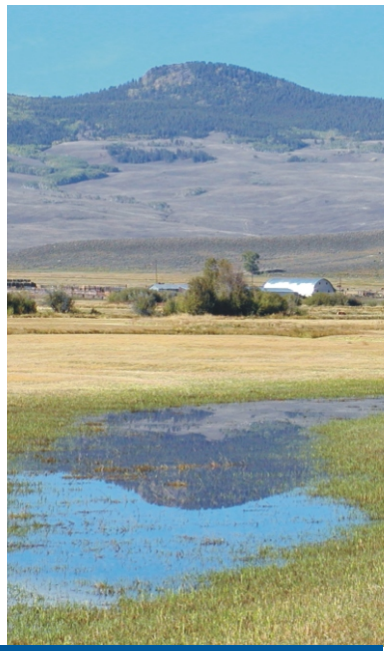
COLORADO
DEPARTMENT OF NATURAL RESOURCES

SWSI
Statewide Water Supply Initiative

COLORADO WATER CONSERVATION BOARD
STATE OF COLORADO
1876
1937

Colorado Water Conservation Board



Statewide Water Supply Initiative

November 2004

Executive Summary

CDM

STATE OF COLORADO

Department of Natural Resources
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, Colorado 80203

Statewide Water Supply Initiative

FOREWORD

November 15, 2004

Fellow Coloradans:

Just a few years ago Colorado celebrated our oldest water right, which at over 150 years old predates Colorado becoming an independent state. Much has changed over the last 150 years, and yet the celebration of this water right is a reminder of our roots and the importance water has played in shaping our state.

Colorado entered the new millennium on the heels of the largest population growth in our state's history. This growth coincided with a relatively wet cycle in which we enjoyed above normal snowfall and precipitation. But all this changed at the end of the 1990s and the first years of the new century with the onset of several very dry years. In some areas of the state, 2002 was the driest year in recorded history.

The last few years are a stark reminder of the importance water plays in our lives; from ranchers on the western slope to those living in Colorado's cities and towns, from farmers on the eastern plains to recreationalists who enjoy our lakes, rivers, and streams. We all depend on water for our survival.

As we look to the future, the wise and thoughtful management of this resource has never been more important. But the need to prepare for our water future goes beyond drought. By the year 2030, another 2.8 million people are going to call Colorado home – a 65 percent increase. Most of these new Coloradans will live along the Front Range urban corridor; the communities that will experience the greatest percentage increases will be on the Western Slope and central mountains.

In light of these changes and challenges, the 2003 Colorado General Assembly authorized the Colorado Water Conservation Board to implement the Statewide Water Supply Initiative (the "Initiative"), an 18-month basin by basin investigation of our existing and future water needs. This was an unprecedented effort. Never before in the history of the state have we developed such a comprehensive picture of our water future. Never before have we assembled all water users – farmers, ranchers, municipalities, industrial users, recreationalists, environmentalists – to look at our future. Never before have we gone to each of Colorado's eight major river basins to explore how much water they use today, how much water they need in the future, and how local water providers are planning to meet that need.

Conducting this study was no easy task. Water is controversial and contentious, and the tensions and conflicts at times have spanned generations. Water is an issue that goes to the core of who we are and what we can be as a state. As a result, this study needed to proceed thoughtfully and strategically, always in respect of the role and jurisdiction of local water providers.

But with the help of hundreds of Coloradans, that is what the Statewide Water Supply Initiative did, and the end result is invaluable. For the first time, we know:

- How much water Colorado will need in 2030, basin by basin;
- What is being done to address our water needs, statewide and by basin;
- How much we are short, and where we are short; and
- What is being done, and what more can be done, about the shortfall.

This information will provide the critical foundation for local water providers and other decision-makers to ensure that we take the necessary steps to provide Coloradans with a safe and reliable water supply.

The Initiative raises serious issues. What will we do to address the impact of losing more than 400,000 acres of irrigated farmlands that will be taken out of production as water is transferred from agricultural to municipal use? What will we do about the dozens of smaller, rural water providers that don't have the financial and planning resources they require to plan and build much needed projects? What steps can be taken to protect the rapidly depleting and non-renewable groundwater upon which many Colorado communities rely? How can we ensure protection of our natural environment? These and other issues will be important for state and local decision-makers to address.

This report does not provide all the answers. No single study can answer questions that have been challenging the best minds of the state for decades. But what SWSI does is provide a common foundation from which all Coloradans can work together to forge solutions that meet all of our needs.

SWSI is not an end – it is a beginning. The next phases of the Initiative will explore issues that reach across river basins and will examine in more detail opportunities to develop and protect our water resources. But even beyond these next phases, SWSI should continue well into the future, not as a state-sponsored study, but as a forum for collaboration and cooperation that brings together all water users across all regions of the state to map out our water future. It is this kind of approach that offers us the best hope for our future.

Russell George
Executive Director
Colorado Department of Natural Resources

Keith Catlin
Chair
Colorado Water Conservation Board

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The Statewide Water Supply Initiative

A Collaborative Assessment of Future Water Needs and Solutions

Preface

Water in Colorado has always been both a source of life and an agent of change. Its path has carved our topography and shaped our culture. Aside from the air we breathe and land we inhabit, no natural resource is more precious. Nothing in the future will have a greater impact on our ability to sustain our way of life and preserve our environment for future generations than water.

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From urban communities along the Front Range, to farming communities in the Lower Arkansas Valley, to the peach orchards and sweet corn fields of the Grand Valley, and the majestic outdoor settings of the Yampa and Gunnison Valleys, water has supported our livelihoods, enabled our quality of life, and sustained our communities and our environment.

In Colorado, the need for wise management of water and the equitable rights to its beneficial use led to the creation of a legal framework of water rights that is a model for the arid states of this nation. Known as the Prior Appropriation Doctrine, this system has served Colorado citizens for over a century of growth and prosperity. It will continue to provide the foundation for water administration and allocation for centuries to come. But new forces and relentless change compel us to more completely understand and efficiently use our water resources, and complement our tradition with both new approaches and contemporary tools.

The variability of supply and periodic scourge of drought, the growth in population and increase in urbanization, the threat to wildlife and loss of habitat, the desire of tourists from around the world to spend their free time in Colorado, the economic opportunities and sought-after quality of life offered by Colorado – and the many other changes in our lifestyles, our interests, our aspirations, and our means are reshaping Colorado as dramatically as our rivers have changed the landscape, and is doing so far more rapidly.

A previous generation of leaders who saw the need to divert and store water for beneficial use built projects like the great series of irrigation canals constructed in the late 1800s that tapped the resources of the Rio Grande to meet the irrigation and supply needs of the San Luis Valley; and the Cheesman Dam, built in 1905 to address Denver's water storage needs; and the Colorado-Big Thompson Project, built in the 1940s and 1950s to bring water across the Continental Divide for beneficial use to northeastern Colorado. We owe much to these visionaries and their commitment to meet the future needs, the very needs we are currently meeting with the water supplies from these projects.

And yet, the Colorado of our forefathers is very different from the Colorado we live in today. On becoming a state, Colorado had a population of 26,000. Today, it is home to over 4 million people. At the turn of the last century, just over 20,000 people lived in Delta, Garfield, and Mesa counties. By the year 2000, that number had increased more than 900 percent to a total of nearly 190,000. In 1876, farming and mining were our primary ways of life. Today, these important industries are joined by technology, tourism, recreation, transportation, financial services, and many other sectors that comprise our diverse economy.

Just as our state has changed, so too has our use of water. Historically, we used our water primarily for mining, agriculture, and industry, and later for municipal purposes as our population grew. Today, recreational activities such as skiing, fishing, and other water-based recreation are an important part of the economy in many communities – communities that experienced significant hardship during the historic low flows of 2002. Environmental needs, such as fish and wildlife habitat, were viewed differently when much of our water infrastructure was built (and our legal framework was developing). Interstate compacts place significant additional requirements on water supplies originating in Colorado, requiring deliveries to downstream states, but also help meet environmental needs within the state. The biggest change, however, has come from the population growth itself, which has forced water providers to

constantly look for new ways to supply their customers with a reliable source of water to meet their daily needs.

Colorado benefited from some relatively wet years in the latter part of the 20th century that, to some extent, masked the full impact of these changes. That ended with the new millennium and the onset of one of the most serious droughts that Colorado has faced since well before it became a state. Reservoir levels hit record lows in 2002 and have yet to fully recover. Municipal water providers across the state were forced to implement significant water use restrictions, and there is concern about the ability of our rivers to supply downstream states with their compact requirements. Agriculture, recreation, municipalities, and the environment suffered serious hardship.

Looking forward, it is hard to predict what Colorado will look like in the coming decades. We do know, however, that 2.8 million more people are expected to call Colorado home by the year 2030. Most of these new residents, almost 2.4 million, will live along the Front Range, but the greatest percentage increases will be seen in the Western Slope and mountain communities. We know these new residents will need water, more water than can be delivered today. Conservation will play an important role, but conservation alone cannot meet all these requirements. New storage projects will be needed and must be pursued, but these can take years or even decades to permit and construct and their success is uncertain. In this setting, cities will increasingly look to agricultural water to meet their needs, creating impacts on rural Colorado that need to be recognized and addressed.

Against this backdrop of change and drought, the Colorado Water Conservation Board (CWCB) determined that it was important to understand and prepare for our long-term water needs.

Beginning in 2001, the CWCB, through its strategic planning process, became very proactive in determining how Colorado uses water, how it will use water in the future, and evaluating how well we are prepared for drought. In 2001 to 2002, CWCB held a series of meetings in each river basin (shown in Figure ES-1) to outline basic issues on water use in Colorado. This effort culminated in the development of Basin Specific Fact Sheets. Later in 2002, a second set of fact sheets were developed outlining water use, growth, and water demand.

These initial efforts were designed to help Coloradans better understand how we are using our water supplies and to begin to understand major issues regarding water resource management and development. In 2001, CWCB also began to think about conducting an assessment of our drought preparedness. This effort culminated in the completion of the Drought and Water Supply Assessment in February 2004.

These previous efforts produced valuable information and set the stage for a more comprehensive and complete analysis of water supply and demands throughout Colorado. The data and information from these studies helped guide the development of what would become known as the Statewide Water Supply Initiative (SWSI).

With the approval of the 2003 General Assembly, CWCB commissioned SWSI, an 18-month study to explore, basin by basin, existing water supplies and existing and projected demands through the year 2030, as well as a range of potential options to meet that demand. This information will help local communities and water providers as they work to plan, manage, and efficiently use Colorado's surface and groundwater resources.

Water has long been a divisive issue in the West, and thus it was important for this study to establish certain ground rules at the very outset.

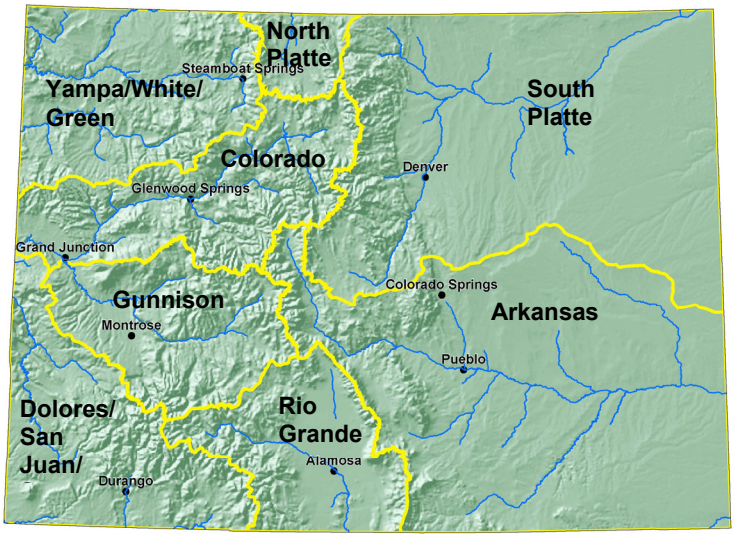


Figure ES-1
Colorado's Eight Major River Basins

- **Local authority and control:** Providing water for municipal and agricultural users is the purview of local water providers. Consequently, it was important that SWSI not take the place of local water planning.
- **Bottom-up, not top-down:** Providers, stakeholders, and communities across Colorado were asked to identify their unique concerns, needs, and issues. SWSI does not take a top-down approach or presuppose what those concerns are or will be.
- **All solutions explored:** All solutions, including conservation, rehabilitation of existing water supply facilities, enlargement, and/or more efficient use of existing water supply facilities, as well as new water supply projects, have been and must continue to be considered.
- **Adherence to Colorado's Doctrine of Prior Appropriation:** The baseline requirement for any water supply or water management solution is that it must be accomplished within the statutory framework of Colorado's existing water rights and water administration system, incorporating Colorado's Doctrine of Prior Appropriation.

Two additional ground rules were set after commencement of the study. First, it was determined that the initial 18-month study would not evaluate transbasin diversion issues. This issue is highly charged, and would have threatened the ability of SWSI to produce meaningful results in the initial 18-month study period. Instead, the CWCB determined it would be most productive to focus on in-basin solutions first and undertake a subsequent effort in 2005 to focus on issues that reach across river basin boundaries. Second, following a tradition of local control over water planning, SWSI would not judge or evaluate the merits or likelihood of success of any of the projects or processes being pursued at the local level. As a result, what is presented in this report is a catalogue of the solutions advanced by local providers.

SWSI can teach us a great deal. SWSI is the most far-reaching and comprehensive effort ever undertaken to understand our state's water supplies as well as the state's existing and future water demands. As a result of this study, we know more today about Colorado's current and future water use than we have ever known before. For example, we know significantly more about:

- What is important to Coloradans about water management
- How much water Colorado will likely need in 2030 by basin
- What is being done to address these needs, statewide and within each basin
- How big a "gap" may exist between projected needs and identified potential solutions
- How important reducing uncertainty associated with implementing water projects is to minimizing the shortfall
- What additional options may be available to close the gap between supply and demand

In addition, we have a deeper understanding of the major trends that are shaping our water use and development, including:

- The intent of many local providers in urban areas to transfer water from agricultural to municipal use, and the impact that will have on agricultural rural communities
- The importance of recreation and the environment and the impact they are having on water use and development in the state
- The lack of financial and planning resources that face smaller, rural providers and agricultural users

These and other findings of SWSI contained in this report will be made available to local providers, citizens, and communities across Colorado information to help them shape and plan their water future.

But beyond these findings, SWSI has provided another critically important benefit for the state – a forum for dialogue focused on developing a common understanding of Colorado's water issues and needs. This forum, and this dialogue, present tremendous opportunities for Colorado; opportunities that could bear fruit long after the SWSI study has ended. It presents an opportunity to take a new approach to address water issues in this state – an approach based on cooperation and collaboration, rather than litigation and conflict.

Colorado has a great tradition of being a leader among the western states in managing and administering its limited water resources and in addressing and solving its water resources challenges and pursuing management alternatives in innovative and effective ways. We want

our future to be as exciting and full of promise as our past. We must, therefore, act today to plan for our water future. To meet the needs of all of Colorado's future – whether it is ensuring that everyone living in the Denver metro area has sufficient water, or ensuring that a farmer in the Grand Valley has enough water for crops, or providing for the needs of fish and wildlife – we should heed the lessons and findings of SWSI and use them to build a better future for all. That is the value that SWSI brings to Colorado.

CWCB is the State agency responsible for:

- Aiding in the protection and development of the waters of the state for the benefit of the present and future inhabitants of the state
- Gathering data and information to achieve greater utilization of the waters of the state
- Establishing policies to address state water supply issues
- Financing water projects
- Identifying and recommending water development projects to the General Assembly

Role of the CWCB

CWCB, as the agency leading SWSI, plays a critical role in establishing water policy in Colorado. The CWCB Board formulates policy with respect to water development programs. The Board assists in the administration of interstate compacts on the Arkansas and Colorado Rivers; administers flood plain programs, water project construction funds, and the Office of Water Conservation and Drought Planning; and participates in endangered species programs. It also acquires and manages all instream flow rights for the state.

CWCB is part of Colorado's Department of Natural Resources (DNR), which administers programs related to the state's water, forests, parks, wildlife, and minerals. CWCB is also responsible for the development and implementation of state resource policies.

CWCB Board Members are appointed by the governor. The CWCB members include representatives from each river basin as well as key state policy makers (i.e., Directors of DNR, CWCB, Agriculture, Colorado Division of Wildlife (CDOW), State Engineer's Office (SEO), and the Attorney General). During SWSI, the CWCB Board dedicated significant time at each of its regularly scheduled meetings to direct, facilitate, and support the implementation of SWSI.

The CWCB's overarching goal for SWSI is to help water providers and state policy makers ensure an adequate water supply for Colorado's citizens and the environment. Resolving Colorado's water supply and water needs is a complex process and will take a sustained and long-term effort. During the execution of SWSI it was apparent that developing trust and open communication would take time. CWCB remains committed to bringing together affected interest groups and facilitating water management solutions with an emphasis on local involvement.

Unanimous agreement on issues, data, and solutions is not always possible. In this report, opinions and ideas provided by the public and Basin Roundtable members have been considered and incorporated. When consensus was achieved, the information is presented as such, but consensus was not always possible.

CWCB is the state's water policy making entity, and in that role it is expected to advance policy and recommendations recognizing that these policies and recommendations do not always enjoy unanimity. In the Recommendations section of this document, the CWCB has deliberated on the information gathered and has put forth its view of the immediate path forward. These recommendations are reflective of the SWSI process, but also acknowledge that these should not be construed to be the recommendations of the Basin Roundtables themselves.

SWSI represents a major step toward addressing our future water supply and water needs. SWSI has identified water supply issues and needs in three timeframes:

1. **Initial Findings** – are presented in this Executive Summary, and provide a comprehensive view of Colorado's water supply needs and an outline of how they will be addressed.
2. **Near-Term Action Items** – are presented in the Recommendations section and represent activities that appear to have a reasonable level of support, a more clear path forward, and that can be addressed by CWCB in the next 1 to 2 years as part of its strategic plan.

3. **Long-Term Action Items** – are also presented in the Recommendations section, includes both the need to monitor ongoing water supply and demand activities, and potential action items that will need additional analysis and consensus building.

The information presented in this Executive Summary and the SWSI Final Report provides a statewide view of supply and demand and an overview of in-basin solutions to meet future demand. During SWSI implementation, it became apparent that the Basin Roundtable process would be significantly improved if a stepped or phased process was used. To be successful, SWSI first needed to examine in-basin water supply and demands, options or alternatives for addressing those demands, and any related issues. With this initial in-basin information as a foundation, we can now have a more orderly and informed analysis of transbasin issues and opportunities.

Over the next several months, SWSI will examine supply and demand issues that reach across river basins and options for addressing those issues. This work will be completed between January 2005 and July 2005 utilizing existing funds authorized by the original SWSI appropriation. During this next phase, CWCB, working with local interests, will evaluate the opportunities and options associated with in-basin solutions and mutually beneficial solutions involving multiple basins.

Finally, it should be emphasized that under current authorities, the CWCB has a finite set of tools to address some of the key issues that affect our water future. Two common themes were heard in every basin in Colorado regarding the role of the state (CWCB) in water resource issues. First, continue to provide technical assistance and regulatory support such as the Decision Support Systems (DSS), and assistance with federal and state regulatory issues, especially in the area of Endangered Species Act (ESA) and National Environmental Policy Act (NEPA). Second, the state (CWCB) needs to provide more financial assistance, especially in the area of non-reimbursable investments. Financial issues are a key to how we can move forward and improve water resource protection and development.

