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How to read this report

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Appendix C
Water Supply Demand Analysis

INTRODUCTION

This Appendix to the FR/EIS provides additional information on the "Water Demand Analysis" discussed in Chapter 1 and Chapter 2 of the FR/EIS. Portions of the Statewide Water Supply Initiative (SWSI) Phase I Report (Colorado Water Conservation Board 2004) that are relevant to the Chatfield Storage Reallocation project are included in this Appendix to the FR/EIS. The entire SWSI report is available online at http://cwcb.state.co.us/IWMD/Pubs.htm. Also included are selected portions of the South Metro Water Supply Study (Black & Veatch et al. 2003). The entire document is available online at http://www.crwcd.org/media/uploads/SouthMetroWaterSupplyStudy11-03.pdf. References and legal citations were omitted from this Appendix, but can be viewed on the original document.

STATEWIDE WATER SUPPLY INITIATIVE

SECTION 1—INTRODUCTION

1.1 Introduction to the Statewide Water Supply Initiative

In 2003, the Colorado legislature recognized the critical need to understand and better prepare for our long-term water needs, and authorized the Colorado Water Conservation Board (CWCB) to implement the Statewide Water Supply Initiative (SWSI). SWSI is a comprehensive study of how Colorado will meet its future water needs.

The overall objective of SWSI is to help Colorado maintain an adequate water supply for its citizens and the environment. SWSI is not intended to take the place of local water planning initiatives. Rather, it is a "forum" to develop a common understanding of existing water supplies and future water supply needs and demands throughout Colorado, and possible means of meeting those needs. CWCB, through SWSI and future efforts, will help support and/or identify solutions to these water supply needs. To help attain this goal, SWSI summarized by river basin, at a reconnaissance level, existing water supplies and demands and projected demands up to 30 years into the future, and a range of potential options to meet existing and future demands. This will allow water providers, state policy makers, and the General Assembly to make informed decisions regarding the management and use of Colorado's surface and groundwater resources.

In many areas, local planning entities have completed studies, identified projects, and are capable of implementing those projects. For areas where specific projects were not identified by water providers or water users, SWSI relied on a stakeholder process. The options developed by the SWSI stakeholder process generally fall within the following categories:

- Conservation
- Agricultural transfers
- Reservoir storage
- Conjunctive use of alluvial or non-tributary groundwater
- Water reuse
- Control of non-native phreatophytes (water consuming plants)

By taking both a basin and statewide perspective, SWSI has identified issues and water supply needs and projects that may require coordination by more than one planning entity, or that may be beyond the capabilities of a single entity. Through the SWSI effort, CWCB has identified possible solutions to achieve a cooperative and collaborative initiative.

1.2 Background on Colorado Water Resources

Eight major river basins drain Colorado, all with their headwaters in the high mountains of the Continental Divide. Rivers east of the Divide flow ultimately into the Gulf of Mexico, while the western rivers find their way, via the Colorado River, to the Gulf of California and the Pacific Ocean.

1.2.2 South Platte River

The South Platte River drains the most populous section of the state and serves the area with the greatest concentration of irrigated agricultural lands. Its waters originate chiefly in the mountain streams along the north half of the Front Range of the Eastern Slope. The main stream moves north, then east, and meets the North Platte in southwestern Nebraska. This basin comprises about 20 percent of the state's land area.

Water supply in the South Platte Basin is supplemented by transbasin diversions from the Colorado River Basin and to a lesser degree from the Arkansas River Basin. Here, new industry and rapidly expanding urbanized areas compete with agriculture for the same supplies of water.

While both rural and urban centers are growing, this growth does not represent agricultural growth since the trend is toward urbanization. Less than one-third of the land in this basin is public land.

1.2.5 Overview of Supplies

In Colorado, both surface and groundwater are used for irrigation and other agricultural uses, municipal and industrial (M&I) supplies, and domestic uses. On the Western Slope, although there is some domestic use of groundwater, the main source of supply is surface water. In the San Luis Valley, both surface and groundwater supplies are used, while on the eastern plains the primary source is groundwater for all uses. Front Range cities rely mostly on surface water (some of it diverted from the Western Slope), but many smaller towns and more rural subdivisions use groundwater. Agriculture and municipalities in the northeastern and southeastern parts of the state use large amounts of surface water including diversions from the Western Slope, but groundwater is also heavily used.

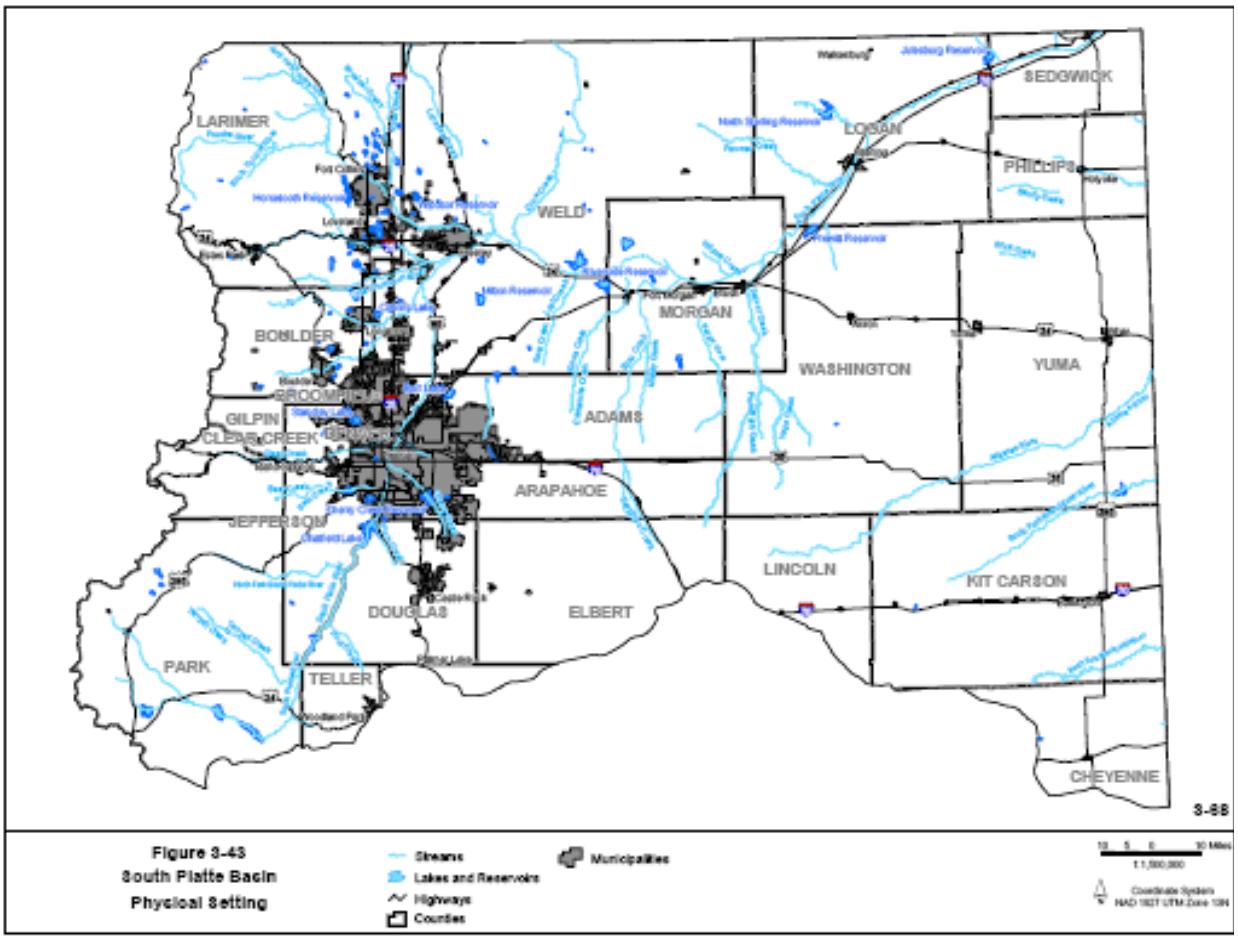
Surface water supplies depend on precipitation, much of which originates as snowpack in the state's high mountainous areas. The Continental Divide dictates the direction of water flow either to the west or to the east for each of the river systems in the state. Colorado is unique in that each of its major river systems originates in the state; water not captured or used in the state flows on to neighboring states and in many cases is governed by interstate compacts and agreements.

There are billions of gallons of groundwater in the confined (artesian) aquifers. Some major aquifers are the Ogallala in eastern Colorado; the Denver Basin, which stretches from Fort Collins to Colorado Springs; and another underlying the San Luis Valley.

SECTION 3—PHYSICAL ENVIRONMENT OF THE MAJOR RIVER BASINS

3.8.1 South Platte Basin Geography

The South Platte Basin (including the Republican River Basin) covers approximately 27,660 square miles in northeast Colorado, Figure 3-43. The largest cities in the basin are Denver (population 560,882), Aurora (population 287,216), and Lakewood (population 144,150).



3.8.2 South Platte Basin Climate

The South Platte Basin receives relatively low precipitation, which can be highly variable from year to year. The basin also has widely variable daily and seasonal air temperatures. The plains region is characterized by small amounts of precipitation averaging between 7 and 17 inches per year. Greater amounts of precipitation accumulate in the mountain region, which receive upwards of 30 inches annually. The foothills of the Front Range, which provide a transition zone between the mountains and the plains, annually receive an average of 17 to 21 inches of precipitation. The potential evapotranspiration exceeds precipitation in the basin in all areas except for the mountain region.

3.8.3 South Platte Basin Topography

The topographic characteristics of the South Platte Basin are diverse. Elevations in the basin range from over 14,000 feet at the headwaters near the Continental Divide to 3,400 feet at the Colorado/Nebraska state line. The headwaters of the South Platte River originate at an elevation of about 11,500 feet.

3.8.4 South Platte Basin Land Use

Approximately one-third of the basin's land area is publicly owned, and the majority of these lands are forest areas in the mountains. Western portions of the basin and its montane and subalpine areas are primarily forested, while the High Plains region is mainly grassland and planted/cultivated land.

3.8.5 South Platte Basin Surface Geology

The mountains are comprised of Precambrian age metamorphic and igneous basement rocks. These rocks come into contact with Mesozoic and Paleozoic sedimentary rocks by a fault that runs north and south just west of Denver. A well-known outcrop is observed along I-70 just west of C-470 revealing the many layers of sedimentary rock that form the Denver Basin.

3.8.6 South Platte Basin Surface Water

The South Platte River emerges out of the mountains southwest of the Denver metro region, flows through the Denver metropolitan urban area, and then enters the High Plains Region.

Major mountain tributaries to the South Platte River from upstream to downstream include the North, Middle, and South Forks of the South Platte River (upstream of Chatfield Reservoir), Bear Creek, Clear Creek, St. Vrain Creek, the Big Thompson River, and the Cache la Poudre River, as shown in Figure 3-43. Tributaries from the Plains region include Plum, Cherry, Sand Creek, Box Elder, Kiowa, Bijou, Badger, Beaver, and Wildcat Creeks. The tributaries as well as the South Platte River have highly variable streamflows, with snowmelt runoff and summer thunderstorms dictating the flow in the spring and summer. The USGS monitors these streamflows with various gages located throughout the basin.

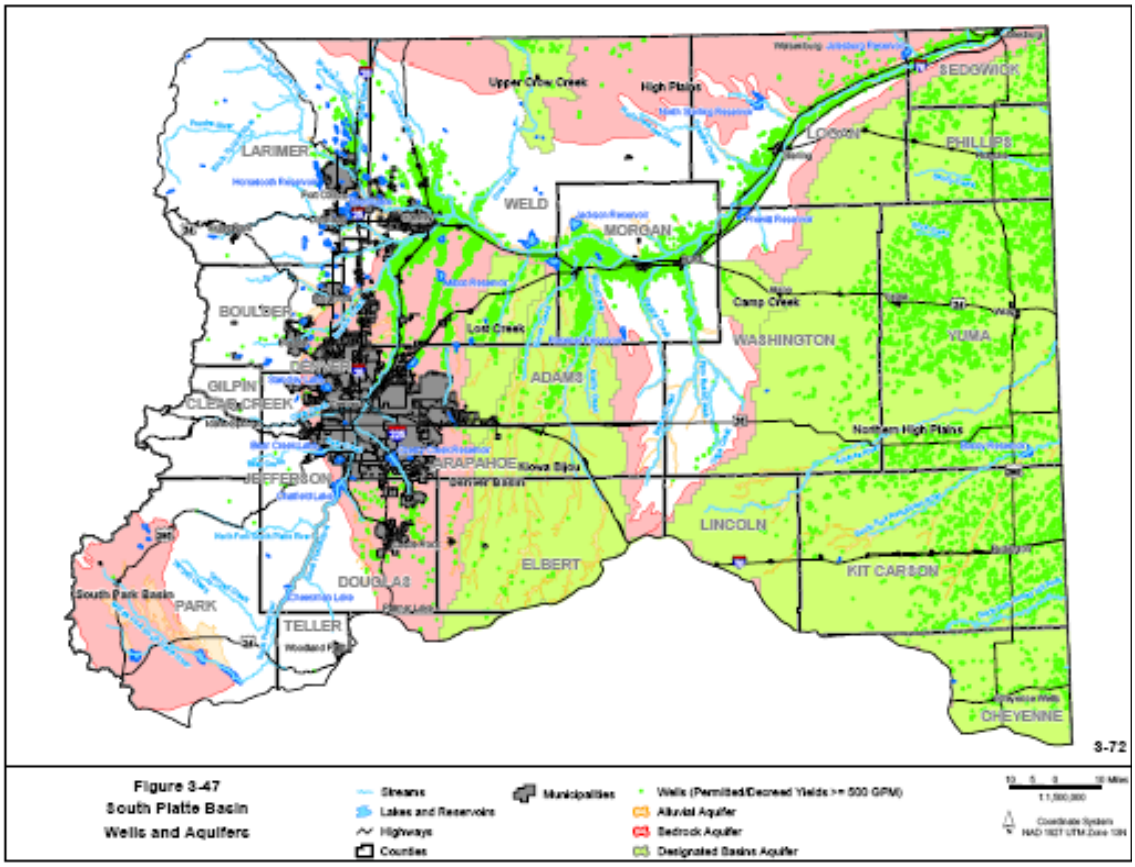
3.8.7 South Platte Basin Groundwater

Groundwater is a substantial resource in the South Platte Basin. Approximately 880,000 acre-feet per year (AFY) of groundwater in the South Platte Basin is used for irrigation, and 100,000 AFY is used to meet municipal, domestic, livestock, industrial, and commercial purposes. These values do not include groundwater pumped from the Ogallala Aquifer. Residents in Phillips, Yuma, Washington, Kit Carson, Cheyenne, Lincoln, and Elbert counties rely almost entirely on groundwater. Those living in the counties of Sedgwick, Morgan, Weld, Adams, and Douglas also use groundwater to meet a large portion of their water demand.

Figure 3-47 shows the location of the significant aquifers in the South Platte Basin and wells with permitted or decreed capacities greater than or equal to 500 gpm. These aquifers are as follows:

- Alluvial Aquifer
- Dawson
- Denver
- Arapahoe
- Laramie-Fox Hills
- Upper Cow Creek
- Camp Creek
- Northern High Plains
- Lost Creek
- Kiowa-Bijou

As shown in Figure 3-47, the bedrock aquifer is comprised of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills. The designated groundwater basins include the Upper Crow Creek, Camp Creek, Northern High Plains, Lost Creek, and Kiowa-Bijou aquifers.



The reach of the South Platte River that begins southwest of the Denver Metro area and continues downstream to the state line is underlain by valley fill sediment forming the alluvial aquifer. This alluvial aquifer is composed primarily of poorly sorted gravel, sand, and clay. The saturated alluvium increases from 20 feet near Denver to over 200 feet at Julesburg with the thickest section running along the center of the historic river channel.

The alluvial aquifer is estimated to contain as much as 8.3 million AF in storage and is hydraulically connected to the river. Therefore, groundwater withdrawals, of which the majority are junior in priority to most surface water rights, can greatly affect the flow of the lower South Platte River. This segment, which is downstream of metro Denver, gives rise to the need for well augmentation plans to protect senior water rights.

