping and reuse, additional facilities should come on line. Because demand projections over time for the Northern Water Providers indicate that the demand for reuse of one-half of the existing 2,410 ac-ft/yr will be met in about 3 to 4 years, thought should be given to locating and constructing portions of a reuse system in the near future.

For those alternatives which involve reservoirs for renewable water, it may be possible to expand existing reservoirs, or construct new reservoirs in stages over time to reflect increasing water demand. Most certainly, pumping and water treatment systems can be constructed for expansion as future water demands come on line.

7.3.6 Regulatory and Environmental Impacts

Regulatory issues related to the proposed water supply alternatives are related to obtaining additional ground water rights for the proposed satellite well field and surface water rights for a new Forest Lakes reservoir or obtaining storage in the proposed Jimmy Camp Reservoir, which is part of CSU's raw water collection system. The proposed satellite well field centroid, located at approximately the intersection of Colorado Highways 105 and 83, is adjacent to the Younger Ranch. This ranch has approximately 5,000 ac-ft of water in storage in Denver Basin aquifers beneath the property (99CW214). All or portions of this water could be available for purchase by the Northern Water Providers. Other northern El Paso County ranches with relatively large Denver Basin water rights portfolios, and potentially available for satellite well fields, include Shamrock, Shamrock East, and Bar X.

Obtaining surface water rights for a future Forest Lakes reservoir may be difficult. Imported water appears to be possible, but may have to be coordinated with CSU. Use of Jimmy Camp or Rampart reservoirs as storage sites would definitely involve CSU who currently own, or will own, these reservoirs. Additional new water storage is currently being planned in Fountain Creek by rehabilitating gravel pits as water storage structures, but likely cannot benefit the Northern Water Providers unless water is physically delivered from these gravel pits to the providers. An exchange of water is not likely to be legally operable during most periods of the year.

Environmental issues related to the proposed alternatives would most likely involve environmental impact statements (EISs) for storage reservoirs. Additional issues will be centered on a satellite well field and construction areas within 300 feet of Monument Creek as a result of the Prebles Meadow Jumping Mouse habitat.

7.4 Infrastructure Analyses for Southern Water Providers

While several regional infrastructure alternatives have been evaluated for the Northern Water Providers to interconnect their systems to provide more efficient water management, the Southern Water Providers (Cherokee, Fountain, Colorado Centre, Stratmoor Hills, Widefield, and Security) already have integrated their water supply systems. The various points of system interconnection are shown on Figure 7-11. As shown on Figure 7-11, not only are the Southern Water Providers interconnected locally, but there are also emergency interconnections to CSU through Cherokee, Colorado Centre, and Stratmoor Hills.

Since a large portion of the Southern Water Providers' water system is provided through Fry/Ark water, there is a large component of reusable effluent after first use. It is estimated that there is approximately 6,000 ac-ft/yr of reusable effluent from a combination of all of the Southern Water Providers.

There are a number of ways that the reusable effluent can be integrated into each of the Southern Water Providers' water systems. Cherokee is completing a new treatment plant with rapid infiltration basins, whereby the reusable effluent will be recharged into the Black Squirrel alluvial aquifer upgradient of its existing alluvial well production field so that, not only does Cherokee achieve reuse of its effluent, but also recharges the system from which it is deriving its supply. This not only recharges Cherokee's source of supply, but also helps to improve the overall water quality that is being extracted by its alluvial production wells by introducing water with lower total dissolved solids than the native flow, which is dominated by irrigation return flows.

Another possibility for the Southern Water Providers is to allow the reusable effluent to flow down Fountain Creek to the Arkansas River and then be exchanged back to Pueblo Reservoir. The water could then be re-pumped through CSU's proposed southern pipeline. However, there are both significant losses and significant costs associated with this option. It has been estimated that as much as 50 percent of the water that would flow down Fountain Creek to the Arkansas River could not be reclaimed, either due to transmission losses that would be assessed or periods of time when the water could not be exchanged back to Pueblo Reservoir, which could be as long as six months in duration (from November through April). In addition, to participate in CSU's southern pipeline, participants have to pay the pro-rata share of capacity used in the pipeline plus a 50 percent surcharge. Therefore, this option may not be particularly attractive to most of the Southern Water Providers.

A third methodology would be the acquisition of additional storage in the vicinity of where reusable effluent is re-introduced to Fountain Creek, so that the reusable effluent could be stored, either directly or by exchange, and then reused during times of need. There are several gravel pits in the area that potentially could be converted to water supply reservoirs for this purpose. However, at this time, none of the Southern Water Providers have obtained a gravel pit for reusable effluent storage.

In summary, reusable effluent is a critical element of the Southern Water Providers' overall water supply system, and it is anticipated that these supplies will be used to their full extent in the future, as water demands grow. The Southern Water Providers are currently exploring potential infrastructure needs that will best fit their plans for the use of this reusable effluent.

While the infrastructure needs for optimizing the use of reusable effluent are a matter of increasing the efficiency of use within a water supply system, there are two issues related to the water supply systems of the Southern Water Providers which may need to be addressed. The first issue is that the Southern Water Providers that obtain their principal supply from the Fountain Valley Authority pipeline may not have a sufficient backup plan should there be problems with delivery of water through the Fountain Valley Authority pipeline. The second issue of concern to the Southern Water Providers who obtain water from the Widefield Aquifer is that of degraded water quality due to upstream industrial uses. These issues could potentially result in infrastructure needs in the future in the form of water storage and water treatment facilities, respectively.

7.4.1 Raw Water Storage

While the Southern Water Providers have emergency interconnections among the individual water supply systems so that they can assist each other in the event of an emergency, there is no redundancy in the water delivery system from Pueblo Reservoir to these entities. For example, if the Fountain Valley Authority pipeline were to have a problem delivering water, there is no alternate means currently in place to deliver this water to the Southern Water Providers. In fact, this situation has occurred in the past. It may be prudent for the Southern Water Providers, either individually or collectively, to evaluate the possibility of obtaining additional raw water storage in the event of problems with delivery from the Fountain Valley Authority pipeline. To evaluate the required storage capacity, we would recommend evaluating historic shutdowns of the Fountain Valley Authority pipeline and the times of year when this occurs. Since water demands vary greatly throughout the year, a shutdown in delivery during the summertime would have a vastly different impact than a similar shutdown in the wintertime.

In addition, because the Southern Water Providers also operate alluvial wells, it should be evaluated whether the alluvial wells can serve as a backup water supply in the event of the Fountain Valley Authority pipeline being shut down, and for how long a period of time.

It is possible that this raw water storage could be combined with the storage of reusable effluent, stored either directly or by exchange. In this way, the raw water storage could be utilized most of the time for storage of reusable effluent, with surcharge storage available for Fountain Valley Authority water on an as-needed basis.

7.4.2 Water Quality Issues in the Widefield Aquifer

There are two major industrial operations upstream of the water suppliers using the Widefield aquifer: Eagle Picher, and Schlage Lock (Schlage). Both Eagle Picher and Schlage (Figure 7-11) have caused significant ground water contamination, both onsite and offsite, of their facilities. The principal ground water contaminants associated with Eagle Picher are sodium and nitrate, while the principal ground water contaminants from the Schlage plant are PCE and TCE. The ground water contamination of both sites has been identified by the CDPHE and both sites are currently being actively remediated by the owners of the property.

The following sections describe the general ground water contamination issues at each of the plant sites and what is being done to contain and/or remediate the ground water contamination.

7.4.2.1 Eagle Picher

The Eagle Picher plant has manufactured nickel-cadmium (nicad) batteries since 1969 when production began at the facility (Figure 7-11). Waste streams from this process were stored in ponds that subsequently were shown to be leaking directly into the underlying ground water (Callaway Environmental Consultants, April 15, 1991).

Ground water monitoring was initiated in 1985 to identify the extent of the contaminated ground water plume issuing from the surface containments. Since that time, Eagle Picher has been collecting samples and conducting remediation on site in an effort to control the source of the contamination. To our knowledge, there has not been downgradient or off-site remediation undertaken by Eagle Picher. Based on annual reports which we have obtained from the CDPHE regarding the remediation efforts at the Eagle Picher plant, even with the remediation efforts, there are still elevated nitrate and sodium concentrations, both in the area of the historic source of contamination and downgradient of the source area (Eagle Picher Technologies, LLC, March 1, 2000).

The Eagle Picher site is likely one of the sources of the observed elevated nitrate-nitrogen concentrations in alluvial ground water being pumped by water providers producing water from the Widefield aquifer. While the Eagle Picher reports indicate that ground water velocities are on the order of 30 feet per year (ft/yr), Widefield aquifer wells operated by both Widefield and Security have already observed PCE contamination from the Schlage facility, which is located further away from these production wells than the Eagle Picher facility. Therefore, given the time frame over which contaminants have been migrating downgradient from Eagle Picher (over 30 years), it would appear that elevated nitrate-nitrogen concentrations from the Eagle Picher facility have also reached these production wells, and likely will continue to do so well into the future (as wells downgradient of the source of Eagle Picher are still showing elevated nitrate-nitrogen concentrations and there is no active remediation in this area).

While current nitrate-nitrogen concentrations are below the drinking water standard of 10 milligrams per liter (mg/L) as nitrogen at the current Widefield aquifer production well locations, this situation could change in the future if higher concentrations of nitrate-nitrogen are located upgradient of these wells and/or any of the municipal water suppliers install new wells that are at different locations within the nitrate-nitrogen plume, i.e. locations where nitrate-nitrogen concentrations are higher. Should nitrate-nitrogen concentrations increase, there could be infrastructure needs related to additional water treatment to produce potable water supplies. Treatment for nitrate removal can be quite expensive and is estimated to cost between approximately $1.00 and $3.00/1000 gal.

It is recommended that ground water monitoring at the Eagle Picher facility, and downgradient of the facility, be tracked by the water supply entities that obtain water from the Widefield aquifer so that future changes in nitrate-nitrogen concentrations can be predicted and appropriate measures to mitigate these effects can be taken by the water supply entities. A better understanding of the source of nitrate-nitrogen concentrations in the Widefield aquifer as it relates to Eagle Picher would also be useful in assessing liability associated with potential additional treatment costs that may be required in the future to remove nitrate from municipal water supplies.

7.4.2.2 Schlage

The Schlage facility is located across the street from the Eagle Picher plant (Figure 7-11) and the general direction of ground water flow beneath the Schlage facility is to the west until ground water enters the Widefield aquifer, then flows generally to the southeast in the Widefield aquifer.

PCE was identified in the local ground water beneath the Schlage facility in 1988. PCE is a dense, non-aqueous phase liquid (DNAPL). DNAPLs are denser than water and, therefore, tend to migrate to the lower portions of the aquifer and potentially collect in low spots in the alluvial contacts with the underlying bedrock. DNAPLs can create significant problems in remediating since they generally do not move with the overall ground water flow, and, when collected in low spots, can "bleed" for long periods of time into the alluvial ground water as flow passes over pockets of high concentrations of DNAPLs (PCE).

It may be that the overall source of PCE at the Schlage facility has not been fully identified, as additional sources of PCE were identified in December 1999 (Handex, September 12, 2000). Current remediation efforts include soil vapor extraction and on-site and off-site ground water recovery systems. However, significant quantities of PCE have entered the Widefield aquifer from historic operations.