In addition to the financial role of CWCB, it is emphasized that at this time, the CWCB's current authority is of facilitator, mediator, and consensus builder, since CWCB does not hold water rights for municipal, industrial, or agricultural uses and does not own or operate water management facilities. This puts CWCB in a unique position and the SWSI process has reinforced this role throughout the state. It is important for CWCB to continue this role and not interfere with local planning but rather be the agency to facilitate solutions that require a statewide perspective.

Defining Colorado's water future is one of the most important challenges the state faces. SWSI assembled a vast amount of information, and the initial findings and recommendations presented in this Executive Summary provide a sound basis to begin to address these challenges. The CWCB will need to continue its efforts and work with all interest groups to make progress resolving the complexities of water use and water resource protection and development.

CWCB's Major Programs include:

- Water supply protection
- Flood protection
- Water supply planning and finance
- Instream flow and natural lake level protection
- Conservation and drought planning
- Water information and education

SWSI Stakeholder Process

The public information and Basin Roundtable participant activities were designed to provide a mechanism and forum for the CWCB Board to solicit and exchange information, and was essential to the success of the project. The Basin Roundtables, with the support of and input from the CWCB Board, defined the overall water management objectives, established performance measures to meet these objectives, and identified solutions for meeting future water needs. Information exchange occurred at the following levels:

Basin Roundtables – where local interests met to exchange ideas, review and present water supply and demand data, summarize planning initiatives, and help guide the development of water supply and demand objectives and strategies for achieving the objectives. This was a consensus building process to address specific issues within each river basin. A portion of each meeting was also devoted to obtaining information and comment from the public.

Roundtable participants in each basin included representatives of:

- Agricultural and ranching community
- Business, development, and civic organizations
- Environmental interests
- Federal agencies (e.g., U.S. Forest Service [USFS], U.S. Bureau of Reclamation [BOR])
- Local Governments not directly providing water (municipal, county, and regional)
- Municipal water providers
- Recreational interests
- Water Conservancy/Conservation Districts
- CWCB Board Member(s) for the basin
- Technical support was provided by: the State Engineer's Office (SEO), Division of Wildlife (DOW), State Parks, and select federal agencies

General Public Outreach – intended to provide a forum specifically for presenting information to and obtaining feedback from the general public. The pubic was kept informed of the progress of the study, and invited to provide public input and feedback, through a variety of activities, including:

- The 2-hour public meeting portion of each of the 30 Basin Roundtable Technical Meetings
- A series of press releases that were issued at key milestones throughout the project
- Presentations to numerous community and stakeholder organizations, including agricultural, environmental, and business groups
- A public comment period specifically reserved for SWSI at each CWCB meeting
- A series of e-mails to a database of over 1,400 Colorado individuals and organizations with an interest in water
- A series of two rounds of Public Information meetings conducted through the course of SWSI
- A project website that was updated throughout the study

One of the key goals of the Basin Roundtable and public involvement process was to learn: *What is important to people in Colorado when they consider how water should be used and managed?* Through the SWSI process, a set of nine major "water management objectives" were developed, refined, and then used to evaluate options for addressing Colorado's future water needs. These objectives represent the overarching interests in water management – they define major goals of water users in clear, understandable terms.

Recognizing that each individual will value these objectives in different ways – that is, each individual will assign a unique importance to each objective relative to the others – individual preferences for the objectives were identified and tracked for each Basin Roundtable member in each basin. Similarly, the relative importance of the objectives from one basin to another was different, indicative of the diversity of the basins and the ways water is used in each.

SWSI Water Management Objectives

- **Sustainably Meet Municipal & Industrial Demands**
- **Sustainably Meet Agricultural Demands**
- **Optimize Existing and Future Water Supplies**
- **Enhance Recreational Opportunities**
- **Provide for Environmental Enhancement**
- **Promote Cost Effectiveness**
- **Protect Cultural Values**
- **Provide for Operational Flexibility**
- **Comply with All Applicable Laws, Regulations, and Water Rights**

Several overall observations can be made from the basin-by-basin assessment of Basin Roundtable members' preferences for the SWSI water management objectives, summarized as follows:

- **Sustainably Meet Municipal and Industrial (M&I) Demands:** A wide range of preferences was evident in each basin. Municipal water interests, as expected,

generally preferred this more strongly than did other interest groups.

- **Sustainably Meet Agricultural Demands:** Also saw a wide range of preferences in each basin. As expected, agricultural interests typically preferred this more strongly than did other interest groups.
- **Optimize Existing and Future Water Supplies:** Relatively strong support for this objective was expressed in each basin, with significant variability between interest groups' perspectives from one basin to another.
- **Enhance Recreational Opportunities:** While recognized as important, other water management objectives generally received greater support, even among recreational and environmental interests in most basins.
- **Provide for Environmental Enhancement:** A very diverse range of support for this objective was expressed, both within each basin and from basin to basin. Environmental and recreational interests typically ranked this as one of the top objectives relative to the others.
- **Promote Cost-Effectiveness:** Generally saw a moderate to low level of support relative to the other objectives, suggesting that many Basin Roundtable members value other objectives more highly than costs.
- **Protect Cultural Values:** This objective saw a moderate to low level of support in most basins, though with wide variability, suggesting an interest in maintaining cultural values but not necessarily at the expense of some of the other objectives.
- **Provide for Operational Flexibility:** This objective was moderately valued in most basins, except in the North Platte Basin, which, on average, valued it less than all of the other objectives.
- **Comply with all Applicable Laws, Regulations, and Water Rights:** The Basin Roundtables acknowledged that all alternatives must squarely meet this objective, and rather than serving as a basis of comparison of alternatives, it instead represents a minimum condition or "gate" that all alternatives must successfully pass through to be considered for implementation.

Together, these objectives and preferences guided the identification and development of potential solutions to Colorado's future water needs throughout the course of SWSI.

Major Findings of SWSI

SWSI explored all aspects of Colorado's water use and development on both a statewide and an individual basin basis. As previously mentioned, SWSI focused on in-basin issues first. Analysis of supply and demand at the statewide level will be conducted in greater detail in 2005. Major findings identified during this first phase of work are based on technical analyses and feedback gathered through Basin Roundtable input. Even though some of these findings are readily apparent to some, it was important that they be affirmed as part of building a foundation and common understanding. Other findings were determined and/or clarified through the SWSI process. These findings are summarized below.

1. **Significant increases in Colorado's population – together with agricultural water needs and an increased focus on recreational and environmental uses – will intensify competition for water.**
2. **Projects and water management planning processes that local M&I providers are implementing or planning to implement have the ability to meet about 80 percent of Colorado's M&I water needs through 2030.**
3. **To the extent that these identified M&I projects and processes are not successfully implemented, Colorado will see a significantly greater reduction in irrigated agricultural lands as M&I water providers seek additional permanent transfers of agricultural water rights to provide for the demands that would otherwise have been met by specific projects and processes.**
4. **Supplies are not necessarily where demands are; localized shortages exist, especially in headwater areas, and compact entitlements in some basins are not fully utilized.**
5. **Increased reliance on nonrenewable, nontributary groundwater for permanent water supply brings serious reliability and sustainability concerns in some areas, particularly along the Front Range.**

6. **In-basin solutions can help resolve the remaining 20 percent gap between M&I supply and demand, but there will be tradeoffs and impacts on other uses – especially agriculture and the environment.**
7. **Water conservation (beyond Level 1) will be relied upon as a major tool for meeting future M&I demands, but conservation alone cannot meet all of Colorado's future M&I needs. Significant water conservation has already occurred in many areas.**
8. **Environmental and recreational uses of water are expected to increase with population growth. These uses help support Colorado's tourism industry, provide recreational and environmental benefits for our citizens, and are an important industry in many parts of the state. Without a mechanism to fund environmental and recreational enhancement beyond the project mitigation measures required by law, conflicts among M&I, agricultural, recreational, and environmental users could intensify.**
9. **The ability of smaller, rural water providers and agricultural water users to adequately address their existing and future water needs is significantly affected by their financial capabilities.**
10. **While SWSI evaluated water needs and solutions through 2030, very few M&I water providers have identified supplies beyond 2030. Beyond 2030, growing demands may require more aggressive solutions.**

Each of these major findings is discussed below.

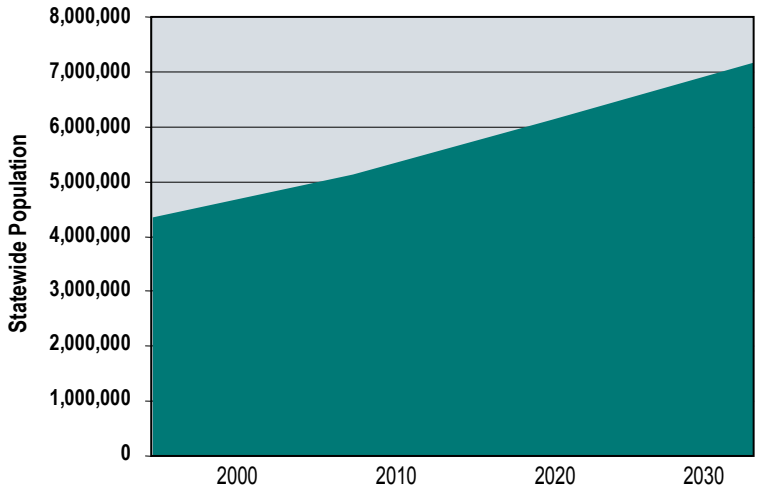
1. Significant Increases in Colorado's Population will Intensify Competition for Water

Colorado's M&I Outlook

M&I water demands are defined as water needed for residential, commercial, institutional, and industrial uses. These demands occur in the state's urban, suburban, mountain, and rural areas. Increases in M&I water demands are primarily driven by population growth (see Figure ES-2).

Colorado has a healthy and growing economy. The state's gross product (a measure of all economic activity) increased from $74.7 billion in 1990 to $173.7 billion in 2001. Moreover, between 1990 and 2001, Colorado gained almost a million new people. The state demographer projects that Colorado will continue its significant growth, adding another 2.8 million residents by 2030. Of that amount, slightly more than 1.5 million, or 54 percent, is due to net migration into the state. The remainder is a function of birth rates that are substantially higher than the number of deaths projected for each year.

This population growth is not limited to the Front Range. The state demographer estimates that West Slope basins will add about 420,000 new residents by 2030, growing at rates higher than those of the Front Range basins.



Basin	2000	2030	Increase in Population	Percent Change 2000 to 2030	Percent Annual Growth Rate
Arkansas	835,100	1,293,000	457,900	55	1.5
Colorado	248,000	492,600	244,600	99	2.3
Dolores/San Juan/San Miguel	90,900	171,600	80,700	89	2.1
Gunnison	88,600	161,500	72,900	82	2.0
North Platte	1,600	2,000	400	25	0.7
Rio Grande	46,400	62,700	16,300	35	1.0
South Platte	2,985,600	4,911,600	1,926,000	65	1.7
Yampa/White/Green	39,300	61,400	22,100	56	1.5
Total	4,335,500	7,156,400	2,820,900	65	1.7

Source: Colorado Department of Local Affairs Demography Section

Figure ES-2
Population Projections by Basin

The statewide population growth from 2000 to 2030 is projected to be about 65 percent. The three fastest growing basins, on a percentage basis, are the Colorado (99 percent), Dolores/San Juan/San Miguel (89 percent), and Gunnison (82 percent) – each with annual average growth rates over 2 percent and with populations that will nearly double over the 30-year period. The more highly-populated basins, the Arkansas and South Platte, have projected population growth rates of 55 percent and 65 percent, respectively, over this period.

By 2030, the Arkansas Basin and the South Platte Basin will be home to a combined total of almost 2.4 million additional residents, bringing the total population in these two basins to over 6 million people, which represents over 86 percent of Colorado's population. In 2030, about 79 percent of the state's population will reside in the following 11 counties: Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer, and Weld (South Platte Basin); and El Paso and Pueblo (Arkansas Basin).

Average M&I per capita water use (measured by taking all M&I water demand divided by permanent population) ranges from 206 gallons per capita per day (gpcd) in the South Platte Basin to over 330 gpcd in the Rio Grande Basin (Figure ES-3).

Per capita use rates can be difficult to directly compare between counties or basins. High per capita rates are not necessarily indicative of inefficient use, much as low rates do not necessarily imply efficient use. For example, water use related to tourism is reflected in historical demand data but not in census data, thus increasing the calculated per capita demands. Major industrial water uses could also drive per capita values upward.

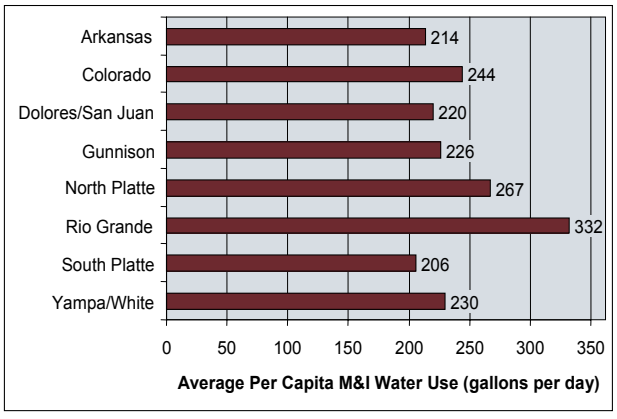


Figure ES-3
M&I Per Capita Water Use (2000)

Residential or commercial properties such as golf courses might be irrigated from non-municipal sources, such as wells or ditch rights, lowering the calculated per capita demand.

Without additional conservation, annual M&I and self-supplied industrial (SSI) water demands would be projected to increase from 1,194,900 acre-feet (AF) in 2000 to 1,926,800 AF by 2030 based on population projections and per capita use rates. However, water conservation that results from the 1992 National Energy Policy Act is projected to reduce the estimated 2030 annual demands by about 101,900 AF. In SWSI, this level of conservation is described as Level 1 conservation. This federal legislation established maximum water use standards for certain residential and commercial indoor plumbing fixtures. This conservation does not reflect the active measures such as metering and water rate pricing that are being implemented, planned, or considered by many water providers across the state, and that are considered in SWSI as a future water supply option for meeting demands. These measures are included in "Levels 2 through 5" conservation is described in more detail in the full report.

Figure ES-4 shows the increase in statewide M&I and SSI water use by 2030, while Table ES-1 presents these water uses by basin.

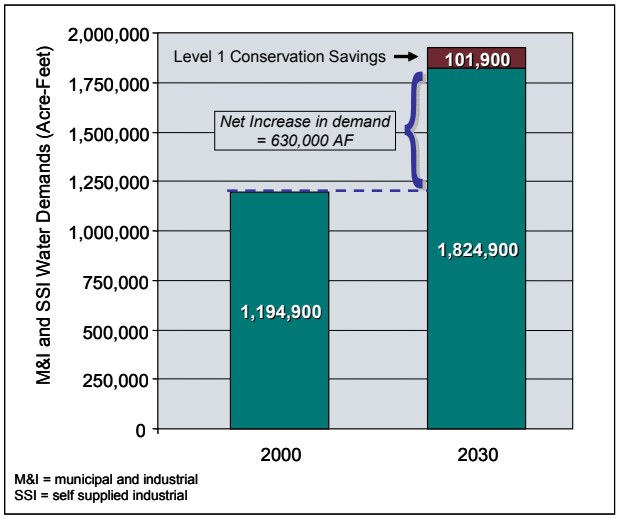


Figure ES-4
Projected M&I Water Demand

Table ES-1 Municipal & Industrial Gross Water Demand in 2000 and 2030

Basin	Estimated Water Demand in 2000 (AF)	Projected Water Demand with Level 1 Conservation in 2030 (AF)	Increase in Water Demand (AF)	Increase in Water Demand (%)
Arkansas	256,900	354,900	98,000	38%
Colorado	74,100	136,000	61,900	84%
Dolores/ San Juan/ San Miguel	23,600	42,400	18,800	80%
Gunnison	20,600	35,500	14,900	72%
North Platte	500	600	100	20%
Rio Grande	17,400	21,700	4,300	25%
South Platte	772,400	1,182,100	409,700	53%
Yampa/White/ Green	29,400	51,700	22,300	76%
TOTAL	**1,194,900**	**1,824,900**	**630,000**	**53%**

Colorado's Agricultural Outlook

Agriculture remains the major use of water in Colorado. Colorado's farm economy grew from $676 million in 1977 to over $1.5 billion in 2001 (U.S. Bureau of Economic Analysis 2001). Agricultural services and forestry represented an additional $1.2 billion in 2001. Agriculture is an important component of Colorado's overall economy. In some areas of the state, agriculture is the vital part of the economy. For example, while the Arkansas and South Platte Basins include highly developed commercial and industrial regions, the rural areas are highly dependent on the agricultural industry and it is a key economic driver. This is generally true statewide in many of our rural communities. One only needs to look to the San Luis Valley, Southwest and Northern Colorado, and the Grand Valley to see the important economic force and role agriculture plays in Colorado.

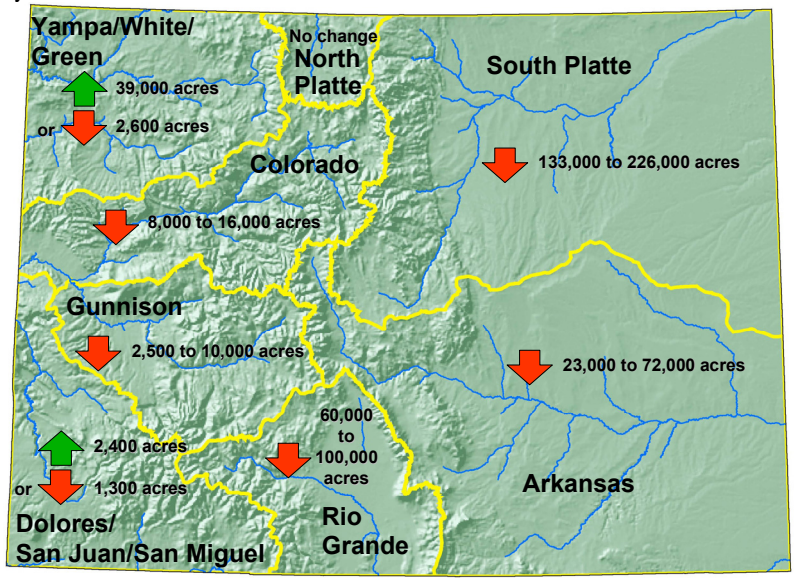
Besides its direct and indirect economic benefits and contributions to the nation's food supply, agriculture is an important cultural value for the state. Agriculture provides open space, creates or enhances riparian habitats and wet meadows, and improves late season river and stream flows, resulting in aesthetic and environmental benefits. Historically, over 90 percent of the state's water use has been associated with agriculture. Beginning in the 1950s, the transfer of agricultural water rights to help meet M&I demands increased, as declines in irrigated acreage in the Front Range were realized. Statewide irrigated acreage in the year 2000 was estimated at approximately 3,100,000 acres. The greatest number of irrigated acres was in the South Platte Basin, with slightly over 1,000,000 irrigated acres.

Table ES-2 Irrigated Acres by Basin

Basin	Estimated Irrigated Acres	Average Total Diversions (AF)
Arkansas	538,100	1,769,900
Colorado	237,700	1,986,900
Dolores/San Juan	255,000	902,200
Gunnison	263,500	1,736,100
North Platte	115,700	396,900
Rio Grande	632,700	1,619,000
South Platte	1,003,500	2,545,500
Yampa/White/Green	118,400	652,000
TOTAL	**3,164,600**	**11,605,000**

Source: Colorado's Decision Support Systems and Basin Roundtable/Basin Advisor input. See Section 5 for details on current estimates and periods of record.

A decline in irrigated acreage is expected to continue for much of the state (see Figure ES-5). A portion of the reduction in irrigated acres will be the result of development of irrigated lands for other uses, primarily M&I. Other irrigated lands will be dried up as M&I water



Source: Colorado's Decision Support Systems and Basin Roundtable/ Basin Advisor input.

