Filling the Gap

Commonsense Solutions for Meeting Front Range Water Needs

> Building and improving on the State Water Supply Initiative 2010, this well-written report outlines a strategy for economically meeting Front Range municipal water demands to 2050 while protecting Front Range streamflows and avoiding further West Slope diversions.

—Chuck Howe,
Professor Emeritus of Economics,
University of Colorado, Boulder

This report is a collaborative effort by Western Resource Advocates (WRA), Trout Unlimited (TU), and the Colorado Environmental Coalition (CEC). Drew Beckwith (WRA) was the lead author, and Dan Luecke was the primary co-author. Drew Peternell, Randy Scholfield, and John Gerstle (TU), Bart Miller (WRA), and Becky Long (CEC) provided significant contributions. Production was facilitated by Nicole Theerasatiankul, Peter Roessmann, and Anita Schwartz (WRA).

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Design by Jeremy Carlson

WESTERN RESOURCE ADVOCATES

TROUT UNLIMITED

COLORADO ENVIRONMENTAL COALITION
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“We will not successfully solve 21st Century water management challenges in Colorado using 19th and 20th Century institutions and approaches.

This is especially true in our State where heightened competition for over-allocated water resources by individual users or sectors is increasingly unproductive—there is not enough water!

The use of multi-objective portfolio approaches is considered to be one of the most constructive options we have available if we are to protect and enhance environmental values while providing adequate and reliable water services to municipalities, industries, and farms.”

—**Peter Binney**
Director of Sustainable Infrastructure, Merrick & Company
former Director of Aurora Water

Snow in the Garden of the Gods.

The Smart Principles

Western Resource Advocates, Trout Unlimited, and the Colorado Environmental Coalition recommend that future water supply management and development efforts adhere to a set of basic, smart principles. We offer these principles as a guide to assure protection of rivers and other natural resources against damage that often results from structural water supply projects. The smart principles are:

1. Make full and efficient use of existing water supplies and reusable return flows before developing new diversion projects.

2. Improve use of existing water supply infrastructure by integrating systems and sharing resources among water users to avoid unnecessary new diversions and duplication of facilities.

3. Recognize the fundamental political and economic inequities and the adverse environmental consequences of new transbasin diversions.

4. Expand or enhance existing storage and delivery before building new facilities in presently undeveloped sites, and expand water supplies incrementally to better utilize existing diversion and storage capacities.

5. Recognizing that market forces now drive water reallocation from agricultural to municipal uses, structure such transfers, where possible, to maintain agriculture and in all cases to mitigate the adverse impacts to rural communities from these transfers.

6. Involve all stakeholders in decision-making processes and fully address the inevitable environmental and socioeconomic impacts of increasing water supplies.

7. Design and operate water diversion projects to leave adequate flows in rivers to support healthy ecosystems under all future scenarios, even if water availability diminishes in the future as a result of climate change or other factors.

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Acronyms, Abbreviations, and Units

°C	degrees Celsius
°F	degrees Fahrenheit
AF	acre-foot or acre-feet
acre-foot	325,851 gallons (the amount of water 2-3 families use in 1 year)
ag/urban	agricultural/urban (in reference to cooperative agreements)
APP	Acceptable Planned Project
C-BT	Colorado-Big Thompson (water supply project)
CEC	Colorado Environmental Coalition
CO_2	carbon dioxide (a greenhouse gas)
CWCB	Colorado Water Conservation Board
DOLA	Colorado Department of Local Affairs
DW	Denver Water
GCM	global circulation model
GPCD	gallons per capita per day
IBCC	Interbasin Compact Committee
IPPs	Identified Projects and Processes
KAF	thousand acre-feet
kWh/AF	kilowatt-hour per acre-foot (a measure of energy intensity)
LIRF	lawn irrigation return flows
MAF	million acre-feet
mgl	milligrams per liter
MWSI	Metropolitan Water Supply Initiative
NCNA	Non-Consumptive Needs Assessment
Northern Water	Northern Colorado Water Conservancy District
PWP	Prairie Waters Project
RO	reverse osmosis
SACWSD	South Adams County Water and Sanitation District
SWSI	Statewide Water Supply Initiative
TDS	total dissolved solids
TU	Trout Unlimited
U.S.	United States (of America)
WRA	Western Resource Advocates
WSD	water and sanitation district
WWTP	wastewater treatment plant

Preface: Planning for Colorado's Water Future

Folks in Colorado have plenty to be thankful for—and water is right at the heart of it all.

Colorado's millions of people, its landscape, its fish and wildlife, and its farms and factories all depend on water. Coloradans place great value on this scarce resource. Whether it falls from the sky as rain or snow, and whether it ends up as part of an ear of corn, a bottle of beer, or instream habitat for trout, water is essential to Colorado's exceptional quality of life.

Sustaining Colorado's lifestyle and economy demands that we preserve the state's waterways. Healthy rivers and streams support a diversity of fish, wildlife, and ecosystems, and draw residents and visitors to the state's world-famous natural areas. Colorado's rivers provide gold-medal trout fisheries and whitewater recreation, and are focal points for urban greenways in communities from Fort Collins to Durango and from Steamboat Springs to Pueblo. Healthy waterways are key to Colorado's outdoor tourism industry, which injects billions of dollars into the economy each year, and to attracting new businesses to the state. All of this is at risk, however, unless decision-makers in Colorado shift to more innovative, balanced approaches for supplying water to a growing population while sustaining Colorado's rivers and streams.

Colorado is a semi-arid state that receives average annual precipitation of only 16 inches. Many rivers and streams are badly depleted as a result of dams and diversion structures that deliver water to farms, factories, and cities. Developing additional water supplies to provide for a growing population threatens to further stress rivers and streams, preventing them from adequately providing their important environmental and biological functions.

Opposite and this page: Camping at Dillon Reservoir.

Whitewater rafting on the Arkansas River.

Colorado's Water Conservation Board (CWCB) and Interbasin Compact Committee (IBCC), local communities, and citizens' roundtables at the river basin level are engaged in a water supply planning process known as the Statewide Water Supply Initiative (SWSI). The SWSI effort is intended to answer the important questions of how much water Colorado will need in the future and how these needs can be met. The most recent SWSI report—titled *SWSI 2010*—forecasts the need to provide an additional 365,000 acre-feet of water by 2050 to the fast-growing municipal and industrial sectors along the Front Range of the South Platte River Basin.

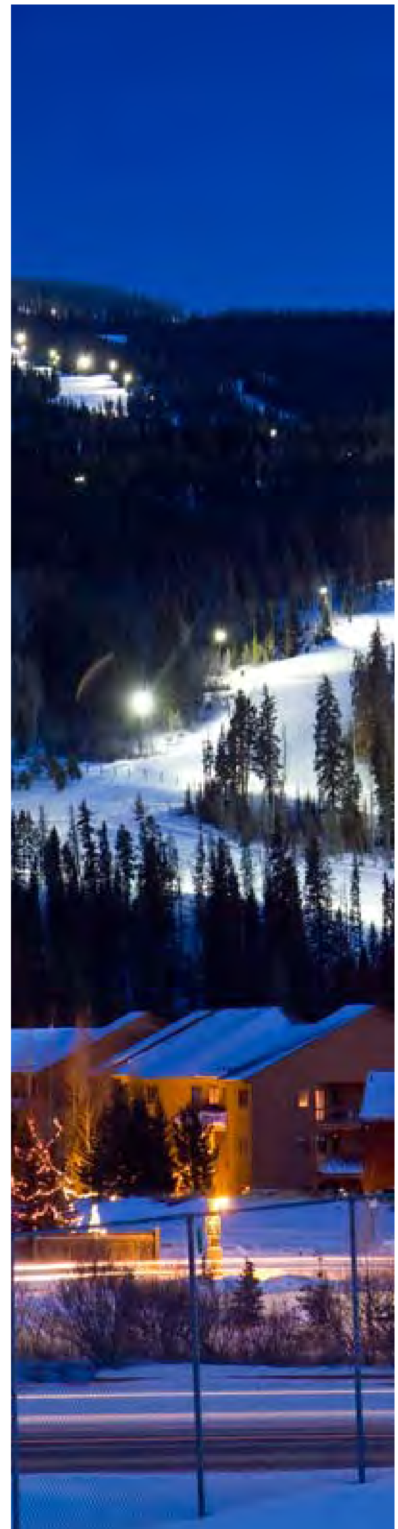
Faced with this projected need, the CWCB and IBCC, together with several basin roundtables, are devising plans for meeting the 2050 Front Range demand. Four strategies are being considered—Identified Projects and Processes (IPPs), increased water conservation, transfer of irrigation water from the agricultural sector to municipalities, and large-scale diversions of water from Colorado's Western Slope to the Front Range. Scenarios for meeting new needs are being developed based on implementation of varying levels of each of the four strategies. Unfortunately, too much attention in this planning effort falls on old, 20th century tools for supplying water—large dams and diversions, pumps and pipelines, and other structural projects that are often environmentally damaging.

As stakeholders in the planning process, Western Resource Advocates, Trout Unlimited, and the Colorado Environmental Coalition recognize the importance of preparing for our water future. However, we are also concerned that many traditional water supply strategies have resulted in adverse impacts to rivers and streams and their associated environmental, recreational, and economic values. Rather than continuing old patterns, 21st century water development must account for instream flow needs, minimize the adverse environmental impacts of water supply strategies, and even improve stream flows or other environmental conditions on streams that are already depleted. These new challenges require new ways of thinking and new tools.

In a 2005 report called *Facing Our Future: A Balanced Water Solution for Colorado*, we articulated a proactive approach for meeting water needs in the South Platte and Arkansas River Basins while protecting Colorado's environment and quality of life. *Facing Our Future* highlighted cost-effective and common-sense opportunities for growing municipal areas to meet future water needs through water conservation, reuse, and sharing agreements with irrigators. We laid out a set of principles that must guide decisions regarding new water supply in this state.

In that pages that follow, we build on the smart water supply principles established in *Facing Our Future* and—employing updated and widely accepted data—offer a realistic, balanced water supply portfolio that meets the projected needs in the South Platte Basin's Front Range communities while protecting Colorado's waterways, economy, and quality of life. As we describe, by developing select structural water projects, implementing increased water conservation and water reuse projects, and integrating agricultural and municipal water supply systems to allow for increased sharing arrangements, the Front Range of the South Platte Basin can meet its 2050 water needs at a reasonable cost without environmentally damaging water supply developments. The Front Range should pursue the strategies we recommend now, as they all have an important role to play in meeting our future water needs.

Just as we once put down the divining rods and found new ways for providing water supplies, today we must look beyond old ways of thinking and find innovative tools to meet new challenges. The time is now for the state of Colorado and local water providers to embrace new water supply strategies that meet our consumptive water use needs while sustaining the non-consumptive, instream flows that keep our rivers and streams healthy. The methods and ideas laid out in this report should guide choices that are made as we embark on this new era of water supply.



Keysone Resort at night.


Tubers enjoy the Yampa River near downtown Steamboat Springs. Photo: Matt Stensland/Steamboat Pilot and Today.

While current planning efforts still lean towards traditional measures for supplying water, Colorado can chart a new, innovative path forward that protects our rivers, streams, and local communities.

Executive Summary

Growing Water Demands

Nearly 70% of Colorado's population is concentrated on the eastern side of the state in the South Platte River Basin along the "Front Range"—a band of cities and communities located immediately east of the Rocky Mountains. According to state projections, the population of the 11 Front Range counties of the South Platte Basin is projected to grow by 2.5 million people between 2008 and 2050, for a total of close to 5.8 million residents by 2050.[1]

Maintaining a high quality of life in Colorado demands that we preserve the state's waterways.

These new residents will drive demand for additional municipal water supply. Accounting for "passive" reductions in per capita use as old and inefficient appliances and fixtures are gradually replaced over time, demands for the 5.8 million residents and industry along the Front Range will be approximately 1.06 million acre-feet in 2050—an increase of 365,000 acre-feet annually compared to today's water needs.

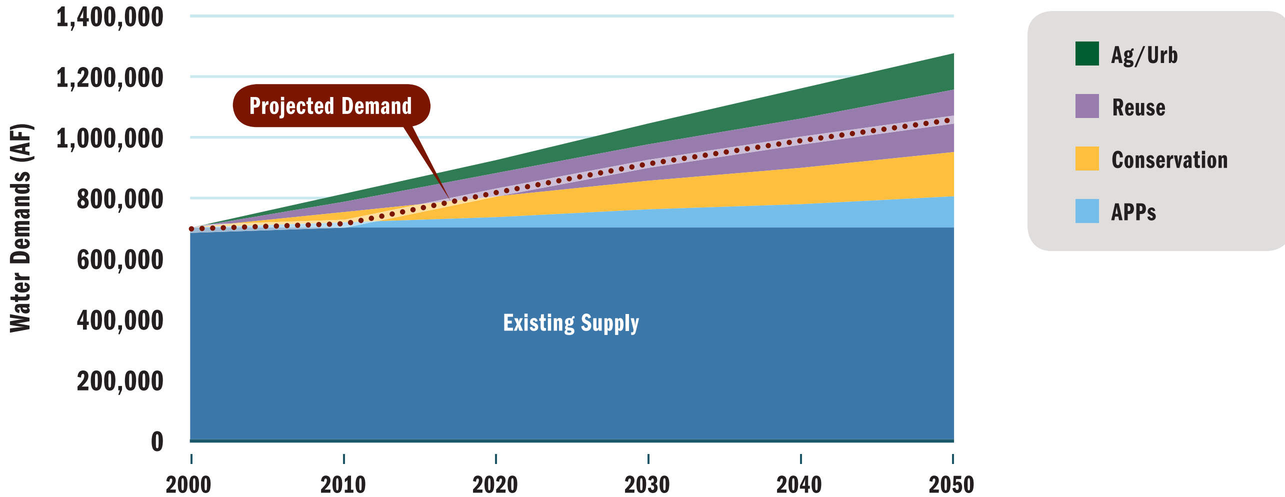
While current planning efforts still lean towards traditional measures for supplying water—dams and diversions, pumps and pipelines, and other structural projects—Colorado can chart a new, innovative path forward that protects our rivers, streams, and local communities.

Our Water Management Portfolio for Meeting Future Needs

This report explores four water supply strategies—acceptable planned projects, water conservation, reuse, and voluntary water sharing with the agriculture sector. As stewards of Colorado's rivers and natural heritage, Western Resource Advocates, Trout Unlimited, and the Colorado Environmental Coalition believe it is imperative for water planning to account for instream flow needs and to minimize the adverse environmental impacts of water supply strategies. In the pages that follow, we offer our view of a water supply scenario that more than fills projected needs in South Platte Basin Front Range communities while protecting Colorado's environment and economy (Figure ES-1). Importantly, our portfolio meets future needs

FIGURE ES 1 OUR PORTFOLIO FOR MEETING FRONT RANGE WATER DEMANDS.