In the lower South Platte River alluvium, there are approximately 10,880 permitted wells with yields ranging in capacity from 1 to 3,000 gpm. The average yield is 430 gpm; however, 50 percent of the wells have a yield of 30 gpm or less, which is biased by domestic wells.

The Denver Basin aquifers, which cover approximately 6,800 square miles, are comprised of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers, are another important water resource for the South Platte Basin. The Denver Basin consists of Tertiary and Cretaceous age sedimentary rocks that supply groundwater for domestic, commercial, municipal, agricultural, and other users.

There are also five Designated Groundwater Basins in the South Platte Basin, which include the Upper Crow Creek, Camp Creek, Northern High Plains, Lost Creek, and Kiowa-Bijou. Designated groundwater is water that under natural conditions would not be used to recharge or supplement continuously flowing surface streams.

The Northern High Plains aquifer, which includes the Ogallala aquifer located in the Republican River Basin, is found in the eastern edge of Colorado in the High Plains region and is a major source of water for this agricultural region. Groundwater withdrawals have exceeded recharge since the early 1960s. The mean well yield from this aquifer is 373 gpm and the median is 20 gpm.

3.8.8 South Platte Basin Water Quality

There is a broad range of water quality in the South Platte Basin, ranging from high-quality mountain streams to those impacted due to urbanization and agricultural activities.

The upper South Platte River watershed is an area that has been affected by historic mining districts (i.e., Mosquito Creek), water resource development (i.e., South Park Dams and water diversions), and severe sediment deposition from forest fires such as the recent Hayman, Buffalo Creek and Hi Meadows fires.

The middle reach of the watershed, from below Chatfield Reservoir to the confluence with the Cache la Poudre River, has experienced some of the most intense use and resultant impacts of any river in Colorado. This segment of the river has seen historic mining districts, explosive urban development, stormwater runoff, extensive hydrologic modification, urban and agricultural nutrient loading, and effects of Superfund sites. Pollutants that have impaired the waters of the South Platte Basin include nitrate, ammonia, and copper. Furthermore, the South Platte River through and downstream of the Denver urban area exceeds E. coli standards.

The lower reach of the South Platte River, from the Cache la Poudre River to Julesburg, has been affected by upstream urbanization, historic agricultural land use, and waste disposal due to animal feeding operations. Non-point source pollution from pesticide and fertilizer runoff is the primary concern in this segment of the lower South Platte River.

Downstream of the Denver area, groundwater in the alluvial aquifer exceeds the nitrate limit for drinking water standards in some areas. The nitrate contamination not only affects the drinking water supply of several eastern plains cities, but can also be detrimental to certain crops when used for irrigation.

Groundwater in the alluvial aquifer near Denver contains approximately 1,000 ppm TDS. This concentration increases to about 4,000 ppm near Sterling. Surface water at the state line with Nebraska has an average TDS concentration of 1,300 ppm. These concentrations are of concern because water containing greater than 2,000 ppm TDS is generally considered to be unsuitable for irrigation.

Stream segments proposed for listing via the 2004 303(d) list and the accompanying Monitoring and Evaluation list are described in Colorado WQCC Regulations 93 and 94. The state's 2004 proposed 303(d) list incorporates several additions from the 2002 list. It includes numerous surface waters that span the basin's diverse topography and land uses. Listed segments proposed for the upper South

Platte and its tributaries, such as Clear Creek, are primarily listed for metals such as cadmium, copper, and zinc. Certain stream segments in urbanized areas are listed for bacteria and other constituents. A variety of constituents comprises the remainder of the listings for other parts of the basin, including several segments listed for selenium.

3.8.9 South Platte Basin Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species

As described above, various reaches of the South Platte River in the Denver Metro Area have water quality issues. High TDS and nitrate in the groundwater of the alluvial aquifer is also a concern.

Acid mine drainage, whirling disease, sedimentation, and wetland protection in the South Platte River headwaters have been problems as well. Wetlands are important in that they "have a well-documented capacity for extracting metals, particularly uranium, from ground and surface waters containing very dilute concentrations of the metals." A 1992 USGS study, Uranium and Other Elements in Colorado Rocky Mountain Wetlands – A Reconnaissance Study, sampled 145 montane and subalpine wetlands in Colorado to assess the concentration of uranium and other heavy metals in the wetlands. Forty-six percent of all the wetlands that were analyzed showed moderate or greater enrichment in uranium. If a wetland is partially or completed drained, oxidation of the organic-rich sediments might liberate the heavy metals that have accumulated in the wetlands over thousands of years. Therefore, the protection of wetlands, a natural water filter, is important to prevent environmental and health concerns.

In addition to impaired areas, threatened and endangered species and areas of high environmental or recreational value require special attention when evaluating water supply projects and water use in the South Platte Basin. For a complete list of federal and/or state listed threatened and endangered fish and other species in the South Platte Basin, along with information on RICDs in Fort Collins, Golden, and Longmont.

An example of an area with high-quality aquatic habitat in the South Platte Basin is the 3-mile section below Cheesman Dam that produces more than 500 pounds of fish per surface acre, mostly rainbow trout from 15 to 22 inches. Other areas that are valued for their fishing opportunities in the basin include the following Gold Medal designated segments:

- The South Fork downstream from the Highway 285 bridge to the inlet of Antero Reservoir
- The Middle Fork downstream from the Highway 9 Bridge (4.9 miles north of Garo) to the confluence of the Middle and South Forks and the South Platte River
- From the Middle and South Forks downstream through Spinney Mountain Reservoir to the buoy line at the inlet of Elevenmile Reservoir
- From Cheesman Reservoir Dam downstream to the North Fork of the South Platte River
- Spinney Mountain Reservoir, on the South Platte River about 5 miles upstream from Elevenmile Reservoir

Areas of high recreational value in the basin include Mount Evans Wilderness Area, Rocky Mountain National Park, and Chatfield State Park.

3.8.10 South Platte Basin Energy and Mineral Resources

More than 250 identifiable minerals have been located in deposits in the South Platte Basin. Other important natural resources in the basin include natural gas, petroleum, and coal. Over 130 million tons of coal was produced from the Denver Basin from 1883 to 1978.

SECTION 4—LEGAL FRAMEWORK FOR WATER USE

4.3 Specific Tools for Addressing Water Needs

There are a number of specific tools within the current legal framework of the Priority System (those with senior rights can require full or partial curtailment of diversions by junior water users) that can be used to address various water supply needs. These specific tools include the following.

4.3.1 Water Storage Rights

There are two different types of water rights – direct flow water rights and storage water rights. Direct flow rights allow a water user to divert water for immediate use, while storage rights allow a water user to divert water and store it to make a beneficial use at a later time. Storage rights, like other water rights, are assigned a priority and must be exercised without injury to other water rights. Storage rights are obviously a very important mechanism for ensuring that water supplies will be adequate in times of drought. Moreover, reservoirs provide year-round water when stream levels drop following the snow melt each year. Over the years, there have been numerous water storage projects undertaken by Colorado irrigation districts, water conservation districts, M&I water providers, and the federal government.

4.3.2 Conditional Water Rights

A conditional water right is defined in the 1969 Act as "a right to perfect a water right with a certain priority upon the completion with reasonable diligence of the appropriation upon which such water right is based." A conditional water right allows an appropriator to secure a place in the priority line before any water is actually applied to beneficial use. To obtain a conditional water right, the applicant must show that the "first step" towards the appropriation has been taken. The "first step" includes the intent to appropriate, plus a demonstration of that intent through "physical acts sufficient to constitute notice to third parties." Once the appropriator actually places the water to beneficial use, an absolute decree may be issued with a priority date relating back to the date the appropriation was initiated through the "first step."

As explained by the Colorado Supreme Court in Public Service Co. vs. Blue River Irrig. Co., a conditional water right "encourage[s] development of water resources by allowing the applicant to complete financing, engineering, and construction with the certainty that if its development plan succeeds, it will be able to obtain an absolute water right." Conditional water rights are crucial to large-scale development projects, including most transmountain diversions and storage projects, because they allow an appropriator to secure a priority and protect its investment when water cannot immediately be placed to beneficial use. Thus, conditional water rights are a tool that may be used to

complete major water projects, including storage reservoirs, transmountain diversion projects, or pipelines to meet water needs.

4.3.3 Changes of Water Rights

A change of water rights is another tool that allows water users flexibility to maximize the potential use of water. As described in the 1969 Act, a change of water rights includes "a change in the type, place, or time of use, a change in the point of diversion," and changes in the manner or place of storage. A change of water right will not be allowed unless it is approved by the water court, upon a finding that the change "will not injuriously affect the owner of, or persons entitled to use, water under a vested water right or a decreed conditional water right."

In a change case, the measure of the water right is the amount that was historically consumed (not the amount diverted) under the water right. Thus, only the amount of water that historically has not returned to the stream system under the original decreed use may be changed to a new place or type of use. This limitation ensures that the change will not enlarge the historical impact of the water right on the stream system, avoiding injury to other water users. In addition, in a change of water right proceeding, the applicant must take appropriate steps to ensure that historical return flows from the use of the water in amount, timing, and location are maintained. This is required because other water users rely, and are legally entitled to rely, on those return flows to support their appropriation and uses of water.

Changes of water rights allow for the reallocation of water resources to meet changing demands. For example, in Colorado, the largest water demand is for irrigated agriculture. With increasing urbanization, however, ever larger amounts of water are needed for municipal uses. To meet this demand, municipal entities can purchase senior agricultural water rights and change them to municipal uses. Likewise, the CWCB can also purchase agricultural water rights and change them to instream flow uses. All of these activities, however, must satisfy the "no injury" requirements in terms of maintaining historical return flows and preventing an expansion of historical CU.

Increasing the efficiency of use of a water right may not require a change of water right proceeding in all instances. For example, an agricultural user may change his method of irrigation (e.g., from flood to drip or sprinkler irrigation), yet still maintain the overall decreed use of irrigation. Although such activities may not require a change of use proceeding in water court, arguably this activity could have a detrimental impact on other water users to the extent that the change in irrigation alters return flows or the CU of a right.

Adjudicating a change of water rights can be time consuming and costly, and formal notification is required by law. Even when no parties object to the change, the process of water court approval takes a minimum of 3 months, and often much longer due to the heavy case load of water court judges. If parties do oppose a change case, it can take years to get a change decree approved by the court. In addition to paying attorneys' fees, an applicant for a change of water rights generally must hire an engineering consultant to prepare a report explaining the technical aspects of the change and develop an accounting form for administering the change. In order to avoid these costs and to speed the process, Colorado's legislature recently enacted legislation that authorizes a water right owner to lease water under the right without formal adjudication of change of water right. This legislation is discussed immediately below.

4.3.4 Leases of Water

During the 2003 legislative session, C.R.S. §§ 37-80.5- 101 to 105 were amended to authorize the State Engineer to create water banks within each water division, and to adopt rules governing their operation. The aim of this legislation is to simplify the process for temporary transfers of water rights by eliminating the adjudication proceedings required for a permanent change of water rights. The statute provides that the rules shall allow for the "lease, exchange, or loan of stored water within a water division," including a transfer to the CWCB for instream flow purposes, without the need to submit to any adjudication proceedings. Notwithstanding the fact that the lease, exchange, or loan is not adjudicated, such arrangements will still be subject to administration by the Division Engineer, within the priority system, to prevent material injury to other water users.

Another area of potential leasing involves agreements between agricultural and municipal/industrial users for interruptible supplies. Although this approach may require obtaining a change of use decree, it would potentially allow flexibility between agricultural and municipal/industrial users to rotate or fallow crops in certain years, thereby freeing up water supplies for municipal/industrial uses during such years. The terms of any such interruptible supply agreements would vary on a case-by-case basis, but could potentially allow for continued agricultural use in some, but not all, years. In order to be effective, such agreements need to be sufficiently long-term and reliable for municipal/industrial users to allow the sale of municipal taps on such basis. Moreover, any such arrangement would necessarily require protections to ensure that no expansion of use could occur to the detriment of junior water rights holders.

4.3.5 Augmentation Plans

An augmentation plan allows a water user to divert water out-of-priority from its decreed point of diversion, so long as replacement water is provided to the stream from another source, to make up for any deficit to other water users. An augmentation plan, like a change of water right, must be approved by the water court and is also subject to the "no injury rule." Accordingly, the 1969 Act requires substituted water to be "of a quality and quantity to meet the requirements for which the water of the senior appropriator has normally been used[.]"

As explained by the Colorado Supreme Court in re Application of Midway Ranches v. Midway Ranches Property Owners Association, Inc., "[a]ugmentation plans implement the Colorado doctrine of optimum use and priority administration, which favors management of Colorado's water resource to extend its benefit for multiple beneficial purposes." Augmentation plans provide a statutory mechanism for many different types of water users, big and small, to obtain water when and where they need it, by using other sources of water to replace or "augment" the out of priority depletions that result from their water use. In times of scarcity, an augmentation plan allows a water user to continue diverting even under a relatively junior priority, so long as it can provide replacement water to satisfy the needs of downstream seniors. As noted above, however, under an augmentation plan, a water user is essentially replacing the amount of water consumed with a different source of water. The water user gets credit for the amount of water it diverts that returns to the stream unconsumed. As a result, increased efficiency of use under an augmentation plan potentially reduces the amount of credit a water user receives for water returned to the stream unconsumed.

4.3.6 Instream Flows

Under the 1969 Act, the CWCB is authorized to appropriate water for "minimum stream flows or for natural surface water levels or volumes for natural lakes to preserve the natural environment to a reasonable degree." Appropriations for instream flows may only be made by the CWCB, not by private individuals (however, it is noted that a few private instream flows were obtained in the early 1970s upon initial passage of the statute, but this is no longer allowed under the law), and must be made within the priority system, consistent with the restrictions in Sections 5 and 6 of Colorado's Constitution. The CWCB can also acquire water rights for instream flows "by grant purchase, donation, bequest, devise, lease, exchange, or other contractual agreement."

In recent years, Colorado's legislature has expanded the resources available to the CWCB to protect instream flows. In 2002, the legislature increased the sources of funding that the CWCB may use to acquire water for instream flows, to include "any funds available to it, other than the construction fund created in section 37-60-121, for acquisition of water rights and their conversion to instream flow rights. In 2003, the legislature amended § 37-83-105, C.R.S., which provides for temporary loans or exchanges of water between water users in times of drought without requiring adjudication of a change of water rights, to allow the CWCB to receive loaned water for instream flow purposes on a temporary basis, not to exceed 120 days, in any basin where the Governor has declared a drought or other emergency. Such loans are subject to a determination by the State Engineer that other water users will not be injured.

It is essential that the state be able to acquire water rights for instream flow purposes in order to protect wildlife and the environment in a prior appropriation state during times of drought. Since Colorado water law does not allow the state to consider environmental factors in allocating or administering water, the only way for the state to ensure protection of stream flows for public purposes is by acquiring water rights, itself, within the priority system. By acquiring a water right with an enforceable priority, the state can place environmental concerns on equal footing with agricultural, commercial, municipal, and other uses of water. This means that in times of scarcity, the state's instream flows will be protected in a manner consistent with their priorities – to the extent the priorities are junior to other water rights, the CWCB's instream flows will be curtailed to make water available to other senior water users, and to the extent the CWCB's priorities are senior, the CWCB may request the Division Engineer to curtail more junior users to protect its instream flows.

In Colorado, recreation is a recognized beneficial use. Governmental entities can appropriate water solely for the purposes of recreation and boating. Recent enthusiasm for kayaking, and the appropriation of water for in-channel use, has sparked further debate among water users regarding this use of water.

For example, the City of Golden pursued an application for an in-channel water right for a kayak course. Golden sought to appropriate 1,000 cfs for this purpose, which essentially equates to all the water in Clear Creek during peak flow in most years. On appeal, the Supreme Court, from which one member recused himself, split equally, so that the water court's decree adjudicating this issue was affirmed.

In reaction to various claims for in-channel recreation rights, the General Assembly enacted legislation limiting the right to appropriate RICDs to municipal entities for "minimum streamflow as

it is diverted, captured, controlled, and placed to beneficial use between specific points defined by physical control structures for a reasonable recreation experience in and on the water." Applicants for such rights now must forward their application to the CWCB for review. After reviewing the application, the CWCB makes a recommendation to the water court on whether the application should be granted, granted with conditions, or denied.