Figure ES-5
Projected Change in Irrigated Acreage by 2030

providers acquire and transfer agricultural water rights from outside their service areas for use within their service area. Additional reductions in irrigated lands are projected for the South Platte, Arkansas, and Rio Grande Basins as a result of the lack of affordable water supplies to provide augmentation for well pumping (South Platte and Arkansas) and the need to reduce overpumping of groundwater resources in the Rio Grande. Additional information regarding these dynamics is presented in Section 5 of the full report.

By 2030, statewide agricultural gross diversions could range from 10,200,000 AF to 11,000,000 AF depending on the amount of irrigated acreage that exists. By 2030, agricultural water use is projected to represent approximately 86 percent of the state's total water use (Figure ES-6).

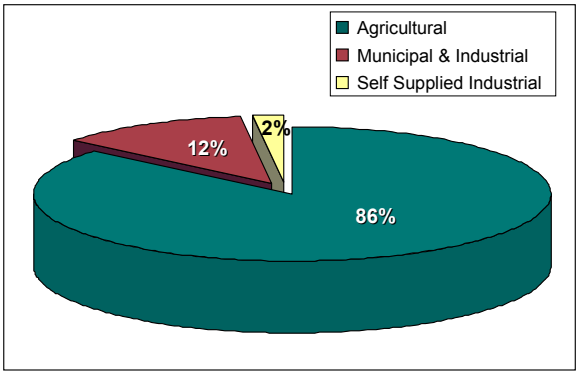


Figure ES-6
Relative Proportions of Agricultural, M&I, and SSI Gross Water Use in 2030

Agricultural water shortages are common in many parts of the state. Figure ES-7 illustrates the basins where the DSS data exists (West Slope basins and the Rio Grande) and the water districts where average annual water shortages of greater than 10 percent exist. Colorado's DSSs are a series of databases and tools that CWCB and the Colorado Division of Water Resources are developing to analyze and model water use in each basin. These numbers represent average annual shortages and it should be noted that many additional agricultural water users have shortages during "below average" water years. The South Platte and Arkansas are estimated to have average annual shortages greater than 10 percent for nearly all water districts within these basins.

Environmental and Recreation Outlook

Recreation and tourism are economically vital to Colorado. Recreational activities are also important to the quality of life for many Coloradans. According to the Colorado Office of State Planning and Budgeting (2002), recreation and tourism inject about $8.5 billion into the state's economy and employ about 8 percent of the total workforce. Water-related activities, including winter sports, comprise a significant component of the recreational attractions drawing tourists to Colorado. The most prevalent water-based activities include flatwater and river-based activities, fishing, boating, rafting, and snow skiing (water used for snowmaking).

To illustrate the impacts of water shortages on recreation, the Colorado River Outfitters Association reported that the 2002 drought caused a 39 percent drop in whitewater rafting user days from 2001 levels.

Decreed instream flow and recreational in-channel diversion (RICD) water rights were inventoried in SWSI. The CWCB Instream Flow program is responsible for obtaining water rights to protect the natural environmental and making recommendations to the water court regarding RICDs. Since 1973, CWCB has obtained instream flow water rights for over 8,000 miles of streams and has obtained lake level water rights for 475 natural lakes. As a result of input from the Basin Roundtable process, SWSI has also explored other methods for evaluating environmental and recreational needs. Additional work will be needed in this area to determine important resource areas and to identify different methods for conserving, protecting, or restoring these resources.

Summary

Clearly, the combination of significant increases in M&I demands, continued major agricultural needs, and new interests in the use of water for recreational and environmental purposes, creates a high potential for competition and intensifying conflicts over water use. This reality provides a strong impetus for the multiple-objective, multiple-benefit approach to water management and future solutions to Colorado's water needs undertaken in SWSI.

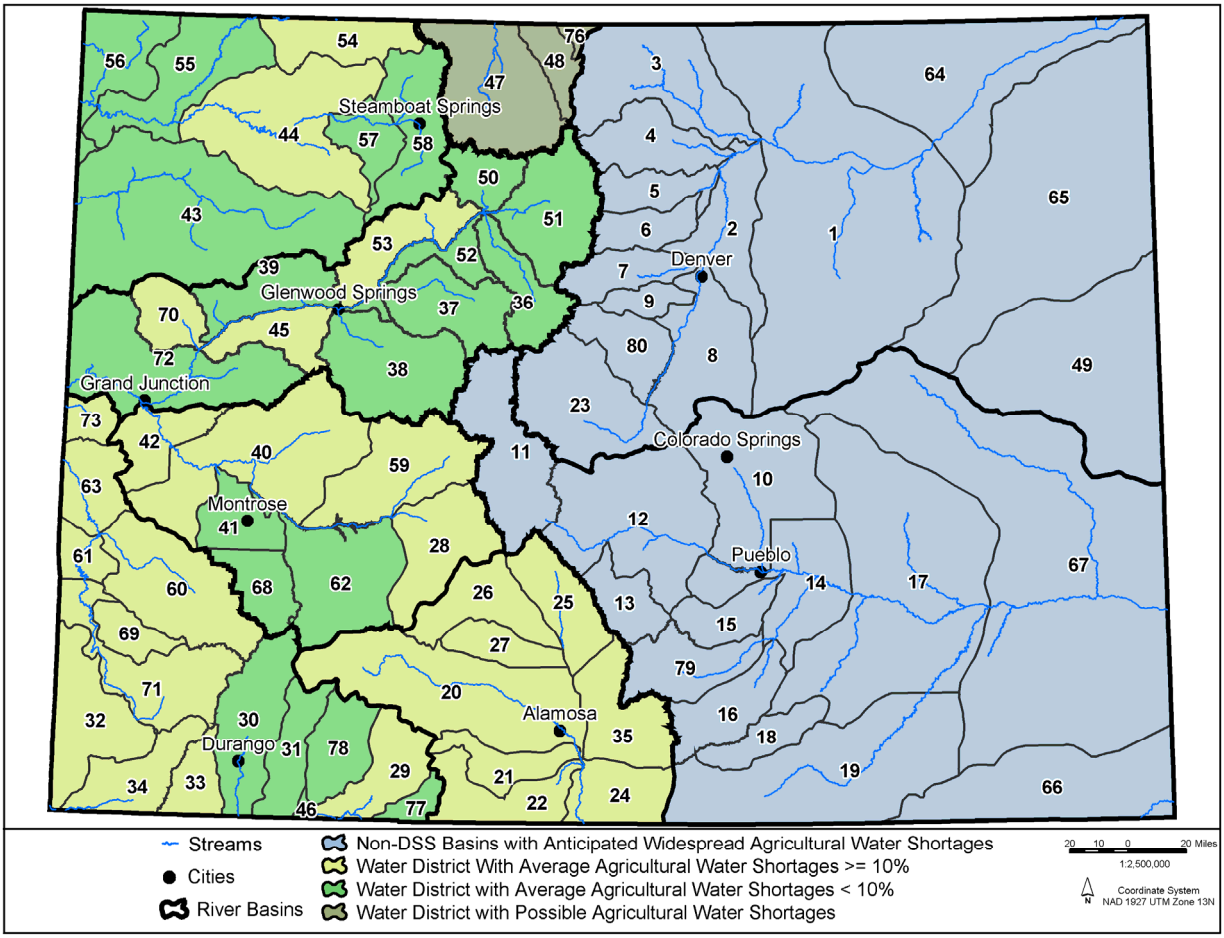


Figure ES-7
Summary of Agricultural Water Shortages by Water District

2. Projects and Processes that Local M&I Providers are Implementing or Planning to Implement Have the Ability to Meet About 80 Percent of Colorado's M&I Water Needs Through 2030

SWSI's unprecedented look at Colorado's future water needs found that while M&I demands will increase substantially by 2030, optimally approximately 80 percent of that increase may be met through successful implementation of projects and processes already underway or planned for implementation by M&I water providers.

All types of water use, ranging from M&I to agricultural, recreational to environmental, are expected to be significant in 2030. Among those, M&I needs in Colorado are expected to see the greatest increase. Through the Basin Roundtables, SWSI examined how the future water needs of each use and user could be met. In many cases, water management solutions were more numerous and further developed for M&I uses, while agricultural, recreational, and environmental solutions were less well defined.

The water management solutions identified by the Basin Roundtable members were compiled for each basin, and categorized as:

- **Identified Projects and Processes:** those solutions that are relatively well-defined and can reasonably be expected to be implemented between now and 2030
- **Options for Future Alternatives to Meet the Remaining Supply versus Demand Gap:** those solutions that have significant implementation issues to be resolved before they can move forward, or are

more conceptual in nature and/or are likely to be implemented in later years

In developing the catalog of options for meeting future needs, it became evident that many entities have developed specific projects or water management solutions to meet their needs ("identified projects"), while others had initiated a "process" – an ongoing study or dialog – to do so ("identified processes"). In the latter case, evaluations of different water management solutions might be ongoing, but the entities sponsoring the process have established the process with the intent of meeting the water needs of one or more users in the future. Other solutions for meeting future needs – the Options for Future Alternatives to meet the remaining gap in supply versus demand – were identified by the Roundtables as being potentially suitable for implementation, but in need of further evaluation as part of a longer-term strategy for meeting needs.

Thus, the Identified Projects and Processes are those solutions that have been identified by the project sponsors or collaborators as moving forward with implementation reasonably expected to occur between now and 2030. For many M&I water providers, part of the Identified Projects and Processes includes increased conservation measures over Level 1 conservation. Some Identified Projects and Processes involve storage, reuse, or additional diversions from existing transbasin projects. In keeping with SWSI's intent to not interfere with local planning, SWSI did not seek to judge the merits or probability of success of any individual project or group of projects. Rather, it was assumed for initial purposes that the Identified Projects and Processes will meet their water supply objectives (e.g., yield) and will be used to address the increases in demands, lowering the supply gap.

The "remaining supply versus demand gap" for M&I uses was estimated through discussions with water providers and local governmental officials and examination of demand projections. This remaining gap is the result of water providers indicating that while they might have projects or other solutions in mind for meeting future demands, they saw significant implementation challenges and were less confident of successful implementation without additional assistance. The remaining gap also consists of areas where there are known limitations on available supplies or where future growth is projected in areas where there is not currently a water provider. The estimate of gap was subtracted from the overall increase in demands for M&I, along with additional savings from Level 1 conservation anticipated by 2030, to identify the demands that will be met by the Identified Projects and Processes, including additional conservation beyond Level 1.

SWSI found that under the most optimistic scenario, if fully implemented, the Identified Projects and Processes are capable of meeting about 80 percent of the state's projected M&I water needs through 2030. That is, statewide, about 511,800 AF of the 630,000 AF gap projected in 2030 could be addressed with the Identified Projects and Processes, leaving a remaining gap in supply of about 118,200 AF statewide.

Figure ES-8 shows the total increase in M&I water demand *after* accounting for additional savings from Level 1 conservation for each basin ("supply need" on the chart), along with the relative proportion of that supply need that could be met by the Identified Projects and Processes' yields ("identified" portion of the supply need on the chart) and the remaining gap between supply and demand after those Identified Projects and Processes are implemented ("gap" on the chart). Table ES-3 provides a summary of the Identified Projects and Processes by basin and the amount of demand estimated by project sponsors and collaborators that they would satisfy, with the exception of the North Platte Basin, which has a very low projected increase in M&I demands.

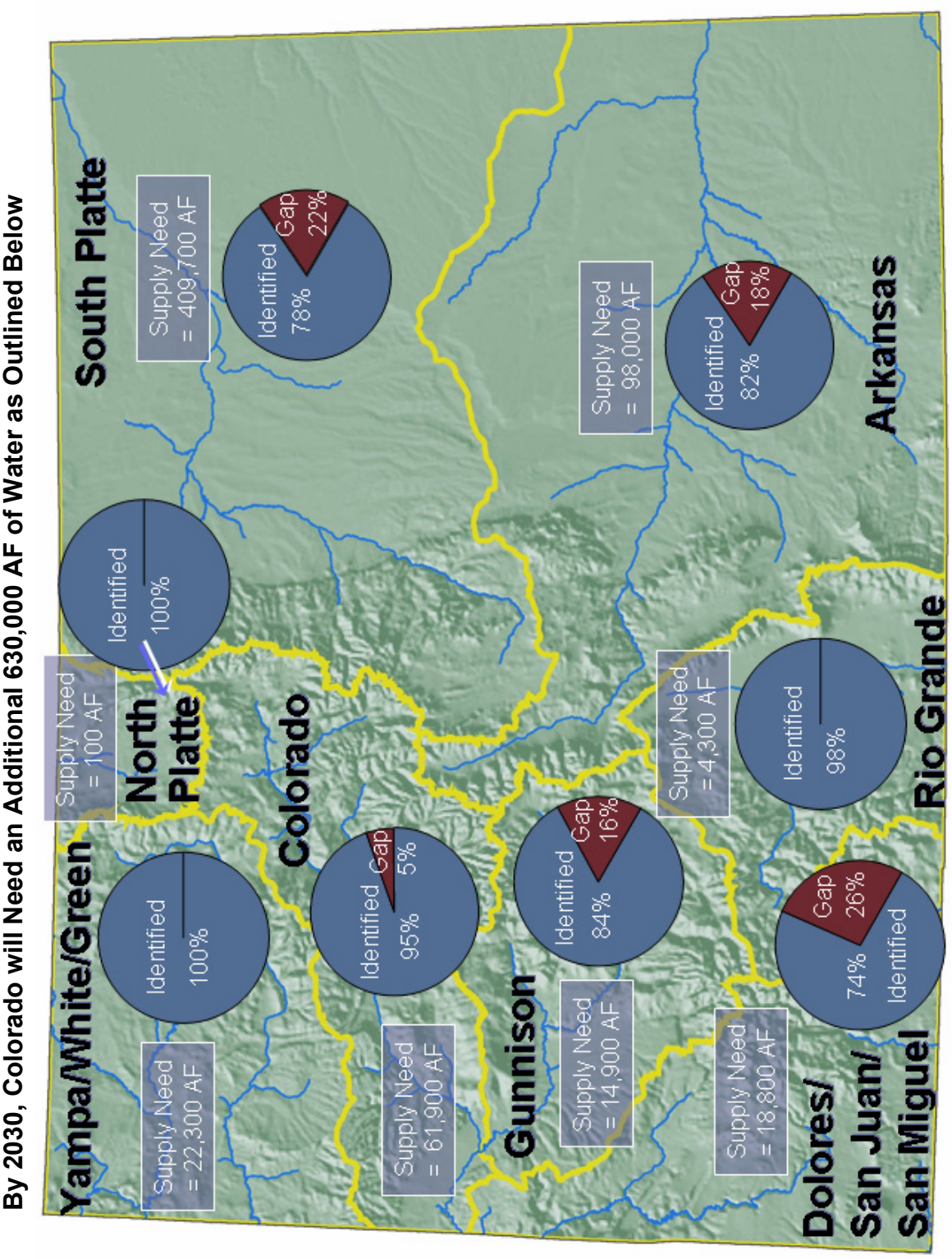


Figure ES-8
Effectiveness of Identified Projects and Processes in Meeting 2030 M&I and SSI Demands

Table ES-3 Major Identified Projects and Processes by Basin and Subbasin or County

Basin Counties or Subbasins	Estimated Demand met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
Arkansas Subbasins		
Upper Arkansas Lake, Chaffee, Teller, Fremont	7,100	■ Preferred Storage Options Plan (PSOP) – Re-operation of the Fryingpan-Arkansas (Fry-Ark) Project – Turquoise and Pueblo Reservoir Enlargements – 10 to 12 percent reduction in demand for storage via conservation ■ Augmentation Plans ■ Increased use of Fry-Ark M&I allocation directly or for augmentation ■ Agricultural transfers
Urban Counties El Paso, Pueblo	71,900	■ Active conservation ■ PSOP ■ Maximizing existing water rights ■ Alluvial aquifer recharge and pumping with augmentation and advanced water treatment ■ Reuse for non-potable irrigation on parks and golf courses and other landscaping ■ Exchanges ■ Agricultural transfers ■ Southern Delivery System to deliver existing water rights ■ Increased use of Fry-Ark allocation
Lower Arkansas Crowley, Bent, Prowers, Otero	0	■ Active Conservation ■ PSOP ■ Arkansas Valley Pipeline ■ Exchanges ■ Increased use of Fry-Ark allocation ■ Agricultural transfers ■ Alluvial groundwater pumping with augmentation and advanced water treatment ■ Use of local ditch water for irrigation of landscaping
Eastern Plains Elbert, Lincoln, Cheyenne, Kiowa, Baca	0	■ Groundwater (non-tributary)
Southwestern Arkansas Custer, Huerfano, Las Animas	1,900	■ Existing water rights ■ Augmentation Plans ■ Agricultural transfers ■ Storage and treatment of water in Trinidad Reservoir
TOTAL	**80,900**	
Colorado Counties		
Eagle River Mainstem	12,500	■ Existing supplies ■ Agricultural transfers ■ Ruedi Reservoir contracts for augmentation of surface or alluvial groundwater diversions
Garfield	11,700	■ Existing supplies ■ Agricultural transfers ■ Ruedi and Wolford Reservoir contracts for augmentation of surface or alluvial groundwater diversions
Grand	3,200	■ Existing supplies ■ Upper Colorado River Process (UPCO) to identify needs and potential solutions
Mesa	14,800	■ Existing supplies ■ Agricultural transfers ■ Ruedi and Wolford Reservoir contracts ■ Jerry Creek Reservoir

Table ES-3 Major Identified Projects and Processes by Basin and Subbasin or County

Basin Counties or Subbasins	Estimated Demand met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
Pitkin	8,500	■ Existing supplies ■ Ruedi Reservoir contracts for augmentation of surface or alluvial groundwater diversions
Summit	8,200	■ Existing supplies ■ Upper Colorado River Process (UPCO) to identify needs and potential solutions
TOTAL	**58,900**	
Dolores/San Juan/San Miguel Counties		
Archuleta	3,300	■ Dry Gulch Reservoir ■ Existing supplies and water rights
Dolores	200	■ Existing supplies and water rights
La Plata	5,900	■ Animas-La Plata Project ■ Existing supplies and water rights
Montezuma	3,100	■ Dolores Project ■ Existing supplies and water rights
Montrose	700	■ Existing supplies and water rights
San Juan	-	■ Existing supplies and water rights
San Miguel	700	■ Existing supplies and water rights
TOTAL	**13,900**	
Gunnison Counties		
Delta	4,000	■ Tri-County Water Conservancy District Water Rights ■ Existing Water Rights ■ Agricultural transfers
Gunnison	100	■ Meridian Lake acquisition ■ Existing Water Rights ■ Augmentation Plans
Hinsdale	-	■ Existing Water Rights ■ Augmentation Plans
Mesa	1,600	■ Existing Water Rights ■ Agricultural Transfers
Montrose	6,100	■ Tri-County Water Conservancy District Water Rights ■ Existing Water Rights
Ouray	700	■ Existing Water Rights
TOTAL	**12,500**	
Rio Grande Counties		
Alamosa	1,900	■ Existing water rights, groundwater and augmentation plans
Conejos	500	■ Existing water rights, groundwater and augmentation plans
Costilla	-	■ Existing water rights and groundwater
Mineral	100	■ Existing water rights, groundwater and augmentation plans
Rio Grande	900	■ Existing water rights, groundwater and augmentation plans
Saguache	800	■ Existing water rights, groundwater and augmentation plans
TOTAL	**4,200**	
South Platte Subbasins		
Denver Metro Denver, Jefferson, Adams	108,100	■ Active Conservation ■ Existing supplies ■ Denver Northern Firming ■ Thornton Water Supply and Storage Company transfer ■ Agricultural transfers ■ New storage (including gravel lakes) and reservoir enlargements ■ Reuse for non-potable irrigation of parks and golf courses and other landscaping ■ Treating lower quality water sources