It is known that PCE that has historically been released from the Schlage facility has reached some of the municipal water supply wells in the Widefield aquifer, which are located over 2 miles downgradient from the point where contaminants would enter the Widefield aquifer. Widefield Water and Sanitation District municipal wells W-1, W-2 and C-1 are currently being treated to remove PCE from the ground water extracted by these wells. In addition, Security Water and Sanitation District well S-10 also has a system that removes PCE from water pumped from this well. Given the extent of the PCE plume that has been identified in the Widefield aquifer, and the characteristics of DNAPLs in general, it is likely that treatment will be necessary at these wells into the foreseeable future. In the documents that we reviewed at the CDPHE, there has been no plan to contain the PCE in the Widefield aquifer, other than well head treatment for municipal supply wells. Therefore, the installation of additional wells would likely also encounter significant PCE contamination.

From an infrastructure standpoint, it appears that Schlage is shouldering the responsibility and costs associated with the treatment of PCE at the municipal water supply well heads so that there is no additional cost incurred either by the municipal water suppliers or by customers of the municipal water suppliers. Therefore, while there may be additional capital and operation and maintenance costs associated with well head treatment, these costs are being borne by Schlage. In addition, it is our understanding that Schlage is taking steps to prevent further PCE movement into the Widefield aquifer and has also installed sentry wells in the vicinity of existing potable water production wells as an early warning system. It is likely that pumping by Schlage at the downgradient locations will help contain additional nitrate contamination from Eagle-Picher as well.

It is recommended that this issue be monitored carefully, because even with the diminishment of PCE concentrations, there is the potential for substantial PCE concentrations to accumulate in low spots and to continue to cause water quality problems long after the expected diminishment of these concentrations based on travel times in the alluvial aquifer. It is believed that the well head treatment for PCE is likely a permanent requirement at all municipal supply wells in the Widefield aquifer in this vicinity into the foreseeable future.

7.5 Conclusions

This planning-level infrastructure assessment has looked at several potential alternatives for providing both interim and long-term water supplies to various El Paso County water providers. In all cases, the infrastructure alternatives were sized and costed for County water demands estimated to occur in the year 2020. Interim water supplies were assumed to come from Denver Basin ground water with reuse under augmentation plans from reuse of Denver Basin water. Long-term renewable water supplies were assumed to come from surface reservoir water storage in two locations: either the proposed Jimmy Camp reservoir or a new reservoir in the Forest Lakes subdivision. Additional planned storage may also be available at other locations in El Paso County, such as Rampart Reservoir or gravel pit storage in Fountain Creek. Utilization of gravel pit storage for Northern El Paso County Water Providers most likely would be by direct pumping. Our assessment concludes that renewable water in whole, or in part, is the ultimate solution to a secure water supply for the residents of El Paso County.

Many assumptions were used in this infrastructure planning. The reader should be familiar with these assumptions when comparing estimated costs for the various infrastructure alternatives. These assumptions are explicitly stated in the text, tables, and appendices of this report.

7.6 Recommendations

Based on the planning-level assessment of infrastructure for Northern and Southern Water Providers and selected private well users in El Paso County, the following preliminary recommendations are made:

1. Provide water reuse and treatment using the exisiting Bristlecone Reservoir, and expanded Bristlecone Reservoir, or a new reservoir located in Forest Lakes Metropolitan District for the Northern Water Providers.

2. Provide additional interim water supply for the Northern Water Providers through a satellite Denver Basin well field.

3. Provide a renewable water supply from surface water via reservoir storage in either a new Forest Lakes reservoir or from Jimmy Camp Reservoir.

4. Construct water pumping, treatment, and conveyance systems in phases.

5. Provide water reuse using gravel pit storage in lower Fountain Creek for the Southern Water Providers.

6. Continue to have CDPHE require treatment of selected contaminants in the Widefield aquifer so that the quality of the water supply is protected for the Southern Water Providers.

Summary costs of the fourteen alternatives assessed in this infrastructure analysis are given in the following table. These alternatives are recommended for further consideration by the EPCWA.

Alternative	Annual Demand (ac-ft)	Annual Demand that is Renewable/Non-Renewable (ac-ft)	Capital Costs [1,2] ($1,000s)	Annual O&M Costs [1,2] ($1,000s)	Total Annual Costs [1,2,3] ($1,000)
1[a]	5,031	2,480/2,551	$30,909	$4,540	$7,369
1B	7,441	2,480/4,961	$40,013	$6,531	$10,561
1C	5,031	1,860/3,171	$33,958	$4,286	$7,401
1D	5,031	2,480/2,551	$29,441	$4,169	$6,866
1E	7,441	2,480/4,961	$49,242	$6,219	$10,735
2[a]	5,031	5,031/0	$57,525	$4,302	$9,590
2B	5,031	5,031/0	$30,768	$3,855	$6,676
2C	7,441	7,441/0	$53,085	$5,584	$10,462
3A	8,593	8,593/0	$82,192	$6,880	$14,434
4A	5,031	5,031/0	$12,504	$3,683	$4,814
4B	7,441	7,441/0	$16,023	$5,262	$6,709
5A	1,300	0/1,300	$11,806	$1,486	$2,569
5B	1,300	0/1,300	$9,137	$1,307	$2,143
5C	1,300	0/1,300	$8,092	$1,247	$1,987

1 Assumes a 20-year planning horizon.
2 Does not include costs for water rights acquisitions and reservoir construction.
3 Sum of O&M, interest, insurance, taxes, and nondepreciable capital costs.

Combining various infrastructure components can be used to assess other alternatives. These infrastructure components, their capital and O&M costs, and their annual costs are attached in Appendix 7-5.

8.0 Synergistic Projects with Colorado Springs Utilities

The purpose of this phase of the El Paso County Water Report is to investigate whether there are possible areas where CSU and EPCWA water providers can act cooperatively on water rights, water supply, and infrastructure components. One meeting was held with CSU on December 11, 2000 to discuss possible synergistic projects. At that time, CSU indicated that they had recently published a "white paper" on possible institutional approaches for water, wastewater, and storm water within the City of Colorado Springs. This white paper addressed development outside the City in areas of El Paso County within the urban planning area. A copy of this white paper is attached as Appendix 8-1.

8.1 Existing Synergistic Projects

The Fountain Valley Authority was established under Colorado State law in 1979 through an establishing contract between the City of Colorado Springs, the City of Fountain, the Security Water District, the Stratmoor Hills Water District, and the Widefield Water District. Water delivery under the contract started in 1985. The Fountain Valley Authority receives 20,100 ac-ft/yr of water from the Fry/Ark Project. This 20,100 ac-ft/yr of water is allocated as follows:

Colorado Springs	14,353 ac-ft (71.41 percent)
Fountain	2,000 ac-ft (9.95 percent)
Security	1,646 ac-ft (8.19 percent)
Widefield	1,500 ac-ft (7.46 percent)
Stratmoor Hills	601 ac-ft (2.99 percent)
TOTAL	20,100 ac-ft (100 percent)

Each of the EPCWA members of the Fountain Valley Authority (Fountain, Security, Widefield, and Stratmoor Hills) owns water rights in Pueblo Reservoir and pays a conveyance charge for delivery of their share of Fry/Ark water. This delivery charge is collected and paid to the U.S. Bureau of Reclamation through the SECWCD as a payback for construction of the Fountain Valley Authority pipeline from Pueblo Reservoir.

If other members of the EPCWA wish to participate in similar synergistic projects, they also must provide water rights and participate in capital improvement and delivery charge costs for that project. Thus, additional participation in synergistic water infrastructure projects with CSU would require that the EPCWA Northern Water Providers, who currently are dependent on

Denver Basin ground water, have a renewable source of water and enough capital to develop that renewable source.

8.2 Future Synergistic Projects

CSU has defined two approaches to participation of entities in synergistic projects. These two approaches are a Colorado Springs Regional Infrastructure Authority and an Intergovernmental Agreement Without Separate Entity. Both of these approaches can be utilized in conjunction with each other in order to take advantage of the positive aspects of each.

In terms of water supply development and infrastructure, CSU is actively seeking partnership opportunities for the Southern Water Delivery System (SWDS). This system, in conjunction with the Pueblo Water Board, would make water available to providers outside the City limits. The SWDS would impose a fee on water providers within El Paso County to compensate the City of Colorado Springs for revenues lost as a result of development occurring outside the City of the Potential Urban Growth Area.

If an El Paso County water provider joined with CSU in either a regional infrastructure authority or any intergovernmental agreement for water infrastructure development, the following principles would be imposed by CSU:

1. City water would not be committed outside City limits.
2. Participants must supply their own water.
3. Participants must pay a fair share of costs.
4. The plan must include an equitable fee arrangement to protect the City's general fund.
5. The City retains control, but representation of the participant is allowed.

Because State, Federal, and regional permitting agencies have indicated that it is necessary to consider regional planning for water resources development to avoid multiple projects by multiple users for the same purpose, some form of participation with CSU by the EPCWA may be needed to obtain permits for infrastructure construction. The method of participation, economy of scale of large water development infrastructure, and financing options will be major issues related to future synergistic projects with CSU.

8.3 Conclusions

Based on meetings with CSU representatives and review of CSU's white paper (Appendix 8-1) on possible institutional approaches for water development, the following conclusions are presented:

1. Entities within the EPCWA are members of the Fountain Valley Authority which includes CSU and, therefore, are currently participating in a synergistic water project.

2. Future participation in synergistic projects with CSU could include institutional methods such as participation in a regional infrastructure authority or participation under an intergovernmental agreement.

3. Participants in future synergistic projects with CSU must supply their own water, pay a fair share of the costs, pay a fee to the City of Colorado Springs, and agree that the City would maintain control over the project.

9.0 Water Plan for Private Well Owners

There are almost 22,000 individual residential wells in the County, according to the records at the Colorado SEO. A tabulation of the residential wells in the County is shown in Figure 9-1, which is tabulated for the total number of permitted wells in each township and range in the County. Almost 19,000 of the residential wells are completed in the Denver Basin aquifers, while approximately 3,000 of the wells are completed in the southeastern portion of the County, in the Pierre Shale or in the Dakota and Cheyenne aquifers. Therefore, approximately 85 percent of all of the individual residential wells in the County are completed in the Denver Basin aquifers, with approximately 15 percent of the individual residential wells completed in formations other than the Denver Basin aquifers.

Figure 9-2 shows the number of residential wells in the County per square mile, i.e., density of wells. The highest density of residential wells is in the Black Forest area and located directly east of the Northern Water Providers (generally bordering I-25 on the east and west in the northern part of the County). Very low densities of residential wells are observed in both the eastern and southern portions of the County.

Individual residential wells tend to proliferate in rural areas, where homes are often situated on large lots. In these situations, it is generally not economical to provide centralized water and sewer service. However, while water use is low in these more sparsely-populated areas, the aquifers are still experiencing water level declines due to the pumping of others and, ultimately, it may be necessary to drill wells to tap deeper aquifers or to find alternate water supplies altogether. Because of the large volume of water in storage in the Denver Basin aquifers and relatively low usage rate per unit area in the rural part of the County, the time necessary to provide alternate water supplies may be very long. While the timing for needing to drill deeper wells or for finding alternative water sources is unknown, there is the possibility that either, or both, alternatives may be necessary in the future. Therefore, it is prudent to understand the potential water supply alternatives and an assessment of the issues relative to each of these alternatives. The following sections provide information and an evaluation of these water supply alternatives for private well owners in the County.

9.1 Water Supply Alternatives

There are three potential water supply alternatives for individual residential well users. These include:

1. Stay on existing residential wells and drill separate, deeper wells, as necessary, to maintain an adequate water supply.

2. Install a cistern and purchase water to supply the residence.

3. Have either individual or collective homeowners' associations (HOAs) finance the construction of a community-type well or well field, which would serve multiple dwellings and provide limited centralized water service.