Our balanced portfolio of water supply strategies more than fills projected needs in South Platte Basin Front Range communities while protecting Colorado's environment.



without the large, costly, and environmentally damaging transbasin diversions that have been a hallmark of traditional water supply planning.

Acceptable Planned Projects

There is a subset of the state's Identified Projects and Processes (IPPs) that we could accept if designed and implemented pursuant to our smart principles. In this report, we refer to these projects as Acceptable Planned Projects (APPs). The APPs include Chatfield Reservoir Reallocation, Halligan Reservoir Enlargement, Seaman Reservoir Enlargement, Gross Reservoir Expansion, Windy Gap Firming Project, Rueter-Hess Reservoir Expansion, Beebe Draw Aquifer Recharge, and East Cherry Creek Valley's Northern Project.* These APPs, collectively, can provide 102,000 acre-feet of new supply annually.

* Western Resource Advocates, Trout Unlimited, and the Colorado Environmental Coalition are engaged in the environmental review process and related discussions to ensure adequate mitigation is included for these projects.

Conservation

Published literature and the Colorado Water Conservation Board's (CWCB) studies indicate that per capita water use can be significantly reduced over the next 40 years through existing conservation techniques, practices, and technology. A 34% reduction in per capita demand—the CWCB's "high" conservation strategy—would result in a reduction of 362,000 acre-feet of water demand annually by 2050.[2] Achieving the conservation savings for a high conservation strategy will require sustained efforts by water providers and local governments, and may require state legislation, but it is cost-effective and will not compel lifestyle changes or modification to landscaping far beyond what currently exists in many communities. Only active water conservation savings could be used to meet new demands—256,000 acre-feet of the 362,000 acre-feet total. If 60% of the active savings are dedicated to meeting future needs, 153,000 acre-feet of new water supply will be made available annually by 2050.

Reuse

The Metropolitan Water Supply Initiative (MWSI) concluded that by 2030, reuse by Front Range cities would amount to 138,700 acre-feet of water annually, and that future plans for reuse beyond 2030 for the Denver area alone would total about 171,000 acre-feet per year.[3] By maximizing exchange opportunities and substitution plans, significantly increasing both direct and indirect reuse, and constructing the WISE and Prairie Water's Projects, the South Platte Basin will have an estimated 199,000 acre-feet of reuse water available annually to meet new demands in 2050.

Ag/Urban Cooperation

Municipal water supplies can be increased with financial benefit to the agricultural community through the use of systems integration and voluntary ag/urban sharing arrangements, like rotational land fallowing, interruptible supply agreements, and water leasing. The MWSI estimated that there is as much as 495,000 acre-feet of agricultural water available upstream of Greeley for sharing with South Platte municipalities.[4] Assuming the physical and administrative structures are put in place, we believe 25% of the 495,000 acre-feet could be shared with cities under innovative arrangements that do not require permanently drying irrigated acreage, thus producing approximately 120,000 acre-feet of new supply annually.

> **"Urban conservation, indirect reuse, and potentially win-win ag-urban cooperative water sharing arrangements play major roles in this strategy, while a select subset of new projects already on the books of municipalities is integrated with the nonstructural alternatives. This strategy should command consideration by water planners at State and local levels."**
>
> **—Chuck Howe,**
> **Professor Emeritus of Economics,**
> **University of Colorado, Boulder**

Recommendations

Colorado can chart an innovative path forward that differs from the traditional approach of building large dams and pipelines to meet the Front Range's growing water needs.

Planning for Colorado's water future is at a critical juncture. The SWSI process presented an abundance of information regarding water supplies, and the basin roundtables and IBCC are engaged in discussions about what the "next steps" should be. We believe Colorado can chart an innovative path forward, one that differs from the traditional approach of building large dams and pipelines to meet the Front Range's growing water needs.

The portfolio of APPs, conservation, reuse, and ag/urban sharing described in this report, which is based on conservative assumptions, would produce 200,000 acre-feet of water in excess of the Front Range's 2050 demands. While each strategy has its individual trade-offs, our portfolio does not require additional, large-scale, environmentally damaging transbasin diversions to the Front Range from the Western Slope.

Mountain ranch land in Colorado.

Based on rigorous data analysis, this report offers several key recommendations that water planners and policy makers should consider carefully in forging Colorado's water future:

- Close the projected Front Range "gap" with balanced strategies that are more cost-effective and environmentally friendly than transbasin diversion projects.

- Protect Colorado's rivers, streams, and lakes as an integral part of any future water development strategy. Non-consumptive uses of water—for fishing, whitewater recreation, and other uses—are worth billions of dollars annually to our state economy and are critical to the quality of life in this state.

- Pursue only those Identified Projects and Processes that can be constructed and operated according to the "smart" principles delineated in this report.

- Implement more aggressive water conservation strategies. Conservation is often the cheapest, fastest, and smartest way to gain "new" water supply, and many Front Range utilities have significant opportunities to boost their existing water conservation efforts.

- Listen to Front Range homeowners, who consistently express a willingness to adopt enhanced conservation measures in order to protect rivers and other mountain resources.

- Maximize the role of water reuse in meeting the future needs of Colorado's residents, and work to improve public perception and acceptance of reuse projects.

- Cooperate with agriculture on voluntary water sharing agreements that benefit both municipalities and the agricultural community without permanently drying irrigated acres. Alternatives to "buy and dry" transfers present the best opportunities for our future.

By following these recommendations, Colorado can more than meet the future water needs of its northern Front Range communities while minimizing impacts to the state's rivers and streams.

Majestic bull elk in spring velvet.

Water flowing in Colorado's rivers and streams sustains a diversity of life—from the fish that live directly in the water, to birds and mammals that rely on streams for habitat and food supplies.

Water and the Environment

Healthy, flowing rivers are among Colorado's most vital natural resources—nurturing the environment, supporting communities, powering the economy, and drawing residents and visitors alike to this state's world-famous natural areas. Maintaining a high quality of life in Colorado demands that we preserve the state's waterways.

Water flowing in Colorado's rivers and streams sustains a diversity of life—from fish, invertebrates, and a host of other species that live directly in the water, to birds and large mammals that rely on streams for habitat and food supplies. In the West, 65% of the species rely on the riparian and aquatic environment, which makes up less than 5% of the land area. Flowing rivers and streams also provide clean drinking water supplies, dilute water pollution, and support greenways in many communities, thus contributing to quality of life and Colorado's attractiveness to residents and businesses.

Healthy waterways are also key to Colorado's outdoor recreation and tourism industries, which inject billions of dollars into the state's economy. For example, whitewater parks in Breckenridge, Golden, Steamboat Springs, and Vail produced nearly $13 million dollars per year for these small communities in the early 2000s.[5] The total value of rafting on the Colorado River and its tributaries within the state of Colorado has been calculated to be $114.5 million per year.[6] And the total economic expenditures for fishing in Colorado were nearly $543 million dollars in 2006.[7] While recreational participation and expenditure data do not fully capture the value of instream flows, the contribution of these activities to the state's economy is undeniable.

Yet today, many of Colorado's rivers and streams suffer from severely diminished stream flows. Long-standing agricultural water uses and growing water demands for municipal and industrial purposes place heavy demands on Colorado's limited water supply and its natural waterways. Across the state, river and stream flows are often insufficient to support healthy fisheries, environments, and recreational economies.

Developing additional water supplies to provide for a growing population threatens to make the problem worse. For example, serving future Front Range demands through transbasin diversion projects that take additional water from the Western Slope, even with good-faith mitigation, will

“We’re seeing what Windy Gap (diversions) have done to us in the last 25 years. There’s less fish, there’s less bugs, there’s less water, there’s less everything—and now they’re wanting more. We better stop and look at this and make sure we don’t have a huge disaster.”

—Wes Palmer,
Manager, Skylark Ranch

still further deplete waterways already stressed by diversion projects and undermine Western Slope economies and quality of life. It is incumbent upon all of us to be stewards of Colorado’s rivers and natural attributes. Water planning must quantify and meet instream flow needs with the same level of energy, enthusiasm, and financial resources applied to developing new supplies.

Instream Flow Needs

Instream flow rights protect water flowing in rivers for environmental purposes. While the CWCB’s instream flow program is an important tool for protecting environmental values, instream flow rights are latecomers to Colorado’s water allocation system. Thus, most instream rights are “junior” to water rights for out-of-stream agricultural, industrial, and municipal water uses; instream flow rights often are left with little water after “senior” consumptive use water rights are met. Additionally, the majority of these instream flow rights are for minimum flows, in high elevation streams, and many streams have no instream rights or protections at all, leaving them vulnerable.

As our understanding of instream values has increased, there is a growing recognition that more must be done to identify, protect, and enhance non-consumptive needs. Colorado’s basin roundtables have completed Phase I of their Non-Consumptive Needs Assessment (NCNA), identifying stream reaches or watersheds that support important non-consumptive values. The CWCB is now working with basin roundtables, local watershed groups, and others on Phase II of the NCNA to identify existing and planned projects that will meet or protect the non-consumptive needs identified by the roundtables. Next steps will include an evaluation of whether the existing or planned projects are sufficient to meet the non-consumptive needs.

Future Water Planning

Instream non-consumptive water needs must become wholly integrated into water planning efforts. No longer can rivers and streams be an afterthought, bearing the adverse impacts of water development projects. Fortunately, the CWCB and other organizations are developing new methods of quantifying non-consumptive flow needs over large geographic areas and in specific reaches. Water providers should use these tools to inform water supply project siting and design. As we plan for a sustainable water future, instream non-consumptive needs must play a much larger role than they have in the past.

Upper Colorado – a River on the Brink

The Upper Colorado River system is famous for its gold-medal trout waters and recreation opportunities, but our state's namesake river system is in trouble. The Colorado-Big Thompson Project, the Windy Gap Project, and the Moffat Collection System Project divert water out of the Upper Colorado River across the Continental Divide for use on the Front Range. At present, an annual average of about 65% of the native flows of the Upper Colorado River Basin are diverted to the Front Range. Impacts on the ecological health of the river system are profound and include:

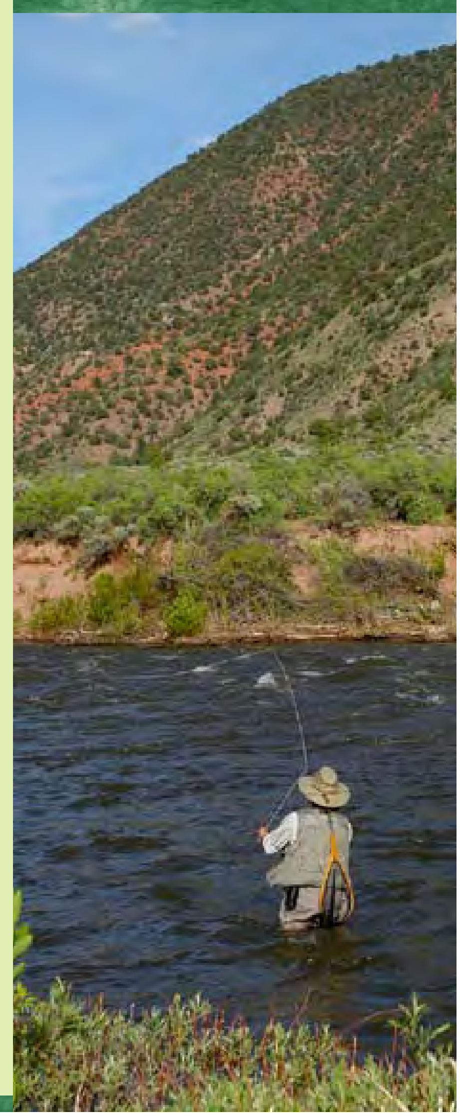
- Stream reaches that at times are almost completely dry.
- A loss of biological diversity, most notably a dramatic decrease in stoneflies, sculpin, and other healthy habitat indicator species, as well as dramatic decreases in trout biomass. A recent Colorado Division of Wildlife report warned that "increased future water diversions may exacerbate these trends."
- A spike in water temperatures in late summer, which violate state temperature standards and cause severe stress upon coldwater trout populations.
- The absence of high-water spring flushing flows and a corresponding increase in silt, weeds, and algae blooms.
- A marked decline in water quality and clarity in Grand Lake due to degraded Windy Gap water pumped through the lake.

Plans to expand transmountain diversions through the Windy Gap Firming Project and the Moffat Collection System Project could increase the portion of native Upper Colorado water diverted to the Front Range to an annual average of 85%, pushing the Colorado and Fraser Rivers and many of their tributaries to the brink of ecological collapse.

Front Range water providers must take steps to protect this priceless resource. Designing measures to protect these resources is becoming more and more difficult as streams become so dewatered that biological responses become non-linear and difficult to predict. Monitoring and adaptive management that keep project proponents accountable, and require them to adjust their operations to respond to unpredicted negative responses, is essential if these projects are to move forward – even if it means less certainty about the project's future yield. Any future water diversions from the Upper Colorado must not endanger the health of the Colorado and Fraser Rivers and their tributaries. Diversion projects must be designed and operated to leave adequate flow in the rivers under all circumstances, even if water supplies in the Upper Colorado Basin diminish in the future as a result of climate change, as many scientists project. Moreover, state leaders must work to quantify and meet the instream flow needs of all of our state's rivers and streams.

Diversion dam on Jim Creek, a tributary of the Fraser River. Photo: Mark Conlin.

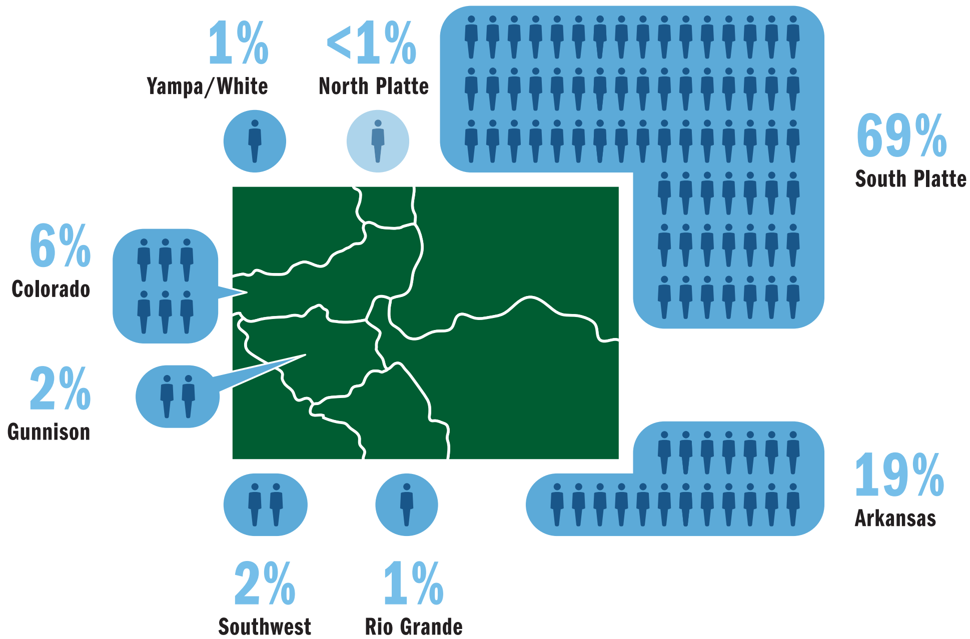
For more information, see the Trout Unlimited video "Tapped out: The Upper Colorado on the brink," at www.defendthecolorado.org.



