COLORADO DEPARTMENT OF NATURAL RESOURCES

SWSI
Statewide Water Supply Initiative

COLORADO WATER CONSERVATION BOARD
STATE OF COLORADO
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Colorado Water Conservation Board

Statewide Water Supply Initiative

November 2004

Report

CDM

Statewide Water Supply Initiative Report

Prepared for:

State of Colorado
Colorado Department of Natural Resources
Colorado Water Conservation Board
1313 Sherman, Room 721
Denver, Colorado 80204

Prepared by:

CDM
1331 17th Street, Suite 1200
Denver, Colorado 80202

In association with:

GBSM
Riverside Technology, Inc.
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November 2004

STATE OF COLORADO

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

Statewide Water Supply Initiative

Bill Owens
Governor

Russell George
Executive Director
Department of
Natural Resources

Rod Kuharich
Director
CWCB

Dan McAuliffe
Deputy Director
CWCB

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	Keith Catlin
Executive Director	Chair
Colorado Department of Natural Resources	Colorado Water Conservation Board

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Acronyms

°F	degrees Fahrenheit
AF	acre-feet
AF/Ac/Yr	acre-feet per acre per year
AFY	acre-feet per year
AHRA	Arkansas Headwaters Recreation Area
ARRMP	Arkansas River Recreation Management Plan
BA	biological assessment
BLM	Bureau of Land Management
BMP	Best Management Practices
BOR	U.S. Bureau of Reclamation
BOWW	Board of Water Works
CBM	coalbed methane
CBT	Colorado-Big Thompson
CDOW	Colorado Division of Wildlife
CDPHE	Colorado Department of Public Health and Environment
CDPOR	Colorado Department of Parks and Outdoor Recreation
cfs	cubic feet per second
CGS	Colorado Geological Survey
CNHP	Colorado Natural Heritage Program
CPR	Conserve, Protect, Restore
CRSP	Colorado River Storage Project
CRWCD	Colorado River Water Conservation District
CSES	Center for the Study of Earth from Space
CU	consumptive use
CUSP	Coalition for the Upper South Platte
CWA	Clean Water Act
CWCB	Colorado Water Conservation Board
CWRPDA	Colorado Water Resources and Power Development Authority
DNR	Department of Natural Resources
DOI	Department of the Interior
DOLA	Department of Local Affairs
DSS	Decision Support Systems
DWR	Division of Water Resources
EIS	Environmental Impact Statements
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
F.I.R.E.	finance, insurance, and real estate
FERC	Federal Energy Regulation Commission
FONSI	Finding of No Significant Impact
Fry-Ark	Frying-Pan Arkansas
GDP	gross domestic product
gpcd	gallons per capita per day
gpm	gallons per minute
GSP	gross state product
IWR	irrigation water requirements
KW	kilowatts

M&I	municipal and industrial
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NCCGWQQ	Northwest Colorado Council of Governments Water Quality and Quantity
NCWCD	Northern Colorado Water Conservancy District
NEPA	National Environmental Policy Act
NISP	Northern Integrated Supply Project
NLCD	National Land Cover Data
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Services
NWCOG	Northwest Council of Governments
NWIS	National Water Information System
OGCC	Oil and Gas Conservation Commission
ORV	outstanding remarkable values
PACSM	Platte and Colorado Simulation Model
PAWSD	Pagosa Area Water and Sanitation District
PBO	Programmatic Biological Opinion
ppb	parts per billion
ppm	parts per million
PSOP	Preferred Storage Options Plan
RICDs	Recreational in-channel diversions
SDS	Southern Delivery System
SDWA	Safe Drinking Water Act
SECWCD	Southeastern Colorado Water Conservancy District
SEO	State Engineer's Office
SJRBRIP	San Juan River Basin Recovery Implementation Program
SPPP	South Platte Protection Plan
SSI	self-supplied industrial
SWSI	Statewide Water Supply Initiative
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
UAWCD	Upper Arkansas Water Conservancy District
UGRWCD	Upper Gunnison River Water Conservancy District
UPCO	Upper Colorado River Basin
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WatSIT	Water Supply Investigation Tool
WSL	water supply limited
WQCC	Water Quality Control Commission
WQCD	Water Quality Control Division

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.

> ***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.***

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.

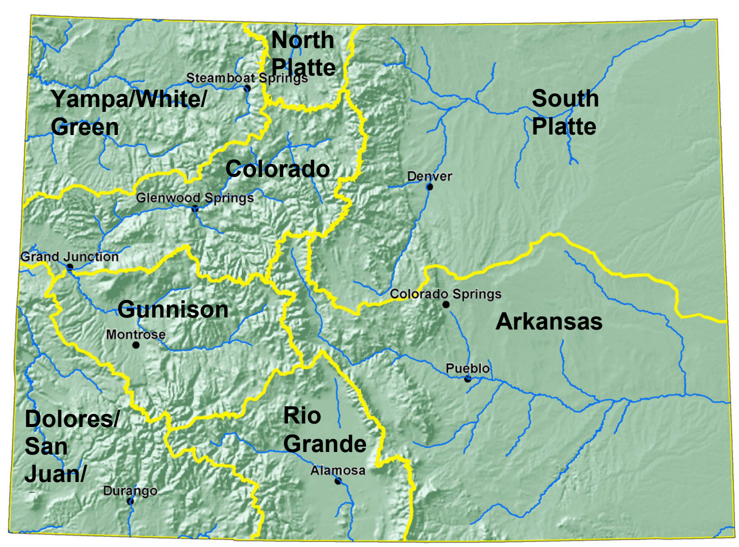


Figure ES-1
Colorado's Eight Major River Basins

- **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.

Initial Findings Supply and Demand In-Basin Solutions Timeframe – June 2004-December 2004	Near-Term Action Items Cross Basin Issue and Opportunities Timeframe – December 2004-July 2005	Long -Term Action Items Ongoing Implementation Timeframe – July 2005 forward

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.

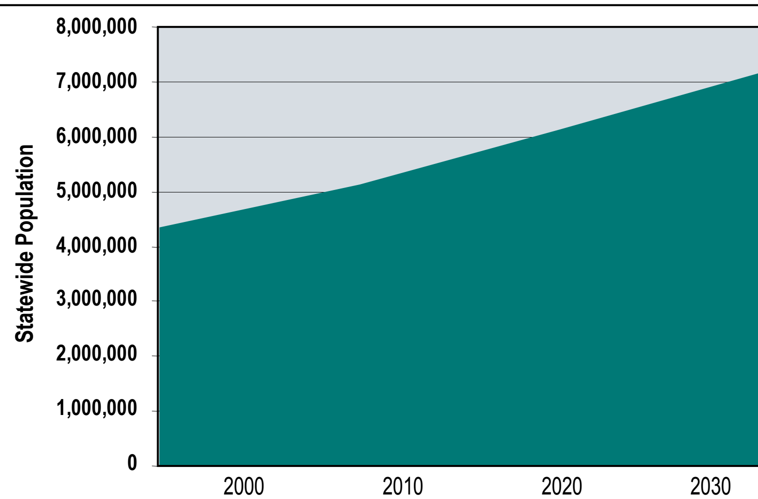
1. Significant Increases in Colorado's Population will Intensify Competition for Water

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.

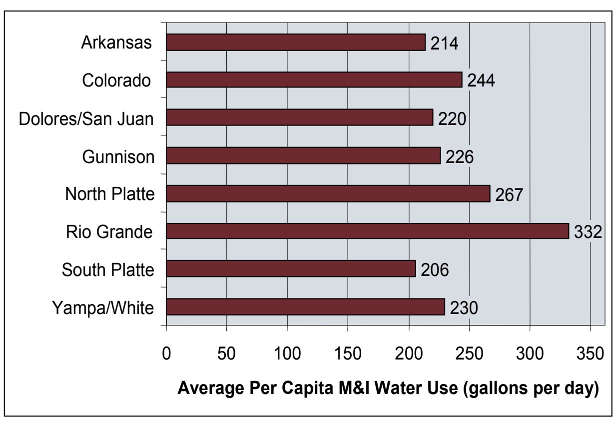


Figure ES-3
M&I Per Capita Water Use (2000)

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.

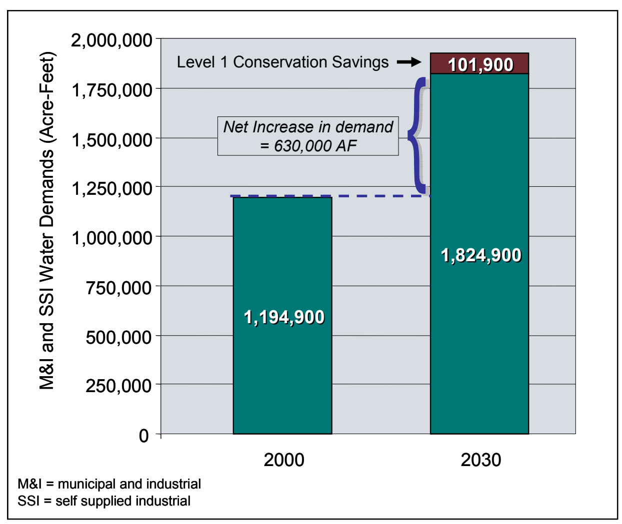


Figure ES-4
Projected M&I Water Demand

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.

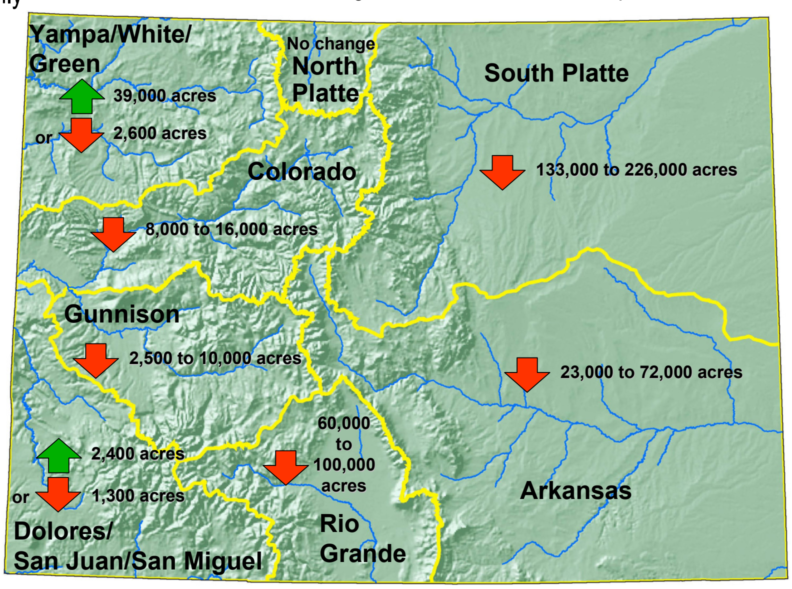
Besides its direct and indirect economic benefits and contributions to the nation's food supply, agriculture is an important cultural value for the state. Agriculture provides open space, creates or enhances riparian habitats and wet meadows, and improves late season river and stream flows, resulting 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).

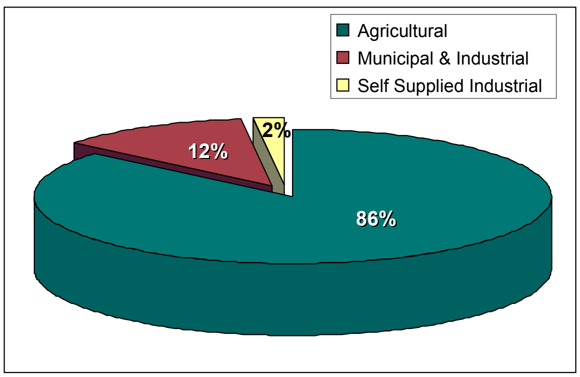


Figure ES-6
Relative Proportions of Agricultural, M&I, and SSI Gross Water Use in 2030

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.

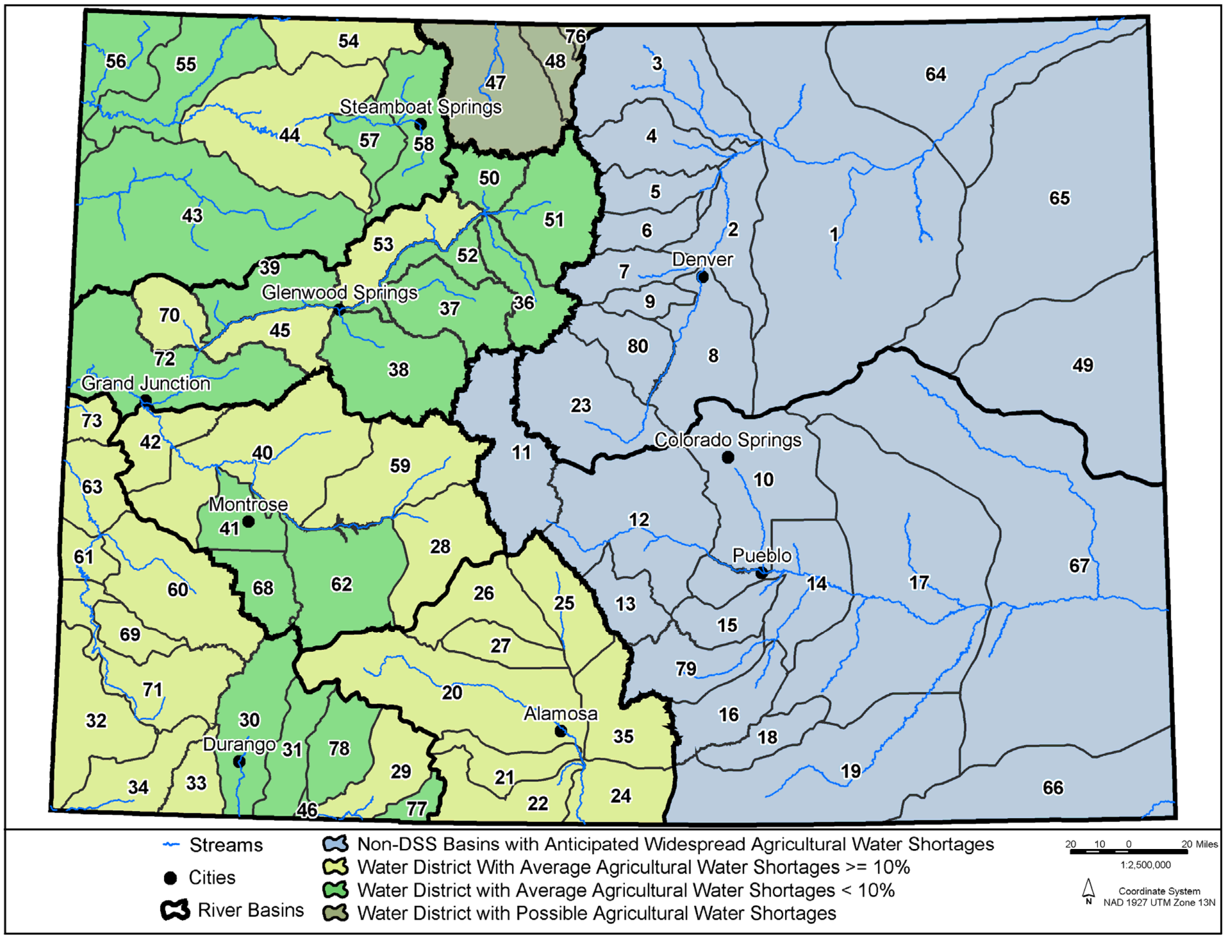


Figure ES-7
Summary of Agricultural Water Shortages by Water District

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.

By 2030, Colorado will Need an Additional 630,000 AF of Water as Outlined Below

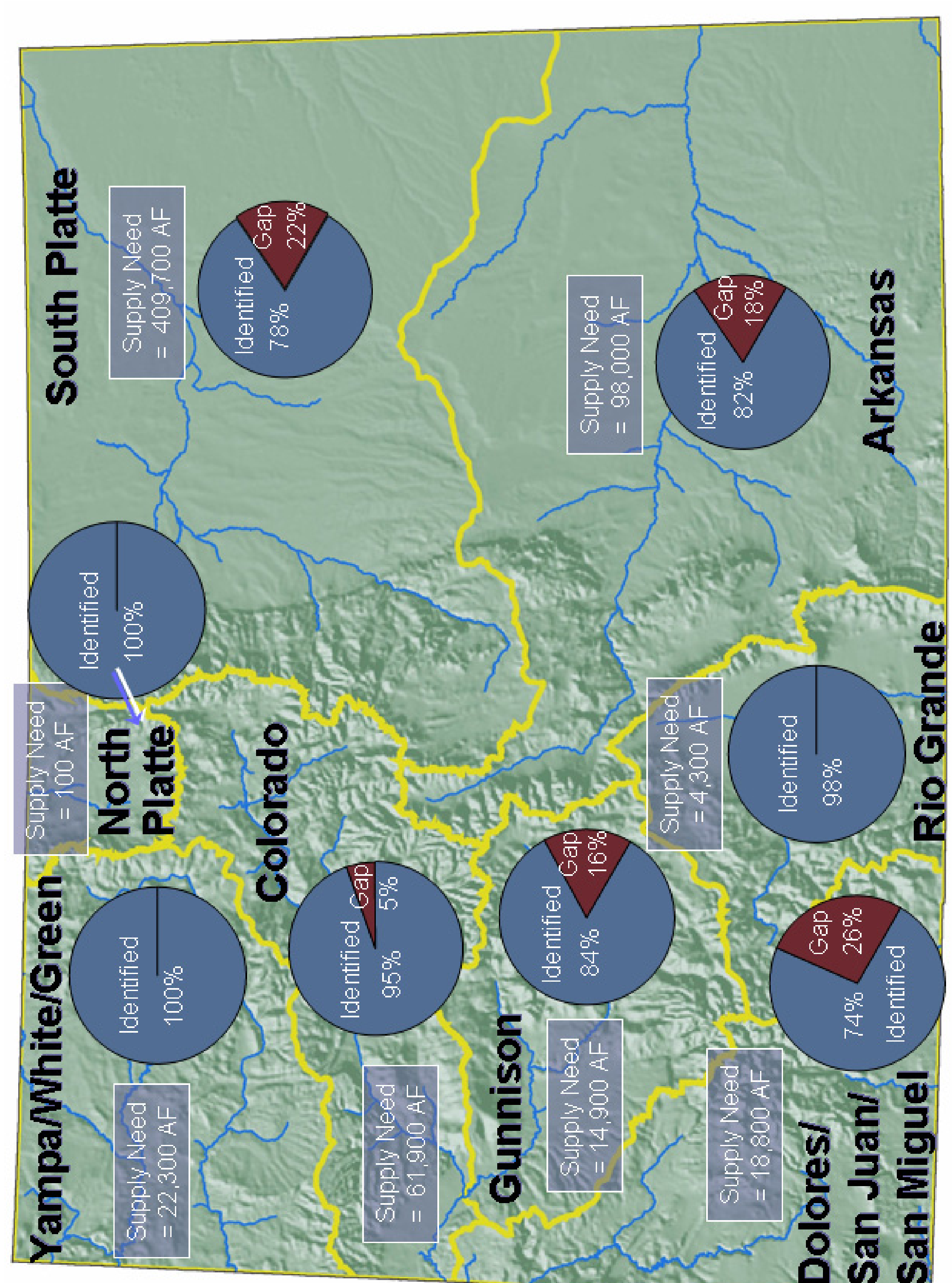


Figure ES-8
Effectiveness of Identified Projects and Processes in Meeting 2030 M&I and SSI Demands

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

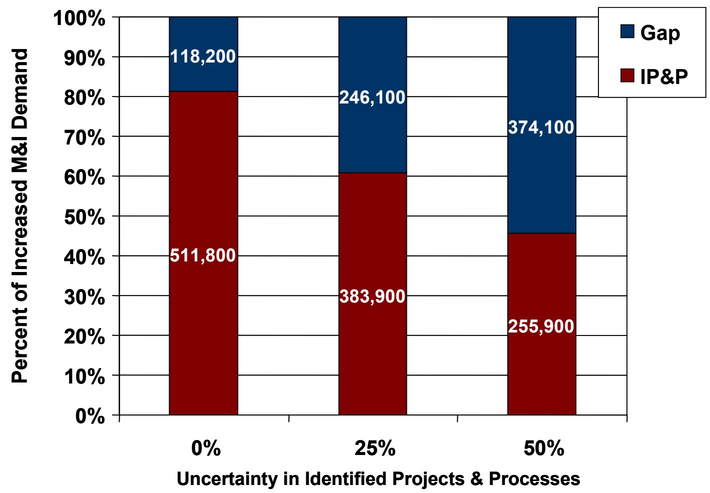


Figure ES-9
Implications of Uncertainty in Identified Projects and Processes on Meeting 2030 M&I and SSI Water Needs

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.

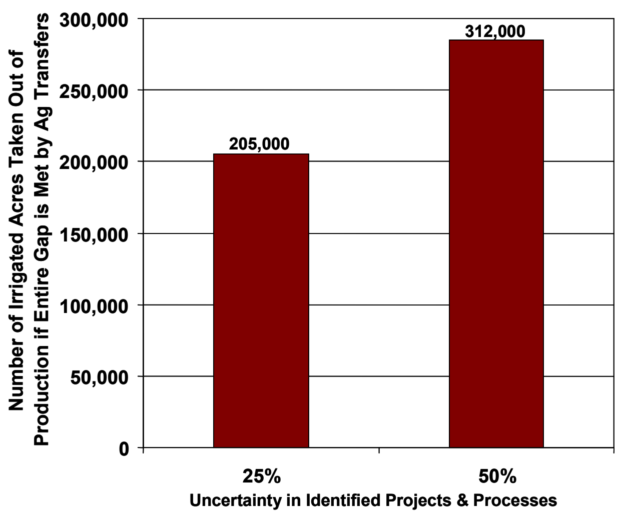


Figure ES-10
Potential Impact on Irrigated Agricultural Acres if Identified Projects & Processes are Not Implemented

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.

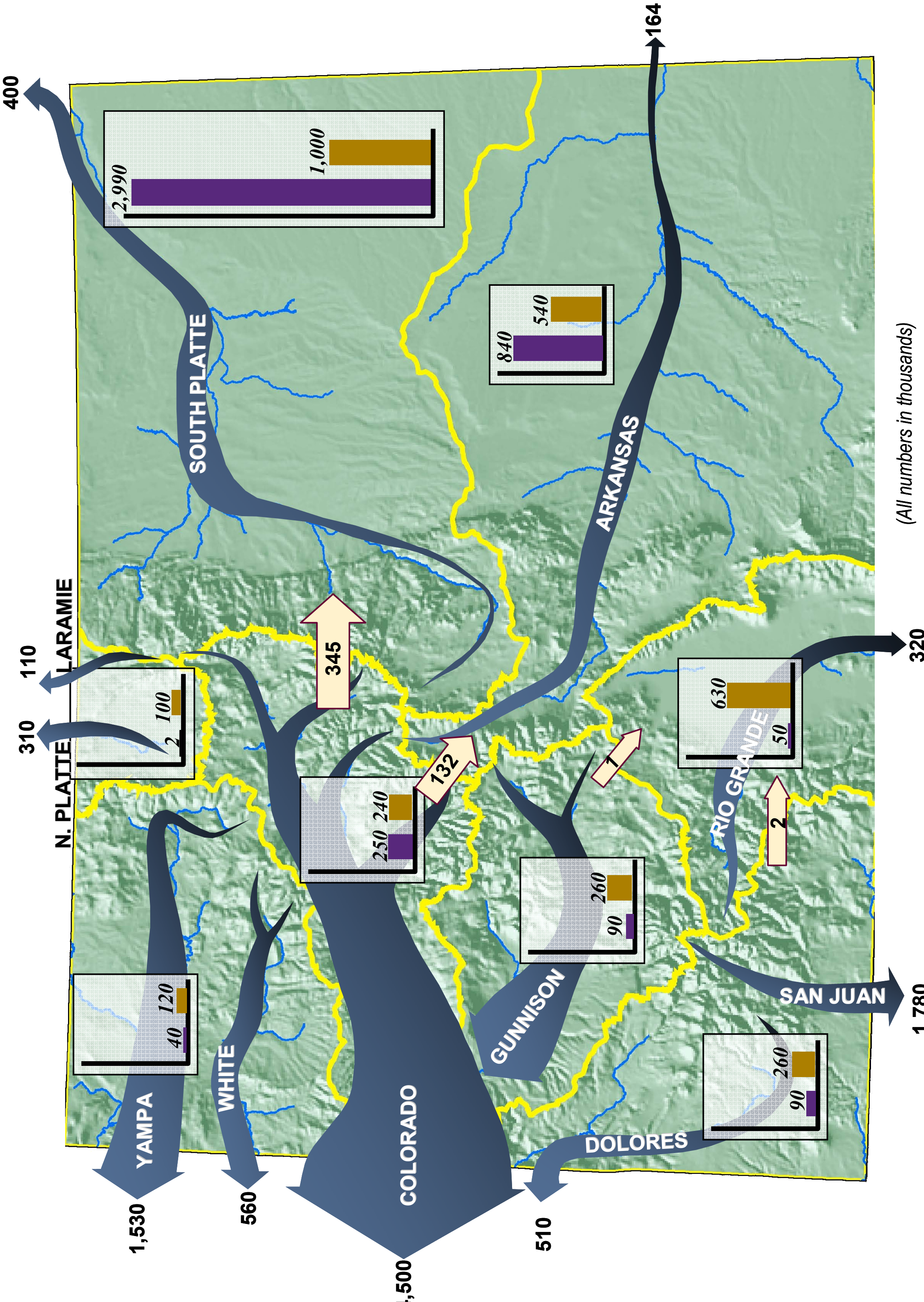
In addition to Colorado water law and interstate compacts and decrees, federal laws can influence water development. In Colorado, the ESA should be considered when analyzing water supply. There are endangered species programs in the South and North Platte, Colorado, Gunnison, Yampa/ White/Green, and 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	—



(All numbers in thousands)

Population (2000; Source: DOLA)

Irrigated Acres (2000; Source: SWSI estimate)

Water transferred between basins (AFY; Source: SEO 2003)

Flow leaving the state (AFY; Source: SEO 2003)

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.

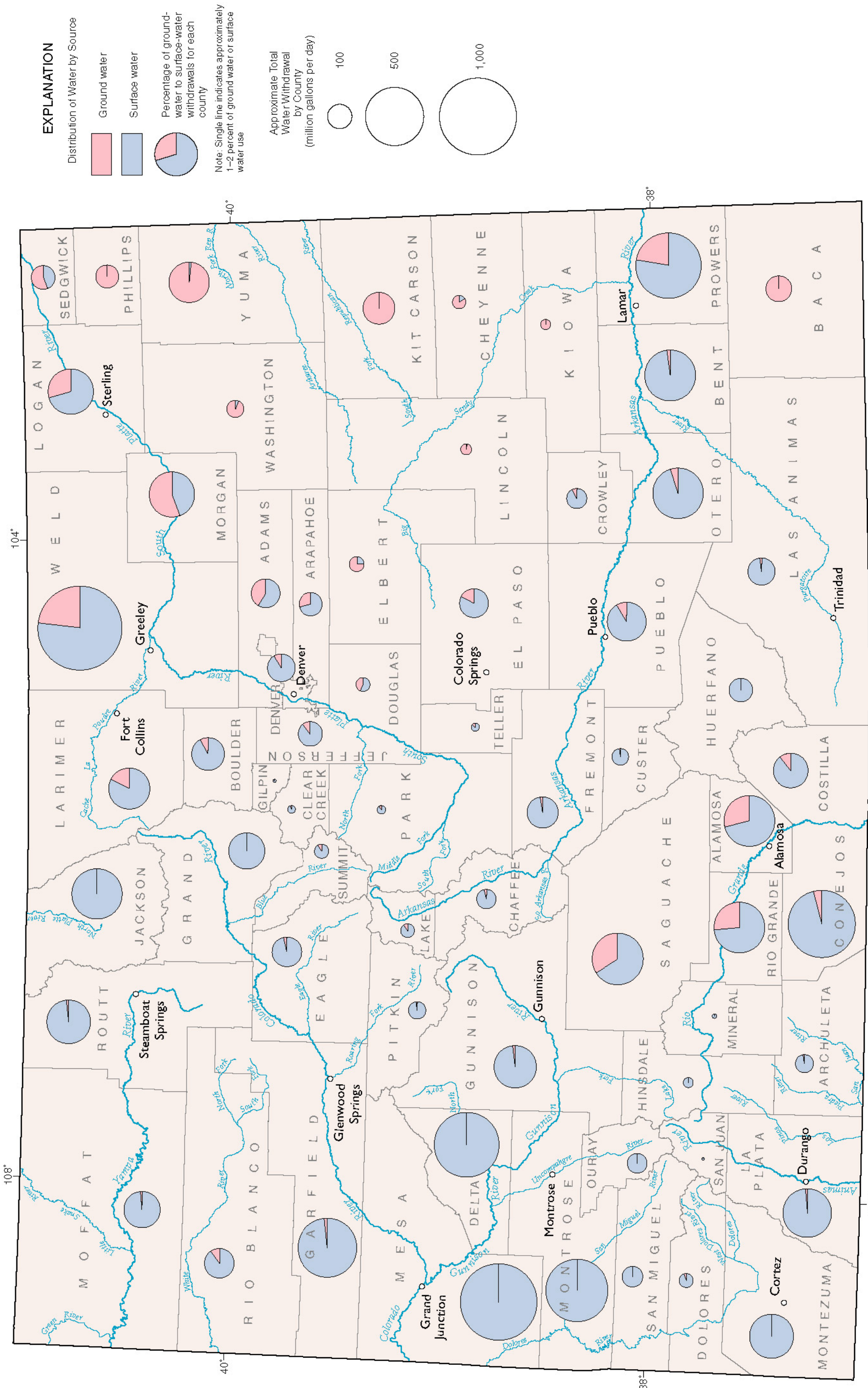
Much of Colorado is underlain by abundant groundwater but its use as a water supply is limited in many areas by the physical or the legal constraints on the aquifer supplies. Either limitation affects the reliability and sustainability of groundwater as a source of supply. The physical availability is 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.

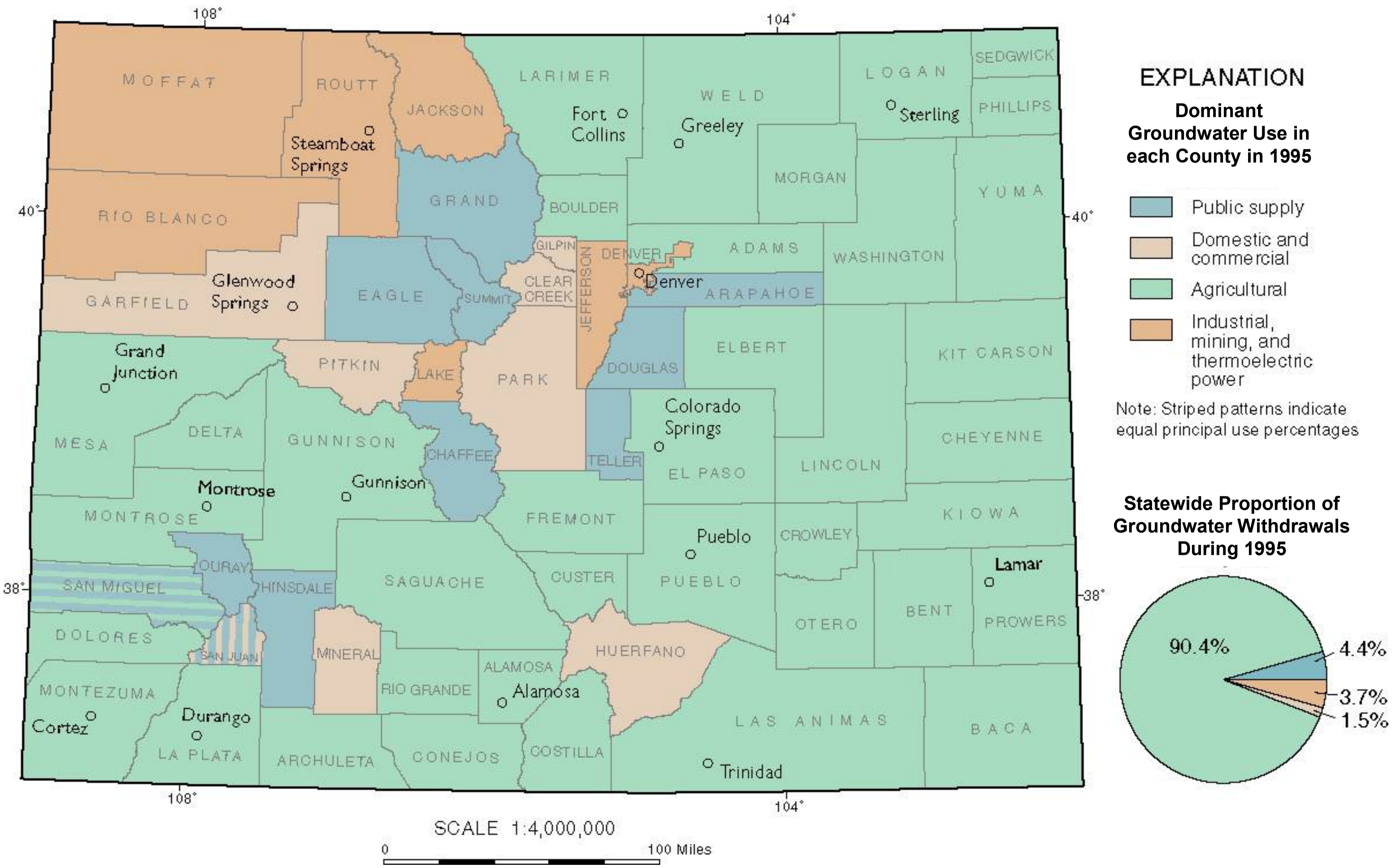
Aquifers in the state range from those in the shallow unconfined alluvial sediments along the major river systems to the deeper confined aquifers in many of the bedrock deposits. The mountain areas also contain groundwater in fractured bedrock that is highly variable in amount and distribution. Unfortunately, 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.



Source: Colorado Geological Survey, 2003

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



Source: Colorado Geological Survey, 2003

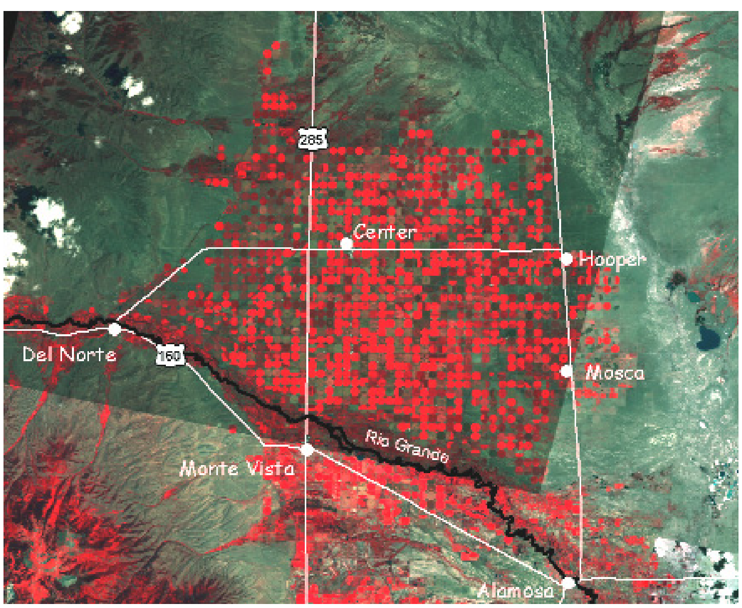
Figure ES-13
Distribution of groundwater withdrawals during 1995

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.

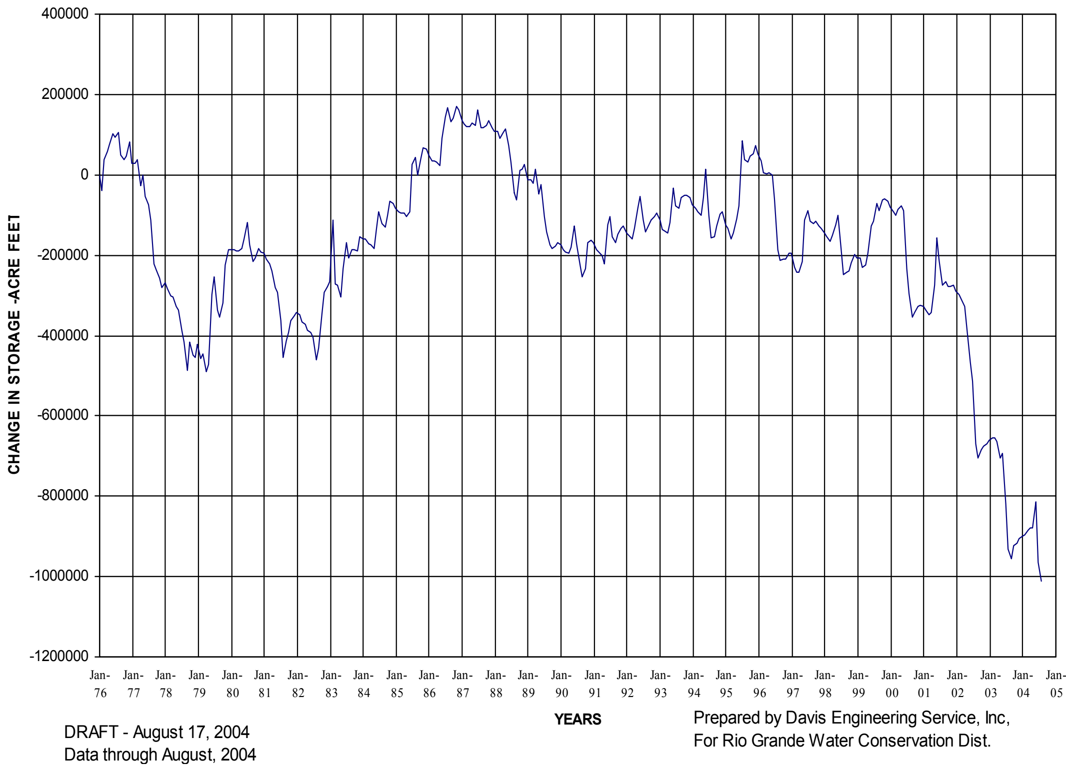


Figure ES-15
Change in Unconfined Aquifer Storage West Central San Luis Valley

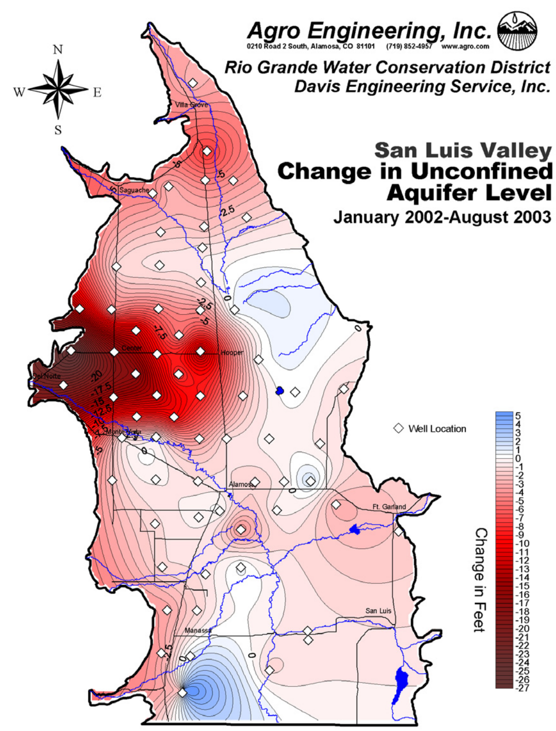


Figure ES-16
San Luis Valley Change in Unconfined Aquiver Level

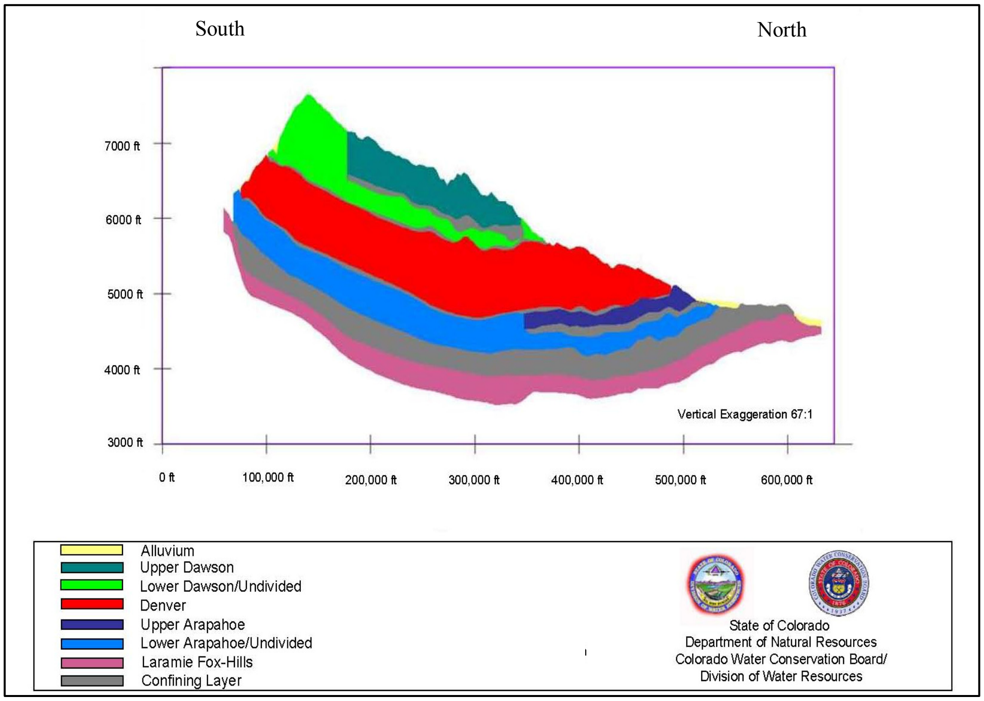


Figure ES-17
South Platte River Basin Denver Basin Aquifer
South-North Cross-Section

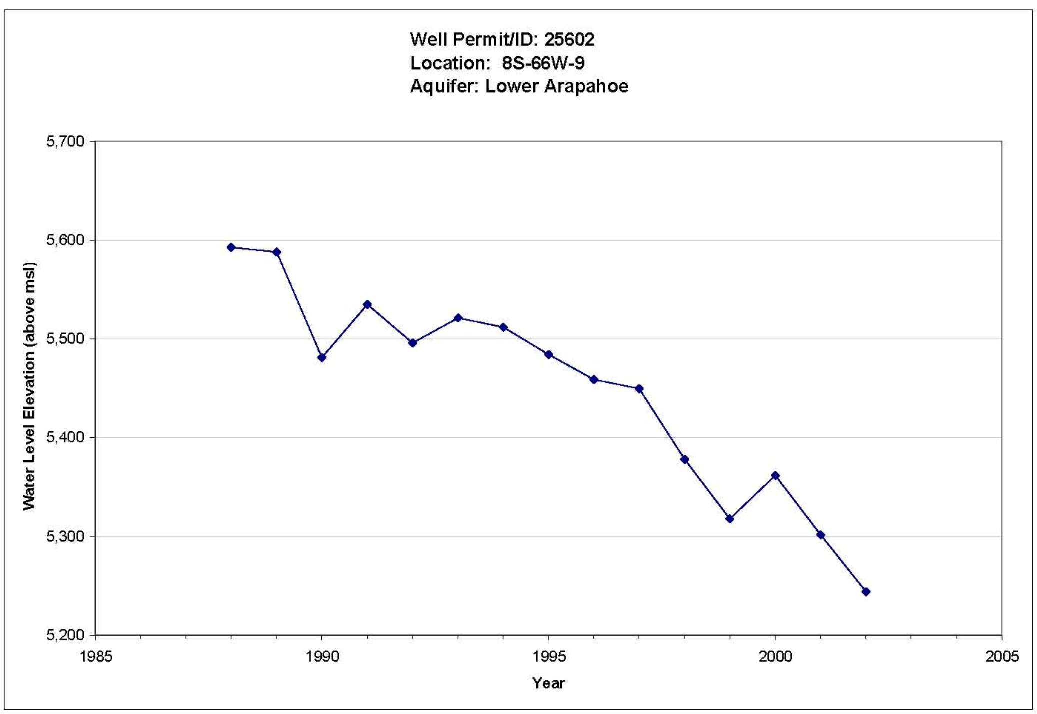


Figure ES-18
Lower Arapahoe Aquifer Water Elevation

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

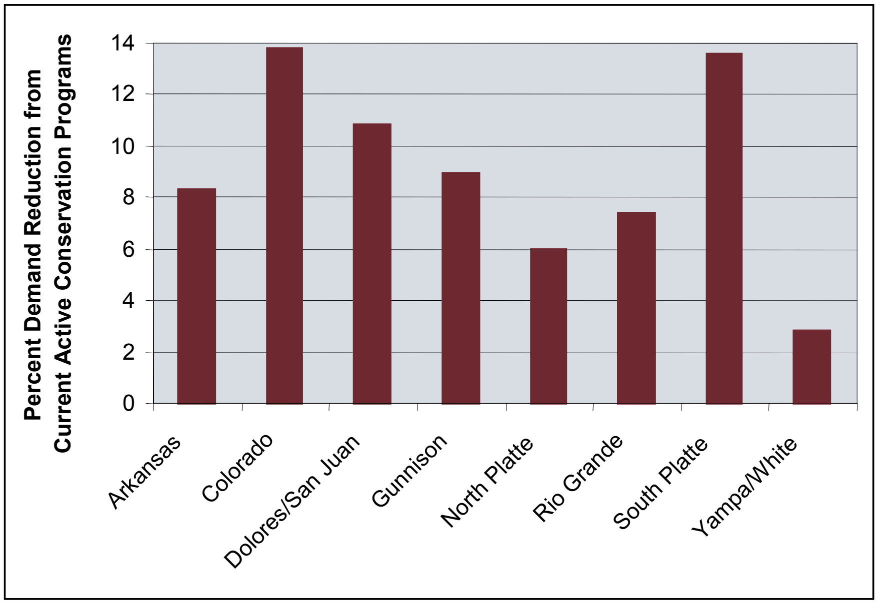


Figure ES-19
Estimated Water Demand Savings by 2030
Associated with Current Active Water Conservation Programs

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.

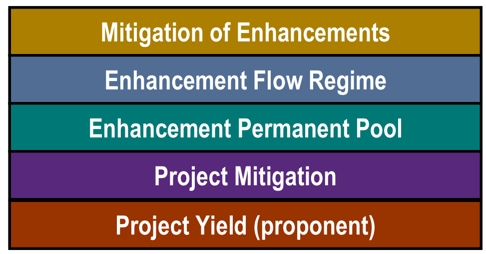


Figure ES-20
Components of a Water Project Incorporating Environmental and Recreational Enhancements

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.