4. Participate in a regional water supply distribution system that would provide water from a central point and distribute it to a defined area.

Individual residential wells are the cheapest source of water , both to develop and to use. A typical residential well, which is generally 300 feet in depth, or less, costs less than $5,000 to $7,500 to drill, complete, and equip, which is less than a typical municipal water tap fee. Once the well is installed, the cost for use is solely related to the electricity to drive the submersible pump, which typically is only a few cents per 1,000 gallons, as compared to $2 to $5 per 1,000 gallons for municipal water. Therefore, from a cost standpoint, individual residential wells are a very attractive option for rural homeowners.

However, as water levels decline, particularly in the Denver Basin aquifers, yields from residential wells will likely decrease, potentially to the point where sufficient water is not being produced from the shallowest aquifer beneath the property, which is typically the aquifer tapped by most residential wells. To tap a deeper aquifer requires a new well permit from the Colorado SEO and the drilling of a new, deeper well. Existing wells probably cannot simply be deepened, new wells from the ground surface have to be constructed. Therefore, there is not only the additional cost of drilling deeper, but there is also the cost to drill through the same strata where the original well was completed. The cost of developing water in deeper aquifers can progressively get much higher. In addition, equipment costs for pumping become more expensive as water levels are deeper and the subsequent electrical costs also increase.

In the Denver Basin, most residential wells are completed in the Dawson aquifer, the uppermost water-bearing formation of the Denver Basin aquifer group. This means that progressively deeper wells could potentially be drilled into the Denver, Arapahoe, and, ultimately, the Laramie-Fox Hills formations. However, this would result in residential wells which could be

1,000 to over 2,000 feet deep, which begins to make it impractical for individual homeowners to maintain and operate such deep wells.

Installing a cistern and purchasing water, rather than drilling a deeper well, is a possible option. However, the long-term cost of hauling water and the inconvenience does not make this an attractive option, except in extreme cases where no other viable water supply option is available.

One alternative, when homeowners wish to tap the deeper Denver Basin aquifers, is the use of a community-type well. In this scenario, either one, or multiple, HOAs could form a Special District to operate one, or more, deep Denver Basin aquifer wells, where the homeowners would share the cost of developing the community-type well and then hire an operator to operate and maintain the well and the distribution system to the service area of the community-type well. However, since these types of systems serve 100, or less, homes and cover a fairly limited area, it is likely the system would be operated by the HOA due to the significant costs associated with setting up a special district.

The fourth option would be a large, regional water distribution system which potentially would be operated by one, or more, existing districts, where service would be extended into large-lot residential areas to replace individual wells. This is the most expensive of the three options, since it typically requires very large infrastructure costs to provide pipelines and pump stations over an extended area, with very few service taps. Given the large costs related to both the capital costs for infrastructure installation and the subsequent operation and maintenance costs, this option would likely only be attractive if the water supply being provided was from a renewable source, thus greatly increasing the long-term reliability of the water supply to the residential users.

The following section provides an evaluation of the various water supply alternatives for meeting large-lot residential use.

9.2 Evaluation of Water Supply Alternatives

9.2.1 Individual Wells

From a cost standpoint, individual residential wells provide the best option for residential use on large lots, as long as there is sufficient quantity of water at an acceptable quality. However, both quantity and quality can be issues, depending on location, the aquifer tapped, and the changes in water level over time.

Water quantity and quality can vary spatially, although generally both are considered adequate at the current time, both in the Denver Basin and in the Dakota/Cheyenne Formation. Locally, there can be water quality issues, such as excessive concentrations of iron and manganese and high total dissolved solids concentrations, but each of these constituents can be dealt with by using individual treatment systems in the residences.

As water levels continue to decline, both water quantity and quality issues can increase. Water level declines obviously indicate a reduction in the volume of water available for use, which can affect the production rates of individual wells, but these declines in water levels can also result in increased water quality problems. As air is introduced into the formation as water levels decline, additional chemical reactions can occur, both in the well and in the distribution system, causing significant operational problems. Quantity and quality problems are likely to develop at an earlier time in the areas of higher-density development of residential wells versus areas of lower-density wells. Based on the map shown in Figure 9-2, it is likely that the area around Black Forest could experience the first problems associated with water quantity and quality as a result of ongoing use of the Denver Basin aquifers. Conversely, areas in the eastern and southern parts of the County, where residential well use is minimal, may not experience significant changes in water quantity or quality based on the very limited use of the water supplies in these areas.

Because individual residential wells are the cheapest way to obtain potable water supplies for rural residences, it is likely that individual wells will continue to be the predominant source of water in these rural areas. We are not aware of situations in the County at the current time where widespread quantity and/or quality issues are rendering water supplies unusable. We would, however, recommend that residential users monitor changes in both water quantity and water quality over time so that they have an understanding of changes which may be affecting the usability of their well water supply.

9.2.2 Community-Type Well

In areas where individual wells may need to be drilled quite deep, it can be cost-effective to drill a community-type well that would serve a number of homes. In this way, while one well would cost considerably more than a residential well, there would be an economy of scale related to installing one well and pipelines versus multiple individual wells.

In areas where residences can tap the shallowest aquifer beneath their property, it is likely most cost-effective to continue to use individual residential wells. However, as described in the previous section, as water levels decline, it may be necessary to tap deeper aquifers to maintain a viable water supply. At that point in time, community-type wells become more attractive as a means to extract water for neighborhoods from deeper aquifer systems.

The principal limitations associated with a community-type well include:

1. Any well that serves more than fifteen residences is considered by the CDPHE as a public water supply and would, therefore, be subject to water quality testing and meeting water quality standards. This would require having a licensed operator for the well and would result in additional costs being incurred, due to reporting requirements and using an operator.

2. The installation of a community-type well that is considered a public water supply, i.e., serving more than fifteen homes, would likely require the formation of a district, would be operated by a maintenance entity, or would be operated by contract with an established water company. This would then require the operation and maintenance of the well and pump system, as well as the distribution system to the homes being served.

3. Additional fees would likely be charged, beyond the amount that individual residential homeowners would be accustomed to pay when they operated individual wells.

4. A community-type well can typically only serve a limited number of homes due to the production potential of the well, the ability to serve within a limited elevation difference due to pressure changes, and the logistics of the distribution system that would be required to serve homes on large lots.

The advantages of a community-type well include:

1. The ability to set mill levies if the district is formed to raise money to operate the system.

2. A greater degree of reliability, as the community-type well would not only provide water to many homes, but would also provide fire protection.

3. Water quality would be monitored to demonstrate that it meets then-current CDPHE potable water supply standards.

4. The ability to provide technical, managerial, and financial capability to run the water supply system would have to be demonstrated to the CDPHE's satisfaction, which provides a measure of security for residents who would then be served by the water supply system.

In summary, community-type wells have applications in certain situations that should be evaluated on a site-specific basis. Typical situations where a community-type well should be considered include (a) areas where water level declines are causing residences to drill to deeper aquifer systems, (b) areas where water quality is causing significant problems with well production, and (c) areas where residences would like to centralize their water supply for more consistent water pressures and the additional security of fire protection.

9.2.3 Regional Water Supply System

The development of a regional water supply system for residential use is not practical on a County-wide basis. In some areas of the County, residential well density is less than one residential well per square mile (Figure 9-2). The only area where a regional water supply system potentially could be viable would be in the northwestern portion of the County, near the Black Forest area (Figure 9-2). This is the area where residential wells are the most dense, with up to sixty wells per square mile in some areas. However, this is still a density of one well per ten acres, and the infrastructure cost per tap serviced would still be very high, compared to individual residential wells.

Section 7 describes three potential regional water supply systems which could be developed to serve the residences in the northwestern part of the County. These alternatives would provide water from a proposed CSU Jimmy Camp Creek Reservoir, a satellite well field in the northern portion of the County, or water from a proposed Forest Lakes Reservoir, with subsequent pumping via pipeline to a central point, where water would then be distributed to residential wells (Figure 7-7).

As Section 7 describes, the least expensive regional water supply system, comprised of storage in Forest Lakes Reservoir (Alternative 5c), would have a capital cost of over $8,000 per acre-foot and an annual operating cost of approximately $2,000 per acre-foot, solely for the pipeline and conveyance system. These capital costs would not include water rights acquisitions or reservoir construction costs. Thereafter, the cost to produce the water would be almost $5 per 1,000 gallons. It is apparent that a regional water supply system would be extremely expensive to implement for individual residential use. It is likely that this type of system would only be feasible in the low-density, rural areas of the County as an option of last resort.

Another possible regional water supply system would be for an existing municipality/district to develop the Denver Basin aquifer water from beneath a rural subdivision(s) or from a satellite well field (Alternative 5a) for use to support the subdivision and to provide additional water supplies for the municipality/district. However, for this possibility to be attractive to both the homeowners and the municipality/district, it would have to (a) provide a secure water supply for the homeowners and (b) cover the municipality/district costs. This option would also be very expensive to implement and would still be reliant upon existing, non-renewable ground water resources.

9.3 Conclusions

Based on the evaluation of potential water plans for private well owners, the following conclusions are offered:

1. From a cost standpoint, individual wells are still the least expensive means to provide water supplies for large-lot rural residences.

2. Water level declines in the future will create water quantity and water quality issues at some residential wells, which may require residents to seek alternate water supplies. The time line for these declines is presently unknown and will vary from location to location, as it is related to (a) location within the basin, (b) the extent of use of the aquifer tapped by the residential user by other users, (c) the proximity of others pumping in the aquifer, and (d) which of the Denver Basin aquifers is tapped, as water supply availability varies from aquifer to aquifer.

3. At the current level of development, water supplies in the southern portion of the County will likely be adequate, as there is only minimal use of the Dakota/Cheyenne formations.

4. Residential well users in the Denver Basin can elect to drill individual wells into deeper Denver Basin aquifers as water levels decline or to convert to community-type well systems.

5. Community-type well systems should be evaluated on a site-specific basis, as they are not necessarily the best solution in all cases.

6. A regional water supply system would likely be the last option as replacement water supply for individual wells, simply due to the logistics of installing such a system and the very high costs associated with a regional water supply system.

10.0 Potential Water Import Projects

Section 7.0 described several infrastructure options for the Northern Water Providers to extend the useful life of their primary water supply source, the Denver Basin aquifers, as well as more long-term options related to bringing renewable water resources to the Northern Water Providers. However, Section 7 only described the potential infrastructure needs and did not address the potential sources of these renewable water supplies. An overview of potential renewable water resources that may be available for El Paso County water providers, both the Northern Water Providers and the Southern Water Providers, is presented in this section.

10.1 Description of Potential Projects

The ideal situation for El Paso County water providers would be to develop sufficient renewable water supplies to serve all of its customers, and maintain the non-renewable water supplies of the Denver Basin as an emergency water supply in times of drought, since the Denver Basin aquifers' water supply availability is not subject to short-term variabilities in the hydrologic cycle. However, the development of renewable water resources is not a simple process.

The local stream systems which flow through western El Paso County, Monument Creek and Fountain Creek, are fully appropriated, meaning that in all but the wettest of years there is no water available for use by El Paso County water providers (beyond that which has already been developed). Other sources of surface water within El Paso County, such as within the Upper Black Squirrel Designated Basin, are relatively water poor (hence, this is the reason that the designated basin was set up in the first place) and one of the EPCWA members (Cherokee) currently extracts water from the lower end of the designated basin. Further development in the upper basin could jeopardize Cherokee's water supply. Therefore, there is little opportunity to develop additional renewable water supplies with native surface waters in El Paso County.