4.3.7 New Appropriations

Making a new appropriation is always an option for water planning. Although some river basins are currently over-appropriated, in every basin there are usually a few days a year in which a free river condition exists and all rights can divert. Thus, while a 2004 priority is a very junior right, and will probably not have a reliable supply of water during the periods of high senior demands, it may still be possible to divert water under such a right at peak flow times. In addition, one could use an augmentation plan in conjunction with a very junior right to obtain a stable water supply.

To make an appropriation, one must have a specific intent to divert water for a beneficial use and perform a physical act in furtherance of that intent. Today, new appropriations are often made by filing an Application for a Water Right in the water court. However, no appropriation can be made when "the proposed appropriation is based on the speculative sale or transfer of the appropriative rights." This anti-speculation doctrine prevents individuals or entitles from acquiring water rights solely to sell to others. The waters of Colorado are a public resource and as such are not to be hoarded by those who do not have a present use for the water.

4.3.8 Groundwater Rights

In Colorado, there are four different types of groundwater:

- Tributary groundwater
- Non-tributary groundwater
- Not non-tributary groundwater
- Designated groundwater

The classification in which the groundwater falls determines how the water is allocated. Thus, while tributary groundwater is subject to the prior appropriation system, non-tributary groundwater and not non-tributary groundwater is allocated according to land ownership, and designated groundwater is subject to a modified prior appropriation system within each designated basin.

Tributary groundwater is water that is hydrologically connected to a surface stream. In Colorado, all groundwater is presumed to be tributary to a surface stream. In the early 1900s, Colorado courts held that tributary groundwater is subject to the prior appropriation system. The court based its decision, in part, on the fact that wells that intercept tributary groundwater actually deplete the stream flow to the detriment of senior surface appropriators.

Non-tributary groundwater is statutorily defined as that groundwater, outside the boundaries of a designated basin, "the withdrawal of which will not, within one hundred years, deplete the flow of a natural stream … at an annual rate greater than one-tenth of one percent of the annual rate of withdrawal." The right to use non-tributary groundwater is purely a function of statute. The General Assembly has recognized that non-tributary groundwater is a finite resource and has specifically

declared that "such water shall be allocated…upon the basis of ownership of overlying land. Rights to use non-tributary groundwater are limited to "that quantity of water, exclusive of artificial recharge, underlying the land owned by the applicant or underlying land owned by another" who has consented to the applicant's withdrawal. The annual withdrawal of this type of groundwater is further limited in accordance with a 100-year aquifer life.

Not non-tributary groundwater is groundwater located within one of the Denver Basin aquifers (the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers in the Denver Basin, which extends roughly from Fort Collins to Colorado Springs and from the foothills eastward), but outside the boundaries of a designated basin, the "withdrawal of which will, within one hundred years, deplete the flow of a natural stream…at an annual rate of greater than one-tenth of one percent." Not non-tributary groundwater is also allocated on the basis of land ownership. However, the owner of a not non-tributary well must have a plan for augmentation in place before withdrawing such water.

Designated groundwater is groundwater that would not be available to fulfill surface rights or groundwater that has been the principal water supply for the area for at least 15 years and is not adjacent to a naturally flowing stream. Designated groundwater exists within designated groundwater basins. The Ground Water Commission establishes designated groundwater basins through a notice and hearing procedure when evidence becomes available that groundwater within a specific geographic area meets the above noted criteria. Each designated groundwater basin is administered according to a modified prior appropriation system.

4.3.9 Reuse

Colorado law generally provides for one use of water by the original appropriator. The water that is not consumed by an appropriator's first use is returned to the stream system, either as surface run-off or through subsurface infiltration. Junior appropriators, who are entitled to have stream conditions as they exist at the time of their appropriation, rely on these return flows to fulfill their decreed rights.

Thus, water that is brought into a watershed from a source unconnected with the receiving system termed "foreign" water may be reused by its owner. Foreign water includes non-tributary groundwater introduced into a surface stream as well as water imported from an unconnected stream system ("transmountain water"). Importers of foreign water enjoy rights of reuse that native water appropriators do not have. Such water is deemed "fully consumable" and can be used and reused to extinction so long as the user maintains dominion and control over the water. Dominion and control in this context refers to the intent to recapture or reuse such water, and is not lost when a municipal provider delivers water to a customer's tap or when consumers use such water to irrigate lawns. Dominion over the water is not lost if the importer intends to reuse such water and has some method to track or recapture the water.

In addition, agricultural water rights that are changed to municipal use may also generate fully consumable water that can be used to extinction. This is because the applicant in a change of use proceeding may take credit for, and reuse, the historical CU associated with the prior decreed use. Under this scenario, the amount of water attributable to the historical CU of the senior water right may be used and reused to extinction. Although this is not "foreign water" by definition, it is another source of fully consumable water.

In addition, in some circumstances, applicants for new water rights may obtain decrees that allow a new appropriation to carry with it a "fully consumable" designation that allows the diverted water to be used and reused to extinction if the initial appropriator has, from the beginning, a plan to reuse the water. Recently, challenges to these types of applications have focused on whether the claimed use and reuse to extinction is speculative in nature.

Any water that is deemed fully consumable may be reused to extinction. In practice, municipal exchanges involving fully consumable water (in most instances municipal effluent or lawn irrigation return flow credits), have been a means to reuse fully consumable water. Recently, municipal entities have also started to operate wastewater reclamation projects where fully consumable water, in the form of effluent, is treated to a high standard and used for outdoor irrigation purposes within the municipality's service area. These projects involve pumping the treated, fully consumable effluent to irrigate portions of a service area and thereby reducing demand for municipal potable supplies for irrigation. Reuse projects involving either pumping or exchanges potentially help increase efficiencies and reduce or postpone the overall demand for new water supplies.

4.3.10 Conservation Activities

Conservation practices associated with both municipal and agricultural uses can be an important tool in meeting long-term water supply needs. Demand reduction is an important component of water planning. To the extent that conservation practices are reliable, and/or permanent in nature, such practices can reduce the overall demand for water and thereby reduce any shortfall in supply.

Conservation measures can also take the form of increased efficiencies. However, not all water conserved through more efficient uses corresponds to an increase in overall water supply to a water user. For example, a water user could take steps to eliminate certain phreatophytes and thereby "salvage" additional water. That water, however, is owed to the stream and does not necessarily accrue to the benefit of the specific water user conducting the "salvage" activity, since a water user cannot take credit for a "salvage" activity and thereby divert more water. Salvage water is owed to the stream to be diverted by downstream water users pursuant to the priority system.

SECTION 6—WATER NEEDS ASSESSMENT

6.3.7 South Platte Basin

6.3.7.1 Identified Projects and Processes for M&I, SSI, and Agricultural Users

Major Identified Projects and Processes for the South Platte Basin are summarized in Table 6-36. For reference, Figure 6-11 provides a map of subbasins, counties, and major cities in the basin as referenced throughout this discussion.

Most M&I water providers indicated that they believe they will be able to meet 2030 needs using existing supplies, projects that are now underway, and future plans and projects. Most providers are pursuing enlargement of existing reservoirs and new storage, and consider those actions critical to meeting future needs.

Table 5-36 Major Identified Projects and Processes in South Platte Subbasins

Subbasins (Counties)	Estimated Demand met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
Denver Metro (Adams, Denver, Jefferson)	108,100	■ Active Conservation ■ Existing supplies ■ Denver Northern Firming ■ Thornton Water Supply and Storage Company transfer ■ Agricultural transfers ■ New storage (including gravel lakes) and reservoir enlargements ■ Reuse for non-potable irrigation of parks and golf courses and other landscaping ■ Treating lower quality water sources
South Metro (Arapahoe, Douglas, Elbert)	38,300	■ Active Conservation ■ Implementation of South Metro Conjunctive Use Plan or alternative ■ Reuter-Hess Reservoir ■ Aurora Long-range Plan ■ East Cherry Creek Plan ■ Agricultural transfers and reuse ■ Additional non-tributary groundwater ■ Reuse for non-potable irrigation of parks and golf courses and other landscaping ■ Indirect potable reuse by blending return flows with raw water supplies ■ Treating lower quality water sources
Upper Mountain (Clear Creek, Gilpin, Park, Teller)	16,500	■ Drilling of exempt wells ■ Cooperative agreements with existing major water providers ■ Development of tributary groundwater supplies and plans for augmentation with agricultural transfers and new storage
High Plains (Cheyenne, Kit Carson, Lincoln, Phillips, Washington, Yuma)	800	■ Additional non-tributary groundwater
Northern (Boulder, Larimer, Weld)	146,500	■ Active Conservation ■ Windy Gap Firming ■ Northern Integrated Supply Plan ■ Halligan and Seaman Reservoirs enlargement ■ New storage including gravel lakes ■ Agricultural transfers ■ CBT acquisition ■ Reuse for non-potable irrigation of parks and golf courses and other landscaping ■ Exchanges ■ Annexation policies ■ Treating lower quality water sources ■ Use of local ditch rights for landscape irrigation
Lower Platte (Logan, Morgan, Sedgwick)	8,900	■ Augmentation of tributary groundwater with agricultural transfers ■ CBT acquisition
TOTAL	319,100	

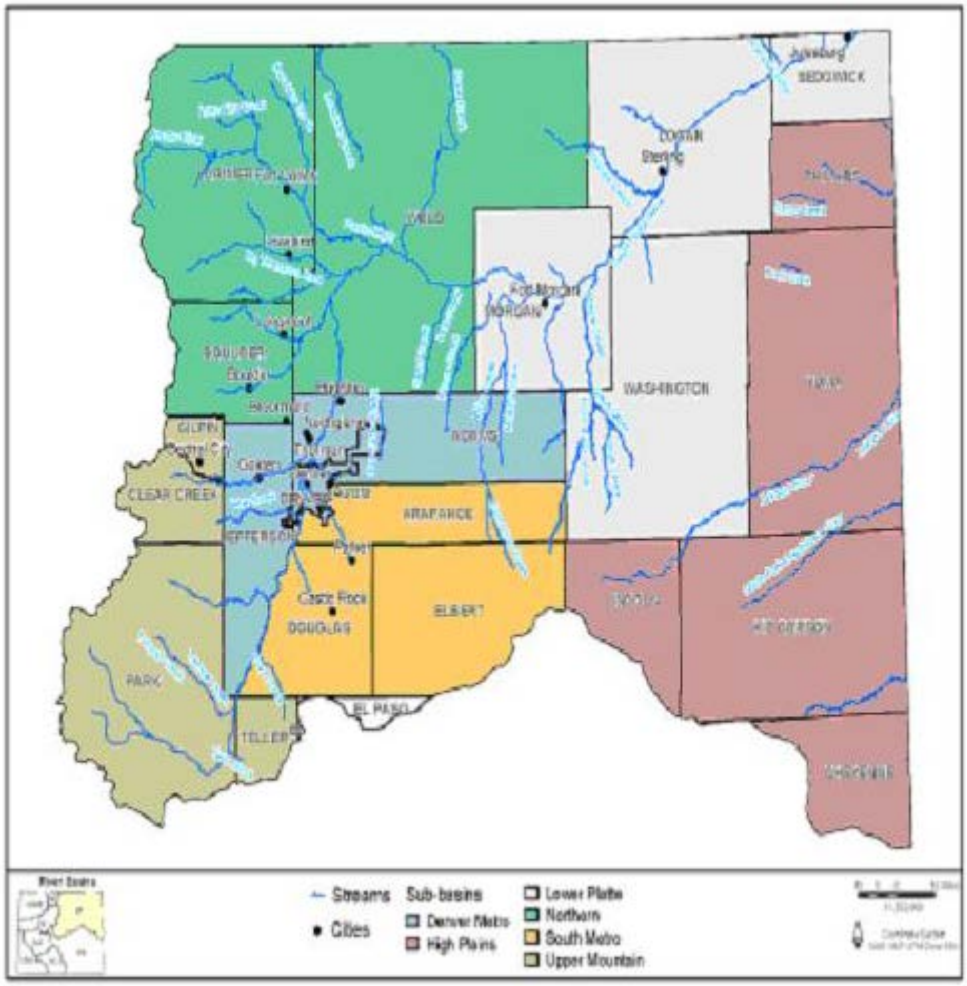


Figure 6-11
South Platte Basin Location Map

Reuse is being pursued by almost all cities that own reusable supplies. The trend toward the use of gravel lake sites that are no longer mined for storage of reusable effluent will expand. The potential for future water rights exchanges of effluent will be considerably less, especially in the Denver and South Metro areas as most of the exchange potential has already been tied up with existing exchange water rights applications. These exchanges, however, will continue to be made when and where feasible. Direct reuse of effluent is largely focused on non-potable uses such as irrigation of parks and golf courses, though other non-potable uses are becoming more prevalent (e.g., power plant cooling water supply). A few cases of indirect potable reuse – intentionally augmenting raw drinking water supplies with treated reclaimed domestic wastewater effluent – are being implemented or planned, and more are likely in the future as water treatment technology advances. The disposal of the waste streams from the treated effluent will be a significant challenge and expense and may limit this option.

While additional conservation is a part of most water providers' plans to meet future water supply needs, most providers do not foresee or propose to implement levels of conservation such as severe

limitations or bans on grass lawns. As in the Arkansas Basin, many providers cite the following as their reasons not to move toward aggressive conservation measures:

- Drought reliability
- Quality of life
- Customer acceptance
- Lawn watering is an indirect source of water supply (can be utilized during periods of drought by restricting water use)
- Operational flexibility

In fact, most providers contacted through SWSI indicated that they would likely acquire additional agricultural rights rather than implement aggressive levels of conservation where the quality of life would be significantly impacted.

Many water providers in the basin's Northern Subbasin indicated that their Identified Projects and Processes include relying on obtaining additional shares of CBT Project water. However, some caution is warranted, in that demand for CBT water will likely exceed the available supply. In addition, much of these transfers of CBT will come from agricultural users that are using the water to firm existing in-basin supplies. As these shares are transferred, the reliability of the overall remaining agricultural supplies will decrease.

Other projects vital to meeting the future needs of Northern Subbasin M&I users are the NCWCD's Northern Integrated Supply Plan (NISP), Windy Gap Firming, and Halligan and Seaman Reservoir enlargements sponsored by the Cities of Fort Collins and Greeley, respectively. The Windy Gap Firming Project, as with the Denver Water Northern system firming project, involve increased diversions of transbasin water from Grand County, which will reduce the availability of water to meet future Grand County M&I, recreational, and environmental needs.

Denver Metro

For Denver Water, the Northern Firming Project, which will increase the reliability of the Moffat Tunnel system, is an integral part of Denver Water's plan to meet future demands. It is important to note that the NCWCD Windy Gap and Denver Firming Projects are, similar to agricultural firming projects proposed in the Gunnison and other basins, designed to increase the reliability of existing supplies and reduce shortages, but are not a new water source. Other providers in the Denver Metro area will rely on existing supplies, reuse, exchanges, gravel lake storage, new storage and reservoir enlargements, and agricultural transfers.

South Metro

The South Metro area has a projected future increased demand of 88,000 AFY. Among the major water providers in this area, Aurora is embarking on its long-range plan to meet future needs as its key Identified Process. This plan will rely heavily on the recapture and reuse of its return flows and agricultural transfers from downstream of the Denver Metro area. The East Cherry Creek Valley Water and Sanitation District is implementing a similar program and the Parker Water and

Sanitation District has recently received a permit for the construction of Reuter-Hess Reservoir. The South Metro Water Supply Study included many of the water providers in Arapahoe and Douglas Counties that currently rely primarily on non-tributary, non-renewable groundwater. As noted in the South Metro Study, the costs of continued reliance on non-renewable Denver Basin aquifer water will increase dramatically as well yields decline and additional wells and infrastructure are needed to maintain current level of groundwater pumping. These costs will not resolve the issue of the long-term reliability of the resource and the ultimate need to develop a renewable source of water. To continue to use as well yields decline, the amount needed ("the gap" between supply and demand) will become significantly larger in the northern portion of the basin. The South

Metro Study identified potential solutions including the development of a CU project, where surface water would be diverted, stored, and treated in wet years to reduce the reliance on groundwater pumping. The South Metro users' needs of approximately 40,000 AF would increase by an additional 40,000 AFY if non-tributary wells fail or become technically or economically infeasible to continue current levels of groundwater pumping in the future. There are no reliable surface water supplies that can be developed from the South Platte using surface water diversions as the sole water supply source. The South Metro Water Providers have indicated that additional alternatives need to be developed for meeting future South Metro water needs.