Table ES-3 Major Identified Projects and Processes by Basin and Subbasin or County

Basin Counties or Subbasins	Estimated Demand met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
South Metro Arapahoe, Elbert, Douglas	38,300	■ Active Conservation ■ Implementation of South Metro Conjunctive Use Plan or alternative ■ Reuter-Hess Reservoir ■ Aurora Long-range Plan ■ East Cherry Creek Plan ■ Agricultural transfers and reuse ■ Additional non-tributary groundwater ■ Reuse for non-potable irrigation of parks and golf courses and other landscaping ■ Indirect potable reuse by blending return flows with raw water supplies ■ Treating lower quality water sources
Upper Mountain Gilpin, Clear Creek, Pane, Teller	16,500	■ Drilling of exempt wells ■ Cooperative agreements with existing major water providers ■ Development of tributary groundwater supplies and plans for augmentation with agricultural transfers and new storage
High Plains Phillips, Yuma, Washington, Lincoln, Kit Carson, Cheyenne	800	■ Additional non-tributary groundwater
Northern Larimer, Boulder, Weld	146,500	■ Active Conservation ■ Windy Gap Firming ■ Northern Integrated Supply Plan ■ Halligan and Seaman Reservoirs enlargement ■ New storage including gravel lakes ■ Agricultural transfers ■ Colorado Big Thompson (CBT) acquisition ■ Reuse for non-potable irrigation of parks and golf courses and other landscaping ■ Exchanges ■ Annexation policies ■ Treating lower quality water sources ■ Use of local ditch rights for landscape irrigation
Lower Platte Morgan, Logan, Sedgwick	8,900	■ Augmentation of tributary groundwater with agricultural transfers ■ Colorado Big Thompson (CBT) acquisition
TOTAL	**319,100**	
Yampa/White/Green Subbasins		
Moffat	10,300	■ Existing supplies and water rights and reservoirs and reservoir enlargements (Stagecoach and Elkhead)
Rio Blanco	600	■ Existing supplies and water rights from White River and tributaries
Routt	11,400	■ Existing supplies and water rights and reservoirs and reservoir enlargements (Stagecoach and Elkhead)
TOTAL	**22,300**	

3. To the Extent That These Identified M&I Projects and Processes Are Not Successfully Implemented, Colorado Could See a Significantly Greater Reduction in Irrigated Agricultural Lands

In considering the M&I Identified Projects and Processes, the SWSI team and Basin Roundtable members recognized that there is at least some uncertainty in the implementation of these projects and processes. That is, for various reasons, any project that is not yet fully implemented could fail to result in the full water supply amount envisioned. For example, there will likely be some competition for available water supplies, because in some cases, providers have identified the same future sources. Some providers, mindful of the uncertainty, are currently pursuing multiple projects, but will not need to complete all of them. Others will need every identified project to meet future demands. Other solutions may yield less or store less than currently envisioned due to permitting constraints or other factors.

Some projects may never be permitted or may never be constructed due to implementation constraints. Uncertainty, high costs, and the protracted time frame associated with project permitting is a major issue for new water projects. Improving the permitting process at the federal level (e.g., special use permits, Section 404 permits) and at the county level (e.g., County 1041 permitting) could reduce the costs and time associated with water supply project development. More discussion on this topic is needed. Some have indicated that this is an obstacle, while others are concerned that impacts of water development could go unmitigated.

Without judging the merits of specific Identified Projects and Processes, SWSI sought to understand the potential implications of the uncertainty associated with the Identified Projects and Processes. It was assumed that the projected additional savings associated with Level 1 conservation are certain to occur, because low-flow devices will continue to be installed in new construction and replace older, higher-flow devices in response to the National Energy Policy Act of 1992.

In order to illustrate how future water needs will change if all Identified Projects and Processes are not implemented, uncertainty levels of 25 percent and 50 percent were applied to the yield of the Identified Projects and Processes to illustrate a range of possible outcomes. The results highlight the importance of

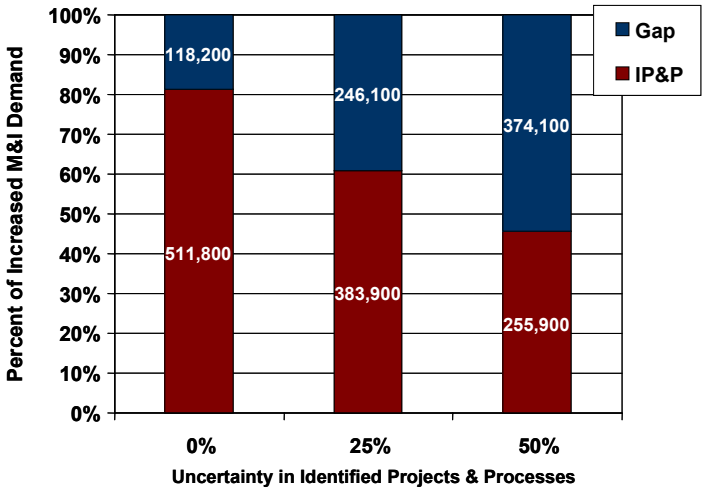


Figure ES-9
Implications of Uncertainty in Identified Projects and Processes on Meeting 2030 M&I and SSI Water Needs

fcurrently-identified solutions in meeting Colorado's future water demands. Figure ES-9 illustrates the implications of uncertainty in the Identified Projects and Processes. If a portion of the Identified Projects and Processes fails to be fully implemented, demand and competition for Colorado's water resources will be further increased and the need to implement alternative solutions will be evident.

Any yield that would otherwise have come from Identified Projects and Processes for M&I use might instead be satisfied with additional permanent agricultural transfers or new water supply projects or a combination of both. History has shown that M&I providers will indeed find a way to meet their customers' needs, and agricultural water is oftentimes the least expensive and most readily-available source for meeting those needs.

Thus, it is possible that a failure to implement any portion of the Identified Projects and Processes could result in even greater impacts to irrigated agriculture and the economies dependent thereon. A range of potential changes to irrigated acres was shown in Figure ES-5. The lower end of the range (least reductions in acreage) reflects the assumption that all Identified Projects and Processes, including additional conservation, are successfully implemented. As noted, not all of the reduction in irrigated acreage would be available for transfer to meet M&I needs.

To illustrate the possible impacts of the uncertainty of the successful implementation of Identified Projects and Processes, Figure ES-10 shows the total acres of irrigated farm land that could be removed from irrigated production if 25 to 50 percent of the Identified Projects and Processes were not successfully implemented, and the resulting gap in supply were met by agricultural transfers. It is important to note that agricultural transfers will require storage to firm the water supply for municipal and industrial uses.

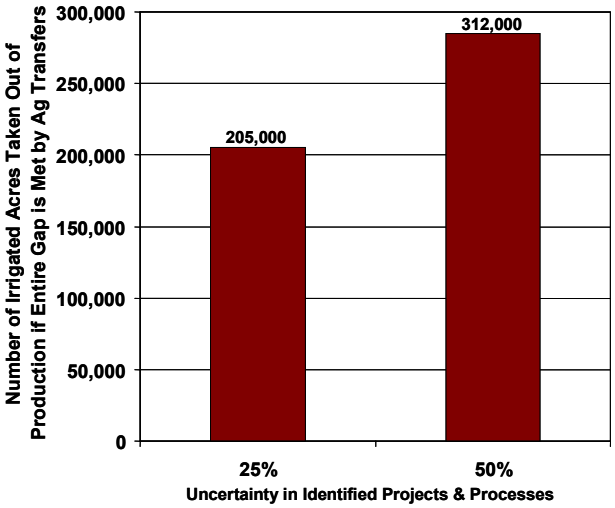


Figure ES-10
Potential Impact on Irrigated Agricultural Acres if Identified Projects & Processes are Not Implemented

In addition, the negative consequences that result from agricultural land dry-up are not fully understood and documented. Understanding the tradeoffs between transferring an existing agricultural water use versus developing new storage of unappropriated water is essential to making wise water resource management decisions. SWSI will examine this issue in more detail during the next phase of work (2005).

It is also important to point out that in many agricultural communities, the owners of water rights often wish to retain their ability to sell or lease their water. This can and has been a divisive issue in some of our basins. In Colorado, water rights are property rights and farmers and ranchers must retain their ability to sell or transfer their water under a free market system. This tenet is vital to retain the economic value of the water and is an important option to M&I providers as they strive to meet their future needs.

4. Supplies are Not Necessarily where Demands Are; Localized Shortages Exist; Compact Entitlements are Not Fully Utilized.

All basins except for the North Platte and Yampa/White/Green have identified future gaps in meeting 2030 M&I water demands that are not addressed by the Identified Projects and Processes. Basins that have developable supplies may still show gaps due to the geographic location of demand in relation to the available supplies. Developable supplies are defined as water supplies that can be developed with new water projects or water rights and require both the physical and legal availability of the water supplies.

Localized M&I shortages are projected in most basins. Many headwaters areas will see significant percentage increases in M&I needs and these areas will also be seeking to address recreational and environmental uses. Some of these headwater areas will have limitations on future water development due to lack of available flows both on average and during drought (seasonal or dry year limitations due to lack of physical availability) or downstream senior water rights demands. The existence of senior water rights will require the replacement of new junior consumptive uses (augmentation of depletions) to downstream senior agricultural and municipal diversions, CWCB instream flow rights, and recreational in-channel diversion water rights. Some of the mountain headwater areas, such as Gunnison County in the Gunnison Basin and Grand and Summit Counties in the Colorado Basin are projected to have gaps in meeting demands, even though these basins have supplies that can be developed by future water projects because supplies are not at the location of demand. Other headwater areas, such as Chaffee County in the Arkansas Basin, have gaps and there are no additional supplies to develop. Meeting future water demands in Chaffee County will require the use of existing supplies or the transfer of water from other uses such as agriculture.

In the Dolores/San Juan/San Miguel Basin, much of the growth in M&I needs will likely occur in areas or tributary basins between some of the larger surface water supplies. The areas between Pagosa Springs and Durango, the La Plata Basin, the upper portion of the San Miguel Basin, and some areas near Cortez will need additional infrastructure to store and transport water to the demand locations.

The physical availability of water is illustrated in Figure ES-11. As shown in the figure, water supply generally increases as you move downstream and there are greater quantities of water in the western part of Colorado versus the eastern part. In the past, the ability to transfer water from its origin to places of need has been a major factor in Colorado's success in attaining and maintaining healthy economic growth and development. Currently, about 5 percent of Colorado's water is transferred between basins. However, because most of these transfers originate in headwaters areas, some have contributed to localized water shortages. In many cases, current and future demands are in the upstream areas. In addition, the largest growth is projected for the Arkansas and South Platte Basins where existing supplies are more limited. Because of this, there will be increasing pressure in these basins for more development or water transfers.

Finally, it is important to note that the physical availability of water, even as the flow leaves the state, does not necessarily indicate that there are developable supplies, since the water must be legally available. Some of this flow may be committed as required deliveries under interstate compacts. Flow availability can also be affected by endangered species programs.

Legally available or developable water is governed by Colorado water law, interstate compacts, and interstate equitable apportionment decrees. These interstate compacts and decrees require Colorado to deliver certain amounts of water to downstream states or restrict uses of water in Colorado. A listing of the interstate compacts, decrees, and endangered species recovery programs, and an evaluation of the ability to develop additional water supplies under the compacts or decrees, is shown in Table ES-4. Colorado has not fully utilized or maximized its compact entitlements except for the Rio Grande and Arkansas Basins. These two basins do not have significant remaining unappropriated water that could be developed into reliable water supplies with a firm yield.

In addition to Colorado water law and interstate compacts and decrees, federal laws can influence water development. In Colorado, the ESA should be considered when analyzing water supply. There are endangered species programs in the South and North Platte, Colorado, Gunnison, Yampa/ White/Green, and Dolores/San Juan/San Miguel Basins. In general terms, these programs are designed to address endangered species needs while allowing for current water use and new water development. Flow criteria and habitat management are important components to these endangered species programs and water supply development must be consistent with program goals. Historic water use is typically addressed by providing off-setting measures via flow or habitat management, control of non-native species, and captive breeding and reintroduction. New depletions, if covered by the program, must meet specific criteria to receive programmatic coverage and an expedited ESA Section 7 review. Meeting the federal requirements for protection of the endangered species can potentially impact the ability to develop available water supplies, since most water supply development projects will require a federal permit.

Figure ES-11 provides a snapshot of current conditions in Colorado's major river basins, including population, irrigated agricultural acreage, and physical stream flow and interbasin transfers. The physical flows exiting the state from the South Platte and Arkansas Basins are significantly lower than those exiting from other basins – comprising less than 6 percent of the state's totals – reflecting these basins' natural hydrology and the significant populations and irrigated acreages present in each. The result is consumption of the vast majority of native and imported supplies along the Front Range and eastern plains. In contrast, Western Slope basins see significantly less consumption of native supplies.

Other in-basin shortages will occur in areas that have limited surface water supplies or non-renewable groundwater. Unincorporated El Paso County in the Arkansas Basin and Douglas County in the South Platte Basin are examples of areas that currently rely heavily on non-renewable groundwater to meet existing demands. Gaps are projected in these areas, since these supplies are not replenished and continued groundwater pumping will reduce the yield of existing wells, which will further increase the gap between supply and demand. Other areas, such as unincorporated areas of Park and Jefferson Counties in the South Platte Basin, have limited groundwater availability in the mountain areas and future development may be limited unless surface water supplies are developed and delivered to these areas to supplement the limited groundwater.

Table ES-4 Major Interstate Compacts, Decrees, and Endangered Species Programs by Basin

River Basin	Flows Legally Available under Compact or Decrees for Future Development	Interstate Compact, Equitable Apportionment Decrees and Endangered Species Recovery Programs	Year of Compact or Decree
Arkansas		Arkansas River Compact	1948
		Kansas vs. Colorado	1995
Colorado	✓	Colorado River Compact	1922
		Upper Colorado River Compact	1948
		Upper Colorado Endangered Fish Recovery Program	—
Dolores/San Juan/ San Miguel	✓	Colorado River Compact	1922
		La Plata River Compact	1922
		Upper Colorado River Compact	1948
		Animas-La Plata Project Compact	1969
		San Juan Endangered Fish Recovery Program	—
Gunnison	✓	Colorado River Compact	1922
		Aspinall Unit Operations	—
		Upper Colorado River Compact	1948
		Upper Colorado Endangered Fish Recovery Program	—
North Platte/Laramie	✓	Nebraska vs. Wyoming	1945
		Wyoming vs. Colorado	1957
		Platte River Endangered Species Program	—
Rio Grande		Rio Grande River Compact	1938
		Costilla Creek Compact	1944
South Platte	✓	South Platte River Compact	1923
		Republican River Compact	1942
		Platte River Endangered Species Program	—
Yampa/White/Green	✓	Colorado River Compact	1922
		Upper Colorado River Compact and Yampa River Portion	1948
		Upper Colorado Endangered Fish Recovery Program	—

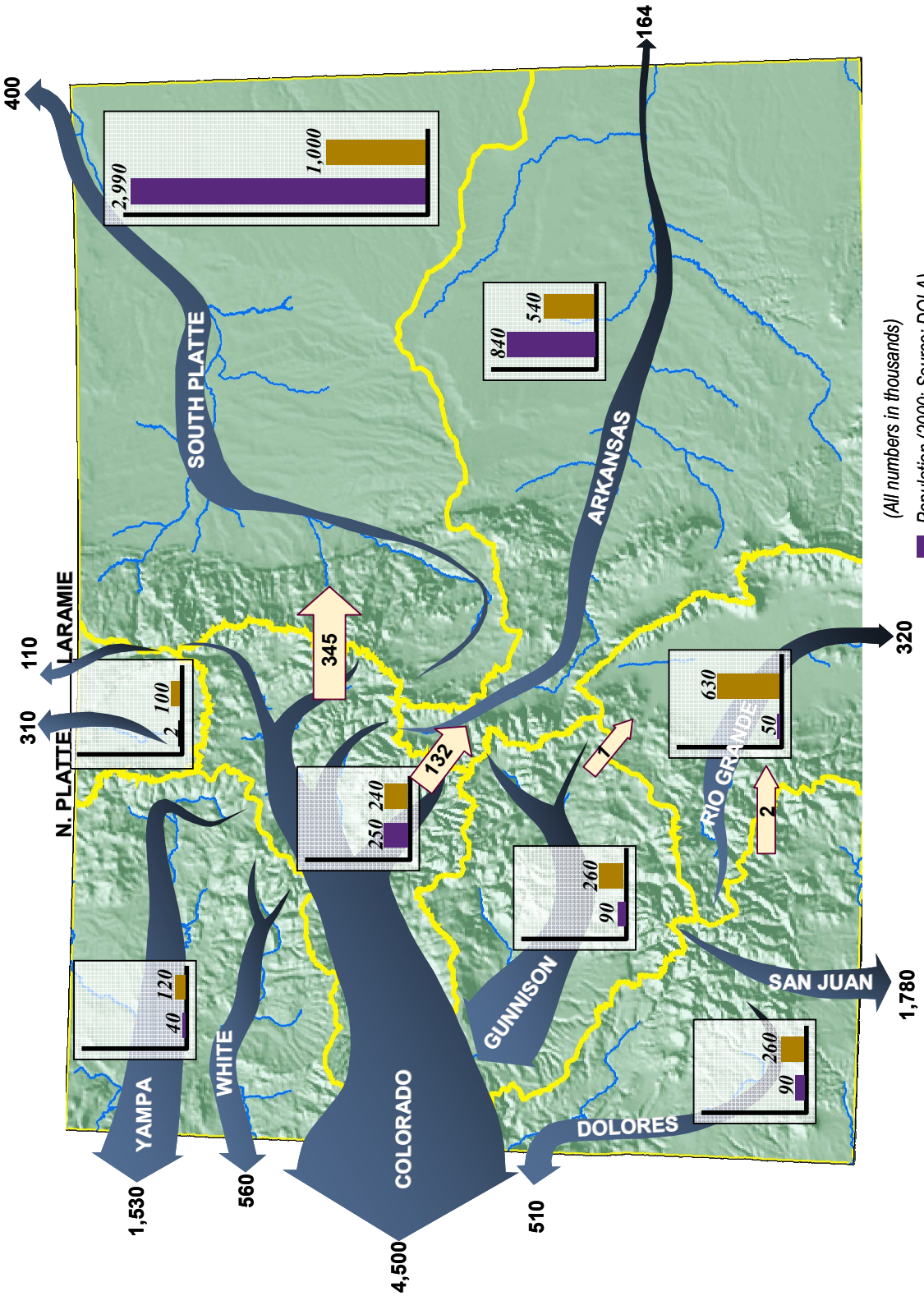


Figure ES-11
Estimates of Current Flows, Population, and Irrigated Acreage, by Basin

5. Increased Reliance on Nonrenewable, Non-tributary Groundwater for Permanent Water Supply Brings Serious Reliability and Sustainability Concerns in Some Areas, Particularly Along the Front Range

The state's aquifers are a valuable water resource that is under increasing pressures for development. Recent court cases have heightened the scrutiny of groundwater use, while the drought of 2002 has highlighted the physical constraints to continuous pumping of some regional aquifers. These challenges, when coupled with a complex hydrology, point to groundwater as an area for ongoing concern as a source of water supply.