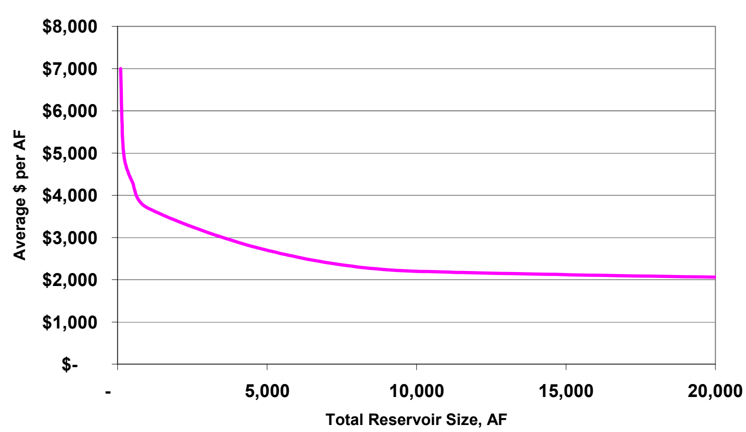


Figure ES-21
Generalized Unit Costs for New Storage Based on Total Reservoir Size

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.

CWCB Board Members

Keith Catlin, Gunnison Basin, CWCB Chair
Don Ament, Colorado Commissioner of Agriculture
Russell George, Executive Director, Colorado Department of Natural Resources
Felicity Hannay for Ken Salazar, Colorado Attorney General
Rod Kuharich, Director, CWCB
Bruce McCloskey, Director, Colorado Division of Wildlife
Hal Simpson, State Engineer and Director, Colorado Division of Water Resources
Barbara Biggs, South Platte Basin
Robert Burr, North Platte Basin
Harold Miskel, Arkansas Basin
John Redifer, Colorado Basin
Donald Schwindt, Dolores/San Juan/San Miguel Basin
Tom Sharp, Yampa/White/Green Basin
Eric Wilkinson, South Platte Basin
Raymond Wright, Rio Grande Basin

CWCB Management Team

Rod Kuharich, Director, CWCB
Randy Seaholm, CWCB Section Chief
Rick Brown, CWCB Project Manager

Consulting Team

Susan Morea, Project Manager, CDM
Kelly DiNatale, Technical Director, CDM
Paul Brown, Lead Facilitator, CDM
John Rehring, CDM
Nicole Rowan, CDM
Steve Coffin, Public Relations, GBSM

Arkansas Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

- Dan Henrichs, High Line Canal
- Leroy Mauch, Lower Arkansas Valley Water Conservancy District
- Robert Wiley Jr., Colorado Farm Bureau

Business, Development and Civic Organizations

- Bob Jackson, Pueblo Businessman
- Dennis O'Neill, East Twin Lakes Ditches and Waterworks
- Dave Sarton, Colorado Springs Chamber of Commerce

Environmentalists and Related Organizations

- Steve Craig, Colorado Trout Unlimited
- SeEtta Moss, Arkansas Valley Audubon Society

Local Governments not Directly Providing Water

- Gary Barber, El Paso County Water Authority
- Jim Bensberg, El Paso County Board of Commissioners
- Matt Heimerich, Crowley County Board of Commissioners

Municipal Water Providers

- Alan Hamel, Pueblo Board of Water Works
- Joe Kelley, City of La Junta
- Phil Tollefson, Colorado Springs Utilities

Recreational and Related Organizations

- Reed Dils, former Rafting Company owner
- Greg Felt, River Outfitter

Water Conservancy/Conservation Districts

- Jim Broderick, Southeastern Colorado Water Conservancy District
- Terry Scanga, Upper Arkansas Water Conservancy District
- Julie Scaplo, Lower Arkansas Valley Water Conservancy District

Technical Advisors

- Pat Edelmann, U.S. Geological Survey
- Mike French, Colorado Parks & Outdoor Recreation
- Mark Hillman, Colorado Senate
- Doug Krieger, Division of Wildlife
- Andy McElhany, Colorado Senate
- Steve Miller, CWCB Staff
- Tom Musgrove, Bureau of Reclamation
- Tom Pointon, Basin Advisor
- John Tonko, Division of Wildlife
- Steve Witte, Division Engineer
- Brad Young, Colorado House of Representatives

Colorado Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

- Richard Connell, Colorado Farm Bureau
- Carlyle Currier, Rancher
- Chris Jouflas, Rancher
- Dick Proctor, Grand Valley Water Users Association

Business, Development and Civic Organizations

- Reeves Brown, Club 20
- Paul Ohri, Businessman

Environmentalists and Related Organizations

- Kristine Crandall, Roaring Fork Conservancy
- John Trammell, Colorado Trout Unlimited

Local Governments not Directly Providing Water

- Tilman Bishop, Mesa County
- Tom Long, Summit County
- Tom Stone, Eagle County
- Lane Wyatt, Summit Water Quality Committee

Municipal Water Providers

- Bruce Hutchins, Grand County Water & Sanitation
- Gary Roberts, Town of Breckenridge

Recreational and Related Organizations

- Bill Baum, General Council for Winter Park
- Rick Sackbauer, Vail Resorts

Water Conservancy/Conservation Districts

- Larry Clever, Ute Water Conservancy District
- Dave Merritt, Colorado River Water Conservation District

Technical Advisors

- John Currier, Basin Advisor-Assistant
- Carol DeAngelis, Bureau of Reclamation
- Scott Fifer, Basin Advisor
- David Graf, Division of Wildlife
- Kathy Hall, Basin Advisor
- Greg Hoskin, former CWCB Board Member
- Alan Martellaro, Division Engineer
- Kurt Mill, Parks and Outdoor Recreation
- Catherine Robertson, Bureau of Land Management
- Ed Warner, Bureau of Reclamation

Dolores/San Juan/San Miguel Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

- Pat Greer, Rancher
- Gregg Johnson, La Plata/Archuleta County Farm Bureau
- Mark Ragsdale, Rancher
- Sid Snyder, San Juan Basin Farm Bureau
- John Taylor, Rancher

Business, Development and Civic Organizations
Steve Harris, Harris Water Engineering
Fred Kroeger, Kroeger Hardware
Mike Preston, Fort Lewis College

Environmentalists and Related Organizations
Peter Butler, Animas River Stakeholders Group
Charles Wanner, San Juan Citizens Alliance

Local Governments not Directly Providing Water
Art Goodtimes, San Miguel County Board of Commissioners
Curt Moore, La Plata County

Municipal Water Providers
Carrie Campbell, Pagosa Area Water & Sanitation District
Jack Rogers, City of Durango
Bruce Smart, Cortez Utilities

Recreational and Related Organizations
Tom Knopick, Duranglers Flyfishing Shop
Ed Zink, Trail Alliance – La Plata County

Water Conservancy/Conservation Districts
Philip Saletta, Dolores Water Conservancy District
Raymond Snyder, San Miguel Water Conservancy District

Indian Tribes
Jim Formea, Southern Ute Indian Tribe

Technical Advisors
Ken Beegles, Division Engineer
David Graf, Division of Wildlife
Pat Page, Bureau of Reclamation
Kelly Palmer, U.S. Forest Service
John Porter, Basin Advisor
Rick Ryan, Bureau of Land Management
Janice Sheftel, Basin Advisor

Gunnison Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies
Ted Collin, Ouray County
Greg Peterson, Gunnison County Stockgrowers
Clint Stroud, Delta County
Bill Trampe, Rancher

Business, Development and Civic Organizations
Gary Garland, Real Estate Developer

Environmentalists and Related Organizations
Jeff Crane, North Fork River Improvement Association
Steve Glazer, High Country Citizens Alliance

Local Governments not Directly Providing Water
Carol Drake, Hinsdale County
Richard Sale, City of Delta
Dave Ubell, Montrose County

Municipal Water Providers
Dick Margetts, Project 7 Water Authority

Recreational and Related Organizations
David Gann, The Nature Conservancy
Ted Hermanns
Hank Hotze, Black Canyon & Gunnison Gorge Expeditions

Water Conservancy/Conservation Districts
Mike Berry, Tri-County Water Conservancy District
Marc Catlin, Uncompahgre Valley Water Users Association
Kathleen Curry, Upper Gunnison River Water Conservancy District
Dave Kanzer, Colorado River District
Peter Kasper, North Fork Water Conservancy District
Karen Shirley, Upper Gunnison River Water Conservancy District
Gregg Strong, Redlands Water & Power Co.

Technical Advisors
Dick Bratton, Basin Advisor
David Graf, Division of Wildlife
Sherman Hebein, Division of Wildlife
Jim Hokit, Basin Advisor
Frank Kugel, Division Engineer
John McClow, Basin Advisor-Assistant
Ed Warner, Bureau of Reclamation

North Platte Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies
Blaine Evans, MacFarland Reservoir
Tom Hackelman, Walden Reservoir Company
Cary Lewis, North Park Stockgrowers
Lucy Meyring, Colorado Cattlemen Association

Environmentalists and Related Organizations
Eric Wagner, Coalition for Sustainable Resources

Local Governments not Directly Providing Water
Rick Wyatt, Jackson County Commissioner

Municipal Water Providers
Kyle Fliniau, Town of Walden
Mark Russell, Walden Public Works

Recreational and Related Organizations
Chad Brown, Owl Mountain Ranch
John Ziegman, Buffalo Creek Ranch

Water Conservancy/Conservation Districts
Jim Baller, Water Conservancy District
Bob Carlstrom, Water and Power Authority
Ken Crowder, Jackson County Administrator

Technical Advisors
Dave Harr, Bureau of Land Management
Mark Lanier, U.S. Fish and Wildlife Service
Bob Plaska, Division Engineer
Steve Puttmann, Division of Wildlife
Carl Trick II, Basin Advisor

Rio Grande Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies
Roy Helms, Rio Grande Water Users Association
Alan Miller, Rancher
Marty Shellabarger, Rancher
Travis Smith, San Luis Valley Irrigation District
Roger Wakasugi, Trinchera Irrigation Company
John Werner, Saguache Creek Water Users Association

Business Development and Civic Organizations
Leroy Salazar, Business Interests

Environmentalists and Related Organizations
Kate Booth Doyle, Rio Grande/Rio Bravo Coalition
Christine Canaly, San Luis Valley Ecosystem Council
Joel Condren, Trout Unlimited

Local Governments not Directly Providing Water
Charlotte Bobicki, San Luis Valley Association of County Commissioners
Cathy McNeil, San Luis Valley Association of Conservation Districts

Municipal Water Providers
Don Koskelin, City of Alamosa

Recreational and Related Organizations
Obbie Dickey, Guide and Outfitter

Water Conservancy/Conservation Districts
Allen Davey, Rio Grande Water Conservation District
Mike Gibson, San Luis Valley Water Conservancy District
Bob Robins, Conejos Water Conservancy District

Technical Advisors
Mike Blenden, U.S. Fish and Wildlife Service
Peter Clark, Rio Grande National Forest
Ralph Curtis, Assisting Ray Wright
Jeff Johnson, Division of Wildlife
Doug Krieger, Division of Wildlife
David Robbins, Assisting Ray Wright
John Tonko, Division of Wildlife
Steve Vandiver, Division Engineer

South Platte Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies
Frank Eckhardt, Consolidated Ditches
Phil Mortensen, Upper Platte and Beaver Canal Company
Fred Walker, Water Supply and Storage Company

Business, Development and Civic Organizations
Ken Crandall, Realtor
Rob Nanfelt, Home Builders Association of Colorado
Ken Vaught, Coors Brewing Company

Environmentalists and Related Organizations
Lynda James, Park County Land & Water Trust Fund
Dan Luecke, Environmental Interest
David Nickum, Trout Unlimited

Local Governments not Directly Providing Water
Bill Jerke, Weld County
John Metli, Elbert County
James R. Sullivan, Douglas County

Municipal Water Providers
Lisa Darling, City of Aurora
Harold Evans, City of Greeley
Ron Hellbusch, Director of Public Works and Utilities, City of Westminster
John Hendrick, Centennial Water and Sanitation District
Jim Kiefer, City of Brighton
Dave Little, Denver Water
Pat Mulhern, South Metro Water Supply Study Board

Recreational and Related Organizations
Kent Higgins, Orvis Guide
Joe McCleary, Rocky Mountain Golf Course Superintendent's Association

Water Conservancy/Conservation Districts
Tom Cech, Central Colorado Water Conservancy District
Brad Wind, Northern Colorado Water Conservancy District

Technical Advisors
Paul Flack, Parks and Outdoor Recreation
Jim Hall, Division Engineer
Carolyn McIntosh, former CWCB Board Member
Brian Person, Bureau of Reclamation
Steve Puttmann, Division of Wildlife
Dick Stenzel, Basin Advisor

Yampa/White/Green Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

Bill Dunham, Rancher, Water Commissioner
Jay Fetcher, Rancher
T. Wright Dickinson, Rancher

Business, Development and Civic Organizations

Mike Long, Energy and Industry
Jay Wetzler, Motel Owner

Environmentalists and Related Organizations

Rick Hammel, Environmental Interest
Mike Tetreault, Nature Conservancy

Local Governments not Directly Providing Water

Bert Clements, Moffat County Land Use Board
Doug Monger, Routt County
Darryl Steele, Moffat County

Recreational and Related Organizations

Peter Van De Carr, Backdoor Sports
Kent Vertrees, Blue Sky West

Water Conservancy/Conservation Districts

Dan Birch, Colorado River Water Conservation District
Ann Brady, Rio Blanco Water Conservancy District
Frank Cooley, Yellow Jacket Water Conservancy District

Municipal Water Providers

Eric Berry, Town of Yampa
Bob Stoddard, Mt. Werner Water and Sanitation District

Technical Advisors

Bill Atkinson, Division of Wildlife
John Fetcher, Basin Advisor
David Graf, Division of Wildlife
Bob Plaska, Division Engineer
David H. Smith, former CWCB Board Member
Melissa Trammell, Dinosaur National Monument

Section 1
Introduction

1.1 Introduction to the Statewide Water Supply Initiative

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

- Define clear purpose and objectives
- Incorporate stakeholders in decisionmaking
- Develop institutional framework for implementation
- Develop funding strategies
- Utilize multi-faceted approach to water resources development

> *"A brighter future for our farmers and ranchers – indeed all of Colorado – depends on all of us focusing this year on our water policy… We must launch a Statewide Water Supply Initiative."*
>
> **– Governor Bill Owens**
> **State of the State Address**
> **January 16, 2003**

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

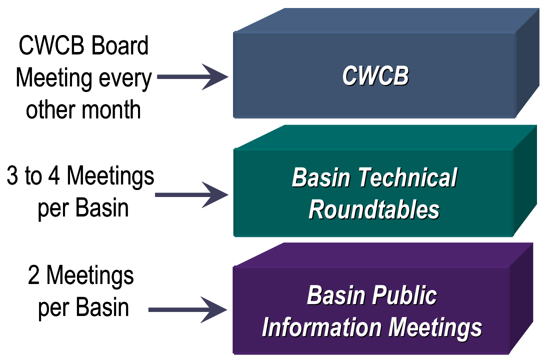
In many areas, local planning entities have completed studies, identified projects, and are capable of implementing those projects. SWSI documented and summarized these identified projects or processes that are in place to address future water needs. Where entities need implementation assistance, SWSI addressed planning and implementation needs, identified projects for possible implementation, and developed strategies for project implementation including potential cooperative and collaborative efforts. For areas where specific projects were not identified by water providers or water users, SWSI relied on a stakeholder process. The options developed by the SWSI stakeholder process generally fall within the following categories:

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

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

1.1.1 SWSI Communication and Community Involvement Process

The public information and Basin Roundtable participant involvement activities were intended to provide a mechanism and forum for the CWCB to solicit and exchange information, which was essential to the success of the Initiative. The Basin Roundtables, with the support of and input from the CWCB Board, defined the overall water management objectives, associated performance measures to meet these objectives, and developed options for meeting future water needs. Information exchange occurred at these levels and a total of 48 meetings were completed.



Colorado Water Conservation Board – meets every 2 months to discuss and resolve water issues and to support water planning in Colorado. The CWCB has representatives from each river basin as well as key state policy makers (i.e., Directors of Department of Natural Resources [DNR], CWCB, Department of Agriculture, Colorado Division of Wildlife [CDOW], State Engineer's Office [SEO], and the Attorney General). During the SWSI process, the entire CWCB dedicated significant time at the regularly scheduled meetings to facilitate and support the implementation of SWSI. The CWCB has reviewed information from the public and Basin Roundtables, and provided input on the development of water supply and demand objectives and the strategies for achieving those objectives. The CWCB will support the efforts of each individual basin and also focus on identifying and resolving potential conflicts among basin objectives and strategies. Opportunity for Basin Roundtable participant and public input were provided at each meeting.

Basin Roundtable Technical Meetings – 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. The focus was primarily on 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.

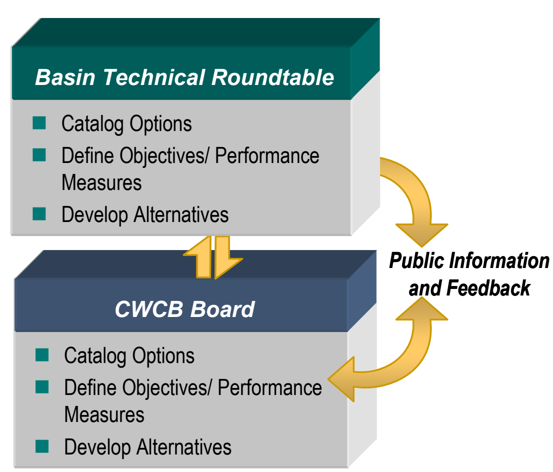
Roundtable participants in each basin included:

- 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

Basin Public Information Meetings – intended to provide a forum specifically for presenting information to and obtaining feedback from the general public.

> *One objective of SWSI is to inform local interests and the general public about the project. This was accomplished by providing information to the public on the water supply and water demand management issues, the study process, and involving local interests in the Basin Roundtable discussions. Another goal of SWSI is to develop public support for the consensus building and public involvement process by developing and providing information, improving general knowledge, broadening the discussions, and making all information available statewide.*

The overall flow of information for the study process is depicted generally in this diagram and is described in more detail in the following pages.



1.2 Background on Colorado Water Resources

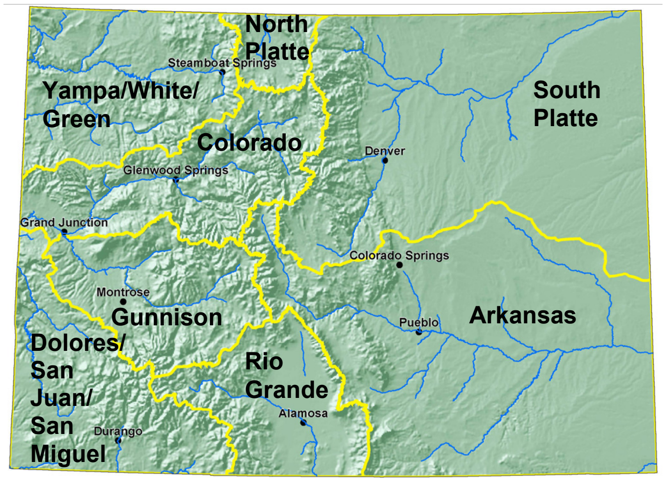
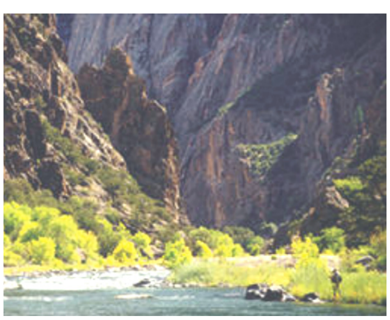


Figure 1-1
Colorado's Eight Major River Basins

Eight major river basins drain Colorado, all with their headwaters in the high mountains of the Continental Divide. Rivers east of the Divide flow ultimately into the Gulf of Mexico, while the western rivers find their way, via the Colorado River, to the Gulf of California and the Pacific Ocean. The interrelationship of these eight basins is described below in the context of four major river systems originating in Colorado.

1.2.1 Colorado River, Gunnison River, Yampa/White/Green Rivers, and Dolores/San Juan/San Miguel Rivers

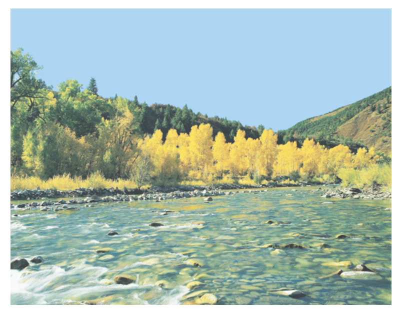
The Colorado River system drains over one-third of the state's area. Originating in the north central mountains, the main stream of the Colorado flows southwesterly and is met at Grand Junction by the Gunnison River before flowing west into Utah. The Yampa and the White move westward across the northwest quadrant of the state to the Utah border where they join the Green, another tributary of the Colorado. The San Miguel and the Dolores begin near the southwestern corner and travel north along the western border and into Utah. The San Juan and its tributaries collect the water in the southernmost regions west of the Divide and carry it into New Mexico.



Less than 20 percent of the entire Colorado River Basin lies inside Colorado, but about 75 percent of the water in the entire river basin originates in the state. Much of this water has been allocated by compact or treaty. Transmountain diversions of these supplies also occur to other parts of the Colorado River Basin states. Over 60 percent of the land in this basin is federal land. In Colorado, transbasin diversions account for about 5 percent of the total supply, or about 500,000 acre-feet (AF).

1.2.2 South Platte River, Republican River, and North Platte River

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



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

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

The Republican River Basin drains approximately 7 percent of the state's area in northeastern Colorado. The area is predominantly agricultural. Water supplies in the basin come from the Republican River and its tributaries, but the primary source of water is groundwater from the Northern High Plains Aquifer, also known as the Ogallala Aquifer.

At the time of SWSI implementation, the Republican River Basin had just completed the settlement of a lawsuit between Kansas and Nebraska, which eventually also included Colorado. In general, the lawsuit resulted in the need to reduce some of the consumptive use (CU) in the basin in Colorado. The Colorado State Engineer is responsible for administering the terms of the settlement. For these reasons, at this time, the CWCB elected not to focus on the Republican River Basin as part of SWSI.

1.2.3 Arkansas River

The Arkansas River begins in the central mountains of the state, near Leadville. It travels eastward through the southern part of Colorado toward the Kansas border. Several tributaries flow from the high southern mountains toward it from the southwest, and there is some drainage from the higher plains north of the main stream.

The basin includes slightly less than one-third of the state's land area. Over 20 percent of the land is publicly owned. A high percentage of the land is devoted to agriculture and about one-third of this land is irrigated. Increasing urbanization is occurring in the Arkansas River Basin.

1.2.4 Rio Grande

The Rio Grande drainage basin is located in south central Colorado and is comparatively small with less than 10 percent of the state's land area. Land is about evenly divided between public and private ownership.

It is largely rural, and agriculture is the main industry in the basin. Since it lies between two high mountain ranges, the San Juan and the Sangre de Cristo, it is somewhat isolated. This factor, coupled with a reduction in logging and mining, has suppressed employment opportunities and has resulted in a recent decline in population.

1.2.5 Overview of Supplies

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

> *The right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied.*
>
> **~ Article XVI, Section 6, Colorado Constitution**

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

There are billions of gallons of groundwater in the confined (artesian) aquifers. Some major aquifers are the Ogallala in eastern Colorado; the Denver Basin, which stretches from Fort Collins to Colorado Springs; and another underlying the San Luis Valley. See Section 7 of this report for more detailed information on water supply.

1.3 Water Institutions

1.3.1 State Water Institutions

The **CWCB** is appointed by the governor and formulates policy with respect to water development programs. The board also develops and designates floodplains, provides water project construction funds, supports the Office of Water Conservation and Drought Planning, acquires and manages all instream flow rights for the state, and assists in compact administration. The CWCB lies within Colorado's Division of Water Resources (DWR).

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
- Identifying and recommending water development projects to the General Assembly

The **DNR** administers programs dealing with water, forests, parks, wildlife, minerals, and development of a state resource policy. It also coordinates all natural resource activities.

The **Colorado Wildlife Commission** is appointed by the Governor, supported by the CDOW, and is responsible for wildlife management, including the acquisition of water necessary for wildlife purposes. The commission is also responsible for the preservation or conservation of wildlife, assessing mitigation of impacts on fish and wildlife caused by development, and coordination with other state agencies in the acquisition of instream flow rights.

The **Colorado Department of Public Health and Environment (CDPHE)** also plays an important role in state water management. The Water Quality Control Commission (WQCC), part of CDPHE, is appointed by the Governor to establish policy and set standards with respect to surface and groundwater quality. The Water Quality Control Division (WQCD), on the other hand, is responsible for the enforcement of these regulations, as well as certifying all wastewater treatment operators.

The **Colorado Water Resources and Power Development Authority (CWRPDA)** is appointed by the governor as an independent authority to initiate, acquire, construct, and operate water projects. It has the authority to finance projects through the issuance of revenue bonds and administers a revolving loan fund for wastewater treatment plant construction.

Water Conservancy Districts, authorized in the 1937 Water Conservancy Act, are political subdivisions with power to levy property tax to build and maintain water storage and distributions projects and to lease or sell water. There are 46 conservancy districts in Colorado. These districts should not be confused with Water Conservation Districts, however, which among other things survey existing water resources and take actions to ensure that there is an adequate supply of water for present and future use.

Other important state government surface water entities include:

- **State Engineer** – overall responsibility for management of state surface waters, tributary groundwater, and diversions
- **Division Engineers** – act under the supervision of the State Engineer to enforce water rights and water distribution under those rights
- **Water Judges** – appointed by the Colorado Supreme Court to hear all water cases within their respective water divisions
- **Water Referees** – work for the water courts and judges, and investigate and rule on water rights (their rulings may be appealed by a water judge)

Key state groundwater agencies include:

- **State Groundwater Commission** – establishes rules for designated groundwater basins
- **State Engineer** – carries out the decisions of the Groundwater Commission and issues well permits
- **Local Groundwater Management Districts** – made up of water users who may regulate the irrigation wells in their districts (but may not issue permits)

1.3.2 Federal Water Institutions

Many federal departments and agencies also play important roles in statewide water management. Many of these groups have overlapping jurisdictions regarding development and management of water resources as they affect Colorado. Key federal agencies include:

- **Office of Management and Budget** – reviews all proposals for appropriation of funds for water-related programs
- **Department of the Interior (DOI)** – includes the Bureau of Land Management (BLM) and National Park Service
  - **BOR** – develops and manages projects (e.g., reservoirs) in the west for the delivery of water for irrigation, M&I use, and power generation
  - **U.S. Fish and Wildlife Service (USFWS)** – administers the Endangered Species Act (ESA), manages fisheries, and conducts a wide range of other activities that affect fish and water-based wildlife
  - **U.S. Geological Survey (USGS)** – collects, analyzes, and publishes information on the nation's water resources (including flow and water quality data)
- **U.S. Environmental Protection Agency (EPA)** – administers the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) and overseas water quality standards for interstate waters
- **U.S. Army Corps of Engineers (USACE)** – plans, designs, builds, and operates water resources and other civil works projects
- **U.S. Department of Agriculture (USDA)** – provides leadership on food, agriculture, natural resources, and includes:
  - **USFS** – promotes the health, diversity, and productivity of the Nation's forests and grasslands
  - **Natural Resources Conservation Service (NRCS)** – partners with local entities to help conserve, maintain, and improve our natural resources and environment
- **Council on Environmental Quality** – responsible for advising the president and federal agencies on environmental policies and procedures and issuing guidelines for the preparation of Environmental Impact Statements (EIS)

1.3.3 Non-Governmental Interest Groups

Many non-governmental groups play important roles in state water resources decisionmaking. The Colorado Water Congress consists of various water resources stakeholders representing industry, agriculture, government, recreation, and others. The Congress is actively involved with water legislation and regulatory decisions affecting both water quantity and quality. Various environmental groups are also actively involved in the state's water resources management, including the Nature Conservancy, Sierra Club, National Wildlife Federation, Trout Unlimited, and Colorado Environmental Coalition, to name a few. These groups lobby for environmental legislation and against legislation that weakens water quality controls or limits recreational opportunities. They also take legal action against projects that are viewed by those groups as being environmentally or recreationally destructive. In addition to the Congress and environmental organizations, the Colorado Foundation for Water Education is a statewide non-profit and non-advocacy organization that provides water resource information and education.

1.4 CWCB History and Mission

The CWCB was created in 1937. The CWCB Mission is to:

> ***Conserve, Develop, Protect and Manage Colorado's Water for Present and Future Generations***

1.4.1 Fundamental Goals

The CWCB must develop and implement programs to:

- Conserve the waters of the state for wise and efficient beneficial uses
- Develop waters of the state to:
  - Preserve the natural environment to a reasonable degree
  - Fully utilize state compact entitlements
- Protect the waters of the state and encourage maximum beneficial use without waste
- Assist in the management of the waters of the state in situations of extreme weather conditions – during both floods and droughts

These fundamental goals apply to all of the major programs and projects undertaken by the CWCB, and to the staff working within this organization.

The CWCB must also maintain and sustain its autonomy and identity with respect to other state and federal entities, while collaborating and cooperating with local, state, and federal entities and others in service to the citizens of Colorado.

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

1.4.2 Structure, Authority, and Role of the Board

The CWCB consists of 15 members. The Governor appoints one representative Board member from each of the state's eight major river basins and one representative member from the City and County of Denver. All appointees are subject to Senate confirmation and serve 3-year terms. The Executive Director of DNR is also a voting member of the Board. The Executive Director of the CWCB, the State Engineer, the Attorney General, the Director of the CDOW, and the Commissioner of the USDA are ex-officio, non-voting members.

To the greatest extent possible, Board appointees are persons experienced in water resource management; water project financing; engineering, planning, and development of water projects; water law; irrigated farming; and/or ranching. No more than five appointees can be members of the same political party. By statute, six voting members constitute a quorum for the conduct of business, with six affirmative votes needed for the Board to take a position on any matter.

1.5 Drought of 2002

Drought is a fact of life in the western United States. While the scientific community's technical ability to predict and anticipate major hydrologic cycles is constantly improving, highly accurate forecasts are not yet achievable. Looking back, the 1990s was a decade of above average precipitation through most areas of the state. This relatively wet hydrologic period coincided with substantial population growth in Colorado. In the early 2000s, and in particular 2002, severe drought conditions dominated nearly every part of the state and brought water supply issues to the forefront of public and political attention. Calls on senior water rights that had never before been called out occurred in 2002; reservoir levels for major municipalities reached unprecedented low levels and prompted widespread public concern and significant mandatory water use restrictions in many urban areas.

The Colorado Drought Mitigation and Response Plan provides a systematic means for the State of Colorado to reduce the impacts of water shortages. The Plan does not create a new government entity to deal with drought, but provides a means for coordinating the efforts of public and private entities that would be called upon to deal with drought impacts.

The role of the Board, as defined in the Statute, includes:

- Establishing policy to address state water issues
- Exercising the exclusive authority of the Board to hold instream and natural lake level water rights to protect the environment
- Mediating and facilitating resolutions of disputes between basins and water interests
- Maintaining and upholding fiduciary responsibilities related to the management of state resources including, but not limited to, the Construction Fund and the Severance Tax Trust Fund
- Representing citizens within individual basins
- Identifying, prioritizing, and recommending water development projects to the general assembly

The CWCB's Drought & Water Supply Assessment was conducted in the fall of 2002. The primary goal of the study was to analyze and summarize information gathered during the assessment that would provide justification for initiatives that drive future resource allocation to benefit local communities susceptible to drought.

State water planners and managers had reason to improve their understanding of drought and drought impacts on the Colorado water user community, given changing public perceptions, competing uses for water, and the impacts of the current drought. For these reasons, the CWCB undertook the Drought & Water Supply Assessment to engage Colorado water users to:

- Determine how prepared Colorado has been for drought
- Identify limitations, and related measures, to better prepare us for future droughts

The major objective that has been identified for the state to address with respect to Colorado's water users needs is to improve water availability and reliability statewide, which is not differentiated by water use or user. In fact, all water users in all geographic regions identified a need for improved water availability and reliability – including water for domestic and municipal use, water for agricultural use, water to support natural stream flows and lake levels, water for firefighting, and water for commercial and industrial use.

Summary of Recommendations from the Drought & Water Supply Assessment:

Major Objective for State Water Policies

- Improve water availability and reliability statewide

Areas of Practice to Achieve the Major Objective*

- Improve public understanding and knowledge of state water and water resource issues
- Support infrastructure needs of water users
- Support technical assistance needs of water users

* Based on data and opinions collected from Colorado's water

Related areas of practice that Colorado's water users identified as needing state involvement, which will address the major objective, include:

- Improving public understanding and knowledge of state water and water resources issues
- Supporting infrastructure needs of water users
- Supporting technical assistance needs of water users

By addressing these three specific areas of practice, the state can address the major objective of improving water availability and reliability statewide.

1.6 Acknowledgements

SWSI is the product of the vision, commitment, and dedication of countless Coloradans toward meeting the state's future water needs. Governor Owens and the Colorado Legislature provided strong direction and support for moving the project forward. The DNR and its Director, Russell George, gave continuous support to SWSI. CWCB Board members are to be commended for providing the foresight needed to undertake SWSI, committing significant time in shaping and guiding the process, and giving unwavering support for the Initiative. The Director of CWCB, Rod Kuharich, likewise committed his time and support for the project and dedicated staff resources toward ensuring SWSI's success. CWCB's Project Manager, Rick Brown, was consistently the "voice of SWSI," devoting much of his energy to meeting the significant demands of the project, and working hard to truly understand the issues and interests of Basin Roundtable members and the general public.

The SWSI consultant team led by CDM was staffed as follows: Project Director – Susan Morea; Technical Director – Kelly DiNatale; Engineering Analysis – John Rehring; Project Management – Nicole Rowan; Project Facilitation – Paul Brown; Decision Science – Dan Rodrigo; Water Supply Analysis – Gordon McCurry; Demographics/Demands – Bill Davis; Public Relations – Steve Coffin, GBSM; Data Analysis – Steven Malers, Riverside Technology inc. and Erin Wilson, Leonard Rice Consulting Water Engineers; Environmental Analysis – Tom Pitts, Water Consult.

We are also grateful to the following CWCB staff who helped produce this final report: Randy Seaholm, Dan McAuliffe, Ray Alvarado, Dan Merriman, Steve Miller, Andy Moore, Michelle Garrison, Mike Serlet, and Carolyn Fritz.

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. This participation and insight is greatly appreciated. Basin Roundtable members are acknowledged below.

Arkansas Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

Dan Henrichs, High Line Canal
Leroy Mauch, Lower Arkansas Valley Water Conservancy District
Robert Wiley Jr., Colorado Farm Bureau

Business, Development and Civic Organizations

Bob Jackson, Pueblo Businessman
Dennis O'Neill, East Twin Lakes Ditches and Waterworks
Dave Sarton, Colorado Springs Chamber of Commerce

Environmentalists and Related Organizations

Steve Craig, Colorado Trout Unlimited
SeEtta Moss, Arkansas Valley Audubon Society

Local Governments not Directly Providing Water

Gary Barber, El Paso County Water Authority
Jim Bensberg, El Paso County Board of Commissioners
Matt Heimerich, Crowley County Board of Commissioners

Municipal Water Providers

Alan Hamel, Pueblo Board of Water Works
Joe Kelley, City of La Junta
Phil Tollefson, Colorado Springs Utilities

Recreational and Related Organizations

Reed Dils, former Rafting Company owner
Greg Felt, River Outfitter

Water Conservancy/Conservation Districts

Jim Broderick, Southeastern Colorado Water Conservancy District
Terry Scanga, Upper Arkansas Water Conservancy District
Julie Scaplo, Lower Arkansas Valley Water Conservancy District

Technical Advisors

Pat Edelmann, U.S. Geological Survey
Mike French, Colorado Parks & Outdoor Recreation
Mark Hillman, Colorado Senate
Doug Krieger, Division of Wildlife
Andy McElhany, Colorado Senate
Steve Miller, CWCB Staff
Harold Miskel, CWCB Board Member
Tom Musgrove, Bureau of Reclamation
Tom Pointon, Basin Advisor
John Tonko, Division of Wildlife
Steve Witte, Division Engineer
Brad Young, Colorado House of Representatives

Colorado Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

Richard Connell, Colorado Farm Bureau
Carlyle Currier, Rancher
Chris Jouflas, Rancher
Dick Proctor, Grand Valley Water Users Association

Business, Development and Civic Organizations

Reeves Brown, Club 20
Paul Ohri, Businessman

Environmentalists and Related Organizations

Kristine Crandall, Roaring Fork Conservancy
John Trammell, Colorado Trout Unlimited

Local Governments not Directly Providing Water

Tilman Bishop, Mesa County
Tom Long, Summit County
Tom Stone, Eagle County
Lane Wyatt, Summit Water Quality Committee

Municipal Water Providers

Bruce Hutchins, Grand County Water & Sanitation
Gary Roberts, Town of Breckenridge

Recreational and Related Organizations

Bill Baum, General Council for Winter Park
Rick Sackbauer, Vail Resorts

Water Conservancy/Conservation Districts

Larry Clever, Ute Water Conservancy District
Dave Merritt, Colorado River Water Conservation District

Technical Advisors

John Currier, Basin Advisor-Assistant
Carol DeAngelis, Bureau of Reclamation
Scott Fifer, Basin Advisor
David Graf, Division of Wildlife
Kathy Hall, Basin Advisor
Greg Hoskin, former CWCB Board Member
Alan Martellaro, Division Engineer
Kurt Mill, Parks and Outdoor Recreation
John Redifer, CWCB Board Member
Catherine Robertson, Bureau of Land Management
Ed Warner, Bureau of Reclamation

Dolores/San Juan/San Miguel Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

Pat Greer, Rancher
Gregg Johnson, La Plata/Archuleta County Farm Bureau
Mark Ragsdale, Rancher
Sid Snyder, San Juan Basin Farm Bureau
John Taylor, Rancher

Business, Development and Civic Organizations

Steve Harris, Harris Water Engineering
Fred Kroeger, Kroeger Hardware
Mike Preston, Fort Lewis College

Environmentalists and Related Organizations

Peter Butler, Animas River Stakeholders Group
Charles Wanner, San Juan Citizens Alliance

Local Governments not Directly Providing Water

Art Goodtimes, San Miguel County Board of Commissioners
Curt Moore, La Plata County

Municipal Water Providers

Carrie Campbell, Pagosa Area Water & Sanitation District
Jack Rogers, City of Durango
Bruce Smart, Cortez Utilities

Recreational and Related Organizations

Tom Knopick, Duranglers Flyfishing Shop
Ed Zink, Trail Alliance – La Plata County

Water Conservancy/Conservation Districts

Philip Saletta, Dolores Water Conservancy District
Raymond Snyder, San Miguel Water Conservancy District

Indian Tribes

Jim Formea, Southern Ute Indian Tribe

Technical Advisors

Ken Beegles, Division Engineer
David Graf, Division of Wildlife
Pat Page, Bureau of Reclamation
Kelly Palmer, U.S. Forest Service
John Porter, Basin Advisor
Rick Ryan, Bureau of Land Management
Donald Schwindt, CWCB Board Member
Janice Sheftel, Basin Advisor

Gunnison Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

Ted Collin, Ouray County
Greg Peterson, Gunnison County Stockgrowers
Clint Stroud, Delta County
Bill Trampe, Rancher

Business, Development and Civic Organizations

Gary Garland, Real Estate Developer

Environmentalists and Related Organizations

Jeff Crane, North Fork River Improvement Association
Steve Glazer, High Country Citizens Alliance

Local Governments not Directly Providing Water

Carol Drake, Hinsdale County
Richard Sale, City of Delta
Dave Ubell, Montrose County

Municipal Water Providers

Dick Margetts, Project 7 Water Authority

Recreational and Related Organizations

David Gann, The Nature Conservancy
Ted Hermanns
Hank Hotze, Black Canyon & Gunnison Gorge Expeditions

Water Conservancy/Conservation Districts

Mike Berry, Tri-County Water Conservancy District
Marc Catlin, Uncompahgre Valley Water Users Association
Kathleen Curry, Upper Gunnison River Water Conservancy District
Dave Kanzer, Colorado River District
Peter Kasper, North Fork Water Conservancy District
Karen Shirley, Upper Gunnison River Water Conservancy District
Gregg Strong, Redlands Water & Power Co.

Technical Advisors

Dick Bratton, Basin Advisor
Keith Catlin, CWCB Chair
David Graf, Division of Wildlife
Sherman Hebein, Division of Wildlife
Jim Hokit, Basin Advisor
Frank Kugel, Division Engineer
John McClow, Basin Advisor-Assistant
Ed Warner, Bureau of Reclamation

North Platte Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

Blaine Evans, MacFarland Reservoir
Tom Hackelman, Walden Reservoir Company
Cary Lewis, North Park Stockgrowers
Lucy Meyring, Colorado Cattlemen Association

Environmentalists and Related Organizations

Eric Wagner, Coalition for Sustainable Resources

Local Governments not Directly Providing Water
Rick Wyatt, Jackson County Commissioner

Municipal Water Providers
Kyle Fliniau, Town of Walden
Mark Russell, Walden Public Works

Recreational and Related Organizations
Chad Brown, Owl Mountain Ranch
John Ziegman, Buffalo Creek Ranch

Water Conservancy/Conservation Districts
Jim Baller, Water Conservancy District
Bob Carlstrom, Water and Power Authority
Ken Crowder, Jackson County Administrator

Technical Advisors
Robert Burr, CWCB Board Member
Dave Harr, Bureau of Land Management
Mark Lanier, U.S. Fish and Wildlife Service
Bob Plaska, Division Engineer
Steve Puttmann, Division of Wildlife
Carl Trick II, Basin Advisor

Rio Grande Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies
Roy Helms, Rio Grande Water Users Association
Alan Miller, Rancher
Marty Shellabarger, Rancher
Travis Smith, San Luis Valley Irrigation District
Roger Wakasugi, Trinchera Irrigation Company
John Werner, Saguache Creek Water Users Association

Business Development and Civic Organizations
Leroy Salazar, Business Interests

Environmentalists and Related Organizations
Kate Booth Doyle, Rio Grande/Rio Bravo Coalition
Christine Canaly, San Luis Valley Ecosystem Council
Joel Condren, Trout Unlimited

Local Governments not Directly Providing Water
Charlotte Bobicki, San Luis Valley Association of County Commissioners
Cathy McNeil, San Luis Valley Association of Conservation Districts

Municipal Water Providers
Don Koskelin, City of Alamosa

Recreational and Related Organizations
Obbie Dickey, Guide and Outfitter

Water Conservancy/Conservation Districts
Allen Davey, Rio Grande Water Conservation District
Mike Gibson, San Luis Valley Water Conservancy District
Bob Robins, Conejos Water Conservancy District

Technical Advisors
Mike Blenden, U.S. Fish and Wildlife Service
Peter Clark, Rio Grande National Forest
Ralph Curtis, Assisting Ray Wright
Jeff Johnson, Division of Wildlife
Doug Krieger, Division of Wildlife
David Robbins, Assisting Ray Wright
John Tonko, Division of Wildlife
Steve Vandiver, Division Engineer
Raymond Wright, CWCB Board Member

South Platte Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies
Frank Eckhardt, Consolidated Ditches
Phil Mortensen, Upper Platte and Beaver Canal Company
Fred Walker, Water Supply and Storage Company

Business, Development and Civic Organizations
Ken Crandall, Realtor
Rob Nanfelt, Home Builders Association of Colorado
Ken Vaught, Coors Brewing Company

Environmentalists and Related Organizations
Lynda James, Park County Land & Water Trust Fund
Dan Luecke, Environmental Interest
David Nickum, Trout Unlimited

Local Governments not Directly Providing Water
Bill Jerke, Weld County
John Metli, Elbert County
James R. Sullivan, Douglas County

Municipal Water Providers
Lisa Darling, City of Aurora
Harold Evans, City of Greeley
Ron Hellbusch, City of Westminster
John Hendrick, Centennial Water and Sanitation District
Jim Kiefer, City of Brighton
Dave Little, Denver Water
Pat Mulhern, South Metro Water Supply Study Board

Recreational and Related Organizations
Kent Higgins, Orvis Guide
Joe McCleary, Rocky Mountain Golf Course Superintendent's Association

Water Conservancy/Conservation Districts
Tom Cech, Central Colorado Water Conservancy District
Brad Wind, Northern Colorado Water Conservancy District

Technical Advisors

Barbara Biggs, CWCB Board Member
Paul Flack, Parks and Outdoor Recreation
Jim Hall, Division Engineer
Carolyn McIntosh, former CWCB Board Member
Brian Person, Bureau of Reclamation
Steve Puttmann, Division of Wildlife
Dick Stenzel, Basin Advisor
Eric Wilkinson, CWCB Board Member

Yampa/White/Green Basin Representatives

Agricultural, Ranching, Ditch and Reservoir Companies

Bill Dunham, Rancher, Water Commissioner
Jay Fetcher, Rancher
T. Wright Dickinson, Rancher

Business, Development and Civic Organizations

Mike Long, Energy and Industry
Jay Wetzler, Motel Owner

Environmentalists and Related Organizations

Rick Hammel, Environmental Interest
Mike Tetreault, Nature Conservancy

Local Governments not Directly Providing Water

Bert Clements, Moffat County Land Use Board
Doug Monger, Routt County
Darryl Steele, Moffat County

Recreational and Related Organizations

Peter Van De Carr, Backdoor Sports
Kent Vertrees, Blue Sky West

Water Conservancy/Conservation Districts

Dan Birch, Colorado River Water Conservation District
Ann Brady, Rio Blanco Water Conservancy District
Frank Cooley, Yellow Jacket Water Conservancy District

Municipal Water Providers

Eric Berry, Town of Yampa
Bob Stoddard, Mt. Werner Water and Sanitation District

Technical Advisors

Bill Atkinson, Division of Wildlife
John Fetcher, Basin Advisor
David Graf, Division of Wildlife
Bob Plaska, Division Engineer
Thomas Sharp, CWCB Board Member
David H. Smith, former CWCB Board Member
Melissa Trammell, Dinosaur National Monument

1.7 Overview of Report

The report follows the tasks outlined in SWSI as described below. It should also be noted that each project task involved the Basin Roundtable, which represented interest groups throughout the state.

- Section 2 outlines the **Statewide Demographic, Economic, and Social Setting.**
- Section 3 describes the **Physical Environment of the Major River Basins.**
- Section 4 provides an overview of the **Legal Framework for Water Use** in Colorado.
- Section 5 looks at **Projected Water Use** for municipal, industrial, agricultural, environmental, and recreational needs.
- **An Assessment of Water Needs** is presented in Section 6, which identifies the gap between supply and demands and describes identified projects and processes for meeting future needs.
- Section 7 summarizes the **Availability of Existing Water Supplies** employing tools such as the CWCB Decision Support Systems (DSS) to analyze water supply availability for each of the major river basins.
- Section 8 outlines **Options for Meeting Future Water Needs.**
- Section 9 describes the **Evaluation Framework for SWSI**, which hinged on developing objectives and associated performance measures for evaluating options.
- In Section 10, **Basin-Specific Options** are presented, describing specific options that could be used to meet future water needs.
- Section 11 describes **Implementation** measures that can be undertaken to build on the findings of SWSI toward meeting Colorado's water needs.