High Plains

In the High Plains subbasin, continued reliance on non-tributary groundwater supplies is expected to occur to meet future M&I needs. The northern High Plains Ogallala aquifer is anticipated to provide for the limited M&I growth anticipated in this region.

Lower South Platte

The Lower South Platte area will rely on existing rights and agricultural transfers for well augmentation and CBT acquisitions for surface water supply. Water supplies for additional power generation at the Xcel power generating facility in Brush will need to be developed.

Upper Mountain

The Upper Mountain areas primarily rely on groundwater for M&I demands. These areas will have the challenge of the limited physical availability of groundwater. Much of the groundwater is in fractured bedrock and well yields can be highly variable and decline as additional growth occurs. Certain areas in the basin may have self-limiting growth due to the lack of sufficient groundwater and the inability to deliver surface water supplies. Many of these areas already experience reduced well production. Park County has approximately 25,000 pre-1972 platted lots, which are not required to provide augmentation. Many of these lots are platted with high densities. These approved densities may impact well yields, trucked water or onsite storage tanks may be required to meet peak demands for some in-home domestic uses if additional development occurs. Jefferson County is in the process of regulating densities in certain mountain areas in order to prevent over development of the limited groundwater resources.

Agriculture

Based on discussions with South Platte Basin Roundtable members, it is expected that agricultural transfers will continue to occur to meet a portion of the basin's growing M&I needs. This will likely manifest itself through outright purchases, developer donations, and development on irrigated lands.

However, not all agricultural acquisitions can be transferred to existing water intakes. As a result, the use of dual water systems delivering local ditch water through pressurized non-potable water lines will increase.

There is very little irrigated land remaining in the Denver and South Metro areas that can be transferred for M&I use and many of these providers will be looking downstream for agricultural supplies. These supplies will be very expensive to develop as agricultural rights in the South Platte Basin have increased in price and long pipelines of 30 to 70 miles and advanced water treatment facilities will be required to treat these lower quality water sources to potable drinking water standards. The disposal of the waste stream from the advanced water treatment facilities will be a long-term challenge as treatment of these waste streams are very expensive and the waste streams represent up to 20 percent of the total water production.

These agricultural transfers will also require that significant additional storage be constructed to provide carry-over supplies for the non-irrigation season and dry periods. It is estimated that approximately 2 AF of average year agricultural water supplies and 3 AF of storage are needed to produce 1 AF of firm M&I annual yield.

Agricultural transfers may also result in reduced groundwater tables if historic return flows are not made in the location of historic irrigation. These transfers have the potential for impacts on both domestic and agricultural wells.

Agricultural shortages are prevalent and expected to continue throughout the entire basin. The CBT Project was designed to reduce agricultural shortages in the northern area, but the transfers of CBT shares from agricultural to M&I use will increase shortages. The need for augmentation sources for alluvial agricultural wells along the South Platte has become a critical need. As M&I demands increase and providers turn to increased use of their reusable supplies and agricultural transfers, the availability of augmentation supplies for agricultural users decreases and agricultural users cannot compete with M&I providers on the price of augmentation water. Also, the increased use of reusable supplies and potential reduction in return flows from M&I water conservation efforts may result in reduced flows, decreasing available supplies for downstream agricultural users. Significant reductions in irrigated lands will occur in the South Platte unless augmentation supplies are developed for agricultural well augmentation and alternative sources of M&I water are identified.

Water supply gaps for individual water providers were not developed for the South Platte Basin. Most water providers indicated that they believed they would be able to meet 2030 demands. Many of these same providers, however, identified the same sources of future supply. It is unlikely that there are sufficient supplies to meet the acquisition and water development plans of all of the providers, though it cannot be accurately predicted which providers will fall short in their plans.

6.3.7.2 Recreational and Environmental Information

6.3.7.2.1 Flow Considerations

In January 2004, the USFS released a Wild and Scenic River Study Report and Final EIS for 99.5 miles of river including the North Fork of the South Platte River and segments of the South Platte River. All of the South Platte River study corridor and much of the North Fork of the South Platte River study corridor lie within the boundaries of the Pike National Forest (National Forest). Both

areas, however, include many private and local government inholdings. The study corridors also contain a 6.6-mile stretch of the North Fork of the South Platte River that lies outside the National Forest boundary. This section is mostly in private ownership but includes some public lands managed by Denver Water and Jefferson County Open Space.

National Forest System lands in the study corridors are managed in accordance with the Land and Resource Management Plan for the Pike and San Isabel National Forests, Comanche and Cimarron National Grasslands (Forest Plan), approved in November 1984. Pending the outcome of the suitability analysis, Segments A, B, and C in the South Platte study corridor are included in a special management area under the Forest Plan. The special management area, called the "Scenic River Corridor," provides additional protection to preserve the characteristics that made the segments eligible for potential Wild and Scenic designation. Similarly, Segments D and E on the mainstem and Segment H on the North Fork are protected under an interim management plan.

Attributes being protected include the stream's free-flow, water quality, and outstandingly remarkable values (ORVs). The special protection will continue until the study river either is added into the Wild and Scenic River System or is found not suitable for such designation by the USFS, the USDA, or Congress.

If a Wild and Scenic designation is approved, the interim direction would be replaced by a "River Management Plan"; if it isn't approved, the management of the area would be released from special protection and would revert back to the general provisions of the Forest Plan.

Management practices under the current Forest Plan vary greatly by river section, but generally emphasize developed and semi-primitive recreation opportunities, wildlife habitat needs, forage and cover on big game winter ranges, and productive tree stand management.

After the USFS, Denver Water is the next largest land manager or owner in the area. Denver Water's lands are managed for water delivery, dispersed recreation, summer home rentals, and resource protection to ensure high water quality. Over many years, Denver Water had acquired most of the non-federal land along the South Platte from Deckers to the North Fork confluence, and along the North Fork from the confluence to Ferndale, in anticipation that these lands would be inundated by its planned Two Forks Reservoir. Plans for the Two Forks Project were abandoned indefinitely, however, after a 1989 ruling by EPA that the project would violate the CWA.

The USFS intends to protect the outstandingly remarkable values, free-flow, and water quality of eligible segments of the South Platte River through a cooperative process with USFS legal authorities added. The river corridor's ORVs, free-flow, and water quality are to be managed under a federal/state/local government partnership as outlined in the South Platte Protection Plan (SPPP).

The purpose of the SPPP is to protect the ORVs identified by the USFS and preserve water supply functions without designating the river under the Wild and Scenic Rivers Act. These values are historical, fishery, geological, recreational, scenic, and wildlife resources. The SPPP also recognizes that Colorado's Front Range communities rely heavily upon the South Platte for drinking water supply and other M&I uses and that agriculture throughout northeastern Colorado depends heavily on South Platte flows. The ORVs must be protected in the context of preserving these functions as well. The interests of all these communities can be maintained through common dialogue toward an

approach in which the many values on the river – habitat, ecosystem, and human-based – can all be addressed in coordination and balance with one another. Mutual respect for the many important uses is central to the SPPP. It creates a cooperative management structure of local, state, and federal agencies. The underlying principle is no loss of existing or future water supply. The major components of the SPPP are:

- Protect canyons.
- A streamflow management plan, including: no loss of existing or future water supply; minimum outflows from Spinney Mountain, Elevenmile, and Cheesman Reservoirs; ramping (changing gradually) outflow changes from Elevenmile and Cheesman Reservoirs and the Roberts Tunnel; new valves, monitors, and gages; channel work on North Fork to be coordinated with CDOW; public input to annual operating plans; stream channel maintenance and improvement; designation of desirable outcomes; and goals for water suppliers to use as guidance in their operating decisions as follows:
  - Operate Spinney Mountain, Elevenmile, and Cheesman Reservoirs to release stored water to maintain minimum outflow when inflow is low.
  - Operate Spinney Mountain, Elevenmile, and Cheesman Reservoirs for outflows in an optimum range the remainder of the year.
  - Operate Elevenmile and Cheesman Reservoirs outflow for optimum temperatures and ramping of daily temperature fluctuations to benefit fisheries below the dams.
  - Consideration of whitewater and fisheries in Roberts Tunnel discharges, within the limitations described in the Streamflow Management Plan.
  - Revise annual operating plans to limit fluctuations when the potential exists to harm vulnerable life stages of brown or rainbow trout. Future water projects, especially those that would significantly extend bank-full stream conditions, would require an analysis by the project proponent of channel capacity related to adequate protection of fisheries habitat and populations, channel stability, and maintenance of the ecosystem.
- A Management Partnership for Recreation, Wildlife, Scenery, and Other Values.
- Cooperative water quality initiatives would be implemented through the Coalition for the Upper South Platte (CUSP), which is composed of interested local governments, agencies, and parties in the basin. This coalition was originally known as the Upper South Platte Watershed Protection Association.
- Endowment. Front Range local governments and water suppliers would contribute at least $1 million to be spent on the values identified by the USFS.
- Enhancement Board. A coordinating forum, the Friends of the South Platte River, Inc., would provide comments and responses on activities such as land use or land management planning decisions, as well as deciding expenditures from the endowment.

- Withdrawal of 1986 applications for conditional storage rights. Both Denver Water and the Metropolitan Denver Water Authority would withdraw Water Court applications for 780,000 AF of additional storage at the Two Forks Reservoir site.

- Alternative to development of Denver's rights-of-way. Denver Water and environmental groups have proposed a working relationship that could lead to alternative projects and allow Denver Water later to relinquish its 1931 rights-of-way on the South Platte at the Two Forks site. As a demonstration of good faith in pursuing alternative projects, Denver Water would voluntarily impose a moratorium on applications for development of the rights-of-way for a period of 20 years from formal acceptance of the SPPP.

- Provision for limited development. In addition, Denver Water and other present and future water suppliers would continue to have access to the river for operational and maintenance purposes.

Enforcement of the SPPP would be provided by a written agreement between the USFS and those entities making commitments within the SPPP. Public participation would be involved under certain circumstances.

The agency is not completing the Wild and Scenic River suitability study at this time to allow for a period of review of the adequacy of the SPPP. The USFS will, however, amend the Forest Plan to maintain the findings of eligibility and classification to the maximum extent possible under its existing authorities. River corridor management will be monitored and periodically reviewed to ensure continued protection of free-flow, ORVs, and water quality. The monitoring program will rely on current indicators and the standards and guidelines from the Forest Plan.

The development of agreements among participating interests is envisioned as part of implementing the SPPP. However, under the Preferred Alternative, such agreements are not considered mandatory. The Preferred Alternative also considers criteria for determining whether the SPPP is actually being implemented and working properly.

CWCB holds numerous instream flow rights for the major rivers and tributaries in the South Platte Basin (http://cwcb.state.co.us/isf/ Downloads/ Index.htm). These rights are year-round with seasonal variability as reflected in the range of flows shown.

No CWCB instream flow rights have been decreed on the Republican River or the South Fork of the Republican River (http://cwcb.state.co.us/isf/ Downloads/ Index.htm).

6.3.7.2.2 Water Based Recreation

The following federal project reservoirs in the South Platte River and Republican River Basins offer water-based recreational activities in addition to authorized project purposes:

Bonny Reservoir

Bonny Dam and Reservoir provides water for recreation and flood control and are on the South Fork of the Republican River near Hale, Colorado just west of the Kansas border in Yuma County. They are features of the Armel Unit, Upper Republican Division, Pick-Sloan Missouri Basin Program. The reservoir has approximately 2,095 surface acres. Fishing is well known and excellent.

Fishing season is year-round. Camping, hunting, hiking, picnicking, and wildlife viewing can be enjoyed at Bonny Lake State Park. With seasonably warm waters, dependable winds, and sandy beaches, Bonny Lake State Park is a destination for swimmers, water skiers, and windsurfers. Other recreational opportunities include boating and recreational vehicles. Recreation at the site is managed by the CDPOR for the BOR (http://www.recreation.gov/detail.cfm?ID=48 and http://www.usbr.gov/dataweb/html/armel1.html).

Carter Lake

Carter Lake Dam and Reservoir are features of the CBT Project in the South Platte Basin. Its authorized purposes are irrigation, M&I, and recreation. Carter Lake is located in the foothills west of Loveland at an elevation of 5,760 feet. Three miles long and about one mile wide, Carter Lake is a 1,100-acre reservoir surrounded by 1,000 acres of public lands and is popular for fishing, sailing, camping, swimming, scuba diving, rock climbing, and water skiing. Developments include 5 campgrounds with 151 campsites and 3 boat launch ramps. A concession-operated public marina is located at the north end of the lake. A concession for members only (Sail Club) is operated on the northwest shore of the lake. A handicap accessible trail has been constructed at the south shore. Picnicking and wildlife viewing are also available. The reservoir is open year-round. Water levels are low in late summer because of seasonal drawdown. Recreation is managed by Larimer County Parks and Open Lands (http://www.recreation.gov/detail.cfm?ID=49 and http://www.co.larimer.co.us/parks/carter.htm).

Flatiron Reservoir

Flatiron Dam and Reservoir provides water for irrigation, M&I, and recreation, and are located on Chimney Hollow Creek 8 miles southwest of Loveland, Colorado in the South Platte Basin. The dam and reservoir are features of the CBT Project. Facilities include 1 campground with 41 campsites. Total available surface acreage for recreation is 47 acres, surrounded by 200 acres of public land. No boating is allowed. Primary recreational activities include fishing and camping. The primary sport fish available is rainbow trout. Additional recreational opportunities include picnicking and recreational vehicles. Facilities and campground are closed in winter due to ice and snow. Recreation is managed by Larimer County Parks and Open Lands (http://www.recreation.gov/detail.cfm?ID=52 and http://www.co.larimer.co.us/parks/Flatiron.htm).

Horsetooth Reservoir

Horsetooth Reservoir is located in the foothills about 5 miles west of Fort Collins in the South Platte Basin. It provides water for irrigation, M&I, and recreation. The reservoir is at an elevation of 5,430 feet. As part of the CBT Project, it furnishes the main water supply for the Poudre Valley. The reservoir is 6.5 miles long. Developments include 4 campgrounds, 111 campsites, and 7 boat launch ramps. A concession-operated public marina is located at the Inlet Bay area. A concession-operated restaurant is located in the South Bay. A developed public swim beach is located on the west side of the lake. Total water surface available for recreation is approximately 1,900 surface acres, surrounded by 2,000 acres of public land. Primary recreation activities include fishing, power boating, water skiing, and camping. Primary sport fish include rainbow trout, crappie, smallmouth bass, white bass, wiper, largemouth bass, and walleye. Additional recreational opportunities include hiking, picnicking, and wildlife viewing. The reservoir is open year-round. Recreation is managed by Larimer County

Parks and Open Lands (http://www.co.larimer.co.us/parks/Horsetooth.htm and http://www.recreation.gov/detail.cfm?ID=66).

Lake Estes

Lake Estes, a feature of the CBT Project, is formed by Olympus Dam constructed across the Big Thompson River in the South Platte Basin. Its authorized purposes are irrigation, M&I, and recreation. Recreation facilities include a nine-hole golf course, five picnic and associated day-use areas, and a marina. Water surface available for recreation is 185 surface acres. Power boating is limited, but available. Sailing opportunities exist. Fish species available are largely rainbow trout. Facilities are closed in winter due to ice and snow. Additional recreational opportunities include biking, camping, hiking, horseback riding, and wildlife viewing (http://www.recreation.gov/detail.cfm?ID=67).

Mary's Lake

Mary's Lake provides water for irrigation, M&I, and recreation, and is located about 2 miles from Estes Park, in the South Platte Basin. There is a concession-developed campground accommodating 270 campsites, including both RV sites with utility hookups and tent camping sites. Water surface available for recreation is approximately 42 acres. No boating is allowed. Primary recreation activities include camping, fishing, and picnicking. Primary fish species include rainbow trout. Facilities are closed in winter due to ice and snow (http://www.recreation.gov/detail.cfm?ID=88).