Much of Colorado is underlain by abundant groundwater but its use as a water supply is limited in many areas by the physical or the legal constraints on the aquifer supplies. Either limitation affects the reliability and sustainability of groundwater as a source of supply. The physical availability is the amount of water an aquifer can produce, in both the short- and long-term, and primarily affects the sustainability of the resource. The legal availability is the amount of water that can be extracted from an aquifer under the water rights administration system that exists in a particular area, and can affect the reliability of the supply. Economic constraints associated with higher pumping costs may also limit the development of these supplies. Although an aquifer may be capable of producing water reliably under varying climate conditions (wet and dry years) for many decades, if it is not replenished by renewable supplies and if demands on it are too high it would not be considered a sustainable resource.

Increased demands combined with the drought since the late 1990s have resulted in declining groundwater levels in several regions and a forced reduction in use and tighter regulation of wells in some areas. Together, these events call into question the overall sustainability and reliability of many of the largest groundwater supplies, and suggest that our understanding of these supplies and their uses needs to be improved.

Colorado is fortunate to contain a variety of aquifers that are present in virtually every county. Whether the water is drawn from a shallow alluvium to irrigate crops or lifted 1,500 feet from deep bedrock to supply suburban homes, the favorable economics of groundwater development has become integral to the growth of our state.

Aquifers in the state range from those in the shallow unconfined alluvial sediments along the major river systems to the deeper confined aquifers in many of the bedrock deposits. The mountain areas also contain groundwater in fractured bedrock that is highly variable in amount and distribution. Unfortunately, many of these aquifers have a limited ability to supply usable and sustainable quantities of water. This is due to several factors including: their limited size, aquifer composition that does not allow it to readily yield water, and/or because the aquifer is not replenished quickly enough by external sources of water. The bedrock aquifers in particular have very limited and very slow natural recharge. Their supplies are typically not tributary to surface water sources and for all practical purposes are a non-renewable resource.

Groundwater use is widespread and comprises almost 20 percent of the total water used in Colorado. As shown in Figure ES-12, groundwater use is a significant portion of overall water use in the South Platte, Arkansas and Rio Grande River Basins. Due to the methods used to report water use, it is possible that groundwater use is underestimated and could represent a larger proportion of water use than shown on Figure ES-12. Figure ES-13 identifies the dominant use of groundwater for each County in the year 1995, even though the total amount of groundwater used in many areas might be small. Statewide, agriculture makes up about 90 percent of all groundwater withdrawals.

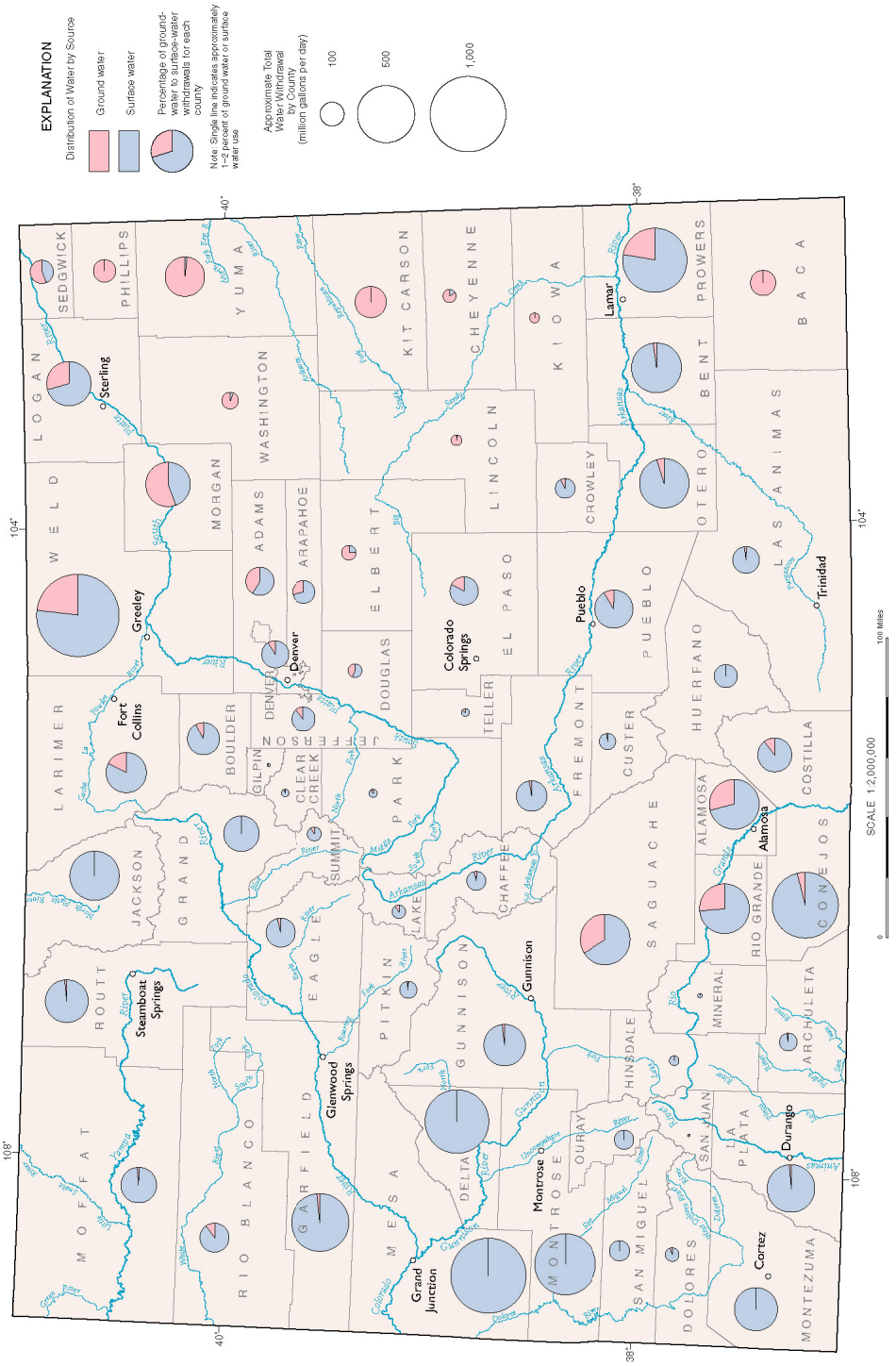


Figure ES-12
Distribution of ground versus surface water withdrawals by county in 1995

Source: Colorado Geological Survey, 2003

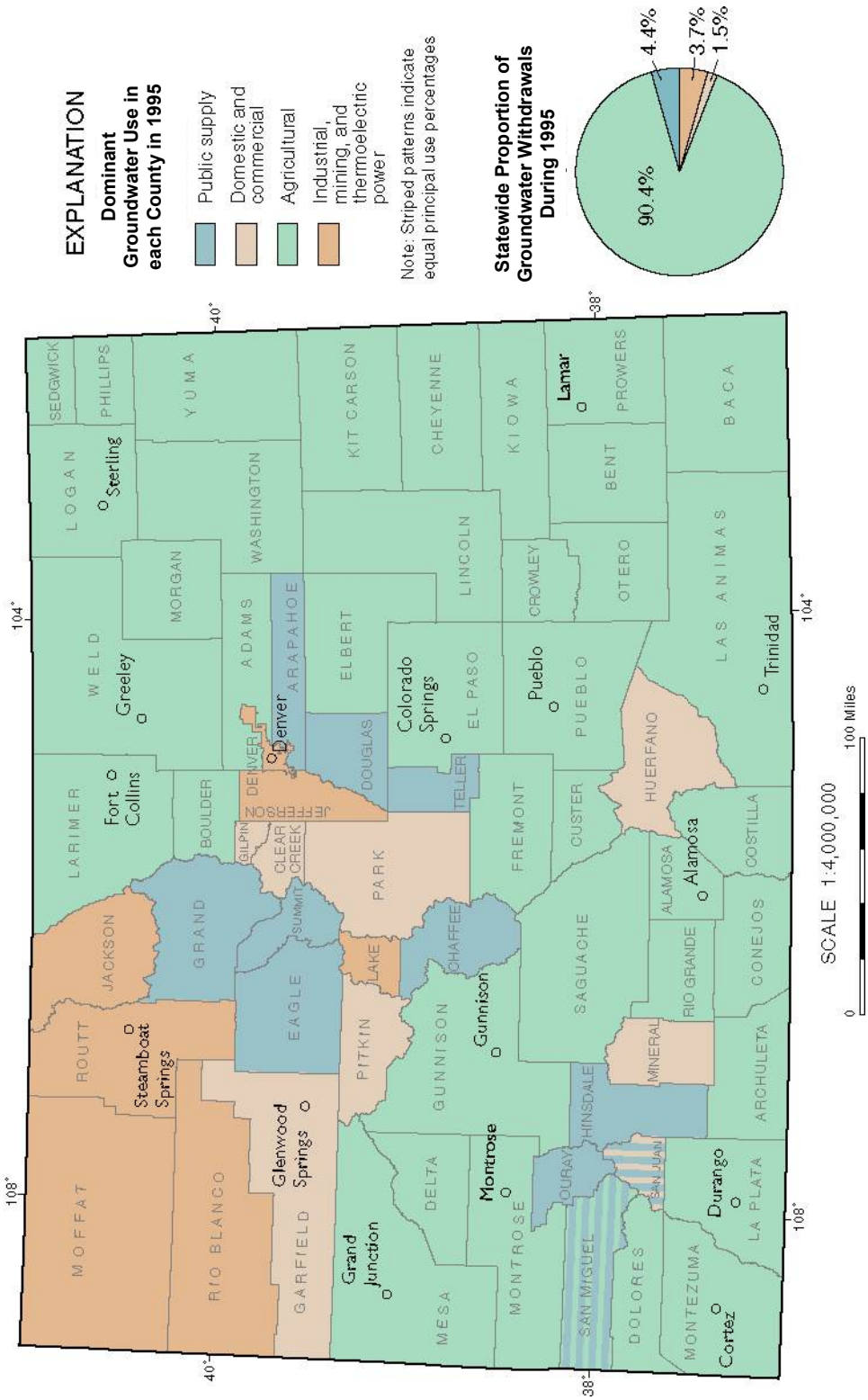


Figure ES-13
Distribution of groundwater withdrawals during 1995

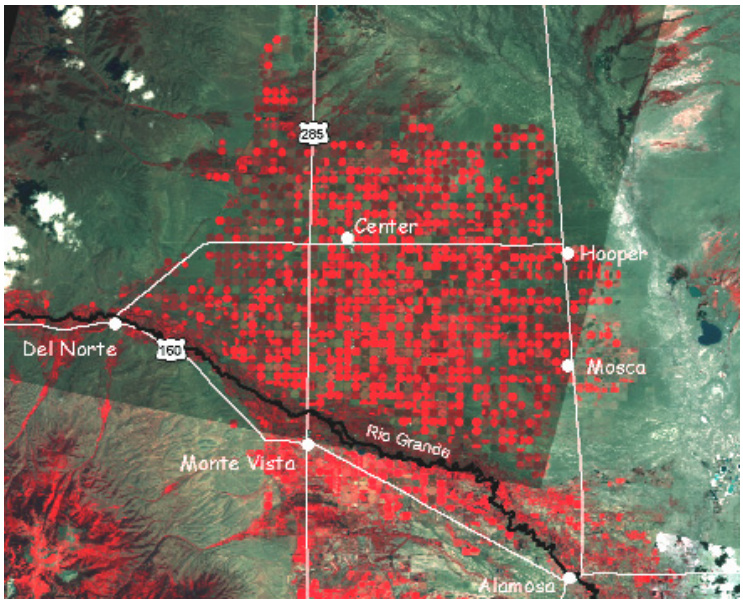
Source: Colorado Geological Survey, 2003

Physical Constraints on Groundwater Use

Many of the state's aquifers can supply limited quantities of water on a sustainable basis because of their physical characteristics. One example of this is the Closed Basin aquifer that comprises most of the San Luis Valley in the south-central part of the state. This aquifer supports large-scale agricultural production through center-pivot sprinkler irrigation (Figure ES-14). When the drought of the late 1990s began, and included one of the driest years in recent history (2002), diversions of water by the agricultural ditch systems from the Rio Grande River were severely limited. Likewise the lack of precipitation reduced surface recharge and water directly available to crops, stimulating increased pumping from the unconfined aquifer. The result has been a significant change in the volume of water stored in the aquifer and a decline in the groundwater levels in the San Luis Valley. Figure ES-15 shows that aquifer storage has been on a downward trend since 2000. Figure ES-16 illustrates the drop in water level from January 2002 through August 2003.

The Rio Grande Basin is an example of the effects of continued groundwater pumping when recharge by surface diversions is constrained during drought. While this balance between inflows (recharge) and outflows (pumping) is clearly unsustainable, more immediate concerns relate to increased pumping costs and decreased well yields. An increase of flow in the Rio Grande and increased precipitation in the San Luis Valley would increase recharge to the aquifers and help raise water levels, but, as suggested by the water level declines in recent years, the Closed Basin aquifer must be managed and used carefully.

A second example of an aquifer that is physically limited is the vast Denver Basin non-renewable bedrock aquifers, located between Greeley and Colorado Springs. Figure ES-17 provides a cross-section through the Denver Basin highlighting the four major aquifers. The aquifers are very thick and contain a significant amount of water. Unfortunately, their yield is low compared to the alluvial aquifers because of the composition of the aquifers. Impervious rock layers exist between and even within each of these aquifers and inhibit the movement of the water. The result is aquifers that are "confined," but likewise are very limited in their ability to produce water and to receive natural recharge. The confining pressure of the overlying rock causes the water in a well, when initially drilled, to sustain an artesian pressure. This upward, artesian pressure caused the earliest of these Denver Basin wells, like the one that serviced the Brown Palace in Denver in the 19th century, to actual flow without pumping.



Source: CWCB - using 1998 imagery

Figure ES-14
Center pivot irrigation crop circles in the San Luis Valley

Groundwater withdrawals for suburban communities along the Front Range have increased dramatically in many areas of the basin in the past 2 decades, particularly in the South Metro Denver region in Douglas and Arapahoe Counties and more recently Northern El Paso County. There are very few sources of renewable surface water supplies available for these areas. In the South Metro Denver area some wells (such as in the more productive Arapahoe Aquifer) are showing declines as much as 30 feet per year (see Figure ES-18) and over 250 feet total decline in the aquifer water level over an area tens of square miles in size. As water levels continue to drop there are concerns about loss in the yield of individual wells. Additional wells will be needed to sustain the delivery of water at the original rate, which will increase pumping costs dramatically.

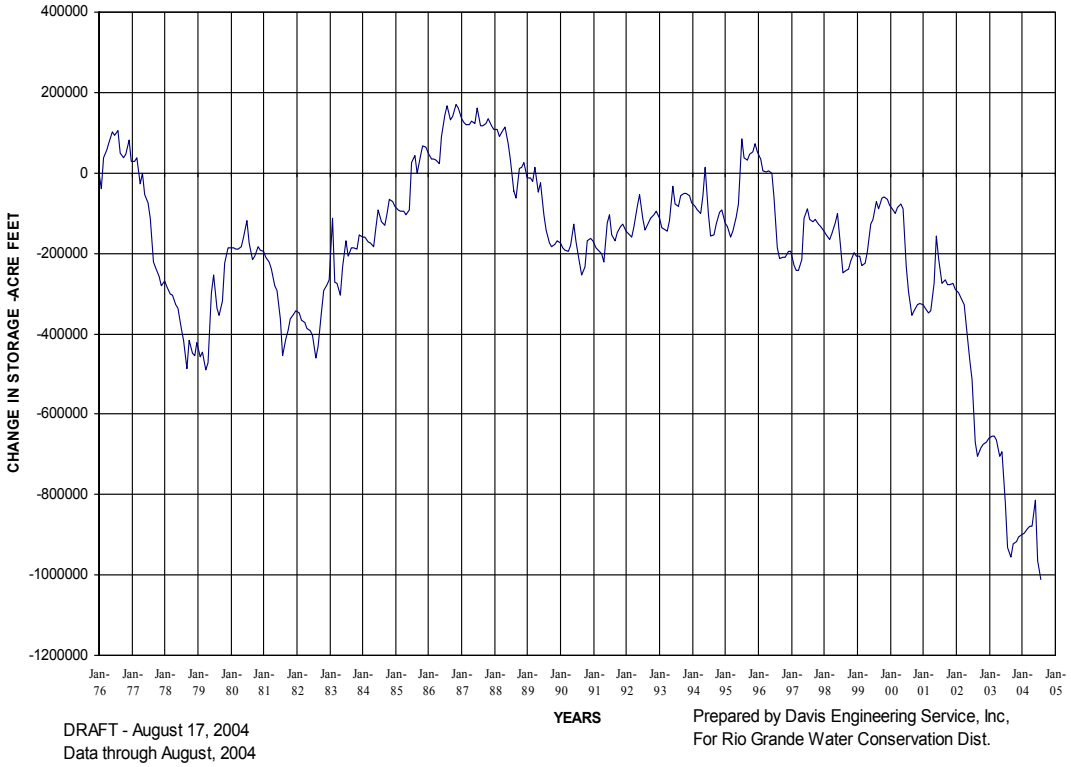


Figure ES-15
Change in Unconfined Aquifer Storage West Central San Luis Valley

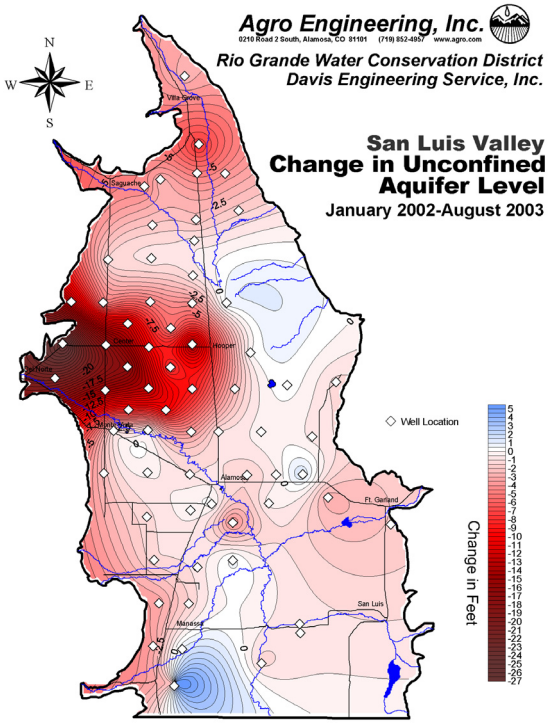


Figure ES-16
San Luis Valley Change in Unconfined Aquiver Level

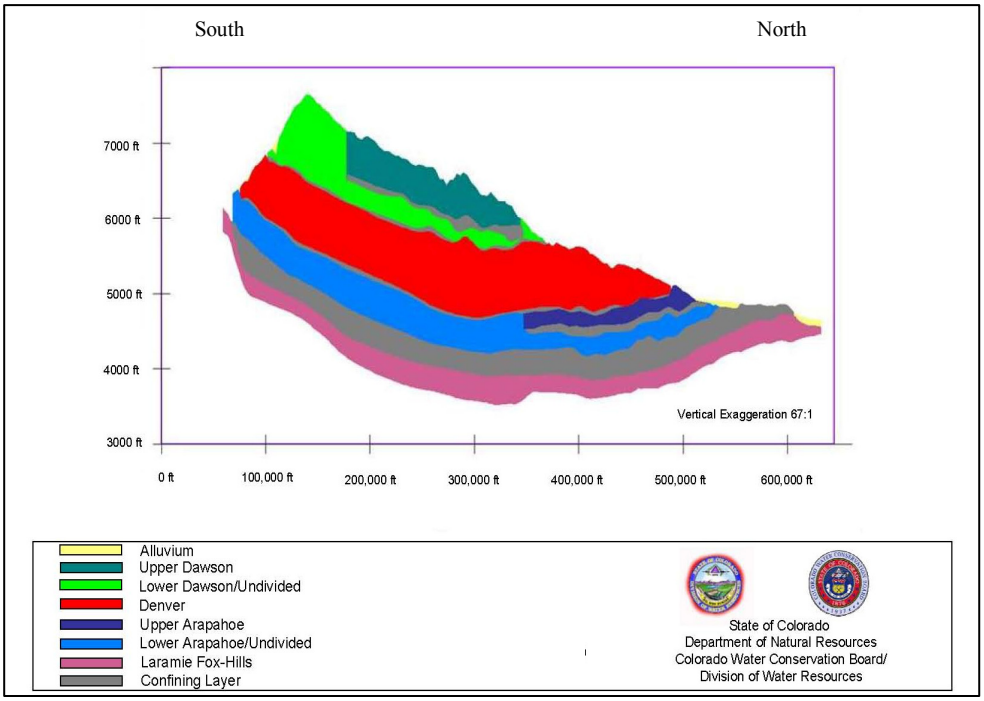


Figure ES-17
South Platte River Basin Denver Basin Aquifer
South-North Cross-Section