Section 2
Statewide Demographic, Economic, and Social Setting

As the state's population continues to grow, additional demands will be placed upon Colorado's water supplies. To characterize recent trends and existing conditions, this section presents an overview of:

- The state's current and projected population and other key demographic factors
- The role of water in Colorado's major economic sectors
- The social setting surrounding water management
- The statewide environmental setting
- The statewide institutional and regulatory setting
- Water quality

Each of these components has an important role in determining current and future water use patterns in the state. Section 3 explores some of these parameters on a more detailed, basin-by-basin basis.

2.1 Colorado's Historical and Projected Demographics

2.1.1 Population

The State of Colorado, the 24th most populous state in the United States according to the 2000 Census, was the third fastest growing state in the nation in the 1990s, surpassed only by Nevada and Arizona. Population increases have a significant impact on water planning and management strategies. Accurate population estimates are critical in understanding future water demands and therefore affect the decisions involved in meeting those demands.

Population projections were obtained from the Colorado Department of Local Affairs (DOLA) Colorado Demography Office. The DOLA dataset includes county population projections from 2000 to 2030 in annual increments. A complete listing of the population projections is provided in Appendix A.

Some counties in Colorado cross major river basin boundaries, which required their populations to be appropriately allocated among basins. Given the reallocation of population for the multi-basin counties, the total population per basin was determined. The population projections for years 2000 and 2030, percent change over 30 years, and the annual growth rates are shown in Table 2-1 for each basin.

Colorado's population is expected to increase by 65 percent from over 4.3 million people to approximately 7.1 million people between 2000 and 2030. Of the approximate 2.8 million population increase projected over this time frame, 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 (DOLA 2003).

Table 2-1 Population Projections by Basin

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 DOLA Demography Section

The populations in the West Slope basins of the Colorado, Dolores/San Juan/San Miguel, and Gunnison Rivers are projected to nearly double over the next 30 years. The populations in the Arkansas, Rio Grande, South Platte, and Yampa/White/Green Basins will increase between 35 percent and 65 percent. The North Platte Basin is projected to have the lowest growth rate over the 30-year planning period.

Additional detail regarding the population projections and their use in developing estimates of future water use is included in Section 5.

2.1.2 Additional Demographic Information

Historical demographic data are compiled by DOLA and the U.S. Census Bureau. Beyond basic population figures, demographic factors influence the rates and patterns of water use. To characterize recent trends and current conditions, the following data were examined for Colorado, and where available data allowed, aggregated on a major river basin basis:

- Households and family size
- Age
- Employment
- Median household income

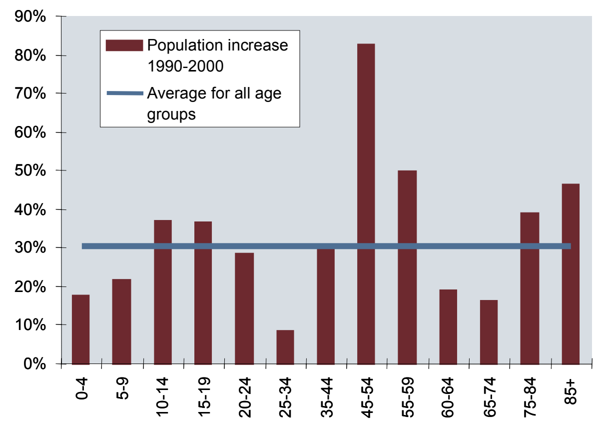
Table 2-2 summarizes current (2000) conditions and changes in the number of households, housing units, and families. While Colorado's population increased from 1990 to 2000 by about 31 percent, the number of households, families, and housing units increased at slightly lower rates, indicating an increase in the average household and family size.

Table 2-2 Statewide Demographic Trends 1990 to 2000

Parameter	1990	2000	Change
Total households	1,282,489	1,658,238	29.3%
Total housing units	1,477,349	1,808,037	22.4%
Total families	854,214	1,084,461	27.0%
Average household size	2.51	2.53	0.9%
Average family size	3.07	3.09	0.7%

Source: Colorado DOLA Profile of General Demographic Characteristics 1990-2000

Trends in the age of Colorado's population were also evident in the 1990s, as indicated in Figure 2-1. These data suggest that the state's population follows the national trend of an aging populace as the "baby boomers" advance in age and average life expectancies increase. This in turn could have implications on water use patterns as they relate to movement to multi-unit dwellings, changes in recreational activities, and associated water use quantities and patterns.



Source: Colorado DOLA Profile of General Demographic Characteristics 1990-2000

Figure 2-1
Colorado Population Increase by Age Group, 1990-2000

Colorado's economy is dependent on a diverse set of employment sectors. In 2000, about 2.2 million civilians over the age of 16 were employed in the state. County-level DOLA employment data for 2000 were aggregated into major basins. These data are summarized in Table 2-3 on the following page, indicating the total employment and the percentage of jobs in each basin attributable to the various DOLA labor categories. Aggregation of county-level data into major river basins assumed that the split of demographic properties between basins in multi-basin counties follows the estimated basin-by-basin split of population described above.

As shown in Table 2-3, more than 70 percent of the state's employment is in the South Platte Basin and another 17 percent is in the Arkansas Basin. The majority of this employment is in the Front Range counties. The Colorado Basin accounts for five percent of the state's employment. The North Platte and Yampa/White Basins combined account for one percent of the state's employment, while the Rio Grande, Dolores/San Juan, and Gunnison Basins combined account for about five percent of the state's employment.

Table 2-3 2000 Employment by Industry as a Percentage of Total Jobs in Each Basin

	Arkansas	Colorado	Dolores/San Juan// San Miguel	Gunnison	North Platte	Rio Grande	South Platte	Yampa/White/Green	Statewide
Employment by Industry by Each Basin									
Agriculture, Forestry, Hunting & Mining	8,584	3,043	1,887	2,919	242	2,054	23,478	2,450	44,658
Construction	33,501	16,151	6,719	5,210	86	1,595	133,416	3,496	200,174
Manufacturing	36,463	4,173	2,294	2,718	23	806	154,140	552	201,169
Wholesale Trade	9,123	2,696	1,146	1,228	27	879	60,785	455	76,339
Retail Trade	48,344	13,449	5,947	5,614	69	2,296	181,224	2,903	259,845
Transportation, Warehousing, and Utilities	16,969	4,816	2,193	1,868	38	929	78,765	1,578	107,155
Information	13,898	2,468	857	864	16	354	89,995	503	108,955
Finance, Insurance, & Real Estate	24,935	8,689	2,693	2,226	25	1,031	128,181	1,505	169,285
Professional, Scientific, Management, and Administrative	38,507	9,795	3,091	2,998	45	836	200,695	1,581	257,548
Education, Health, and Social Services	73,476	15,100	7,844	7,585	113	4,528	262,206	3,635	374,486
Arts, Entertainment, Recreation, Lodging and Food Services	35,504	21,182	6,195	5,080	31	1,714	126,740	3,067	199,513
Other Services	21,363	4,637	2,238	2,171	30	946	72,549	951	104,885
Public Administration	22,848	4,265	2,125	1,753	48	1,106	67,885	1,153	101,182
Total	383,516	110,464	45,229	42,232	793	19,074	1,580,058	23,827	2,205,194
Percent of Total by Basin	17.39%	5.01%	2.05%	1.92%	0.04%	0.86%	71.65%	1.08%	100.00%
Employment by Industry as a Percent of Total in Each Basin									
Agriculture, Forestry, Hunting & Mining	2%	3%	4%	7%	3%	11%	1%	10%	2%
Construction	9%	15%	15%	12%	9%	8%	8%	15%	9%
Manufacturing	10%	4%	5%	6%	14%	4%	10%	2%	9%
Wholesale Trade	2%	2%	3%	3%	3%	5%	4%	2%	3%
Retail Trade	13%	12%	13%	13%	13%	12%	11%	12%	12%
Transportation, Warehousing, and Utilities	4%	4%	5%	4%	3%	5%	5%	7%	5%
Information	4%	2%	2%	2%	3%	2%	6%	2%	5%
Finance, Insurance, & Real Estate	7%	8%	6%	5%	5%	5%	8%	6%	8%
Professional, Scientific, Management, and Administrative	10%	9%	7%	7%	10%	4%	13%	7%	12%
Education, Health, and Social Services	19%	14%	17%	18%	21%	24%	17%	15%	17%
Arts, Entertainment, Recreation, Lodging and Food Services	9%	19%	14%	12%	9%	9%	8%	13%	9%
Other Services	6%	4%	5%	5%	4%	5%	5%	4%	5%
Public Administration	6%	4%	5%	4%	3%	6%	4%	5%	5%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Department of Labor and Employment 2000

About 40 percent of the statewide employment in 2000 is in three sectors: (1) retail trade, (2) professional, scientific, management, and administrative services, and (3) education, health, and social services. Statewide, agricultural employment is less than two percent of total employment, although this sector of the economy accounts for the majority of water use in the state. Historical employment data for the State of Colorado since 1970 show that employment in the retail trade has maintained a steady percentage of total employment while the services sector has grown steadily over time. Thirty years ago, the state had a larger percentage of total employment in the manufacturing sector and government sector than today.

A review of Colorado's largest private sector employers in 2003 show that 4 of the top 10 employers are retail businesses (Wal-Mart, Kroger, Safeway, and Target), 2 of the top 10 are in the health care sector (Centura Health and Columbia/ HealthOne), and the remaining top 10 employers in the state are in telecommunications (Qwest Communications), recreation (Vail Resorts), aerospace (Lockheed Martin), and air transportation (United Airlines). A review of the top 30 employers are indicative of the state's strength in the services sector from traditional services (e.g., health, education, tourism) to high-tech services (telecommunications, information management, software development). Within these sectors, Colorado's economy supports a wide range of businesses, from small businesses to multi-national corporations.

Table 2-4 shows the state's economy as measured in dollars generated, or gross state product (GSP) from 1980 to 2000 and by major industry sectors. As discussed in Section 2.2, agriculture and mining remain an important part of the state's economy with increased production, but a decreasing share of total employment and total state output (Colorado Office of Economic Development and International Trade 2004). The manufacturing sector also shows increasing production in terms of GSP over time, but a decreasing percentage of the overall state economy.

Statewide, the services sector has been growing in both total output and as a percentage of the statewide economy. The Services sector accounted for nearly one-quarter (23 percent) of the total gross state product in 2000. Similarly, the transportation industry has grown as a percentage of the state's economy, as suggested in the review of the state's top employers. The retail trade sector and the finance, insurance, and real estate (F.I.R.E.) sectors combined account for another 27 percent of the state's GSP.

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Table 2-4 Historical Colorado Gross State Product by Industry

Year	Farms	Ag. services, forestry, and fishing	Mining	Construction	Manufacturing	Transportation and public utilities	Wholesale trade	Retail trade	Finance, insurance, and real estate	Services	Government	Total Gross State Product
Historical Colorado GSP by Industry												
1980	944	142	2,124	2,538	5,229	3,619	2,653	3,814	6,296	5,462	5,625	38,446
1985	1,091	267	2,129	3,417	7,447	5,846	3,816	6,159	10,430	9,663	8,787	59,050
1990	1,544	341	1,770	3,052	9,343	8,011	4,599	7,169	12,198	15,098	11,576	74,701
1995	1,147	559	1,586	5,562	13,018	12,562	6,900	10,581	18,136	23,747	15,224	109,021
2000	1,219	1,084	2,841	11,197	16,697	20,516	11,115	15,872	29,978	39,466	19,358	169,341
Percent of Total GSP												
1980	2.5%	0.4%	5.5%	6.6%	13.6%	9.4%	6.9%	9.9%	16.4%	14.2%	14.6%	100.0%
1985	1.8%	0.5%	3.6%	5.8%	12.6%	9.9%	6.5%	10.4%	17.7%	16.4%	14.9%	100.0%
1990	2.1%	0.5%	2.4%	4.1%	12.5%	10.7%	6.2%	9.6%	16.3%	20.2%	15.5%	100.0%
1995	1.1%	0.5%	1.5%	5.1%	11.9%	11.5%	6.3%	9.7%	16.6%	21.8%	14.0%	100.0%
2000	0.7%	0.6%	1.7%	6.6%	9.9%	12.1%	6.6%	9.4%	17.7%	23.3%	11.4%	100.0%

Source: U.S. Bureau of Economic Analysis (http://www.bea.doc.gov/bea/regional/gsp/)

The range of employment by basin gives an indication of the types and amounts of water use that might be expected in each basin, as more specifically developed in projections of M&I water uses in Section 5. The role of water in Colorado's economy is explored in more detail in Section 2.2.

County-level median household income data for the year 1999 from DOLA were also aggregated by basin. These data are summarized in Figure 2-2.

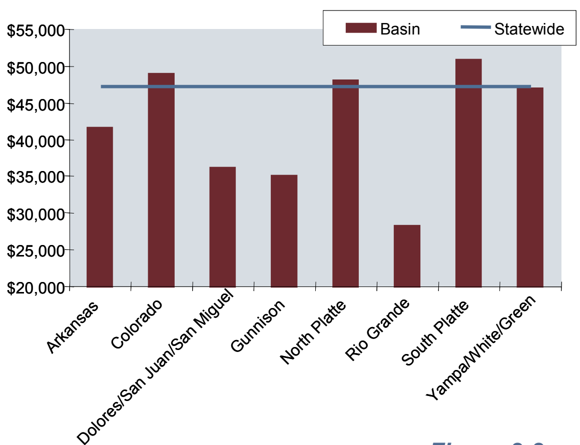


Figure 2-2
Median Household Income by Basin, 1999

2.2 Economic Status and Trends and the Role of Water

Water plays an important role in Colorado by sustaining many economic activities. Colorado relies on snowmelt for much of its yearly water supply; in times of drought or water shortages, economic consequences may occur, as was evident during the drought of 2002. The options developed for meeting future water needs must be sensitive to the implications each can have on the state's various economic sectors. These supply options will be critical to many economic segments in the state that will continue to rely on consistent and dependable water supplies.

This section presents an overview of Colorado's economy, with special emphasis on the segments most reliant upon water supplies. These segments are identified as:

- Urban economy
- Agriculture
- Mineral
- Recreation and tourism

The agricultural sector is the largest consumptive user of Colorado water as shown in Figure 2-3. The tourism and recreation sector is a fast growing sector of the economy and is reliant upon several water-based activities. The mining sector has nearly always had periods of growth and decline, and has essential water needs in what are often water scarce areas.

During recent years, the nation as a whole has been in an economic recession. However, signs of the economy strengthening are apparent with consumer spending on the rise, increased job growth, and consistency with the residential real estate market.

Colorado experienced significant growth in the 1990s when influxes of people migrated to the state associated with new jobs. According to the Colorado Economic Outlook prepared for the Colorado Demography Office (Center for Business and Economic Forecasting Inc. 2004), this resulted in a large construction boom that created 10,000 new jobs each year. The 2004 Outlook notes that this economic and population growth has slowed in the last few years: in the last 3 years, Colorado lost more than 100,000 jobs due to lags in the real estate and construction activity arena, and decreases in real estate sales and income were apparent. However, recent improvement in the Colorado economy can be seen beginning early in 2004, although the 2004 Outlook predicts that the growth is not expected to reach the rates seen in the 1990s.

A summary of key variables in Colorado's economic forecast from the 2004 Outlook is presented in Table 2-5 for years 2001 through 2006.

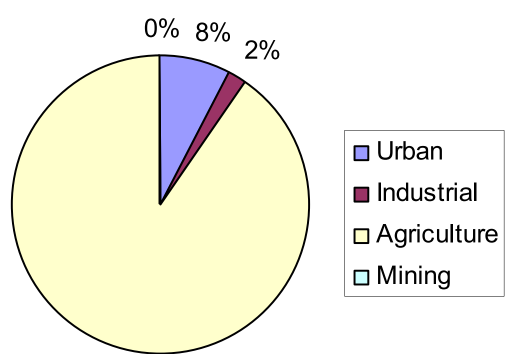


Figure 2-3
Percent Urban, Industrial, Agricultural, and Mining Water Use in Colorado

Table 2-5 Colorado's Economic Forecast (percent change unless otherwise indicated)

	2001	2002	2003	2004	2005	2006
Jobs	0.6	-1.9	-1.5	0.4	3.1	2.8
Manufacturing Jobs	-4.9	-8.7	-6.0	-1.9	1.5	3.3
Personal Income	3.6	0.8	2.0	4.3	6.3	7.1
Real Personal Income	-0.8	-1.2	1.2	4.3	5.5	5.5
Unemployment Rate	3.7	5.7	6.0	5.3	5.0	4.9
Housing Permits (thousands)	54.2	47.4	40.7	38.6	33.9	32.7
Retail Sales	1.7	-0.1	-0.3	4.5	4.7	5.6
Inflation (Denver CPI)	4.4	2.1	0.9	0.0	0.8	1.5
Population	2.4	1.7	1.2	1.1	1.2	1.3
Net Migration (thousands)	59	28	9	16	18	29

Source: Colorado Economic Outlook, Center for Business & Economic Forecasting, Inc., June 1, 2004 (http://dola.colorado.gov/demog/Economy/Forecasts/CBEFOutlook.pdf)

2.2.1 Urban Economy

Colorado's main urban economic areas are concentrated along the Front Range, stretching from Fort Collins in the northern portion of the state to the core region of the Denver Metropolitan area and then southward to Pueblo. In these urban areas, employment in the service industry, such as medical providers, other businesses, and professional services, are prevalent. As noted above, these industry sectors play a vital role in the growth of Colorado's economy. The manufacturing industry is also important to the statewide economy, comprising food products, printing and publishing, machinery, and electrical instruments.

While the urban economy may not demand as much water as other sectors of the economy, such as agriculture, the urban economy is sustained by the availability of a secure water supply and the guarantee of water quality. The 2004 Outlook reports that:

- The manufacturing sector has been in decline since the late 1990s, but is projected to experience a gradual recovery in the upcoming years.
- During the 1990s, the technological and telecommunications area became an important employer for Colorado's workforce. These industries have weakened in the last few years, but the technology industry is now showing signs of improvement and will add jobs to the workforce beginning at the end of 2004.
- Retail sales are an important contributor to the urban economy. State retail sales have not been strong recently, decreasing the last 2 years, but economic forecasts indicate recovery of retail sales will occur in 2004 and 2005.

2.2.2 Agricultural Economy

2.2.2.1 Irrigated Farmland in Colorado

Agriculture is the largest consumptive user of Colorado water, and is one of the state's most significant economic sectors, encompassing a large share of the land in the state. Table 2-6 is a summary of irrigated farmland trends in Colorado from 1987 to 1997. The USDA's National Agricultural Statistics Service (1997) reports that irrigated farmland in Colorado rose from 3,013,773 acres in 1987 to 3,430,129 acres in 1997. Note that these estimates differ from the estimates of irrigated acreage reported in Section 5 due to the use of different sources and methods. The number of farms with irrigation increased from 14,913 in 1987 to 15,470 in 1997, while the average irrigated land per farm increased from 202 acres per farm to 222 acres per farm over the same period. This increase in irrigated land is largely attributable to the increase in the numbers of farms with less than 50 irrigated acres (rising from 5,753 farms in 1987 to 6,685 farms in 1997) and those with more than 500 irrigated acres (rising from 1,484 farms in 1987 to 1,820 farms in 1997).

Table 2-6 Trends in Irrigated Farmland in Colorado: 1987 to 1997

	1987	1997
Total Irrigated Farmland (acres)	3,013,773	3,430,129
Total Farms with Irrigated Land (# of farms)	14,913	15,470
Farms with less than 50 Irrigated Acres	5,753	6,685
Farms with 50 to 500 Irrigated Acres	7,676	6,965
Farms with more than 500 Irrigated Acres	1,484	1,820
Average Irrigated Land per Farm (acres/farm)	202	222

Source: U.S. National/Agricultural Statistics Service (www.nass.usda.gov/census97/volume1/co-6/co1_08.pdf)

2.2.2.2 Farm Gross State Product

The U.S. Department of Commerce's Bureau of Economic Analysis reports that the GSP in Colorado attributable to farming rose from $676 million in 1977 to $1.5 billion in 2001 in current (nominal or not adjusted for inflation) dollars. Table 2-7 is a summary of trends in the agriculture component of Colorado's economy from 1977 to 2001 relative to the agriculture component of the U.S. economy gross domestic product (GDP) through the same period.

The value of farm output in Colorado and total Colorado GSP in real (chained or adjusted for inflation) dollars is shown in Table 2-8. The GSP that is attributable to Colorado farms rose from $1.20 billion in 1986 to $2.15 billion in 2001 in 1996 dollars. However, the relative percentage of the farm sector contribution to the cumulative chained-dollar GSP for all industries in Colorado has remained relatively stable over the same period – between 1 and 2 percent, as shown in Table 2-7.

Table 2-7 Nominal Gross State Product Attributable to Colorado Farms, Total Colorado Industry, and United States Farms from 1977 to 2001 in Current Millions of Dollars

Year	Nominal GSP/GDP ($ million)			Percent of Colorado Total Industry GSP Attributable to Colorado Farms	Percent of Total U.S. Farm GDP Attributable to Colorado Farms
	Colorado Farms	Colorado Total Industry	U.S. Farms		
1977	676	25,229	47,205	2.7%	1.4%
1980	944	38,446	56,106	2.5%	1.7%
1985	1,091	59,050	67,100	1.8%	1.6%
1990	1,544	74,701	79,575	2.1%	1.9%
1995	1,147	109,021	73,187	1.1%	1.6%
2000	1,219	169,341	77,817	0.7%	1.6%
2001	1,517	173,772	80,596	0.9%	1.9%

Source: U.S. Bureau of Economic Analysis: (www.bea.doc.gov/bea/regional/gsp/).

Table 2-8 Real GSP Attributable to Colorado's Farms, Total Colorado Industry, and United States Farms from 1986 to 2001 in Millions of Dollars (1996 Dollars)

Year	Chained-Dollar GSP/GDP			Percent of Colorado Total Industry GSP Attributable to Colorado Farms	Percent of Total U.S. Farm GDP Attributable to Colorado Farms
	Colorado Farms	Colorado Total Industry	U.S. Farms		
1986	1,200	80,012	77,484	1.5%	1.5%
1990	1,633	86,973	84,155	1.9%	2.1%
1995	1,339	111,244	85,452	1.2%	1.7%
2000	1,887	158,173	120,488	1.2%	2.4%
2001	2,152	159,308	114,317	1.4%	2.8%

Source: U.S. Bureau of Economic Analysis: (www.bea.doc.gov/bea/regional/gsp/).

Table 2-9 Employment in Farming versus Employment in All Colorado Industries: 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Employment in Farming in Colorado	46,852	45,483	45,801	43,240	43,690	39,739	44,999
Employment in all Colorado Industries	1,031,728	1,285,327	1,654,180	1,926,148	2,054,770	2,448,120	2,958,899
Farming Percentage	4.5%	3.5%	2.8%	2.2%	2.1%	1.6%	1.5%

Source: U.S. Bureau of Economic Analysis: (www.bea.gov/bea/regional/reis/default.cfm#a)

2.2.2.3 Farm Employment

Employment in farming in Colorado accounts for a relatively minor portion of the state's total employment. Table 2-9 shows the percent contributions to total statewide employment attributable to farming in Colorado from the period 1970 to 2000. Farming employment has declined from about 5 percent 30 years ago to less than 2 percent in 2000.

Employment in farming, in absolute terms, is not an insignificant component of the Colorado economy, employing roughly 45,000 people in 2000. Table 2-9 illustrates how farming employment has remained fairly steady from 1970 to 2000, while steadily decreasing as a fraction of total employment as other employment sectors have increased.

2.2.3 Recreation and Tourism in Colorado

Recreation and tourism activities are economically important in Colorado. According to the Colorado Office of State Planning and Budgeting Memorandum on the Economic Impact of Drought (2002), tourism spending injects $8.5 billion into Colorado's economy and 8 percent of the work force is employed in recreation and tourism activities. Water-related activities, including winter sports, comprise a significant portion of the recreation attractions drawing tourists to Colorado. The most prevalent water-based activities are fishing, boating, and skiing. Water needs for recreation are generally non-consumptive and can be complementary to environmental water needs. One example is maintaining minimum instream flows to provide fish habitat and thereby benefiting recreational fishing.

Recreation and tourism expenditures are not compiled separately in federal government statistics. Various Colorado state agencies and public interest groups compile economic data on recreation and tourism. A significant portion of recreation and tourism expenditures are related to water. Some activities, such as boating and fishing, are totally dependent on water availability. Other activities, such as hunting, wildlife viewing, and camping, are impacted by water availability but not considered water-based recreation. Recreation and tourism expenditures are primarily contained within the services category of major industrial categories. The major subcategories within the services category are Hotels and Lodging, Eating and Drinking Places, Air Transportation, Automotive Rental and Leasing, Amusement and Recreation Services, and Retail Excluding Restaurants and Gas Stations.

2.2.3.1 Skiing

Between 1997 and 2003, skier visits (days) in Colorado have varied between 11,000,000 and 12,000,000 annually, according to Colorado Ski Country USA, the official recorder of ski statistics. The number of skier visits has not grown during these years, but has varied based upon economic and weather conditions. Colorado resorts use a relatively insignificant amount of water for snow making compared to Colorado's overall water consumption, but it can have a significant local environmental impact on high mountain streams near the ski resorts.

A published report on the economic impact of the skiing industry in Colorado was not found. The January 14, 2003 Snow Journal states that skiers spend $1.7 billion in Colorado, which has an estimated economic impact of $4.2 billion (the source of these statistics is not cited). An economic analysis of the Vermont ski industry estimated that the average per trip expenditure for ski visitors was $876 in 1999. Based upon 11,000,000 skier days, the $1.7 billion annual expenditure in Colorado would equal $154.54 per skier day. Since ski trips are usually several days, the Colorado expenditure figure is consistent with the Vermont economic analysis.

2.2.3.2 Boating

Boat registration around Colorado has increased from 91,579 in 1996 to 104,880 in 2001. Boating in Colorado is centered in lakes and reservoirs where boats are used for fishing and water skiing in addition to pleasure boating. It is difficult to estimate participation rates for lake boating because different government agencies maintain the different lakes. The impact of lake levels on boating has not been estimated, but low lake levels can be expected to hamper boating.

Visitor days to Colorado State Parks average over 11,000,000 per year. The Colorado Division of Parks and Outdoor Recreation (CDPOR) estimates that boating at the lakes and reservoirs at these state parks generates over $375 million per year to the state economy. Boating at other public and private lakes and reservoirs is not included in this estimate (CDPOR 2004).

River boating in Colorado is largely associated with river rafting and kayaking. These river boating activities have expanded rapidly during the past 10 years and are very reliant upon water availability. For example, according to the Colorado River Outfitters Association, the number of whitewater rafting user days jumped from 208,940 in 1988 to 523,587 in 2001. The 2002 drought was reported to have caused a 39 percent drop in whitewater rafting to 319,562 user days. The Colorado River Outfitters Association also states that the economic impact of whitewater rafting increased in nominal terms from $75 million in 1993 to $125 million in 2001. Using these figures, the economic impact equals $391 per user day (Colorado River Outfitters 2003).

2.2.3.3 Fishing

Fishing has the largest number of participants of any water-based sport. There were 915,000 participants in fishing in Colorado in 2001. Table 2-10 shows statistics from National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, published by the U.S. Census Bureau (2001). Fishing occurs in Colorado's lakes, reservoirs, and streams.

Table 2-10 Colorado Fishing Statistics

	1991	1996	2001
Anglers in-state	778,000	830,000	915,000
Days in-state	6,284,000	8,232,000	9,267,000
State Resident Anglers	567,000	671,000	626,000

Source: 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation

Table 2-11 lists expenditures in Colorado by United States residents for fishing in 2001, broken out by sub-categories.

Table 2-11 Fishing Expenditures in Colorado (Thousands of Dollars)

Revenue Source	Total Revenue
Food and Lodging	$157,182
Transportation	$102,845
Other Trip Costs	$45,689
Fishing Equipment	$75,412
Auxiliary Equipment	$22,147
Special Equipment	$199,673
TOTAL	**$602,948**

Source: 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation

The expenditures per angler day average about $65 ($602,948,000 divided by 9,267,000 angler days) for food and lodging, transportation, other trip costs, and equipment.

2.2.3.4 Recreation and Tourism Employment

Employment in recreation and tourism in Colorado accounts for about 8 percent of the state's total employment. Table 2-12 illustrates how recreation and tourism employment has increased in recent years. In this table, the 1997 and 1999 values for employment in all industries are interpolated.

Table 2-12 Employment in Tourism vs. Employment in all Colorado Industries

	1995	1997	1999	2000
Employment in Tourism		197,898	212,222	
Employment in all Industries	2,448,120	2,550,276*	2,652,432*	2,958,899
Tourism Percentage		7.8%	8.0%	

Source: Center for Business and Economic Consulting Inc. Tourism Jobs in Colorado, April 27, 2001. U.S. Bureau of Economic Analysis www.bea.gov/bea/regional/reis/default.cfm#a)
*Denotes Interpolated Data

2.2.3.5 Golfing

In 2002, the Colorado golf industry directly contributed over $560 million into Colorado's economy as detailed in Table 2-13. Based on a survey conducted in 2003, Colorado had 264 golf courses, which is over half of the 466 total in the Mountain Region (Wyoming, Utah, and the northern half of both Arizona and New Mexico). The total acres of land invested in Colorado golf courses in 2002 was 35,600 acres, of which 19,837 were in irrigated turf grass. A notable trend in water resource management at golf courses is the use shift of some irrigation water from surface water to reclaimed wastewater. The use of reclaimed water is growing significantly. In 2002, 61 percent of irrigation water came from surface water while 10 percent was from reclaimed water. By 2002, surface water use had declined to 52 percent and reclaimed wastewater had increased to 20 percent (Davies et al. 2004).

Table 2-13 Colorado Golf Course Revenues (2002) (Millions of Dollars)

Revenue Source	Total Revenue
Green Fees	$189.51
Golf Cart Rentals	$47.82
Other Rentals	$9.76
Driving Range	$16.95
Pro Shop Merchandise	$52.88
Food and Beverage	$90.16
Dues/Initiations	$134.81
Other	$18.16
TOTAL	**$560.06**

Source: Davies, S., P. Watson, D. Thilmany. 2004. Resource and Environmental Aspects of Golf in Colorado. Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, Colorado. April 2004-APR 04-01.

2.2.4 Mining in Colorado

Economic and employment statistics for mining include non-fuel mineral production, coal mining, and oil and gas production. Government statistics on these industries are compiled by the USGS, the Bureau of Economic Analysis, and the U.S. Energy Information Administration. The Colorado Mining Association and the Colorado Petroleum Association also compiled data used in this report.

2.2.4.1 Non-fuel Mineral Production

The value of Colorado non-fuel mineral production was $717,344,000 in 2000. The dominant minerals, based upon value of production, are gold, sand and gravel, stone for aggregates, and molybdenum. Table 2-14 shows the value of minerals produced in 1999, 2000, and 2001.

Table 2-14 Non-Fuel Mining Production Value (Thousands of Dollars)

	1999	2000	2001
Gold/Silver	W	68,000	W
Molybdenum	W	54,000	W
Sand/Gravel Construction	217,000	216,000	197,000
Crushed Stone	75,500	81,900	87,700
Other Mining and Withheld Data	281,500	297,444	292,300
TOTAL	**574,000**	**717,344**	**577,000**

Source: USGS Minerals Yearbook - 2002

W = Withheld to avoid disclosing company proprietary data, included with other Mining and Withheld Data.

The Regional Economic Information System of the Bureau of Economic Analysis provides historical production figures, as shown in Table 2-15. The value of non-fuel mining production provided by the USGS differs from the GSP figure provided by the Bureau of Economic Analysis because different methodologies are used to estimate the figures. USGS figures are based upon output reported by producers.

Table 2-15 Colorado Non-Fuel Mining Production (Millions of Current Dollars)

Year	1980	1985	1990	1995	2000	2001
GSP	496	202	147	326	360	377

Source: Bureau of Economic Analysis

Despite Colorado's mining heritage, and the fact that Colorado has the world's largest molybdenum mine and a large gold mine, Colorado is not considered a major mining state based upon value of production. The USGS does not rank Colorado in the top 10 mining producing states.

2.2.4.2 Oil and Gas Production

Water is typically injected into mature oil fields to increase oil and gas extraction. The amount of water used for oil and gas extraction is not significant, and may decline in future years. Nitrogen and carbon dioxide are increasingly being used for oil field injection instead of water in several western states. According to the Colorado Petroleum Association, in 2000 Colorado oil and gas extraction employment averaged 7,200 jobs, oil production was valued at $400 million, and gas production was valued at $2,830 million.

The Regional Economic Information System of the Bureau of Economic Analysis provides historical figures, as shown in Table 2-16 below. The value of oil and gas production provided by the Colorado Petroleum Association differs from the GSP figure provided by the Bureau of Economic Analysis because different methodologies are used to estimate the figures.

Table 2-16 Colorado Oil and Gas Production (Millions of Current Dollars)

Year	1980	1985	1990	1995	2000	2001
GSP	1,417	1,733	1,446	2,280	2,280	2,461

Source: Bureau of Economic Analysis

The production of coalbed methane (CBM) gas has increased rapidly in recent years. CBM production requires the removal of water from coal seams. The method of disposing CBM water and the impact of CBM production on aquifers are subjects of some public concern. Research has not clearly established any impact to aquifers from CBM production.

2.2.4.3 Coal Production

Coal mining uses water primarily for dust control. The amount of water used in coal mining is relatively insignificant. According to the USGS, the production value of Colorado coal in 2001 was approximately $574 million.

Coal production has increased in Colorado in recent decades according to the U.S. Energy Information Administration. Nevertheless, based upon production figures, Colorado is not considered a top coal producing state. From 1970 to 2000, annual coal production in Colorado increased from about 5 million short tons to a little less than 30 million short tons. As a comparison with the top producer, Wyoming produced 700 million short tons of coal in 2001.

The Regional Economic Information System of the Bureau of Economic Analysis provides historical production figures, as shown in Table 2-17. The value of coal production provided by the USGS differs from the GSP figure provided by the Bureau of Economic Analysis because different methodologies are used to estimate the figures. USGS figures are based upon output reported by producers.

Table 2-17 Colorado Coal Production (Millions of Current Dollars)

Year	1980	1985	1990	1995	2000	2001
GSP	211	194	177	222	202	230

Source: Bureau of Economic Analysis

2.2.4.4 Mining Gross State Product

The U.S. Department of Commerce's Bureau of Economic Analysis reports that the GSP in Colorado attributable to mining rose from $967 million in 1977 to $3.1 billion in 2001 (in current or nominal dollars). Table 2-18 is a summary of the mining component of Colorado's economy from 1977 to 2001 relative to the mining component of the U.S. economy GDP through the same period.

The value of mining output in Colorado and total Colorado GSP in real (chained) dollars is shown in Table 2-19 on the following page. The GSP that is attributable to Colorado mining, including coal mining and oil and gas production, rose from $1.44 billion in 1986 to $2.45 billion in 2001 in 1996 dollars. However, the relative percentage of the mining sector contribution to the cumulative chained-dollar GSP for all industries in Colorado has remained relatively stable over the same period – between 1 and 2 percent, as shown in Table 2-18.

2.2.4.5 Mining Employment

Employment in mining in Colorado accounts for a relatively minor portion of the state's total employment. Mining employment has declined from 1.7 percent of the state's workforce in 1970 to only 0.8 percent in 2000.

Employment in mining is not a major component of the Colorado economy, employing roughly 22,000 people in 2000. Table 2-20 on the following page illustrates how mining employment increased from 1970 to 1985, and then decreased from 1985 to 2000. The importance of mining employment has fluctuated over the years but has recently decreased, relative to the Colorado economy.

Table 2-18 Nominal GSP Attributable to Colorado Mining, Total Colorado Industry, and United States Mining from 1977 to 2001 in Current Millions of Dollars

	Nominal GSP/GDP ($ million)			Percent of Colorado Total Industry GSP Attributable to Colorado Mines	Percent of Total U.S. Mining GDP Attributable to Colorado Mines
Year	Colorado Mines	Colorado Total Industry	U.S. Mines		
1977	967	25,229	54,008	3.8%	1.8%
1980	2,124	38,446	113,084	5.5%	1.9%
1985	2,129	59,050	135,323	3.6%	1.6%
1990	1,770	74,701	111,875	2.4%	1.6%
1995	1,586	109,021	95,651	1.5%	1.7%
2000	2,841	169,341	133,082	1.7%	2.1%
2001	3,068	173,772	139,040	1.8%	2.2%

Source: U.S. Bureau of Economic Analysis: (www.bea.doc.gov/bea/regional/gsp/).

Table 2-19 Real GSP Attributable to Colorado's Mining Sector, Total Colorado Industry, and United States Mines from 1986 to 2001 in Millions of Dollars (1996 Dollars)

	Chained-Dollar GSP/GDP			Percent of Colorado Total Industry GSP Attributable to Colorado Mining Sector	Percent of Total U.S. Mining GDP
Year	Colorado Mining	Colorado Total Industry	U.S. Mining		
1986	1,436	80,012	93,460	1.8%	1.5%
1990	1,615	86,973	105,839	1.9%	1.5%
1995	1,824	111,244	112,972	1.6%	1.6%
1996	1,720	117,118	113,037	1.5%	1.5%
1997	2,397	127,314	116,967	1.9%	2.0%
1999	2,421	145,524	114,680	1.7%	2.1%
2000	2,252	158,173	101,886	1.4%	2.2%
2001	2,449	159,308	106,757	1.5%	2.3%

Source: U.S. Bureau of Economic Analysis: (www.bea.doc.gov/bea/regional/gsp/).

Table 2-20 Employment in Mining versus Employment in All Colorado Industries: 1970-2000

	1970	1975	1980	1985	1990	1995	2000
Employment in Mining in Colorado	17,758	22,799	43,389	47,832	31,384	25,887	22,299
Employment in all Colorado Industries	1,031,728	1,285,327	1,654,180	1,926,148	2,054,770	2,448,120	2,958,899
Mining Percentage	1.7%	1.8%	2.6%	2.5%	1.5%	1.1%	0.8%

Source: U.S. Bureau of Economic Analysis: (www.bea.gov/bea/regional/reis/default.cfm#a)

2.2.5 Summary and Conclusions

Colorado's economy is diverse, although 40 percent of the statewide employment in 2000 is in three sectors: (1) retail trade; (2) professional, scientific, management, and administrative services; and (3) education, health, and social services. Growth of the services sector has been driven in part by a growth of the traditional services (e.g., health, education, tourism) and in part by the growth of high-tech services (telecommunications, information management, software development). Statewide, the services sector accounted for nearly one-quarter (24 percent) of the total GSP in 2001. The retail trade sector and the F.I.R.E. sectors combined account for another 28 percent of the state's GSP. Other elements of the state's economy such as agriculture, manufacturing, and government services have continued to provide a steady contribution to the state's overall output, but the contributions of these sectors to the state's overall economy have declined as a percent of total employment and output. All of Colorado's major industrial (commercial) categories require a safe and reliable water supply. In order to provide for current and future economic stability and growth, it is essential that water be managed and developed to meet current and future needs.

Data from the USDA indicate that irrigated farmland in Colorado increased from 1987 to 1997. Agriculture's contribution to Colorado's GSP is in relative decline as a percent of total GSP, but the agriculture sector GSP has continued to expand in absolute terms.

Employment in farming in Colorado has fluctuated somewhat over the past 30 years in absolute terms. However, as total employment in Colorado has risen steadily, the number of people employed in farming has been a decreasing percent of total employment in Colorado.

Data from the Colorado Statewide Comprehensive Outdoor Recreation Plan and the 2001 National Survey of Fishing, Hunting, and Wildlife - Associated Recreation show the demand for water-based recreation has increased during the past 10 years as the Colorado population has increased. The importance of recreation and tourism in the Colorado economy has also increased during the past 10 years. The measurement of GSP, income, and employment derived from recreation and tourism is difficult to estimate because of the way the government compiles economic data.

The three major water-based recreation activities in Colorado are skiing, boating, and fishing. Water-based recreation and tourism is generally a non-consumptive use of water. The availability of water in streams and in reservoirs has a major impact upon water-based recreation. People in Colorado's urban areas also participate in these activities.

All three segments of mining have had a long-term presence in Colorado. Non-fuel mineral production uses water for leaching and processing. Coal mining uses water for dust control. The oil and gas industry uses water to enhance production from older fields. The relative importance of mining to the Colorado economy has declined in recent decades.

2.3 Statewide Social Setting

Water is clearly important to Coloradans, as its availability, use, and particularly its limitations – as evidenced in recent drought conditions in many parts of the state – has an impact on virtually every citizen. The early phases of the SWSI process included a series of public information meetings to help gauge the level and types of interest in water use and water planning throughout the state, and to help guide the assessment of future water needs and strategies for meeting those needs. A second round of public information meetings was held in conjunction with the fourth round of Basin Roundtable Technical Meetings.

This section presents highlights from the SWSI public information meetings. These meetings provided the most current and broadly accessible venue for the public to share its opinions about water management in Colorado. In the first round of public information meetings, a total of 11 meetings were conducted around the state, with one or two meetings held in each basin in August and September 2003. Public notification of the meetings included paid advertising, press releases, public service announcements, flyers, and notification of civic organizations. The meetings were each attended by about 25 to 60 people, representing interests such as agriculture, water users, municipalities, and utilities, but environmental interests were generally the dominant group. The second round of public information meetings was advertised through press releases around the state and through Basin Roundtable members, consisting of one meeting per basin in August and September 2004. Public comment was also taken at the 30 Basin Roundtable Technical Meetings and 7 CWCB meetings. Meeting summaries for all Basin Roundtable Technical Meetings are included in Appendix B.

The key issues brought forth in the public meetings in each basin are highlighted in Table 2-21. Because this was an open public meeting, views expressed in the meeting are those of the participating individuals and thus may not be representative of the majority of basin residents. Moreover, the list of issues brought up at each meeting may not be complete, in that meeting attendance and participation was widely encouraged but purely voluntary.

The input received via these meetings was used in the formulation of water management objectives and options throughout the SWSI process. Additional public comment was received at the end of each Basin Roundtable Technical Meeting that reflected on the meetings' discussions and provided additional public feedback on the progress of SWSI or other water management and use issues. The Basin Roundtable process is more fully described in Section 9.

Further evidence of the importance of water as part of the statewide social setting is seen in the media coverage afforded to water issues in Colorado. While media coverage tends to increase in intensity when drought conditions prevail, newspaper, radio, and television coverage of water issues is frequent in all parts of the state under virtually all hydrologic conditions. This coverage included widespread coverage of SWSI in each basin, often timed to coincide with major SWSI events such as Basin Roundtable Technical Meetings and public information meetings.

Throughout SWSI, the state's social setting as it applies to water became evident through the passion and commitment expressed by Basin Roundtable members, agencies, and the public, representing a broad diversity of opinions, needs, and visions for the future.