Woman fly-fishing on the Colorado River.

FIGURE Nº 1 2008 POPULATION DISTRIBUTION BY RIVER BASIN.

The vast majority of Colorado's population is concentrated on the eastern side of the state, a trend that is expected to continue through 2050.



Growing Municipal Water Needs

Population of the South Platte River Basin

The overwhelming majority of Colorado's population is concentrated on the eastern side of the state — in fact, 69% now live in the South Platte Basin (Figure 1), a trend that is expected to continue through 2050.[8]

Although a super-majority of residents live within the South Platte Basin, Colorado's population is particularly concentrated along the "Front Range" — a band of cities and communities located immediately east of the Rocky Mountains. Projected population increases over the coming decades are *the* driving force for our state's increasing municipal water demands. Consequently, this report focuses on the water supply strategies available to the Front Range area of the South Platte Basin. Throughout this report, any reference to the Front Range means the counties of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Elbert, Jefferson, Larimer, Teller, and Weld.

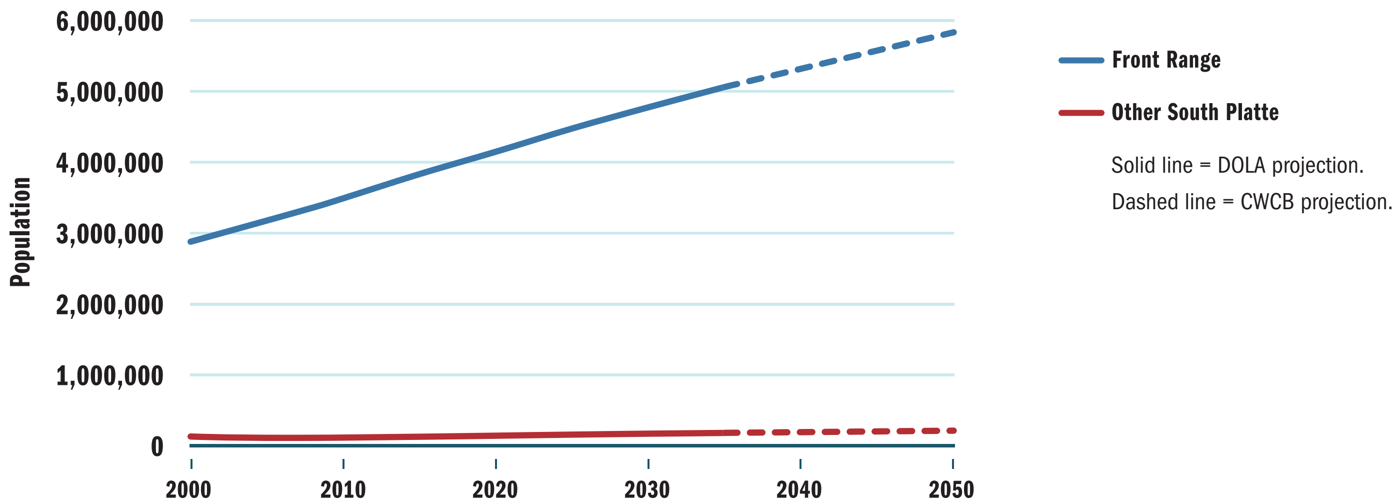
According to Colorado Department of Local Affairs (DOLA), the population of the Front Range is expected to increase by nearly 1.7 million people between 2008 and 2035, for a total population of just over 5 million residents. Additional modeling performed by the CWCB suggests the Front Range could grow by 2.5 million people between 2008 and 2050 under a medium population growth scenario, for a total population of close to 5.8 million residents by 2050 (Figure 2).[9]

Colorado's population is particularly concentrated along a band of cities and communities located immediately east of the Rocky Mountains.

Construction in Denver, CO.

FIGURE Nº 2 POPULATION PROJECTIONS FOR THE SOUTH PLATTE BASIN.

The population of the Front Range is expected to nearly double between 2008 and 2050 for a total population of close to 5.8 million residents under a medium population growth scenario.



Front Range Projected Water Demand

Increasing population along the Front Range will drive demand for additional municipal water supply. In July 2010, the CWCB released a final report estimating these future demands.[10] Herein, we use CWCB's estimates of future demand under a medium population growth scenario that include the effects of passive conservation.* The CWCB estimates that demands for the 5.8 million residents and industry of the Front Range in 2050 will be approximately 1.06 million acre-feet annually (Figure 3).

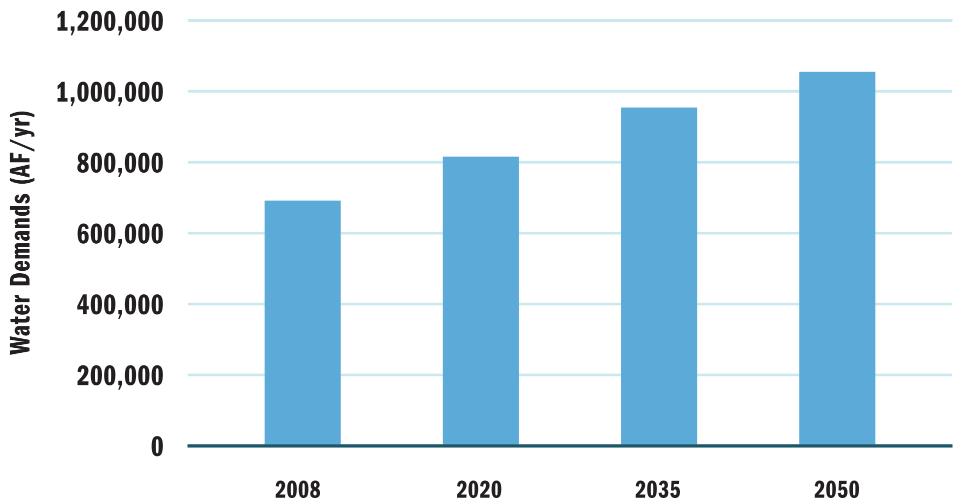
Existing Water Supplies

Front Range providers obtain municipal water supplies from local surface water and groundwater, as well as through transbasin diversions from the Western Slope. It is difficult to estimate the total municipal water supply available in any one year, so the CWCB uses year 2008 demands as a proxy for existing water supplies because it is assumed that all demands in 2008

* The CWCB estimates passive conservation will reduce per capita demands by 10% between 2008 and 2050.

FIGURE Nº 3 PROJECTED FRONT RANGE WATER DEMANDS.

The CWCB estimates Front Range demands in 2050 will be approximately 1.06 million acre-feet annually under a medium population growth scenario.



were met with available supplies. For the Front Range, this equates to a water supply (from both local and transbasin sources) of approximately 695,000 acre-feet per year.

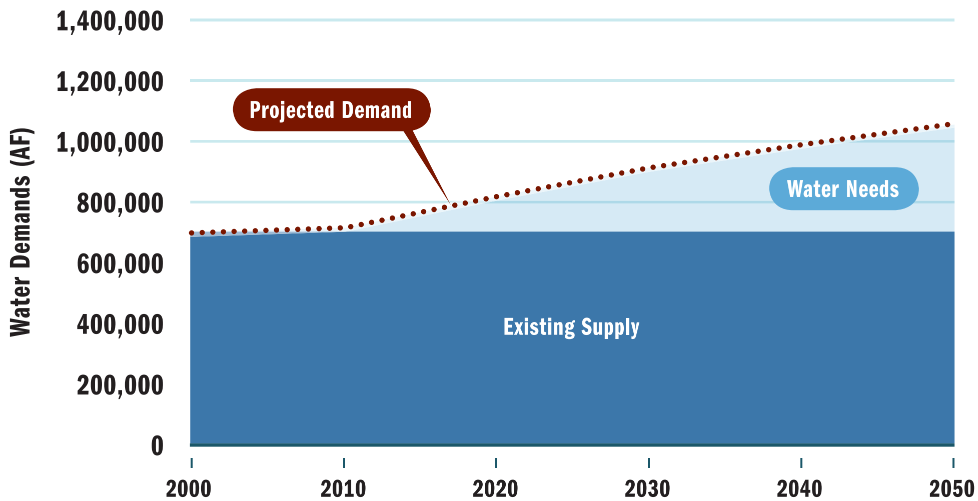
Future Municipal Water Needs

With existing supplies of 695,000 acre-feet annually and projected demands in 2050 of 1.06 million acre-feet, the Front Range will require additional water supply to meet the demands of its growing population (Figure 4). We assume the Front Range will need 365,000 acre-feet of additional supply by 2050 to fully meet projected demands.

It is important to note a few things. First, this needs projection is for the Front Range as a whole, and does not take into account more localized water supply and demand issues; a lack of data precludes more specific analysis. Second, the water needs described here are not the same as CWCB's projected "gap" for this area because: 1) we merge the South Platte and Metro basins, 2) we exclude non-Front-Range counties from our analysis, and 3) our needs projection does not account for the additional supply that would result from all Identified Projects and Processes. Finally, we do not account for potential climate change impacts or a reduction in groundwater availability in the basin, which are important concerns for us, as well as for some water providers.

FIGURE Nº 4 ESTIMATE OF FRONT RANGE WATER NEEDS.

Using the most current CWCB data, we assume the Front Range will need 365,000 acre-feet of additional supply by 2050 to fully meet projected demands.



Meeting Municipal Water Needs

In the following chapters of this report, we describe how development of select structural water projects, increased water conservation, water reuse projects, and agricultural and municipal water supply cooperation can more than meet the Front Range's 2050 water needs without additional, large-scale, environmentally damaging water supply developments from the Western Slope. For each of these strategies we provide:

- A description of what the strategy is and how it works, with examples
- A discussion of the concerns associated with increased implementation of the strategy
- An estimate of the potential future volume of water available from the strategy

Climate Uncertainty and Western Water Supplies[11]

The U.S. Global Climate Change Research Program has concluded that "[h]uman-induced climate change appears to be well underway in the Southwest." During the 20th century, global average surface temperatures increased by 0.6°C (1°F) and multiple data sets confirm widespread warming in the western U.S. over that same period, consistent with the global trend.

Climate change may already be impacting western water resources. Although the continental U.S. generally became wetter during the 20th century, scientists analyzing long-term observational trends report evidence of increased drought severity and duration in the western U.S. Global climate models project further water cycle changes, which, combined with increasing temperatures that will drive increased demands, may signal serious water supply and water rights administration challenges in the decades and centuries ahead.

Recent model projections indicate that as climate change advances, the Intermountain West and Southwest is likely to become drier as well as hotter. In a recent comprehensive assessment, researchers found that 46 of 49 global circulation model (GCM) simulations project a more arid southwestern U.S. in future years. Looking forward to mid-century, 23 of 24 GCM runs project decreased runoff for the Upper Colorado River on the order of 5% to 20%. Ominously, climate change models predict that droughts will become the norm in the Southwest and that some will be more severe than any experienced in centuries.

Beyond affecting water supply, warmer temperatures also affect water quality and fish habitat. Researchers examining this response found that the effect of doubled carbon dioxide (CO_2) concentrations on lake water temperatures could cut in half the habitat available for coldwater fish, while habitat for warm-water fish would increase. A warmer and drier climate in the western U.S. would reduce stream flows as well as increase stream temperatures, with severe consequences for coldwater fish, such as native trout. Warmer temperatures and reduced stream flows also enhance the growth of nuisance aquatic organisms, such as blue-green algae, which in turn can lead to low-oxygen conditions that threaten aquatic life. These potential impacts to the quantity and quality of water supplies underscore the need for providers to integrate and address climate change into their water planning.

As climate change advances, the West is likely to become drier as well as hotter.

Water trickles through a sandstone desert canyon wash.

Fly fishing and canoeing on Dillon Reservoir in Summit County, Colorado.

Acceptable Planned Projects

Front Range water providers are pursuing a wide range of water supply development options, such as more fully exercising existing water rights, building new pipelines, enlarging reservoirs, and transferring water from agriculture. This section identifies the specific projects that Front Range communities are planning that Western Resource Advocates, Trout Unlimited, and the Colorado Environmental Coalition could accept, **if designed and implemented pursuant to our "smart" principles.** We call these projects Acceptable Planned Projects (APPs). We estimate that APPs can provide 102,000 acre-feet of additional water supply annually by 2050.

The "Smart" Principles

In *What the current drought means for water management in Colorado*[12] and *Facing Our Future: A Balanced Water Solution for Colorado*,[13] we recommended that future water supply management and development efforts adhere to a set of basic smart principles. We offered those smart principles as a guide to assure protection of rivers and other natural resources against damage that often results from structural water supply projects. The smart principles are:

- Make full and efficient use of existing water supplies and reusable return flows before developing new diversion projects.

- Improve use of existing water supply infrastructure by integrating systems and sharing resources among water users to avoid unnecessary new diversions and duplication of facilities.

- Recognize the fundamental political and economic inequities and the adverse environmental consequences of new transbasin diversions.

- Expand or enhance existing storage and delivery before building new facilities in presently undeveloped sites, and expand water supplies incrementally to better utilize existing diversion and storage capacities.

- Recognizing that market forces now drive water reallocation from agricultural to municipal uses, structure such transfers, where possible, to maintain agriculture and in all cases to mitigate the adverse impacts to rural communities from these transfers.

These principles are as relevant today as they were six years ago.

• Involve all stakeholders in decision-making processes and fully address the inevitable environmental and socioeconomic impacts of increasing water supplies.

These principles are as relevant today as they were six years ago.

To account for our growing understanding of the possible effects of climate change on water supplies, we add an additional principle to the list:

• Design and operate water diversion projects to leave adequate flows in rivers to support healthy ecosystems under all future scenarios, even if water availability diminishes in the future as a result of climate change or other factors.

Issues Associated with Structural Projects

Reservoirs have been part of Colorado's water development strategy since the late 1800s, in response to our highly variable stream flows. Today, Colorado has more than 7.5 million acre-feet of reservoir storage. About 25% of this capacity directly supports municipal water uses and this fraction is growing, mostly as cities acquire agricultural water rights with their associated storage. The South Platte Basin is second only to the Colorado River Basin in the amount of storage in place.