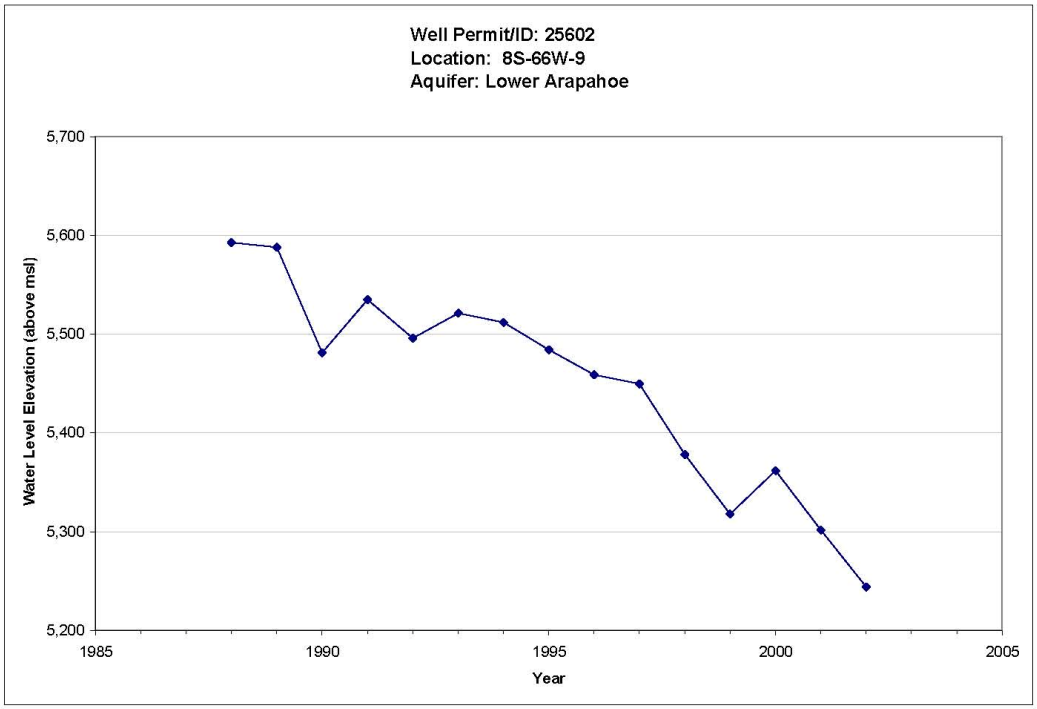


Figure ES-18
Lower Arapahoe Aquifer Water Elevation

Some further groundwater development is still possible in unincorporated El Paso County and in the South Metro Denver area. Although many water providers in the South Metro Denver region are working diligently to secure additional surface water supplies, the non-renewable bedrock aquifer supplies continue to be mined at an increasing rate. The increased reliance on nonrenewable, non-tributary groundwater for permanent water supply in many portions of the Denver Basin region brings with it serious reliability and sustainability concerns.

Legal Constraints on Groundwater Use

Some of the most productive aquifers in the state include the alluvial aquifers along the South Platte and Arkansas Rivers. These aquifers are in direct hydraulic communication with their adjacent rivers. The river water helps sustain groundwater levels in these alluvial aquifers as does seepage from irrigation canals and from surface water used for irrigation that percolates into and recharges the aquifers. An exception to this, where groundwater levels are declining, is in regions such as along the South Platte River in Morgan County where sprinkler (center pivot) systems have been installed that minimize percolation and return flows.

Today there generally has not been a limit to the physical supplies of these alluvial aquifers, but there is very clearly a limit to their legal availability. In both the Arkansas and South Platte Basins, most of the well pumping is junior in water right priority to the older surface water rights. Pumping effects on the surface water flows must be replaced and detailed plans for replacement or substitute supplies have been worked out over the years for most wells. As a result of the litigation between Kansas and Colorado over the interstate Compact with Kansas on the Arkansas River, well users in Colorado are having to restrict their historic uses. On the South Platte River, over 4,000 alluvial well users are having to adhere to new rules that may restrict their future use of this abundant supply so as to not affect the rights of senior surface water users.

The ongoing issues of water rights, either in-state or across state boundaries, have made the issue of legal availability of water a significant one for many groundwater users and have also called into question the reliability of the alluvial aquifer supplies. The physical and legal availability of alluvial aquifer supplies also need to consider the value of those aquifers in providing baseflow to streams that help maintain riparian wildlife habitat and preserve aquifer supplies so that they are available for use during times of drought. These factors should be considered as components in both the sustainability and reliability of the state's groundwater resources.

Conclusion

Groundwater as a source of water supply finds itself at a juncture of legal and physical constraints. As an economic and practical source of water for both agriculture and domestic use, the further development of groundwater is highly probable. Concerns about reliability and sustainability are appropriate within the context of drought and the administration of our water resources under the Prior Appropriation Doctrine.

6. In-basin Solutions Can Help Resolve Gaps Between M&I Supply and Demand, but There Will Be Tradeoffs and Impacts on Other Uses

The Identified Projects and Processes developed by the Basin Roundtables and Options for Future Alternatives formulated as part of the SWSI process generally fall under one of six families of options:

- Conservation Options, including:
  - Active Municipal & Industrial Conservation Measures
  - Agricultural Efficiency Measures
- Agricultural Transfers, including:
  - Permanent Agricultural Transfer
  - Interruptible Agricultural Transfer
  - Rotating Agricultural Transfer (Fallowing) with Firming for Agricultural Use
  - Water Banks

- Development of Additional Storage, including:
  - Development of New Storage Facilities
  - Enlargement of Existing Storage Facilities
- Conjunctive Use of Surface Water and Groundwater
  - Non-renewable Bedrock Aquifers
  - Alluvial Aquifers
- M&I Reuse, including:
  - Water Rights Exchanges
  - Non-potable Reuse
  - Indirect Potable Reuse
- Control of Non-Native Phreatophytes

The options under these categories have the potential to help resolve the remaining gaps for each basin. Public and institutional support are important factors for these options to be successfully implemented and sustainable. The support and the willingness to implement and maintain the projects will be, in turn, dependent on the extent to which each option meets the basins and the project's water management objectives.

These objectives (presented earlier in this Executive Summary), coupled with associated performance measures that indicate the extent to which the options meet the objectives, were used to explore potential benefits, tradeoffs, and issues associated with the options as indicated in Table ES-5.

Water development and use has occurred at varying rates and levels throughout the state. In some areas, supplies are already taxed and further development may have undesirable effects on agriculture, the environment, and recreation. In other areas, future development may occur with fewer effects.

In some areas of the state, and particularly along the Front Range, agricultural transfers are a commonly used option to increase supplies to meet the majority of M&I needs – a reflection of the changing nature of the West from rural to more urbanized communities. While this is a valid and viable approach, it represents only one way of meeting M&I demands. Many alternative approaches can and should be explored, each with tradeoffs that result from the diverse nature of the SWSI management objectives.

Of note is that most large water providers reportedly plan for meeting demands during a repeat of a historical drought (normally 1950s hydrology) without the need for water use restrictions. Clearly, local projects (the "Identified Projects and Processes") are key to closing the supply/ demand gap.

Also of interest in many basins is the potential for rehabilitating existing storage facilities to restore or enhance their storage capacities. While Colorado has a number of so-called "restricted" dams that could be rehabilitated to increase storage, there is limited potential because the amount of physical storage that could be gained in most basins is limited.

The SWSI process analyzed the technical information in light of the management objectives, as prioritized by the individuals participating in the Basin Roundtables. Due to the multi-objective nature of the process, tradeoffs exist and difficult choices often must be made. The SWSI process identified general alternatives that seem to best meet the sometimes-conflicting water management objectives. Options that address more than one objective – those that offer benefits in more than one aspect and to more than one user – are more likely to be supported and implemented, based on the preferences unique to each basin.

Table ES-5 Potential Benefits and Issues of Families of Options for Resolving Supply and Demand Gaps

Option	Potential Benefits	Potential Issues
Conservation Options		
Active Municipal & Industrial Conservation Measures *Examples:* ■ Metering ■ Increasing water rate pricing ■ Rebates for efficient water using appliances ■ Incentives for reducing high water use landscaping ■ Restrictions on amount of lawn area	■ Implementation costs can be significantly lower than new water supply development ■ No permit requirements to implement ■ Implementation is within control of the water provider and does not require approval of other entities ■ No new diversions required from rivers or streams ■ Can stretch existing supplies ■ Potential water quality benefits ■ Lesser environmental impacts than new storage ■ Can reduce water and wastewater treatment, distribution, and collection capital and operations and maintenance costs	■ May result in demand hardening and decrease supply reliability if conserved water is used for new growth and water restrictions are needed during droughts ■ Customers may be unwilling to accept mandated conservation measures ■ Impacts on utility revenues as a result of reduced demand ■ Loss of return flow credits that must be replaced with other sources ■ May not increase supplies for providers with augmentation plans if they receive full credit for all return flows ■ Some urban water providers may be at a high level of conservation
Agricultural Efficiency Measures *Examples:* ■ Ditch lining ■ Conversion of flood irrigation to gated pipe ■ Installation of sprinklers	■ Can stretch existing supplies ■ May reduce non-crop consumptive use ■ Potential water quality benefits ■ No new diversions required from rivers or streams ■ No permit requirements to implement	■ Loss of return flows may impact downstream water rights and environment ■ Ability to pay ■ Water rights limitations, cannot sell or transfer salvaged or saved water ■ Potential compact issues ■ May increase downstream calls ■ May result in an unauthorized increase in CU in historically water short systems ■ May impact groundwater tables and wells in the area
Agricultural Transfers		
Permanent Agricultural Transfer The acquisition of agricultural water rights and the cessation of irrigation on these historically irrigated lands. Water rights are transferred to other uses.	■ Permanent water right ■ Usually more senior water rights with greater reliability and less storage required to produce a firm annual yield ■ Simpler permitting than a new reservoir storing new water rights ■ Does not increase depletions within the basin ■ Return flows from the historic consumptive use are consumable and can be reused ■ Lesser environmental impacts than a new water storage project	■ Local socio-economic impacts as a result of dry-up of agricultural lands ■ Dry-land has a substantially lower assessed value than irrigated agricultural land, which affects local tax revenue ■ Water court procedure required to change the use of agricultural water rights ■ Revegetation of lands to be dried up required under certain circumstances ■ Potential loss of open space ■ Potential loss of wetlands and riparian habitat ■ Approximately 3 AF of storage is required to produce 1 AF of firm annual yield for M&I use ■ May impact groundwater tables and wells in the area unless historical returns are made in the exact location

Table ES-5 Potential Benefits and Issues of Families of Options for Resolving Supply and Demand Gaps

Option	Potential Benefits	Potential Issues
Interruptible Agricultural Transfer An agreement with agricultural users that allow for the temporary cessation of irrigation so that the water can be used to meet other needs.	■ Improves M&I reliability by providing water during dry years ■ Provides more stable income to agricultural users during droughts ■ Preserves agricultural use as opposed to a permanent dry-up ■ Less storage or water development is needed to provide a reliable supply during drought years	■ There is disagreement over whether interruptible supplies should remain in irrigation in perpetuity ■ Agricultural supplies may not be in needed location or of sufficient quantity to meet the demands ■ Agricultural rights must have dry year yields ■ May need to adjudicate change of water right for M&I use ■ Determination of transferable amount can be complicated and other water users must be protected ■ Soil, weed, labor and equipment management issues must be considered during those years when irrigation is not occurring
Rotating Agricultural Transfer (Fallowing) with Firming for Agricultural Use An agreement with a number of agricultural users that provides for the scheduled fallowing of irrigated lands on a rotating basis so that the water not irrigating fallowed lands can be used for other uses. Includes a set aside and storage of some of the yield to provide a pool for use by the agricultural users during below average water supply years.	■ Improves M&I reliability ■ Provides more stable income to agricultural users ■ Preserves agricultural use as opposed to a permanent dry-up ■ May provide for a firming of agricultural supplies ■ Provides for annual water deliveries ■ Provides for conjunctive use with non-tributary groundwater, such that groundwater can be a drought supply, extending the life of the groundwater supply	■ There is disagreement over whether rotating agricultural supplies should remain in irrigation in perpetuity ■ May be more expensive than permanent agricultural transfer ■ Some agricultural demands such as hay and orchards are difficult to fallow and may not be appropriate for a rotating fallowing program ■ Agricultural supplies may not be in needed location or of sufficient quantity ■ May need to adjudicate change of water right for M&I use ■ Determination of transferable amount can be complicated and other water users must be protected ■ Soil, weed, labor and equipment management issues must be considered during those years when irrigation is not occurring ■ Storage may be required to firm yield for all parties
Water Banks A mechanism where water users can announce they have unused supplies that can be leased by other users.	■ Can improve supplies for users acquiring water from the water bank ■ Can preserve agricultural use by allowing alternative uses on an interim basis ■ Provides a stable income to agriculture if water bank is successful ■ Provides for flexibility in water management	■ Water may no be available from the water bank when needed ■ May need to adjudicate change of water right for M&I use ■ Determination of transferable amount can be complicated and will have objectors that must be protected ■ Soil, weed, labor and equipment management issues must be considered during those years when irrigation is not occurring ■ Challenges in starting a market

Table ES-5 Potential Benefits and Issues of Families of Options for Resolving Supply and Demand Gaps

Option	Potential Benefits	Potential Issues
Development of Additional Storage		
Development of New Storage Facilities Construction of new storage facilities. Storage options include on channel and off-channel reservoirs or gravel lakes.	■ Can diversify water sources if water to be stored is from a new source ■ Can increase the reliability of supply and reduce risk of supply shortfalls ■ Does not impact existing water rights if storing under a new water right ■ Can potentially reduce the pressure to transfer agricultural rights ■ Captures an unused resource ■ Maximizes compact entitlements ■ Increases overall system efficiencies by minimizing system spills ■ Increase the yield of exchanges and non-potable reuse for irrigation ■ Required to firm the yield of agricultural transfers ■ May provide flat water recreation opportunities ■ Potential for hydropower generation	■ There may be significant environmental impacts. These impacts are likely to be more significant than if enlarging existing storage facilities. ■ Loss of recreation associated with free-flowing streams, such as fishing, rafting, kayaking. ■ Water quality impacts can be associated with impounded water. ■ Cultural impacts associated with inundation of lands. ■ Permitting and mitigation can be expensive and lengthy with an uncertain outcome. ■ A significant amount of storage may be required to produce an acre-foot of firm yield. The amount of storage required will be basin and water rights specific.
Enlargement of Existing Storage Facilities Increasing the available storage in existing storage facilities. Options include raising dam embankments, dredging and raising spillway levels.	■ Fewer environmental issues than new storage ■ Permitting and mitigation requirements may be less stringent than new storage ■ Can increase the reliability and reduce risk of supply shortfalls ■ Other benefits are the same as development of new storage	■ Environmental and recreation impacts can also occur here depending on the size of facility. ■ May not diversify water sources ■ Permitting and mitigation requirements can be expensive and lengthy with an uncertain outcome ■ May have a high storage to yield ratio, depending on the water to be stored ■ Limited number of reservoirs to enlarge, since most reservoirs are not cost-effective to enlarge ■ Limited volume of increased storage available ■ May not be cheaper than new storage since original structures have not been designed or constructed to current engineering standards
Conjunctive Use of Surface Water and Groundwater		
Non-renewable, Bedrock Aquifers The diversion and well injection of surface water supplies into a bedrock aquifer during times of surplus surface water and extraction of groundwater during times of insufficient surface water supplies. The intent is to extend the life of non-renewable groundwater sources.	■ Recharges aquifers that have very low or almost non-existent rates of recharge ■ Maximizes the beneficial use of nonrenewable aquifers and extends their useful life ■ Evaporation is minimized ■ Lesser environmental impacts than reservoir storage ■ The permitting process is simpler than for developing surface water storage ■ Can use existing infrastructure during non-peak demand periods ■ Potable quality water can be withdrawn ■ Significant volumes of potential aquifer storage available	■ Surface water supplies must be available for recharge ■ Water has to be treated to potable water quality and must be chemically compatible with native groundwater before recharge to reduce clogging ■ All of the recharged water may not be recoverable ■ High energy costs incurred for recharge and pumping ■ May need additional wells or storage and surface water treatment to meet peak demands ■ Injection rates usually are low ■ Additional storage needed to capture peak surface water flows for recharge

Table ES-5 Potential Benefits and Issues of Families of Options for Resolving Supply and Demand Gaps

Option	Potential Benefits	Potential Issues
Alluvial Aquifers The recharge of alluvial aquifers through diversion and infiltration of surface water supplies during times of surplus surface water and extraction of groundwater during times of insufficient surface water supplies.	■ Potential alternative to some reservoir storage options ■ Evaporation is minimized ■ Lesser environmental impacts than reservoir storage ■ Helps maintain wetlands and riparian habitat ■ Simpler permitting than reservoir storage ■ Streamflows can be diverted and recharged without additional treatment costs ■ Can use existing structures for recharge ■ Recharge can occur with low capital and operating costs ■ Significant volumes of potential aquifer storage available ■ Relatively high recharge rates exist ■ Can be used to increase and time streamflows for environmental enhancements ■ Can be used to augment agricultural well pumping	■ Surface water supplies must be available for recharge ■ Water quality may be degraded during recharge ■ Water must be treated if used for potable purposes ■ Advanced water treatment may be required ■ May lead to elevated water table conditions which could damage structures ■ The recharged water will eventually return to the river system if not used or recaptured and can be unrecoverable ■ May need additional wells to meet peak demands ■ May need storage to capture peak surface water flows for recharge ■ Requires a water court approval process
M&I Reuse		
Water Rights Exchanges The exchange of legally reusable return flows for water diverted at a different location.	■ Improves M&I reliability ■ Maximizes successive uses of water ■ Maximizes beneficial use of water ■ May not require additional diversion structures or other facilities ■ Lesser environmental impacts than a new water supply project ■ Implementation costs can be significantly lower than new water supply development	■ Requires that there be sufficient exchange potential ■ Substitute supply must be suitable for downstream water uses within the statutory framework ■ There may be water quality objections from downstream users ■ Must have storage to regulate year round effluent flows and meet demands during irrigation season ■ Previously unused reusable effluent historically resulted in reduced or more junior river calls controlling the river ■ River calls may become more senior, impacting all users
Non-potable Reuse The capture and use of legally reusable return flows for the irrigation of urban landscapes or for industrial uses.	■ Improves M&I reliability ■ Maximizes successive uses of water ■ Maximizes beneficial use of water ■ May not require new diversion structures ■ Lesser environmental impacts than a new water supply project ■ Does not use higher quality drinking water for irrigation	■ Can be very expensive ■ Must have consumable effluent to reuse ■ Wastewater treatment plant needs to be near irrigation demands ■ Must have storage to regulate year round effluent flows and meet demands during irrigation season ■ Previously unused reusable effluent historically resulted in reduced or more junior river calls controlling the river ■ River calls may become more senior, impacting all users ■ Public acceptance of the reuse of effluent for landscape irrigation must be achieved

Table ES-5 Potential Benefits and Issues of Families of Options for Resolving Supply and Demand Gaps

Option	Potential Benefits	Potential Issues
Indirect Potable Reuse The capture of legally reusable return flows and reintroduction of these captured flows into the municipal raw water supply.	■ Improves M&I reliability ■ Maximizes successive uses of water ■ Maximizes beneficial use of water ■ Lesser environmental impacts than a new water supply project ■ May not require new diversion structures	■ Can be very expensive ■ Must have consumable effluent to reuse ■ Raw water treatment plant and/or pump back station needs to be constructed ■ Existing and future regulatory compliance ■ Disposal of treatment waste stream ■ Previously unused reusable effluent historically resulted in reduced or more junior river calls controlling the river ■ River calls may become more senior, impacting all users ■ Public acceptance of the use of return flows for drinking water must be achieved
Control of Non-Native Phreatophytes		
Control of Non-Native Phreatophytes The reduction or elimination of non-native plants that consume significant volumes of water along rivers and streams.	■ Benefits all users: M&I, Agriculture, Environment, and Recreation ■ Reduces non-beneficial consumption of water ■ Creates additional supplies without new water storage or other infrastructure	■ Any water saved would be administered under the water rights system ■ Does not benefit specific users and thus funding by water users will be a challenge ■ Would require regional cooperation and funding from a regional, state or federal agency ■ Demonstration projects may provide better information on costs and benefits ■ It is not clear that the vegetation that replaces the non-native species will use less water ■ Demonstration projects are planned in the Rio Grande and Arkansas and USGS is updating potential water savings estimates

Examples of those multi-objective options are described in Table ES-6.