Table 2-21 Summary of Water Management Issues by Basin from Public Information Meetings

Basin	Meeting Locations and Dates	Key Issues Expressed by Public Meeting Participants
Arkansas	La Junta 8/27/03 Colorado Springs 8/28/03	■ State needs to have long-term and drought emergency water plans ■ Broad public involvement in SWSI advocated ■ Need to maintain water flows for recreation (rafting and fishing) ■ Conservation and landscape alteration cited as means to improve water supply ■ Conjunctive use of groundwater/surface water ■ Water quality is a concern ■ Agricultural water use efficiencies discussed ■ Interruptible supply options discussed ■ Transfer of agricultural water rights could threaten local economy ■ Preserve ability to sell water rights ■ Need to obtain water from elsewhere – all water in basin appropriated ■ Additional / better storage needed ■ Look at other economic solutions for agriculture so less need for selling rights ■ Explore alternatives to selling water rights – water banks and leasing
	Pueblo 9/7/04	■ Proposed Arkansas Valley transfers could potentially make up some of the South Platte Basin's deficit ■ Water quality of transfers is important ■ The Upper Arkansas should not move water away from rural communities in the Lower Arkansas ■ Outfitters on rivers want to see tourism become a major industry ■ Environmental enhancements and being proactive is much cheaper than being reactive ■ CWCB could assist in the National Environmental Policy Act (NEPA) process by helping with involvement of interest groups ■ Water quality and salinity issues could be addressed by taking some lands out of production ■ There are benefits from agriculture inefficiencies ■ Need to work more cooperatively and SWSI is a start
Colorado	Glenwood Springs 8/27/03	■ The public must understand future implications of transbasin diversion ■ Process for resolving conflicts is needed ■ Encourage basins to be self sufficient ■ Need for more storage capacity ■ Important to understand water management assumptions ■ Educate Front Range that Western Slope water is not unlimited ■ Water management is vital for all basins ■ Growth is a concern ■ Competing interests for water supply
Colorado (cont.)	Glenwood Springs 8/25/04	■ Use it or lose it mentality may result in inefficiencies - the measure of a water right is the Consumptive Use not the amount diverted ■ In times of drought if you transfer the water on an interruptible basis this could have the unintended consequence of reducing groundwater availability ■ Meeting Endangered Species and Compact commitments can be adversely impacted by water reuse ■ CWCB should develop some policies regarding water planning and operational plan ■ Look at smaller, local, off channel reservoirs ■ Multiple benefits – CWCB should make a strong recommendation in support of recreation, enhancing flows and involving the public ■ SWSI only projected to 2030, but growth will continue

Table 2-21 Summary of Water Management Issues by Basin from Public Information Meetings

Basin	Meeting Locations and Dates	Key Issues Expressed by Public Meeting Participants
Dolores/San Juan/ San Miguel	Bayfield 9/3/03 Dove Creek 9/4/03	▪ More storage capacity needed ▪ Funding for storage projects – particularly how to make smaller projects affordable ▪ Literature and public education about conservation and reuse programs ▪ Getting the right people at the technical meetings, including oil and gas companies ▪ Science-based solutions – such as cloud seeding, should be sought ▪ Need way to work with the other states in the Four Corners area ▪ Preserve the agricultural lifestyle and economy – keeping agricultural water as agricultural water ▪ Need to adequately account for future demand and growth ▪ Instream flow rights can and is affecting water use and development ▪ More flexibility in using and storing water ▪ Incentives for municipal conservation and education of other basins that water is not unlimited
	Durango 8/16/04	▪ In water management, we need to look at the tradeoffs and unintended consequences of every action ▪ Agricultural efficiency (sprinkler irrigation) should be further investigated ▪ Communicate messages regarding the value of irrigated agriculture, quality of life/aesthetics issues, and open space ▪ SWSI process should continue as this dialogue is beneficial with SWSI's statewide vision, especially for rural Colorado
Gunnison	Gunnison 8/28/03	▪ Consider innovative funding strategies for smaller projects ▪ Enhancement of current storage facilities needed ▪ More attention to groundwater management ▪ Education for Front Range that Western Slope water is not unlimited ▪ Not interested in developing water to fuel more growth ▪ Make sure all those with power (like federal government) and all affected are part of the process
	Montrose 8/24/04	▪ Western Slope threat of compact call from Lake Powell could be even more severe than other compact calls ▪ Environmental needs are not looked at by state law as beneficial use ▪ Contingent valuation method provides mechanism to weight value of environmental uses/needs ▪ If project proponent cannot pay for project cost, it's inefficient use of resource ▪ Who pays for environmental benefits, depends on the individual situation, who has the property rights ▪ Pleased to see conservation such a strong focus of the fourth meeting ▪ Cities need instream flow for wastewater operations
North Platte	Walden 8/26/03	▪ North Platte decree limits storage, usage, alternatives ▪ Stream management, instream flows and affects on agriculture were major concern ▪ Better forest management could yield better stream flows ▪ Endangered species issues in Nebraska could affect the North Platte ▪ Storage in small fishing ponds cited as possibility ▪ Town of Walden proposing small storage facility outside of town to improve treated water capabilities
	Walden 8/10/04	▪ Concern was expressed that population projections for North Platte are too low ▪ Recreational pressure from the Front Range will increase ▪ Concern was expressed that ESA issues on South Platte could impact West Slope

Table 2-21 Summary of Water Management Issues by Basin from Public Information Meetings

Basin	Meeting Locations and Dates	Key Issues Expressed by Public Meeting Participants
Rio Grande	Alamosa 9/3/03	▪ Some voiced need for additional storage ▪ Others voiced need for sustainable storage ▪ Water's importance to recreation noted ▪ Water restrictions on new housing/tourism should be considered ▪ Need to recharge aquifers and monitor
	Alamosa 8/19/04	▪ Sub-surface irrigation should be advanced ▪ Aurora is paying for drip systems in Arkansas Basin and drying up portion of land ▪ Need to understand impacts of all water supply options ▪ Concern over impacts to agriculture ▪ Homeowner Associations should not require bluegrass ▪ Rio Grande Basin cannot afford the cost to solve over-pumping issues ▪ Public education is important ▪ Once 20-30 percent of wells in basin go dry, irrigated acres will decline and aquifer will recover ▪ Rio Grande growth rate seems low due to growth in South Fork and Crestone area
South Platte	Greeley 9/4/03 Denver 9/8/03	▪ Need to focus on conservation and education ▪ Concerns about endangered species issues in Nebraska ▪ Concerns on funding for new projects ▪ Concerns on recharging groundwater ▪ Plan better for long-term growth ▪ How does future water development impact agriculture and rural economies ▪ Concerns on diversity of basin and needs ▪ SWSI process: Inform and involve public, present information understandably ▪ Set goals for river and stream use, then work collaboratively to manage the resources accordingly ▪ Diverse needs in the South Platte Basin; solutions must address all of them ▪ Water quality issues, e.g., Hayman fire, others ▪ Consider growth control to conserve water ▪ Need to study conjunctive use and reuse ▪ Consider setting environmental goals for streams and rivers
	Denver 9/8/04	▪ There is an issue of providers competing for same water ▪ Providers do not fully disclose project details/plans ▪ Water transfers and multiple uses raises concerns about water quality and treatment ▪ There is a need for high level water symposium including top thinkers and discussing Colorado's issues ▪ Potential for SWSI to serve as basis for taking discussion to next level ▪ Lack of characterization of agriculture situation and their motive/interest in water transfers raises questions
Yampa/White/ Green	Steamboat Springs 8/21/03	▪ Concern that Front Range usage of water would affect flow availability in the Yampa due to compact requirements ▪ Need for additional water storage projects, particularly smaller projects ▪ Concern that tributary levels were low, and that would affect towns along those tributaries
	Steamboat Springs 8/11/04	▪ Concern with water quality of reused water ▪ Before we start diverting more water from Western Slope, we need to do more conservation on Front Range ▪ Oil shale development unlikely ▪ Environment provides flood control ▪ There is no balance for instream flows - water rights are junior and administered by CWCB whose priority is not instream flow ▪ There is a recovery program in place as part of Elkhead Enlargement that will help but it is at the expense of peak flows ▪ At some time we are going to run out of food and fiber with all of these agriculture transfers ▪ We need more money available to build water projects than buy water rights for instream flows ▪ Remember mitigation, i.e., cannot make new wetlands

2.4 Statewide Environmental Setting

A brief overview of the physical and environmental features of the state that may affect or be affected by water development and management activities is presented in this section. Basins that contain environmentally sensitive areas, critical habitat areas, and species that would affect or be affected by water management and development practices are identified. Additional information on these topics is provided on a basin level in Section 3.

Colorado has three distinct physical regions – the Great Plains in eastern Colorado, the Rocky Mountains in Central and Northwestern Colorado, and the Colorado Plateau in Southwestern Colorado. Flat and rolling plains and tablelands characterize the Great Plains. Short-grass and mixed-grass prairie is scattered with trees and shrubs and occasional valleys, canyons, or mountains break the extensive view. The South Platte River flows through the northern portion of the region while the Arkansas River flows through the southern region. To the west, the Rocky Mountains rise as high as 14,000 feet and have pronounced vegetational zonation. The various zones, including alpine tundra, montane forest, and dry, rocky slopes of the foothills, support a variety of plants and animals. The rugged Colorado Plateau consists of tablelands and mountains reaching as high as 12,600 feet. The Colorado River cuts across the north, adding even greater diversity to the grasslands, woodlands, and mountains of the Plateau (USGS 1998).

The State of Colorado has nearly 4 million acres of designated wilderness in its more than 14 million acres of national forest land (Colorado Foundation for Water Education 2004), and includes pristine areas in both mountain and plains environments. Environmentally sensitive areas are present in national or state parks and monuments, wilderness areas, national and state forests, and other sensitive federal and state land uses. A combination of these areas exists throughout each basin.

Sensitive habitats identified include those of:

- Federally-listed endangered species
- State-listed threatened and endangered species
- State species of special concern (not a statutory category)

Various federal and/or state listed fish species are present in the Arkansas, Colorado, Dolores/San Juan/San Miguel, Gunnison, Rio Grande, South Platte, and Yampa/White/Green Basins. There are no federal and/or state listed fish species found in the North Platte Basin. Other threatened, endangered, or state species of concern are also listed in each of the eight river basins. See Section 3 for more detail.

2.5 Institutional and Regulatory Setting

Water projects developed in Colorado will normally have to comply with three significant federal laws: Federal CWA, NEPA, and ESA. In the process of compliance with these laws, other federal laws may come into play. This section describes, in general terms, the federal and local permitting process for water projects. In addition to these, major federal regulatory special use permits may be required if a project is located on federal land. There are also local permits such as the 1041 permitting process which many apply. Colorado Water Law, including discussion on Colorado Water Rights, Interstate Compacts, Equitable Apportionment Decrees, Memoranda of Understanding, and specific tools within the current legal framework of the Priority System that can be used to address various water supply needs, are discussed in Section 4.

2.5.1 Federal Clean Water Act

Two sections of the CWA normally apply to water project development. Section 404 regulates the discharge of dredged and fill materials into the waters of the United States, including wetlands. A permit from USACE is needed to conduct these activities. Section 401 requires that any applicant for a federal permit will obtain a certificate that any such discharge will comply with state regulations, including water quality standards and other element regulations.

2.5.1.1 Section 404

Section 404 of the federal CWA regulates the discharge of fill material into waters of the United States, including wetlands. Activities in waters of the United States that are regulated include water resource projects such as dams, diversions, and levees.

The basic premise of the program is that no discharge of dredged or fill material can be permitted if a practicable alternative exists that is less damaging to the aquatic environment or if the nation's waters would be significantly degraded. In applying for a permit, the applicant must show that steps have been taken to avoid wetland impacts where practicable, potential impacts to wetlands have been minimized, and compensation has been provided for any remaining, unavoidable impacts through activities to restore or create wetlands.

The basic form of authorization used by USACE is the individual permit. Processing such permits involves evaluation of individual, project-specific applications in what can be considered three steps: pre-application consultation (for major projects), formal project review, and decisionmaking. Of great importance to the project evaluation is the USACE public interest balancing process. The public benefits and detriments of all factors relevant to each case are carefully evaluated and balanced.

The following general criteria for the public interest review are considered in the evaluation of the permit application (33 CFR 320.4(a)(2)): 1) the extent of the public and private need for the project; 2) whether there are practicable alternative locations or methods that may be used to accomplish the objective of the proposed project where unresolved conflicts exist as to the use of a resource; and 3) the extent and permanence of the beneficial or detrimental effects the proposed work is likely to have on the private and public uses of impacted lands and water.

USACE is required to comply with NEPA prior to issuing a 404 permit. However, if an EIS is developed by another federal agency, separate NEPA compliance by USACE is not required. The decision on whether to authorize or deny the permit application is determined by the outcome of this evaluation. USACE may perform an alternatives analysis, and require compensatory mitigation, or other conditions, to address environmental impacts for all permits. Mitigation is a component of USACE's regulatory program. The amount of mitigation required is commensurate with the anticipated impacts of the project. The goal of mitigation is to replace resource functions and mitigate other impacts.

2.5.1.2 Section 401

Section 401 of the federal CWA states that any applicant for a federal permit to conduct any activity that may result in any discharge into the navigable waters shall provide the permitting agency with a certification from the state that any such discharge will comply with state regulations. Thus, anyone needing a 404 permit must also obtain 401 certification from the state to ensure maintenance of state water quality standards by the activity, both during construction and operation. The primary purpose of 401 certification is to assure that the issuance of these federal permits and licenses will result in compliance with state water quality requirements.

In Colorado, CDPHE Regulation No. 82 (401 Certification Regulation) authorizes the WQCD to certify, conditionally certify, or deny certification of federal licenses and permits in accordance with Section 401 of the federal CWA and sets forth Best Management Practices (BMPs) applicable to all certifications except for Federal 402 permit certifications, and the procedures for developing conditions to be included with certification, where necessary. Certifications issued by WQCD apply to both the construction and operation of the project and apply to the water quality impacts associated with the project. Denial of certification triggers denial of the federal permit or license for which certification is requested.

2.5.2 National Environmental Policy Act

The intent of NEPA is to have federal agencies consider environmental issues in all decisionmaking. The act requires full disclosure about major actions taken by federal agencies and accompanying alternatives, impacts, and possible mitigation. This act also requires that environmental concerns and impacts be evaluated during planning and decisionmaking.

Proposed federal actions triggering NEPA include construction of a project, permits and/or authorizations from federal agencies, federal funding, contracts with federal agencies, and easements or rights-of-way with federal agencies required to cross federal lands, or any other action where a federal decision is required. Once it has been established that there is a proposed federal action, the next step is to determine relevant environmental issues, the potential magnitude of environmental impacts, and the appropriate level of NEPA documentation.

Construction of water projects frequently requires an EIS addressing both construction and operation of the project. The EIS will address impacts on land use, socio-economics, hydrology, water rights and stream flows, water quality, vegetation of wetlands, wildlife, fisheries, threatened and endangered plant and animal species, cultural resources, recreation, transportation, sensitive environmental areas, water supply, hydropower, energy consumption, state species of special concern, flood control, soils, geology, air quality, and noise. Other issues may also be addressed if in the public scoping process.

The NEPA analysis focuses on the environmental impacts of the proposed action, any adverse environmental effects that cannot be avoided, the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments of resources. The analysis addresses direct and indirect impacts, and defines mitigation measures for impacts that must be carried out by project sponsors. The data and analysis developed are commensurate with the significance of the impact. The EIS analysis must be in sufficient detail to identify all significant impacts. For water projects, this process will likely take a minimum of 2 years, and a maximum of 5 years, depending on the scope and impacts of the project.

The NEPA process must integrate and incorporate the requirements of other statutes, and Executive Orders including those on Indian Trust assets, Indian sacred sites, and environmental justice. On completion of the NEPA process, the federal action agency will issue a record of decision. The federal agency's record of decision incorporates all of the environmental commitments made by the applicant in order to mitigate the impacts of the project and to comply with other federal laws, including the Fish and Wildlife Coordination Act, National Historic Preservation Act, ESA, other laws, and Executive Orders. The environmental commitments are also incorporated into any permits issued by USACE, or other agencies, that are needed to implement the project, and those commitments become enforceable terms of the permit.

2.5.3 Endangered Species Act

Section 7(a)(2) of the ESA requires consultation with the USFWS for any federal action that may affect a species listed as threatened or endangered (listed species). This consultation process may result in USFWS issuing a biological opinion identifying actions to be undertaken to avoid jeopardizing a species, adversely modifying critical habitat, or an acceptable level of incidental take resulting from the proposed action and reasonable and prudent measures to offset the incidental take. Implementation of reasonable and prudent measures is non-discretionary by the federal action agency.

The initiation of Section 7 consultation requires the identification of a proposed federal action that may adversely affect federally-listed threatened or endangered species. Therefore, consultation often is not initiated until the later stages of the NEPA process and usually only on the preferred alternative. A biological assessment (BA) is prepared by the federal action agency that identifies impacts on endangered species. The BA and other information are used by USFWS in preparing the biological opinion. A 135-day period is allowed for the Service to complete a biological opinion following initiation of formal consultation. However, this period will very likely be extended on complex projects for up to 1 year or more.

The Section 7 regulations require that the effects of a proposed action are added to the baseline to determine if the species is jeopardized by the totality of actions that may affect it (cumulative impact). If the species is jeopardized by the proposed action, in addition to all other actions, then a jeopardy biological opinion with reasonable and prudent alternatives is issued. The project sponsor is normally required to implement the reasonable and prudent alternatives. Some of the actions emanating from a consultation process (i.e., agency commitments, reasonable and prudent alternatives, and reasonable and prudent measures) may require changes to alternatives, and can affect the NEPA process by presenting actions that have not been fully evaluated.

2.5.4 1041 Regulations

The "1041 regulations" are a special case of land use powers relating to matters of statewide concern, and have been used by some counties to control water project development within the county. The regulations give counties review and approval authorities over the siting, design, and construction of water project facilities. They do not give a county the power to regulate activities that occur in another county, nor to prohibit a change in the point of diversion to a location in another county as often occurs in an agricultural to urban transfer. 1041 regulations can regulate new water supply development projects and agricultural-urban transfers that require a new diversion and/or pipeline to be sited in a county where the water has been historically used for agriculture.

2.5.5 Federal Special Use Permits

When a water project involves land development on federal land, it must be permitted by the entity with jurisdiction over the land and/or over the particular activity. For example, a water project on federal land will require a special use permit from the land-administering agency, e.g., the U.S. Forest Service or the U.S. Bureau of Land Management. Such permits are broadly termed special use permits. Consistent with the issuing agency's jurisdiction, they address all resources that may be affected by the project, including soils, vegetation, wildlife, threatened and endangered species, surface water, groundwater, wetlands, air, cultural resources, human populations, and others.

2.6 Water Quality

The quality of Colorado's water resources is critically important to all human and non-human water uses and users – whether municipal, industrial, agricultural, recreational, or environmental. Colorado is fortunate to be home to the headwaters of virtually every stream in the state, and as such, many stream segments are pristine. However, both natural and human-caused factors can influence water quality, such as:

- Geological formations
- Topographic and climatological factors
- Vegetation types and densities in watersheds
- Discharges of pollutants from point sources
- Non-point discharges such as runoff from various land uses
- Return flows from irrigation practices
- Stream channel modifications
- Changes in flow that can affect water quality

Beyond historical land uses – such as mining activities from 100 years or more ago that still influence water quality today – there are significant changes in Colorado that continue to exert an influence on the water quality of streams and groundwater throughout the state. Increases in population, along with the changes in land use that accompany them, can impact Colorado's high-quality waters. In urban areas, increased discharges of treated wastewater are highly regulated and controlled. Urban runoff also brings a host of potential contaminants to receiving waters through stormwater collection systems and discharges. At the same time, increased recreational uses and additional population in mountain recreational areas has the potential to affect water quality. Meanwhile, runoff from agricultural land uses – in particular, nutrient loadings and animal waste – continues to be an important non-point source of contaminants to receiving waters in every major river basin in the state.

The federal CWA establishes minimum national requirements for the protection of surface waters. In Colorado, statutory authority to implement CWA requirements is given to the Colorado WQCC, which establishes state water quality control policies through the development of water quality regulations, including setting water quality standards for all waters in the state. The CDPHE's WQCD is charged with implementation and administration of the state's water quality protection program within the regulatory framework established by the WQCC, including maintaining, improving, and restoring water quality through activities such as permitting and monitoring.

Waters not meeting state standards for their designated uses are deemed "impaired" under the federal CWA. Designated uses include categories such as aquatic life, recreation, drinking water supply, and agricultural uses. The WQCC is charged with identifying and listing all impaired stream segments in the state. The resulting list is known as the 303(d) list, referring back to the original CWA section requiring this analysis. Once the state has identified impaired waters on its 303(d) list, it is required to prioritize them based on the severity of pollution and other factors and, where appropriate, develop a "Total Maximum Daily Load" (TMDL) for each water body. The process of developing a TMDL includes determining the cause(s) of the water quality problems, identifying pollutant sources, and establishing the allowable amounts or loads of specific pollutants that the impaired water body can receive from each identified source without exceeding the standards set for that water body. The TMDL must include a margin of safety, waste load allocation (for point sources), and a load allocation (for non-point sources and natural background). Once a TMDL is established, it is implemented through the state's point and non-point source water quality control programs.

WQCC Regulation 93 documents the state's 303(d) list of impaired waters that are targeted for TMDL development. Regulation 94 establishes the "Monitoring and Evaluation List" that contains a separate list of water bodies that are suspected of having water quality problems, but there is insufficient data to determine whether the water bodies are impaired. Water bodies on the Regulation 94 list are the focus of additional monitoring to determine whether they should be placed on the state 303(d) list.

Colorado's proposed 2004 303(d) list, which was submitted to EPA in March 2004 for review and approval, includes water quality-impaired stream segments in each of the state's eight major river basins. Impairments for various stream segments throughout the state are based on diverse parameters that include but are not limited to metals, bacteria, nitrates, pH, dissolved oxygen, and sediment. In July 2004, EPA found that the state's 2004 list only partially met the requirements of Section 303(d) of the CWA. While EPA agreed that the water bodies on the state's proposed list were impaired, EPA found that the state should have included six additional water bodies on its 303(d) list. Further information regarding TMDLs in each basin is included in Section 3.

Section 3
Physical Environment of the Major River Basins

3.1 Statewide Overview

Evaluations conducted under SWSI followed CWCB's delineations of Colorado's eight major river basins, as shown in Figure 3-1. The basins include the Arkansas, Colorado, Dolores/San Juan/San Miguel, Gunnison, North Platte, Rio Grande, South Platte, and Yampa/ White/Green Basins. Basin descriptions were completed to gather information on the current physical, institutional, regulatory, demographic, economic, and social settings as they relate to water use in each of these basins. The purpose of this section is to provide an overview of these factors for reference in the SWSI process. These descriptions are broken down into the following major sections for each basin:

- Geography
- Climate
- Topography
- Land Use
- Surface Geology
- Surface Water
- Groundwater
- Water Quality
- Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species
- Energy and Mineral Resources

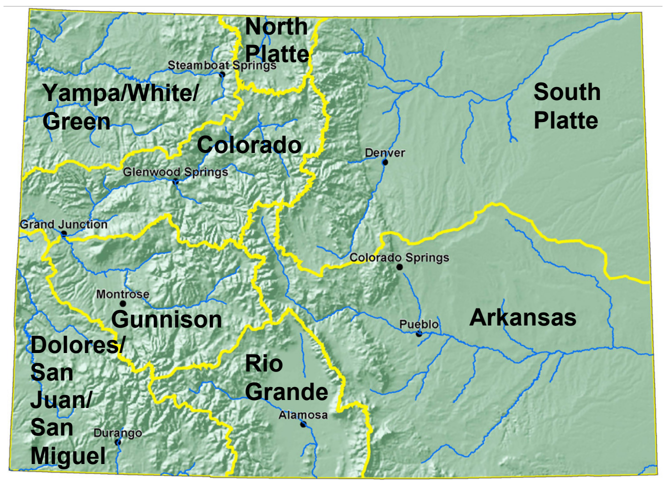


Figure 3-1
Colorado's Eight Major River Basins

Virtually all of these topics are interconnected or affect the state's water supplies and water quality – either through natural or man-made/induced factors. The topography of the Continental Divide, the backbone of Colorado's Rocky Mountains, dictates the direction of water flow either to the west or to the east for each of the river systems in the state. The Divide is also home to the headwaters of several major rivers and their tributaries that run throughout Colorado. The Colorado River begins in Rocky Mountain National Park in eastern Grand County and flows to the west toward the Pacific Ocean. The Colorado River system comprises an area that covers approximately one-third of the state, including the major tributary systems of the Yampa, White, and Dolores Rivers. Nearly 70 percent of the water that leaves Colorado flows through the Colorado River and its tributaries. However, only a small fraction of the state's population lives within this corridor.

In contrast, over half of Colorado's land area and 85 percent of the state's population lies in the South Platte and Arkansas Basins, which contribute only about 5 percent of the flows leaving the state. These two river systems travel from the east side of the Continental Divide to the Mississippi River and ultimately the Gulf of Mexico. The Rio Grande, accounting for 3 percent of the water exiting Colorado, flows south into New Mexico, then east to the southern border of Texas, and into the Gulf of Mexico. The Animas, Florida, and San Juan Rivers and their tributaries also flow south into New Mexico, and make up almost 20 percent of the water leaving the state. The North Platte and Laramie Rivers flow north into Wyoming and make up about 4 percent of the water leaving the state (Colorado SEO 2003). Other surface water resources, which cover about 164,000 acres throughout the state, include lakes and reservoirs (CDPHE 2000).

Groundwater resources also play a pivotal role in meeting Colorado's water needs. In 1995, groundwater withdrawals in Colorado were slightly more than 2.5 million AF, with agricultural users comprising about 90 percent of this amount. Overall, groundwater withdrawals by agricultural and M&I users in 1995 represented slightly more than 20 percent of the state's total for these uses, with the remainder coming from surface water supplies. The median value for groundwater use as a percentage of total use for all counties in the state is 9 percent, with agricultural areas in the eastern plains and in the San Luis Valley in south central Colorado relying more substantially on groundwater over surface water sources (Colorado Geological Survey [CGS] 2003).

The state's unique topography and climate are clearly intertwined with its water resources. Topography is an important component of water resources planning, in that it dictates the direction of natural flows within a watershed. Much of the state's precipitation is concentrated on its mountainous and western slope areas. Snowpack in the state's alpine headwaters areas provides the vast majority of water supplies, with spring runoff causing significant flow peaking in virtually all of the state's river systems. Groundwater storage and its recharge are also largely affected by the topography and climatological patterns that characterize the state.

Water quality can be affected by geography and various land uses including runoff from point and non-point discharge sources. For example, mining in the mountainous regions, urbanization along the Front Range, and agriculture in the eastern plains and elsewhere can impact the quality of the state's waters and aquatic habitats. Habitat degradation, nutrient loading, soil erosion, and increased stormwater runoff are only a few examples of the concerns associated with rapid urbanization, particularly in the mountain recreational areas (CDPHE 2000).

Improving water quality and restoration and protection of water bodies in Colorado is occurring through programs such as the TMDL process, Gold Medal fisheries establishment, instream flow programs, and federal and state listed threatened, endangered, and species of special concern. These programs were presented in Section 2, and key flow issues are also discussed by basin in Section 6. More specific information on these protection measures are presented below for each basin, along with the topics described above.

Each section that follows describes one of Colorado's eight major river basins. Figures associated with the descriptions of each basin are compiled at the end of each basin's write-up.

3.2 Arkansas Basin

3.2.1 Arkansas Basin Geography

The Arkansas Basin is spatially the largest river basin in Colorado covering an area of 28,268 square miles, or 27 percent of the surface area of the state (Wolfe 2003, CDPHE 2000). It comprises the southeast portion of the state, as shown in Figure 3-2. The largest cities in the basin are Colorado Springs (population 373,328) and Pueblo (population 103,846) (DOLA 2003).

3.2.2 Arkansas Basin Climate

The climate in the Arkansas Basin is characterized by a high degree of variability with average daily temperatures ranging from 46 degrees Fahrenheit (°F) in the upper river valley to 55°F in the lower valley (Smith and Hill 2000). Temperature extremes in the lower valley can range from 0°F in the winter to 100°F in the summer (Abbott 1985). Precipitation also varies greatly within the basin. Figure 3-3 shows a contour plot of the average annual precipitation throughout the basin. Basinwide average annual precipitation ranges from less than 10 inches per year in the plains to over 30 inches per year in the high mountain regions.

3.2.3 Arkansas Basin Topography

Steep slopes characterize the western part of the Arkansas Basin, while relatively flat plains characterize the eastern portion. The headwaters of the Arkansas River begin near Leadville at an elevation of more than 14,000 feet and drop to 3,340 feet at the Colorado and Kansas state line, representing a more than 10,000-foot change (CGS 2003).

3.2.4 Arkansas Basin Land Use

Land use in the Arkansas Basin (USGS 1992) is shown in Figure 3-4 and summarized in Table 3-1. Grassland and forest are the predominant land use types in the basin covering approximately 67 percent and 13 percent of the basin, respectively. The grassland areas are concentrated in the central portion of the basin whereas the forested land is located on the western portions of the basin.

Table 3-1 Land Cover Data for the Arkansas Basin

Land Cover	Basinwide Area (sq. miles)	Basinwide Percent of Total	Statewide Area (sq. miles)	Statewide Percent of Total
Grassland	19,043	67.4%	41,051	39.5%
Forest	3,654	12.9%	29,577	28.4%
Planted/ Cultivated	2,621	9.3%	13,737	13.2%
Shrubland	2,421	8.6%	16,883	16.2%
Developed	219	0.8%	923	0.9%
Barren	213	0.8%	1,219	1.2%
Open Water	84	0.3%	590	0.6%
Wetland	13	0.04%	80	0.08%
TOTAL	**28,268**		**104,060**	

Source: USGS 1992 NLCD

3.2.5 Arkansas Basin Surface Geology

Geology ranging from Precambrian to Quaternary age is exposed in the Arkansas Basin. In the mountain province, Precambrian metamorphic schists and gneisses intruded by igneous rocks abound. The plains province is dominated by multiple layers of sedimentary rocks, and Quaternary alluvium fills the reaches along the lower Arkansas River.

3.2.6 Arkansas Basin Surface Water

The perennial streams comprising the headwaters of the Arkansas River are supplied by the snowpack of the mountains surrounding the area of Leadville, Colorado (Abbott 1985). The Arkansas River flows out of the mountains, through the deep canyons near Cañon City, and across the plains until it leaves the state and enters Kansas just east of Holly, Colorado. Along its journey to Kansas, several major tributaries enter the river. A map of the basin showing the Arkansas River and its major tributaries is provided in Figure 3-2.

To monitor streamflow, numerous USGS streamflow gages are maintained in the Arkansas Basin. Five of these gages were selected to summarize historic flows in the basin across a broad spatial scale. The locations of these gages are shown in Figure 3-5. Table 3-2 summarizes the mean annual streamflow, period of record, and drainage area for each gage. As indicated by the table, mean annual flows are highest in the upstream reaches of the Arkansas River near Cañon City. Major surface water diversions and segments with decreed instream flow rights are also indicated in Figure 3-5.

3.2.7 Arkansas Basin Groundwater

Groundwater in the Arkansas Basin is located within the following aquifers:

- Alluvial Aquifer
- Denver Basin
- High Plains
- Raton Basin
- Dakota-Cheyenne
- Wet Mountain Valley and Huerfano

Figure 3-6 shows the outline of the aquifers broken down into three groups: alluvial, bedrock (Raton Basin and Dakota-Cheyenne), and Designated Basin (High Plains). Also shown in the figure is the location of wells in the Arkansas Basin with a permitted or decreed yield of 500 gallons per minute (gpm) or higher. Information from the 2003 Colorado Ground Water Atlas was used as the basis for this section (CGS 2003).

Table 3-2 Summary of Selected USGS Stream Gages for the Arkansas River Basin

Site Name	USGS Site Number	Mean Annual Streamflow (AFY)	Mean Annual Streamflow (cfs)	Period of Record (Years)	Drainage (sq. miles)
Arkansas at Cañon City	07096000	534,289	738	1890-2002	3,117
Fountain Creek at Pueblo	07106500	73,304	101	1922-2002	926
Arkansas at Las Animas	07124000	157,836	218	1939-2002	13,976
Purgatoire near Las Animas	07128500	67,633	93	1922-2002	3,306
Arkansas at Lamar	07133000	135,856	188	1913-2002	18,830

Source: USGS National Water Information System (NWIS) web/HydroBase database

The unconfined alluvial aquifer of the Arkansas River, comprised of glacial silts to large boulders, is primarily recharged by surface water infiltration from the river as well as from many ditches and canals. Irrigation also plays a role in the recharge of the alluvial aquifer. Depth of water in the lower valley generally ranges between 5 and 30 feet and in the upper valley between 5 and 58 feet. Trends in hydrographs since the 1970s show a general increase in the water table elevation, which can be attributed to irrigation return flows. Irrigation is the major use of the alluvial aquifer groundwater. However, in Chaffee and Lake Counties, public water supply is the primary use of alluvial groundwater.

The major aquifers of the Raton Basin include the Raton, Vermejo, and Trinidad formations, and the Cuchara and Poison Canyon formations. Sources of recharge for the aquifers include runoff from the Sangre de Cristo Mountains, precipitation infiltration, and infiltration from streams and lakes. The depth to water generally increases in the aquifers from northwest to southeast, indicating a southeastern direction of groundwater flow. In all areas but the southeast corner of the basin, water can be encountered at less than 200 feet below ground surface.

The Dakota-Cheyenne aquifer lies under the majority of the Arkansas Basin. The stratigraphy of this unit ranges from well-sorted sandstone to fine-grained shales. The aquifer provides water for irrigation and domestic water supply in the basin. Due to the diversity of the aquifer stratigraphy, well yields can range from around 5 gpm to over 1,000 gpm.

The High Plains aquifer is found in the eastern portion of the basin and is considered a "Designated Basin" by the State of Colorado. A Designated groundwater basin is not adjacent to a continuously flowing natural stream or a stream that fulfills a surface water right. A designated groundwater basin is established by the Colorado Groundwater Commission in accordance with Section 37-90-106 of the Colorado Revised Statutes. The High Plains aquifer is a major source of water for southeast Colorado. Because of this, groundwater withdrawals have exceeded recharge since the early 1960s. The depth of wells generally increases eastward toward the Colorado-Kansas state line, and in the Arkansas Basin the saturated thickness of the aquifer ranges between zero and 50 feet.

3.2.8 Arkansas Basin Water Quality

Surface water quality in the Arkansas Basin is "generally good" and portions of the headwaters have been designated by the State of Colorado as Outstanding Waters. All streams, lakes, and reservoirs within Mount Massive and Collegiate Peaks Wilderness Areas are currently considered under the designation of Outstanding Waters. However, there is some water quality concern in the basin near the Arkansas River headwaters in the historic mining districts and downstream toward the Colorado-Kansas state line. The major water quality issues in the basin are related to acid mine drainage in the headwaters, and urban runoff and salinity in the lower basin. Additionally, return flows from agricultural and municipal water uses concentrate naturally occurring salts, arsenic, and selenium in the basin (CDPHE 2002).

Acid mine drainage was a significant problem in parts of the Upper Arkansas River, especially along the segments of the East Fork, St. Kevin's, and California Gulches. Treatment plants have been constructed to control discharge quality from the Yak Tunnel and the Leadville Drain. Although much improvement has been made, high metal concentrations are still observed. The waters of Cripple Creek and Fourmile Creek are also impaired as a result of historic mining (CDPHE 2002).

Urban areas are another contributor to water quality degradation. Urban stormwater runoff can constitute a majority of flow in parts of the basin during high flow periods, while during low flow periods many of the streams are dominated by M&I effluent (CDPHE 2002).

Surface water quality trends were identified using data from the USGS flow gage and water quality station on the Arkansas River at Lamar from the years 1968 to 1998. Water quality trends suggest that total sulfate, hardness (calcium carbonate), and conductivity are decreasing slightly, while total alkalinity is increasing (CDPHE 2002). Salinity appears to be increasing in the downstream direction in the Arkansas River. A recent study showed an increase from 300 parts per million (ppm) total dissolved solids (TDS) east of Pueblo to 4,000 ppm near the state line (CGS 2003).

As discussed in Section 2.6, the TMDL process evaluates and allocates pollutant loads in impaired waters listed on the Colorado 303(d) list. Stream segments in need of TMDLs, and those of concern with inadequate quantity or quality of data to assess impairment, are compiled into Regulation 93 and Regulation 94 lists, respectively.

Figure 3-7 identifies the locations of surface waters in the Arkansas Basin that are listed on Colorado's 2002 303(d) list. Stream segments proposed for listing on the 303(d) list and the Monitoring and Evaluation list are described in Colorado WQCC Regulations 93 and 94. The state's 2004 proposed 303(d) list incorporates several additions from the 2002 list. It includes numerous stream segments of the mainstem and its tributaries listed for selenium, primarily in the middle and lower (eastern) portions of the basin. Proposed 2004 higher-priority listings in the basin are primarily associated with metals constituents in the upper basin.

Groundwater in the upper Arkansas River Valley is generally suitable for use as potable water supply with a few exceptions caused by acid rock drainage and septic system effluent contamination. Groundwater in the lower Arkansas Basin alluvial aquifer is considered to be of fairly good quality (CGS 2003). However, similar to the river, the groundwater increases in salinity with distance downstream. Groundwater or surface water with TDS concentrations greater than 2,000 ppm is generally considered to be unsuitable for irrigation without further treatment (CDPHE 2002).

3.2.9 Arkansas Basin Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species

A major concern for the Upper Arkansas River Valley is the acid-mine drainage from many of the historic mining locations surrounding the headwaters of the Arkansas River (CGS 2003). One of these sites is the California Gulch Superfund site near Leadville, Colorado. Large volumes of mining waste were left at the site due to the intense historical mining activities, contaminating soils and surface water runoff (EPA 2003). In 1990, the Yak Tunnel Treatment Plant was built, which greatly improved water quality, but sources still affect and degrade the soil and water quality in the California Gulch (EPA 2003).

In addition to impaired areas, threatened and endangered species and areas of high environmental or recreational value require special attention when evaluating water supply projects and use patterns in the Arkansas Basin. Appendix C presents a complete list of federal and/or state listed threatened and endangered fish and other species in the Arkansas Basin.

As discussed in Section 2.4, the CDOW awards the Gold Medal designation to waters that have high-quality aquatic habitat, a high percentage of trout 14 inches or longer, and the potential for trophy trout fishing and angling success. There are no Gold Medal designated waters in the Arkansas Basin.

The Arkansas River has become one of the state's largest water-based recreational attractions. Areas of high recreational value in the basin, including the Arkansas headwaters, whitewater reaches on the Arkansas River, Lake Pueblo State Park, and Buffalo and Collegiate Peaks Wilderness areas, are discussed in the environmental report provided in Section 6.

Figure 3-8 shows the locations of some of the basin's key aquatic species habitat.

3.2.10 Arkansas Basin Energy and Mineral Resources

The headwaters of the Arkansas have been impaired due to intense mining of molybdenum, gold, and silver. Waters that have been affected include most of the drainages in the Leadville area, Lake Creek, and Chalk Creek (Water Colorado 2003, CDPHE 2000).

Colorado Springs Utilities operates three hydroelectric power plants in the basin capable of producing a total of 33 megawatts of electricity (Colorado Springs Utilities 2003). Xcel Energy operates a thermal-electric power generating facility in Pueblo.

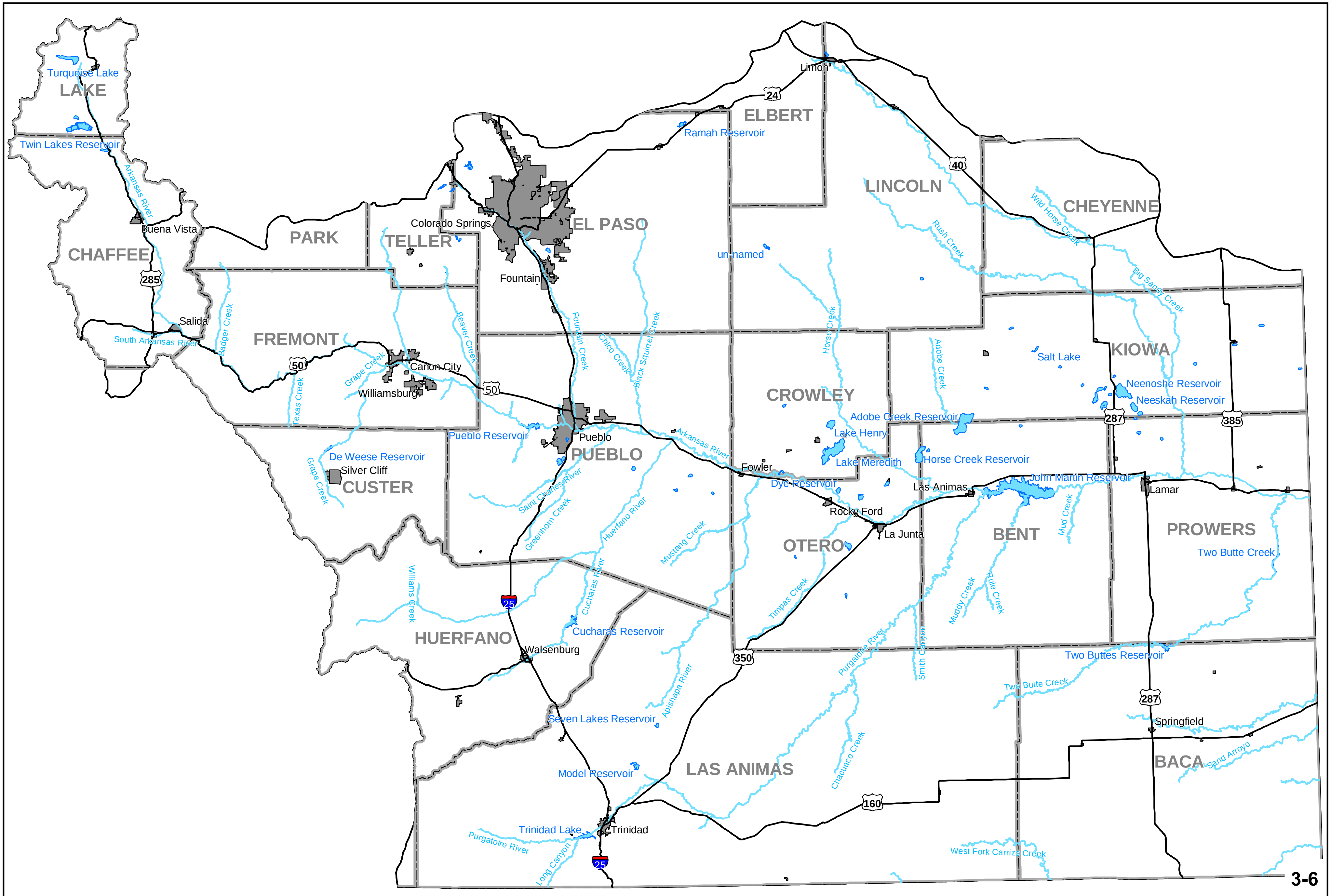
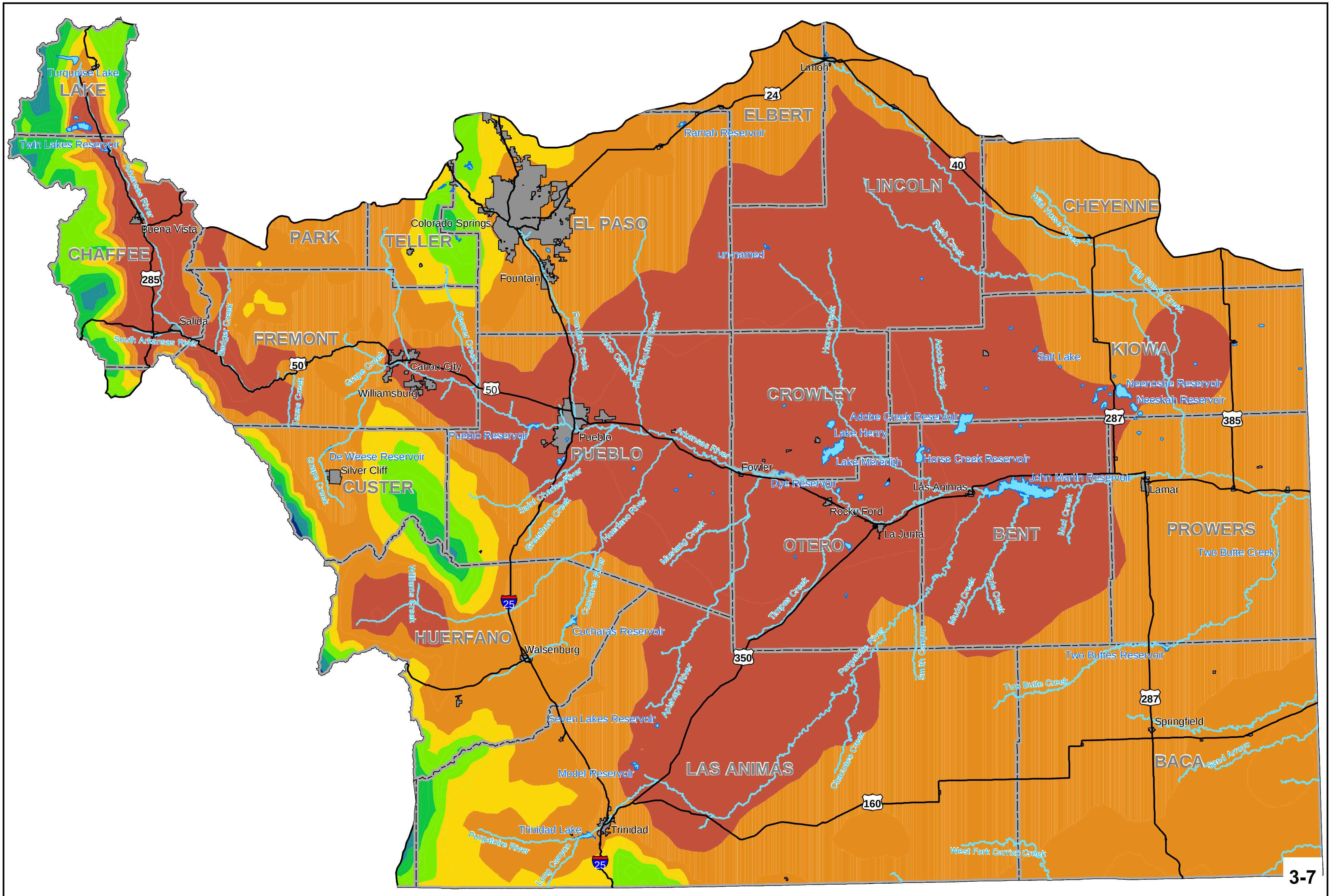


Figure 3-2
Arkansas Basin
Physical Setting

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

10 5 0 10 Miles
1:1,500,000

N
Coordinate System
NAD 1927 UTM Zone 13N



3-7

Figure 3-3
Arkansas Basin
Mean Annual Precipitation

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

Mean Annual Precipitation, Inches
7.0 - 13.0
13.1 - 17.0
17.1 - 21.0
21.1 - 27.0
27.1 - 33.0
33.1 - 39.0
39.1 - 63.0

10 5 0 10 Miles
1:1,500,000
N
Coordinate System
NAD 1927 UTM Zone 13N

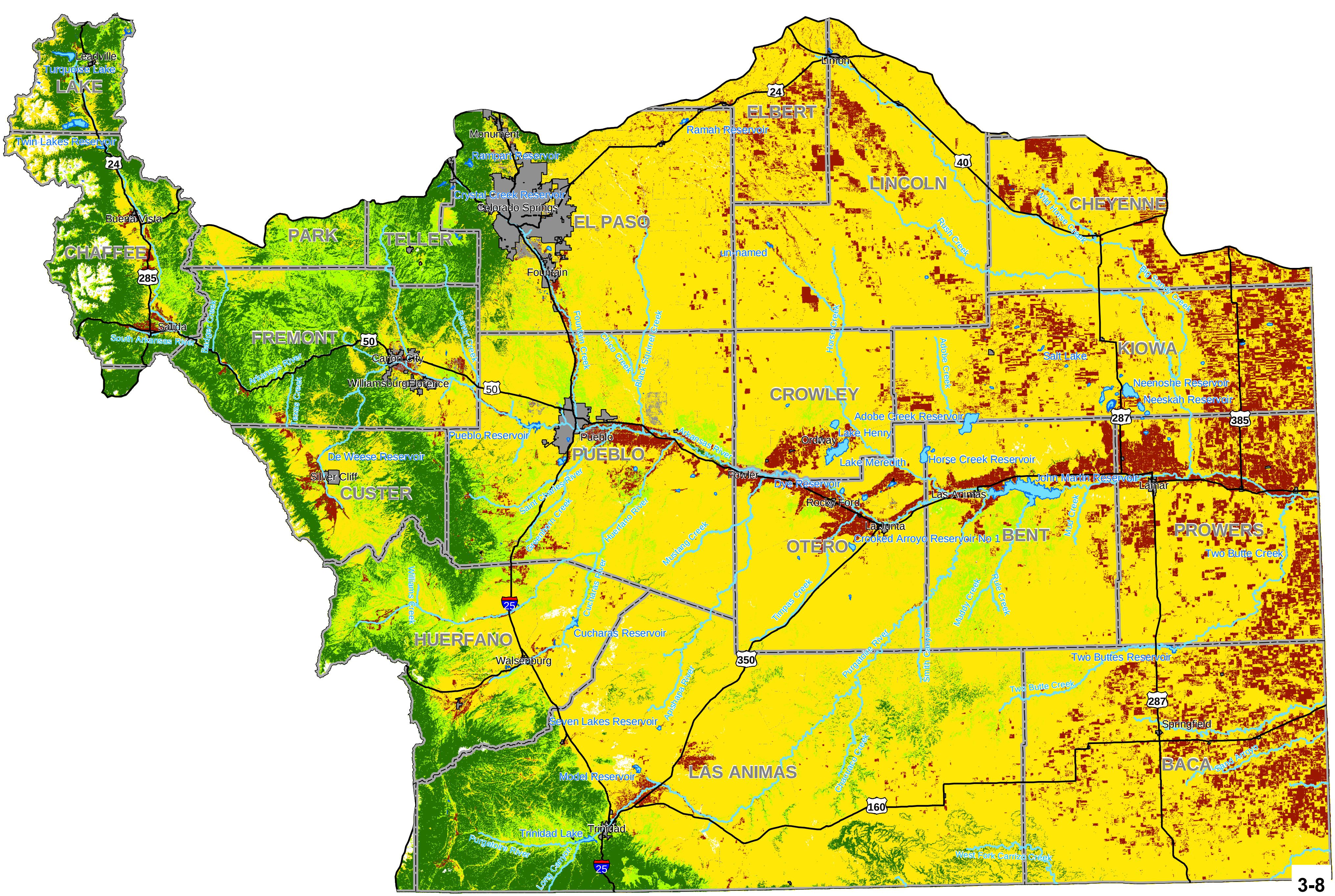


Figure 3-4
Arkansas Basin
Land Use

Streams
Lakes and Reservoirs
Highways
Counties

Municipalities

Land Cover
- Open Water
- Developed
- Barren
- Forest
- Shrubland
- Orchards/Vinyards
- Grassland
- Planted/Cultivated
- Wetland