The traditional purpose for building reservoirs has been to capture excess runoff, which occurs in large volumes relatively infrequently. Consequently, traditional reservoirs are fairly large and located directly in a stream channel. In addition to their environmental impacts, such large, on-stream reservoirs have other major limitations:

The Moffat Pipeline, part of Denver Water's Gross Reservoir Enlargement project. Photo: Mark Conlin.

• Reservoirs are costly to build and cannot easily be expanded incrementally in response to growing demands. Rather, they must be paid for and constructed "up front," which increases their financial risk and diminishes their economic feasibility.

• As a basin becomes over-appropriated, additional storage produces ever-diminishing returns, in terms of water yield, because unappropriated runoff occurs less frequently and storage carry-over periods become longer.

• Evaporation losses compound the diminishing yield problem, becoming a major limiting factor in reservoirs' ability to provide relief, both over extended drought conditions and during severe droughts that occur every few decades.

• Sedimentation of reservoirs further decreases yield and can only be remedied through the manual removal of accumulated sediment, which is both time-intensive and very costly.

- Given the diminishing returns for new storage projects, storage-yield ratios for reservoirs designed to store wet-year water for drought protection are, at best, 5-to-1. This means that for 100,000 acre-feet of additional firm annual supply, the reservoir would have to store over 500,000 acre-feet and would cost well over one billion dollars.

New pipeline proposals—becoming more popular in the traditional water supply planning dialogue—are marred by the same problems because reservoirs are still needed to store any water transferred through a pipeline. Pipelines are also extremely costly to build; the CWCB estimates that six potential pipeline proposals being considered today would each cost in the range of $8-10 billion for capital costs alone.[14] In addition, any new pipeline will require a significant amount of energy to pump water over great distances. Furthermore, these proposals require pumping large quantities of water from remote areas of Colorado or other states, where compact entitlement concerns, water quality issues, relationships with neighboring states, and the local political unpopularity of these projects add to the list of hurdles.

With these limitations in mind, some water providers are increasingly developing "smart storage"—smaller reservoirs designed to optimize already-developed supplies, and capture unappropriated peak-season runoff, to some extent. Smart storage is now commonly developed as a means for capturing and re-regulating reusable return flows, increasing the yields of exchange rights and augmentation plans, re-regulating the yields of changed irrigation rights to meet municipal demand patterns, and increasing yields from existing water rights and transbasin diversions. In some cases, existing traditional storage capacity has been rededicated to smart storage purposes, with resulting increases in yields.

Gross Reservoir is located near Boulder, CO.

Front Range Acceptable Planned Projects

The CWCB refers to water supply projects that are currently in the planning and initial implementation phases as Identified Projects and Processes (IPPs). Because some IPPs do not meet our smart principles, this report does not utilize the complete list of Front Range IPPs. Instead, we present a subset of "Acceptable Planned Projects" (APPs) that are listed and described in Table 1. Note that the far right column of the table identifies issues that must be resolved before we could accept these projects.

CWCB's SWSI 2010 report provides estimates of potential yield for the APPs, even though yield estimates are in flux for some projects.[15] Using the CWCB's estimates, and excepting the Prairie Waters and WISE Partnership Projects, which are included in the Reuse Strategy section of this report, our APPs could collectively produce approximately 102,000 acre-feet of new water supply annually by 2050. This is represented by the APP wedge in Figure 5.

FIGURE Nº 5 ESTIMATE OF FRONT RANGE NEEDS INCLUDING THE ACCEPTABLE PLANNED PROJECTS STRATEGY.

APPs could collectively produce approximately 102,000 acre-feet of new water supply annually by 2050.

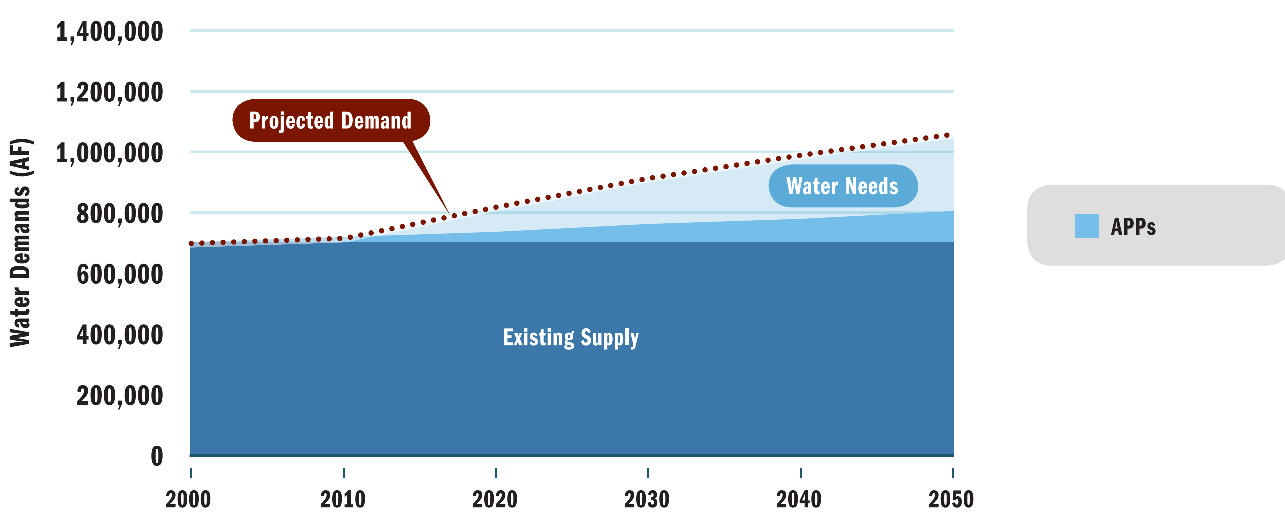


TABLE Nº 1 FRONT RANGE ACCEPTABLE PLANNED PROJECTS.

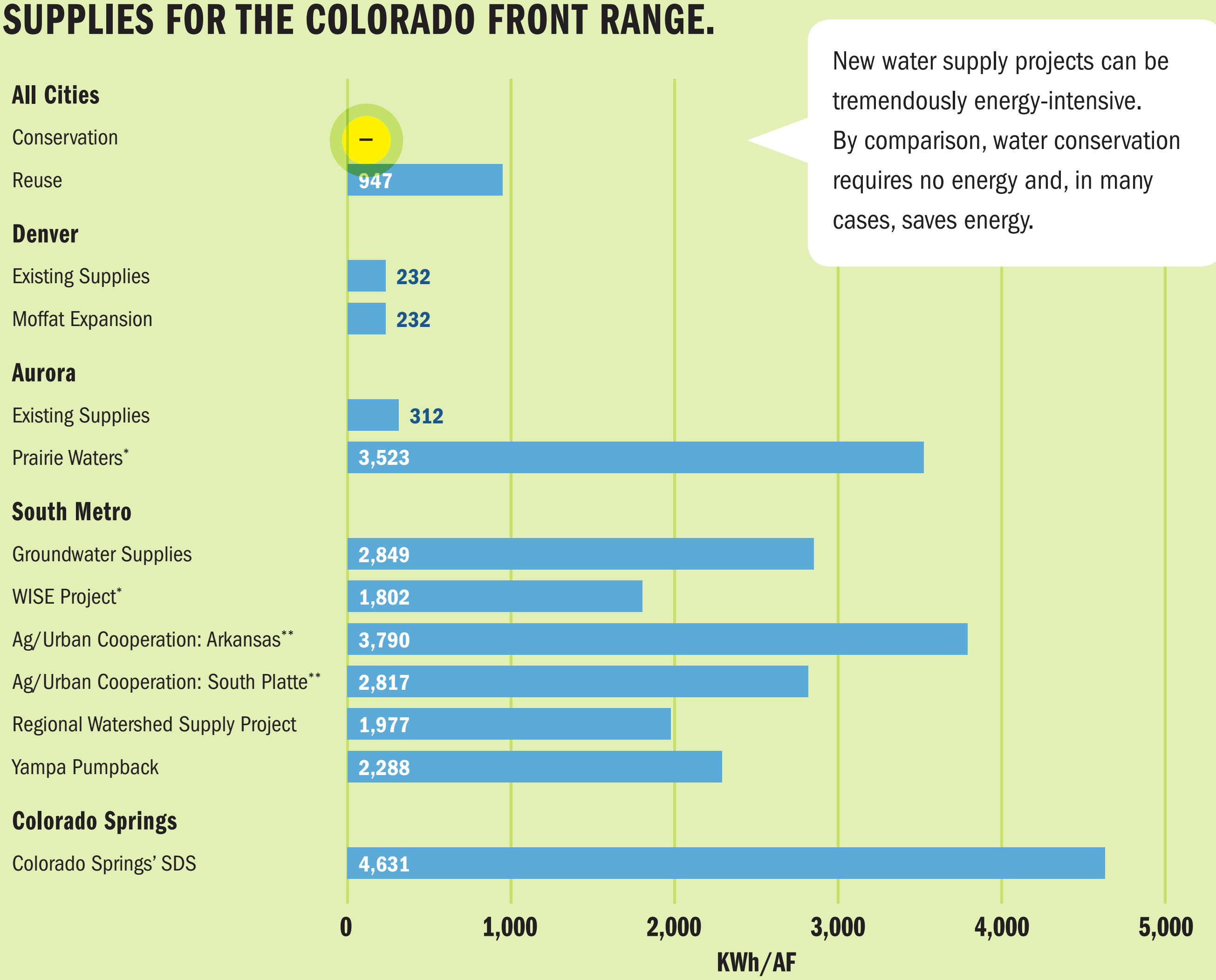
Project Name (Beneficiary)	Potential Yield (AF/year)	Description	Issues To Be Resolved
Reservoirs			
Chatfield Reservoir Reallocation (several central South Platte water suppliers)	8,000	Modify recreational facilities; reallocate 20,600 AF of storage from flood control to urban, agricultural, and instream uses.	Assess and minimize impacts of reservoir fluctuation on recreational facilities, wetlands, and bird habitats.
Gross Reservoir Enlargement (Denver Water)	18,000	Increase storage in existing reservoir by 72,000 AF.	Implement urban efficiency measures first. Adopt adequate, enforceable measures to protect/ restore affected upper Colorado River Basin streams, and South Boulder Creek water quality and flows.
Halligan Reservoir Enlargement (Fort Collins)	7,000	Increase storage in existing reservoir by 33,500 AF.	Implement urban efficiency measures first. Protect/restore N. Fork Poudre and Poudre River water quality and flows.
Rueter-Hess Reservoir Enlargement (Parker and other south Denver metro area providers)	15,000	Increase storage in existing reservoir by 54,000 AF.	Maximize use of in-basin surface water supplies, reuse, and conservation savings.
Seaman Reservoir Enlargement (Greeley)	10,000	Increase storage in existing reservoir by 38,000 AF.	Implement urban efficiency measures first. Protect/restore N. Fork Poudre and Poudre River water quality and flows.
Windy Gap Firming Project (Municipal Subdistrict of Northern Water)	32,000 (depends on "pre-positioning")	Construct new reservoir at Chimney Hollow to ensure reliable supplies of Windy Gap water.	Implement urban efficiency measures first. Adopt adequate, enforceable measures to protect/ restore affected upper Colorado River Basin flows.
Other			
Northern Project Pipeline, Phase II+ (East Cherry Creek Valley WSD, south Denver metro area providers)	5,000	Purchase of additional water rights and construction of reverse osmosis treatment plant.	Brine disposal. Assess and minimize potential impacts to stream flows and water quality.
South Platte and Beebe Draw Aquifer Recharge Project (Brighton)	7,000	Use Beebe Draw alluvium for storage, with pipeline and treatment for delivery of potable water.	Assess and minimize potential impacts to stream flows and water quality.
TOTAL	**102,000**		

Reuse			
Prairie Waters Project [PWP] (Aurora)	10,000 (ultimate capacity of 50,000 if and when needed)	Thirty-four-mile pipeline capturing reusable water rights, junior South Platte water rights, and agricultural water rights.	Brine disposal. Assess and minimize potential impacts to stream flows and water quality.
WISE Partnership (Denver Water [DW], Aurora, south Denver metro area providers)	10,000 (up to 18,000 with full build-out of PWP)	Uses PWP to capture DW's reusable transbasin return flows when capacity is available; water delivered in most years to south Denver metro area providers.	Brine disposal. Assess and minimize potential impacts to stream flows and water quality. DW must have agreement with Aurora about when capacity is available.

Water-Energy Nexus[16]

The water supply strategies Colorado chooses to pursue come with large implications for energy use and greenhouse gas emissions. Energy is used to pump, treat, distribute, and heat water, as well as to treat and discharge wastewater. The *energy intensity* of Colorado's water supplies, or the energy embedded in each acre-foot of water delivered for use, varies considerably across the Front Range. Cities, such as Denver and Fort Collins, that rely on high-quality, gravity-fed supplies use very little energy to supply customers with water. But many south Denver metro area cities use tremendous amounts of energy to pump water from deep Denver Basin aquifers. New supply projects, such as Colorado Springs' Southern Delivery System, will rival the most energy-intensive water supplies in the West today. Water supplied via conservation and efficiency uses no energy and actually saves energy in many cases.

ENERGY INTENSITY OF EXISTING AND PROPOSED SUPPLIES FOR THE COLORADO FRONT RANGE.



* Water delivered through Aurora's Prairie Waters Project will be mixed with water stored in Aurora Reservoir, making the overall energy intensity approximately 1,200 kWh/AF. Similarly, Denver Water expects the WISE project will mix Prairie Waters Project water and its gravity-fed supplies for an overall energy-intensity of 1,050 kWh/AF.

** Both ag/urban cooperation strategies include the energy used for reverse osmosis treatment and pumping from a point in eastern Colorado.

The Conservation Strategy

Published literature and CWCB studies indicate that per capita water use can be significantly reduced over the next 40 years through existing conservation techniques, practices, and technology. A 34% reduction in per capita demand through active and passive conservation — CWCB's "high" conservation strategy — would result in a reduction of 362,000 acre-feet of water demand annually by 2050. Only a portion of this water would be available to meet new demands, however, as some might be dedicated to improving system reliability or augmenting stream flows. Assuming 60% of active conservation savings are dedicated to growth, 153,000 acre-feet of new water supply would be made available annually by 2050.

Water Conservation Defined

The term "water conservation" means different things to different people. For purposes of this report, water conservation is a permanent reduction in per capita water usage resulting from long-term implementation of water saving practices and technologies. This is synonymous with improving water efficiency — conserving water allows us to do more with less.