The options that perform well in meeting more than one of the objectives have the ability to provide the supply necessary to fill the demand gaps, in the basins where these exist. This is particularly true when the options are implemented conjunctively, as balanced alternatives to meet demands while also meeting many of the management objectives.

It is important to note that not all of the multi-objective options are feasible in every basin. For example, the predominance of hay production and orchards in certain areas of the West Slope may render a rotating fallowing program impractical. Agricultural efficiency, while having multiple benefits, also must be carefully evaluated in terms of its impacts on return flows, other water users, compact requirements, and the environment.

Many of the Identified Projects and Processes, as well as the family of options developed during the SWSI process, include some storage components. Options that are not storage options *per se*, either require, or may be enhanced by, the addition of storage to:

- Firm M&I and/or agricultural supplies by storing the additional supply generated by the option
- Firm agricultural supplies by storing during wet years when a given agricultural user could have economically irrigated
- Provide environmental and recreational pools for storage projects whose primary purpose is meeting M&I needs

Clearly, multiple solutions will be needed in each basin to meet the multiple and diverse demands for water that have been identified and projected. Water supply challenges exist and will intensify in the coming years, and many unique solutions will be needed.

Table ES-6 Multi-Objective Options

Option	Potential to Meet the Objective	Measured by
M&I Reuse for Irrigation	■ Sustainably meet M&I demands	■ The option has very good potential to reliably provide additional supply during a drought.
	■ Optimize existing and future water supplies	■ Has the ability to maximize successive uses of non-tributary groundwater and other legally reusable water.
	■ Protect cultural values	■ It helps maintain the quality of life unique to each basin. In residential areas it maintains the current landscape. In rural areas, the return flows may benefit downstream users.
Rotating Ag transfers with Firm Yield for Agriculture	■ Sustainably meet M&I demands	■ The option has very good potential to reliably provide additional supply during a drought.
	■ Sustainably meet agricultural demands	■ The option has good potential to reliably meet agricultural demands, by contracting with agricultural users in a rotating, yearly basis. Storage provided firms the supply to allow agricultural users to produce during dry years.
	■ Provide for environmental enhancement	■ It has the potential to improve water quality by emphasizing the cyclical retirement of agricultural lands with higher concentrations of pollutants of concern.
	■ Protect cultural values	■ It helps maintain the quality of life unique to each basin. In residential areas it maintains the current landscape. In rural areas, the return flows may benefit downstream users.
	■ Provide for operational flexibility	■ Provides for short-term transfer of water to different users/uses, while protecting water rights.
M&I and Agricultural Conservation	■ Sustainably meet M&I demands, and Sustainably meet agricultural demands, respectively	■ The M&I conservation option has very good potential to reliably provide additional supply during a drought. The Ag conservation option has good potential to help to reliably meet agricultural demands.
	■ Optimize existing and future water supplies	■ These options minimize non-beneficial consumption, help maximize successive uses of non-tributary groundwater and other legally reusable water.
	■ Promote cost effectiveness	■ Moderate levels of M&I conservation, and introduction of canal lining, sprinklers, and drip irrigation are cost competitive with other alternative sources of water.
	■ Protects cultural values	■ Although M&I conservation requires changes in consumer behavior and may impact landscape to some extent, agricultural conservation improves reliability of supply and makes agriculture viable.
New Reservoir and Reservoir enlargement to Firm Existing Water Rights	■ Sustainably meet M&I demands, and Sustainably meet agricultural demands, respectively	■ Reservoir storage has very good potential to reliably provide additional M&I supply during a drought, and very good potential to firm agricultural needs.
	■ Protect cultural values	■ It helps maintain the quality of life unique to each basin in residential areas where it maintains the current landscape. In rural areas, existing water rights are used by junior water users.

7. Water Conservation (Beyond Level 1) Will Continue to be Relied Upon as a Major Tool for Meeting Future M&I Demands, but Conservation Alone Cannot Meet All of Colorado's Future Needs

Water conservation will continue to be relied upon as a major tool for meeting future demands for Colorado. Conservation can be a cost-effective means to manage water demands, is an option that is under the control of the individual water provider, and does not require any state or federal permits. However, water conservation can harden demand and reduce operational flexibility.

It is necessary to distinguish between water conservation and temporary demand modification measures such as drought restrictions. Temporary drought restrictions include requests for voluntary demand reductions or mandatory water use restrictions during drought conditions. This type of demand modification usually involves drastic, temporary behavioral changes such as not watering lawns, trees, plants, or not washing the car. Droughts can also result in permanent water conservation benefits, such as retrofitting indoor plumbing devices with more efficient water saving devices or reducing or eliminating high water use landscaping. During the most recent drought, many water providers contacted as part of the SWSI effort reported that mandatory restrictions resulted in short-term water demand reductions of 20 to 30 percent. Ongoing water use savings at these levels are usually not sustainable without significant impacts to quality of life.

A Level 1 conservation effect, which will occur over time, has been built into the SWSI planning assumptions. Level 1 conservation results in demand reductions from implementation of federal legislation that established maximum water use standards for certain residential and commercial indoor plumbing fixtures. This conservation requires no action on the part of water customers or water providers. It is estimated that by 2030, Level 1 conservation will result in demand reduction in Colorado of approximately 101,900 AF.

Additional water conservation savings are anticipated over time as water providers continue existing water conservation programs and implement additional water conservation measures. These efforts beyond Level 1 conservation are included as part of many water providers/ Identified Projects and Processes to meet future M&I demands. This active water conservation impact requires the active efforts of water providers and water customers to maintain and expand water conservation programs.

Water providers may begin water conservation efforts by metering all customers and implementing a program of systematic leak detection and repair of water distribution lines, meters and hydrants. Typical water conservation measures offered by water providers may include:

- Water use efficiency information and public school programs
- Rebates for low-flush toilets and high efficiency clothes washers
- Water use audits of residential, commercial, and industrial customers
- Water use audits of large landscape areas and irrigation systems
- Implementing tiered water rate structures that increase rates in proportion to usage

More advanced or aggressive conservation efforts may include:

- Rebates for landscape replacement and turf removal
- Ordinances restricting landscape areas
- Rebates for irrigation moisture sensors and evapotranspiration based controllers
- Ordinances requiring sub-metering of master-metered properties
- Ordinances requiring water fixture retrofit upon sale of properties
- Ordinances eliminating single-pass cooling systems
- Rebates for installation of non-water using urinals by non-residential customers

According to a survey (Colorado Municipal League 1994), most water providers are engaged in some level of active conservation for long-term reduction in water demands. Information from the Municipal League survey was used to approximate the current level of active conservation effort in each basin. SWSI estimates these current active conservation programs could result in additional water demand savings ranging from 3 to 14 percent by basin, or an estimated 231,000 AF statewide, by 2030 (see Figure ES-19) if the current level

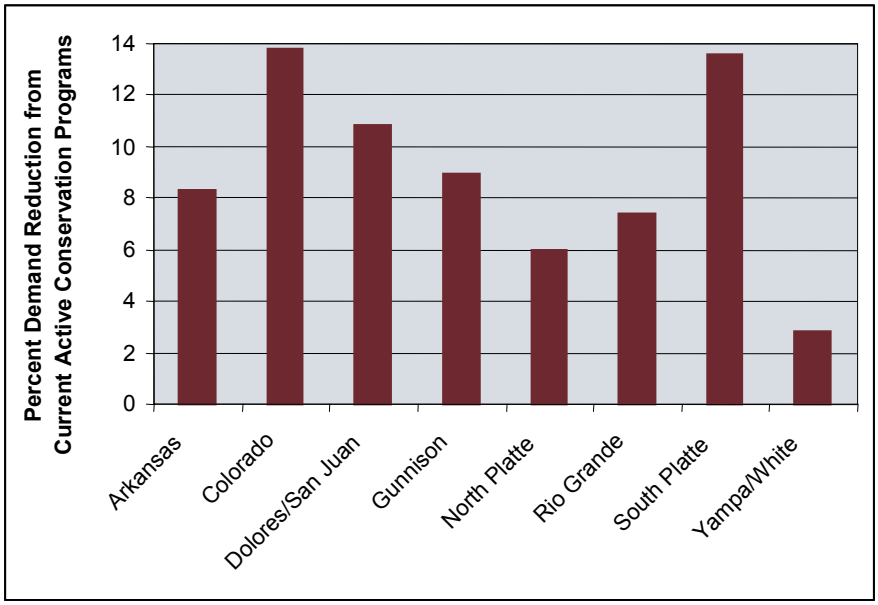


Figure ES-19
Estimated Water Demand Savings by 2030
Associated with Current Active Water Conservation Programs

of effort is sustained over the entire period. Additional conservation savings are factored into the Identified Projects and Processes for many water providers.

Many of the major M&I providers are already at Level 2 and 3 conservation. This makes meeting all future needs through conservation even more difficult and unlikely. Reductions in demand associated with conservation are also, in part, affected by the ratio of SSI to M&I use. For example, the potential reduction is lower in the Yampa/White/Green Basin because a significant portion of that basin's increased demand will be associated with SSI needs.

The reduction in water demand from continuation of the current level of conservation will help Colorado water providers meet future demands. Additional conservation beyond Level 1 is part of many providers' Identified Projects and Processes. However, reliance on water conservation to meet all additional water demands is not possible. While citizens will respond by temporarily reducing water use during drought conditions, and many are willing to make technological improvements in water use efficiency, there are technical and social limits to long-term water conservation. Conservation levels that would need to be imposed to meet all future demands would result in a significant change in the quality of life for most Coloradans.

Also, as Colorado water providers and water customers continue to implement long-term water conservation, it may be harder to expect the 20 to 30 percent demand reductions that were seen in the recent drought for future year droughts. This is due to the "demand hardening" effect. As water customers become more efficient in their everyday use, there is less "room" to conserve – that is, many of the measures that can be taken to reduce both indoor and outdoor water use have at that point become commonplace. Significant further reductions in water use would require more aggressive mandatory measures over time that could impact Coloradans' quality of life. Moreover, if the water that is conserved through these aggressive measures is then used to support increasing demands associated with growth, that water is no longer available to address temporary mandatory demand reductions in response to future drought conditions.

Finally, many water providers today claim credit for return flows from treated wastewater effluent and lawn watering (as prescribed in their water rights). Therefore, reducing lawn watering or indoor water use may reduce return flows and may not result in a net increase in available supply.

8. Environmental and Recreational Uses of Water are Expected to Increase with Population Growth. These Uses Help Support our Tourism Industry, Provide Recreational and Environmental Benefits for our Citizens, and is an Important Industry in Many Parts of the State. Without a Mechanism to Fund Environmental and Recreational Enhancement beyond the Project Mitigation Measures Required by Law, Conflicts Among M&I, Agricultural, Recreational, and Environmental Users Could Intensify.

Colorado was the third fastest growing state during the 1990s and this high growth rate is projected to continue. One of the primary factors for this growth rate is the quality of life in Colorado. In addition to the attractive climate, the natural environment of the Rocky Mountains and the wide array of recreational opportunities attract new residents and businesses. Recreational opportunities include skiing and snowboarding, golf, hunting, bicycling, camping, hiking, backpacking, reservoir-based recreation, stream and lake fishing, watchable wildlife, rafting and kayaking, boating and water skiing. Many of these recreational activities are water-based (fishing, boating, rafting, kayaking and water skiing) or rely on water to support the activity (turf watering for golf and snowmaking for skiing and snowboarding.)

In addition to the recreational opportunities for residents, recreation and the natural environment support tourism, a major economic driver, in many parts of the state. In many headwaters counties, recreation and tourism are the largest industries. As population growth continues, there will be increasing and competing demands for water. The new permanent residents and businesses will require water for their domestic uses, residential landscaping, urban recreation, and the associated municipal, commercial, and industrial uses that accompany population growth. These same residents will also seek water-based and other types of recreation in Colorado's natural environment.

In many parts of the state, the Basin Roundtables identified the need to enhance the environment and recreational opportunities. Many local efforts to evaluate and address environmental and recreational enhancements have been identified in each basin during the SWSI process. Voluntary efforts such as flow management agreements to provide for the timing of flows between reservoirs have been successfully used in some basins. Similar agreements could be explored as part of future water management solutions.

As water supply projects are developed for future M&I and agricultural needs, federal permitting is required by law to provide for avoidance and mitigation of adverse impacts. The permit process requires an examination of the potential to avoid and minimize project impacts, prior to considering mitigation alternatives. No significant degradation of the environment is allowed, even with mitigation. The permitting process for any new water project plus providing for the legally required mitigation can be very expensive and may render some projects too costly for the project proponents. This is especially true for agricultural and smaller or rural water providers that have a limited revenue base to pay for the project costs.

The development of reliable water supplies for agricultural, municipal, and industrial uses will compete with the desire to preserve the natural environment and to maintain and enhance water-based recreation opportunities. However, there may be opportunities to achieve benefits for multiple users or use types with any project or water management solution. Desired environmental enhancements include but are not limited to:

- Providing flow to enhance streams or lakes for fisheries or endangered species
- Improving habitat for fisheries and endangered species
- Improving water quality
- Preserving and expanding wetlands
- Enhancements of the riparian corridors

Potential recreational enhancements include but are not limited to:

- Providing instream flows for rafting and kayaking
- Permanent reservoir pools for flat-water recreation

While it is very difficult for water providers to pay for new water projects, environmental and recreational interests have even more limited resources to provide for the desired enhancements. The CWCB has an instream flow water rights program that provides for the appropriation

of water flows to preserve the natural environment to a reasonable degree. These are relatively junior water rights (post 1970) but because they are in-channel and non-consumptive rights, they are always in a position to call new junior rights or affect changes made to senior rights thereby maintaining the status quo. Some environmental interests would like to see more senior water rights available to guarantee minimum flows at all times. Recent legislation (SB 02-156) authorizes the CWCB to accept interests in water rights to preserve or improve the environment. Additionally, local governmental entities can appropriate flows for Recreational In-Channel Diversions (RICD) to preserve existing available flows for recreational uses such as rafting and kayaking.

The desire to provide for enhancement of the existing environment in addition to the mitigation required by law has created significant conflicts between M&I and agricultural water users on the one hand, and environmental and recreational interests on the other. Given the complexity of project design and stakeholder negotiations, it may be difficult in some cases for stakeholders to clearly delineate required mitigation from desired enhancement. Since environmental and recreational interests often do not have the ability to pay for the acquisition of senior water rights, they often seek additional concessions, beyond the legal requirements, from water project proponents during the permit process. Seeking these additional concessions can create significant conflict and litigation, increase transaction costs, delay project permitting, and may render a project infeasible from an engineering or financial standpoint. Thus the failure of the project to move forward results in the loss of the potential enhancements, and increases the gap between supply and demand.

In addition to M&I, the need for environmental and recreational enhancements will become more important with additional population growth. Unless a mechanism to fund environmental and recreational enhancement beyond the project mitigation measures required by law is developed, conflicts will continue. Water project proponents do not believe that they should have to fund or otherwise provide for environmental and recreation enhancements (beyond required mitigation) that benefit the general public beyond their direct customer base. Water providers have indicated during the SWSI process that they would be willing to consider the development of environmental and recreation features such as reservoir pools for environmental and recreational flow releases if the costs for these additional enhancements are not borne by the project proponents.

A model of the concept to provide for additional environmental and recreational enhancements is shown in Figure ES-20. This concept is based on the federal model for water project development used in the past where recreational enhancements were not part of the project cost to be repaid by water users, since these enhancements benefited the public as a whole.

Figure ES-20
Components of a Water Project Incorporating Environmental and Recreational Enhancements

Under this example, the project proponent would pay for the storage needed for the proponent's own needs, plus mandatory mitigation measures. Additional storage could be constructed to provide for a permanent reservoir pool for flat-water recreation and fish habitat, plus yield to provide for enhanced stream flows for recreational and environmental purposes. These enhancements – beyond the proponent's needs and required mitigation – would come at additional costs that would not be borne by the project proponent, as the environmental and recreational enhancements would benefit the general public.

Environmental and recreation interests, however, often do not have any other mechanism to provide for the desired enhancements except for seeking to make the project proponents pay for these enhancements as part of the permit approval process. These interests may contend that water development has impacted the natural environment and recreational opportunities available to the public, and thus the project proponents should provide for these enhancements as mitigation to the public. Under the above example, the project proponents would have significant project costs and the project might thus become economically infeasible to implement.

Failure to provide for a means to fund environmental and recreational enhancements could create additional conflict, increase the cost of water development, delay project implementation, preclude some water users from developing a reliable supply, and prevent the creation of the desired enhancements. Further dialogue to identify potential funding mechanisms and to better define the distinction between mitigation and enhancement comprises one of the key SWSI recommendations.

9. The Ability of Smaller, Rural Water Providers and Agricultural Water Users to Adequately Address Their Existing and Future Water Needs is Significantly Limited by Their Financial Capabilities

Agricultural and smaller, rural water providers face a number of challenges in developing new supplies. Agricultural users in many areas have a less than full supply for existing irrigated lands and would benefit from more dependable and predictable supplies. Smaller and rural water providers, including water conservancy districts providing augmentation water, also need to create more reliable supplies for existing uses during dry years as well as developing supplies for future water demands.