10 5 0 10 Miles
1:1,500,000

N
Coordinate System
NAD 1927 UTM Zone 13N

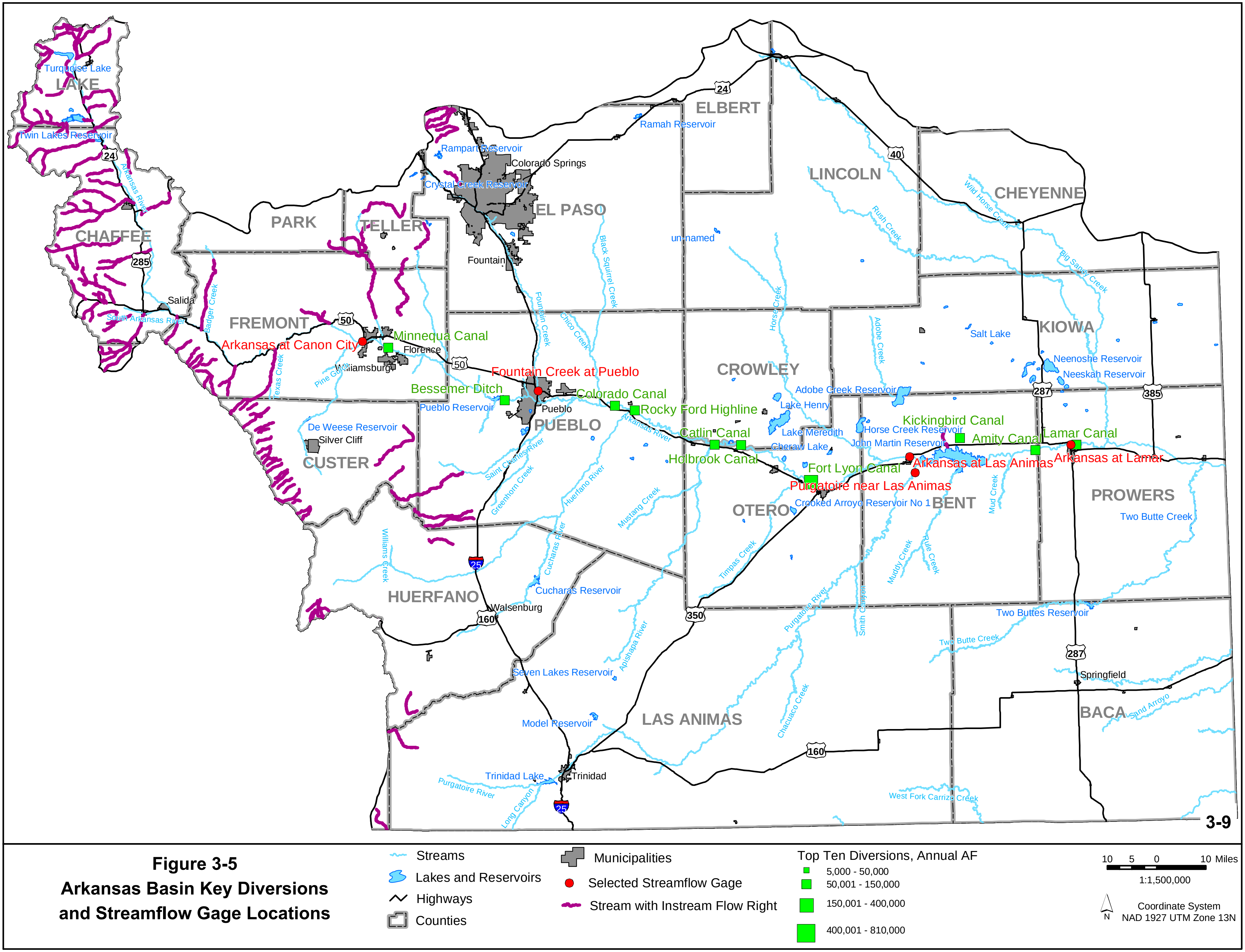


Figure 3-5
Arkansas Basin Key Diversions and Streamflow Gage Locations

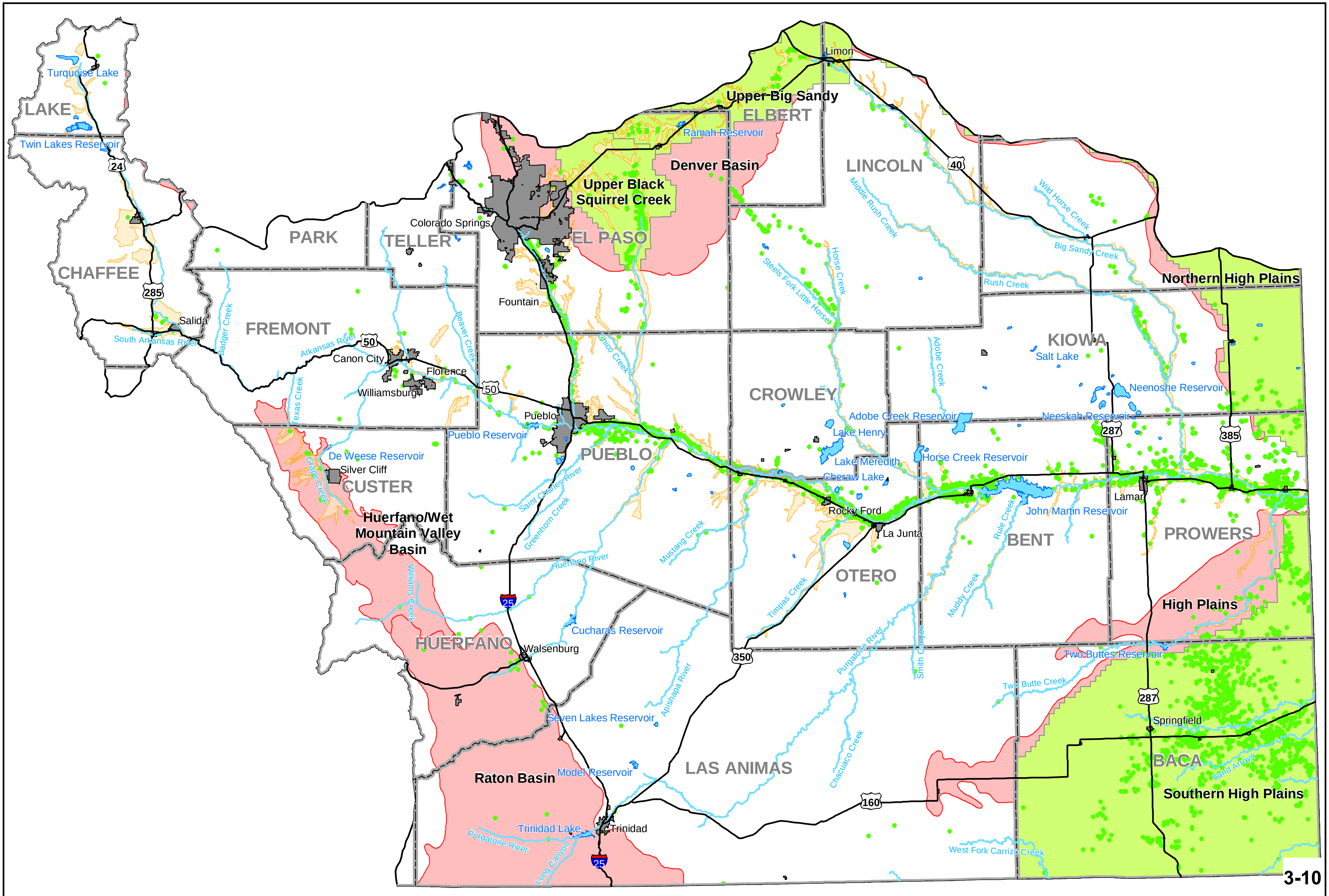


Figure 3-6
Arkansas Basin
Wells and Aquifers

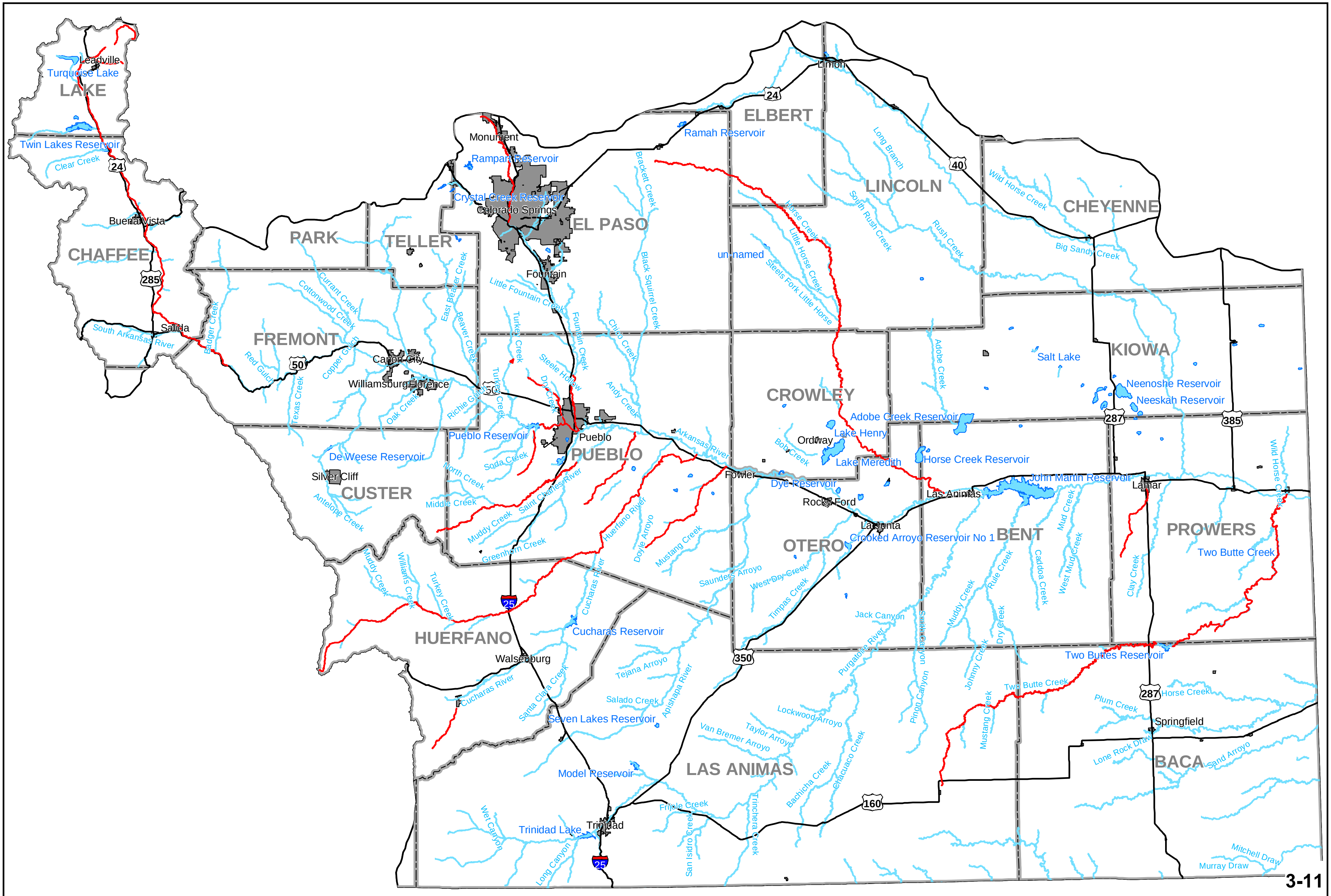


Figure 3-7
Arkansas Basin
303 (d)-Listed Streams

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
303d Streams
303d Lakes

10 5 0 10 Miles
1:1,500,000
N
Coordinate System
NAD 1927 UTM Zone 13N

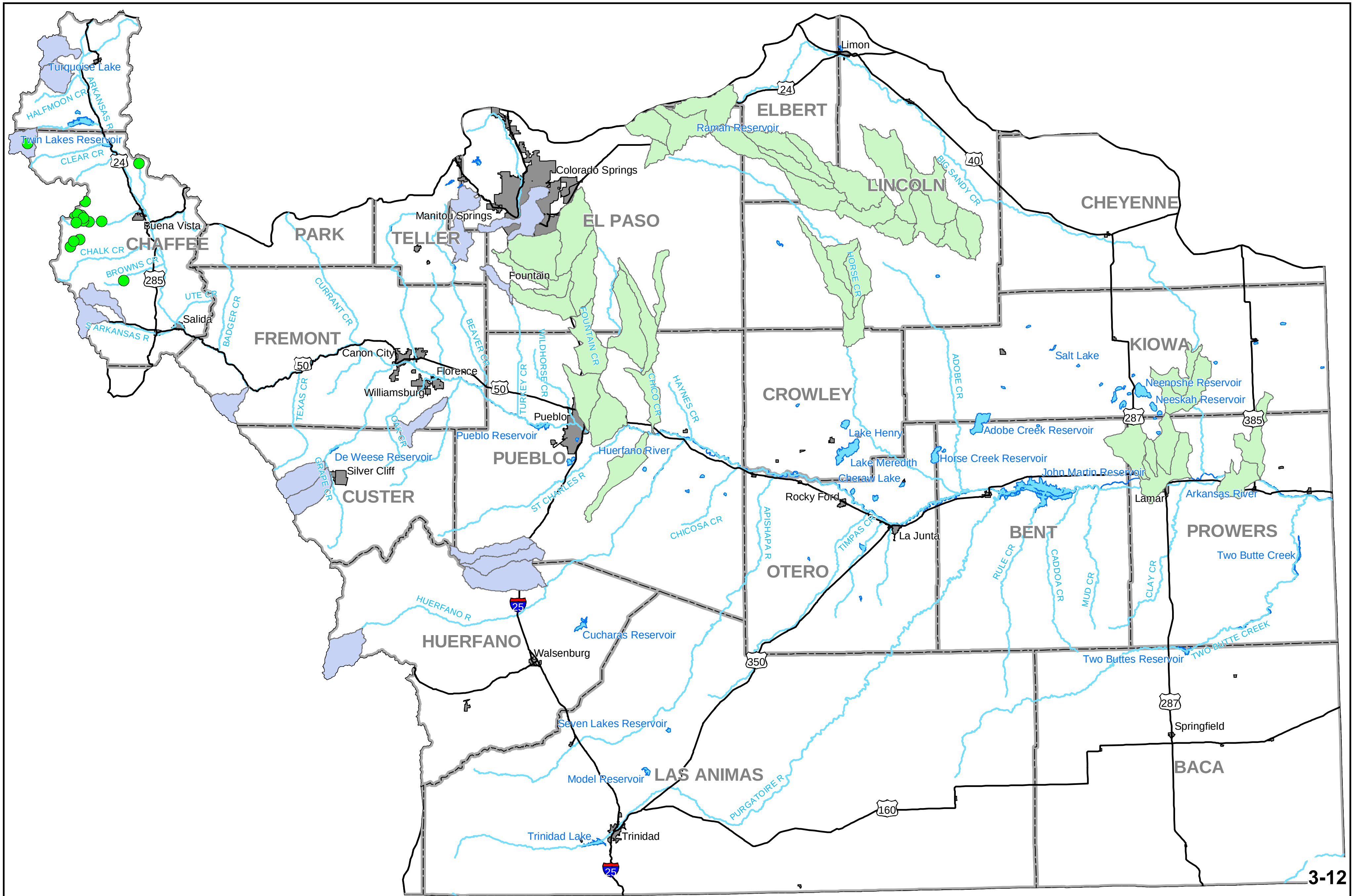


Figure 3-8
Arkansas Basin
Areas of Environmental Concern

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Boreal Toad Critical Habitat
Federal Candidate Species - Arkansas Darter
Greenback Cutthroat Trout Areas

The Arkansas River Basin does not contain any Federally Listed Critical Habitat Streams, or Gold Medal Trout Streams

10 5 0 10 Miles
1:1,499,601

N
Coordinate System
NAD 1927 UTM Zone 13N

data source: Colorado Division of Wildlife

3.3 Colorado Basin

3.3.1 Colorado Basin Geography

The Colorado Basin, as depicted in Figure 3-9, encompasses approximately 9,830 square miles (Crifasi 2000; CGS 2003). The largest cities in the basin are Grand Junction (population 45,669) and Glenwood Springs (population 8,301) (DOLA 2002).

3.3.2 Colorado Basin Climate

Because of large changes in altitude, the climate in the basin varies dramatically from alpine conditions in the east to semiarid in the west (Benci and McKee 1977; USGS 1994). Figure 3-10 shows a contour plot of the average annual precipitation throughout the basin. Average annual precipitation ranges from less than 10 inches per year in the Grand Valley to greater than 45 inches per year in the high mountains (mainly winter and early spring snowfall) (Apodaca et al. 1996; CGS 2003).

3.3.3 Colorado Basin Topography

Elevations in the basin range from greater than 13,000 feet in the headwater areas to about 4,300 feet where the Colorado River exits the state (CGS 2003). The basin's mountainous headwaters areas gradually give way to a series of canyons and gentler terrain as the river follows the Interstate 70 corridor toward Grand Junction, the Grand Mesa, and the Utah border.

3.3.4 Colorado Basin Land Use

Land use in the Colorado Basin (USGS 1992) is shown in Figure 3-11 and Table 3-3. A substantial portion of the basin is comprised of federally owned land. Livestock grazing, recreation, and timber harvest are the predominant uses of federal lands. Active and inactive mines can be found in the basin. Coal mining occurs in the central portion of the Roaring Fork Valley and in the lower Colorado Valley (CDPHE 2002). Rangeland and forest are the predominant land uses in the Upper Colorado Basin (about 85 percent) (USGS 1994). Forested land is present throughout many parts of the basin.

Table 3-3 Land Cover Data for the Colorado Basin

	Basinwide		Statewide	
Land Cover	Area (sq. miles)	Percent of Total	Area (sq. miles)	Percent of Total
Forest	5,569	56.7%	29,577	28.4%
Shrubland	2,237	22.8%	16,883	16.2%
Grassland	1,301	13.2%	41,051	39.5%
Planted/ Cultivated	325	3.3%	13,737	13.2%
Barren	224	2.3%	1,219	1.2%
Open Water	114	1.2%	590	0.6%
Developed	54	0.6%	923	0.9%
Orchards/ Vineyards	5	0.05%	5	0.00%
Wetland	1	0.01%	80	0.08%
TOTAL	**9,830**		**104,060**	

Source: USGS 1992 NLCD

3.3.5 Colorado Basin Surface Geology

The underlying bedrock in the Colorado Basin area consists predominantly of crystalline and sedimentary rocks. Alluvium, consisting of stream, landslide, terrace, and glacial deposits, is present in valleys throughout the basin (Apodaca et al. 1996).

3.3.6 Colorado Basin Surface Water

The headwaters of the mainstem of the Colorado River are within Rocky Mountain National Park in eastern Grand County. The Colorado River flows southwest approximately 230 miles through Grand, Eagle, Garfield, and Mesa Counties and exits the state at the Utah border. Tributaries of the Colorado, including the Fraser, Blue, Eagle, and Roaring Fork Rivers (Figure 3-9) also drain Summit and Pitkin Counties as well as portions of Routt, Gunnison, and Rio Blanco Counties.

The Colorado River accounts for approximately 44 percent of the streamflow leaving the state (Colorado SEO 2003). Interstate compacts with other Colorado basin states limit development of the basin yield. Between 450,000 and 600,000 AF is diverted to Eastern Colorado annually.

Numerous USGS streamflow gages are maintained in the Colorado Basin. Six of these gages were selected to summarize historic flows in the basin across a broad spatial scale. The locations of these gages are shown on Figure 3-12 along with the location of major diversions and segments with decreed instream flow rights in the basin. Table 3-4 summarizes the mean annual streamflow, period of record, and drainage area for each gage. As the table indicates, an average of about 4.5 million AF of water leaves the state annually via the Colorado River at the state line.

3.3.7 Colorado Basin Groundwater

Most of the water used within the Colorado Basin comes from surface water sources. Annual groundwater withdrawal data from 1995 indicate groundwater use by the counties encompassing the river basin varies from less than 1 percent in Grand and Mesa Counties to a maximum of 9 percent in Summit County (Solley et al. 1998). Because of the shallow well depths and water levels, alluvial groundwater is readily developed in rural areas for agricultural and domestic purposes. Aquifers located within the Colorado Basin are as follows (CGS 2003):

- Alluvial Aquifer
- Piceance Basin
- Eagle Basin
- Dakota-Cheyenne
- Middle Park Basin

Figure 3-13 presents the aquifers broken down into two groups: alluvial and bedrock (Piceance Basin, Eagle Basin, Dakota-Cheyenne, and Middle Park Basin). The distribution of alluvial deposits in the Colorado Basin varies greatly from one reach to the next. The alluvial deposits, as mapped by USGS geologic quadrangle maps, are primarily located near the Towns of Eagle and Gypsum, along the Roaring Fork River, Roan Creek, and from the Town of Palisade to the Colorado-Utah state line. Alluvium is very limited or non-existent in the canyon sections of the Colorado River where the bedrock is exposed (CGS 2003). The saturated thickness of the alluvium in the basin is represented by the interval from the water table to the underlying bedrock. Welder (1987) reported that test holes in the alluvium of Roan and Parachute Creeks penetrated 80 feet and 70 feet, respectively, of saturated permeable sand and gravel. For the Fraser River, Apodaca and Bails (1999) report alluvial saturated thickness ranging from 14 to 45 feet, averaging 21 feet in the spring, and ranging from 7 to 20 feet in the fall with an average of 15 feet. Private wells used for domestic and agricultural irrigation uses are common throughout the watershed (Colorado Groundwater Association 1999). Major production wells (those with rights that exceed 500 gpm) are also shown in Figure 3-13.

3.3.8 Colorado Basin Water Quality

Upper Colorado River watershed water quality issues largely are related to impacts due to growth, mining, and the protection of threatened and endangered fish species. Growth related water quality issues are becoming increasingly important as the population continues to grow at rates among the highest in Colorado. Sediment and nutrient loading to streams in the watershed have the potential to create significant water quality problems. These loadings are caused primarily by runoff from construction activities at new subdivisions, commercial centers, roads, ski area expansions, and naturally erosive soils (CDPHE 2002).

Salinity has long been recognized as one of the major issues on the Colorado River. The salt loads in the river system originate primarily from easily eroded saline-rich sedimentary rocks that are extensive in the lower basin. The Colorado River Basin Salinity Control Program is designed to prevent a portion of this salt supply from moving into the river system (Colorado River Basin Salinity Control Forum 2002).

Table 3-4 Summary of Selected USGS Stream Gages for the Colorado Basin

Site Name	USGS Site Number	Mean Annual Streamflow (AFY)	Mean Annual Streamflow (cfs)	Period of Record (Years)	Drainage (sq. miles)
Blue River below Green Mountain Reservoir	09057500	328,785	454	1942-2002	599
Eagle River below Gypsum	09070000	412,586	570	1946-2002	944
Roaring Fork at Glenwood Springs	09085000	877,836	1,213	1906-2002	1,451
Plateau Creek near Cameo	09105000	128,999	178	1936-2002	592
Colorado River near Kremmling	09058000	733,654	1,013	1962-2002	2,382
Colorado River near State Line	09163500	4,555,526	6,292	1913-2002	17,843

Source: USGS NWIS web/HydroBase database

Nearly half of the salinity in the Colorado River System is from natural sources. Saline springs, erosion of saline geologic formations, and runoff all contribute to this background salinity. Irrigation, reservoir evaporation, out-of-basin exports, and M&I sources make up the balance of the salinity loading in the Colorado Basin. Estimated salt sources and percentages for the mainstem and waters tributary to the Colorado River at Hoover Dam have been estimated as follows (EPA 1971):

- Natural – 47 percent
- M&I and out-of-basin exports – 4 percent
- Reservoir evaporation – 12 percent
- Irrigated agriculture – 37 percent

Another water quality issue that has historically been the center of attention is metals pollution attributed to a Superfund site and inactive mining areas. The Eagle River is impacted by metals pollution from the Eagle Mine Superfund site near Gilman, although remediation has significantly decreased metal loads to the Eagle River and Cross Creek over the last several years. Peru Creek, the upper Snake River, and French Gulch in Summit County are all heavily impacted by acid mine drainage from abandoned or inactive mines (CDPHE 2002).

Agricultural activities also affect water quality in the Colorado Basin. Nutrients derived from fertilizers can indirectly cause detrimental effects on aquatic fauna by overstimulating the growth of various algal species. Pesticides are commonly used in agricultural areas in the Upper Colorado Basin and its major tributaries, which can cause damaging effects on the biota because of acute or chronic toxic exposure. Studies conducted on the water quality of irrigation return flows in the Upper Colorado Basin have indicated adverse effects on biota from pesticides and selenium, a naturally occurring element in the soil (Apodaca et al. 1996).

Figure 3-14 identifies the locations of surface waters in the Colorado Basin that have been listed for impairment for one or more parameters on Colorado's 2002 303(d) list. Stream segments proposed for listing via the 2004 303(d) list and the accompanying Monitoring and Evaluation list are described in Colorado WQCC Regulations 93 and 94. The state's 2004 proposed 303(d) list incorporates several additions from the 2002 list. It includes significant numbers of mainstem and tributary stream segments as being impaired for selenium, largely in the lower portions of the basin. The 2004 proposed listings for impairment in the upper part of the basin are primarily associated with metals such as copper, cadmium, lead, and zinc.

The water quality of streams can also be affected when interbasin water transfers decrease the dilution capability of the streams by removing water from the system. Interbasin water transfers generally occur near the stream headwaters, and the amount of streamflow diverted can be a substantial part of the streamflow near these sources. The numerous reservoirs, water diversions, and municipal discharges in the basin alter the natural streamflow, which can affect the aquatic habitat and water quality of the streams (Apodaca et al. 1996).

3.3.9 Colorado Basin Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species

The 15-Mile Reach, the stretch of the Colorado River from the Grand Valley Diversion Dam near Palisade to the Gunnison River, is an area of environmental concern in the Colorado Basin. The 15-Mile Reach is of concern for the following reasons:

- The 15-Mile Reach provides valuable spawning habitat for the endangered Colorado pikeminnow and razorback sucker fish species.
- The 15-Mile Reach provides an optimum balance between temperature and food availability for adult Colorado pike minnow in the Colorado River.
- The 15-Mile Reach provides an important refuge for endangered fishes should a catastrophic event cause a loss of population in the Gunnison River or in the Colorado River below the Gunnison River confluence (USFWS 1999).

Several regulations and operating plans have been developed to maintain adequate water supply for the 15-Mile Reach, as discussed in Section 6.

In addition to impaired areas, threatened and endangered species and areas of high environmental or recreational value require special attention when evaluating water supply projects and use patterns in the basin.

Areas in the Colorado Basin with high-quality aquatic habitat have been awarded the Gold Medal designation. The reaches in the Colorado Basin include:

- Blue River from Dillon Reservoir Dam downstream to the Colorado River (34 miles)
- Gore Creek from Red Sandstone Creek downstream to the Eagle River (4 miles)
- Colorado River from Windy Gap to Troublesome Creek, 3 miles east of Kremmling (20 miles)
- Fryingpan River from Ruedi Reservoir Dam downstream to the Roaring Fork River (14 miles)
- Roaring Fork River from the Crystal River downstream to the Colorado River (12 miles)

Figure 3-15 shows the locations of some of the basin's key aquatic species habitat.

Other areas of high recreational value in the basin, including Green Mountain Reservoir, Lake Granby, Rocky Mountain National Park, and Indian Peaks Wilderness area, are discussed in Section 6.

3.3.10 Colorado Basin Energy and Mineral Resources

Metal mining is an important economic activity in the headwater areas of the Colorado Basin. Past and present mining activities have included the extraction of metals such as copper, gold, lead, molybdenum, nickel, silver, vanadium, and zinc (USGS 1994). In addition, there is the potential for production of synthetic fuels in the Upper Colorado River and its tributaries by the extraction and processing of oil shale and/or coal, which would require significant quantities of water. A synfuels production level of 3 million barrels per day (oil equivalent) could consume about 450,000 AF of water annually (U.S. Water Resources Council 1981).

Xcel Energy owns and operates the Shoshone hydroelectric power plant in Glenwood Canyon 10 miles upstream of Glenwood Springs. The power plant has a 1,250 cubic foot per second (cfs) water right that was adjudicated on December 9, 1907, and an additional water right of 158 cfs decreed on February 7, 1956 (ENARTECH 1995). The capacity of the power plant is 14,400 kilowatts (KW).

Under present water rights administration, junior upstream water rights can be placed on call by the Shoshone Demand whenever the flow of the Colorado River at the power plant is less than 1,408 cfs. During most years, the Shoshone rights place a call on the river from mid-August through mid-April of the following year. In dry years, the call is initiated earlier and may begin in early June. A water right call originating from the Shoshone Demand can affect a significant number of water users located upstream of this demand. Areas subject to a Shoshone call include the Eagle River Basin and all other areas upstream of Dotsero (ENARTECH 1995).

In addition to the Shoshone plant, the City of Aspen is licensed by the Federal Energy Regulatory Commission (FERC) to operate a hydropower facility at Ruedi Dam and Reservoir. The FERC license recognizes that Aspen's hydropower production objectives are subordinate to other uses but allows Aspen to generate electricity with any flows resulting from operation of the reservoir (Finding of No Significant Impact [FONSI] No. EC-1300-02-03).

Hydropower facilities are also located on Green Mountain Reservoir and Williams Fork Reservoir. Green Mountain Reservoir has a capacity of 154,645 AF. There are two generating units at the Green Mountain Power Plant, capable of producing 21,600 KW (http://www.ncwcd.org). The Williams Fork Dam & Power Plant sends water and electricity to the Western Slope when Denver diverts water to the city elsewhere. Standing 217 feet above the Williams Fork River streambed, the dam backs up a reservoir of nearly 97,000 AF of water, and the power plant's capacity is 3,158 KW (http://www.denverwater.org).

The Piceance Basin holds vast quantities of natural gas in the seams of its coal formations, representing one of the largest natural gas reserves in the United States. Extraction of CBM involves removal of groundwater to release the gas; this water is typically either discharged to the surface or reinjected.

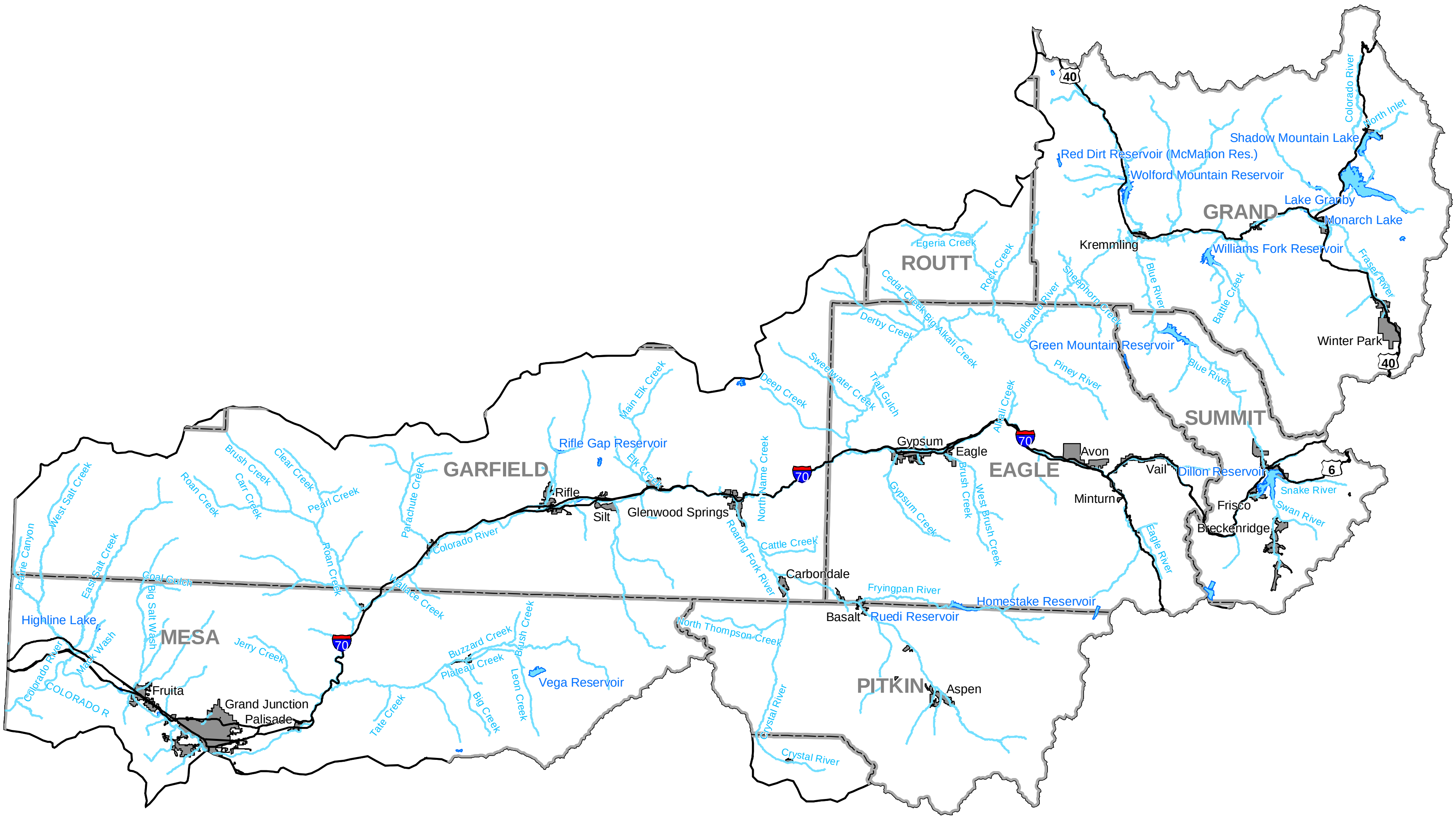


Figure 3-9
Colorado Basin
Physical Setting

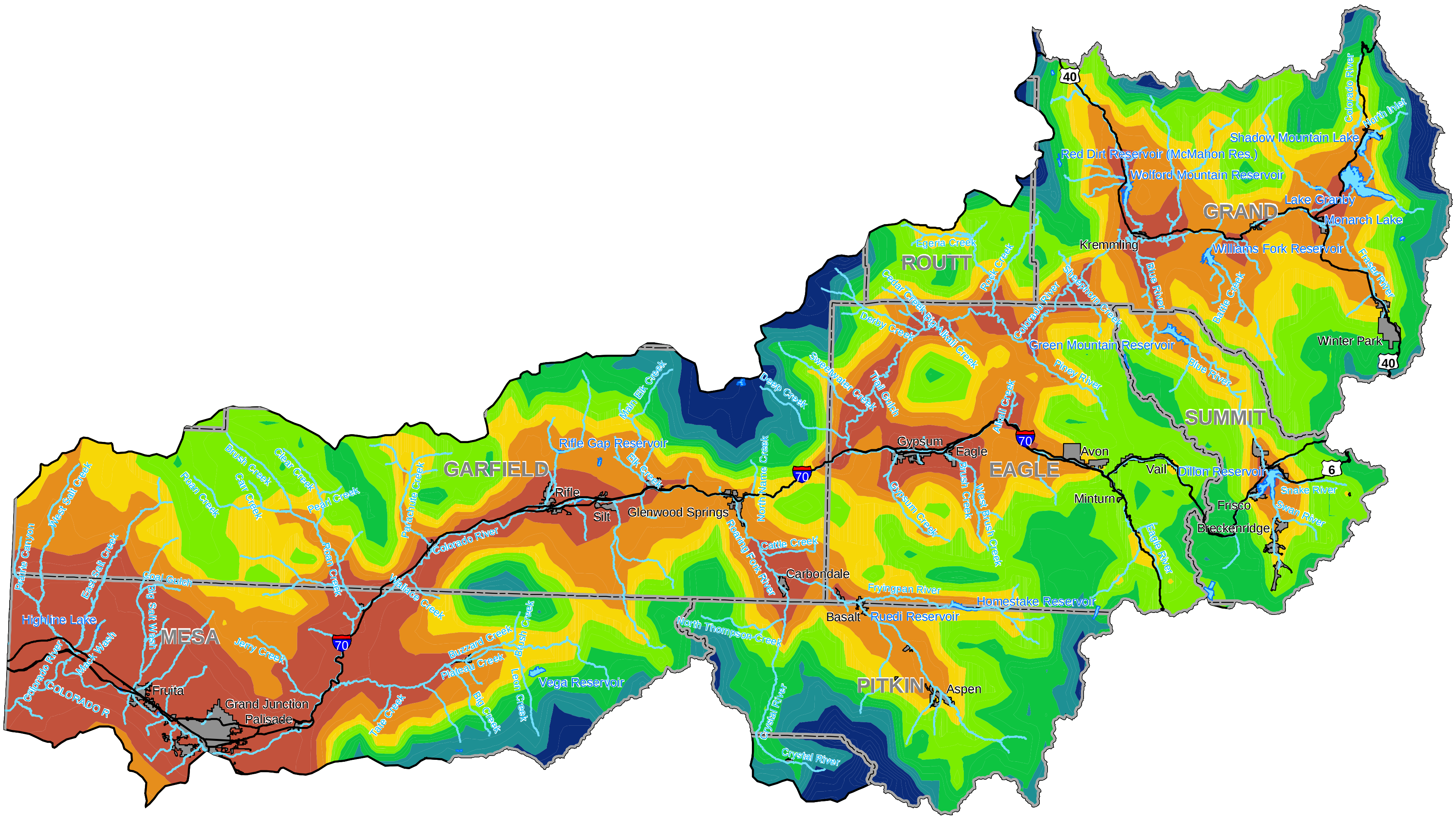


Figure 3-10
Colorado Basin
Mean Annual Precipitation

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

Mean Annual Precipitation, Inches

- 7.0 - 13.0
- 13.1 - 17.0
- 17.1 - 21.0
- 21.1 - 27.0
- 27.1 - 33.0
- 33.1 - 39.0
- 39.1 - 63.0

10 5 0 10 Miles

1:1,200,000

N

Coordinate System
NAD 1927 UTM Zone 13N

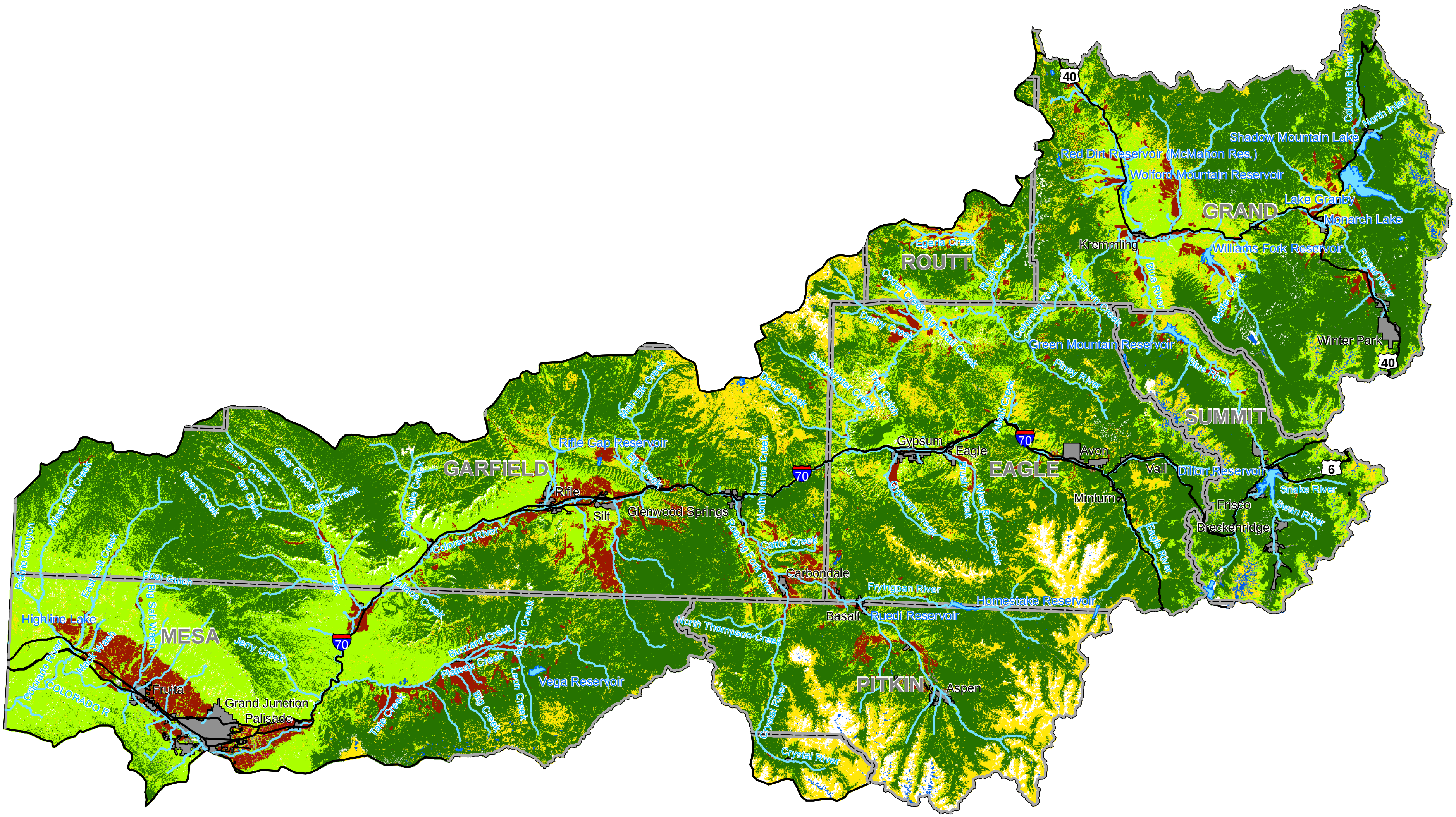
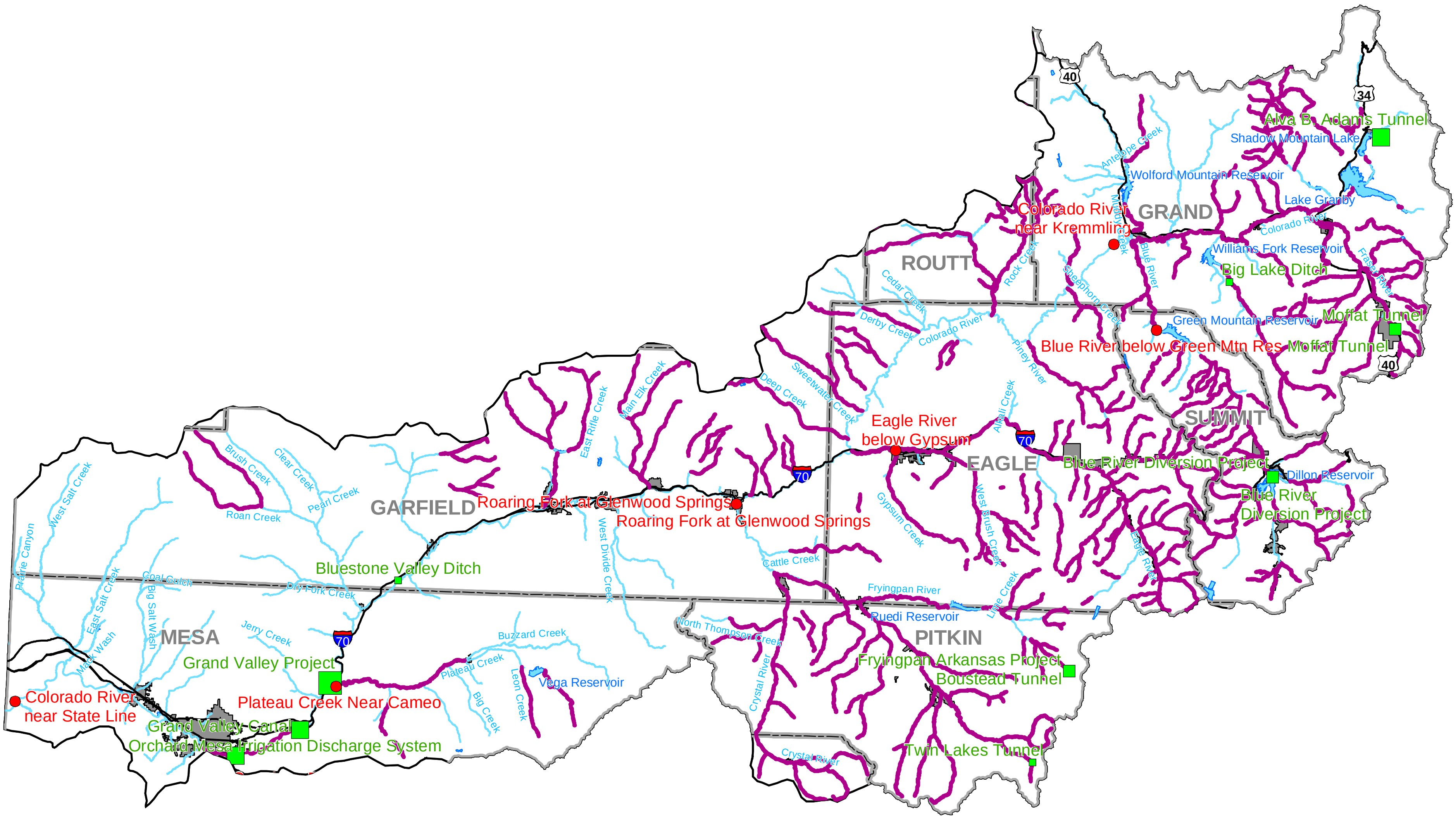