Water conservation is often the cheapest, fastest, and smartest way to gain "new" water supply.[17] While conservation does not increase the total amount of water a provider can utilize, water that is saved through conservation can be put to other uses, in effect, stretching existing supplies. Conserved water can be used by a utility to fulfill new customer demands, increase supply reliability, or provide additional flows to the environment.

Water conservation also creates other benefits for a water utility. Reductions in per capita demand allow utilities to delay and/or downsize expensive new water source, treatment plant, and system expansion projects. Water conservation demonstrates leadership to the customer base, addresses community values, can decrease operating costs for the water provider (especially through decreased energy use), and often results in mutual benefits to other water sectors. Furthermore, improving water efficiency is a "no-regrets" strategy that enables water providers to maintain local control of their water supply, and it is inherently flexible, able to move and shift as need dictates, unlike concrete dams and steel pipelines.

Water conservation and efficiency can be achieved through a variety of practices and technologies. Conservation efforts can be price-based, like adjusting water rates, or non-price-based, like educating consumers about the value of water. Conservation can be focused at the utility level, such as leak detection and repair, or at the customer level, such as clothes washer rebates. City land use planning and state-level legislative efforts can also promote conservation. And conservation can be focused on indoor or outdoor measures, aimed towards commercial or industrial customers, and approached through regulatory or voluntary measures. In short, there are multitudes of ways to use our water resources more efficiently.

Existing Levels of Conservation

Most Front Range water providers are currently engaged in active conservation efforts, such as education and outreach programs, leak detection, and financial incentives for decreasing water use. These efforts are in addition to passive conservation savings that accrue naturally and do not require the utility to assert any active effort to reduce water use.* The following are just a few examples of the different types of active conservation programs utilities are implementing across the Front Range:

- Denver Water offers a $125 rebate to customers for replacing an old toilet with a high-efficiency model.
- The city of Broomfield requires customers to add organic matter to the soil before installing turf grass and limits turf coverage to 60% of the landscaped area of any new single-family home.
- The city of Louisville employs a water rate structure that increases water use charges by 150% when customers use more than 20,000 gallons per month.

State statute requires water providers in Colorado that serve more than 2,000 acre-feet of water annually to have a conservation plan on file with the CWCB.[18] These conservation plans detail many of the other active conservation practices and efforts being implemented by utilities to increase water efficiency.

Issues Associated with Conservation

Some water providers express concern and resistance when asked to increase water conservation efforts. A few of the most often repeated concerns are discussed below.

* The CWCB estimates passive conservation will result in a 10% reduction in per capita use between 2008 and 2050.

Demand Hardening

One long-asserted claim is that long-term conservation can reduce the water savings potential during water shortages. According to the so-called "demand-hardening" argument, today's non-essential water uses provide a cushion in the system that can be eliminated during dry years as a drought-response measure.

The demand-hardening argument is unconvincing. First, the potential impact of demand hardening is often overstated. Where citizens reduce per capita demand through technological and efficiency improvements, additional savings can be achieved during drought through behavioral changes. For example, even with a significant increase in conservation, the predominant residential landscape along the Front Range will continue to be bluegrass for many years to come. Thus, there will continue to be opportunities to decrease irrigation of bluegrass lawns during dry years as a drought-response measure, and bluegrass can survive for extended periods with little water.

An example from the city of Long Beach, CA, provides evidence that demand hardening is overstated. As a result of 22 years of continuing long-term conservation efforts, *total* potable water consumption in Long Beach is at the same level as it was in 1965, despite major increases in population. Even in the wake of these significant conservation savings, the city's recent drought-

Summer rock garden, Colorado.

Front Range Citizens Want to Conserve

Results from a comprehensive 2005 survey of Denver Water customers clearly show that the majority of citizens support increasing water conservation efforts. Major survey results include:

73% of respondents agree or strongly agree that DW customers should conserve to reduce impacts on mountain regions in the state. 12% disagree.

71% of respondents agree or strongly agree that new homes being built should be restricted on how much grass they can water. 17% disagree.

60% of respondents say their quality of life was not affected by the 2002 drought (and related watering restrictions).

33% of those who changed their water use since the drought, said they did so because "it's the right thing to do." This is the #1 reason.

Reference: Denver Water (BBC Research and Consulting). 2005. Denver Water Customer Perceptions. Final Report. June 3.

response measures decreased use an additional 17.2% below the historical 10-year average.[19]

Second, economic considerations undermine demand-hardening arguments. Research has indicated that ignoring conservation and building excess water supply capacity is highly uneconomical.[20] In addition, implementing long-term conservation programs is significantly cheaper than eliminating waste during drought years through water use restrictions. One study estimated that conservation is one-quarter of the price of dry-year drought-response measures.[21]

In a semi-arid state, policies should promote efficient use of water.

Third, it is questionable public policy to encourage overuse of any limited resource. In a semi-arid state like Colorado, where environmental health, the recreation economy, and the overall quality of life depend on instream flows and other uses of water, policies should promote efficient use of water and should discourage behaviors that necessitate additional water diversions from rivers and streams.

Fourth, demand hardening is only a concern during times of shortage, and only if the majority of conserved water is used to serve new customers.[22] Most utilities will dedicate only a portion of conservation savings to serving new growth (we assume 60% in this report), reserving the remainder of conservation savings for system reliability or instream flow augmentation purposes. In times of drought, conserved water dedicated to these other purposes could be redirected to serving base demands, thus avoiding demand-hardening problems.

The CWCB's most recent conservation study has deflated the demand-hardening argument by stating, "based on the current state of knowledge, concerns about demand hardening are not a sound argument against implementing long-term water conservation programs."[23]

Permanency of Conservation Savings

Another concern that water providers often express is that conservation savings achieved over the past decade may not be permanent. On average, Colorado citizens decreased per capita water use by 18% from 2000 to 2008.[24] The majority of these savings are attributed to behavioral changes, such as decreasing sprinkler run times or turning off the faucet while brushing teeth. Some utilities argue that, unlike technological improvements, these behavioral changes may shift over time. Although we agree that behavioral changes are not necessarily permanent in the way that technological changes are, there is no reason to believe that education and outreach efforts would not be sufficient to sustain behavioral changes and the associated reductions in per capita water usage. Many providers report a shift towards an ethic of conservation within their customer base.

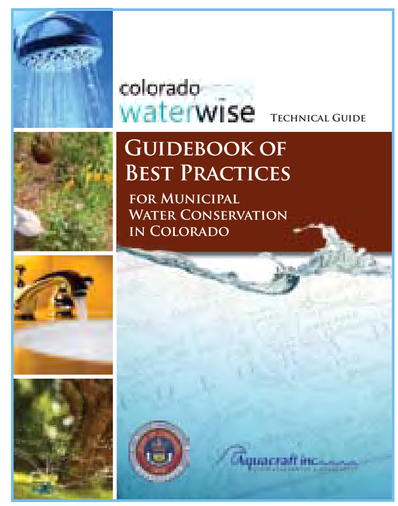
Furthermore, if the majority of water savings are due to behavioral changes, there are additional prospects for implementing technologically based conservation strategies (e.g., high-efficiency toilets and appliances, low-flow showerheads, and landscape retrofits).

Impacts on Return Flows

Another concern raised is the potential impact increased conservation may have on return flows and the availability of water for downstream water rights holders or reuse projects. Conservation measures only impact return flows and downstream water uses if they result in an increase in the proportion of diverted water that is consumed. On the indoor side, water conservation efforts have very little impact on the consumptive use of water because the vast majority of water that enters a home transfers to the wastewater collection system and is then discharged back to the stream. Given a set quantity of water diverted into the utility's water distribution system, efficiency improvements will, for example, allow more homes to flush their toilets with the same amount of water returning to the stream. On the other hand, outdoor conservation efforts that decrease water waste and improve irrigation efficiency may lead to a reduction in return flows available for downstream users. However, even the outdoor conservation effects would likely be offset by the increase in municipal discharges resulting from the overall increase in water use attributable to a growing population.

The Uniqueness of Water Providers

Water providers often assert that utilities and communities are unique and that "one size does not fit all" when it comes to conservation programs. While there may be some differences between providers, the foundational measures identified in Colorado WaterWise's best practices handbook—such as implementing conservation-oriented rate structures—should be implemented by *every utility* regardless of size, location, or demographics.[25] The handbook also describes additional conservation tools beyond the base measures. Communities can tailor these tools to meet their individual needs and circumstances.



Find the handbook at coloradowaterwise.org/BestPractices.

Estimate of Future Conservation

While many conservation programs are underway, municipal utilities along the Front Range have much room to improve upon their existing water conservation efforts. The CWCB's SWSI 2010 conservation study identifies realistic conservation strategies that offer significant and cost-effective water savings for all Colorado customers. Through the use of active utility programs, codes and regulations, landscape and irrigation changes, and improved utility water loss control measures, the state estimates that a "high" water conservation strategy could reduce 2008 per capita water demand 34%

Local Citizen Demonstrates Conservation Success[39]

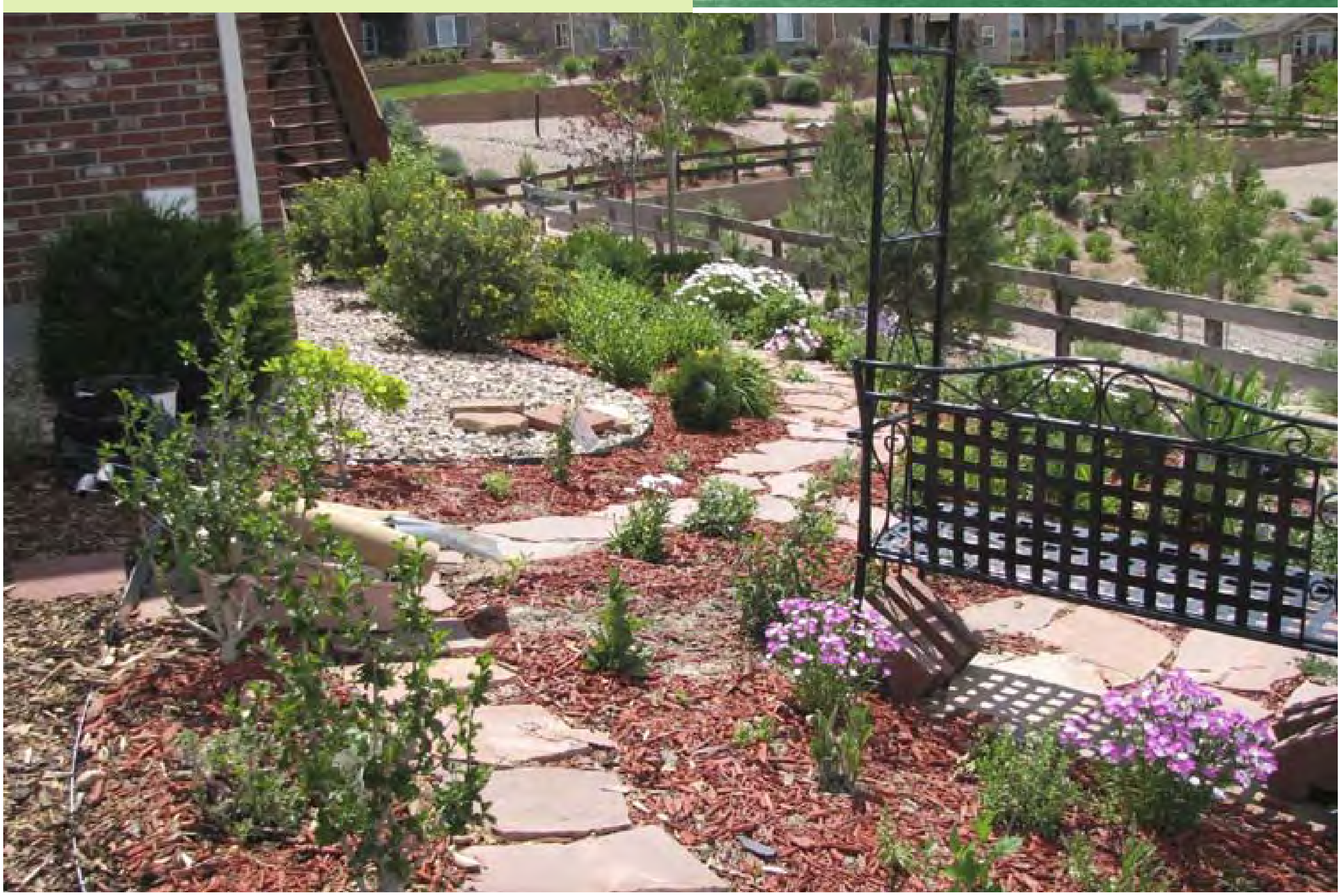
Front Range homeowner Diane Woods is one of many who have revamped their landscape as part of Aurora Water's xeriscape rebate program. The program—often referred to as "Cash for Grass"—provides up to $1 per square foot for turf grass that is replaced with low water use landscaping. "It was a concern for the environment" that drew Diane to changing her landscape, she says. After removing most of her sod, she replanted with drought-tolerant bushes and flowers. Aurora Water paid her a total of $3,400 to transition to xeriscaping.

Many homeowners like Diane Woods are happy with Aurora's rebate program, especially when they get their summer water bill. "From $280 a month to $89 two years later, so definitely it did conserve water," she says. While weather variations and plant sizes do affect water use, Diane will be reaping conservation savings for years to come.

▲ Diane Woods' front walkway. Photo courtesy of Aurora Water.

Diane Wood will be reaping savings for years to come.

▼ An outdoor seating area in Diane Woods' backyard. Photo courtesy of Aurora Water.



by 2050.* This high water conservation strategy is equivalent to reducing demand by 1% per year—a conservation target previously described by Western Resource Advocates.[26]

Importantly, achieving a 34% reduction in per capita water use will not require measures, lifestyle changes, or landscaping modifications beyond those already being implemented in many Colorado communities. Rather, the water savings rely on increased adoption of water-efficient fixtures and appliances, full implementation of conservation-oriented water rate structures, limited replacement of high water demand plantings with lower water demand plantings, and reductions in utility water loss. The CWCB's conservation study details the methodology used to determine this level of savings, provides extensive documentation for the reduction estimates, and uses the Colorado WaterWise best practices manual to list the measures necessary to achieve projected savings.

Reducing per capita water use by 34% will not require measures, lifestyle changes, or landscaping modifications beyond those already being implemented in many communities.