Development of significant additional renewable water resources will likely have to come from trans-basin sources, i.e., other than Monument and Fountain Creeks. The following sections describe potential water supplies sources that are being discussed currently by various entities as future developable, renewable resources. This does not imply that any, or all, of these sources will be available in the future, as environmental and political considerations have a great deal of impact on the ultimate development of renewable water resources that are going to be transmitted out of their basin of origin.

10.1.1 Marketable Pool at Blue Mesa Reservoir

The general location of the marketable pool water in Blue Mesa Reservoir is shown in Figure 10-1. This project, while it has gone through several reincarnations, is essentially attempting to appropriate water from the Upper Gunnison River basin as either a new appropriation of unappropriated water or to purchase from the United States Bureau of Reclamation (BUREC) water that has already been decreed to the Aspinall Unit (marketable pool).

This project had its origins with the National Energy Resources Company (NECO) in 1984 when it obtained a conditional Water Court decree for the Union Park Reservoir project, which would be located upstream from Taylor Park Reservoir in the headwaters of Taylor River, which is a tributary to the Gunnison River. It was proposed that water stored at the Union Park Reservoir project would be piped over Cottonwood Pass into the Arkansas River drainage where it would then be delivered to the Front Range metropolitan water users via existing infrastructure owned by Denver/Aurora/Colorado Springs.

In a subsequent Water Court case, NECO sought to increase the conditional rights for the Union Park project. This case was dismissed based on the fact that NECO was seeking a speculative appropriation. Therefore, NECO sought a municipal water supply partner that had a need for the water supplies to defeat the speculative aspects of the application. Arapahoe County subsequently acquired the rights to the Union Park project and proceeded with another application in Water Court. While this application was recently denied by the Colorado Supreme Court, in its opinion, the Supreme Court stated that there are 240,000 acre-feet of decreed water available "for contractual use by future Colorado water users" in the Aspinall Unit. What this means is that BUREC owns these water rights in the Aspinall Unit and if BUREC is willing to sell these water rights, they can be put to beneficial use by **any** Colorado water users, not just Gunnison River in-basin water users. A separate 60,000 acre feet of water is set aside in the Aspinall Unit for these in-basin uses.

There is now a project known as the Central Colorado Project (CCP) that is being promoted as the means to develop the decreed water rights in the Aspinall Unit. In a letter dated March 13, 2002, the EPCWA requested of Colorado's congressional delegation that these water rights be considered as part of the 2002 House of Resolution 3881 study bill for enlarging Pueblo and Turquoise Reservoirs.

While the marketable pool has been identified as a potential renewable water resource, there are still significant political and environmental obstacles to the actual development of these water supplies. At this time, it is unknown whether BUREC is willing to enter into any contractual agreements to allow the use of this marketable pool and there is no obligation that BUREC allow the use of these water resources on the Front Range. In addition, there is a current Water Court case pending by the National Park Service to appropriate significant flows in the Gunnison River through the new Black Canyon of the Gunnison National Park. While the appropriation of flows would be junior to the Aspinall Unit rights, since a Federal Agency is applying for these rights, it could affect BUREC's desire to sell Aspinall Unit rights that are upstream of Black Canyon of the Gunnison National Park to Front Range users.

Delivery of this water to the Front Range would also require significant infrastructure installations, as well as changes in flow in several river systems. Two possible infrastructure plans to deliver CCP water are shown in Figure 10-2. One plan would deliver water to the South Platte River Basin and the other plan would deliver water to the Arkansas River Basin. This would require an extensive environmental analysis that would trigger action under the National Environmental Policy Act (NEPA) which would require the preparation of an environmental impact statement. At this time, development of renewable water resources from the Aspinall Unit for use along the Front Range is possible, although not highly probable in the near future.

10.1.2 Baca Ranch Water Supply and Delivery Project

The location of the Baca Ranch Water Supply and Delivery Project (Baca Ranch Project) is shown in Figure 10-1. The Baca Ranch Project was conceived as a means to extract up to 150,000 ac-ft/yr from an unconsolidated aquifer in the San Luis Valley. This ground water is recharged annually by runoff from the Sangre de Cristo Mountains and, therefore, would be a renewable water supply.

The concept of the project is to pump water from the unconsolidated aquifer and replace any depletions caused to stream systems from the pumping of this ground water with senior surface water rights also owned by the Baca Ranch. In this way, water supplies from the unconsolidated aquifer could continue to be diverted even at times when it would otherwise be out of priority.

The proposed delivery of this water would be by pipeline from the Baca Ranch north over Poncha Pass to Salida where the water would be released into the Arkansas River and allowed to flow downstream to Pueblo. The water would then be re-pumped and conveyed via a pipeline north to water providers along the Front Range. A schematic of how this water would be delivered is shown in Figure 10-3.

The potential removal of a large volume of water from the San Luis Valley on a continuous basis created significant local opposition to this proposed project. However, there has not been a Water Court application for the Baca Ranch Project because the project has never fully subscribed by bona fide water providers and, therefore, would be dismissed by the Water Court as speculative. Because of this, there has never been a court decision related to the Baca Ranch Project.

One other complicating factor for this project is the use of Pueblo Reservoir for non-project water, i.e., water not part of BUREC's Fry/Ark Project. As will be discussed in the following section, there are significant issues being raised currently regarding storage of non-project water in Pueblo Reservoir. While the Baca Ranch Project water would be new water introduced into the Arkansas River, Pueblo Reservoir would only be used as a terminal storage vessel to route water into a pipeline. Under these circumstances, non-project water storage may be allowed by BUREC.

Currently, the United States Congress has authorized the purchase of the Baca Ranch to be part of a newly-formed Great Sand Dunes National Park. However, the funding for the purchase of the Baca Ranch has not been completed and, therefore, the ultimate fate of the Baca Ranch is unknown at this time. While the transactions have not been completed, we would rate the viability of the Baca Ranch Project as possible, but not probable.

10.1.3 CSU Southern Delivery Pipeline

According to CSU sources, there is sufficient water supply availability for CSU customers into the foreseeable future. However, the infrastructure needed to deliver this water in a timely manner is currently a limiting factor on water supply availability. Therefore, CSU is currently pursuing the SDPS, which seeks to store non-Fry/Ark Project water in Pueblo Reservoir after Pueblo Reservoir has been expanded. This water would then be transported north to the CSU service area for use. Currently, Fountain is also participating in the SDPS. The proposed Southern Delivery Pipeline route is shown in Figure 10-4.

This proposed project is an excellent example of the political and environmental ramifications of developing additional renewable water resources in any stream system in the State of Colorado. While the two previous import projects that have been described would be the development of new water resources, this project is an expansion of an existing facility to allow for more efficient use of existing, adjudicated water supplies. As described below, even the further development of existing supplies, through some existing infrastructure, can be a very difficult, costly, and time-consuming process.

The proposed project is part of a plan developed by the SECWCD, which proposes to increase yield through existing reservoirs by re-regulation of the Fry/Ark Project by up to 48,500 acre feet, and then to expand both Pueblo Reservoir and Turquoise Reservoir by 54,000 acre feet and 19,600 acre feet, respectively, to provide additional storage to increase yields. This is commonly being referred to as the Preferred Storage Options Plan (PSOP). According to the PSOP, the re-regulation of the Fry/Ark Project and additional storage will be necessary, not only for CSU, but also for all Fountain Valley Authority members, which includes Fountain, Security, Stratmoor Hills, and Widefield.

There is currently pending in congress House Resolution 3881, which seeks to authorize a study of re-regulating the Fry/Ark Project and the expansion of Pueblo Reservoir and Turquoise Reservoir. As part of this study, it is proposed that CSU would be able to store non-Fry/Ark Project water in Pueblo Reservoir for its subsequent use in the CSU service area.

This PSOP proposal is being opposed by the City of Pueblo based on minimum stream flow concerns through the city, as well as potential sediment load issues to the lower Arkansas River. The State of Kansas is also opposing this project on the basis that it may have a negative impact on the Arkansas River Compact, and the Federal government has also registered an opposition related to the interstate compact. The Federal government recommends that the BUREC, which regulates these reservoirs, conduct a thorough study to assess potential impacts, which could take several years to complete.

In summary, while CSU has adjudicated water rights in the upper Arkansas River Basin, these rights cannot currently be delivered in an efficient manner due to lack of adequate infrastructure. According to the PSOP, the same fate could await the Fountain Valley Authority members if re-regulation and additional storage is not implemented. However, it appears that it could take years to determine whether this project can proceed. In addition to the issues related to the re-regulation and storage of non-project water in Pueblo Reservoir, CSU also has to comply with the National Environmental Policy Act (NEPA) to mitigate any environmental impacts associated with the SDPS.

Several of the EPCWA Southern Water Providers have shown an interest in the SDPS, however, at this time the cost associated with participating in this project are considered to be too high. As described in Section 7.4, one possibility for the Southern Water Providers would be to allow reusable effluent to flow down Fountain Creek to the Arkansas River and then be exchanged back to Pueblo Reservoir. This water could then be re-pumped through CSU's proposed Southern Delivery Pipeline. However, because of the anticipated channel and other losses associated with the amount that would be released versus the amount that could be pumped back, as well as CSU's required cost sharing, at this time this does not appear to be an economical means to develop additional renewable water supplies.

We would anticipate that some form of this project will ultimately be implemented, although what form that implementation takes and how long it takes before water is actually delivered to the CSU service area, is unknown at this time.

10.1.4 Conversion of Agricultural Water Rights

Agricultural water rights are a potential renewable water supply source for EPCWA water providers. Since these water rights have already been adjudicated, the historic consumptive use associated with these water rights can potentially be converted to municipal use in a Water Court proceeding. While El Paso County is predominantly within the Arkansas River drainage basin, it should be noted that the distance from Monument to Fort Morgan is essentially the same as the distance from Monument to Rocky Ford. Therefore, there potentially could be agricultural water rights available for conversion either within the Arkansas River Basin or within the South Platte River Basin. These water rights, once converted to municipal use, would then have to be pumped and piped back to the County for use.

In the Arkansas River Basin, there are two major ditch systems downstream of Pueblo, the Rocky Ford Ditch and the Fort Lyon Ditch. Much of the available water on the Rocky Ford Ditch has been purchased by the City of Aurora, however, the Fort Lyon Canal system potentially has significant agricultural water rights available for purchase. Likewise, there have been recent sales of agricultural water rights in the lower South Platte River Basin between Sterling and Julesburg and it is likely that additional agricultural water rights are available in the lower reaches of the South Platte River. Potential areas where agricultural rights may be available for conversion are shown in Figure 10-1.

While the technical procedure for converting agricultural water rights to municipal use has been well established in previous Water Court proceedings, the primary issues associated with the conversion of agricultural water rights to municipal use are environmental and political. There is significant opposition to the drying up of agricultural lands, not only for the loss of agricultural production, but also for potential changes in habitat and erosion potential. Therefore, significant environmental issues have been raised related to the conversion of agricultural water rights. There are also political ramifications associated with the retirement of agricultural lands, such as (a) the retirement of the lands from the tax roles, (b) the loss of agricultural production solely for the purpose of serving residential homes, and (c) the movement of water that has historically been used in specific areas for use at remote locations.

Even with the potential ramifications of converting agricultural water rights to municipal use, we believe that this option represents the best potential for EPCWA water providers in the near future. The fact that these water rights are already adjudicated and only have to go through a change of use in a Water Court proceeding makes it a comparatively simpler process than the development of new renewable water resources at this time. That is not to say that this would be a simple, or inexpensive, process, only that part of the procedure is established and accepted by the Colorado Water Courts. Therefore, we would rate the conversion of agricultural water rights to municipal use as a probable future renewable water supply source.