Pinewood Lake

Pinewood Lake is located about 12 miles southwest of Loveland, west of Carter Lake, at an elevation of 6,580 feet. It provides water for irrigation, M&I, and recreation. The lake and dam are part of the CBT Project in the South Platte Basin. Developments at the lake include 3 campgrounds with 18 campsites and 1 boat launch ramp. The total available water surface acreage for recreation is about 100 acres surrounded by 327 acres of public land. Only no-wake power boating is allowed. Primary recreational activities include fishing, camping, and boating. Primary sport fish available are rainbow trout. Picnicking and wildlife viewing are also available. Recreation is managed by Larimer County Parks and Open Lands (http://www.co.larimer.co.us/parks/Pinewood.htm and http://www.recreation.gov/detail.cfm?ID=89)

Four sections of the South Platte River have been awarded Gold Medal designation:

- The South Fork downstream from the Highway 285 bridge to the inlet of Antero Reservoir
- The Middle Fork downstream from the Highway 9 bridge (4.9 miles north of Garo) to the confluence of the Middle and South Forks of the South Platte River
- From the Middle and South Forks confluence downstream through Spinney Mountain Reservoir to the buoy line at the inlet of Elevenmile Reservoir
- From Cheesman Reservoir Dam downstream to the North Fork of the South Platte River

The 3-mile section of the South Platte below Cheesman Dam produces more than 500 pounds of fish per surface acre, mostly rainbows 15 to 22 inches.

Spinney Mountain Reservoir, on the South Platte River about 5 miles upstream from Elevenmile Reservoir, also has been awarded Gold Medal designation.

SECTION 8—OPTIONS FOR MEETING FUTURE WATER NEEDS

8.1 Developing Options for Future Water Needs

This section outlines the broad strategies that can be used to address Colorado's water supply needs. These strategies are comprises of different methods or "options" that can be implemented independently or in combination with other options. When several options are combined, the resulting portfolio of options is termed a water supply alternative. A group of individual options that are similar in nature can also be combined into "families of options" as described in the next subsection. Implementation of the Identified Projects and Processes is critical to meeting Colorado's future water demands. Unless these projects and plans move forward, significant additional water supplies, in addition to the remaining gaps projected in Section 6, will be required.

As discussed in Section 6, through the Basin Roundtable process it was determined that approximately 80 percent of Colorado's future water supply needs can be addressed via projects and processes that are being pursued by local water providers. Water supply options that could be used to address the remaining 20 percent and the uncertainty associated with the Identified Projects and Processes were developed during the Basin Roundtable process.

8.2 Families of Options

The Identified Projects and Processes listed in Section 6 and additional future options generally fall under one of the following categories, or "families" of options:

- Water Conservation, including:
  - Active M&I Conservation
  - Agricultural Efficiency Measures
- Agricultural Transfers, including:
  - Permanent Agricultural Transfer
  - Interruptible Agricultural Transfer
  - Rotating Agricultural Transfer Fallowing with Firm
- Yield for Agriculture
- Development of Additional Storage, including:
  - Development of New Storage Facilities
  - Enlargement of Existing Storage Facilities
- Conjunctive Use of Surface Water and Groundwater, including:
  - Bedrock Aquifers
  - Alluvial Aquifers
- M&I Reuse, including:
  - Water Rights Exchanges

- Non-potable Reuse
- Indirect Potable Reuse

- Control of Non-Native Phreatophytes

The options included under these categories can be evaluated individually or in combination to help meet the remaining water supply needs for each basin. The likelihood that these options will be successfully implemented and sustainable depends, in part, on the public and institutional support. That support is to a large extent dependent on how well each option meets the SWSI water management objectives. Thus, the above options were evaluated in terms of their performance according to the management objectives and grouped into alternatives.

8.2.1 Conservation

8.2.1.1 Municipal and Industrial Water Conservation

M&I water conservation programs result in improved water use efficiency. M&I water savings occur through the modification of water-using fixtures (e.g., showers, landscapes, cooling towers) and behaviors (e.g., showering time, irrigation schedules, maintenance schedules, etc.). The effects of conservation on M&I water demand are the result of both passive and active water conservation efforts. These conservation efforts, though somewhat unpredictable in their rate of success since they require changes in consumer behavior, can be effective means of reducing water supply needs, with little cost to the community.

8.2.1.2 Evaluating New Supply from M&I Water Conservation

The ability to develop new supplies from water conservation or to carry over conserved water for later use is dependent on the type of water rights used. The potential for conservation must be evaluated on an individual M&I water provider basis, considering the types of water rights owned and the return flow obligations that apply to these water rights.

8.2.1.3 Agricultural Conservation (Efficiency Improvements)

Agricultural conservation or agricultural efficiency implementation is a means to create new water supply that must be carefully evaluated since Colorado water law and interstate compacts may limit or preclude the use of this option to increase supply. This option involves increasing the efficiency of water used for irrigation, so that more of the water that is diverted from streams and rivers or pumped from groundwater meets the direct CU needs for agricultural crops. Typical agricultural efficiency measures include canal lining or the conversion of irrigation practices and technology from flood irrigation to gated pipe or the installation of sprinklers or drip irrigation systems. These measures are designed to reduce the delivery losses that occur as water is diverted from a stream or as groundwater is pumped and delivered to the farm or ranch or as it is applied to the crops.

8.2.2 Agricultural Transfers

Agricultural uses currently account for more than 80 percent of the water diverted and consumed in Colorado. Many agricultural users hold senior water rights that can potentially be changed in use to provide a significant source of M&I water supply. In agricultural transfers, farm land is usually "dried up" or no longer irrigated and the water historically used for irrigation of this land is used for meeting M&I or other needs, such as dedication to CWCB for instream flow purposes. The total

water available under a change of agricultural water rights typically depends on the historical CU of the water for agricultural purposes: this is a measure of the water right for transfer. In addition, the yield of an agricultural water right may depend upon the location of the new use of the water. For example, in general, if the water is to be diverted through the same ditch system as historically, a transfer to M&I use may allow diversions of all of the water previously diverted at the historical farm headgate though the historic CU cannot be increased. The water that may be diverted on a transfer of water from an agricultural use to one out of the basin will be limited to the historical CU. Meanwhile the historical return flows must be maintained; storage may be needed to ensure that other water rights that historically relied on return flows are protected. After the historical return flows have been replicated, it is legal for the transferred "consumable" water to be used and reused to extinction.

8.2.2.1 Permanent Agricultural Transfers

Permanent agricultural transfers involve the permanent acquisition of agricultural water rights, the cessation of irrigation on the historically irrigated lands (dry up), and the transfer or change of a water right to M&I or other uses, such as dedication to the CWCB for instream flow purposes.

8.2.2.2 Interruptible Agricultural Transfers

Interruptible agricultural transfers consist of temporary arrangements where agricultural water rights can be used for other purposes. The agreement with agricultural users allows for the temporary cessation of irrigation so that the water can be used to meet other needs.

8.2.2.3 Rotating Agricultural Transfers with Storage to Firm Agricultural Demands

A third concept was developed during the Basin Roundtable process in an attempt to capture the benefits of a permanent agricultural transfer without the negative impacts. This concept, rotating agricultural transfers with storage to firm agricultural supply consists of a type of interruptible agricultural transfer arrangement involving several agricultural parties and one or more M&I users. Each agricultural user would agree not to irrigate for 1 year out of a set period of years corresponding to the number of agricultural users in the program making the flows available to M&I users. For example, if 10 agricultural users joined the arrangement, each would take their turn not irrigating in 1 year out of 10. The M&I user would obtain a constant annual yield, with this yield coming from a different agricultural user each year. An additional element would be to set aside of a portion of the water from the agricultural lands not irrigated in each year to be placed into storage to firm the yield to the agricultural users that are part of the agreement. This agricultural firming pool would be used in below average years to increase the yield for those agricultural users that are irrigating that year.

8.2.2.4 Water Bank

In addition to permanent agricultural transfers, water banks have been authorized by the Colorado legislature. A pilot program was established in the Arkansas Basin. The water bank provides a mechanism for leasing water on a short-term basis without permanently transferring a water right to another user. Entities with stored water rights have the options to lease their water during times of drought or when it will not be put to beneficial use.

8.2.3 Development of Additional Storage

Storage projects capture water during high flow years and seasons to be used during low flow periods. These storage projects include the construction of new reservoirs, enlargement of existing reservoirs, or rehabilitation of existing reservoirs that have reduced storage volumes due to various structural problems (e.g., spillways unable to meet the current probable maximum flood criteria, etc.). Storage options included in the SWSI process include the construction of new storage facilities to capture legally available flows under a new water rights appropriation, the construction of new storage facilities to maximize the yields of existing water rights, including exchange priorities and conditional storage rights, and the enlargement of existing reservoirs. The rehabilitation of existing reservoirs that are under voluntary or mandatory storage restrictions was evaluated during the Basin Roundtable process. It was determined that while there are many reservoirs with restricted capacities, the total potential storage to be gained from rehabilitation efforts is small in comparison to Colorado's overall need.

8.2.3.1 New Storage Projects

New storage projects include the construction of dam embankments to create on-channel or off-channel reservoirs. Off-channel reservoirs require the construction of diversion or pumping facilities from the river or stream to deliver the diverted water to storage. Another option for the development of new storage is the conversion of gravel pits to gravel lakes. These lakes are formed by reclaiming and lining pits created through gravel mining operations. Diversion or pumping facilities are also required to deliver water to gravel lakes. Storage options will vary greatly in their feasibility, and project considerations, such as firm yield, capital costs, and permitting are site specific.

8.2.3.2 Expansion of Existing Storage Facilities

The expansion of existing storage facilities can be a cost-effective means to develop additional storage. Options for increasing storage in existing facilities include raising dam embankments, dredging of sediments, and deepening reservoirs and raising spillway levels. The expansion of existing storage facilities has several benefits including:

- There are likely to be less environmental and recreational issues than for new storage, since the reservoir already exists.
- Permitting and mitigation requirements may be less difficult than for construction of a new storage facility.
- Existing water rights are not affected if the water is to be stored under a new water right.
- The expansion of storage to capture unappropriated water can potentially reduce the pressure to transfer water from existing uses (i.e., agricultural water) to meet future water needs.
- The expansion of storage for unappropriated water captures an unused resource.
- The expansion of storage helps to maximize compact entitlements for beneficial use within the State of Colorado.

- Overall system efficiencies are increased by minimizing system spills.
- The yields of exchanges and non-potable reuse for irrigation are increased. Maximizing the reuse of consumable return flows requires storage, since return flows occur year-round, but the demand for irrigation is seasonal.
- Storage is required to firm the yield of transfers of agricultural water rights. If additional storage is not constructed, additional agricultural water rights will be needed to ensure adequate supply during below normal runoff conditions. The potential issues and conflicts in expanding existing reservoirs include:
- Environmental and recreation impacts can also occur here depending on the size of facility.
- Expanding existing storage facilities does not diversify water sources and the risks of structural failures or water quality catastrophes are not reduced.
- Permitting and mitigation, though typically less difficult than that for new storage, can still be expensive and lengthy with an uncertain outcome.
- A significant amount of storage may be required to produce an acre-foot of firm yield. The amount of storage required will be basin and water rights specific.
- There are a limited number of reservoirs that can be enlarged. Many reservoirs are not cost-effective to enlarge.
- There is a limited volume of increased storage available through reservoir enlargements.
- The enlargement of existing reservoirs may not be cheaper than new storage. The original dam embankments and spillways, in many instances, were not designed or constructed to current engineering standards. Upgrading the existing facilities to be compatible with an enlargement may not be cost effective.

8.2.4 Conjunctive Use of Surface Water and Groundwater

Colorado's groundwater supplies are abundant but are limited in many areas by physical or legal availability or economic feasibility issues. Physical limitation affects the reliability and sustainability of groundwater as a source of supply. Physical availability measures the amount of water an aquifer can produce, both in the short- and long-term, and primarily affects the sustainability of the resource. Legal availability relates to the amount of water that can be extracted from an aquifer under the water rights administration system that exists in a particular area, and can affect the reliability of the supply. In the context of water supply, aquifers can be categorized as being renewable or non-renewable.

Aquifers that are located adjacent to rivers in the alluvial floodplain deposits usually have a hydrologic interaction with those rivers, and dynamically get water from or discharge water to the rivers throughout their reaches. Aquifers of this type are referred to as tributary aquifers. They usually are unconfined aquifers that are relatively shallow. Tributary aquifers are considered to be a

renewable source of water since they are hydrologically linked to renewable supplies such as precipitation and infiltration of surface water.

The other category of aquifer, non-renewable, is one that is not replenished from renewable sources such as rivers or infiltration of rainfall. Non-renewable aquifers generally are located deep below the land surface, in consolidated bedrock deposits, and would be classified as confined aquifers. A non-renewable aquifer may be capable of producing water reliably under varying climate conditions (wet and dry years); but it may only last 50 to 100 years and would therefore not be considered a sustainable resource. Recharge of non-renewable bedrock aquifers is very slow and withdrawal rates usually exceed recharge. As water levels decline in a non-renewable aquifer additional wells would be required to maintain a given pumping rate. These non-renewable aquifers are unreliable as a permanent, sustainable water supply.

Conjunctive use of surface water and groundwater can maximize the benefits and reliability of both surface water and groundwater sources of supply. In its simplest form, conjunctive use involves using surface water when surface supplies are ample, such as during average to above average runoff conditions, and recharging aquifers with available surface water. When surface water supplies are in short supply, such as during below average runoff conditions, groundwater supplies would be used to a larger degree to meet demands. Both bedrock and alluvial aquifers can be used in a conjunctive use water supply operation by serving as a water storage bank. Deposits are made in times of surface water supply surplus and withdrawals occur when available surface water supply falls short of demand.

8.2.4.1 Bedrock Aquifer Conjunctive Use

Bedrock aquifer conjunctive use involves capturing and using surplus surface water supplies for immediate use or injecting these surplus surface water supplies into the bedrock aquifer through wells. The intent is to extend the life of non-renewable groundwater sources.

8.2.4.2 Alluvial Aquifer Conjunctive Use

Alluvial aquifer conjunctive use involves diverting surplus surface water supplies and recharging the alluvial aquifer. Recharging is typically accomplished by canal infiltration or spreading basins, and then pumping the groundwater when needed as a source of supply or when the timing of accretions to the river system is needed to meet demands (for example, stream depletion requirements or streamflow enhancements).

8.2.5 Municipal and Industrial Reuse

M&I reuse involves a second or consecutive uses of consumable water supplies that have first been used to meet municipal or industrial needs but not fully consumed. The first aspect important to understand in reuse projects is the consumptive and non-consumptive components of water use. Water use is generally divided into CU (i.e., water that is in effect consumed and eliminated from the system) and non-CU (i.e., water returning to the system after use by infiltration into the ground, or water returning to the system as effluent from wastewater treatment plants after use in households). Reuse projects seek to recycle that portion of the water not consumed. M&I consumable return flows can be reused through several methods. Three general types of reuse projects were included for consideration in the SWSI process: water rights exchanges, non-potable reuse and indirect potable reuse.

8.2.5.1 M&I Reuse by Water Rights Exchanges

M&I reuse by water rights exchanges involves the exchange of legally reusable return flows for water diverted at a different location. Water is diverted at one source in exchange for water replaced to downstream users from a different source. In an M&I reuse exchange, the amount of non-CU water returned to the system, e.g., via effluent flows and/or return flows from landscape irrigation, depends on the CU associated with the demand (i.e., the higher the CU, the lower the percent of total diversions that can be reused).

The non-CU water can be reused multiple times, theoretically to extinction, with the total available water reduced with each application, since each time the water is diverted for reuse, a portion of it is consumed by the use. Increases in yield that can be achieved through the successive use and reuse of the return flows to extinction. For example, if there are no return flows from the use of 1 AF of consumable water, then there is no additional yield and the total yield is one acre-foot. If 50 percent of the return flows from an M&I use of consumable water were exchanged and the return flows from each successive use used to extinction, the total yield realized from 1 AF of consumable water is 1.6 AF. This is based on an assumed M&I CU of 35 percent and return flows of 65 percent.

8.2.5.2 Non-potable Reuse

Non-potable reuse involves the capture and use of legally reusable return flows for the irrigation of urban landscapes or for industrial uses such as cooling or process water. Since return flows from landscape irrigation are hard to capture in one location, non-potable reuse to date has involved the reuse of consumable effluent discharged from wastewater treatment facilities.

The effluent undergoes additional treatment to meet non-potable reuse standards. This treatment usually involves filtration and additional disinfection. As noted, it is infeasible to capture return flows from landscape irrigation, though additional yield could be achieved if the landscape irrigation return flow points and amounts are identified and exchanged to upstream points.