Published literature also indicates that achieving a 34% reduction in water use over 40 years is possible using existing techniques, practices, and technology. Increasing block rate structures have been found to be the most effective method of reducing urban demand as compared to all non-price methods,[27] producing household reductions in water use in the range of 20% to 40%.[28,29] Retrofit studies show that overall residential demand can immediately be reduced by an average of 40% as a result of installing more efficient appliances and fixtures.[30] Modeling studies show that indoor and outdoor use in single-family residential properties can each be reduced by 40% using efficient fixtures and low water use landscapes.[31] And water conservation experts state that current overall municipal demand can be reduced by up to 50%.[32,33]

There will be financial costs to achieving a high level of conservation savings, but they will be significantly cheaper than traditional "concrete and steel" approaches to water supply development. The CWCB has detailed the cost of conserving water in several reports. In SWSI II, the CWCB estimated the average cost to achieve a suite of conservation measures to be around $10,600 per acre-foot, with the less expensive measures costing as little as $1,000 to $2,000 per acre-foot.[34] In a 2010 analysis of Colorado providers' water conservation plans, the average cost to implement conservation programs over the next 10 years is estimated to be $6,327 per acre-foot.[35] In the CWCB's SWSI 2010 conservation strategies report, the average cost of implementing conservation programs that would produce savings commensurate with the high strategy is $8,183 per acre-foot.[36] These are all substantially less than the $30,000 to $40,000 per acre-foot estimated for just the capital costs of new supply proposals from the Western Slope.[37]

Achieving a 34% reduction in per capita use will require real effort and investment by water providers, as well as state and local governments.

* GPCD reduction is 31.6% for the Metro Basin and 38.2% for the South Platte Basin in the high conservation scenario. The population-weighted reduction for these two basins combined is 33.7%, or approximately 34%, which is equivalent to the statewide average reduction.

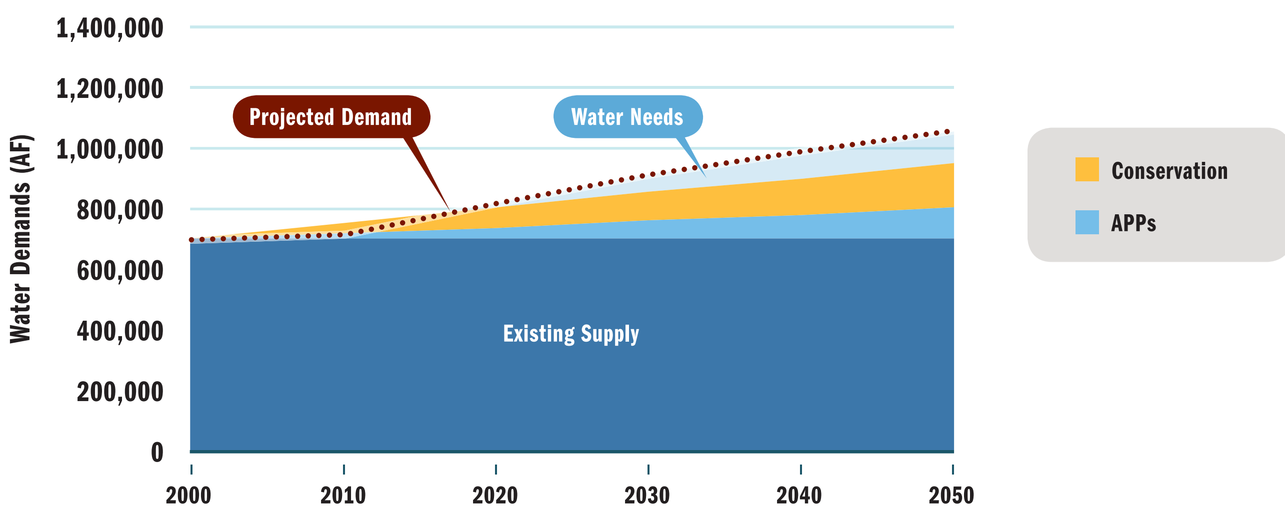
However, just as water supply projects are not built by themselves, water conservation savings must be achieved through concerted effort, and 40 years is a substantial amount of time to implement effective conservation programs and attain real water savings.

Each provider will differ on what it chooses to do with conserved water, putting it towards new customer demands, supply reliability, environmental mitigation, or some combination of the three. We conservatively assume that 60% of actively conserved water will be used to supply new customer demand, based on discussions with, and the past behavior of, water providers.

If the Front Range achieves a 34% reduction in per capita use, demand would be reduced by 362,000 acre-feet per year in 2050. Almost a third of these savings are attributable to passive conservation, equating to 106,000 acre-feet, leaving 256,000 acre-feet gained through active conservation. If 60% of the active conservation savings are dedicated to meeting new demands, 153,000 acre-feet of new water supply will be made available annually. This quantity is represented by the conservation wedge in Figure 6.

FIGURE Nº 6 ESTIMATE OF FRONT RANGE WATER NEEDS INCLUDING THE ACCEPTABLE PLANNED PROJECTS AND CONSERVATION STRATEGIES.

If 60% of active conservation savings are dedicated to meeting new demands, 153,000 acre-feet of new water supply could be made available annually to Front Range communities in 2050.



The Reuse Strategy

Ten years ago, the Denver area was utilizing over 50,000 acre-feet of reusable return flow water each year. Today, utilities are pursuing even more reuse opportunities. Providers are using abandoned gravel pits for storage of reusable supply and are directly reusing effluent for non-potable irrigation. As water treatment technology advances and reuse opportunities are maximized, it is reasonable to project that by 2050 there will be close to 200,000 acre-feet of direct and indirect reuse occurring annually on the Front Range.

Categories of Reusable Water

Water reuse is any arrangement that utilizes legally reusable municipal return flows to increase municipal water supplies. Return flows are water that returns to a river after being treated at a wastewater treatment plant or to alluvial aquifers via percolation. Reuse can be accomplished in at least two ways: 1) return flows can be physically reused for non-potable and potable purposes; or 2) return flows can be reused under various substitution or exchange arrangements.*

To increase water supply through reuse, municipal return flows must be legally reusable. Under Colorado water law, reusable water available to Front Range water utilities can generally come from the following sources:

- Water imported to the South Platte or its tributaries from another river basin
- Nontributary groundwater from Denver Basin aquifers
- The historically consumed portion of water rights changed from one use to another, such as from irrigation to municipal use
- Water diverted under a water right that has been decreed to allow for reuse

* An exchange is generally an arrangement in which one junior water user makes available to a senior user water owned by the junior (e.g., reusable effluent), in exchange for permission to use or divert an equivalent amount of water to which the senior user would otherwise be entitled.

Existing Reuse Along the Front Range

The Metropolitan Water Supply Investigation (MWSI) included an extensive analysis of water reuse in Front Range cities of the Denver metro area as of the late 1990s, and the potential for future reuse by the year 2030 and beyond.[40] The authors of the report developed a computational model and collected a substantial database. Information ranged from stream flow and diversion records to plans for reusable return flows. The goal was to establish estimates of current and future reuse in the Denver area. They also looked at reuse in other Front Range urban areas north of Denver, though in less detail.

At the time the MWSI was completed, Denver area water users were utilizing approximately 53,300 acre-feet of reuse water per year through various substitution arrangements and were directly reusing another 1,000 acre-feet for urban irrigation purposes (Table 2). About 80% of reuse was in the form of South Platte and Clear Creek exchanges; the balance consisted primarily of augmentation for alluvial wells in the Cherry Creek and Plum Creek Basins. As of 1999, less than 10% of the region's existing water supply was derived from reuse, but most water utilities were in the process of expanding reusable supplies.

TABLE Nº 2 SUMMARY OF REUSE IN THE DENVER METRO AREA IN 1999 (ACRE-FEET PER YEAR).*

Provider	Substitute	Direct Reuse	Total
Denver Water	22,000	0	22,000
Aurora	5,800	400	6,200
Douglas County†	2,400	600	3,000
Thornton	3,000	0	3,000
Westminster	3,700	0	3,700
Arvada	500	0	500
Other‡	15,900	0	15,900
TOTAL	**53,300**	**1,000**	**54,300**

* Data from MWSI.

† Includes all Douglas County Water Resource Authority providers.

‡ Includes Brighton, Broomfield, Englewood, Golden/Coors, Northglenn, SACWSD, and miscellaneous providers.

Issues Associated with Reuse

Potential limits to reuse include its cost, storage requirements, public acceptance, instream flow and water quality effects, and agricultural concerns. These concerns are legitimate and will require effort to resolve. Reuse, however, remains an integral and viable water supply option for the Front Range.

Cost

Direct reuse (potable or non-potable) can be costly from both a capital and O&M (operations and maintenance) perspective. The CWCB estimates direct non-potable reuse to cost approximately $7,000 per acre-foot, including infrastructure requirements. Costs for indirect potable reuse are estimated to be $13,500 per acre-foot.[41] Denver Water and Aurora both indicate that costs for their reuse projects are high, but are not yet in positions to provide firm values.*

The costs of a potable supply project using a combination of return flow from the Metropolitan Wastewater Treatment Plant (Metro) and diversions from the South Platte River will be high. The water quality in the South Platte River below Denver is variable due to upstream wastewater discharges, storm water events, and other forms of nonpoint source pollution. Designing a potable supply project to accommodate such water quality variability will be particularly challenging.

However, in areas where tertiary treatment of wastewater return flow is already required and where the water quality of the receiving stream is relatively high, the costs of potable reuse may be lower. Higher water quality standards in the future are likely to decrease the incremental expense of reuse. Furthermore, the CWCB estimates that some new supply projects may range between $30,000 and $40,000 per acre-foot for capital costs and an additional investment of $1,000 per acre-foot for operations and maintenance — substantially more expensive than reuse.[42]

Recycled water projects use “purple pipe” to convey supply from the treatment plant to the point of use.

* Both Denver Water and Aurora are well along with their reuse projects, but because they are complicated, the utilities are still in the process of developing reliable cost estimates, according to personal communications with representatives of Denver Water and city of Aurora, June 2010.

Storage Requirements and Utility Cooperation

Storage will be necessary to regulate the timing, treatment, and redistribution of reuse water. The amount of storage is dependent on not only the level of reuse activities and the number of participants involved, but also the willingness of the participants to develop an integrated approach to storage development and management.

Storage needs decline when systems are integrated. For example, Denver Water determined that it would need approximately 12,000 acre-feet of return flow storage to maximize its exchange yields and to reliably deliver 15,000 acre-feet of non-potable reuse water. In making this determination, Denver Water assumed that it would be using its own reusable return flow from the Metro treatment plant as a sole supply for its non-potable reuse plan. The authors of MWSI, by contrast, considered return flow storage requirements from an integrated perspective. Available supplies included Denver Water's reusable return flow, Aurora's reusable return flow, and free river supplies on the South Platte at the Burlington Ditch (with its headgate just upstream of the Metro outfall). These three supplies were used to meet Denver Water's and Aurora's exchange opportunities and to supply Denver Water's 15,000-acre-foot non-potable reuse project. The results of this analysis indicated that the total return flow storage requirement for meeting these three demands could be reduced to less than 3,000 acre-feet, illustrating the reduced storage requirements of integrated operations.

Public Acceptance of Potable Reuse

Direct potable reuse of wastewater is still uncommon in the U.S. In places where it has been implemented or seriously considered, public acceptance has been generally favorable, provided that adequate research, education, monitoring, and oversight activities are completed. A key focus of education is to explain the high level of water quality treatment being utilized to make the water safe to drink. Public acceptance of potable reuse in Front Range communities will take time, but already has grown over the past decade. Further education and outreach will help increase acceptance of potable reuse as a source of supply.

Instream Flow Issues

Instream flow requirements between upstream points of diversion and downstream points of return flow release can limit exchange potential for indirect reuse projects. Below Strontia Springs Dam, for example, federal permit conditions require Denver Water to bypass water during certain times of the year. Denver Water has access to approximately 10,000 acre-feet of storage in Chatfield Reservoir for use in recapturing bypass flows, but Denver Water's opportunities to exchange water recaptured in Chatfield back to Strontia Springs are limited by operational constraints that are designed to protect Chatfield recreational uses.

Currently, there is no formal instream flow protection requirement for the South Platte River below Chatfield Reservoir. While the CWCB is not pursuing an instream flow right, work is underway to develop and improve recreational amenities, wildlife habitat, and scenic values in the South Platte corridor. This effort includes an analysis of the amount of instream flow that may be necessary to maintain water quality, aquatic habitat, scenic values, and recreational activities, such as rafting and kayaking. Official instream flow requirements for the South Platte below Chatfield will reduce exchange potential.

Water Quality Issues

Water quality in the Denver metro reach of the South Platte River may be impacted by indirect reuse as a result of increased upstream diversions. Exchanges to upstream points of diversion could substantially reduce instream flows below Chatfield Dam at certain times of the year. These stream flow reductions would decrease the assimilative capacity of the stream, resulting in higher concentrations of pollutants from both point and nonpoint sources. Notably, the greatest exchange potential occurs during the spring and early summer, when stream flows are highest, and thus there is a substantial amount of dilution water available. It is unlikely that exchanges would substantially impact the operation of downstream wastewater treatment plants because effluent limits for those plants are typically based upon low stream flow conditions when there is little or no exchange potential.

Wastewater treatment plant.

Energy Implications of Reuse

Reuse typically uses less energy than some new water supply proposals, but it is certainly not zero. Because most utilities already treat wastewater to secondary or tertiary standards before discharging it to rivers, to implement reuse strategies, utilities only need to expend the incremental energy required to bring water from secondary or tertiary standards up to end-user standards.

For the WISE and Prairie Waters reuse projects to be both water- and energy-smart, they should commit to meeting a portion of their energy demands with renewable sources of energy. Regulated electric utilities in Colorado must meet a 30% renewable energy standard by 2020; that is, 30% of their electricity sold in Colorado must be generated by qualifying renewable resources. At a minimum, new water supply projects should meet the same standard; 30% of a water project's energy demands should be met with renewable sources of energy.

Agricultural Perspective

Indirect reuse in the Denver metro area would result in agricultural producers in the lower South Platte Basin using treated return flows for irrigation water. This gives rise to concerns regarding the potential environmental and economic impacts on crop production, public health, and worker safety. Acceptable water quality requirements for various agricultural applications are not well-defined and continue to be the subject of much debate. The primary concerns for irrigated agriculture in treated wastewater return flow are pathogenic organisms, nutrients, salinity, and trace elements. Although wastewater treatment plants must meet state water quality standards, the experience of agricultural users in other states suggests that reuse water can be a viable supply.

Future Reusable Water Supplies

According to the MWSI, the amount of water potentially available for reuse to the Denver area was approximately 133,000 acre-feet per year as of the late 1990s. Based on utilities' plans for development of additional water sources over the succeeding 30 to 50 years, the reusable return flow supply was expected to increase to about 268,000 acre-feet per year (Table 3).

TABLE Nº 3 DENVER AREA REUSABLE SUPPLIES AND RETURN FLOWS (ACRE-FEET PER YEAR).*

Provider†	Reusable Supply (1999)	Future Reusable Supply‡
Denver Water	50,000	95,000
Aurora	26,000	38,000
Douglas County	11,000	46,000
Thornton	5,000	24,000
Westminster	4,000	5,000
Arvada	1,000	2,000
Other	11,000	18,000
Subtotal	**108,000**	**228,000**
Reusable LIRF's§	25,000	40,000
TOTAL	**133,000**	**268,000**

* Data from MWSI.