Figure 3-11
Colorado Basin
Land Use



3-20

Figure 3-12
Colorado Basin Key Diversions and Streamflow Gage Locations

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Selected Streamflow Gage
Stream with Instream Flow Right

Top Ten Diversions, Annual AF
5,000 - 50,000
50,001 - 150,000
150,001 - 400,000
400,001 - 810,000

10 5 0 10 Miles
1:1,200,000
N
Coordinate System
NAD 1927 UTM Zone 13N

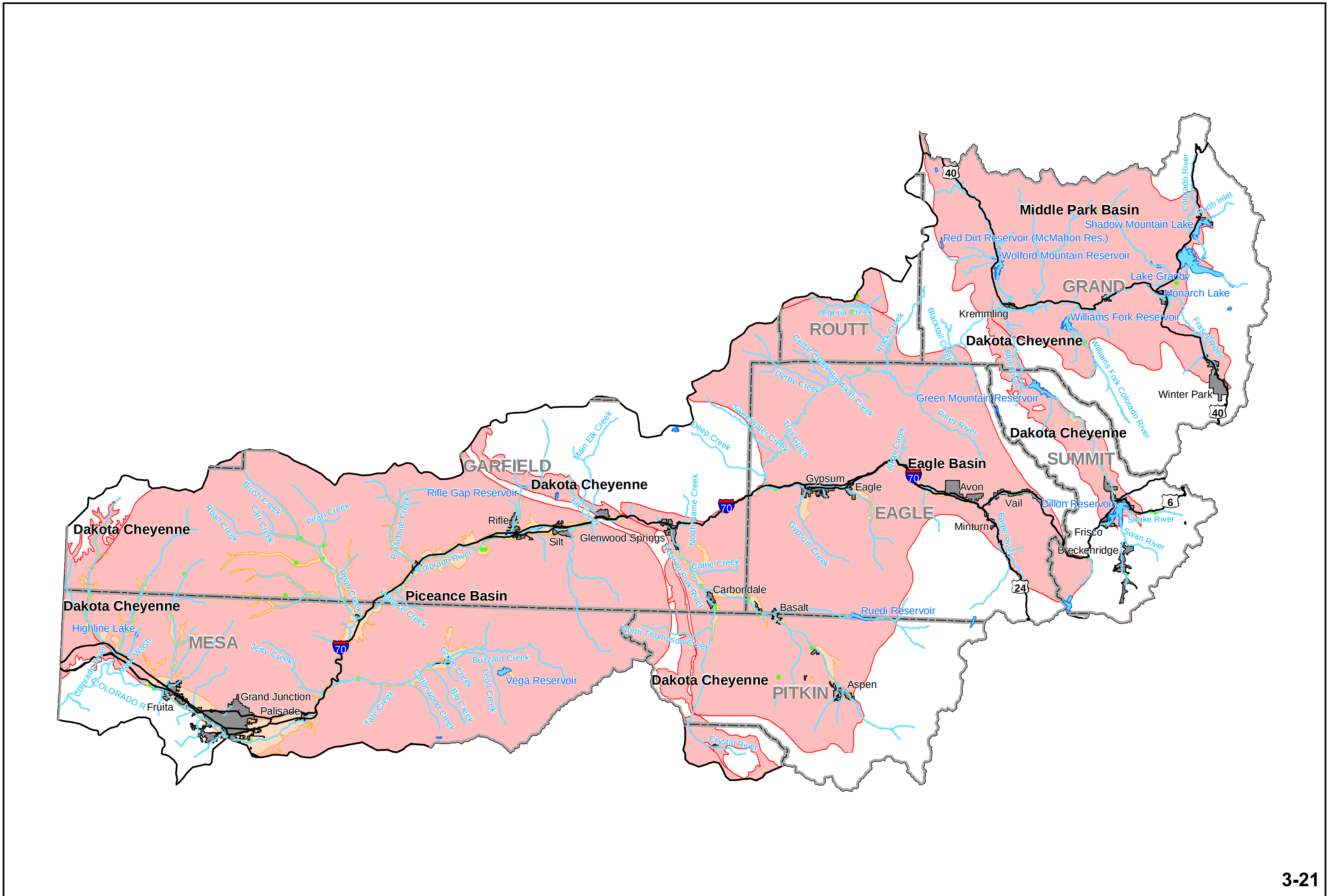


Figure 3-13
Colorado Basin
Wells and Aquifers

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Wells (Permitted/Decreed Yields >= 500 GPM)
Alluvial Aquifer
Bedrock Aquifer

10 5 0 10 Miles
1:1,200,000
N
Coordinate System
NAD 1927 UTM Zone 13N

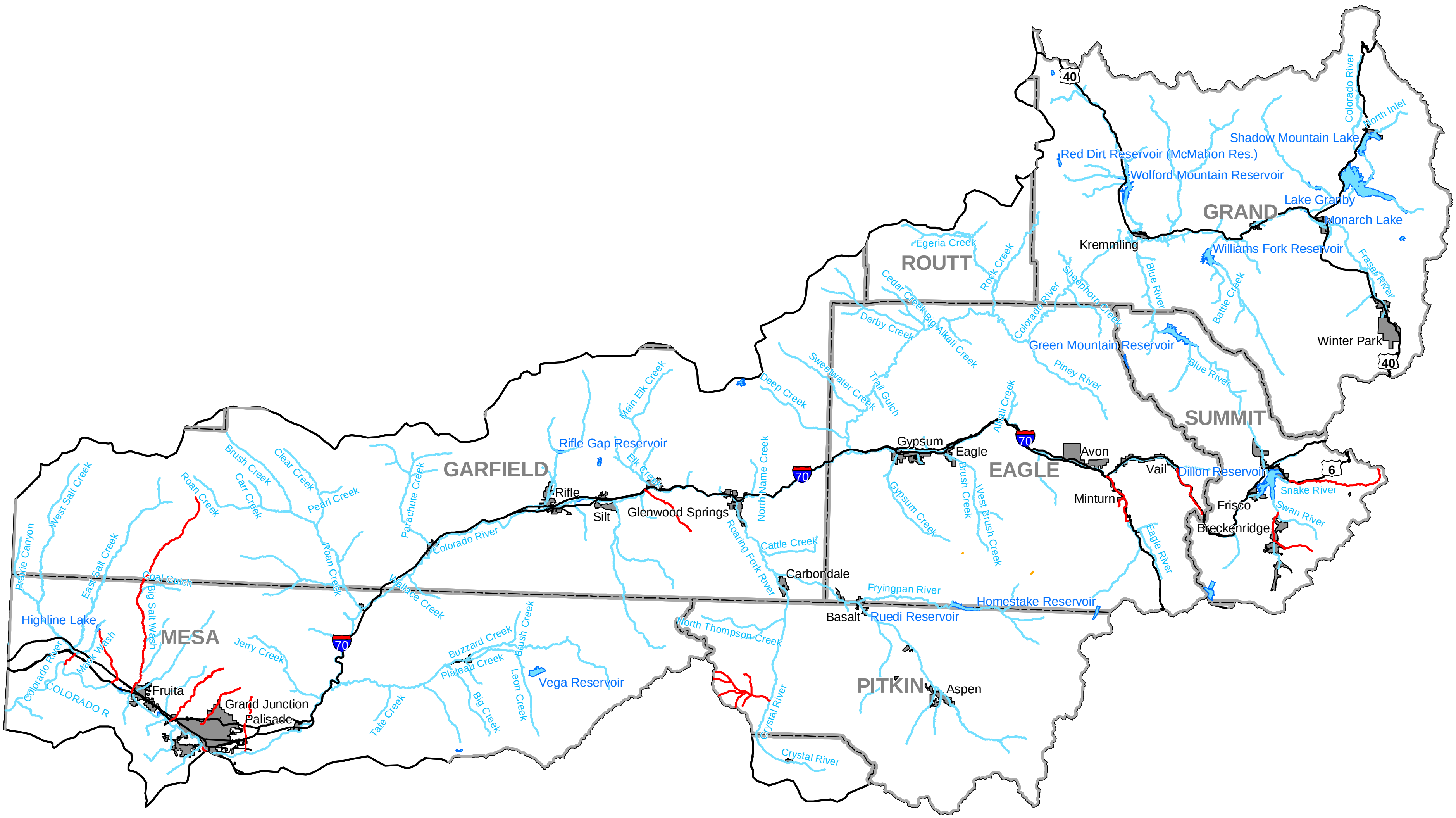
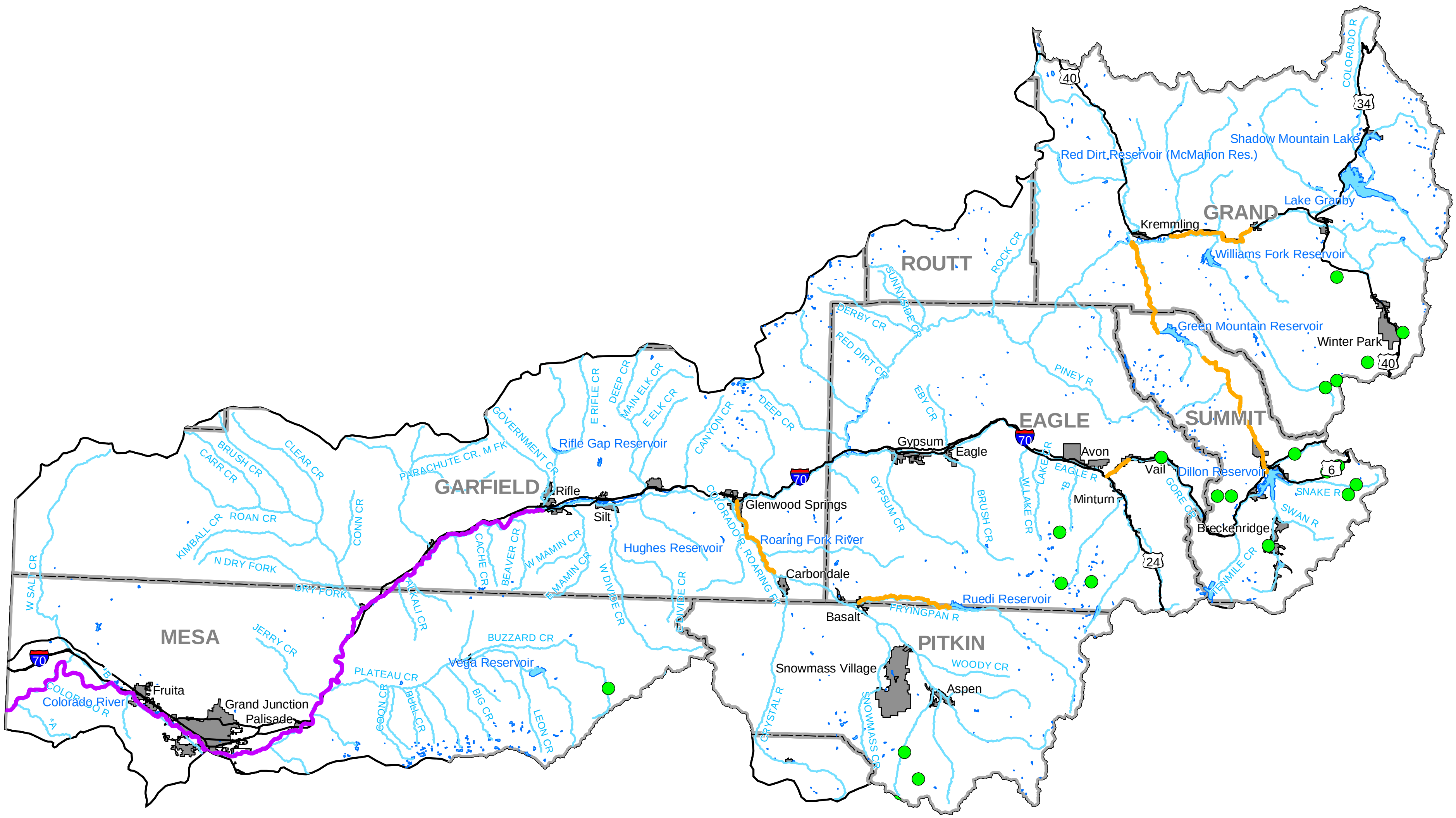


Figure 3-14
Colorado Basin
303(d)-Listed Streams

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
303d Streams
303d Lakes

10 5 0 10 Miles
1:1,200,000

N
Coordinate System
NAD 1927 UTM Zone 13N



3-23

Figure 3-15
Colorado Basin
Areas of Environmental Concern

data source: Colorado Division of Wildlife

- Streams
- Lakes and Reservoirs
- Highways
- Counties
- Municipalities
- Boreal Toad Critical Habitat
- Federally Listed Critical Habitat
- Gold Medal Trout Stream

The Colorado River Basin does not contain any Greenback Cutthroat Trout Areas,or Arkansas Darter Areas

9 4.5 0 9 Miles

1:1,200,000

N

Coordinate System
NAD 1927 UTM Zone 13N

3.4 Dolores/San Juan/ San Miguel Basin

3.4.1 Dolores/San Juan/San Miguel Basin Geography

The Dolores/San Juan/San Miguel Basin is located in the southwest corner of Colorado as shown in Figure 3-16. It covers an area of approximately 10,169 square miles. The largest cities within the basin are Durango (population 15,213) and Cortez (population 8,238) (DOLA 2003). The Upper San Juan River and its tributaries also flow through two Native American reservations in the southern portion of the basin:

- Ute Mountain Ute Reservation
- Southern Ute Indian Reservation

3.4.2 Dolores/San Juan/San Miguel Basin Climate

The Dolores/San Juan/San Miguel Basin is in the semi-arid high desert, which is typified by fairly cold winters, dry springs, late summer monsoons, and pleasant autumns. Temperatures in Pagosa Springs range from -3 to 82°F. Precipitation occurs mostly in the form of rain during localized but intense summer thunderstorms and snowfall in the mountains. Average annual precipitation ranges from greater than 40 inches per year in the San Juan Mountains to less than 13 inches per year near the Colorado-Utah state line (CGS 2003). Figure 3-17 shows color-fill contours of the average annual precipitation.

3.4.3 Dolores/San Juan/San Miguel Basin Topography

Elevations in the San Juan River system range from greater than 14,000 feet in headwater areas of the Animas and Los Piños Rivers down to 4,500 feet, where the Mancos River exits the state just east of the Four Corners. The San Juan Basin is characterized by rugged terrain, including mesas, terraces, escarpments, canyons, dry washes (arroyos), and mountains. Elevations in the Dolores Basin range from about 14,200 feet near the Dolores River headwaters, to 4,100 feet at its confluence with the Colorado River in Utah. The terrain of the Dolores Basin consists of high plateaus with deeply incised canyons and dry arroyos (CGS 2003).

3.4.4 Dolores/San Juan/San Miguel Basin Land Use

Land use in the region is highly variable and often reflects a conflict between historic and modern uses. Agriculture and ranching predominate in the lower elevations of Dolores, San Miguel, and Montrose Counties as they have for many generations. Tourism and recreation have become more prevalent in the region as the Animas, Piedra, Dolores, and San Miguel Rivers offer both fishing and rafting opportunities (CGS 2003). Montezuma and La Plata Counties are dominated by agriculture, grassland, and forested land use types. Figure 3-18 shows land cover by category for the Dolores/San Juan/San Miguel Basin (USGS 1992). Table 3-5 is a summary of the data shown in Figure 3-18 and indicates that over three-quarters of the basin consists of forest and shrubland. These areas are prevalent throughout the basin.

Table 3-5 Land Cover Data for the Dolores/San Juan/San Miguel Basin

Land Cover	Basinwide Area (sq. miles)	Basinwide Percent of Total	Statewide Area (sq. miles)	Statewide Percent of Total
Forest	5,122	50.4%	29,577	28.4%
Shrubland	3,192	31.4%	16,883	16.2%
Grassland	1,118	11.0%	41,051	39.5%
Planted/ Cultivated	496	4.9%	13,737	13.2%
Barren	192	1.9%	1,219	1.2%
Open Water	32	0.3%	590	0.6%
Developed	16	0.2%	923	0.9%
Wetland	1	0.01%	80	0.08%
TOTAL	**10,169**		**104,067**	

Source: USGS 1992 NLCD

3.4.5 Dolores/San Juan/San Miguel Basin Surface Geology

Outwash terrace deposits are present along most of the San Juan River tributaries as a result of glaciation of the upper valleys. The deposits do not typically exceed 30 feet in thickness (Stone et al. 1983; CGS 2003). Historic and current mining activity is prevalent in upper basin mountains. The sedimentary rocks in the region include pockets of coal, oil, and uranium. Historically, the area was also mined for gold, silver, and copper.

3.4.6 Dolores/San Juan/San Miguel Basin Surface Water

The flow of the San Juan River is generally to the west, flowing into the Colorado River in southeast Utah. The Dolores River flows to the west and northwest, joining the Colorado River in eastern Utah. Major tributaries to the San Juan River include the Piedra, Los Piños, Animas, Florida, La Plata, and Mancos Rivers and McElmo Creek, shown in Figure 3-16. The San Miguel River, downstream of McPhee Reservoir, is the major tributary to the Dolores River. An average of 2.3 million AF leaves the state via the rivers of the Dolores and the San Juan Basins each year, which represents around 20 percent of the total water flow out of Colorado (Wolfe 2003).

Examples of mean annual streamflow, length of record, and the drainage area of the stream at five USGS gages are presented in Table 3-6. The locations of these gages are shown in Figure 3-19.

3.4.7 Dolores/San Juan/San Miguel Basin Groundwater

Most of the water used within the basin comes from surface water sources. Aquifers located within the Dolores/San Juan/San Miguel Basin are as follows (CGS 2003):

- Alluvial Aquifer
- Paradox Basin
- San Juan Basin

The location of the aquifers and production wells with permitted or decreed capacities that exceed 500 gpm are shown in Figure 3-20. The bedrock aquifer includes the Paradox Basin and San Juan Basin.

The Dolores/San Juan/San Miguel Basin contains numerous aquifers throughout its stratigraphic sequence. Significant aquifers in the Colorado portion of the Dolores/San Juan/San Miguel Basin include the Quaternary alluvium, Tertiary Animas Formation, Cretaceous Mesa Verde Group and Dakota Sandstone, and sandstones of the Jurassic Morrison Formation. As compared to other regions in the State of Colorado, there is relatively little groundwater use in the Dolores/San Juan/San Miguel Basin (CGS 2003).

Most municipalities obtain their water from surface water sources in this area. The small town of Ophir, however, utilizes a groundwater supply. Many homeowners associations and campgrounds also use groundwater as their primary supply (EPA 2001; CGS 2003). Domestic water supply is the primary use of groundwater in San Miguel and Dolores Counties, whereas agriculture is the primary use of groundwater in Montrose and Mesa Counties.

3.4.8 Dolores/San Juan/San Miguel Basin Water Quality

The Dolores/San Juan/San Miguel Basin generally has high quality surface water except in the headwaters of the Animas River near Silverton and the Dolores River near Rico. In these two areas, historic mining operations have been the cause of high metal loads accumulating in the headwaters. Local efforts are being made to mitigate this problem. Another area of concern for the Dolores Basin is the accumulation of salt from the Paradox Valley (CDPHE 2002).

Table 3-6 Summary of Selected USGS Stream Gages for the Dolores/San Juan/San Miguel River Basin

Site Name	USGS Site Number	Mean Annual Streamflow (AFY)	Mean Annual Streamflow (cfs)	Period of Record (Years)	Drainage (sq. miles)
Animas River at Durango	09361500	566,571	783	1887-2002	692
San Juan River near Carracas	09346400	457,983	633	1961-2002	1,230
Los Pinos River at La Boca	09354500	173,947	240	1951-2002	520
McElmo Creek near Colorado-Utah State Line	09372000	37,647	52	1951-2002	346
Dolores River near Bedrock	09171100	299,576	414	1971-2002	2,145

Source: USGS NWISweb/HydroBase database

The Dolores River picks up an estimated 205,000 tons of salt annually as it crosses the Paradox Valley. The BOR's Paradox Unit is designed to prevent this natural salt load from entering the Dolores River and degrading the water quality of the mainstem of the Colorado River. The Paradox Valley Unit is located near Bedrock, Colorado, about 10 miles east of the Colorado-Utah state line and about halfway between Grand Junction and Cortez, Colorado. The unit intercepts the brine groundwater before it enters the river and disposes of the brine by deep well injection. (www.usbr.gov/dataweb/html/paradox). The Towaoc/Highline Canal of the Dolores Project was also designed to aid in the control of water salinity.

The Upper Animas River watershed has a history of extensive mining activities. Placer gold deposits were discovered in 1871 on Arrastra Creek above Silverton by prospectors following the occurrence of gold upstream. Following the signing of a treaty with the Ute Indians in 1873, between 1,000 and 1,500 mining claims were staked in the Animas River watershed upstream from Silverton (USGS 2000). Surface waters leach metals into the Animas River including aluminum, cadmium, copper, iron, manganese, and zinc from abandoned mines (BLM 2002). The Animas River Stakeholders Group was formed to improve water quality and aquatic habitat in the Animas River.

Figure 3-21 identifies the locations of surface waters in the Dolores/San Juan/San Miguel Basin that have been listed for impairment for one or more parameters on Colorado's 2002 303(d) list. Stream segments proposed for listing via the 2004 303(d) list and the accompanying Monitoring and Evaluation list are described in Colorado WQCC Regulations 93 and 94. The state's 2004 proposed 303(d) list includes McPhee and Narraguinnep Reservoirs (mercury) and segments that include portions of Silver Creek (cadmium, copper, and zinc) and the East Mancos River (copper). Portions of the San Miguel River, Ingram Creek, and Marshall Creek are proposed to be listed for zinc.

3.4.9 Dolores/San Juan/San Miguel Basin Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species

Endangered species and archaeological resources are two key areas of concern for water development in the San Juan and the Dolores Basins.

The San Juan River Basin Recovery Implementation Program (SJRBRIP) was initiated in 1992 with the following two goals (USFWS 1995):

- To conserve populations of the Colorado pikeminnow and razorback sucker in the basin
- To proceed with water development in the basin in compliance with federal and state laws, interstate compacts, Supreme Court decrees, and federal trust responsibilities to the Southern Utes, Ute Mountain Utes, Jicarillas, and the Navajos

Ongoing and proposed activities under the SJRBRIP include re-regulation of flows from Navajo Dam to better meet species needs, control of nonnative fishes, propagation and introduction of target species, and identification and removal of fish-passage barriers (USFWS 1995).

Federal agencies participating include the USFWS, BOR, BLM, and Bureau of Indian Affairs. The States of Utah, Colorado, and New Mexico are also participating. Other participants include the Navajo Nation, Southern Ute Indian Tribe, Ute Mountain Ute Tribe, Jicarilla Apache Tribe, and non-Federal water development interests (USGS 1991).

There are numerous and significant archaeological sites located in the southwestern corner of the Dolores and San Juan Basins. Ancient Puebloan ancestors occupied the area from approximately A.D. 1 to A.D. 1300 and left remarkable remains, thereby creating an important historic preservation region, including Mesa Verde National Park, the Ute Mountain Ute Tribal Park, Chimney Rock, and a portion of Hovenweep National Monument. The presence of the archaeological resources may require mitigation efforts in the development of water resources within the basins.

In addition to impaired areas, threatened and endangered species and areas of high environmental or recreational value require special attention when evaluating water supply projects in the Dolores/San Juan/San Miguel Basin. For a complete list of federal and/or state listed threatened and endangered fish and other species in the Dolores/San Juan/San Miguel Basin, see Appendix C.

A portion of the Animas River south of Durango has been awarded the Gold Medal designation, as indicated in Figure 3-22. Figure 3-22 shows the locations of some of the basin's key aquatic species habitat.

Areas of high recreational value in the basin, including numerous reaches for whitewater rafting, are discussed in Section 6.

3.4.10 Dolores/San Juan/San Miguel Basin Energy and Mineral Resources

Mining and energy resources have played a major role in the development of the region. Natural gas and oil have been extracted from deep wells within the Dolores/San Juan/San Miguel Basin for years, and a recent interest in CBM gas has resulted in a new energy boom in the region (CGS 2003). The Late Cretaceous Fruitland Formation of the San Juan Basin of Colorado and New Mexico contains more than 200 billion tons of coal from which over 2 trillion cubic feet of methane and 246 million barrels of water have been produced (Wray 2000).

Gold and silver mining began in the San Juan Mountains in the 1870s and peaked in activity between 1905 and 1911. The area was heavily explored for uranium in the 1960s and 1970s and salt beds within the basin were considered as deep-disposal sites for radioactive wastes in the 1970s and 1980s. Both oil and gas development and hard rock mining have affected water quality in the region.

The Town of Pagosa Springs has developed a municipally operated geothermal heating system, which provides space heating to public buildings, school facilities, residences, and commercial establishments at a cost significantly lower than the cost of available conventional fuels. The geothermal aquifer supporting the Pagosa Springs system lies directly under the town. In addition to the geothermal use in Pagosa Springs, there are approximately 15 other geothermal springs located within the Dolores and San Juan Basins (http://waterknowledge, colostate.edu).

Within the Dolores and San Juan Basins, there are the following small hydroelectric power plants that generally serve localized areas:

- Towaoc Canal Power Plant (Dolores Project)
- McPhee Dam Power Plant (Dolores Project)
- Vallecito Power Plant (Pine River Project)
- Lemon Reservoir Dam Hydroelectric Power Plant (Florida Project)
- Jackson Gulch Project (Mancos Project)
- Tacoma Station (Cascade/Electra Lake Reservoir)

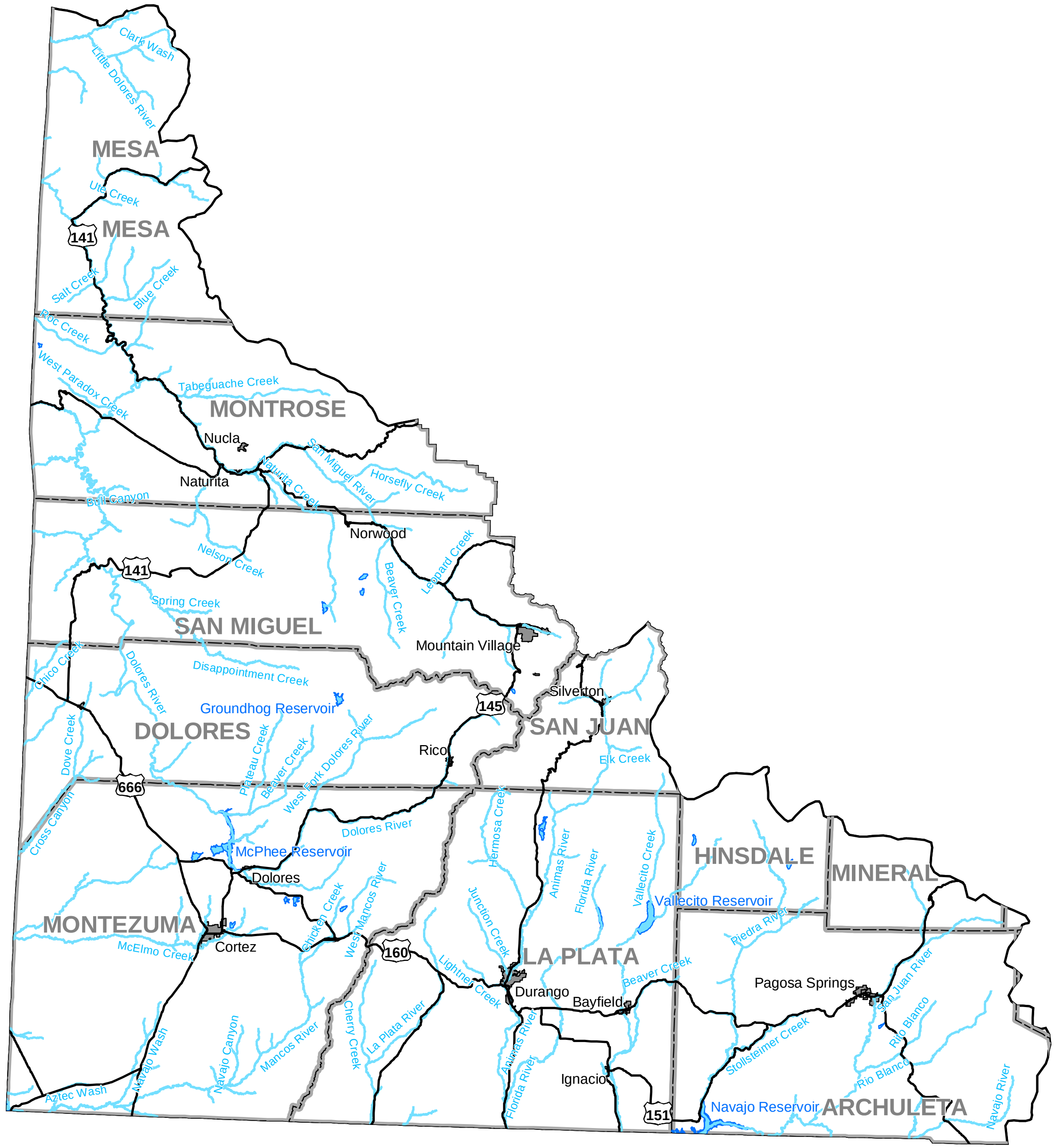


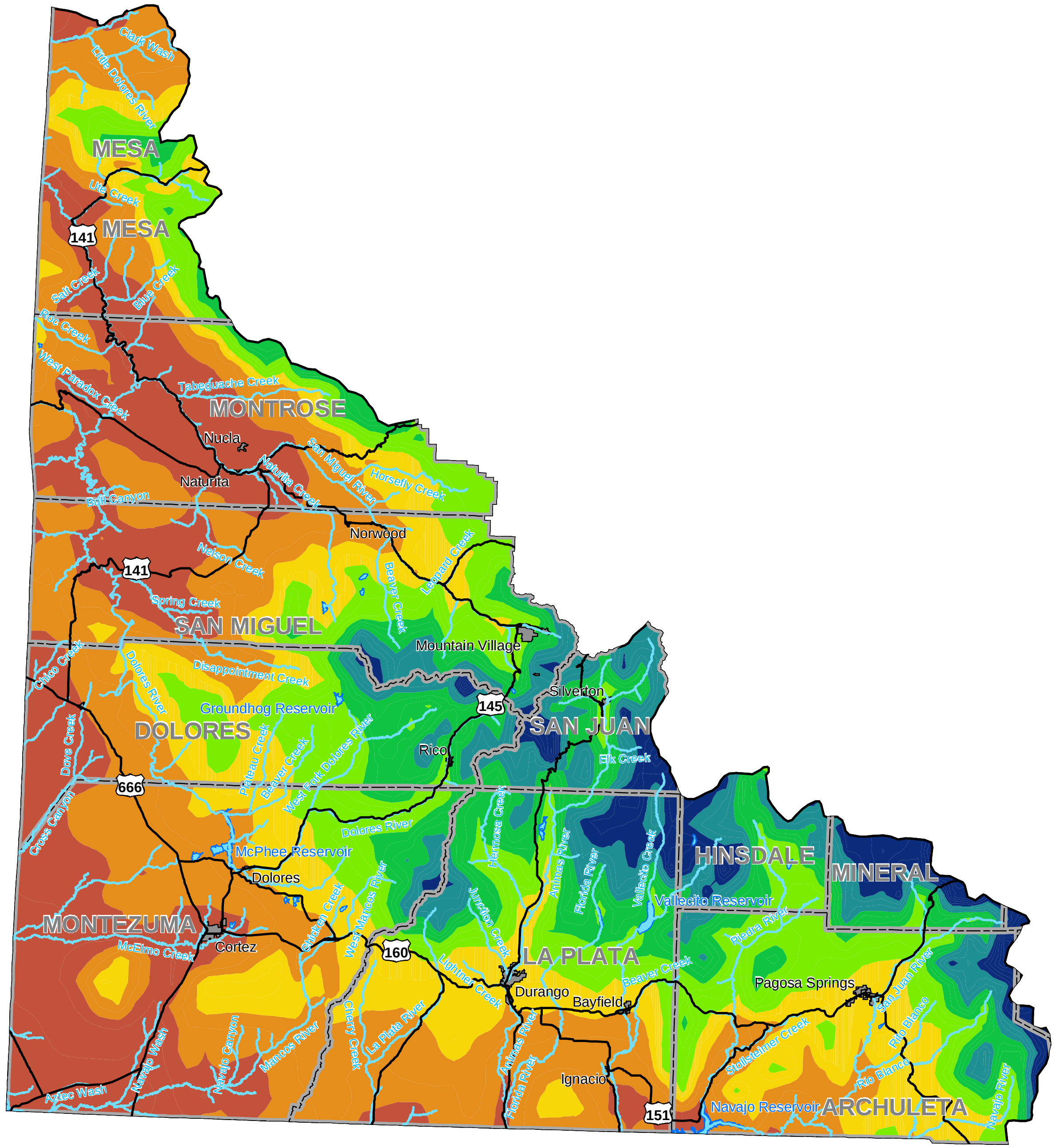
Figure 3-16
Dolores/San Juan/San Miguel Basin
Physical Setting

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

10 5 0 10 Miles
1:1,400,000

N

Coordinate System
NAD 1927 UTM Zone 13N



3-29

Figure 3-17
Dolores/San Juan/San Miguel Basin
Mean Annual Precipitation

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

Mean Annual Precipitation, Inches

7.0 - 13.0
13.1 - 17.0
17.1 - 21.0
21.1 - 27.0
27.1 - 33.0
33.1 - 39.0
39.1 - 63.0

10 5 0 10 Miles
1:1,400,000

N

Coordinate System
NAD 1927 UTM Zone 13N

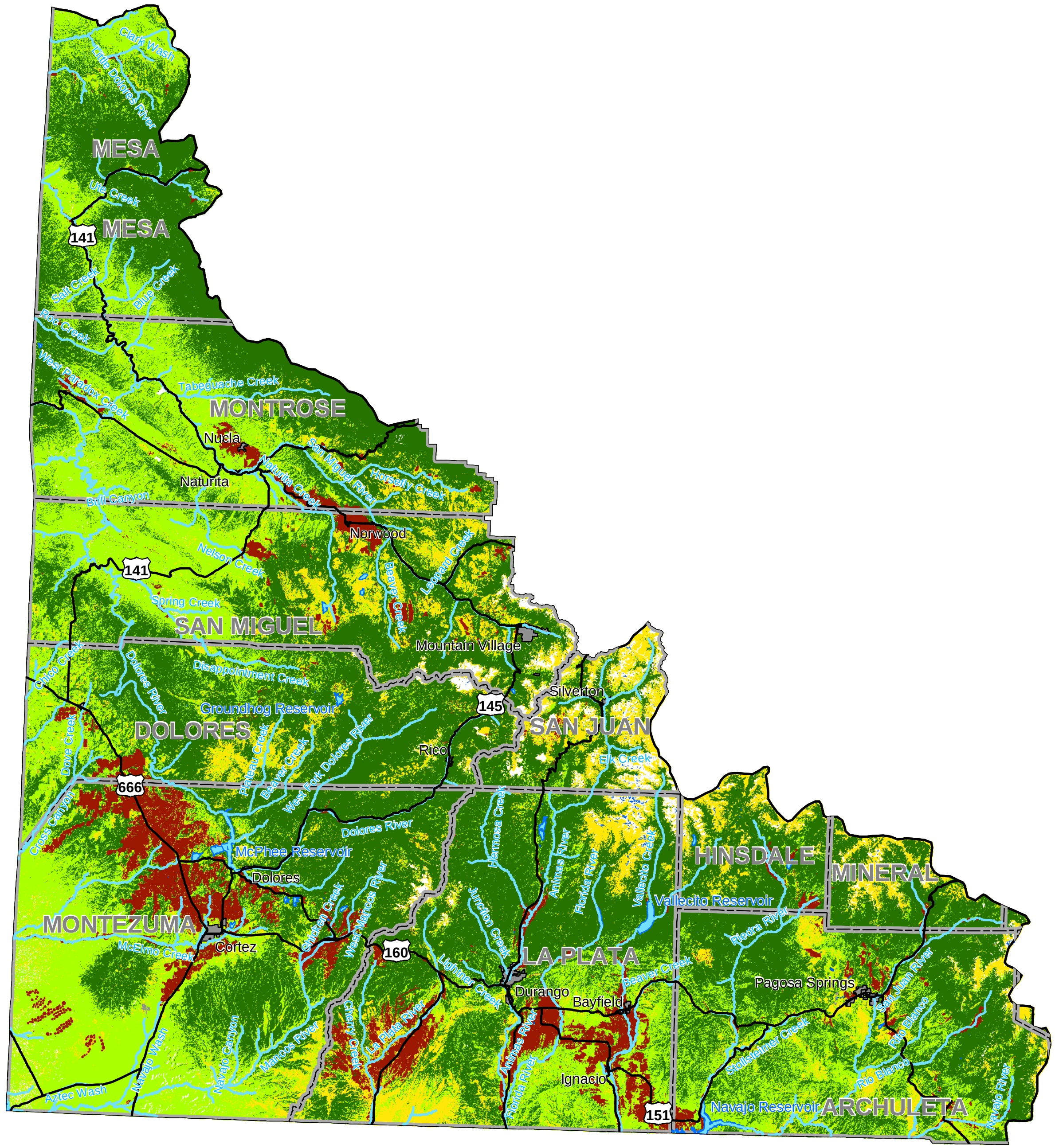


Figure 3-18
Dolores/San Juan/San Miguel Basin
Land Use

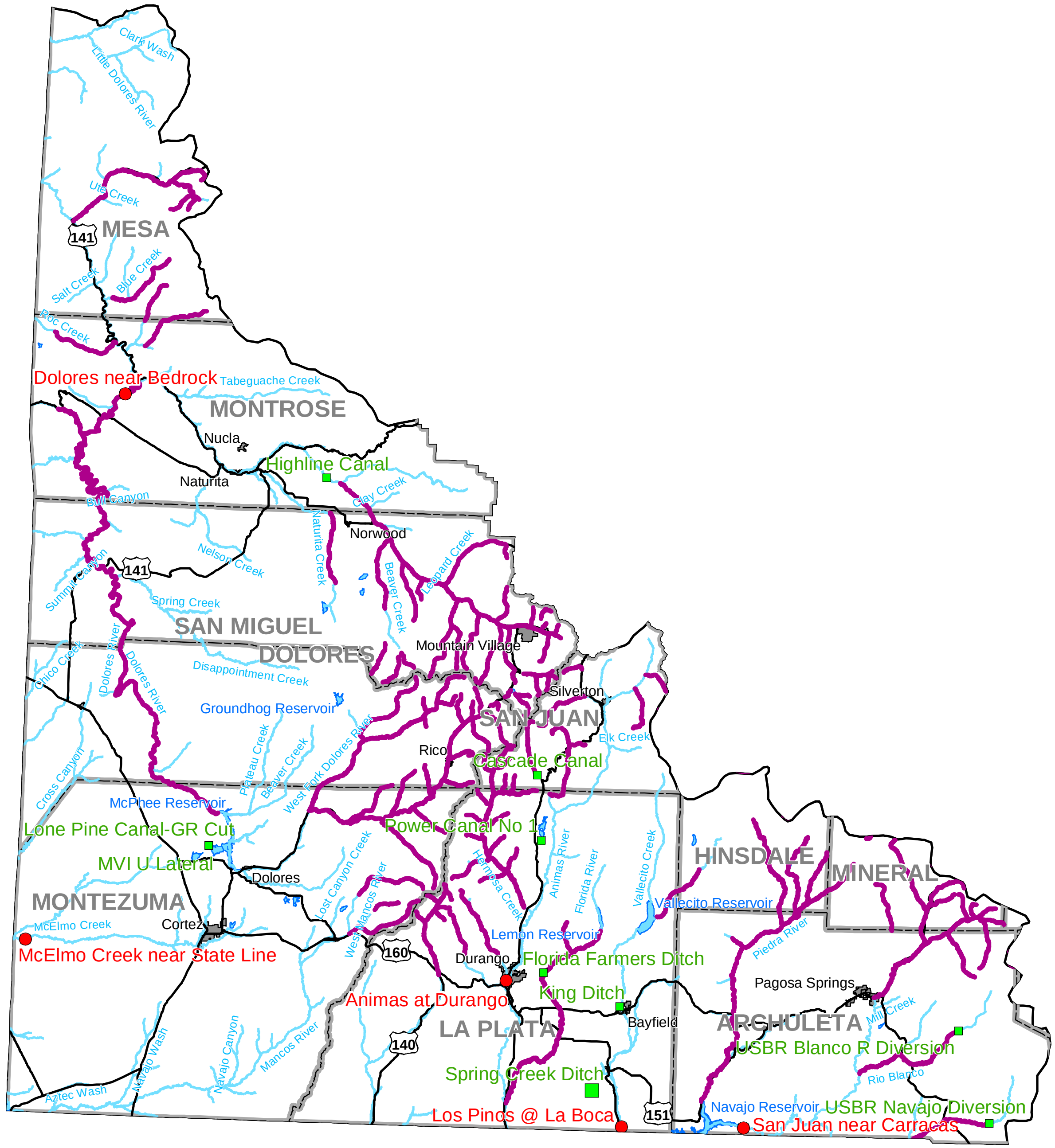


Figure 3-19
Dolores/San Juan/San Miguel Basin Key
Diversions and Streamflow Gage Locations

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Selected Streamflow Gage
Stream with Instream Flow Right

Top Ten Diversions, Annual AF
5,000 - 50,000
50,001 - 150,000
150,001 - 400,000
400,001 - 810,000

10 5 0 10 Miles
1:1,400,000
N
Coordinate System
NAD 1927 UTM Zone 13N

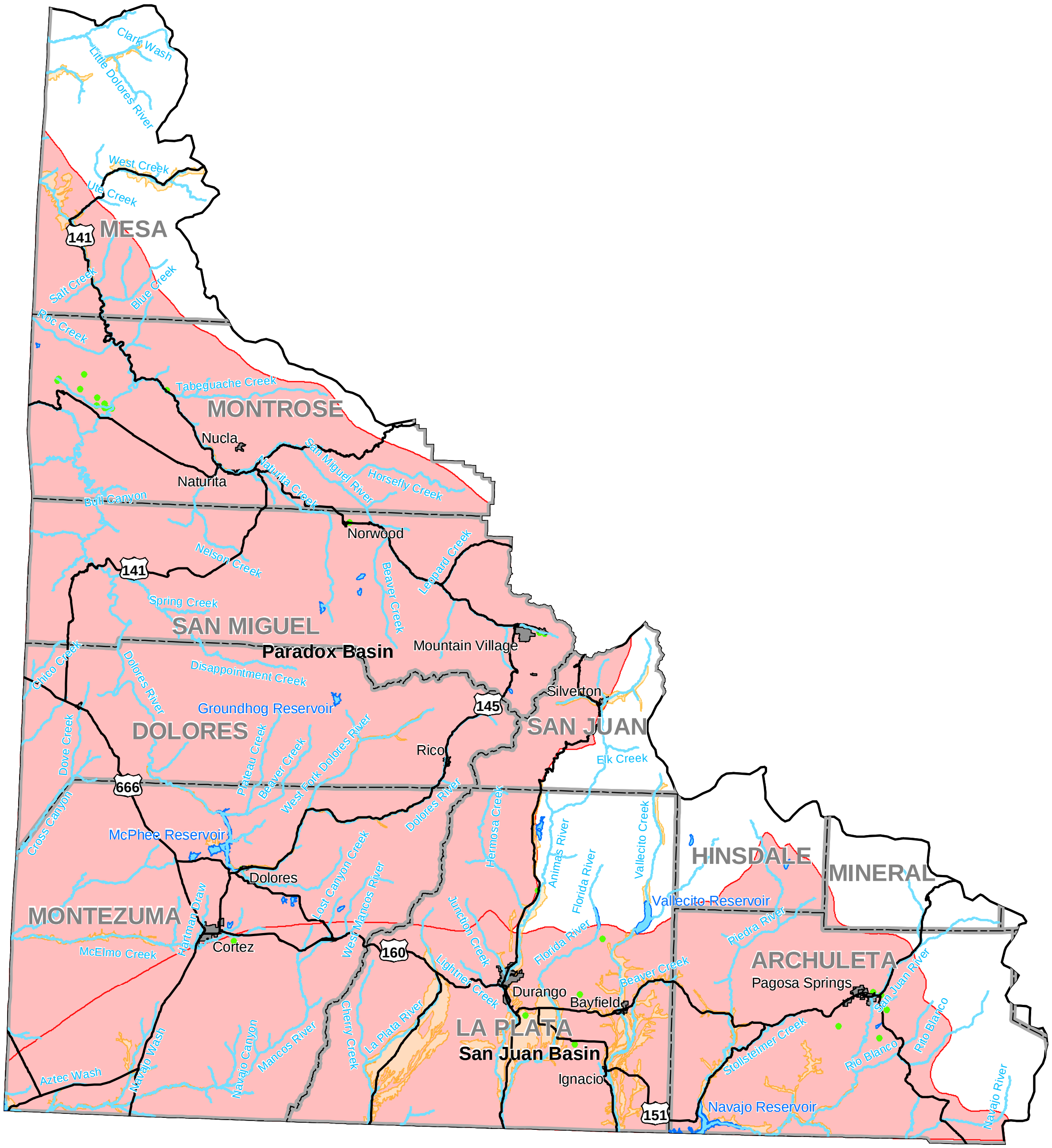


Figure 3-20
Dolores/San Juan/San Miguel Basin
Wells and Aquifers

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Wells (Permitted/Decreed Yields >= 500 GPM)
Alluvial Aquifer
Bedrock Aquifer

10 5 0 10 Miles
1:1,400,000

N
Coordinate System
NAD 1927 UTM Zone 13N

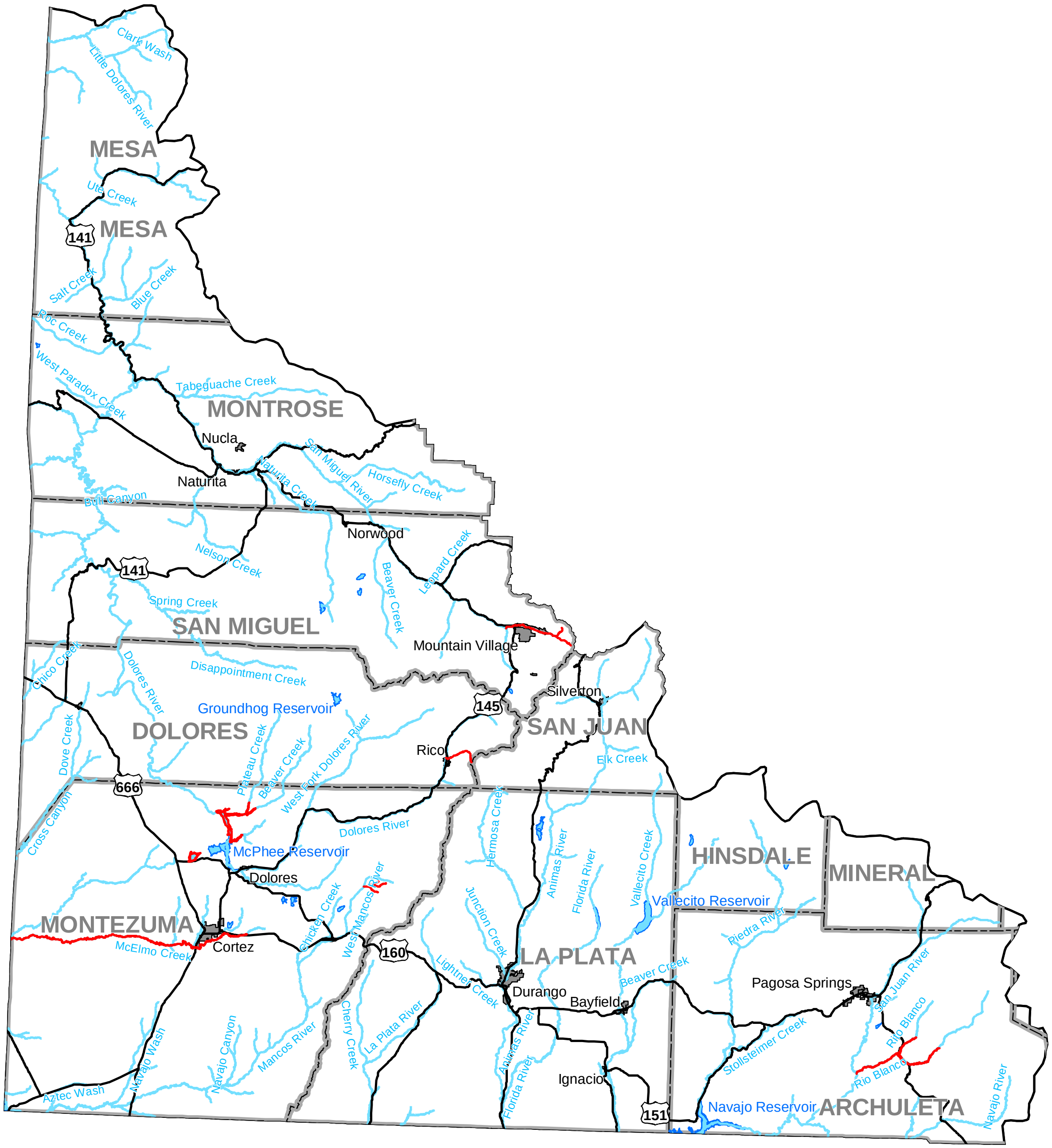


Figure 3-21
Dolores/San Juan/San Miguel Basin
303(d)-Listed Streams

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
303d Streams
303d Lakes

10 5 0 10 Miles
1:1,400,000

N
Coordinate System
NAD 1927 UTM Zone 13N

Figure 3-22
Dolores/San Juan/San Miguel Basin
Areas of Environmental Concern

- Streams
- Lakes and Reservoirs
- Highways
- Counties
- Municipalities
- Gold Medal Trout Stream

Data source: Colorado Division of Wildlife

The Dolores/San Juan/San Miguel River Basins do not contain any Boreal Toad Critical Habitat, Federally Listed Critical Habitat Streams, Greenback Cutthroat Trout Areas, or Arkansas Darter Areas

10 5 0 10 Miles
1:1,400,000

N
Coordinate System
NAD 1927 UTM Zone 13N

3.5 Gunnison Basin

3.5.1 Gunnison Basin Geography

The Gunnison Basin, Figure 3-23, stretches over 8,000 square miles of western Colorado, extending from the Continental Divide to the confluence of the Gunnison and Colorado Rivers near Grand Junction. The largest cities in the basin are Montrose (population 14,153), Delta (population 7,827), and Gunnison (population 5,271) (DOLA 2003).