8.2.5.3 Indirect Potable Reuse

Indirect potable reuse involves the capture of legally reusable return flows and reintroduction of these captured flows into the municipal raw water supply. The return flows that are captured may have been discharged to a river or stream and mixed with other waters. Other options include the capture of treated wastewater effluent and additional treatment. The captured flows are then reintroduced into the M&I raw water supply system. The water may require advanced water treatment methods beyond the existing level of treatment used for the current water supply before the recaptured water was introduced into the raw water supply.

8.2.6 Control of Non-Native Phreatophytes

This option would consist of a basinwide or a focused-area program for the removal and control of non-native phreatophytes that consume water that could otherwise be used by any of the basin users: agricultural, M&I, recreational, or environmental. Non-native phreatophytes are invasive plant species that consume water. Of particular concern in Colorado are tamarisk trees. Methods of removal include: mechanical removal, prescribed burning, biological control, and herbicide application. While state and federal programs are beginning to evaluate phreatophyte control options in more depth, the costs and benefits (e.g., yields) of phreatophyte control programs are largely

unknown at this time. Demonstration projects are planned in the Rio Grande and Arkansas Basins, and USGS is updating estimates of potential water savings.

SECTION 10—BASIN-SPECIFIC OPTIONS

Section 6 of this report presented the future water supply options that water providers are pursuing to meet their needs. SWSI has termed these options "Identified Projects and Processes" and it is estimated, under a best case scenario, that approximately 80 percent of

Colorado's future needs can be met by implementation of these options. However, that leaves a remaining gap of 20 percent (118,200 AF). In addition, if some portion of the Identified Projects and Processes are not successfully implemented, it may be prudent to have some conceptual solutions that could be pursued. The types of options available were described in Section 8. This section outlines some of the basin-specific options, which when combined are termed Alternatives, that could help address unmet future water supply needs.

10.1 Overview of Basin-Specific Issues

In each of the eight river basins, various key activities related to water supply planning and basin specific issues were identified during the SWSI process and Basin Roundtable Technical Meetings. This section summarizes the basin specific activities and issues related to water planning and water resource management and environmental and recreational options. In addition, existing conditional storage rights and restricted reservoir sites in each basin were identified and discussed during the process and are also summarized.

10.1.1 Conditional Storage Rights

Consistent with SWSI's objective of identifying various water management possibilities, the concepts of enhancing water supplies throughout Colorado by perfecting conditional storage rights and rehabilitating existing reservoirs were explored. A conditional water right is not an absolute water right, and therefore has not been put to beneficial use. A conditional storage right must have two elements in order to exist. First, there must be an intent, and secondly, an act. An intent is a plan that includes diligently proceeding with actions until eventually the full beneficial use of the water is realized. An act could be as simple as staking the location of the structure. Cities are given more flexibility in this process, having only to show expected requirements based on validated growth projections. However, because some conditional storage rights holders have priority dates senior to existing absolute junior rights, if they fully exercise their rights, junior water rights holders would be affected. Conditional storage rights can therefore play an important role in the development of the state's water resources if they were to be fully implemented. Conditional storage rights are discussed in more detail under each basin.

10.1.2 Restricted Reservoirs and Potential New Storage Sites

Periodically, the SEO compiles a list of dams that are on restrictions throughout the state. This list, current as of August 2004 in this report, describes the various reservoirs in the state that are in severe disrepair, have inadequate spillways, spillway erosion, or other structural defects. These facilities have restricted storage levels less than the normal operating capacity. If these reservoirs were to be rehabilitated and storage restrictions removed, additional water could be stored and

available to meet increased demands. In addition to perfecting conditional storage rights and rehabilitating restricted reservoir sites, hundreds of potential reservoir sites that exist throughout the state could also aid in water supply planning efforts. After passage of a 1986 House Bill, the CWCB began compiling an inventory of these potential damsites, as well as maintaining and updating it periodically. A minimum potential storage volume of 20,000 AF or more was selected when developing the inventory. A review of the State Engineer's water rights tabulation, publicly available literature, and input from consulting engineers, Division Engineers, and various Water Conservancy Districts were used to compose the list. Included in the inventory is a review of the State Engineer's Reservoir Water Rights Tabulations, which identified sites with conditional decrees equal to or greater than 5,000 AF.

10.1.9 South Platte Basin

10.1.9.1 South Platte Basin Gap Analysis Issues

As presented in Section 6, the gap analysis process presented at the Basin Roundtable Technical Meetings provided information on the Identified Projects and Processes that M&I water providers are reasonably confident of implementing to meet 2030 water demands. Key activities related to water supply planning and basin specific issues raised throughout the meetings and SWSI process with respect to M&I and SSI demands in the South Platte Basin include the following:

- The South Platte is a diverse and heavily urbanized basin. Agriculture is still the dominant water use but rapid changes are occurring and the impacts to rural communities are a key concern.
- Turf based recreation (soccer, baseball, golf, football), parks, and urban landscape is very important to the economy and an important component to quality of life.
- Many of the major surface water providers believe they will be able to meet 2030 needs through existing supplies, projects underway, and future plans and projects.
- New storage and enlargement of existing reservoirs will be major components in meeting 2030 demands.
- Approximately 2 to 3 AF of storage is needed to carry over agricultural water rights transferred for use by M&I users in the non-irrigation season and for below-average runoff years.
- Reuse is being pursued by most providers that have reusable supplies through implementation of the following:
  - Water rights exchanges.
  - Non-potable use for irrigation of parks and golf courses.
  - Groundwater recharge.
  - Gravel lake storage for storing reusable return flows for later use for exchange or non potable irrigation.

- Water conservation is a part of most water providers' plans to meet future water supply needs.
- Most providers do not foresee or propose to implement extreme (Level 5) conservation due to concerns over:
  - Water demand hardening and the related impact on reliability of supply during droughts.
  - Quality of life impacts as a result of financial impacts and/or reduced landscaping.
  - Customer acceptance of very high water rates or the inability to landscape as they desire.
  - Lawn watering is a source of water supply and can be used during periods of drought by restricting water use.
- Most providers indicated they would acquire additional agricultural rights to meet future demands rather than implement extreme levels of conservation that would have adverse impacts on their customers.
- Water reuse and conservation will put added pressure on agriculture as return flows diminish.
- Return flows from M&I lawn watering are used to maintain historical agricultural return flow requirements from transferred agricultural rights. Reducing these return lawns through water conservation may result in the need for the M&I provider to acquire other sources of water to maintain the required return flows.
- Competition for water is fierce and it is unclear how much competition there is for the same water supplies.
- The lack of any new major water storage in the last 20 years has led to the use of non-renewable groundwater in Douglas, Arapahoe, and northern El Paso Counties (El Paso County is in the Arkansas Basin). Explosive growth in these counties coupled with the lack of surface water supplies led to the creation of multiple small water districts and makes coordinated water development a challenge and less efficient, especially in light of limited renewable surface water supplies.

Agricultural issues noted throughout SWSI in the South Platte Basin include:

- There are average annual shortages throughout the basin.
- The continued pressure on the transfer of Colorado Big Thompson units from agriculture to M&I will further increase shortages as CBT water is a supplemental agricultural supply.
- The Lower South Platte groundwater users need alternatives for developing augmentation supplies for irrigation wells. Over 60,000 acres of currently irrigated lands may no longer be irrigated due to recent well augmentation requirements.

10.1.9.2 South Platte Basin Supply Availability Issues

In the South Platte Basin, the following issues were identified regarding supply availability:

- The South Platte River Compact allows further development of available flows.
- The success of an endangered species program is critical to help protect current and future uses.
- By 2030, there will be full utilization of:
  - Existing rights.
  - Transbasin diversions.
- RICDs and CWCB instream flow water rights may impact the ability to manage water supplies upstream of these water rights.
- Development of conditional water rights will continue.
- Groundwater recharge projects will expand.
- Agricultural efficiency, especially conversion to sprinklers, is reducing return flows. Changes in irrigation efficiency will affect return flow patterns.
- Normal agricultural calls may become more senior, resulting in an increase in the number of junior water rights that are out of priority. Factors contributing to this include:
  - Development of gravel lake storage to capture M&I return flows.
  - Increased reuse of M&I return flows.
  - Increased irrigation efficiencies.
- Winter calls can be expected to increase, reducing free river periods. Increased winter calls may reduce the timeframe in which recharge can take place.
- Water supply estimates in the South Platte Basin are reconnaissance level. A DSS is not available to analyze all of the potential interactions of M&I development of conditional storage rights and reduced return flows as described above.

10.1.9.3 South Platte Basin Summary of Conditional Storage Rights

To portray the conditional storage rights present in the South Platte Basin, the area was described using water districts as shown in Figure 10-24. The 15 water districts in the South Platte Basin can also be described using the main stream systems, which are shown in Table 10-19.

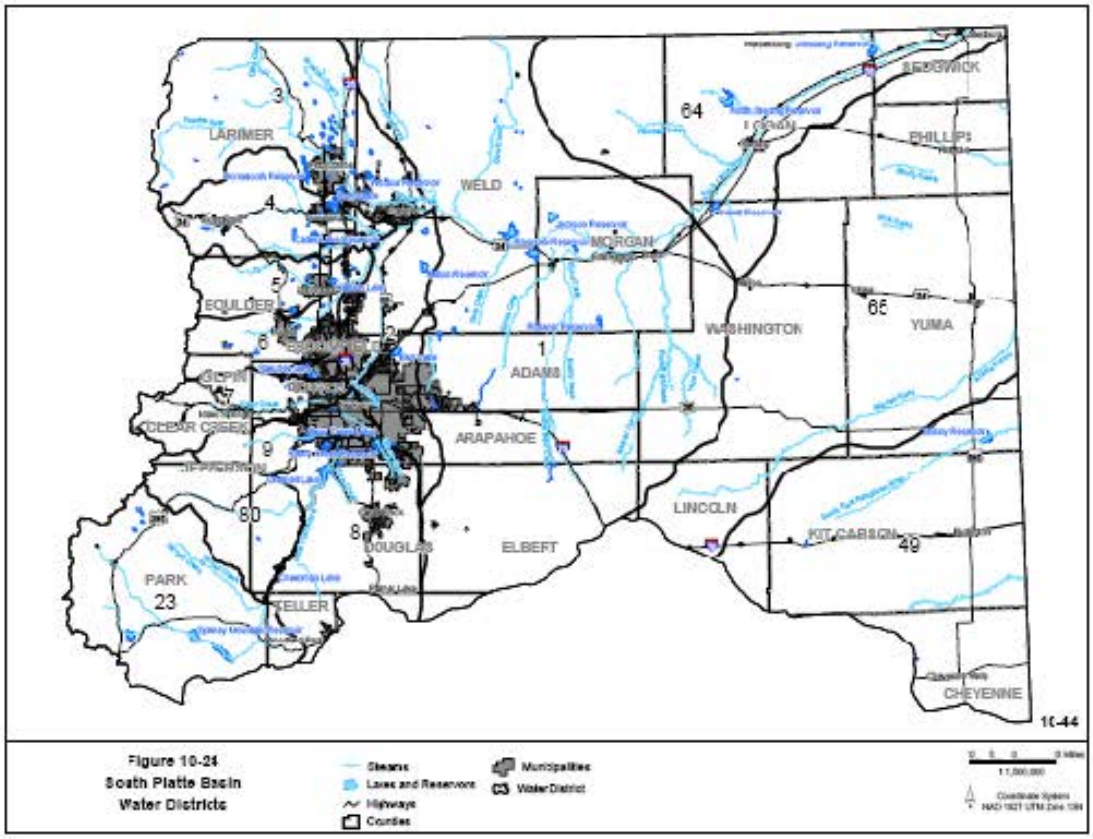


Table 10-19 South Platte Basin Water Districts and Associated Stream Names

Water District	Stream Name
1	Lost/Kiowa/Bijou/Crow Creeks and S. Platte River
2	S. Platte River
3	Poudre River
4	Big/Little Thompson Rivers
5	St. Vrain Creek
6	Boulder Creek
7	Clear Creek
8	S. Platte River
9	Bear Creek
23	Middle Fork S. Platte River
49	S. Fork Republican River
64	S. Platte River
65	Arikaree River
80	N. Fork S. Platte River
101	S. Platte River

Various water districts in the South Platte Basin contain conditional storage rights that date back to the early 1900s and extend to present day. As shown in Table 10-20 there are 3.6 million AF of conditional storage rights in the basin. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation. Water District 1, followed by District 8 in the South Platte Basin, has the largest volume of conditional storage rights. This is depicted in Table 10-20. Water District 1 has almost 1.4 million AF of conditional storage rights and Water District 8 has nearly 638,000 AF. The most recent priority time period of between 1980 and 2002 has the largest amount of conditional storage rights in the South Platte, about 1.8 million AF, which far exceeds available supplies. The 1960 to 1980 period follows with a total of approximately 892,000 AF. A map of the locations of the conditional storage rights in the South Platte Basin is shown in Figure 10-26. Different colored circles are used to represent the total volume of conditional rights that each location holds. Most of the rights are held in the western portion of the basin and along Interstate 76. This figure also shows the locations of potential damsites in the South Platte Basin, as discussed in Section 10.1.9.4 below. In the South Platte Basin, many M&I providers have reservoir enlargement plans that will help them grow into existing rights and allow development of some existing conditional water rights.

Table 10-20 Volume of Conditional Storage Rights by Priority (AF) in the South Platte Basin

Water District	Stream Name	1900-1920	1920-1940	1940-1960	1960-1980	1980-2002	Total
1	Lost/Kiowa/Bijou/Crow Creeks and S. Platte River	250,012	6,358	0	413,368	719,406	1,389,144
2	S. Platte River	1,596	20,965	0	16,682	78,055	117,298
3	Poudre River	0	0	29,472	5,184	384,397	419,053
4	Big/Little Thompson Rivers	0	19,926	0	1,703	21,421	43,050
5	St. Vrain Creek	1,677	0	13,594	71,649	170,871	257,791
6	Boulder Creek	4,978	4,755	83,870	34,985	22,917	151,505
7	Clear Creek	18,345	0	180	18,774	175,154	212,453
8	S. Platte River	0	336,368	20	220,620	80,921	637,929
9	Bear Creek	1,834	36	0	5,006	7,915	14,791
23	Middle Fork S. Platte River	327	111,423	0	74,306	133,578	319,634
49	S. Fork Republican River	0	0	0	75	0	75
64	S. Platte River	0	0	0	14,301	8,839	23,140
65	Arikaree River	0	0	0	0	330	330
80	N. Fork S. Platte River	0	1,938	0	15,052	17	17,007
Total		278,769	501,769	127,136	891,705	1,803,821	3,603,200

10.1.9.4 South Platte Basin Summary of Restricted Reservoirs and Potential Storage Sites

The total volume of restricted storage in the basin is 48,929 AF. Eighteen restricted reservoirs are located within Water District 1, totaling about 25,000 AF of lost storage, and two reservoirs are located in Water District 64 with slightly less than 10,000 AF of lost storage. More than 7,000 AF of storage is lost in the seven restricted reservoirs in Water District 23. Given the limited water supply availability in the South Platte Basin, recovery of storage lost to restrictions should be explored in more detail. While the other water districts in the South Platte Basin have restricted damsites, except Districts 49, 80, and 101, each district has less than 5,000 AF of potential storage if repairs were made. Figure 10-26 shows the locations of potential damsites identified by the CWCB in the South Platte Basin, along with the conditional storage rights locations. Different colored circles are used to

represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage.