† Same user groups as Table 2.

‡ Cumulative estimate, includes reasonably certain supplies.

§ Lawn irrigation return flows (LIRF).

Future Plans for Reuse

According to the CWCB's recent study of IPPs, immediate plans for additional Denver area and northern Front Range reuse total between 20,000 and 28,000 acre-feet.[43] According to the MWSI, future plans for reuse in the Denver metro area alone total 171,000 acre-feet per year by 2050. This consists of substitution and exchange agreements as well as some non-potable direct reuse. Adding the metro area WISE Partnership project to Denver Water's direct reuse (10,000 acre-feet), and substituting the Prairie Waters project for Aurora's direct reuse (10,000 acre-feet)* — neither of which were envisioned when MWSI was completed — we estimate future reuse at 184,300 acre-feet per year (Table 4). Importantly, this estimate does not include the reuse opportunities available to water utilities north of the Denver metro area, which MWSI estimated to be about 15,000 acre-feet.

TABLE Nº 4 SUMMARY OF REUSE PLANS IN THE DENVER METROPOLITAN AREA (ACRE-FEET PER YEAR).*

Provider(s)†	Substitute (Future)	Direct Reuse (Future)	Total (Future)
Denver Water	42,400	25,000‡	67,400
Aurora	8,200	10,000‡	18,200
Douglas County	23,500	3,500	27,000
Thornton	24,500	4,000	28,500
Westminster	4,900	1,500	6,400
Arvada	1,900	3,300	5,200
Other	28,600	3,000	31,600
TOTAL	**134,000**	**50,300**	**184,300**

* Data from MWSI.

† Same user groups as Table 2.

‡ Modified from MWSI estimates, see explanation in text.

* The MWSI estimated Aurora's future plans for reuse at 7,000 acre-feet. The first phase of the Prairie Waters Project is 10,000 acre-feet, so the actual increase to Aurora's future reuse plans is 3,000 acre-feet.

Estimate of Front Range Reuse

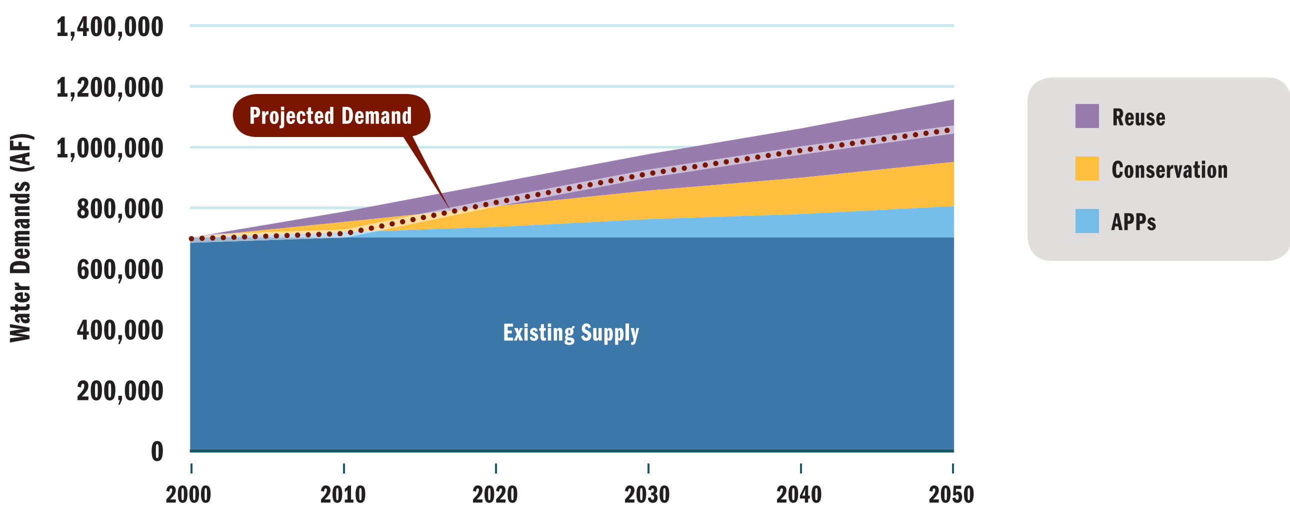
Ultimate levels of reuse could exceed 500,000 acre-feet per year.

Ultimate levels of reuse could potentially exceed 500,000 acre-feet per year, assuming that providers: 1) develop the full amount of reusable supplies currently included in their water supply plans; 2) obtain decrees to reuse all of their legally reusable return flows; 3) reuse to extinction all of their legally reusable supplies via substitution, non-potable reuse, and potable reuse; and 4) have sufficiently large demands for water.

For the purposes of this report, we assume that reuse, direct and indirect, in the Denver metro area will reach 184,300 acre-feet by 2050, and that reuse north of Denver will reach 15,000 acre-feet, for a total of 199,300 acre-feet. This quantity is represented by the reuse wedge in Figure 7.

FIGURE Nº 7 ESTIMATE OF FRONT RANGE WATER NEEDS INCLUDING THE ACCEPTABLE PLANNED PROJECTS, CONSERVATION, AND REUSE STRATEGIES.

Existing and future plans for reuse along the Front Range could total 199,300 acre-feet annually by 2050.



A fine catch.

Harvest time at a Boulder farm.

While the agricultural community may view the growing urban demand as a threat, it is also an opportunity.

The Ag/Urban Cooperation Strategy

The MWSI determined there could be as much as 495,000 acre-feet of agricultural water available annually for sharing with South Platte municipalities.[44] Voluntarily sharing almost any of it would require both additions to the physical infrastructure of existing supply systems in the South Platte Basin and agreements that protect the interests of parties who might wish to enter the cooperative arrangement. If systems are integrated, and agreements between irrigators and municipalities reached, it is reasonable to expect that municipalities could utilize 120,000 acre-feet of agricultural water annually by 2050 without permanently drying irrigated acreage.

Front Range Ag/Urban Cooperation

Agricultural and urban land use patterns in the South Platte Basin have changed dramatically in the last 30 years. Driven to some extent by rapid urban growth, but also other factors more directly related to agriculture, there has been a substantial reduction in irrigated acres from a high in 1976 of 1.02 million acres to approximately 840,000 acres in 2005. The CWCB projects this trend to continue.

Over the past 10 years, there have been intrabasin discussions regarding the benefits associated with sharing information on supply, demand, and system operations. In particular, the SWSI process has detailed the benefits and shortcomings of voluntary ag/urban sharing concepts, which depend, almost without exception, on planned and periodic reductions in irrigation water use. These issues are also now under discussion with some regularity in the basin roundtables and at the Interbasin Compact Committee.

The major benefit of ag/urban sharing arrangements to agricultural interests would be the opportunity to lease water at an attractive price on a schedule established well in advance of actual re-allocations of water. Innovative arrangements, such as rotational fallowing, interruptible supply agreements, water banks, crop changes, and deficit irrigation, could allow for temporary transfer of irrigation water to municipal uses without permanently drying irrigated lands.

While the agricultural community may view the growing urban demand as a threat, it is also an opportunity. As SWSI II states in the "Alternative

The opportunity for agricultural communities to generate a return on a resource that has an ever-increasing value in urban centers, while not losing control of the resource, could be beneficial.

Agricultural Water Transfer Methods" section, water sharing arrangements can "provide more stable incomes to agricultural users." The opportunity for agricultural communities to generate a return on a resource that has a high and ever-increasing value in urban centers, while at the same time not losing control of the resource, could be beneficial.

Ag/Urban Cooperation Examples

The coupling of voluntary land fallowing and water leasing is not unprecedented. It has been utilized in Colorado on both a short-term basis, such as with the Aurora-Rocky Ford High Line lease from 2004-2005, and on a long-term basis, as in the agreement between the Fort Morgan Water Company and Xcel Energy.* From Xcel's point of view, the Fort Morgan agreement has been so successful that it has now entered into a contract with the North Sterling Irrigation District, using a drought insurance concept in which the power company pays the district an annual premium or option payment for the right to 3,000 acre-feet, and then pays a specified price for the water, if needed.

Irrigation ditch with three headgates.

In the Arkansas River Basin east of Pueblo, another substantial fallowing-leasing cooperative is being established with the creation of the Super Ditch Company. The basic concept of the Super Ditch is to pool water rights from several Arkansas River ditch companies to create a centralized entity from which municipalities can lease water. **As of January 2011, more than 1,000 ditch shareholders have indicated an interest in the lease agreements proposed by Super Ditch, with some ditches capturing the interest of over 80% of their shareholders. The Super Ditch Company believes it will be in a position to lease 20,000 acre-feet of water, or more, to municipalities in the coming years.**[45]

Beyond Colorado, perhaps the best known example of a fallowing agreement is the Metropolitan Water District of Southern California-Palo Verde Irrigation District program. With all of these successful examples, and with Front Range utilities continuing to consider costly and problematic proposals to draw additional supplies from the Colorado River, ag/urban cooperation deserves serious attention.

* The Fort Morgan-Excel agreement is a "take or pay" contract for up to 2,500 acre-feet of augmentation water for Xcel's Pawnee wells, which supply cooling water to the Pawnee Power Plant. If available, Xcel purchases augmentation credits; otherwise, Jackson Lake Reservoir water owned by participating Fort Morgan shareholders is delivered via canal to Xcel's Pawnee Power Plant. The delivery period is April through November, and the monthly amount is between 200 and 500 acre-feet.

Systems Integration

The concept of systems integration involves the cooperative use or enhancement of several water supply systems in a manner designed to increase total yield. In mature river basins like the South Platte, with a large number of urban and agricultural water users that are linked but not completely combined, systems integration would enhance the opportunities for conjunctive use of surface and groundwater, return flow management and reuse, and ag/urban cooperative arrangements. All of these measures could increase the firm yield of participating urban users.

Systems Integration Examples

Implementing a cooperative ag/urban water supply agreement will likely require conveyance and storage infrastructure; using existing infrastructure would minimize economic and environmental costs associated with developing new facilities.[†] For example, some water planners view existing Colorado-Big Thompson (C-BT) facilities as a possible system for conveying water to the metro Denver area. While it is the position of the Northern Colorado Water Conservancy District (Northern Water) that the facilities of the C-BT and Windy Gap Projects are legally dedicated to the sole use of water users within its boundaries and may not be used for the benefit of the Denver metro area without a new federal law, a conceptual analysis is warranted.

Consider, for example, an ag/urban agreement between a ditch system or systems (A) located within Northern Water's boundaries and a municipal water user (B) located in the metro Denver area, in which A agrees to make water available to B via an interruptible supply and substitution agreement. Under the agreement, some irrigators in A (call them participants) deliver some of the water from their native (non-C-BT Project) water rights to other irrigators in A (call them non-participants) at a time when the non-participants would otherwise be taking delivery of their C-BT Project water. This "substitute delivery" reduces the non-participants' demand for their C-BT Project water. In essence, the participants' native water is exchanged into the C-BT Project system (say at Carter Lake), from which point it would be delivered to B in the Denver metro area from Carter Lake via a new pipeline.

This operational scheme would have to be developed so as to avoid impacts to C-BT and Windy Gap Project deliveries, and there are a number of

† As an example, delivering an additional 40,000 acre-feet of irrigation water annually to the Denver metro area might require in the neighborhood of 80,000 acre-feet of storage and additional pipelines to move water north to south.

operational issues that would have to be addressed and resolved. Furthermore, any such use of C-BT Project facilities would likely require legal and institutional changes and require the consent of Northern Water and the U.S. Bureau of Reclamation. Nevertheless, it is an option worthy of further consideration.*

There are other opportunities as well. Metropolitan water utilities like Aurora Water and East Cherry Creek Valley WSD are building their own projects that will tap agricultural water and other useable or reuseable water to the north. East Cherry Creek completed the first phase of its Northern Pipeline in 2006 and Aurora recently completed its Prairie Waters Project, another pipeline that will bring water south into the Denver metro area. These systems are linked, either directly or by proximity, with the irrigation systems farther downstream in the South Platte. Of course, to the extent that sharing scenarios involve water systems that have transbasin infrastructure, such as that of Denver Water, Aurora, or Northern Water, it would be imperative that arrangements be structured to prevent those systems from being used to increase transbasin diversions.

Issues Associated with Ag/Urban Cooperation

Potential hurdles to voluntary ag/urban cooperation include agricultural community concerns and instream flow issues. These concerns are legitimate and will require effort to resolve. However, ag/urban cooperation remains an integral and viable water supply option for the Front Range.

Agricultural Community Concerns

Ag/urban sharing agreements must meet the needs of the agricultural community. Leasing cooperatives and leasing agreements that involve a number of ditch companies and irrigation districts (e.g., the Super Ditch Company) will help to address agricultural needs. There are no fixed rules for how such contracts must be structured, but at a minimum, they will have to address the following issues, some of which were discussed in SWSI Phase II:

- All transfers of water from agriculture to the municipal sector must be based on a willing buyer/willing seller model.

* Use of C-BT facilities to deliver water from sources along the foothills would eliminate the need for reverse osmosis as a water treatment unit process to reduce total dissolved solids to acceptable levels (400 mgl). However, for large urban systems like Denver Water, capturing water east of the foothills (downstream) of major wastewater treatment plants might still not require reverse osmosis, because of the large systems' capacity to blend this water with existing supplies to reach limits for total dissolved solids. Personal communication with David Little (Denver Water), August 7, 2010.

- Temporary transfers must be protected against claims of forfeiture for non-use or loss of priority.

- A balance must be struck between farmers' preference for short-term arrangements and municipal utilities' interest in long-term arrangements.

- Transfers should be shareable among multiple participating farmers in order to provide flexibility.

- Transfers must not affect the water supplies of non-participating farmers or ditch companies.

- Market tiers and associated prices must be established to allow participation by entities with water of varying reliability.

- The structure, if not the details, of agreements must be standardized to reduce time and administrative commitments necessary for both their negotiation and implementation.

TABLE Nº 5 ESTIMATE OF GROSS SUPPLY POTENTIAL FOR AG/URBAN COOPERATION IN THE SOUTH PLATTE BASIN (ACRE-FEET PER YEAR).

Sub-Basin	Average Dry-Year Supplies Owned by Agriculture with Diversions Above Greeley*	Average Clean Dry-Year Supplies† with Diversions Above Greeley*
South Platte above Chatfield‡	8,000	8,000
Bear Creek	~0§	~0§
Cherry Creek	~0§	~0§
Clear Creek	13,000#	4,000#
South Platte (Chatfield to Metro)	54,000	~0
South Platte (Metro to Big Thompson)	151,000	~0
Boulder Creek	49,000	24,000
St. Vrain / Left Hand	49,000	24,000
Big Thompson	73,000	47,000
Cache La Poudre	111,000	74,000
TOTAL	**495,000**	**190,000**

* These numbers are estimates; only major ditches have been considered. Numbers listed may include ditch diversions that serve areas within a municipality's planning area. Annual dry-year diversions based on data from 1954, 1955, 1963, 1964, 1966, 1977, and 1981.