10.1.5 Potential "Big Straw " Project

Development of additional renewable water supplies from the west slope is problematic due to depletion issues related to endangered species and a desire to maintain minimum stream flows. Because of these issues, there have been preliminary discussions related to a potential project near the Colorado/Utah state line that would allow stream flows to be fully utilized by west slope interests, but still allow Colorado to utilize its Colorado River Compact entitlements prior to that water being lost to downstream states. This proposed project, initially dubbed "The Big Straw Project", is currently being evaluated by the Colorado Water Conservation Board (CWCB) for potential study. The general location of this project is shown in Figure 10-1.

While obviously in its infancy, this proposed project would address the west slope concerns related to the Front Range increasing depletions from west slope water supplies. Transporting water from the Colorado/Utah state line back to the Front Range would be a large water transmission project but, due to its location, water could be easily diverted for use both in the South Platte River Basin and in the Arkansas River Basin.

While the west slope interests likely would have their issues resolved by such a project, there would be similar issues raised by the downstream states even though Colorado would be within its Colorado River Compact entitlement. By creating storage at the Colorado/Utah state line, there would be re-regulation of flow that could impact endangered species and/or minimum stream flows. Therefore, there likely will be environmental issues associated with this project but the source of these issues will likely come from the downstream states.

We would recommend that the EPCWA remain involved in the process with the CWCB as it relates to the future study of this project, and potentially other water supply projects that could bring additional renewable water resources to the Front Range. While this project may not come to fruition, dialogue and studies that raise awareness relative to the need for more renewable water supplies for the Front Range are beneficial and likely will ultimately result in the development of some renewable water resources.

10.1.6 Designated Basins

There are five designated basins in the general vicinity of El Paso County, both in the South Platte River drainage basin and the Arkansas River drainage basin. Three of these designated basins are shown in Figure 2-1, and include Kiowa-Bijou, Upper Big Sandy, and Upper Black Squirrel Creek. The Lost Creek and North Kiowa-Bijou designated basins are north of these basins in Elbert, Arapahoe, Adams, Weld, and Morgan Counties. The formation of designated basins is premised on the fact that the streams within these basins do not flow to the main stem of the river. Therefore, by nature, designated basins do not have reliable surface water supplies available.

There is some potential for the conversion of the agricultural water rights in designated basins to municipal use, similar to the agricultural rights conversions discussed in Section 10.1.4. However, due to the limited surface water supplies that recharge the alluvial aquifer that have historically provided water for irrigation, we do not believe that these rights in designated basins represent water rights that should be pursued by EPCWA water providers.

One potential source of water from the designated basins would be for an interim solution by utilizing Denver Basin aquifer water in these areas. Generally, the deeper Denver Basin aquifers in the designated basin areas are sparsely used and potential additional water supplies could be developed. However, as has been discussed previously, Denver Basin aquifer water is considered to be an interim solution and in the designated basins approval would have to be obtained from the Colorado Ground Water Commission prior to exporting water outside the designated basin.

10.1.7 Other CSU Import Projects

In meetings with CSU personnel, there does not appear to be additional water available in the CSU system that would be available to EPCWA members. However, Forest Lakes does currently have some surface water storage available and other potential surface water storage sites that could be developed. CSU's Rampart Reservoir is located such that water delivered through Rampart Reservoir could be delivered either to the existing, or proposed, reservoirs within Forest Lakes. Therefore, there is some possibility in the future that an agreement could be reached with CSU for wheeling water through Rampart Reservoir for ultimate storage in the Forest Lakes Reservoir(s). This would likely be newly-developed water (which would have to be developed separately by EPCWA members) and not water that is part of CSU's system.

At this time, since there are no water resources identified that could be routed through Rampart Reservoir, nor is there any agreement with CSU to allow this water to routed through Rampart, this option can be considered only conceptual in nature. It is recommended that EPCWA stay in contact with CSU personnel so that projects that could potentially move water through Rampart Reservoir into the El Paso County area for use by EPCWA water providers can be evaluated in a timely manner when such projects present themselves.

10.2 Implications of Import Water Projects

The development of new water resources projects in today's political and environmental climate is very difficult. The two primary pieces of federal legislation which control the development of new water resources projects are the NEPA and the Endangered Species Act (ESA). Anytime a new water supply project is developed it most likely involves the diversion of water out of streams and/or the storage of water in drainage basins. Due to the potential for dredge/fill operations, these types of operations need to obtain a Section 404 Permit under the Clean Water Act. To do this, there must be an environmental analysis related to the consequences associated with the project and a showing that the proposed project is the least environmentally damaging. This typically results in the need for the preparation of an EIS.

As part of this process, the U.S. Fish and Wildlife Service (USFWS) will also initiate formal consultation under Section 7 of the ESA. As part of this process, depletion mitigation will be required for all new depletions that will occur as a result of the development of new water resources. This requires augmentation water that can be delivered in a time and place to meet the needs of endangered species. Regardless of the location of the depletion relative to the endangered species, USFWS requires 1:1 depletion mitigation. This means that, in addition to the cost of developing new water resources, there are the additional costs associated with purchasing water for augmentation. This would apply to the development of all new, renewable sources, but not to the conversion of existing rights, i.e., agricultural water rights to municipal use.

The NEPA process can typically take up to two to three years to complete if there are no major environmental issues, or longer if the project is controversial. Since this process cannot even be initiated until all the project components have been identified, including the source of water, the timing of water removal and the volume of water to be removed, there is a significant lead time prior to the actual delivery of water to end users. It is for these reasons that EPCWA needs to be pro-active in pursuing potential renewable water resources projects as it appears that the shortest time frame in which new projects can come on line is approximately 10-20 years from inception.

10.3 Conjunctive Use

One of the principal objectives of developing renewable water resources is to lessen the dependence of the EPCWA providers on the non-renewable water resources of the Denver Basin aquifers. However, the ongoing viability of the Denver Basin aquifers is necessary to continue providing reliable water supplies for individual residential users and for potential use during droughts, when renewable water resources may be limited.

While the development of renewable water resources likely will include enough capability to provide carryover storage in times of drought, it is also likely that the amount of storage space available in any renewable water resource project will be limited by physical constraints related to topography. This also constrains the available storage capacity, and the ability to mitigate environmental impacts.

Therefore, as part of any renewable water resources project, conjunctive use should be considered. Conjunctive use is the concept of integrating surface water supplies and ground water supplies to obtain the maximum beneficial use of the available resource. In this context, conjunctive use would involve diverting the maximum amount of available surface resources at all times under any proposed project during times when storage capacity and demands cannot accommodate the full instantaneous supply, and the excess supply could be injected into the Denver Basin aquifers for storage and subsequent use. In this way, all of the available surface water resources are utilized while, at the same time, additional water storage is provided in the Denver Basin aquifers. This process potentially increases the longevity of the aquifers and produces additional water supplies that can be obtained from these aquifers during times of drought.

In fact, there are several economic limitations to conjunctive use. Water that is injected has to be treated to very high quality to prevent clogging of the well and/or aquifer and to meet potability standards that would allow an injection permit to be obtained. Typically, injection can not occur at rates commensurate with the pumping rate of the well, so many injection well locations may be necessary to inject large quantities of water. However, if the Northern Water Providers operated an integrated conjunctive use project, the Denver Basin Artificial Recharge Extraction Rules allow for injection of water at specific locations, with remote extraction of the water at other wells within a contiguous area (Colorado Division of Water Resources, 1995).

Not all areas, or all of the Denver Basin aquifers, are suitable for this type of a conjunctive use project, so the applicability of conjunctive use to each project will have to be evaluated on a site-specific basis.

10.4 Conclusions

There are a number of potential renewable water supply projects in Colorado that may be developed in the future (Figure 10-1). However, there are no currently-permitted projects that are likely to deliver water to EPCWA water providers in the foreseeable future. Therefore, there are several steps that need to be taken, not only to continue to provide reliable water resources to EPCWA customers, but also to help to facilitate the development of new renewable water resource projects.

These steps include:

1. Implement water conservation practices, as described in Section 5.0.

2. Demonstrate the need for additional renewable water supplies to meet the future growth in El Paso County. Demonstration of need is a fundamental component of proceeding under NEPA with a proposed water supply development project.
3. Become proactive in helping coalitions to develop new water resource projects. Local jurisdictions will have a difficult time in the future developing any large-scale water resource projects because of the multitude of issues that will confront any water supply project. Teaming with other water supply entities will help increase both the visibility and the political clout associated with any proposed project.

4. Develop intermediate solutions to meet near-term water supply issues, such as water rights infrastructure development, as described in Section 7.0.

5. Renewable water for the Northern Water Providers will most likely involve the conversion of agricultural water rights to municipal use, either in the Arkansas or South Platte River Basins.

6. EPCWA should pursue most likely projects first (such as conversion of agricultural water rights to municipal use and/or re-regulation/expansion of Pueblo Reservoir), while actively participating in promoting other long-term potential renewable water supply projects (such as a marketable pool at Blue Mesa and/or the Baca Ranch Project).

7. EPCWA should also monitor progress on other long-term projects, such as the "Big Straw" project, to be positioned for participation if the projects go forward.

11.0 Current County Water Supply Standards

The County's water supply standards are included in the Land Development Code, Chapter V, Section 49.5. The primary purpose of these water supply standards is to "determine the sufficiency of the proposed water supply in terms of quality, quantity, and dependability." In terms of quantity and dependability, the County has defined these as "[t]he water supply shall be of sufficient quantity to meet the average annual demand of the proposed subdivision for a period of three hundred (300) years." If a proposed subdivision is relying on renewable water resources, the presumption is that these renewable resources would last the minimum 300-year life. If a proposed subdivision is to rely on Denver Basin aquifer water, this would create an additional limitation beyond the Colorado statutory use provisions.

The 300-Year Rule is essentially a modification of the 100-Year aquifer life designated by State law for use of the Denver Basin aquifers. Under State law, 1/100th of the water in storage can be used annually while, in the County's 300-Year Rule, the developer of the land must show that there is sufficient water in storage to equal 300 times the projected annual demand, i.e., a maximum of 1/300th of the water in storage can be used annually from the Denver Basin aquifers.

The following sections provide a historical background of the 300-Year Rule, based on information provided by the El Paso County Planning Department, an evaluation of the 300-Year Rule and an assessment of future impacts that may be realized as a result of the 300-Year Rule.

11.1 Historical Background

Resolution No. 86-359 Land Use-194 was passed by the El Paso Board of County Commissioners on November 20, 1986, which made the El Paso County Water Resource Management regulations effective as of that date. It was envisioned that these regulations would "promote the public health, safety, and welfare by ensuring that a long-term supply of water, at least 300 years, will be available for all subdivisions." Furthermore, it was the purported intent of these regulations to allow minimal development of Denver Basin aquifer water to generate sufficient revenue to allow the developments to then pursue the purchase of renewable water supplies as the ultimate water supply for that subdivision and/or to encourage annexation of developments that would otherwise be in unincorporated areas. Since County subdivision authority does not apply within incorporated areas, the 300-Year Rule does not apply. Within incorporated areas, the regulations of the municipality apply, which, in most cases, follow the Colorado statutory use provision related to a 100-year aquifer life.

Cherokee, Triview, and Sunset filed suit against the County over the 300-year rule. The Colorado Supreme Court ultimately ruled for the County in this lawsuit, allowing the 300-year rule to be implemented as part of the County's land use regulations.