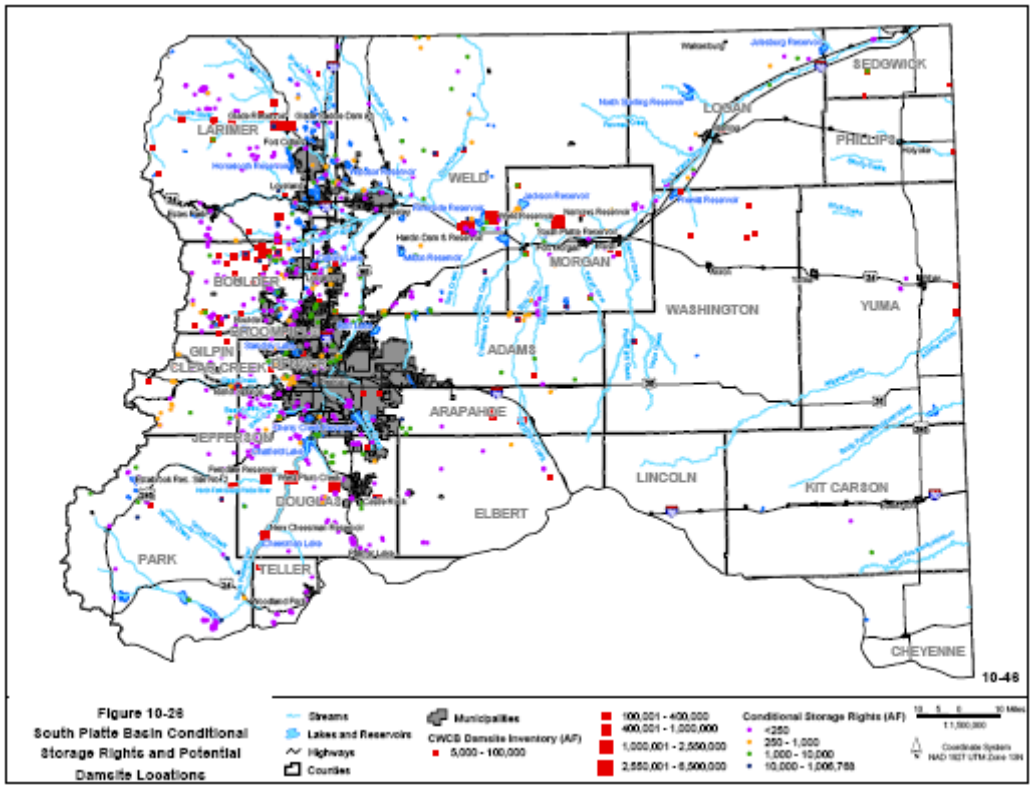


Figure 10-28
South Platte Basin Conditional Storage Rights and Potential Damsite Locations

10.3.7 South Platte Basin

Water needs in the South Platte Basin were identified and characterized in Section 6. While about 78 percent of the basin's increased M&I needs could be met by the Identified Projects and Processes described in that section (if all of the Identified Projects and Processes are fully successful), the remaining gap for M&I, agricultural, environmental, and recreational needs will need to be addressed by additional water management solutions. As discussed in Section 6, the size of the gap will depend on the degree of uncertainty and successful implementation of the Identified Projects and Processes.

A list of projects or water management options for further consideration in meeting the basin's future water needs is presented in Table 10-32. This list was developed and refined through the series of four Basin Roundtable Technical Meetings held in the South Platte Basin, augmented by additional input from the Basin Advisors, Basin Roundtable members, and individual entities throughout the basin. This list represents a broad range of options, both in terms of the types of solutions and their degree of development. In many cases, the options are at a conceptual stage of development and therefore have relatively little information available about their storage size, yield, or other characteristics. In other cases, a concept for meeting needs in more than one location in the basin was identified – such as the generalized items termed "control of non-native phreatophytes." However, each option listed was brought forth in SWSI as a potential means toward meeting future water needs in the basin. In most cases, additional studies or information would be needed to advance these water management options toward implementation. Given the diversity of the South

Platte Basin, the types of water management solutions proposed can be expected to follow the land use patterns in the basin. For example, agricultural solutions will be focused largely on the agricultural lands in the Lower Platte and Northern subbasins, while M&I solutions will focus more intensively on the higher-population areas of the Front Range (Northern, Denver Metro, and South Metro subbasins).

Table 10-32 Potential Future South Platte Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
Standley Lake Enlargement	City of Northglenn	Additional Storage	up to 18,000	up to 6,000	Purpose is to firm the water supply for M&I users. Northglenn has an existing gap that could be addressed through additional storage. Other parties may participate; Yield varies depending upon participants
Tamarack Plan	State of Colorado	Groundwater Recharge and Conjunctive Use	Not Available	10,000	Managed groundwater recharge projects to reregulate flows in a manner that is consistent with the flow-related goals of the Platte River Recovery Implementation Program.
Julesburg Enlargement	CWCB	Additional Storage	15,000	7,800	Addresses lower basin agricultural needs.
Johnson Reservoir	CWCB	Additional Storage	10,600	7,800	Addresses lower basin agricultural needs.
Harmony Ditch West	CWCB	Additional Storage	10,000	6,000	Addresses lower basin agricultural needs.
Groundwater Storage / Alluvial Storage	None	Conjunctive Use of Groundwater	Not Applicable	Not Available	Ongoing programs, new projects anticipated. Could benefit all users and M&I, agricultural, environmental, and recreational.
Flow Control Program between Reservoirs	None	Re-operations	Not Applicable	Not Available	Provide for management of flows between reservoirs for recreational and environmental uses without impact yields to M&I and agricultural users.
Control of Non-Native Phreatophytes	None	Control of non-native phreatophytes	Not Applicable	Not Available	—
Reallocation of Storage in Chatfield Reservoir	Numerous Parties	Reallocation of flood control storage.	20,000	Not Available	Reallocation of flood control storage to allow storage for M&I purposes. Flow management in the South Platte through Denver.
Pawnee Creek Project/Storage Site	None	Additional Storage	Not Available	Not Available	Address agricultural shortages in Lower Platte.
South Metro Water Supply Project	South Metro Water Providers	Storage and non-tributary groundwater conjunctive use		$2-4 billion	Development of new storage to capture South Platte and West Slope water and conjunctive use with non-tributary groundwater.

Specifically, the need to develop additional water management solutions in the South Platte Basin for M&I demands is based on the following:

- Potential for failure of the Identified Projects and Processes to address in-basin needs
- Some future growth areas do not have identified water planning processes
- Limitations in the reliability and sustainability of non-tributary groundwater
- Limitations in the ability to reliably store water under junior water right appropriations
- Competition for the same supplies
- Potential for greater than projected growth

- The success of the proposed Endangered Species Program.
- The potential "domino effect" of increased M&I reuse of consumable supplies, resulting in reduced downstream flows and more senior calls
- Potential impacts of climate change

Based on discussion with the South Platte Basin Roundtable members and the evaluation of options, the following types of options generally meet the objectives of the South Platte Basin Roundtable members and could be further evaluated for their role in addressing the remaining M&I gap in the South Platte Basin:

- Construct new storage to maximize existing water rights and conditional storage rights
- Reservoir enlargements to maximize existing water rights and conditional storage rights
- Additional conservation, possibly coupled with additional storage to enhance reliability
- Rotating Agricultural Transfers
- Agricultural conservation (efficiency improvements) while recognizing the potential negative effects on return flows. Specific options identified through the Basin Roundtable process were cataloged in Table 10-32.

Agricultural water solutions could address the following concerns:

- Recharge plans may be limited in future
- Need for additional storage to "firm up" agricultural water supplies and/or to "firm up" augmentation water
- Increased river calls in the lower river due to reduced return flows and M&I reuse, which will impact both municipal water providers and agriculture
- Potential impacts of climate change

Irrigated agricultural acreage in the South Platte Basin is expected to decline significantly over the course of the next 30 years. Development of irrigated lands, transfer to M&I use, and the inability to augment well pumping will all contribute to this decline. Meeting the South Platte Basin's future agricultural needs will focus primarily on meeting existing needs and firming supplies available to existing agricultural users rather than expanding irrigated acreage. Water management solutions that could be used to support these goals include:

- Construct new storage
- Reservoir enlargements or dredging of existing reservoirs
- Removal of storage restrictions

- Additional development of alluvial aquifer recharge projects
- Improvements in agricultural efficiency, using caution to avoid impacts on downstream users of return flows
- Agricultural purchase of more senior water rights to reduce river calls or provide for well augmentation
- Development of a single entity to coordinate proposed augmentation activities and for the agricultural wells, to maximize the yield of the augmentation plans

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, and restore"). Specific water management solutions discussed through the Basin Roundtable process toward achieving environmental and recreational goals are presented below.

- Tarryall Reservoir Enlargement—CDOW-proposed options to use the additional storage in potential exchange agreements with other entities such as Aurora, Denver, and Centennial. Cheesman and Strontia Springs Reservoirs could enhance sport fishery of Tarryall Creek and South Platte River and wetland development in South Park. CDOW identified this as a high-priority project, but it currently is in the conceptual stages of development.
- Montgomery Reservoir Enlargement—A second CDOW-proposed option involves storing transbasin water rights from the Blue River or South Platte River to improve stream flows and enhance sport fishery in the Middle Fork and mainstem of the South Platte River. Considered a medium priority by CDOW, it is currently in the conceptual stages of development.
- Tamarack Project—This ongoing project is geared toward enhancing native and threatened and endangered species habitats in Colorado and Nebraska by creating pump back recharge river credits and timed flow augmentation. It is an important component of the Three State Agreement between Colorado, Nebraska, and Wyoming, and the DOI, and is considered a high priority by CDOW for ongoing implementation.

SWSI participants also suggested that in any water management action, project sponsors and participants should seek to identify opportunities to return to more natural hydrologic flow patterns in the basin. An example of voluntary efforts to improve flows for environmental purposes is the Upper South Platte River Flow Management Agreement.

SOUTH METRO WATER SUPPLY STUDY

Purpose of the Study

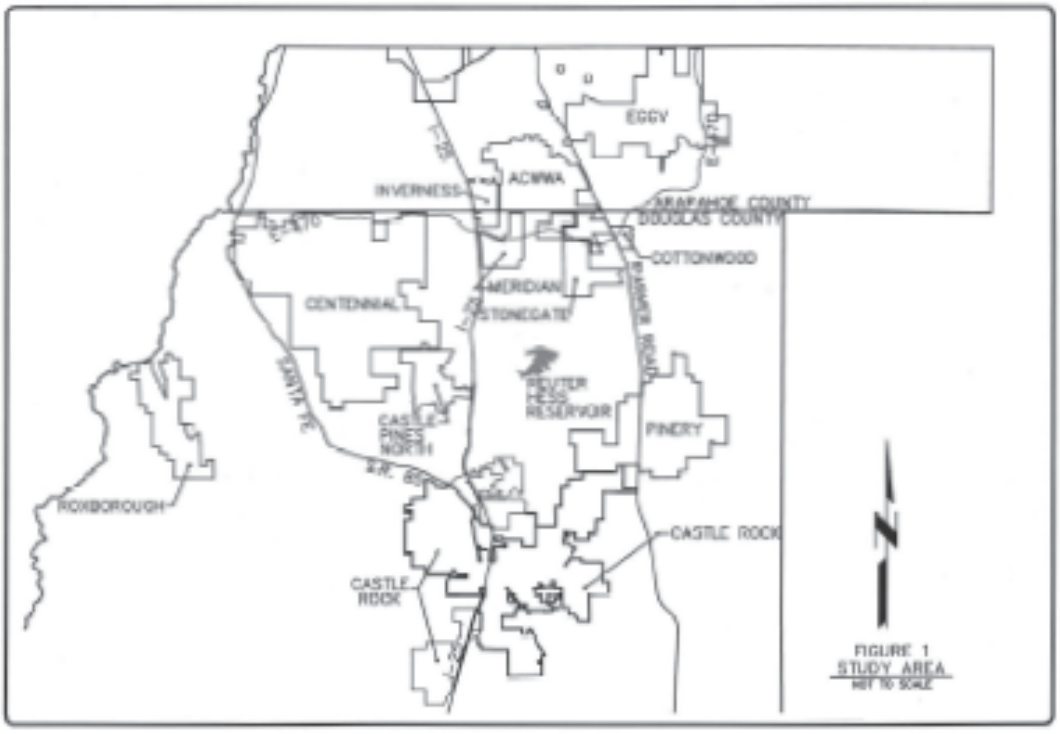
The purpose of this study was to investigate water supply alternatives for the South Metro area through the year 2050.

Currently, the South Metro area's primary source of water supply is the Denver Basin Aquifers, a large ground water reserve underneath the land within the area's boundaries. The question driving this study is whether this water supply source can adequately meet the long term demands of the existing population as well as the demands associated with continued population growth.

Additionally, the study investigates whether there are benefits to using surface supplies from the South Platte and Blue River during wet years, along with ground water. This concept, called "conjunctive use," would help preserve ground water supplies by making use of renewable surface water in years when it is plentiful.

The Study Area

The Study Area includes the service areas of the water providers located in the north half of Douglas County. This area includes the Town of Castle Rock north to the Douglas/Arapahoe County boundary, with the exception of most of the Town of Parker. In addition, much of the urbanized portion of Arapahoe County, located east of I-25, is included. The Study Area is shown in Figure 1.



Population

The challenging water situation in the South Metro Study Area is fueled by extremely rapid population growth during the last 25 years and projected rapid growth in the future. During the 1990's, Douglas County had the nation's fastest growth rate. Between 1990 and 2000, population jumped by 191%. Douglas County growth continues at a similar rate today.

In addition, the Arapahoe County portion of the Study Area includes the rapid growth area of the city of Centennial. The growth rate in this portion of Arapahoe County has been similar to that of Douglas County.

The current and estimated population of the Study Area is shown in Table 1. While the study period extends to year 2050, full development occurs by year 2040.

Table 1
Study Area Population Projections

Year 2000	Year 2020	Year 2040
179,000	359,000	406,000

Water Supply Sources

Water supplies for the Study Area were largely developed during the last 25 years, long after the best sources of surface water from the South Platte River and its tributaries were claimed. While the Study Area has limited surface water from Cherry Creek, Plum Creek and the South Platte River, this water represents only about 25% of the water needed for the area in 2050.

The largest source of available water in the Study Area is deep ground water in the Denver Basin. While this is currently a plentiful source of water, in the future it will be much more difficult and costly to produce at the rates required to serve urban areas. Moreover, the amount of water naturally recharging the deep ground water is very small compared to the water being pumped. Therefore, the volume of water in the aquifer is slowly being depleted. Due to concerns about the long-term viability of the deep ground water, water providers in the South Metro area have taken measures to preserve the deep ground water whenever possible, including pursuing renewable surface water supplies when available.

In general, these water providers have maximized the use of surface water, adopted programs of water conservation, and developed a significant amount of reusable water -- either through augmentation (diverting water in exchange for water returned to the stream) or through non-potable irrigation (water not suitable for drinking). Still, the South Metro area remains heavily reliant upon deep nontributary ground water (water not connected to the surface stream).

Water Demand

The current and future water demands for the Study Area are shown in Table 2. Full development of the area is expected to occur by 2040. These projections are based upon the historical water use of each of the water providers in the study and include residential and commercial uses and system losses, forming the basis for the analysis in this report.

Table 2
Study Area Water Demand Projections (Acre-feet)

Year 2000	Year 2020	Year 2040
42,323	81,732	92,213

Alternatives

All of the water providers in the South Metro area currently have water conservation and reuse (recycling of water) programs in place. However, the water providers recognize that more aggressive water conservation and reuse will be needed in the future. Each alternative described below assumes a 15% reduction in outdoor water use, along with expanded reuse wherever practical.

Alternative 1A - Status Quo.

This alternative investigates the possibility of meeting most of the Study Area's future demand by drilling additional wells in the Denver Basin Aquifers and increasing the area's dependence on deep ground water. It identifies the facilities that will be required and examines the costs of producing additional deep ground water supplies. Today, summer peak season demands are met by pumping the deep ground water at high rates. Alternative 1A assumes that peak demands will continue to be met in this manner.

This alternative assumes that water providers will use their existing water rights in the Denver Basin Aquifers. It further assumes that if these water rights are not sufficient to meet demand, more-deep ground water will be purchased from nearby locations. Alternative 1A also looks at the infrastructure required to produce and deliver the deep ground water to customers (e.g., wells, treatment facilities and delivery pipelines). In cases where deep ground water would need to be purchased from locations outside the service area, well development and the transmission system required to deliver that water to the water provider's system is identified.

Alternative 1B - Status Quo with Storage for Peaking.

Alternative 1B is identical to Alternative 1A except in the method for meeting peak demands. In Alternative 1B, instead of using wells to meet demands during very high summer peak periods (as in Alternative 1A), deep ground water would be pumped on a year-round basis at a much lower rate. During the winter, when the water pumped would be greater than customer demand, the excess would be pumped to new storage reservoirs. In the summer months, when customer demand exceeds the volume of water pumped, water would be withdrawn from storage to meet demand.

Alternative 1B would require far fewer wells than 1A, but storage reservoirs would be needed. In addition, water stored in open reservoirs would require water treatment before being used in the water system. This alternative considers these changes in infrastructure requirements, as well as the associated costs.