3.5.2 Gunnison Basin Climate

Partly due to its topography, the upper Gunnison Basin experiences an unusual climate compared to other regions in Colorado. The winters are often extremely cold. On February 1, 1951, a temperature of 60°F below zero was observed and this is contrasted with summer temperatures that can occasionally exceed 100°F (CWCB and U.S. Bureau of Outdoor Recreation 1979). Average temperatures in the City of Gunnison range from 10°F in January to 61°F in July (http://www.weather.com). Annual precipitation averages greater than 40 inches in the high mountains and less than 10 inches in the lower Gunnison and Uncompahgre valleys (CGS 2003). Mean annual precipitation in the Gunnison Basin is shown in Figure 3-24.

3.5.3 Gunnison Basin Topography

The Gunnison Basin is defined by the Elk Range to the north, the Sawatch Range in the east, the San Juan mountains to the south, and the Uncompahgre Plateau to the southwest. Water traveling from the headwaters to Grand Junction encounters greater than 9,500 feet of elevation change.

3.5.4 Gunnison Basin Land Use

Land use in the Gunnison Basin is shown in Figure 3-25 and summarized in Table 3-7. The Gunnison Basin is largely forested. Forest area is distributed throughout the basin and covers approximately 52 percent of the total basin area. About 5.5 percent of the land in the basin is classified as Planted/Cultivated land and is concentrated in the Uncompahgre Valley between Montrose and Delta with additional concentrations near Gunnison and Hotchkiss (USGS 1992).

Table 3-7 Land Cover Data for the Gunnison River Basin

	Basinwide		Statewide	
Land Cover	Area (sq. miles)	Percent of Total	Area (sq. miles)	Percent of Total
Forest	4,212	52.5%	29,577	28.4%
Grassland	1,634	20.4%	41,051	39.5%
Shrubland	1,464	18.2%	16,883	16.2%
Planted/ Cultivated	440	5.5%	13,737	13.2%
Barren	223	2.8%	1,219	1.2%
Open Water	37	0.5%	590	0.6%
Developed	15	0.2%	923	0.9%
Wetland	1	0.01%	80	0.08%
Orchards/ Vineyard	0	0.00%	5	0.00%
TOTAL	**8,026**		**104,067**	

Source: USGS 1992 NLCD

The USFS, BLM, and National Park Service manage the majority of the public land located within the Upper Gunnison River Water Conservancy District (UGRWCD). USFS and BLM lands are used for livestock grazing, recreation, and wildlife habitat, and to a lesser degree, mining and production of timber (UGRWCD 2003).

Privately owned lands are concentrated in the valley bottoms of the UGRWCD. The majority of private lands are used for production of irrigated hay, pasture, and livestock. Private lands also include municipal, residential, recreational, and conservational uses. Manufacturing and industrial activity is very light in the District (UGRWCD 2003).

3.5.5 Gunnison Basin Surface Geology

Mountain ranges in the eastern part of the basin are composed mostly of Precambrian metamorphic rocks that have been uplifted except for the West Elk and Elk mountains. The West Elks are composed of several uplifted structures, which were formed by igneous intrusions. The Elk Mountains are composed of tightly folded and nearly horizontal faulted sedimentary rocks. In the western part of the basin, a great mass of sedimentary beds, mainly of Paleozoic and Mesozoic ages, several thousand feet thick, rests on the Precambrian basement (CWCB and Colorado Bureau of Outdoor Recreation 1979).

3.5.6 Gunnison Basin Surface Water

The Gunnison Basin collects water from over 8,000 square miles starting just west of the Continental Divide down to Grand Junction, shown in Figure 3-23. The Gunnison River is formed at Almont at the confluence of the Taylor and East Rivers. The Gunnison River flows down toward the City of Gunnison where Ohio Creek joins the mainstem.

After passing Gunnison, the Gunnison River enters Blue Mesa Reservoir, the first of three reservoirs that comprise the Aspinall Unit of the Colorado River Storage Project. After leaving Blue Mesa Reservoir, the Gunnison River flows through Morrow Point and Crystal Reservoirs, the lower two reservoirs of the Aspinall Unit. After flowing through the Black Canyon of the Gunnison National Park and the Black Canyon National Conservation Area, the Gunnison River meets the North Fork of the Gunnison River, approximately 8 miles west of the Town of Hotchkiss.

The Uncompahgre River joins the Gunnison River near the Town of Delta. From Delta, the Gunnison River flows northwest to Grand Junction, gaining flows from both Grand and Uncompahgre Mesas, including tributary flows from Kannah and East Creeks. Figure 3-23 depicts the Gunnison River tributaries discussed above.

Streamflows in the Gunnison Basin are continuously measured at a number of USGS gaging stations. Five of these gages, shown in Figure 3-26, were selected to summarize historical flows in the basin. Table 3-8 presents the USGS streamflow data from these gages. As the table shows, the Gunnison River has significant streamflows near Grand Junction. Figure 3-26 also shows the basins major diversions and segments with CWCB decreed instream flow rights.

3.5.7 Gunnison Basin Groundwater

The alluvial and bedrock aquifers of the Gunnison Basin, shown in Figure 3-27, typically provide less than 1 percent of the water used in the Gunnison Basin (Apodaca et al. 1996). This relatively low rate of groundwater use is offset by extensive development and use of surface water in the basin. Bedrock aquifers in the Gunnison Basin are (CGS 2003):

- Dakota-Cheyenne
- Paradox
- Piceance

Saturated alluvial deposits form the most productive aquifers in the basin, with yields reportedly ranging from 1 to 750 gpm, but more commonly 20 to 40 gpm. The largest number of wells in the basin are located in the alluvial aquifer, with larger yields obtained from wells located along the Gunnison River (Lewis-Russ 2000). Figure 3-27 also shows the major production wells in the Gunnison Basin with a permitted or decreed yield of 500 gpm or higher.

3.5.8 Gunnison Basin Water Quality

Water quality issues in the Gunnison Basin consist largely of impacts from growth, selenium, and mining. The current growth and related development surge in Colorado is particularly evident in the basin. A large number of septic systems in the area have the potential to impact surface water and groundwater supplies (CDPHE 2002).

Several segments of the Gunnison and Uncompahgre Rivers have been listed under section 303(d) of the CWA as impaired due to exceedances of state water quality standards. These exceedances have been associated with mining in the headwaters areas of the basin, and agriculture in the cultivated areas of the lower basin.

Table 3-8 Summary of Selected USGS Stream Gages for the Gunnison River Basin

Site Name	USGS Site Number	Mean Annual Streamflow (AFY)	Mean Annual Streamflow (cfs)	Period of Record (Years)	Drainage (sq. miles)
Taylor River at Almont	09110000	236,409	327	1910-2002	477
Gunnison River near Gunnison	09114500	523,465	723	1910-2002	1,012
Tomichi Creek at Gunnison	09119000	124,055	171	1937-2002	1,061
Uncompahgre River at Delta	09149500	218,442	302	1938-2002	1,115
Gunnison River near Grand Junction	09152500	1,783,759	2,464	1896-2002	7,928

Source: USGS NWIS web/HydroBase database

In 1997, the Colorado WQCC adopted a 5 parts per billion (ppb) aquatic life standard for selenium in the Gunnison Basin. Several stream segments, including a portion of Leroux Creek, Sweitzer Lake, a portion of the Uncompahgre River, and the Gunnison mainstem downstream of the Uncompahgre Valley, were found to exceed this standard (Selenium Task Force 2003). According to a USGS report, subbasins that have the highest levels of selenium are those with extensive Mancos shale outcroppings (Butler and Leib 2002).

Since the development of the new selenium standard, segments in the Gunnison Basin have been listed as impaired and placed on the state's 303(d) list. Because of this listing, the Gunnison Basin Selenium Task Force was formed to address the problem at the local level. This task force is made up of local landowners, state, and federal agencies (www.seleniumtaskforce.org).

Figure 3-28 identifies the locations of surface waters in the Gunnison Basin that have been listed for impairment for one or more parameters on Colorado's 2002 303(d) list. Stream segments proposed for listing via the 2004 303(d) list and the accompanying Monitoring and Evaluation list are described in Colorado WQCC Regulations 93 and 94. The state's 2004 proposed 303(d) list incorporates several additions from the 2002 list. It includes segments in the lower Gunnison Basin and in the North Fork Gunnison River, mostly for selenium. Portions of the upper Gunnison Basin and the Uncompahgre River Basin are listed as being impaired for metals such as copper, zinc, iron, selenium, and cadmium.

3.5.9 Gunnison Basin Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species

As discussed above, issues of concern in the Gunnison Basin include elevated selenium and TDS levels in the Lower Gunnison Basin and impaired waters due to acid mine drainage and agricultural practices.

In addition to impaired areas, threatened and endangered species and areas of high environmental or recreational value require special attention when evaluating water supply projects in the Gunnison Basin. For a complete list of federal and/or state listed threatened and endangered fish and other species in the Gunnison Basin, see information on federal reserved water rights and RICDs located in Appendix C.

An area with high recreational value is the 26-mile reach of the Gunnison River from the upstream boundary of the Black Canyon of the Gunnison National Park to the North Fork of the Gunnison River, which has been awarded Gold Medal designation. This section of the Gunnison is often cited as the best trout water in the state for large numbers of 16 to 25 inch rainbows and browns, with fish over 5 pounds not uncommon.

Figure 3-29 shows the locations of some of the basin's key aquatic species habitat.

Other areas of high recreational value in the basin include Blue Mesa, Taylor Park, and Ridgway Reservoirs; whitewater reaches in the basin; Curecanti National Recreation Area; and the Black Canyon of the Gunnison National Park as discussed in Section 6.

3.5.10 Gunnison Basin Energy and Mineral Resources

The Piceance Basin holds vast quantities of natural gas in the seams of its coal formations, representing one of the largest natural gas reserves in the United States. Extraction of CBM involves removal of groundwater to release the gas; this water is typically either discharged to the surface or reinjected.

Like many of Colorado's mountainous areas, portions of the basin were historically mined heavily in search of the area's vast mineral resources. These historic mining activities continue to have water quality implications today.

The topographic relief along the course of the Gunnison River also affords significant hydropower opportunities. Operations of the Aspinall Unit seek a balance between flow needs, storage needs, and hydropower operations.

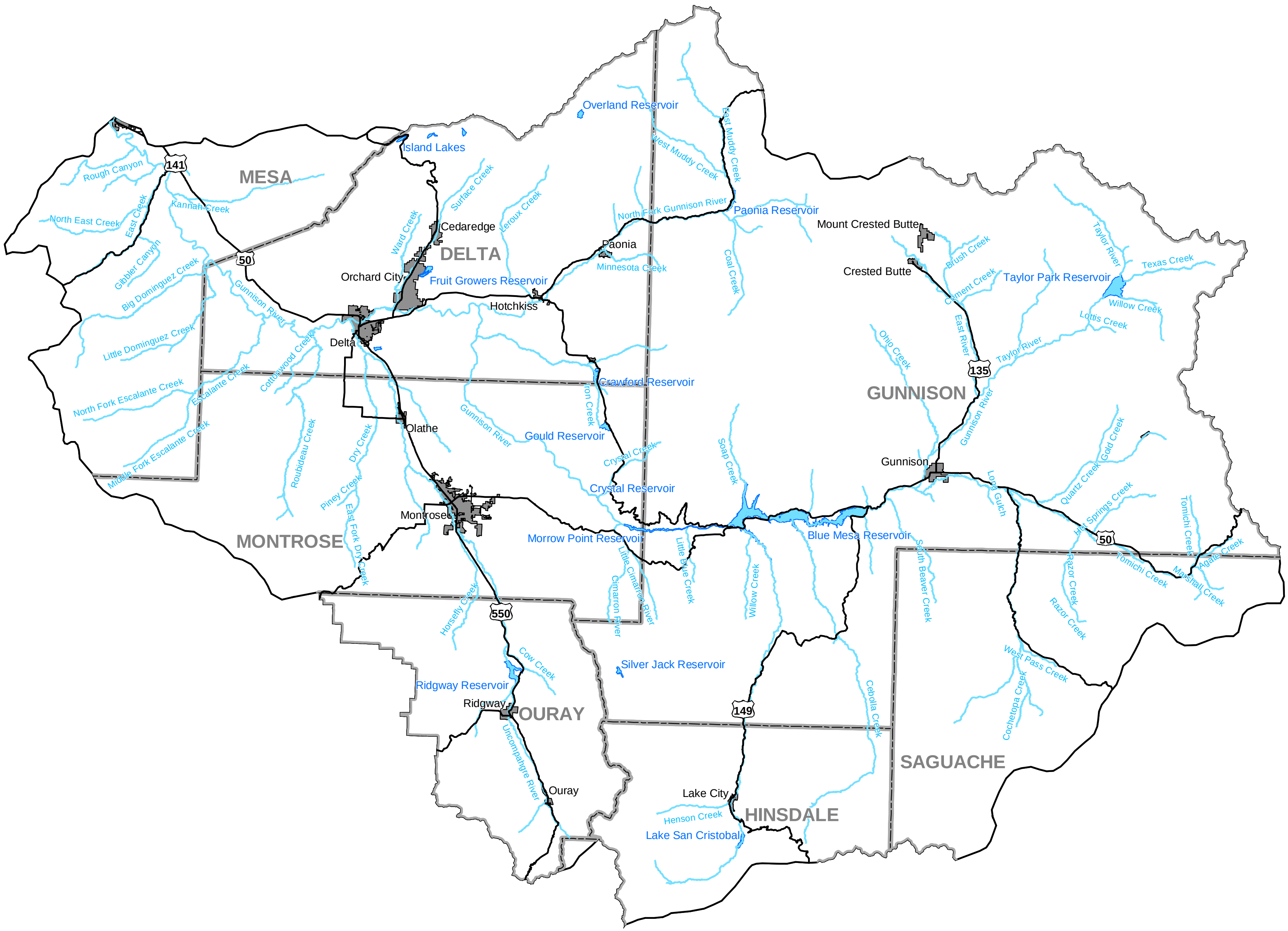


Figure 3-23
Gunnison Basin
Physical Setting

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

10 5 0 10 Miles
1:900,000

N

Coordinate System
NAD 1927 UTM Zone 13N

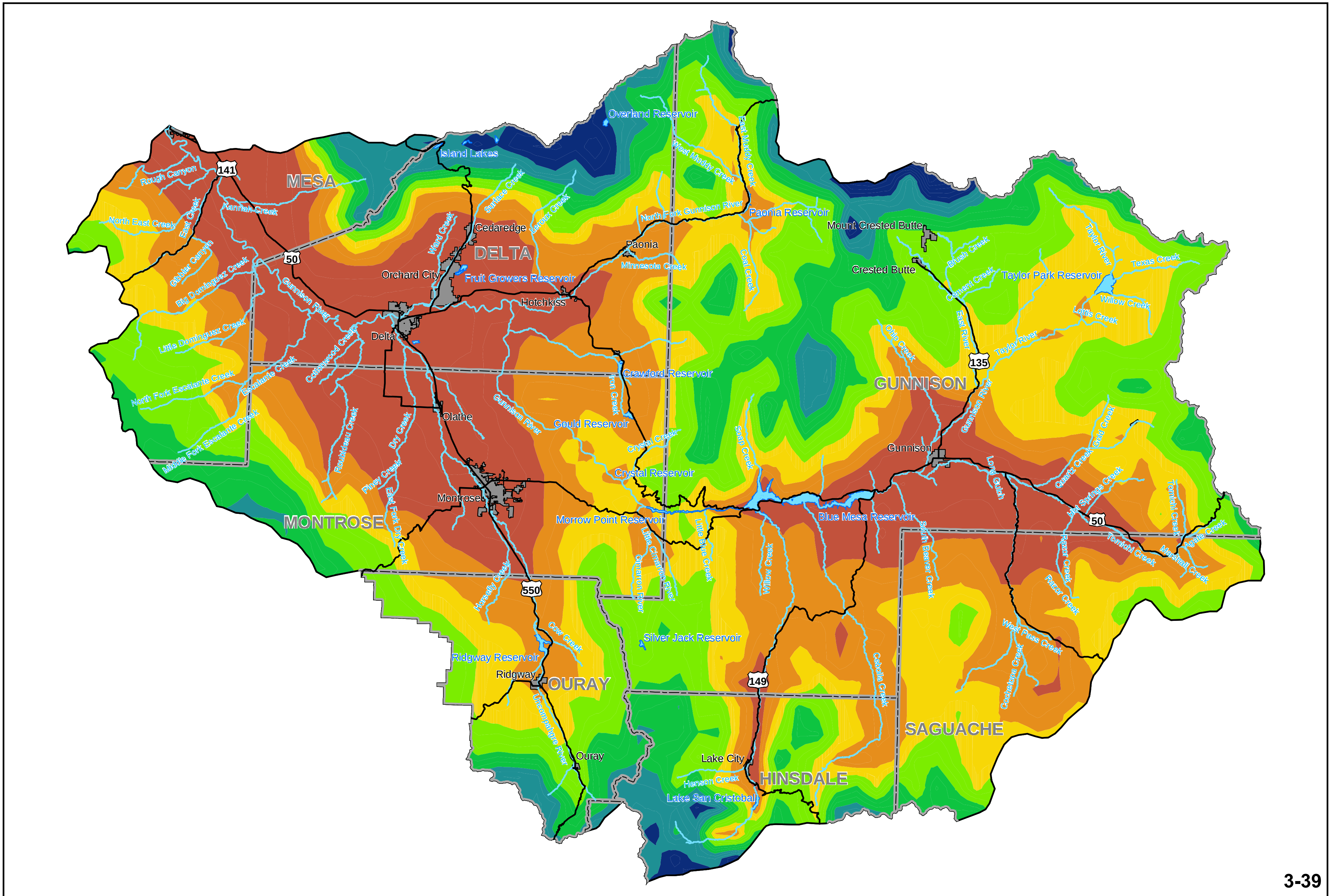


Figure 3-24
Gunnison Basin
Mean Annual Precipitation

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

Mean Annual Precipitation, Inches
7.0 - 13.0
13.1 - 17.0
17.1 - 21.0
21.1 - 27.0
27.1 - 33.0
33.1 - 39.0
39.1 - 63.0

10 5 0 10 Miles
1:900,000
N
Coordinate System
NAD 1927 UTM Zone 13N

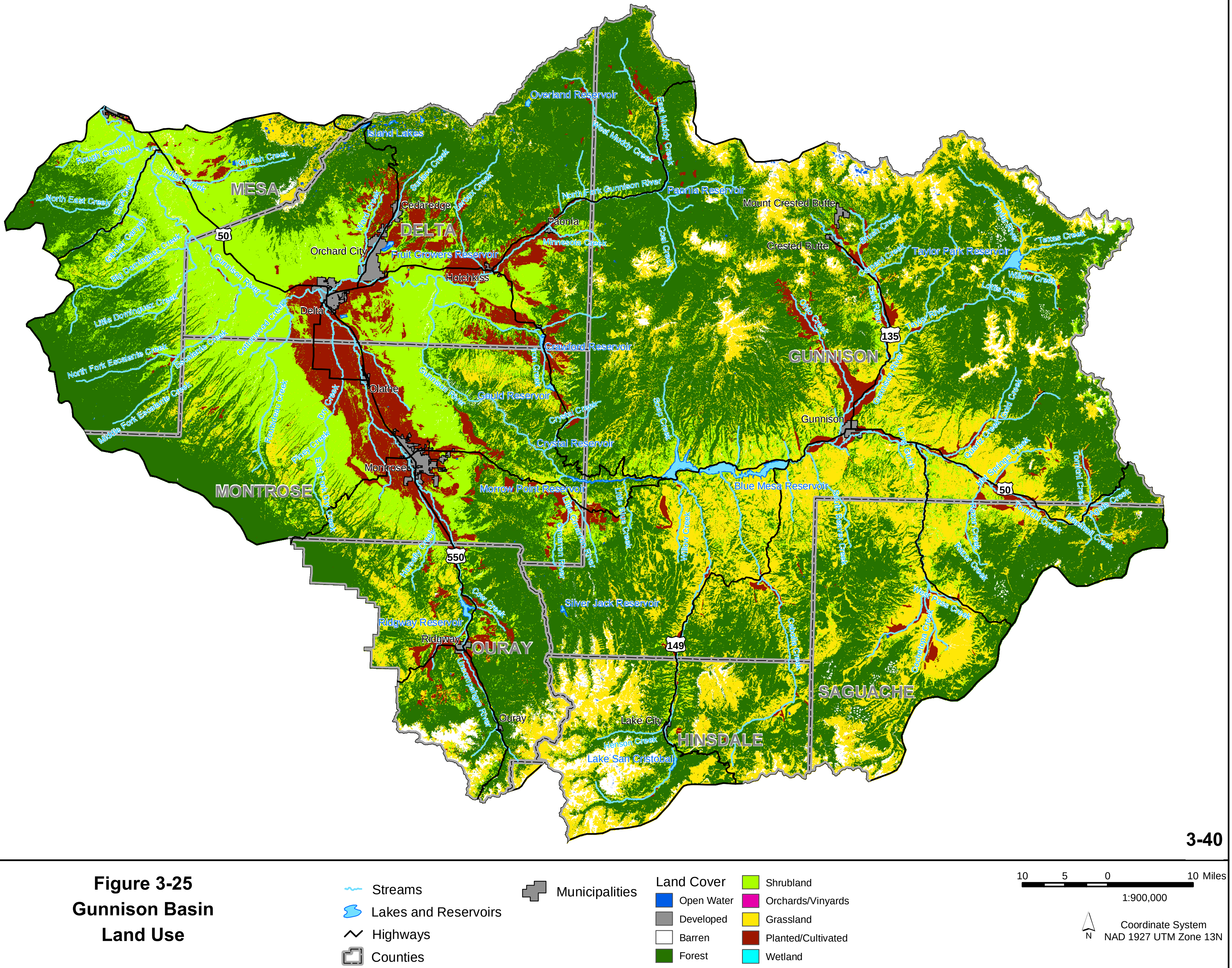
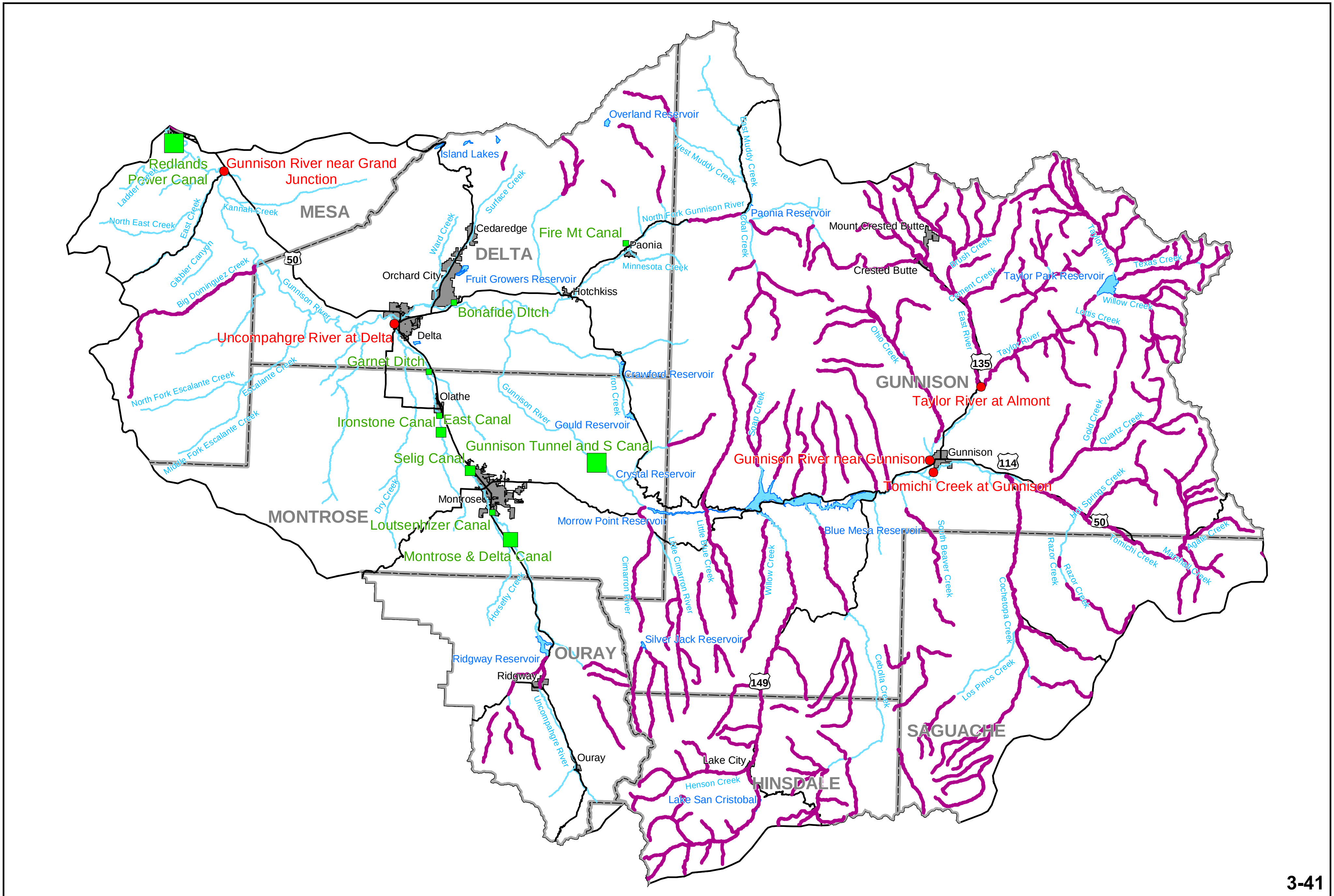


Figure 3-25
Gunnison Basin
Land Use



Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Selected Streamflow Gage
Stream with Instream Flow Right

Top Ten Diversions, Annual AF
- 5,000 - 50,000
- 50,001 - 150,000
- 150,001 - 400,000
- 400,001 - 810,000

10 5 0 10 Miles
1:900,000

N

Coordinate System
NAD 1927 UTM Zone 13N

Figure 3-26
Gunnison Basin Key Diversions and Streamflow Gage Locations

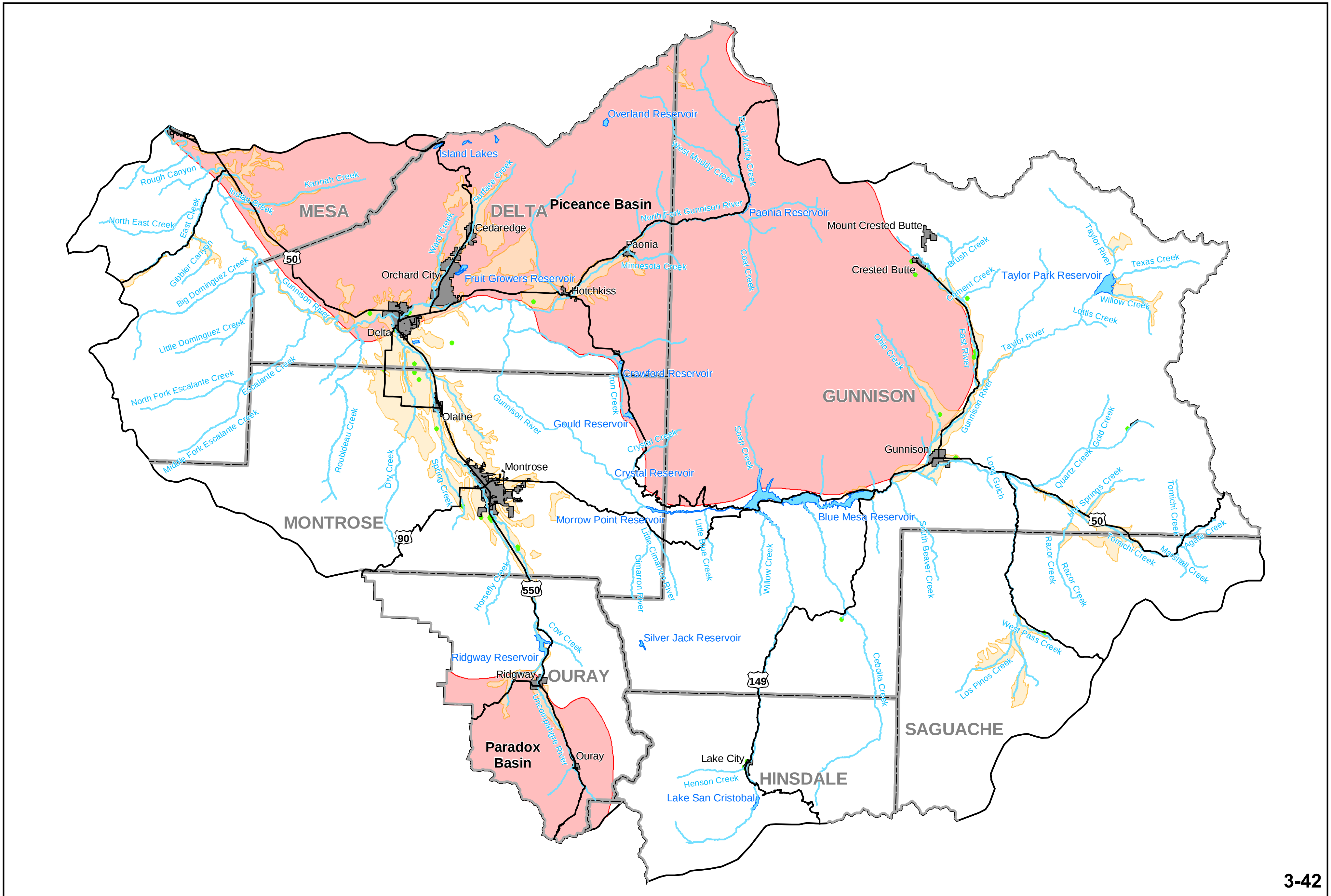


Figure 3-27
Gunnison Basin
Wells and Aquifers

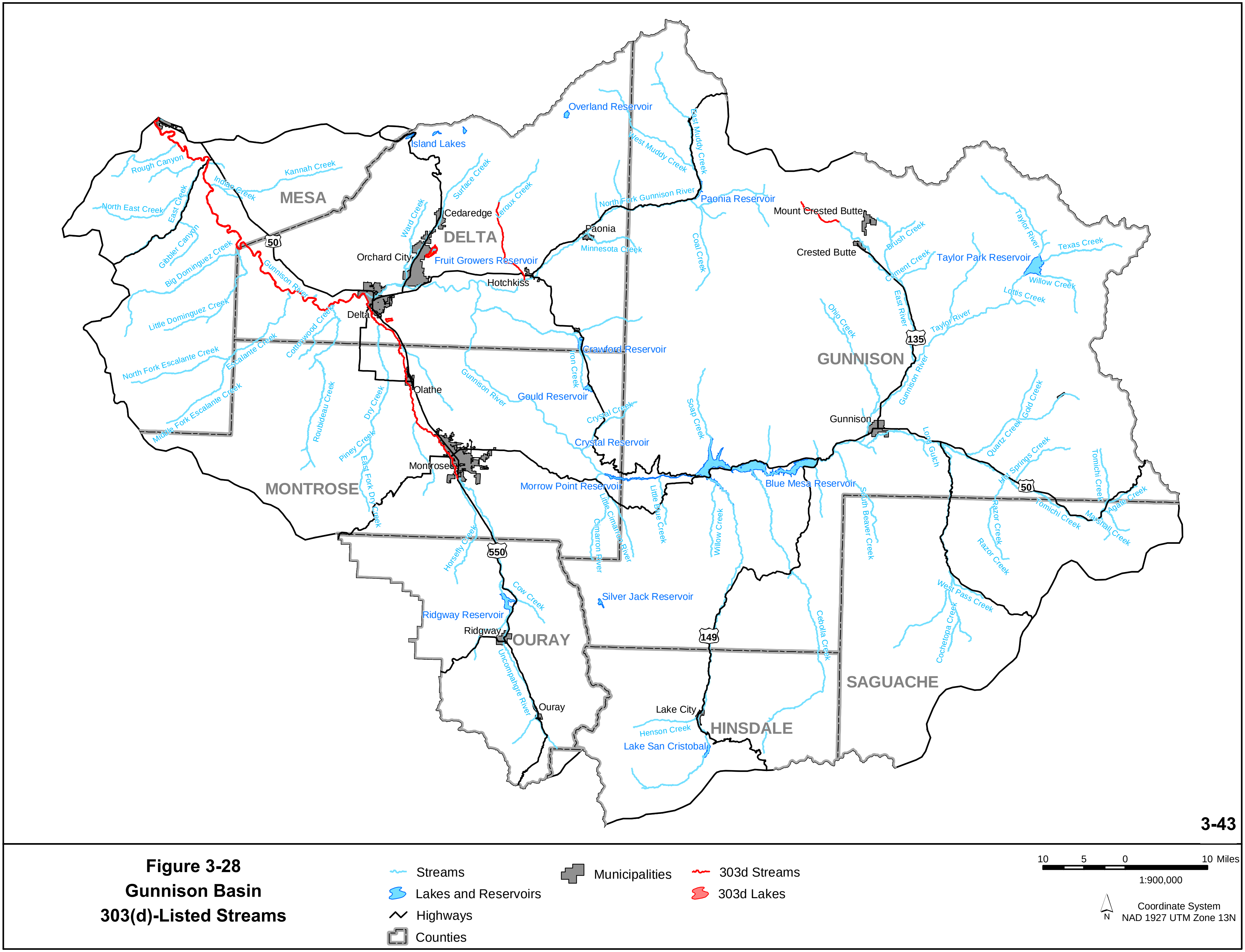


Figure 3-28
Gunnison Basin
303(d)-Listed Streams

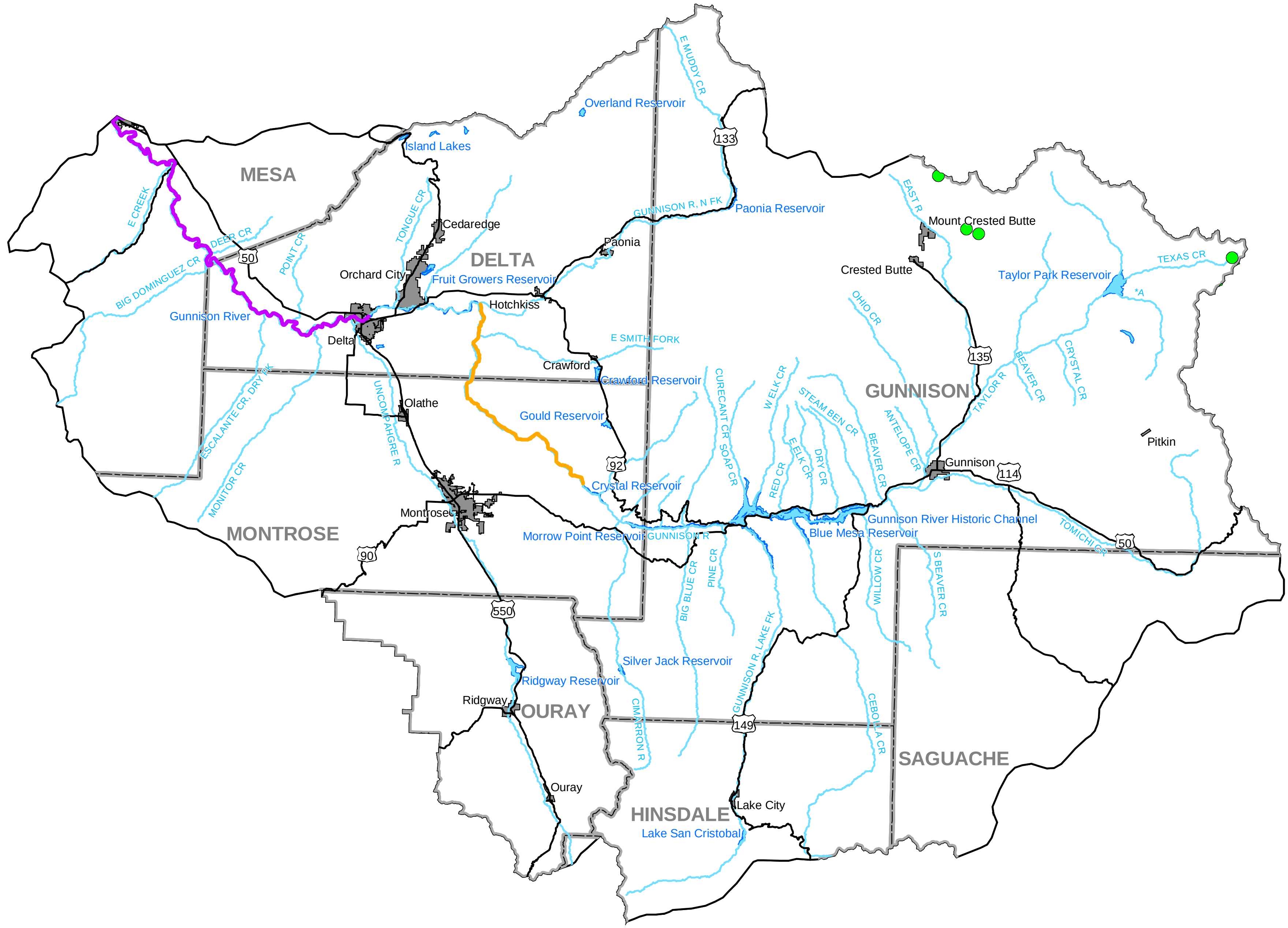


Figure 3-29
Gunnison Basin
Areas of Environmental Concern

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Boreal Toad Critical Habitat
Federally Listed Critical Habitat
Gold Medal Trout Stream

The Gunnison River Basin does not contain any Greenback Cutthroat Trout Areas, or Arkansas Darter Areas

6 3 0 6 Miles

1:950,000

N

Coordinate System
NAD 1927 UTM Zone 13N

data source: Colorado Division of Wildlife

3.6 North Platte Basin

3.6.1 North Platte Basin Geography

The North Platte Basin, shown in Figure 3-30, is located in north central Colorado in Jackson and a small portion of Larimer Counties. The basin covers an area of roughly 2,050 square miles. The population of Walden in Jackson County is 727 people (DOLA 2003).

3.6.2 North Platte Basin Climate

The average annual precipitation for the North Park Basin, which covers the majority of the North Platte Basin, is 19 inches. This average ranges from 11 inches in the valley center, near Walden, to more than 50 inches in the mountains that surround the valley (CGS 2003). Figure 3-31 shows color-fill contours for the average annual precipitation throughout the basin.

3.6.3 North Platte Basin Topography

The North Platte Basin in Colorado is bounded on the east by the Front Range, on the west by the Park Range, on the south by the Rabbit Ears Range, and on the north by the Colorado-Wyoming state line. The land surface elevation of the basin valley ranges between 8,000 and 9,000 feet (CGS 2003).

3.6.4 North Platte Basin Land Use

Land use in the North Platte Basin (USGS 1992) is shown in Figure 3-32 and summarized in Table 3-9. Almost half of the basin is forest (46 percent), located on the edges of the basin boundaries, followed by shrubland (24 percent), and grassland (17 percent). The shrubland is concentrated in the central portion of the basin. Grassland is typically located near the basin edges near the forested areas. Agricultural areas generally follow the basin's streams and rivers.

Table 3-9 Land Cover Data for the North Platte Basin

Land Cover	Basinwide		Statewide	
	Area (sq. miles)	Percent of Total	Area (sq. miles)	Percent of Total
Forest	934	45.7%	29,577	28.4%
Shrubland	481	23.5%	16,883	16.2%
Grassland	357	17.4%	41,051	39. 5%
Planted/ Cultivated	222	10.9%	13,737	13.2%
Open Water	24	1.2%	590	0.6%
Barren	23	1.1%	1,219	1.2%
Wetland	3	0.1%	80	0.08%
Developed	3	0.1%	923	0.9%
TOTAL	**2,047**		**104,067**	

Source: USGS 1992 NLCD

3.6.5 North Platte Basin Surface Geology

The mountain regions in the North Platte Basin are composed of Precambrian age metamorphic rocks that are extensively intruded by granitic igneous rocks. The North Park Basin is filled with sedimentary rock layers. The sedimentary layers range from flat-lying to steeply dipping folded and faulted structures (Pearl 1974).

3.6.6 North Platte Basin Surface Water

The North Platte Basin drains the north-central portion of Colorado and consists of the North Platte River and two major tributaries: the Laramie River and Sand Creek. The North Fork, Grizzly Creek, Michigan River, Canadian River, and Illinois River are tributaries that flow into the North Platte River in Colorado. Sand Creek and the Laramie River flow northward out of Colorado and join the North Platte River in Wyoming. The North Platte River, Laramie River, and Sand Creek are shown in Figure 3-30.

To monitor these streamflows, the USGS has gages in place in the North Platte Basin. Figure 3-33 shows the location of three of these streamflow gages. These gages are located on the North Platte River near Northgate, on the Laramie River near Glendevey, and on Sand Creek at the Colorado-Wyoming state line. They provide representative historical streamflows of the stream systems in the basin, as shown in Table 3-10, which also includes the length of record and the drainage area for each gage. Figure 3-33 also shows the locations of major diversions in the basin and segments with CWCB decreed instream flow rights.

Table 3-10 Summary of Selected USGS Stream Gages for the North Platte River Basin

Site Name	USGS Site Number	Mean Annual Streamflow (AFY)	Mean Annual Streamflow (cfs)	Period of Record (Years)	Drainage (sq. miles)
Laramie River near Glendevey	06657500	52,312	72	1904-1982	101
Sand Creek at Colorado-Wyoming State Line	06659580	7,518	10	1968-2002	29
North Platte River near Northgate	06620000	310,389	429	1915-2002	1,431

Source: USGS NWIS web/HydroBase database

3.6.7 North Platte Basin Groundwater

The more important aquifers in the basin include:

- Valley-fill alluvium
- North Park Formation
- Coalmont Formation

Figure 3-34 shows the location of the significant aquifers in the basin separated into two groups: alluvial (valley-fill alluvium) and bedrock (North Park and Coalmont). The valley-fill alluvium is composed of sand, gravel, clay, and silt and is 80 feet thick in some areas (Pearl 1974). The North Park Formation is a 2,000-foot layer of calcareous sandstone with interbedded layers of siltstone, clay, and volcanic ash. Well yields from this aquifer are typically less than 50 gpm (Pearl 1974). The Coalmont Formation is a 6,000 to 9,000 foot layer of sandstone, shale, conglomerate, and coal beds. This is the primary aquifer in the basin, and well yields are generally less than 10 gpm (Pearl 1974). The Coalmont Formation is estimated to contain 120 million AF of recoverable groundwater; however, only 39 million AF are considered to be economical for withdrawal (CGS 2003). Figure 3-34 also shows the location of wells with permitted or decreed capacities greater than or equal to 500 gpm. In the North Platte Basin there is only one such well located to the west of South Delaney Lake.

Groundwater recharge and discharge are assumed to be equal as there has been no substantial change in the volume of storage in the North Park Basin. The volume of water withdrawn each year is very small compared to the total volume of groundwater storage (CGS 2003).