† "Clean" means diversion does not occur downstream of a major WWTP.

‡ "South Platte above Chatfield" includes South Park ditches (including North Fork South Platte), which are expressed as depletions, not diversions.

§ ~0 = insignificant.

Average annual for period of record (dry-year numbers not readily available; values not included in total).

Instream Flow Issues

The most likely ag/urban sharing arrangements for the Front Range would involve irrigators north of Denver and urban suppliers in the Denver metro region. To the degree that ag/urban agreements result in increased diversions at upstream locations, flows in intervening stream reaches would be diminished. This could affect water quality, environmental, and recreational interests. However, agreements can be structured in ways that minimize and mitigate these impacts.

Estimate of Water Available via Ag/Urban Cooperation

Geographically, the majority of available water supply for ag/urban sharing lies to the north of the Denver metro area. Native flows of the major tributaries to the South Platte between Denver and Greeley (Poudre River, Big Thompson River, St. Vrain River, and Boulder Creek) average almost 700,000 acre-feet per year (Figure 9). Not all of this water is used by agriculture, but a substantial portion is, and some fraction could be made available for cooperative agreements between cities and irrigators.

FIGURE Nº 8 ESTIMATE OF FRONT RANGE WATER NEEDS INCLUDING THE ACCEPTABLE PLANNED PROJECTS, CONSERVATION, REUSE, AND AG/URBAN COOPERATION STRATEGIES.

We assume 120,000 acre-feet of water could be made available annually through voluntary, cooperative ag/urban agreements without permanently drying irrigated lands.

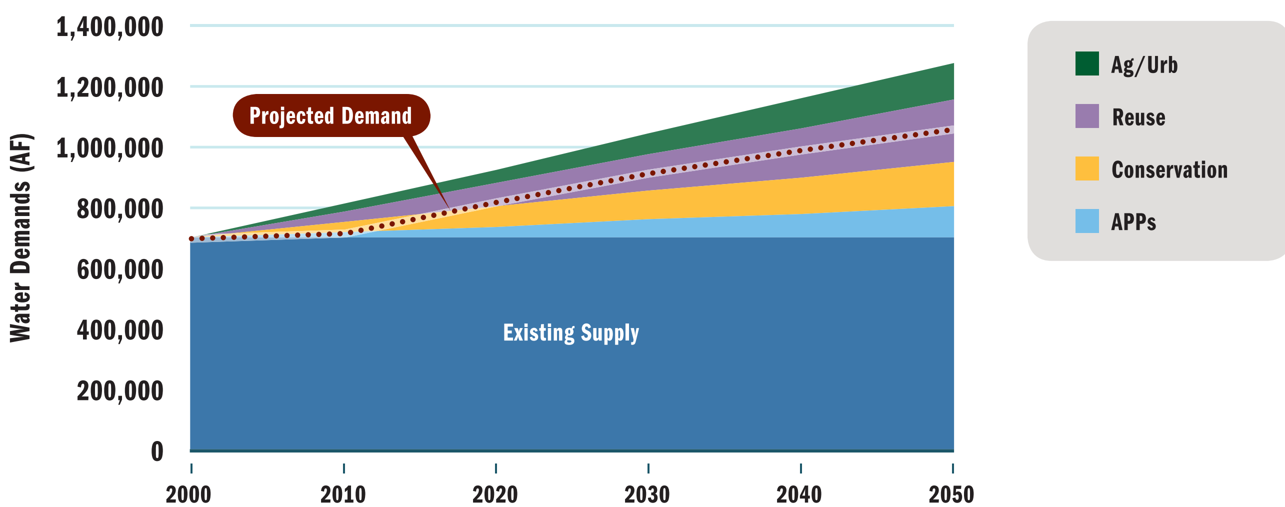
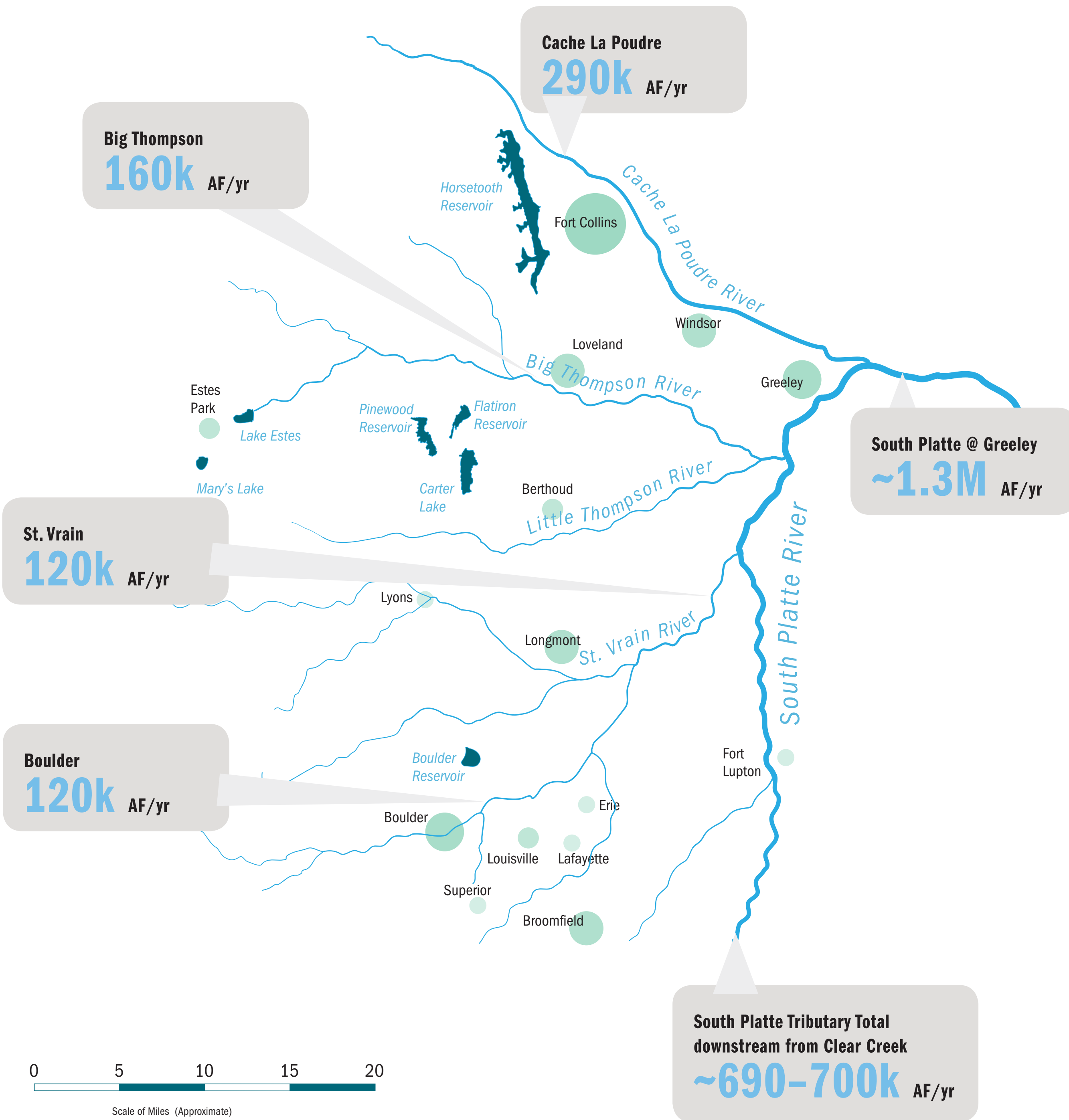


FIGURE Nº 9 SOUTH PLATTE TRIBUTARY AVERAGE ANNUAL NATIVE FLOWS.

Geographically, the majority of available water supply for ag/urban sharing lies to the north of the Denver metro area. Native flows of the major tributaries to the South Platte between Denver and Greeley average almost 700,000 acre-feet per year. Not all of this water is used by agriculture, but a substantial portion is, and some fraction could be made available for cooperative agreements between cities and irrigators.



The MWSI estimated gross quantities of *dry-year water*—a more conservative estimate than the annual average—that might be available for ag/urban transfer on a sub-basin level. The report presents two sets of estimates: dry-year supplies of 495,000 acre-feet and "clean water" dry-year supplies of 190,000 acre-feet—"clean water" referring to diversions that are upstream of a major wastewater treatment plant (Table 5). Some fraction of this water could be moved to municipal uses via voluntary, alternative agricultural transfer arrangements, such as rotational fallowing, crop shifting, or interruptible supply contracts that do not require permanent drying of irrigated acres.

If the necessary infrastructure and agreements were in place, we assume that roughly 25% of the average dry-year supplies (495,000 acre-feet) could be made available annually for ag/urban cooperation, without permanently drying irrigated lands. This would be 120,000 acre-feet per year by 2050, as shown by the ag/urban wedge in Figure 8. According to the CWCB's recent study of IPPs, immediate plans for agricultural transfers in the Front Range total between 40,000 and 53,000 acre-feet.[46]

Energy Implications of Ag-Urban Sharing

The location and configuration of ag/urban sharing agreements will determine their energy requirements. Agreements that divert water high in the basin (i.e., above the Denver metro area and most farming operations) will generally be less energy-intensive because source water is of higher quality, requires less treatment, and could be delivered via gravity. By contrast, arrangements that use water from lower in the basin would involve higher treatment and pumping requirements, and would thus be much more energy-intensive.

Afternoon light on the Front Range.

Recommendations

Water is critical to every component of life in Colorado. The high quality of life we enjoy in this state is at risk, however, unless decision-makers in Colorado shift to more innovative, balanced, and cost-effective approaches for supplying water to our growing population while sustaining our rivers and streams. This report lays out a portfolio of water supply strategies for meeting the future water needs of Front Range communities in the South Platte River Basin without sacrificing the rivers of our majestic headwaters state (Figure 10). We must look beyond old ways of thinking and realize we have many solutions for meeting our future water needs. Today's choices are critical.

Based on rigorous data analysis, this report offers several key recommendations that water planners and policy makers should consider carefully in forging Colorado's water future:

- Close the projected Front Range "gap" with balanced strategies that are more cost-effective and environmentally friendly than transbasin diversion projects.

- Protect Colorado's rivers, streams, and lakes as an integral part of any future water development strategy. Non-consumptive uses of water—for fishing, whitewater recreation, and other uses—are worth billions of dollars annually to our state economy and are critical to the quality of life in this state.

- Pursue only those Identified Projects and Processes that can be constructed and operated according to the "smart" principles delineated in this report.

- Implement more aggressive water conservation strategies. Conservation is often the cheapest, fastest, and smartest way to gain "new" water supply, and many Front Range utilities have significant opportunities to boost their existing water conservation efforts.

- Listen to Front Range homeowners, who consistently express a willingness to adopt enhanced conservation measures in order to protect rivers and other mountain resources.

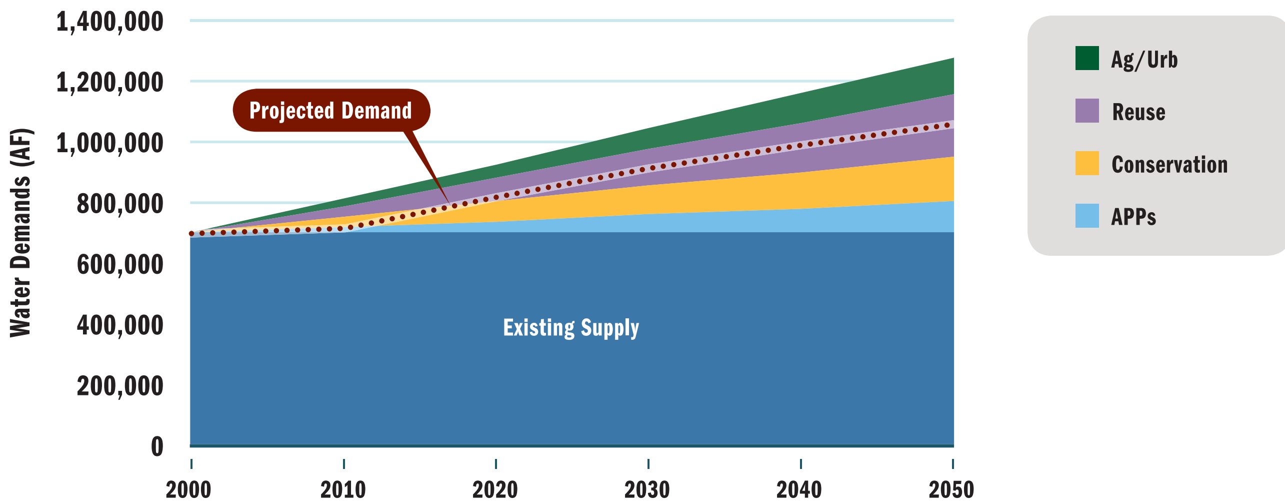
- Maximize the role of water reuse in meeting the future needs of Colorado's residents, and work to improve public perception and acceptance of reuse projects.

- Cooperate with agriculture on voluntary water sharing agreements that benefit both municipalities and the agricultural community without permanently drying irrigated acres. Alternatives to "buy and dry" transfers present the best opportunities for our future.

By following these recommendations, Colorado can more than meet the future water needs of its northern Front Range communities while minimizing impacts to the state's rivers and streams.

FIGURE Nº 10 OUR PORTFOLIO FOR MEETING FRONT RANGE WATER DEMANDS.

Our balanced portfolio of water supply strategies more than fills projected needs in South Platte Basin Front Range communities while protecting Colorado's environment.



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Western Resource Advocates is a nonprofit environmental law and policy organization dedicated to protecting the West's land, air, and water.

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Colorado Environmental Coalition works to protect Colorado's environment by educating and mobilizing citizens, providing technical and organizing assistance to environmental organizations and other allies, and uniting and supporting them in coalitions that defend and preserve Colorado's natural heritage and quality of life.

"Unprecedented unknowns and uncertainties are ahead for Colorado's water resources. The Colorado Environmental Coalition, Trout Unlimited, and Western Resource Advocates are right. All the players in water decisions, from users to regulators, must think anew and create new procedures and laws to deal with these uncertainties. The days of traditional flow projections and 'heaven help the hindmost' mitigation plans are over!"

—George B. Beardsley,
Denver Water Board Member 2004 to 2009,
Municipal Water District Director, and Agricultural Irrigator