Based on interviews with several public water supply entities in northern El Paso County that are EPCWA members, including Palmer Lake, Woodmoor, Monument, Donala, Triview, and Forest Lakes, the 300-Year Rule has had little impact on development within these jurisdictions to date. The Towns of Palmer Lake and Monument are not subject to the 300-Year Rule, nor is Triview by virtue of its annexation into the Town of Monument. Woodmoor, by virtue of its location with low housing densities and minimal outside irrigation, has met the 300-Year Rule without altering its original development plan (Phil Steininger, personal communication, December 10, 2001). While Donala has experienced several inclusions since 1986, all but two were platted prior to 1986 and received a waiver on the 300-Year Rule. Even the two parcels that were not platted also received a waiver because they had deeded their water rights to Donala prior to 1986 (Dana Duthie, personal communication, December 10, 2001.) One development within Donala was subject to the 300-Year Rule but, due to the low density of the development, the 300-Year Rule had minimal impact. Forest Lakes has not started development and there is the potential that the Forest Lakes residential area could be annexed to the Town of Monument, which would then make Forest Lakes not subject to the 300-Year Rule. Currently, the Forest Lakes residential area is proceeding under the County subdivision process and will have to meet the 300-Year Rule for water produced from the Denver Basin aquifers.

According to the County, the 300-Year Rule has been applied in many situations with other water providers in cases where either Denver Basin use has met the 300-Year Rule or a renewable water supply has been used, which is presumed to meet the 300-Year Rule due to the replenishable nature of the water. An example of this is Woodmen Hills, which has purchased renewable water (350 ac-ft/yr) from Cherokee to assist with their development plan.

It is unknown if other small-scale developments have been affected by the 300-Year Rule. Mark Gebhart of the El Paso County Planning Department says that low-density developments (less than one unit per 2.5 ac) generally meet the 300-Year Rule due to low demands. However, it is unknown whether the development was designed at a low density such that the 300-Year Rule would not affect it, or whether the plan was changed prior to submittal to the Planning Department to meet the 300-Year Rule (in which case the County Planning Department would not know that a change had been made) (Mark Gebhart, personal communication, November 7, 2001). Most of these developments are low-density, consistent with the Black Forest and Tri-

Lakes small area plans, and would not be permitted higher densities, regardless of the 300-Year Rule. Since becoming effective in 1986, the 300-Year Rule has been applied to many low density subdivisions. In many large-lot subdivisions, minimal development of Denver Basin aquifer resources is occurring, with most of the Denver Basin aquifer resources remaining in storage.

11.2 Evaluation of the 300-Year Rule

The 300-Year Rule, as adopted, has two basic premises, that Denver Basin aquifer water can provide an interim water supply (for up to 300 years if necessary), while revenues generated from the development of land based on Denver Basin ground water would fund the ultimate purchase of renewable water supplies as the long-term water supply solution. In adopting the 300-Year Rule there was the potential for limitations on growth based on only having one-third of the water available compared to the legal limit allowed by State law. However, as described above, it does not appear that growth has been particularly limited by the 300-Year Rule for four reasons: namely, (1) development with municipalities is not subject to County subdivision regulation, (2) continued buildout of projects started prior to the adoption of the regulation, (3) low density subdivisions, by virtue of the low demand, are not impacted by the 300-Year Rule, and (4) some water suppliers and districts have acquired renewable resources that are deemed to meet the requirements of the regulation.

The following sections evaluate whether the 300-Year Rule has achieved its objectives of maintaining water for 300 years and in helping to develop renewable water supplies.

11.2.1 Maintain Water for 300 Years

The evaluation of a water supply, whether it be for a 100-year life or a 300-year life, is based on the amount of water in storage beneath the property that can be drained by gravity. Therefore, this analysis assumes that (a) no water will move either into or out of storage from beneath this property during the economic lifetime of the aquifer and (b) it is known with certainty what volume of water can be drained by gravity from the aquifers, i.e., the specific yield of the aquifers.

In fact, water is continually moving into and out of any specific piece of property based on hydraulic gradients within the aquifer. Most areas within the Denver Basin are susceptible to greater outflow than inflow in the underlying aquifers. In most cases, the volume of water in storage can be reduced, regardless of the use of Denver Basin water on the property.

Due to the shape of the Denver Basin and the relative pumping in Douglas County versus El Paso County, there is a hydraulic gradient in each of the Denver Basin aquifers from El Paso County north or northwest into Douglas County. Available hydraulic gradient data have been used, as well as aquifer hydraulic characteristic data, to estimate the overall storage outflow from El Paso County to Douglas County, both currently and into the future. Based on population projections, total Denver Basin pumping through the year 2055 has been estimated, using pumping centers at each of the local areas of identified growth. Using the Darcy equation, it is estimated that approximately 7,500 acre ft/year is currently flowing out of El Paso County into Douglas County from the four principal Denver Basin bedrock aquifers. By the year 2055, it is estimated that the annual volume will be 6,600 acre ft/yr. As pumping centers change, the future hydraulic gradients are estimated to actually be less than they are currently. This type of flow has likely been happening as long as the Denver Basin has been in place, due to the natural gradients and bedding, which is from the higher elevations to the lower elevations in the Basin.

Given the estimated total volume of water in storage in the Denver Basin aquifers beneath El Paso County (66,000,000 ac-ft), approximately one percent over a 100-year period is leaving the county regardless of the County's water resource management regulations. This means that, over a 300-year life of the aquifer, approximately three percent of the water supply will be lost just by virtue of water moving out of storage from beneath El Paso County. This does not include the possibility of future satellite well fields in southern Douglas County, such as on Greenland Ranch, or other large ranches, that could further increase the hydraulic gradient from El Paso County to Douglas County. This issue is discussed in Section 11.3.2.

For satellite well fields within El Paso County, the County Attorney's Office has confirmed that the water supply beneath the property can be developed under the 100-Year Rule, but that use of this water would have to provide a 300-year supply at the place of use. Therefore, there will be different standards applied to the use of water from a satellite well field, depending on whether it is used in a district or a municipality (M. Cole Emmons, May 1, 2002).

The specific yield of the Denver Basin aquifers has been estimated, and presumptive values assigned by the State Engineer's Office for the purpose of calculating the volume of water in storage in each of the principal Denver Basin aquifers. However, the actual specific yield of the Denver Basin aquifers is unknown and is currently the subject of considerable debate. Because it is likely that actual specific yield values are less than the presumptive values established by the State Engineer's Office as part of the Denver Basin Rules, there is potentially less water available to be put to beneficial use than was estimated at the time of the enactment of Senate

Bill 5 (1986). However, at this time there is no definitive means to accurately establish the specific yield of each of the Denver Basin aquifers across the entire Denver Basin area due to confined aquifer conditions and lack of a comprehensive data base.

While the intent of the County's 300-Year Rule is to ensure a 300-year water supply for "all subdivisions," this cannot be accomplished when the County does not have subdivision regulation authority over developments within municipalities. Given that the Towns of Monument and Palmer Lake, as well as Triview, operate under the 100-Year Rule, homes served within these communities are not assured a 300-year supply. In addition, due to the factors described above, water districts adjacent to these municipalities, such as Woodmoor, Forest Lakes and Donala, may also not have a 300-year supply, even if the 300-Year Rule is invoked, due to the increased pumping around their boundaries. It appears to be inconsistent to require a 300-year water supply in water districts when adjacent municipalities can still develop based on a 100-year water supply if the intent of the water supply standards is to provide a 300-year water supply in terms of quality, quantity, and dependability for everyone.

This inconsistency in water supply development may have the effect of encouraging annexation into municipalities and directing higher-density developments into municipalities. However, with the exception of the City of Colorado Springs, these municipalities, such as Monument and Palmer Lake, are heavily dependent upon Denver Basin aquifer supplies and have not developed new, renewable water resources as a result of the 300-Year Rule.

All of the Denver Basin aquifers are currently under confined conditions, which allows production rates to remain relatively high. However, as the potentiometric head on the aquifer is reduced and water levels begin to decline below the tops of the aquifers, production rates per well will begin to decline. While it may become increasingly difficult to continue to produce 1/100th of the amount of water in storage from existing and supplemental wells, the lower demand on the Denver aquifer system under the 300-Year Rule will allow the development of Denver Basin aquifer water into the future with fewer supplemental wells.

In general, it is believed that the 300-Year Rule will not ensure a 300-year water supply, because (a) the volume of water in storage is declining independent of use on a specific property, (b) there may be less water available for development than anticipated in the Denver Basin Rules based on the physical aspects of the Denver Basin aquifers, and (c) many entities are producing water at rates consistent with the 100-Year Rule, not the 300-Year Rule. While the 300-Year Rule certainly can serve to extend the life of the Denver Basin aquifers beyond the economic life that will be realized under the statutory 1/100th rule, it doesn't appear that this has actually occurred to date due to most high density developments using the 100-Year Rule and low-density developments being unaffected by either the 100- or 300-Year Rule. Therefore, for the 300-Year Rule to be effective, developments need to fully convert to renewable water, which, while desirable, is not necessarily obtainable.

11.2.2 Development of Renewable Water

It is clear that one of the intents of the 300-Year Rule was to allow developments to create a revenue base from the limited use of Denver Basin aquifer water, then allow renewable water to be purchased and developed as the long-term water supply solution. This objective has obviously not been met, as the major water providers in Northern El Paso County have developed virtually no renewable water resources since the adoption of the 300-Year Rule.

The reason for this is relatively simple. Development fees are used to generate the necessary revenues to build additional infrastructure and to purchase additional resources. Limiting development has the effect of limiting the ability of districts to go out and purchase renewable water supplies.

A financial feasibility study regarding this issue was prepared by the Research and Consulting Group, Inc. in a report dated August 1986 and concluded that anything more restrictive than a 200-Year Rule would make it difficult to generate sufficient revenues to purchase renewable water supplies. One of the premises of the analysis in this research was that all it takes is money for renewable resources to be developed. This report did not acknowledge the other complex political, environmental, and water availability issues associated with the development of renewable water resources that currently exist.

From a political perspective, the 300-Year Rule may actually hinder the potential development of renewable water resources rather than promote it. The reason for this can be found in the Western Slope's general response to the call for the development of more trans-basin water by Eastern slope interests. This response is that the Front Range needs to optimize the use of its available water resources (in this case, the Denver Basin aquifers) before the Western Slope is willing to talk to the Front Range about additional water from the Western Slope. Therefore, if the Western Slope interests believe that El Paso County is not optimizing the use of its Denver Basin aquifer resources, this may actually hinder positive discussions about renewable water with Western Slope interests.

Environmentally, the Clean Water Act and the Endangered Species Act significantly affect the ability and the timing of development of renewable water resources. The physical and legal availability of water is also a major issue, as interstate compacts, senior priority rights, in-stream flows, and endangered species can all play a role in how much water is ultimately available.

There are several major sources of renewable water supplies in Colorado. Potential renewable water supply projects are described in Section 10. The environmental and political issues associated with developing these renewable water projects are also discussed in Section 10.

The development of renewable water either to replace or supplement Denver Basin aquifer water for the Northern El Paso County water providers has been realized only to a very limited extent. Contrary to the presumption in the August 1986 Research and Consulting Group, Inc. report, it has not been just a matter of generating sufficient revenues to purchase renewable water. To facilitate the potential development of renewable water supplies, whether it be trans-basin water supplies from the Western Slope or the retirement of additional historically-irrigated farmland in the Lower Arkansas River Valley or South Platte River basins, the County's water supply standards should be flexible enough to demonstrate that Denver Basin aquifer water is being used efficiently as an interim water supply solution. One of the recommendations of the financial feasibility study by the Research and Consulting Group, Inc. was that one of these flexible, interim solutions would be development of satellite well fields to better utilize the existing Denver Basin aquifer water resources in the County.