Development of new water supplies to meet future water needs is an increasingly competitive and expensive process. The construction of storage to regulate existing and future water rights can be a very complex process with lengthy and expensive permitting and mitigation procedures. The purchase or lease of existing agricultural water rights for M&I use has also become increasingly expensive. Storage is required to regulate acquired agricultural rights for M&I use. This storage is needed to carry water over from the irrigation season to the non-irrigation season and to store water for below average runoff years and to make historic return flows owed to the river system during the non-irrigation season. In addition, the water court process for changing acquired agricultural rights or filing for new water rights is complex and expensive. As a result, water supply development costs, whether from developing new storage or acquiring water rights through agricultural transfers, have increased significantly and are anticipated to continue to increase.

Agricultural users also face an expensive process for developing new supplies. The increased needs for water for all uses now has placed agricultural users in competition with M&I users and environmental and recreational needs for the limited available resources. Agricultural users face the same costly and lengthy permitting process for developing new storage to firm agricultural supplies. In most basins, agricultural users needing to acquire consumptive use water supplies for well augmentation must compete with M&I users who are also seeking these same consumptive use sources. Agriculture cannot compete on an ability to pay basis with M&I users.

Agricultural users generally cannot afford to pay more than $40 to $60 per AF/year (<$1,000 per AF one-time capital cost) for water based on market prices for agricultural goods. Water acquisition and water development capital costs, however, range from $2,000 at the minimum to greater than $15,000 per AF of reliable (firm) annual yield. As a result, agriculture cannot, without subsidies, afford the current cost of water acquisition or development. The high market value of water rights also makes it tempting for agricultural users to sell their water rights to municipal and industrial users and dry-up their irrigated lands, since they can receive a much greater return on their investment than if the water rights remain in agricultural use.

Smaller and rural water providers, including water conservancy districts providing augmentation supplies, also face these high water development costs as they seek to firm existing supplies or develop new supplies. There are significant economies of scale (i.e., fixed costs such as engineering and construction are a greater percentage of cost for smaller storage projects) in developing water supply that are not available to these smaller and rural water providers and conservancy districts since these users do not need and cannot afford large storage projects. In addition, water quality standards drive up raw water treatment costs. Opportunities to joint venture with other users can result in larger, more cost-efficient projects. Water storage costs per AF of storage for the same reservoir site generally decrease as additional storage is constructed.

In addition, every reservoir must have a spillway and outlet works regardless of the reservoir size and these costs decline as the capacity increases. These relative economies of scale also apply to engineering, legal, and administrative costs. Agricultural users and smaller water providers have difficulty paying for the sophisticated

engineering and legal analysis that is required for successful implementation of a new storage project. The cost per AF of storage can exceed $5,000 per AF for a reservoir of less than 500 AF total storage capacity while a reservoir of greater than 100,000 AF can potentially be constructed at a cost of $1,500 or less per AF of storage capacity. Figure ES-21 shows a generalized cost per AF of storage for various reservoir sizes.

Loans for water supply development for smaller and rural water providers and agricultural users are available from the Colorado Water Conservation Board. However, in order to secure a loan, the borrower must demonstrate the financial ability to repay the loan. As noted, water development costs for smaller and rural water providers and small agricultural firming storage projects can be significantly higher per AF of firm yield developed. In addition to these higher unit costs, many smaller water providers and agricultural users may not have the existing and projected revenue base to make the loan payments and/or may lack sufficient collateral. Agricultural users cannot pay the current costs for water supply development and smaller and rural water providers may not have the tax or revenue base to pay the higher unit costs. During the SWSI process, agricultural and smaller and rural water providers have expressed the desire to have non-repayable grants available to help defray some of the out of pocket costs so that water supply firming and development needs can be met.

10. Beyond 2030, Growth Will Continue, and Additional Solutions Will Be Required

Beyond 2030 growth will continue and additional solutions will be required.

- Growth and the need for water will continue beyond 2030
- Very few providers have identified projects to meet demands beyond 2030
- There is very little long range planning for these needs beyond 2030
- Unless additional supplies are identified in the Arkansas Basin, South Platte Basin, and many headwaters communities, additional agricultural water in these basins will be transferred to M&I use
- In order for new solutions to have a higher likelihood of success, they will need to address multiple needs

Traditional uses of water in Colorado are changing as a result of population growth, urbanization, and increased environmental and recreational uses for water. During the SWSI public comment process, this point was stated by many interest groups who were calling for SWSI to be used as a forum to debate growth. Historically, throughout the west and in Colorado, the availability of water does not fuel growth nor does the limitation on water supply limit growth. Some of the fastest growing population centers across the west are also where water is the least plentiful. A vital part of the Colorado system of prior appropriation allows water to be moved from where it originates to where it is put to beneficial use.

Traditional water providers such as municipal and special district water utilities and water conservancy districts do not have the ability nor the responsibility to control growth on a regional or basinwide level. These entities are responsible for providing a reliable, safe, and affordable water supply for the needs of their existing and future customers or constituents. Growth planning is a multi-jurisdictional and complex process with land use decisions generally made at the municipal, county, and regional level of government. Growth restrictions in one jurisdiction have historically resulted in increased growth in surrounding areas. It is beyond the scope of this project to attempt to control future water needs through growth controls. This project, however, looks at the reasonable levels of water demands that can be projected using the State Demographer's population projections.

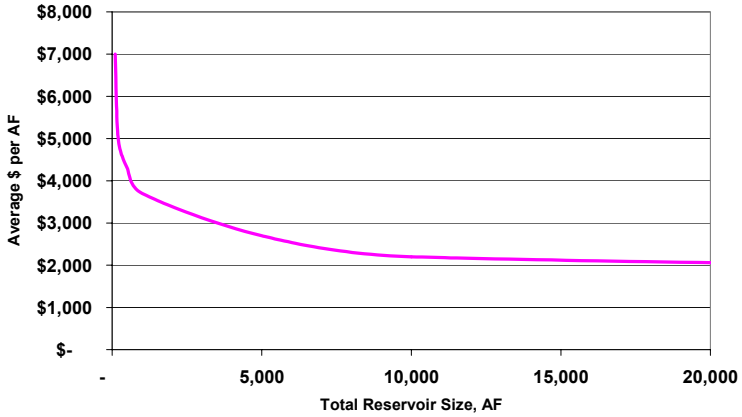


Figure ES-21
Generalized Unit Costs for New Storage Based on Total Reservoir Size

Between 1990 and 2000, Colorado gained almost one million new residents. The state demographer projects that from 2000 to 2030 another 2.8 million residents will be living in Colorado with the majority of the population concentrated in the South Platte Basin. This growth is not limited to the East Slope, as the West Slope will experience the highest percent rates of growth, nearly doubling in population with 250,000 new residents by 2030. Growth in Colorado will continue beyond 2030.

This demographic trend exerts two distinct pressures on Colorado's water resources. More water will be required for the municipal and industrial sector for drinking and outdoor uses. Also, increased population puts more pressure on the environmental and recreational water resources. As water is diverted from streams to meet the domestic, landscape, commercial, recreational, and industrial water needs of the new residents, our surface water and groundwater resources and aquatic ecosystems are increasingly strained. There is also the continued need to supply water for agriculture since the population will require additional food supply. More importantly, as previously discussed, agriculture is the foundation of many of our rural communities. A viable and healthy agriculture industry is essential to maintaining the economic, social, and cultural integrity of rural Colorado.

Most M&I water providers have existing supplies and identified projects and processes to meet their demands through 2030. Very few providers, however, indicated that they have identified projects and processes that will provide for water demands beyond 2030. Water conservation will continue to play a significant role in reducing the need for additional water supplies, but conservation alone cannot meet the needs beyond 2030, even at levels that cause significant impacts to the quality of life in urban areas.

Many of the major water providers in the South Platte Basin, especially those along the foothills, have service areas that are now surrounded by other water providers and will be at or near build-out by 2030. Water providers such as Greeley, Aurora, Thornton, the Tri-Districts in Larimer and Weld counties, and South Adams County Water and Sanitation District, have water service areas that are relatively undeveloped or can expand, and have significant growth potential beyond 2030. In addition to these larger, established water providers, growth in the South Platte beyond 2030 will occur further east along E-470, I-70, and I-76. Some of this growth will be onto former dry-land farming areas that have limited surface water and renewable groundwater supplies. The surface water supplies that are available are of a quality that will require expensive advanced water treatment technologies. Many of these areas that will experience the majority of growth beyond 2030 do not have entities actively engaged in long-range planning efforts, nor are there readily available supplies to meet the projected growth.

Historically the greatest use of Colorado's water resources has been for agriculture. Currently, about 90 percent of the water in Colorado is used for agriculture. When population growth occurs history shows that the water to meet the demands of the new population will largely come from supplies transferred from agriculture if other affordable, high quality water supplies are not available. Beginning in the 1950s, the transfer of agricultural water rights to municipal use began in the South Platte and the Arkansas Basins. This trend continues in the South Platte and the Arkansas Basins as the expense and uncertainty of developing new storage and transbasin water projects directs M&I water providers to look to agriculture for firm water supplies. Between now and 2030 it is anticipated that all basins, with the exception of the North Platte and Rio Grande, will continue to lose irrigated acreage as development occurs on irrigated lands or transfers are made for M&I use. The greatest reductions in irrigated acreage will occur in the largest population basins, the South Platte and the Arkansas Basins.

If new supplies are not developed, the challenge will be to manage these agricultural conversions and continue to support a healthy Colorado agricultural economy and sustainable rural communities. Significant volumes of additional storage will need to be constructed to regulate or firm the yield of these agricultural rights for M&I use as approximately 3 AF of storage may be required to produce 1 AF of firm M&I yield.

Options to the permanent dry-up of agricultural land were identified in the SWSI process. Interruptible supply agreements, rotating agricultural transfers, or water banks can allow for M&I, environmental, and recreational needs to be satisfied without the permanent dry-up of irrigated agriculture. It is important to note that all of these options have limitations, are not viable options in all locations, and must be evaluated on a subbasin level.

In addition, options that involve multiple basins have not yet been developed and analyzed. This effort will occur in 2005 to 2006 and will allow us to explore all mutually beneficial options.

It will be a challenge to meet future demands in highly populated, rapidly growing areas and at the same time protect and enhance the environment and recreational opportunities. Environmental and recreational uses of water for the new population will compete with the M&I needs of this same population. Future solutions will likely need to address multiple objectives, and satisfy multiple interest groups, to be successfully implemented.

There will be a greater need for increased communication, coordination, and cooperation from and intra-basin and inter-basin perspective.

Key Recommendations

The CWCB is the state agency responsible for:

- Aiding in the protection and development of the waters of the state for the benefit of the present and future inhabitants of the state
- Gathering data and information to achieve greater utilization of the waters of the state
- Establishing policies to address state water supply issues; assisting in the mediation of disputes between basins and water interests and facilitating resolution of those disputes
- Identifying, prioritizing, and recommending water development projects to the General Assembly

The CWCB crafted the SWSI project to address these broad responsibilities and to help all of Colorado make informed decisions regarding management of our water resources.

SWSI has challenged the CWCB to find the proper balance between statewide policy and local decision-making. The CWCB remains committed to honoring and respecting local control of water resource development, private property rights, and the Prior Appropriation System. At the same time, our state is changing rapidly and the complexity and scope of water resource management issues requires our full attention and creativity. By taking both a county level and statewide view, we have been able to see how our individual efforts and water resource planning affects Colorado cumulatively.

The CWCB recognizes the value of pooling resources, addressing common goals, and improving cooperation and collaboration among water users and all interest groups that value water. As we face our future water challenges and develop mechanisms to address these challenges, the CWCB is always seeking to understand the appropriate role for the state. Based on the information we have collected over the last several years, via SWSI and other CWCB efforts, it is clear that the state has a key role in developing technical information, helping facilitate resolution of regulatory conflicts, and providing financial assistance. In the future, if a more comprehensive view of water resource development is going to take place, the state will likely need to become a more substantial financial partner. Developing water projects that serve multiple users, implementing solutions to address environmental or recreational needs, and addressing impacts to agriculture and our rural communities may require direct implementation by the state. However, at this time it is not clear that Coloradans are prepared to support these concepts. These overarching concepts will need to be discussed and analyzed in light of the data and information that SWSI has developed and in continued discussions over the next few years.

The development and analysis of water supply and demand data, coupled with dialogue and input gathered through the Basin Roundtable Technical Meetings, Public Meetings, and CWCB Board Meetings, has led the CWCB and SWSI project team to some preliminary recommendations. The following key recommendations have been developed to address Colorado's future water needs. These recommendations are a synthesis by the project team of comments and information gathered during the process and build on key findings. These recommendations are not meant to be consensus recommendations from Basin Roundtable participants.

1. Ongoing Dialogue Among all Water Interests

Ongoing communication and dialogue among all interest groups will help ensure wise management of Colorado's water resources into the future, and may help to reduce conflict among interest groups. Both in-basin discussions and transbasin dialogue are needed to move forward in understanding and addressing the state's water needs. A

continuation of the Basin Roundtable process was supported in many of the basins, considering the depth, breadth, and complexity of the issues discussed in the Basin Roundtable Technical Meetings conducted in each basin through this first phase of analysis. It will take time for this information to "take root" and develop to the point of common understanding before it can truly change the dialogue and debate in the state. Colorado will be restricted in our ability to move forward in meeting our water needs until this happens. Key topics for continuing in-basin and transbasin dialogue could include:

- Issues associated with possible competition for the same sources of water
- Broadening the dialogue to include representatives of future growth areas not currently represented, and local governments and stakeholders in basins that may be impacted by another basin's sources of supply
- Trade-offs of in-basin agricultural transfers vs. new water supply development (either in-basin or transbasin); as discussed earlier the next phases of SWSI will evaluate supply and demand at the statewide level
- Ensuring that future water transfer projects be planned in a way that both the area of origin and the area of beneficial use derive mutual benefits from the proposed project
- Identifying and implementing changes needed to improve and streamline permitting processes
- Collaborative implementation of the Identified Projects and Processes and further development of the Options for Future Alternatives

2. Track and Support the Identified Projects and Processes

Identified Projects and Processes play a critical role in meeting Colorado's future M&I needs. Consequently, there is a need to track and support their implementation. The state should work with individual providers and project sponsors to identify key elements of their future water supply portfolio, then develop a monitoring mechanism to track the progress of those key projects and processes and provide support where needed. Helping identify and resolve implementation issues will be extremely important. Implementation issues will differ with each project but improvements to the permitting process, creating multiple project benefits, and developing greater opportunity for financial support will be key factors to reducing implementation hurdles.

3. Develop a Program to Evaluate, Quantify, and Prioritize Environmental and Recreational Water Enhancement Goals

Progress was made in this first phase of SWSI toward identifying the level of interest in enhancements of flows for environmental and recreational uses beyond the CWCB's existing instream flow program, which is intended to protect the natural environment to a reasonable degree. CWCB should identify stream segments or ecological areas for flow prioritization or enhancement. Working with Basin Roundtable members, the Colorado Division of Wildlife, and other interest groups, the state could begin to develop an objective and reproducible framework for evaluating, quantifying, and prioritizing environmental and recreational water goals. This program could build from the existing authorities of the CWCB Instream Flow program and the "conserve, protect, and restore" approach brought forth through many of the SWSI Basin Roundtable discussions.

4. Work Towards Consensus Recommendations on Funding Mechanisms for Environmental and Recreational Enhancements

SWSI Basin Roundtable discussions indicated a strong interest in further environmental and recreational enhancements. While many roundtable participants concurred that there may be an overall willingness of environmental and recreational beneficiaries to pay for such enhancements, the lack of an existing mechanism for such payment was highlighted. Further dialogue among and between Basin Roundtables should include discussion of alternative payment mechanisms (such as taxes or fees), with the goal of developing a consensus recommendation to be promoted by the CWCB and/or the State Legislature.

5. Create a Common Understanding of Future Water Supplies

To more accurately assess the alternatives available to the state in meeting our future water needs, the analysis of supply availability for each basin will determine developable flows, taking into account factors such as:

- Existing water rights
- Hydrologic conditions
- Compact interpretations
- Federal laws
- Operations of existing and future facilities

6. Develop Implementation Plans Towards Meeting Future Needs

While many of the Identified Projects and Processes are already progressing toward implementation, their successful implementation, and the success of any current or future option, for meeting our water needs will have some degree of uncertainty. To better facilitate successful implementation, the following should be addressed in more detail:

- Addressing gaps in rural areas and smaller water providers
- The limitations of agricultural users' ability to pay for needed supply firming and facility enhancements
- Project permitting and mitigation assistance, recognizing that permit requirements and mitigation have resulted in uncertainty and increased project costs for many users, resulting in many M&I providers moving towards agricultural transfers due to greater certainty and flexibility
- Consideration of a state/federal/local project permitting assistance "team"
- Monitoring and assisting the State Engineer's Office in its Dam Safety Rulemaking to revise the Probable Maximum Precipitation criteria and Spillway Design Criteria to help reduce costs of new projects and increase storage
- Promoting and supporting multiple-benefit projects and solutions

7. Assess Potential New State Roles in Implementing Solutions

The needs and challenges identified by water providers, users, and stakeholders throughout Colorado suggested that new or expanded State roles in several areas may be worth investigating further, such as:

- State role in implementing projects/options to address the remaining gap in each basin, such as possible reconnaissance or feasibility-level investigations
- Enhancing knowledge and use of existing state and federal loan and grant programs, and further assessing the need to expand or revise them
- Developing concepts for new funding programs
- Enhanced role in informing and educating the public about water sources, use, conservation, and options for meeting future needs
- Refining irrigated acreage loss estimates associated with agricultural water transfers and incorporating those results into Colorado's Decision Support Systems
- Developing water availability and sustainability estimates for non-tributary groundwater areas, especially the Denver Basin and Northern and Southern high plains
- Promoting conjunctive use of surface water and groundwater resources
- Promoting and facilitating coordinated operations of existing facilities and infrastructure

8. Develop Requirements for Standardized Annual M&I Water Use Data Reporting

Objective evaluations, comparisons, and projections of water use from county to county and basin to basin were made more difficult in SWSI's first phase by the lack of a consistent set of M&I water use data. To facilitate future efforts, the State should consider developing a standardized water supply and water use reporting mechanism and work with water providers/users to develop consensus on the database format and reporting mechanisms. This includes identifying current and planned levels of conservation. Such a system could also be used in future assessments and planning to compare actual demands with past projections, allowing refinement of estimates and increasing the accuracy and effectiveness of future efforts to assess and provide for Colorado's water needs.

Overview of Report

The full SWSI report provides the background and detail that forms the basis for this Executive Summary. The contents of each section of the full report are described in Table ES-7.

Table ES-7 SWSI Report Overview

Section	Title	Overview
1	Introduction	Introduction and background on SWSI and Colorado water resources; acknowledgements
2	Statewide Demographic, Economic, and Social Setting	Historical and projected demographics; population projections; economic drivers; statewide social, environmental, and institutional and regulatory settings; overview of water quality
3	Physical Environment of the Major River Basins	Background of each of Colorado's 8 major river basins as it relates to water management
4	Legal Framework for Water Use	Major components of Colorado's legal framework for water management
5	Projected Water Use	Projection of future water demands
6	Water Needs Assessment	Identified Projects and Processes; flow issues and recreational components in each basin
7	Availability of Existing Water Supplies	Availability of water supplies throughout Colorado
8	Options for Meeting Future Water Needs	Discussion of types of options available for meeting future water needs
9	Evaluation Framework	Framework for evaluating water management solutions, and its application in SWSI
10	Basin-Specific Options	Water management solutions that could be used to address remaining gaps between supplies and demands
11	Implementation	Summary of basin issues; CWCB's implementation process; funding opportunities; and next steps

Basin Roundtable Members and Participants

SWSI Team members and Basin Roundtable members are acknowledged below. Basin Roundtable members provided untold hours of work on SWSI and served as a wealth of historical knowledge, guiding principles, and ideas for meeting the state's diverse and growing uses for water.

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