Alternative 2 - Non-Tributary Ground Water with Maximum Reuse.

Alternative 2 is a variation of Alternative 1B that assumes all available water that is legally reusable would be reused to extinction regardless of costs and other issues. In Alternatives 1A and 1B, some of the reusable water supplies in the East Cherry Creek Valley Water and Sanitation District, the Town of Castle Rock, the Meridian Metropolitan District and the Roxborough Park Metropolitan District were assumed not to be fully developed.

While Alternative 2 produces a number of additional water reuse opportunities, institutional constraints -- including existing contracts -- may preclude some of these opportunities from being realized.

Alternative 3A - Conjunctive Use with Borrowing from Denver Water Storage.

Alternatives 1A, 1B, and 2 provide strategies to meet demands for the South Metro area without the import of surface water supplies. The "conjunctive use" alternatives, 3A and 3B, examine whether deep ground water can be effectively used conjunctively with surface supplies from the South Platte and Blue River. Conjunctive use alternatives would preserve ground water supplies by making use of renewable surface water in years that it is plentiful.

Since the conjunctive use alternatives, 3A and 3B, each rely on meeting demand with local water supplies alone in dry years, all of the infrastructure of either Alternative 1A, 1B, or 2 needs to be included as part of Alternatives 3A and 3B, except that the number of additional wells under Alternatives 3A and 3B would be fewer because of lower average ground water pumping.

Alternative 3A is a regional approach to water supply development. Water would be imported from the South Platte River and Blue River in wet years - when surface supplies are plentiful - through Denver Water's existing raw water system to the west side of the South Metro area. This water would then be delivered to South Metro water providers through a new pipeline distribution system. Alternative 3A would require limited use of Denver Water's storage capabilities to increase the volume of surface water captured.

In dry years, South Metro water providers would continue to use their existing sources of supply without diverting any water from Denver Water's raw water system. In wet years, water would be borrowed from Denver Water's surface water reservoirs prior to runoff (during the late winter and early spring months) for delivery to Douglas County. This would take place at a time when there normally would not be any water available to a junior water right. The timing and amount of reservoir releases would be based upon two things: 1) Snow pack accumulations during the late winter and early spring; and 2) Denver Water's reservoir levels.

The effect of Alternative 3A would be to lower water levels in the Cheesman and Dillon reservoirs during the late winter and early spring, thereby increasing the potential to capture additional water at these locations during high runoff periods. In years with sufficient above average runoff, water would continue to be delivered to Douglas County via direct diversions under a junior water right at the same time that Denver's reservoirs would be filling. Assuming Denver Water's reservoirs fill sufficiently, the borrowed water could be used by the South Metro water providers without payback of water to Denver Water.

Because wet years cannot be predicted with certainty, however, there would be years where this water "borrowing" would result in draw-downs to Denver Water's reservoirs that would not refill from late spring runoff. In these cases, the borrowed water would have to be paid back to Denver Water. While the water would need to be paid back in the same year, the payback could potentially be delayed until the fall and winter. Payback water would be the same water that was "borrowed" and stored in new South Metro storage reservoirs.

Denver Water's surface water model, PACSM, was used to simulate the delivery of surface water to Douglas County in Alternative 3A. In this model, the water rights used for Douglas County's benefit were assumed junior to those of Denver Water and other major metropolitan water supply systems (e.g. Aurora, Thornton, Englewood, etc.), as well as those of Grand and Summit Counties. This means that this new water right would not impact any other entities' water rights on these rivers.

Alternative 3A assumes 39,000 acre-feet of new reservoir storage would be developed in the South Metro Area to store water borrowed from Denver Water. Also, new raw water pipelines, pumping stations and water treatment facilities would be constructed so that treated water could be distributed to the individual water providers' systems.

Alternative 3B - Conjunctive Use with Free River Water.

Alternative 3B is very similar to Alternative 3A except that water from the upper South Platte and Blue River is diverted directly without using existing Denver Water storage facilities.

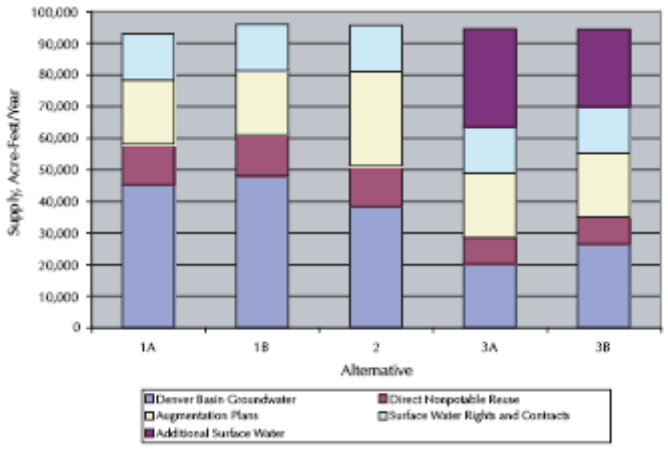
Under this "free river only" scenario, water would be diverted from the South Platte and/or Blue River and would be transported to the South Metro area in the same manner as in Alternative 3A. Normally water would only be available for diversion during periods of relatively high river flows, typically in May and June. Under Alternative 3B, diverted water could be used to directly meet the water demands of Douglas County providers, stored in surface reservoirs, or used to recharge the Denver Basin Aquifers. In general, the infrastructure required in Alternative 3B is the same as Alternative 3A.

Key Findings

Water Supply Comparisons for 2050

The water management model was run for each alternative. The model created a water supply management plan for the individual water providers and for the study area as a whole. The results of the modeling for the area as a whole in 2050 are presented for each alternative in Figure 2 below. These results show the volume of water to be used from each available water supply source. Of particular interest is the volume of ground water pumping required.

Figure 2
Comparison of 2050 Results



The chart above illustrates that the annual volume of ground water pumped is highest in Alternatives 1A and 1B and decreases substantially in Alternatives 2, 3A and 3B. In Alternative 2,

the reduction in ground water use is due to increased reuse of approximately 9,400 acre-feet. This is the maximum amount of reuse that can be achieved. Realistically, it will be less than this projection.

In Alternative 3A, the reduced ground water pumping is due to gross water deliveries from the South Platte and Blue River that would average about 36,000 acre-feet per year, with payback to Denver Water averaging about 10,000 acre-feet per year. Thus, this "free river with borrowing" scenario would produce an average net yield (deliveries minus payback) of approximately 26,000 acre-feet per year. Of this amount, approximately 15,000 acre-feet per year would come from the Blue River and approximately 11,000 acre-feet per year would come from the South Platte River. However, there would be extended dry periods (four years or longer) when there would be little or no surface water available from the South Platte or Blue River under this scenario.

In comparison, Alternative 3B, the free river only scenario, would reduce ground water pumping by producing an average net yield of approximately 19,000 acre-feet per year from the South Platte and Blue River, with about half coming from each. There would be no payback to Denver Water in this scenario.

These results show that ground water pumping can be greatly reduced under Alternatives 2, 3A, and 3B. However, the reduced levels of ground water pumping under Alternative 2 are probably unrealistic due to overly optimistic maximum reuse projections.

Aquifer Water Levels and Pumping Rates Over the Study Period

An important goal in evaluating the Denver Basin Aquifers as a source of water supply for the South Metro area was to understand the viability of the supply on a long term basis. The study found that the key issue today is not the draining of the resource, but instead exceeding the reasonable and prudent production capability of the aquifer system.

The study shows that in urbanized areas, even though the volume of appropriated water may be sufficient to meet demands, the water supply cannot be produced at the appropriated volume without large drawdowns in the aquifer water levels. In the future, these large drawdowns will reduce well production drastically and make production difficult and costly.

Even with expanded conservation and reuse by water providers, the study found that the projected pumping volume will dissipate the artesian pressure from the Denver Basin Aquifers to a large extent over the next 10 to 20 years. This artesian pressure has greatly aided well production in the past since the ability to pump water is directly proportional to pressure. While the water associated with the artesian pressure is a small percentage of the total water volume in the aquifer, the loss in artesian pressure represents a large percentage of the pressure available to obtain water from the aquifers. As such, the problem with continued pumping of the Denver Basin Aquifers is much more related to a significant drop in the rate of well production (the gallons per minute of withdrawal) as opposed to the diminishment of total water stored in the aquifers.

The results of the local well analysis also indicate that the lowering of regional ground water levels is severely compounded by the well-to-well interference that will occur if these aquifers are pumped at the projected rates. The analysis found well-to-well interference can further lower pumping water levels by more than 100 feet.

As regional water levels drop to near the top of the aquifer, the additional drop in ground water levels caused by well-to-well interference will result in a dramatic loss in well production. In 2003, the maximum Arapahoe aquifer pumping rates in the South Metro Area generally ranged from 500 to 600 gpm. The study found that in Alternative 1A the pumping rate will drop in a typical well to 300 gpm by 2010, and to 80 gpm by 2050. The resulting loss in production is somewhat less for other aquifers, however, other aquifers start with much lower production rates than the Arapahoe Aquifer.

Of particular significance is that by the year 2050, a well producing a maximum of 100 gpm in any aquifer will be considered successful in terms of production. But wells producing only 100 gpm are extremely uneconomical and the cost for the number of wells required to meet demand in that scenario will be considerable.

Table 3 shows the total number of additional wells required by alternative and aquifer to meet demands by 2050. Well construction and infrastructure is very costly and these wells represent huge increases in required capital facilities costs.

Table 3
Total Number of Additional Wells By Alternative & Aquifer

Alternative 1A	57	210	954	143	1364
Alternative 1B	32	180	373	75	660
Alternative 2	28	173	115	65	381
Alternative 3A	30	38	146	84	298
Alternative 3B	30	69	140	78	317

Conclusions

The findings of this study indicate that continued reliance on the deep ground water aquifers to meet urban demands in the South Metro Area will result in very large increases in capital and production costs in the foreseeable future, and perhaps the eventual loss of ground water as an economically viable resource.

The study highlights the fact that expected declines in artesian pressure and ground water levels will seriously impact the provider's ability to efficiently produce deep ground water supplies. In every alternative, the artesian pressure will be depleted or reduced to a minimum over the next 20 years, thereby requiring ever-increasing numbers of additional wells to produce the same volume of water. The results of the infrastructure costing analysis show that ground water pumping to meet future demand will be extremely costly. Therefore, any effort to reduce ground water pumping will result in significant cost savings.

The bottom line: From a water management perspective, this study indicates that the South Metro Denver region could drastically reduce its future level of reliance on Denver Basin ground water by vigorously pursuing a combination of water conservation, augmentation and reuse, surface water development, storage, and aquifer recharge initiatives.

Alternative 1A (Status Quo) – This alternative, which relies most on increased ground water pumping, becomes increasingly expensive in the foreseeable future and may be economically unsustainable in the long-term.

Alternative 1B (Status Quo with Storage for Peaking) – This alternative reveals that reducing the number of wells saves significantly more than the cost increase associated with the construction of water storage and treatment.

Alternative 2 (Non-Tributary Ground Water with Maximum Reuse) – The reuse strategies in Alternative 2 should be fully pursued since, in all cases, the cost of developing reuse is less expensive than further development of ground water. To the extent this reuse can be achieved, this alternative becomes an enhancement to Alternatives 1B, 3A and 3B.

Alternative 3A (Conjunctive Use with Borrowing from Denver Water Storage) – This alternative results in surface water import of an average of 26,000 acre-feet per year during the study period, which amounts to about 1.1 million acre-feet less ground water usage than Alternative 1B over the study period.

Alternative 3A is estimated to cost about $300 million more than Alternative 1B including capital, operation and maintenance, and repair/rehabilitation costs.

Alternative 3B (Conjunctive Use with Free River Water) – This alternative is actually less expensive than Alternative 1B when considering all costs. It creates less new surface water yield than 3A, averaging 19,000 acre-feet per year, but the 19,000 acre-feet is gained with about the same capital cost and less total cost than any of the groundwater alternatives. This is because the savings achieved through reduced well pumping almost equals the cost of the infrastructure neccessary to import renewable water and operating costs are considerably less. This plan also avoids the need for a payback scenario to Denver Water and avoids environmental concerns associated with reduced water levels in Dillon and Cheesman Reservoirs.

3A and 3B Additional Cost Considerations – It is important to note two significant considerations in reviewing costs for Alternatives 3A and 3B:

First, Alternative 3A assumes the use of Denver's raw water storage and treatment facilities, and both Alternatives 3A and 3B assume the use of Denver Water's delivery systems to capture and convey flows to the South Metro area. Denver Water has not yet agreed to allow the use of these facilities. If Denver Water were to cooperate in such a plan, they would need to be compensated appropriately for the use of these facilities. While estimated compensation costs to Denver Water are included in these alternatives, at this point the exact compensation and the means of compensation have yet to be determined.

Second, Alternatives 3A and 3B assume additional surface water depletions from the Blue River and the South Platte River. Additional depletions will need to be mitigated, and the cost of mitigation is expected to be substantial. Therefore, the costs for Alternatives 3A and 3B are not complete, and are likely to be significantly higher than presented herein.

The conjunctive use alternatives present a prudent approach to water development. These plans include expanded conservation, high percentages of reuse, and a component of ground water production. The plans conjunctively use surface water and ground water to create a better balance of water supplies -- relying more on surface water in wet years and more on ground water in dry years.

Recommendations

Implement the measures aimed at reducing the volume and the rate of ground water withdrawals, including expanded conservation, maximum reuse, and the import of renewable surface water through a conjunctive use plan. This study indicates the cost of water conservation and water reuse in almost any form is economically beneficial to the South Metro water providers, individually and collectively.

Seek further information from Denver Water and the Colorado River Water Conservation District related to Alternative 3B. The eventual costs of Alternative 3B would include actual charges Denver Water might impose for use of its facilities, mitigation for West Slope impacts and other costs. These costs will need to be added to the currently identified costs for Alternative 3B, before this alternative can be truly compared to the 1B groundwater alternative. However, by 2050, Alternative 3B would reduce the draw on the aquifer system by an estimated 1 million acre-feet and provide an average of 19,000 acre-feet annually of renewable water yield to the South Metro Area. In addition, reuse opportunities could almost double the actual value of supply realized through the importation of this water. Further analysis of this alternative should seek to increase this yield since it would be fairly small for a project of this magnitude.

The other significant benefit of Alternative 3B is that the project could be phased in and partially implemented with minimal initial infrastructure. The water storage and delivery systems of Denver Water are already in place and deliveries of excess water in wet years could be made to a number of participating water providers. Centennial and Inverness already have connections to Denver Water that would allow for delivery of some water under this plan. In addition, with a very short pipeline connection, Denver Water could connect with East Cherry Creek Valley's existing pipeline along C-470 near Quebec Street, enabling water deliveries to ECCV, Meridian, Stonegate and Cottonwood through this pipeline.

However, before this phasing could occur, Denver Water and the Colorado River Water Conservation District have defined a need for a single entity from the South Metro Area to negotiate and implement a potential project. In addition, Denver Water has given no indication that it is amenable to phased implementation.

Alternative 3A should not be entirely eliminated from further consideration at this point. Instead, this plan should continue to be considered as further information is developed with Denver Water and the Colorado River Water Conservation District as part of these potential conjunctive use plans. Alternative 3A provides an additional 7,000 acre-feet of average annual water delivery beyond the 19,000 acre-feet of Alternative 3B. This additional yield would be very important to the South Metro Area.

Additional reuse strategies contained in Alternative 2 should be fully pursued and implemented where these additional reuse opportunities are deemed achievable. This additional reuse would reduce the total cost of water supply

and further maintain the viability of the ground water through an additional reduction in ground water withdrawals.

The decision to pursue a course of action must be made by the water providers as a unified group. The Boards of Directors of each District and the Town Council of Castle Rock will need to decide if they are willing to pursue a conjunctive use plan. These decision-makers also will need to consider a large near-term increase in tap and service fees necessary to fund any of these alternatives.

If the water providers as a group decide to pursue Alternative 3A or 3B, then discussions can be initiated with Denver Water to determine costs, appropriate compensation and other requirements regarding this alternative. At the same time, deliberations could begin with the Colorado River Water Conservation District regarding a study that would identify the impact of stream depletions and consider various mitigation plans that would properly compensate the area for additional surface water diversions.