11.3 Future Impacts of the 300-Year Rule

It appears to date that the 300-Year Rule has had limited impact on the overall growth in the County, either because (a) high-density developments served by municipalities are not subject to the rule, (b) special districts have, at times, received waivers from the 300-Year Rule, (c) the developments are of such low density that the 300-Year Rule has little impact, or (d) new developments have obtained renewable resources or annexed into municipalities. It is likely that in the future, some high-density developments in northern El Paso County will be affected by the 300-Year Rule, thereby limiting future growth that is dependent on Denver Basin aquifer resources. As water levels continue to decline in the Denver Basin aquifers, we believe that limiting future dependency on the Denver Basin aquifers is a prudent objective.

The three main concerns with the 300-Year Rule are (a) that it be fairly applied within the County, (b) the potential for it to be an impediment to the County with respect to the development of renewable water resources from the Western Slope, and (c) the potential for not being able to optimize use due to pumping by others outside the County. The challenge, then, is to provide a reliable water supply for current, and future, northern El Paso County residents, while at the same time to fairly utilize the water resources which are in place and are the least expensive to develop.

One example where the 300-Year Rule may hinder cooperative development of Denver Basin resources is the satellite well field discussed in Section 7. The Northern Water Providers are a combination of municipalities and special districts. Therefore, if there is a cooperative effort to develop a satellite well field, the municipalities would realize three times more yield that could be committed to development than the special districts. This likely would make for very difficult financial cost-sharing arrangements for a plan that should benefit all of the Northern Water Providers by spreading out Denver Basin aquifer use.

To evaluate the future impact of the 300-Year Rule in El Paso County versus ongoing development, both in El Paso County and other areas that are underlain by the Denver Basin that operate under the 100-Year Rule, a numerical ground water model of the Denver Basin aquifers was used to simulate future pumping regimens.

11.3.1 Numerical Model

A numerical model of the Denver Basin aquifers was set up using MODFLOW, the U.S. Geological Survey's modular finite-difference ground water flow model (McDonald and Harbaugh, 1988). This Denver Basin model, using MODFLOW, was originally developed by the Colorado SEO and has been modified by JCHA for previous work. Therefore, the existing model structure was used and only the well input file was modified to simulate various pumping scenarios in northern El Paso County and southern Douglas County to evaluate future water level impacts due to varying development scenarios. For each simulation, a 50-year pumping period was used.

Initially, we simulated the existing conditions, where the principal Northern Water Providers would continue to rely on Denver Basin aquifer water according to the demand schedules presented in Section 1. Monument, Palmer Lake, and Triview would be allowed to develop Denver Basin aquifer water resources according to the 100-Year Rule, while Donala, Woodmoor, and Forest Lakes would be allowed to develop water supplies from the Denver Basin aquifers according to the 300-Year Rule. We then ran a second simulation, which modified the pumping regimen for the Northern Water Providers that are subject to the 300-Year Rule to allow all Northern Water Providers to operate under the 100-Year Rule. This simulation was run to evaluate the difference in water level changes under the two scenarios if all of the entities were allowed to operate under the 100-Year Rule.

For the simulation under the 100-Year Rule, the appropriable volumes for each aquifer were assumed to be available for use based on the decrees of the Northern Water Providers. For the simulation under the 300-Year Rule, it was assumed that only one-third of the appropriable volume in each aquifer was available for use. Since the model simulates continuous pumping, this results in pumping rates in each aquifer that vary by a factor of three, depending on whether the 100-Year Rule or the 300-Year Rule applies. This pumping impact only occurs at the full development of the aquifer water availability.

Additionally, in the simulations it was assumed that the Arapahoe aquifer water would be developed first, followed in order by the Denver, Dawson, and Laramie-Fox Hills aquifers.

Information from the water distribution infrastructure options (Section 7) was then used to evaluate water level changes if each of the Northern Water Providers obtain their future water supplies from a satellite well field, but continue to provide current demands from their existing well fields, as shown in Figure 7.1 and described in Section 1. This simulation used the same demand as the first two simulations; only the pumping centers were redistributed. The intent of this simulation was to evaluate how the County satellite well field would potentially affect future water level changes versus pumping all of the Northern Water Providers' demands from Denver Basin aquifer wells within their service area boundaries.

We then conducted a simulation of a potential well field on Greenland Ranch in southern Douglas County as an example of how increased pumping outside the County could affect County Denver Basin aquifer users. In this simulation, the Northern Water Providers continued to pump their demands, while the Greenland Ranch satellite well field pumped 20,000 ac-ft. This simulation assessed the impact of increased hydraulic gradients from El Paso County to Douglas County as the result of a large satellite well field in southern Douglas County. In Section 11.2.1, we estimated the current exchange of water from El Paso County to Douglas County based on currently-projected pumping patterns. Therefore, this simulation would be an evaluation of the increase in water movement due to a large pumping center in southern Douglas County.

Finally, a simulation of the County satellite well field and the Greenland Ranch satellite well field pumping simultaneously was also conducted to evaluate interference effects on the County well field.

The results of our simulation are provided in the following section.

11.3.2 Modeling Results

For each ground water model simulation, we conducted five comparative analyses to assess water level changes as a result of varying pumping scenarios. The five comparative analyses included:

1. Pumping the Northern Water Providers' Denver Basin aquifer wells at the currently-allowed rates, i.e., under the 100-Year Rule for municipalities and the 300-Year Rule for special districts.

2. Pumping the Northern Water Providers' Denver Basin aquifer wells at the 100-Year Rule rates for both municipalities and special districts. The annual demand remained the same as in scenario (1).

3. Pumping a satellite well field in the vicinity of the Younger Ranch (near the intersection of Highways 83 and 105) to pump future demands of the Northern Water Providers (consistent with Alternative 1d presented in Section 7) (Figure 11-1). The annual demand remained the same as in scenarios (1) and (2).

4. Pumping a satellite well field in southern Douglas County on the Greenland Ranch as an example to evaluate the effect on El Paso County of a large satellite well field in an area of the Denver Basin that is lower in elevation.

5. Pumping a satellite well field in both southern Douglas and northern El Paso Counties simultaneously to evaluate interference effects.

For each of these comparative analyses, water level changes were calculated at each node in the model. Several nodes were selected for evaluating water level changes at specific points in the general vicinity of the Northern Water Providers. These monitoring points are shown in Figure 11-1. For each of these monitoring points (1,2,3,5, and Falcon), water level changes were evaluated in the Dawson, Denver, and Arapahoe aquifers. The Dawson aquifer was chosen because it is the most frequently used aquifer for individual residential use and the impacts to these individual wells would be of concern. The Arapahoe aquifer was chosen because it is the most heavily-used aquifer in the basin and, therefore, impacts to the Arapahoe aquifer would have the most impact to the Northern Water Providers. The Denver aquifer was chosen because it is the second most heavily used aquifer in the basin by municpal/special district water providers. In addition, water level changes were evaluated in the Dawson, Denver, and Arapahoe aquifers at the monitoring point designated "satellite" (Figure 11-1) for the simulations where the El Paso County satellite well field is operating and when both the El Paso County and Greenland Ranch well fields are operating.

Figures 11-2 and 11-3 show the water level effects in the Dawson aquifer as a result of the comparative analyses described above at the five monitoring points. There are no data for the Falcon monitoring point in the Dawson aquifer, as the Dawson aquifer is not present in the Falcon area. As Figures 11-2 and 11-3 show, there is relatively little difference between the water level changes if the Northern Water Providers all operate on the 100-Year Rule versus municipalities operating on the 100-Year Rule and special districts having to operate on the 300-Year Rule (red line versus purple line) outside the general area of municipal pumping (monitoring points 1 and 5). In fact, there is greater drawdown with the 300-Year Rule in effect, because more wells are required to meet the same demand (as production from the Denver and Arapahoe aquifers is limited to one-third of the appropriable volume under the 300-Year Rule). Because of this, within the area of concentrated pumping, the water change is more pronounced (approximately 50 feet more water level change at monitoring point 3 with the 300-Year Rule than without).

Operation of a satellite well field in the northern part of the County to provide future demands for the Northern Water Providers results in less water level change in the Dawson aquifer at the most remote monitoring point (#1), intermediate change at monitoring point 3, and approximately 50 feet more water level change at monitoring point 5 than in the other simulations. This is not an unexpected result, as the same demand is being produced to meet the Northern Water Providers' future growth, yet the pumping of the Denver Basin aquifers has been spread over a wider area and to the east. Therefore, there is less water level change on the west side and more change on the east side.

Similar water level change graphs are presented in Figures 11-4 and 11-5 for the Denver aquifer at each of the five monitoring points (1,2,3,5, and Falcon). Other than at monitoring point 1, there is virtually no difference in the water level changes between the 100-Year Rule, the 300-Year Rule, and operation of the County satellite well field. At monitoring point 1, there is actually approximately 50 feet more drawdown operating without the satellite well field versus operating the satellite well field east of the Northern Water Providers' service areas. This is likely related to the reduction in pumping that is required in the Denver aquifer if all water demands are provided within the service area, versus future water demands being provided at a remote location.

Figures 11-6 and 11-7 present similar data for the Arapahoe aquifer. The response in the Arapahoe aquifer is different from the simulated response in either the Dawson or Denver aquifers. At monitoring points 2, 3, and 5, there is a range of 50 to 100 feet of water level change between operating under the 300/100-Year Rule and all Northern Water Providers operating under the 100-Year Rule (purple and red lines). At monitoring point 1 and Falcon, there is virtually no difference. For the Arapahoe aquifer, the 300-Year Rule does result in less drawdown, as the Arapahoe aquifer is the principal aquifer of use and lowering pumping rates under the 300-Year Rule does lessen water level changes.

When the EPC satellite well field is simulated, there is a decrease in water level change at monitoring points 2 and 3, and an increase in water level change at monitoring point 5, compared to the previous simulations, and virtually no change at monitoring point 1. Monitoring points 2 and 3 show a benefit from the satellite well field because there is less concentrated pumping within the Northern Water Providers' service area boundaries, while monitoring point 5 shows additional water level changes, as it is closer to the satellite well field.

As was estimated in Section 11.2.1, a significant concern to County water users is the pumping of water in other parts of the Denver Basin outside the County. Because the County is generally situated on the southern end of the basin, and at higher elevations than the principal areas of use, it is vulnerable to water movement from these higher elevations to the lower elevations, which can be exacerbated by pumping at the lower elevations and when the aquifers are still confined, e.g., pumping in Douglas County currently when water levels are still above the tops of the formations. Figures 11-8 through 11-13 show the relative water level changes that would result in the Dawson, Denver, and Arapahoe aquifers should a relatively large satellite well field be developed on the Greenland Ranch, as an example of a large satellite well field (Figure 11-1).

As these figures show, there is a noted water level decline as a result of the potential satellite well field on Greenland Ranch which creates an additional 50 feet of water level change in the Dawson aquifer at northern monitoring points 1 and 3 (Figure 11-8) and over 200 feet of additional water level change in the Arapahoe aquifer at northern monitoring point 1 (Figure 11-12). The further south (and away from the satellite field) one moves, the less water level change is observed. Based on the distance to the centroid of the satellite well field, significant water level changes can be observed 11 to 12 miles away in the Dawson, Denver, and Arapahoe aquifers. These figures indicate that there will be a hydraulic effect that can be imposed on County water users, whether it be at Greenland Ranch or at other areas within the basin which can affect hydraulic gradients in the Denver Basin aquifers underlying the County. It should be noted that the model run was conducted mostly under confined aquifer conditions and that under fully unconfined conditions the impacts will be much less. Based on data we currently have available, this could occur within the next 20 to 30 years, where all of the head on the aquifers will be gone.

A simulation was also run to evaluate the changes in water level that would occur at the County satellite well field if another satellite well field were to operate in the same general vicinity as the proposed County well field (e.g., Greenland Ranch satellite well field). Therefore, Figure 11-14 shows the estimated water level changes that would occur if the County satellite well field were operating without other nearby satellite well fields versus the County satellite well field operating in conjunction with another remote satellite well field. As Figure 11-14 shows, in both the Dawson and Denver aquifers, there would be virtually no difference in water levels if a satellite well field were operating at Greenland Ranch coincident with the operation of the proposed County satellite well field. However, in the Arapahoe aquifer, there could be an additional 200 feet of water level change as a result of the operation of a remote well field on the Greenland Ranch. It should be noted that these simulations in the Arapahoe aquifer were conducted under fully confined conditions and that, under unconfined conditions, the water level change difference would be less.

When the impact of the 300-Year Rule is compared to the impact of a remote satellite well field, it is apparent that the County does not necessarily control its own destiny relative to the longevity of Denver Basin aquifer water supplies. Therefore, while the County wants to insure water supplies of sufficient quantity to meet the average annual demand for a period of 300 years, it simply does not have total control over the longevity of the supply that it is trying to protect. In addition, as long as portions of the County operate on the 100-Year Rule, the 300-Year supply can never be achieved.

If the County wants to control land use by the implementation of the 300-Year Rule, it can effectively limit land use densities. However, if the County wishes to preserve the longevity of the nonrenewable Denver Basin aquifer resources through the 300-Year Rule, it cannot necessarily achieve that objective, as demonstrated by the modeling analyses.

11.4 Conclusions

Based on the evaluation of the County's water supply standards, we would offer the following conclusions:

1. The County applies a 300-Year Rule to all new developments within the County, outside of municipal boundaries. This rule is designed purportedly to provide water supplies that are of sufficient quantity to meet the average annual demand of all subdivisions for a period of 300 years.

2. The implementation of the 300-Year Rule for special districts, and new districts, but which does not apply to municipalities, creates an inequity in development which makes it difficult for municipalities and special districts to work on cooperative projects. For example, a satellite well field completed in the Denver Basin aquifers would be able to provide a development density based on a 100-year supply for municipalities, while special districts could only provide a development density based on a 300-year supply (or 1/3 of the development that would be allowed within the municipality).

3. One of the purported purposes of the 300-Year Rule is to allow developments to initiate their growth on the nonrenewable resources of the Denver Basin aquifers and then, based on the revenues generated from the sale of taps, purchase additional renewable water supplies. While this was a laudable goal, it has not been achieved, because (a) sufficient revenues are not generated by low-density development to provide sufficient revenues to purchase renewable water, as identified in the Research and Consulting Group's August 1986 report, and (b) development of renewable water is a difficult issue beyond a simple financial transaction, as it involves very complex environmental, political, and water availability considerations.

4. Ground water modeling analyses indicate that there is little predicted water level change between implementation of the 300-Year Rule and allowing pumping consistent with the Colorado statutory 100-year life. In the Dawson and Denver aquifers, water levels are actually equal to, or higher, under the 100-Year Rule because there is less Dawson and Denver aquifer use. Arapahoe aquifer pumping is curtailed under the 300-Year Rule, since only one-third of the appropriable volume can be pumped, requiring more pumping from the Dawson and Denver aquifers.

5. Only a small percentage of the total water in storage is developed, therefore, water levels under the 300-Year Rule will approximately equal water levels under the 100-Year Rule.

6. A satellite well field in the northern portion of the County to produce some of the Northern Water Providers' future demands lessens the water level change in the Northern Water Providers' area due to the spreading out of Denver Basin aquifer

pumping over a larger area. Therefore, the satellite well field can be a beneficial concept to preserving water levels in the Denver Basin aquifers.

7. A large satellite well field which is in close proximity to the County, but at a lower elevation, has the potential for increasing water level changes in the Northern Water Providers' area. Because this water would be produced under the Colorado statutory 100-year life, there would be no means to prevent the production of this water in the future at locations outside of the County. If this should happen, the County's ability to provide a 300-year life could be reduced.

8. Water level changes that might result from simultaneous operation of satellite well fields in northern El Paso County and southern Douglas County would be negligible in the Dawson and Denver aquifers at the El Paso County satellite well field, but could be relatively large in the Arapahoe aquifer (up to 200 feet) under confined conditions. As the aquifers become unconfined, the interference effects would be reduced.

9. The County and the El Paso County Water Authority should initiate discussions regarding the 300-Year Rule and providing water supplies from the Denver Basin aquifers on an interim basis as a springboard to become more pro-active in pursuing renewable water supply options. The reason we believe these two issues are inextricably tied together is the fundamental political reality that to obtain renewable water supplies in today's political climate requires that the entities seeking these supplies are doing everything possible to optimize the use of available water supplies, but still have water supply needs that will have to be met in the future.

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Glossary

adjudication: The legal process of a hearing and deciding an issue judicially, e.g., obtaining a decree for a water right in Colorado's Water Court.

alluvium: The unconsolidated deposits associated with a stream channel. Typically, these deposits are saturated and form an alluvial aquifer associated with the stream channel.

Amended Arkansas River Rules: Rules put in place on June 1, 1996 by the order of the State Engineer to govern the use, control, and protection of surface and ground water rights located in the Arkansas River and its tributaries.

appropriation: To claim or use as by an exclusive right, e.g., to appropriate water for a beneficial use.

aquifer: A geologic formation which contains sufficient saturated permeable material that could yield a sufficient quantity of water to a well which then may be extracted and applied to a beneficial use.

augmentation plan: A Water Court-approved plan which allows water rights that would otherwise be out of priority to continue to divert based on the depletions associated with this out-of-priority pumping being replaced to the affected stream system.

average day water demand: The total annual water use divided by the number of days in the year.

beneficial use: The use of water in any advantageous, profitable, or helpful way.

buildout: The point in time when all of the zoned units within a water purveyor's service area have been built.

call: A term used to describe when a river system has less water available than the adjudicated water rights. A "call" is placed to cease diversions of all water rights junior to the priority which is not having its adjudicated water right fulfilled.

Central Basin: A term coined for the portion of the Denver Basin system which is not near the subcrop/outcrop of the basin and where the aquifers are currently still fully saturated.

conjunctive use: Integrated use of available surface water supplies and ground water storage to maximize beneficial use of both water resources.

consumptive use: The portion of the water extracted that is consumed as part of the beneficial use of the water, e.g., a portion of the water applied for irrigation is consumed for plant growth (consumptive use) while the remainder infiltrates into the ground and returns to the stream system (return flow).

Dakota/Cheyenne aquifers: Sedimentary bedrock aquifers that are generally the uppermost bedrock aquifers in the southeastern portion of El Paso County in areas where the Denver Basin aquifers have outcropped.

Denver Basin: A bowl-shaped basin which consists of a group of geologic formations that underlie a 6,700 square-mile area along the Front Range of Colorado, extending from Greeley on the north to Colorado Springs on the south, and the Front Range on the west to Limon on the east. The Denver Basin is comprised of four principal aquifers, the Dawson, Denver, Arapahoe, and Laramie-Fox Hills.

depletion: A reduction in the flow in the stream system due to extracting, and consumptively using the water.

designated basin: An area designated by the state because ground water within this area would not, in its natural course, be available to, and required for, the fulfillment of decreed surface rights.

direct flow right: Diversion of water for use directly from the stream or alluvial aquifer with no storage.

doctrine of prior appropriation: The water rights system by which the state of Colorado operates, in which water rights are administered on a “first in time, first in right” basis.

dry year yield analysis: Use of dry year, or drought, conditions to analyze water yield. Provides a conservative estimate of yield.

exchange: A legally-adjudicated process of delivering water to a stream and extracting a like volume at a different point on the stream. A legal process (Water Court action) is required to demonstrate non-injury to water rights in the intervening stream reach.

first use water: The right to extract water from a stream system and provide it to municipal customers. However, any return flows after the use of this water has to be delivered back to the stream system with no right to reuse.

free river: Within the water rights administration system, the time when there are no calls placed on a river and any decreed water right can divert at its adjudicated rate and volume.

Fryingpan-Arkansas Project (Fry/Ark): A trans-basin water supply delivery project operated by the Southeastern Colorado Water Conservancy District, using water from the Fryingpan River, Roaring Fork River, and their tributaries.

in priority: The period of time when a water right can divert under Colorado's doctrine of prior appropriation.

interbedded layers: Geologic formations where there is an alternate layering of water-bearing sands and non-water-bearing clays and shales. All of the Denver Basin formations are comprised of such interbedded layers.

Margin Zone: Designation given to the areas along the edges of the Denver Basin where the formations either subcrop or outcrop, and water levels are currently declining below the top of the aquifers.

nontributary ground water: Water that the withdrawal of which will not , within 100 years, deplete the flow of a natural stream at an annual rate greater than 0.1 percent of the annual rate of withdrawal.

not-nontributary ground water: Water that the withdrawal of which will, within 100 years, deplete the flow of a natural stream at an annual rate of greater than 0.1 percent of the annual rate of withdrawal.

out of priority: The period of time when a water right cannot divert under Colorado's doctrine of prior appropriation.

outcrop: A geologic formation that is exposed at the surface of the land.

peak day water demand: The maximum volume of water used during any one calendar day for a particular use, e.g., a residential home.

planning horizon: The time frame over which a planning document (such as a master plan) considers the future changes that will occur relative to water demand. For the El Paso County water master plan, the planning horizon is the year 2020.

potentiometric surface: The imaginary water surface coinciding with the hydrostatic pressure level of the water in an aquifer.

Pre-Cambrian aquifer: The aquifer formed by the infiltration of water into the fractures that occur in the granitic rocks in the foothills of western El Paso County.

priority date: The date of appropriation given a water right when it is decreed. This places the water right within the priority system and determines when the water right can divert water based on the calling right on the river.

return flow: The portion of water from a water right that has been put to beneficial use which is not consumptively used, and returns to the river, e.g., runoff or underflow from an irrigation practice, or wastewater effluent that is returned to the stream.

reusable water: Water that can be fully consumed (minus replacement and augmentation requirements) through successive uses.

saturated thickness: The thickness of aquifer materials containing sufficient water which can be drained by gravity and placed to beneficial use.

Senate Bill 5: The current law which governs the use of Denver Basin aquifer water. Senate Bill 5 was passed in 1985.

Senate Bill 213: Established that the appropriation of water from the Denver Basin aquifers was based on overlying land ownership. Senate Bill 213 was passed in 1973.

Specific Capacity: A measure of the rate of production of a well per unit of drawdown of the water level decline in the well.

subcrop: A geologic formation that is rising to the surface of the ground but, in certain areas, underlies a stream's alluvial system, e.g., a Denver Basin Formation subcrops the Fountain Creek alluvial aquifer.

trans-basin water: Water that is not native to the Arkansas River Basin and is transported into the basin from other river systems.

tributary water: Water that is associated with the stream systems of the State of Colorado, including surface flow and alluvial ground water flow.

virgin flow: First use water from runoff in the basin, as opposed to return flows from previous use.

Glossary (Continued)

Water Commissioner: An employee of the state who administers the diversion of water rights within a specified area. The District 10 Water Commissioner administers water rights in the Monument Creek and Fountain Creek areas.

Water District 10: The Monument Creek and Fountain Creek drainage areas to the confluence of Fountain Creek with the Arkansas River.