3.6.8 North Platte Basin Water Quality

The North Platte and its tributaries are generally of high-quality water (CDPHE 2002). Elevated levels of TDS are of concern in portions of the basin's groundwater resources affected by coal mining (CGS 2003). The basin has very few permitted wastewater discharges; stream erosion and sediment are the primary water quality issues of concern in the basin. The state's 2002 303(d) list did not include any listings in the North Platte Basin. However, the proposed 2004 303(d) list includes impairment of tributaries to the North Platte in the Illinois River drainage for iron, and Spring Creek for dissolved oxygen. Stream segments proposed for listing via the 2004 303(d) list and the accompanying Monitoring and Evaluation list are described in Colorado WQCC Regulations 93 and 94.

3.6.9 North Platte Basin Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species

As mentioned above, an area of environmental concern in the North Platte Basin is the high TDS concentrations in groundwater in certain historic coal mine areas. There are no federal and/or state listed fish species found in the North Platte Basin. However, some other species are federally and/or state listed as threatened and endangered species in the North Platte Basin. A complete list of these species can be found in Appendix C.

In addition, two areas in the basin have received Gold Medal designation.

- The North Platte River from the Routt National Forest boundary downstream to the Colorado-Wyoming line (5.3 miles). The predominant fish in the North Platte River are brown trout, with rainbow trout also offering sport.
- One of the three lakes in the Delaney Butte Lakes State Wildlife Area, North Delaney Butte Lake. North Delaney Butte Lake is an extremely productive lake that grows trophy brown trout. This wildlife area is located about 10 miles west of Walden.

Figure 3-35 shows the locations of some of the basin's key aquatic species habitat.

3.6.10 North Platte Basin Energy and Mineral Resources

There are no hydroelectric plants in the North Platte Basin. Historical coal mine production has contributed significantly to the economy of the basin in the past.

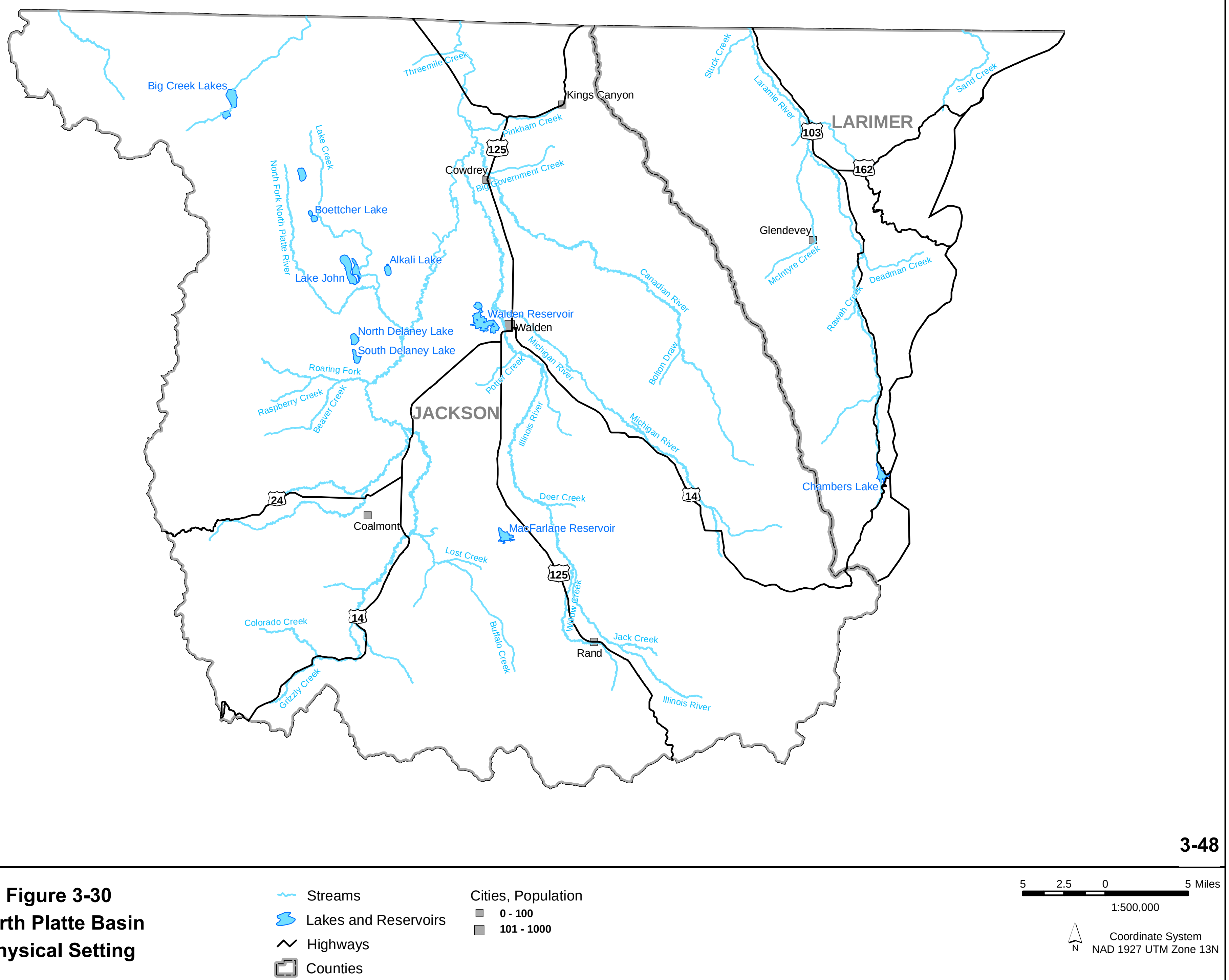


Figure 3-30
North Platte Basin
Physical Setting

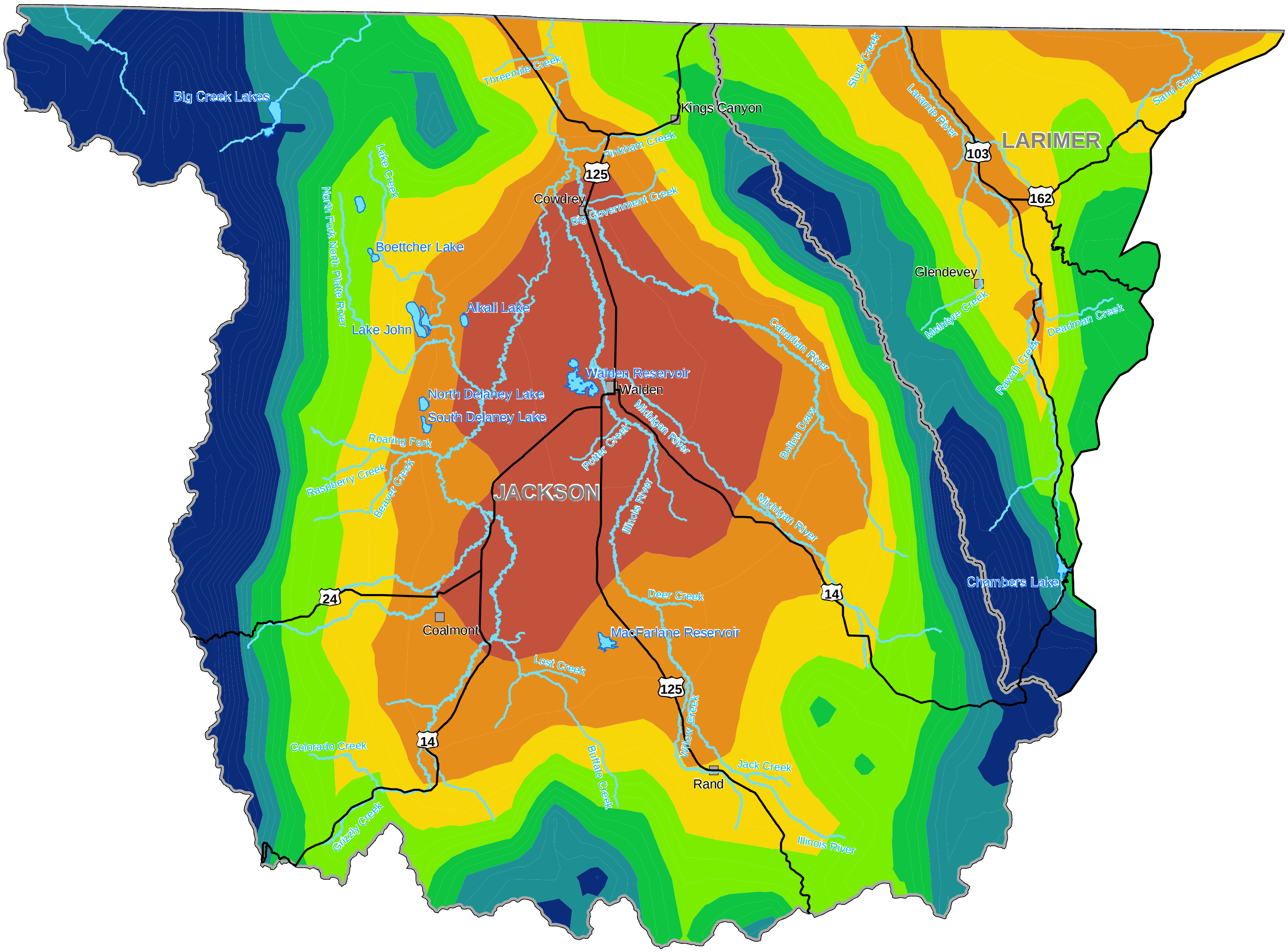


Figure 3-31
North Platte Basin
Mean Annual Precipitation

Streams
Lakes and Reservoirs
Highways
Counties

Cities, Population
0 - 100
101 - 1000

Mean Annual Precipitation, Inches
7.0 - 13.0
13.1 - 17.0
17.1 - 21.0
21.1 - 27.0
27.1 - 33.0
33.1 - 39.0
39.1 - 63.0

5 2.5 0 5 Miles
1:500,000

N
Coordinate System
NAD 1927 UTM Zone 13N

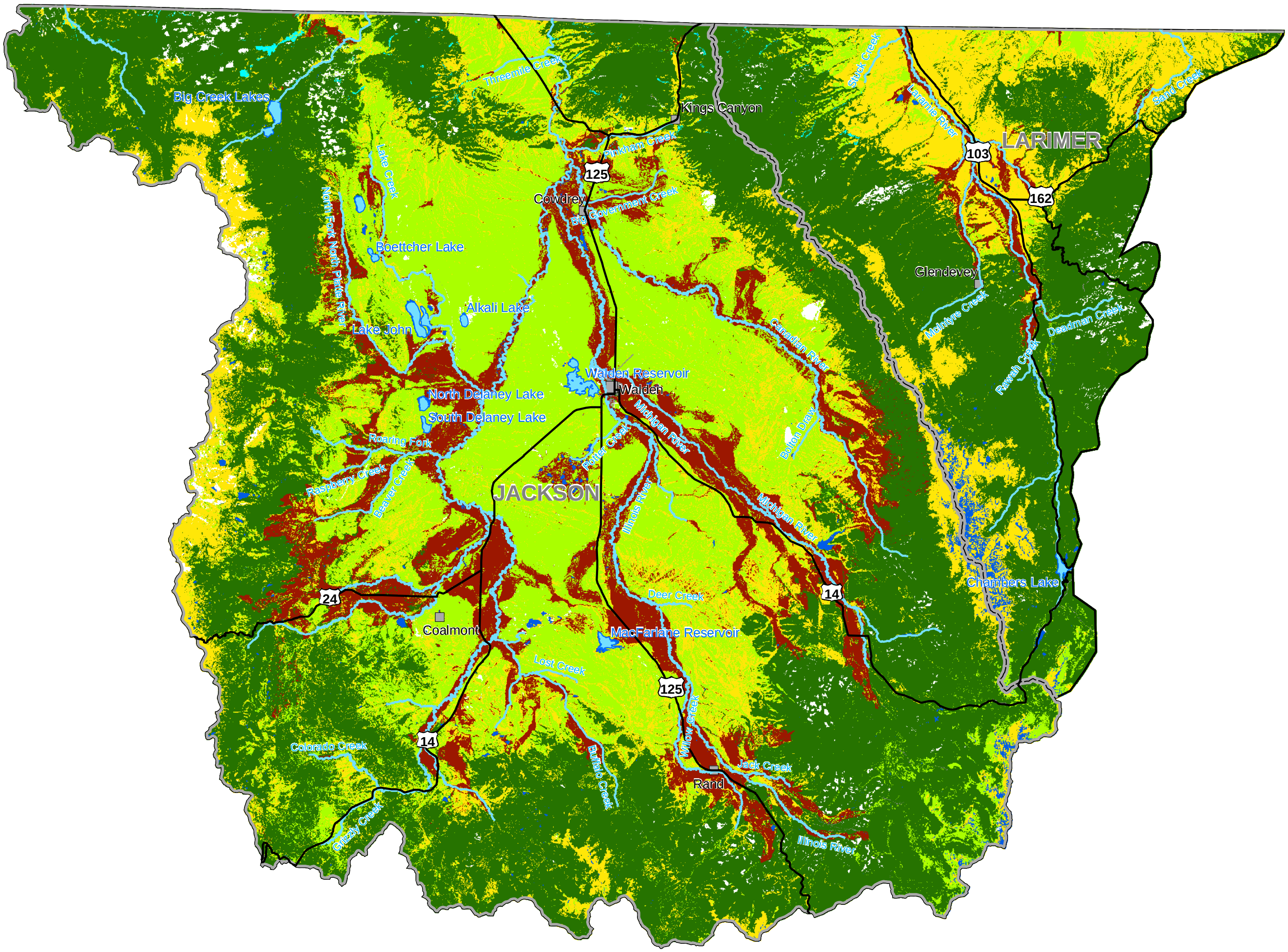


Figure 3-32
North Platte Basin
Land Use

Streams
Lakes and Reservoirs
Highways
Counties

Cities, Population
0 - 100
101 - 1000

Land Cover
Open Water
Developed
Barren
Forest
Shrubland
Orchards/Vinyards
Grassland
Planted/Cultivated
Wetland

5 2.5 0 5 Miles
1:500,000
N
Coordinate System
NAD 1927 UTM Zone 13N

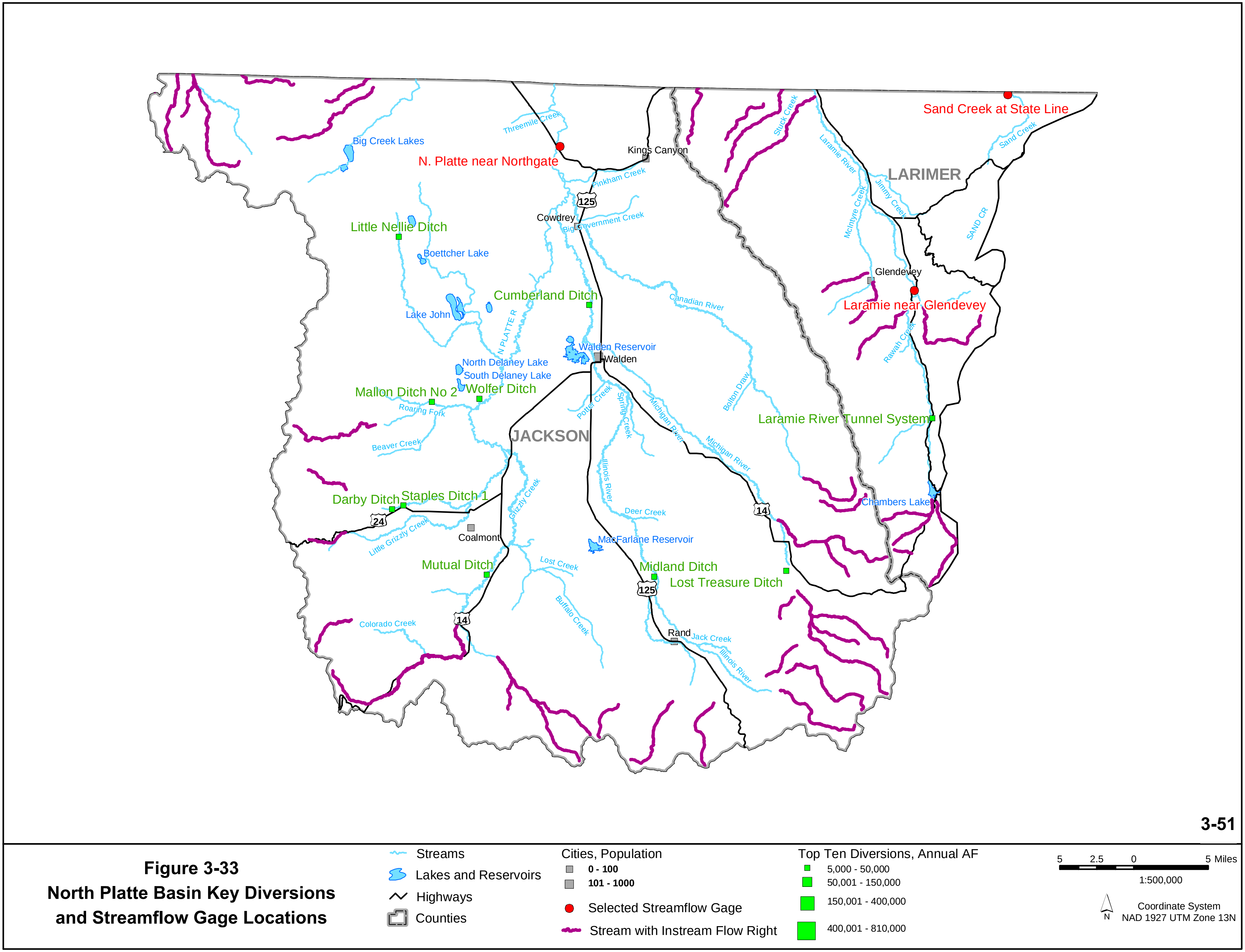


Figure 3-33
North Platte Basin Key Diversions and Streamflow Gage Locations

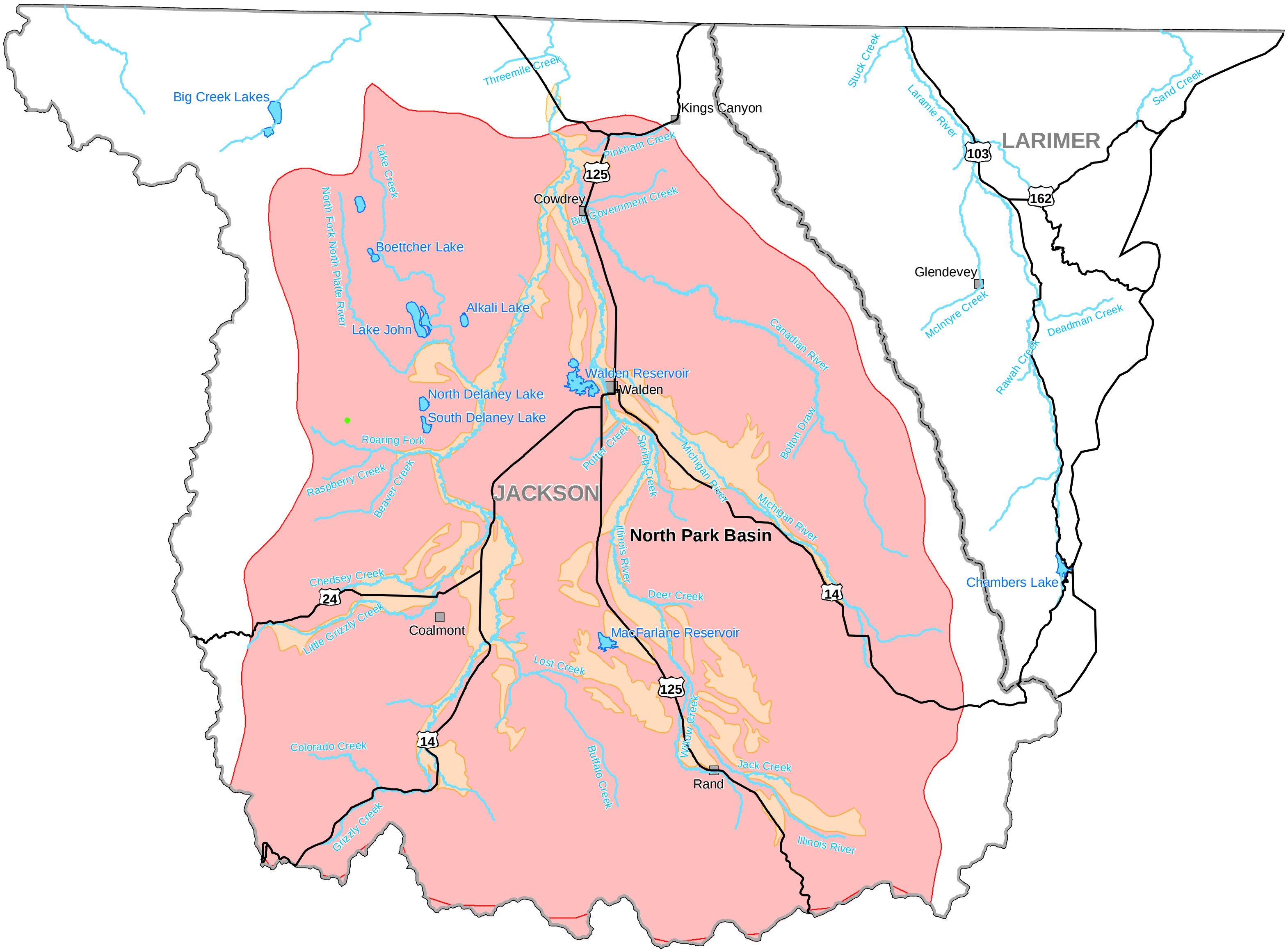


Figure 3-34
North Platte Basin
Wells and Aquifers

Streams
Lakes and Reservoirs
Highways
Counties

Cities, Population
0 - 100
101 - 1000

Wells (Permitted/Decreed Yields >= 500 GPM)
Alluvial Aquifer
Bedrock Aquifer

5 2.5 0 5 Miles
1:500,000
N
Coordinate System
NAD 1927 UTM Zone 13N

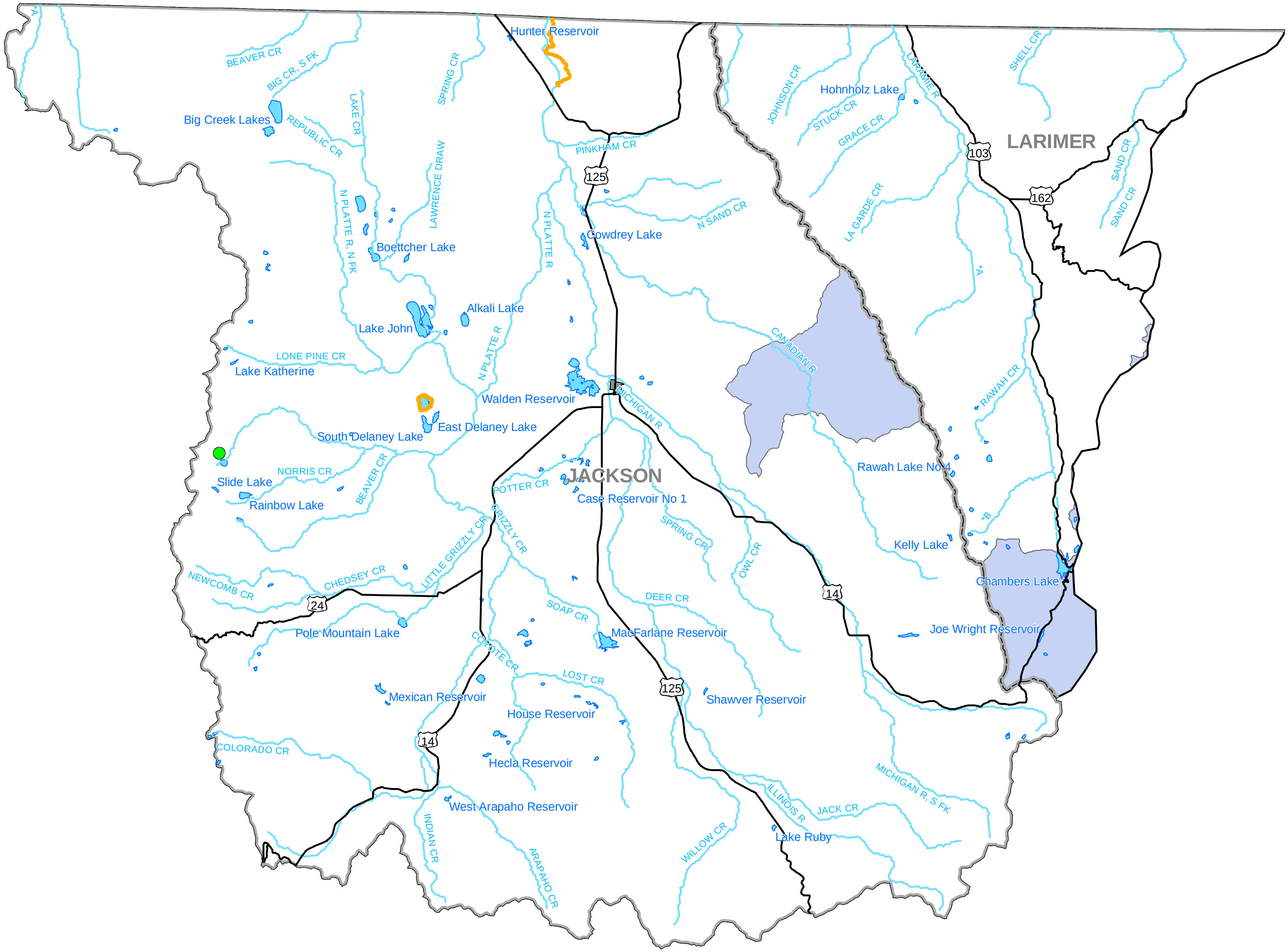


Figure 3-35
North Platte Basin
Areas of Environmental Concern

data source: Colorado Division of Wildlife

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Boreal Toad Critical Habitat
Gold Medal Trout Stream
Gold Medal Trout Lake
Greenback Cutthroat Trout Areas

The North Platte River Basin does not contain any Federally Listed Critical Habitat Streams, or Arkansas Darter Areas

3 1.5 0 3 Miles

1:450,000

N

Coordinate System
NAD 1927 UTM Zone 13N

3.7 Rio Grande Basin

3.7.1 Rio Grande Basin Geography

The Colorado portion of the Rio Grande Basin, located in south central Colorado, encompasses approximately 7,543 square miles, as shown in Figure 3-36. The largest cities or towns in the basin are Alamosa (population 8,248) and Monte Vista (population 4,542) (DOLA 2003).

3.7.2 Rio Grande Basin Climate

The San Luis Valley is a high mountain desert with cool summers and cold winters. The majority of the precipitation occurs as scattered summer afternoon showers or winter snow (CGS 2003). Figure 3-37 shows the mean annual precipitation over the Rio Grande Basin. Average annual precipitation in the central part of the Rio Grande Basin ranges from 6 to 9 inches. Precipitation in the mountains is considerably greater. For example, Wolf Creek Pass, located southwest of South Fork, receives 49 to 56 inches of precipitation annually (NRCS 1999). Due to low humidity, abundant sunshine, and warm temperatures, the average annual evaporation rate often exceeds precipitation, ranging from 35 to 48 inches per year (National Oceanic and Atmospheric Administration [NOAA] 1982).

3.7.3 Rio Grande Basin Topography

The San Juan Mountains in the west, the Sangre de Cristo Range in the northeast, the Culebra Range in the southeast, and the Colorado-New Mexico state line in the south define the Colorado portion of the Rio Grande Basin. The San Luis Valley, a primary feature of the Rio Grande Basin, extends from the foothills of the San Juan Mountains eastward to the foothills of the Sangre de Cristo range and has an average elevation of about 7,500 feet.

3.7.4 Rio Grande Basin Land Use

Figure 3-38 (USGS 1992) shows the land use in the Rio Grande Basin, while Table 3-11 summarizes the data. The majority of the San Luis Valley is privately owned and the greater than 600,000 acres of irrigated land is primarily used for agricultural operations in the central portion of the basin. Areas in the valley that are not irrigated are mostly classified as shrubland (24 percent) and grassland (31 percent). The San Juan and the Sangre de Cristo mountain ranges are largely forested.

Table 3-11 Land Cover Data for the Rio Grande Basin

Land Cover	Basinwide Area (sq. miles)	Basinwide Percent of Total	Statewide Area (sq. miles)	Statewide Percent of Total
Grassland	2,355	31.2%	41,051	39. 5%
Forest	2,342	31.1%	29,577	28.4%
Shrubland	1,811	24.0%	16,883	16.2%
Planted/ Cultivated	787	10.4%	13,737	13.2%
Barren	158	2.1%	1,219	1.2%
Wetland	41	0.5%	80	0.08%
Open Water	35	0.5%	590	0.6%
Developed	14	0.2%	923	0.9%
TOTAL	**7,543**		**104,067**	

Source: USGS 1992 NLCD

3.7.5 Rio Grande Basin Surface Geology

Rocks of various geologic ages are exposed throughout the Rio Grande Basin. Precambrian age crystalline rocks such as granites, gneisses, and schists are found in the Sangre de Cristo Mountains. A section of Paleozoic age sedimentary rocks are present and are exposed along the north and east side of the San Luis Valley. These rocks have been divided into the Manitou Limestone, Harding Sandstone, Fremont Limestone, Chaffee Formation, Kerber Formation, and Minturn Formation (Pearl 1980).

The San Luis Valley is primarily composed of Tertiary age sedimentary rocks of sand, gravel, and clay, derived from the San Juan and the Sangre de Cristo Mountains that border it. The sediments are nearly 30,000 feet thick in portions of the basin and interbedded in part with lava flows (Pearl 1980).

3.7.6 Rio Grande Basin Surface Water

The Rio Grande Basin drains approximately 8,000 square miles of south central Colorado. In the northern portion of the basin, streams flow into the "Closed Basin," an area with no natural surface water outlet, encompassing approximately 3,000 square miles (Wolfe 2003). Outside of the Closed Basin, the Rio Grande and its tributaries collect the runoff from the western and southern portion of the basin.

The headwaters of the Rio Grande, in the western edge of the basin, are just east of the Continental Divide in Hinsdale County. The Rio Grande flows east to the Rio Grande Reservoir where Ute Creek enters from the south. The Rio Grande continues southeast through the San Luis Valley past Monte Vista and the City of

Alamosa. Shortly after passing Alamosa, the Rio Grande then flows straight south, crossing the state line into New Mexico.

The Conejos River is the largest tributary of the Rio Grande and drains the southwest portion of the Rio Grande Basin in Colorado. See Figure 3-36 for the geography of the stream system in the basin.

Streamflows in the Rio Grande Basin are continuously measured at a number of USGS gaging stations. USGS streamflow data were summarized for five sites in the Rio Grande Basin. Figure 3-39 shows the location of the five selected streamflow gages: one on Saguache Creek, two on the Rio Grande, one on the Alamosa River, and one on the Conejos River. Table 3-12 summarizes the mean annual streamflow, period of record, and drainage area for each of these gages. The table indicates that streamflows vary greatly throughout the basin. Figure 3-39 also shows major diversions in the basin and stream segments with decreed instream flow rights.

3.7.7 Rio Grande Basin Groundwater

Groundwater development in the Rio Grande Basin is primarily focused in the San Luis Valley. The groundwater in the San Luis Valley is considered to be located in two major aquifers:

- Unconfined
- Confined

The average annual supply pumped from the aquifers in the San Luis Valley is 380,000 AF (Wolfe 2003), or about one-third of total surface water diversions. Figure 3-40 shows the location of the alluvial and bedrock aquifers and wells with decreed or permitted capacities greater than or equal to 500 gpm.

Throughout most of the San Luis Valley, the unconfined aquifer extends 5 to 100 feet below the land surface. However, in the southeast portion of the valley, along the outer edges of the valley, and along the streams and rivers, the unconfined aquifer can extend to depths of several hundred feet below ground surface (Davis Engineering 1998). In a large part of the valley, a confined or artesian aquifer, which lies under an aquitard called blue clay, averages from 150 to 3,000 feet in depth (Wolfe 2003).

3.7.8 Rio Grande Basin Water Quality

The quality of water exiting the state via the Rio Grande is of very high quality and in other areas of the basin it is generally good (CDPHE 2000). The major water quality concerns in the Rio Grande Basin are due to the effects of historic mining activities. A primary area of concern is the Summitville Mine Superfund site in the Summitville mining district, which operated a surface, heap-leach gold mine from 1984 until December 1992. During operation, the mine leaked cyanide and acidic, metal-laden waters (including dissolved aluminum, copper, iron, manganese, and zinc) into the Wightman Fork of the Alamosa River, significantly impacting aquatic life downstream of the mine for many miles. CDPHE is overseeing a project, begun in 1999, to revegetate the mine site and improve stormwater controls (CDPHE 2002). Other areas that have been impacted from mining include Willow Creek near Creede, Kerber Creek above Bonanza, and the Conejos River within the Platoro mining district (CDPHE 2000).

Table 3-12 Summary of Selected USGS Stream Gages for the Rio Grande Basin

Site Name	USGS Site Number	Mean Annual Streamflow (AFY)	Mean Annual Streamflow (cfs)	Period of Record (Years)	Drainage (sq. miles)
Saguache Creek near Saguache	08227000	43,934	61	1923-2002	595
Rio Grande near Del Norte	08220000	596,901	824	1890-2002	1,320
Alamosa River above Terrace Reservoir	08236000	74,965	103	1914-2002	107
Rio Grande near Lobatos	08251500	408,655	564	1899-2002	7,700
Conejos River near Magote	08246500	217,353	300	1903-2002	282

Source: USGS NWISweb/HydroBase database

Figure 3-41 identifies the locations of surface waters in the Rio Grande Basin that have been listed for impairment for one or more parameters on Colorado's 2002 303(d) list. Stream segments proposed for listing via the 2004 303(d) list and the accompanying Monitoring and Evaluation list are described in Colorado WQCC Regulations 93 and 94. The state's 2004 proposed 303(d) list includes segments in the Alamosa River Basin associated with parameters such as aluminum, copper, lead, zinc, and pH. Other portions of the Rio Grande mainstem and tributaries are included on the 2004 list for parameters that include dissolved oxygen, ammonia, iron, silver, cadmium, copper, lead, mercury, and pH.

3.7.9 Rio Grande Basin Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species

In addition to the acid mine drainage due to closed or abandoned mines, threatened and endangered species and areas of high environmental or recreational value require special attention when evaluating water supply projects and water use in the basin. For a complete list of federal and/or state listed threatened and endangered fish and other species in the Rio Grande Basin, see Appendix C.

Figure 3-42 shows the locations of some of the basin's key aquatic species habitat.

An area with high recreational value in the Rio Grande Basin that has been designated as a Gold Medal fishery is the reach of the Rio Grande from the Highway 149 Bridge at South Fork downstream to the Rio Grande Canal diversion structure at Del Norte.

Other areas of high recreational value in the basin, including the Great Sand Dunes National Park and the Weminuche Wilderness, are discussed Section 6.

3.7.10 Rio Grande Basin Energy and Mineral Resources

There are no hydroloelectric plants in the Rio Grande Basin. Like many of Colorado's mountainous areas, portions of the basin were historically mined heavily in search of the area's vast mineral resources. These historic mining activities continue to have water quality implications today in areas such as the Town of Creede.

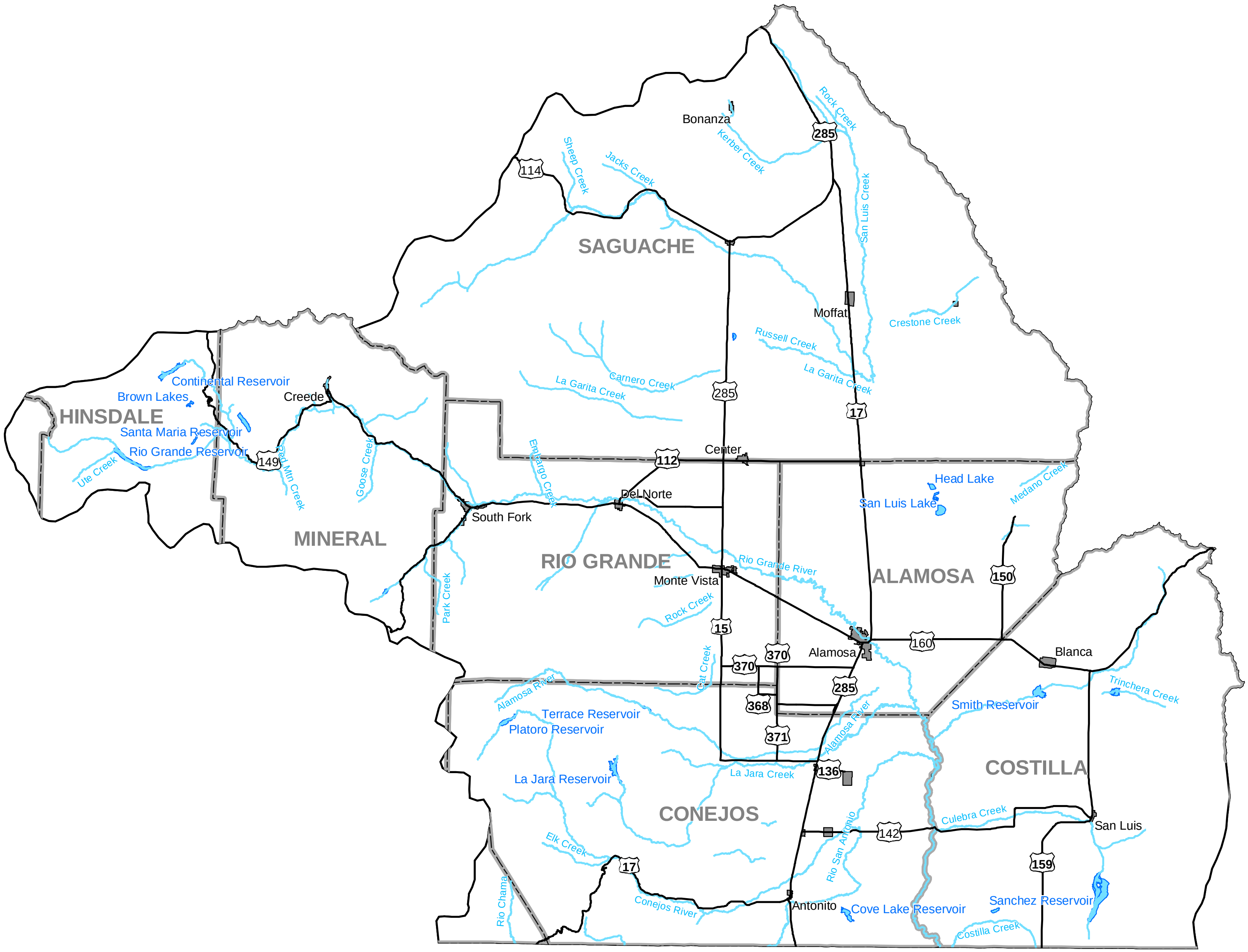


Figure 3-36
Rio Grande Basin
Physical Setting

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

10 5 0 10 Miles
1:1,000,000

N
Coordinate System
NAD 1927 UTM Zone 13N

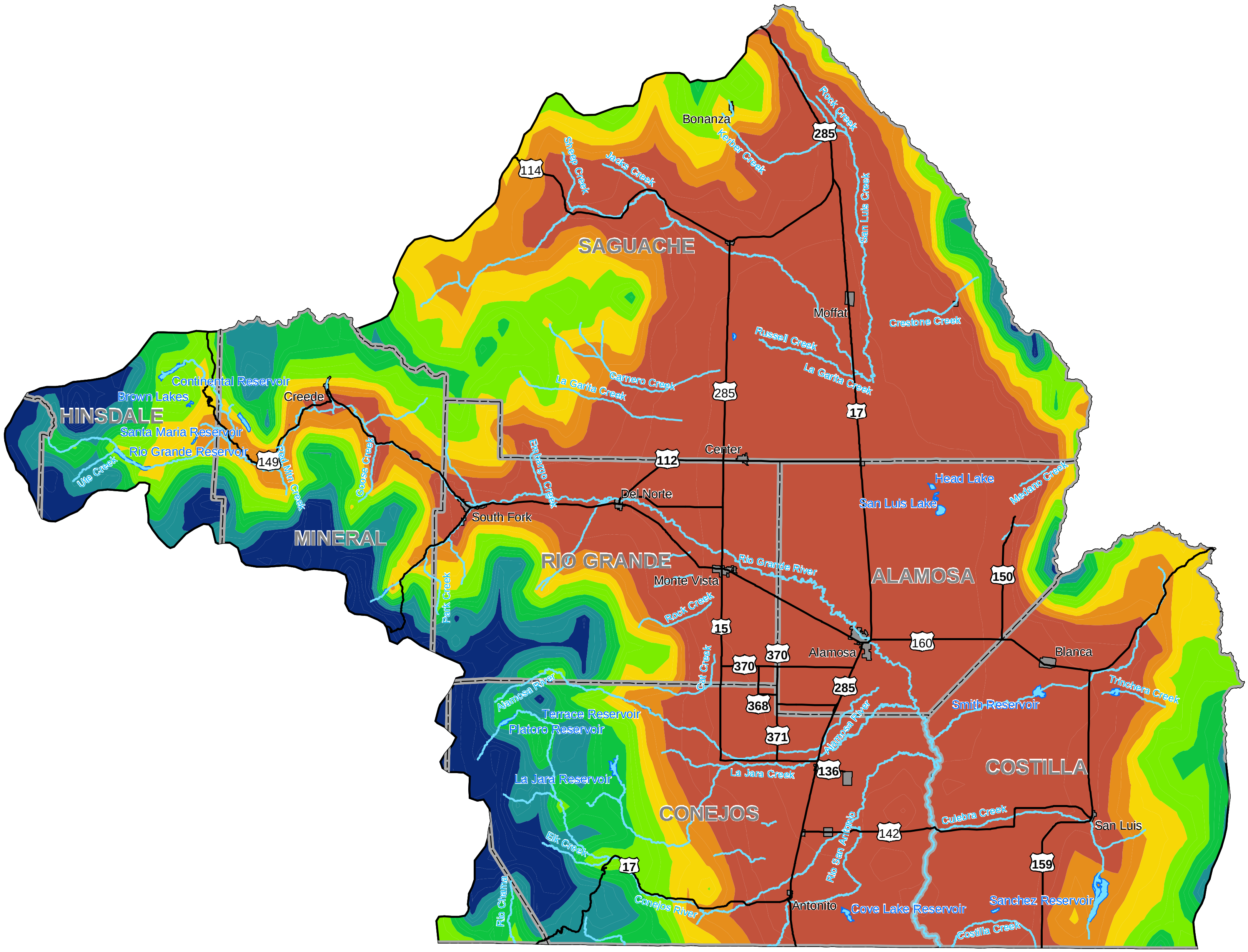


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Figure 3-37
Rio Grande Basin
Mean Annual Precipitation

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

Mean Annual Precipitation, Inches

- 7.0 - 13.0
- 13.1 - 17.0
- 17.1 - 21.0
- 21.1 - 27.0
- 27.1 - 33.0
- 33.1 - 39.0
- 39.1 - 63.0

10 5 0 10 Miles
1:1,000,000

N
Coordinate System
NAD 1927 UTM Zone 13N

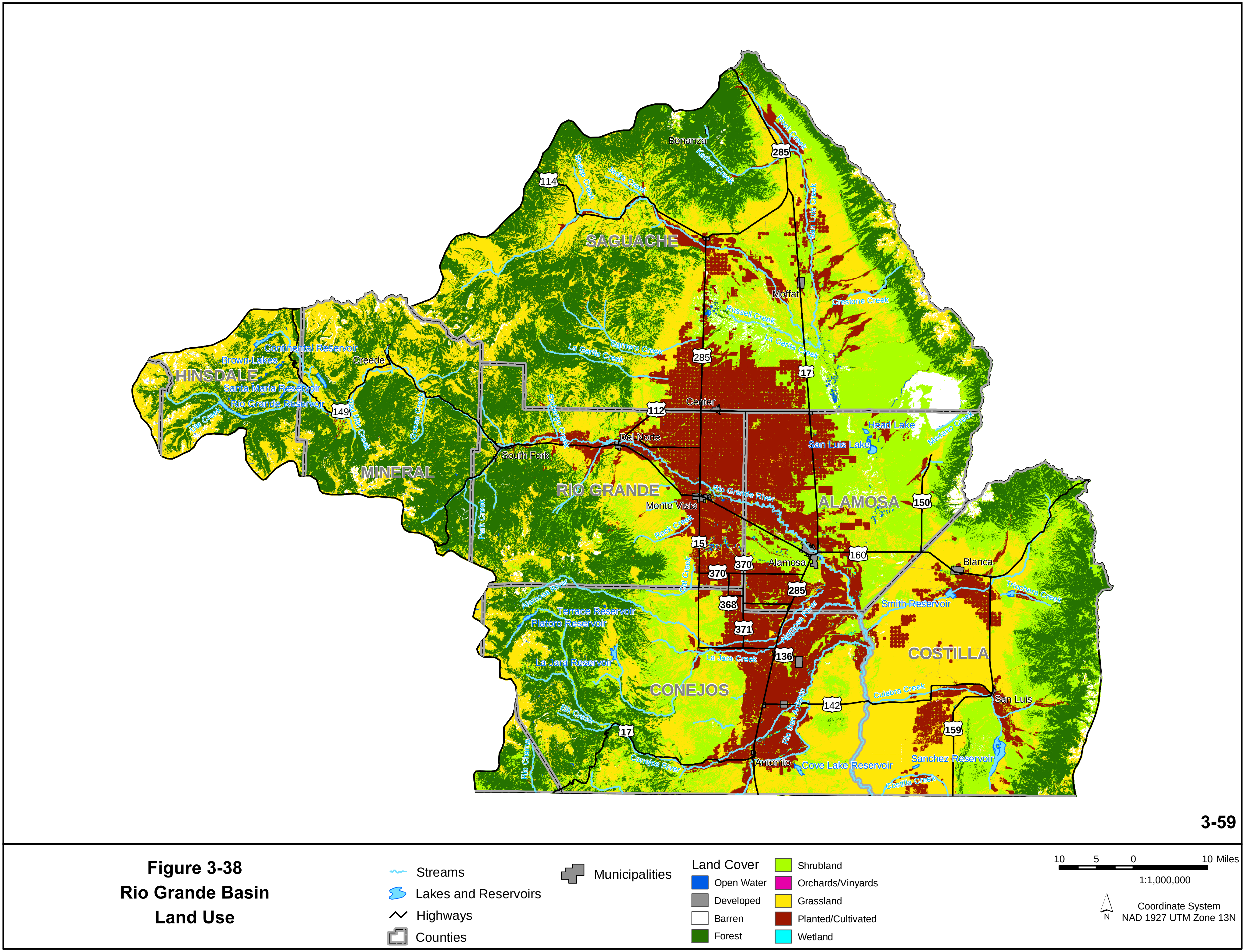

Figure 3-38
Rio Grande Basin
Land Use

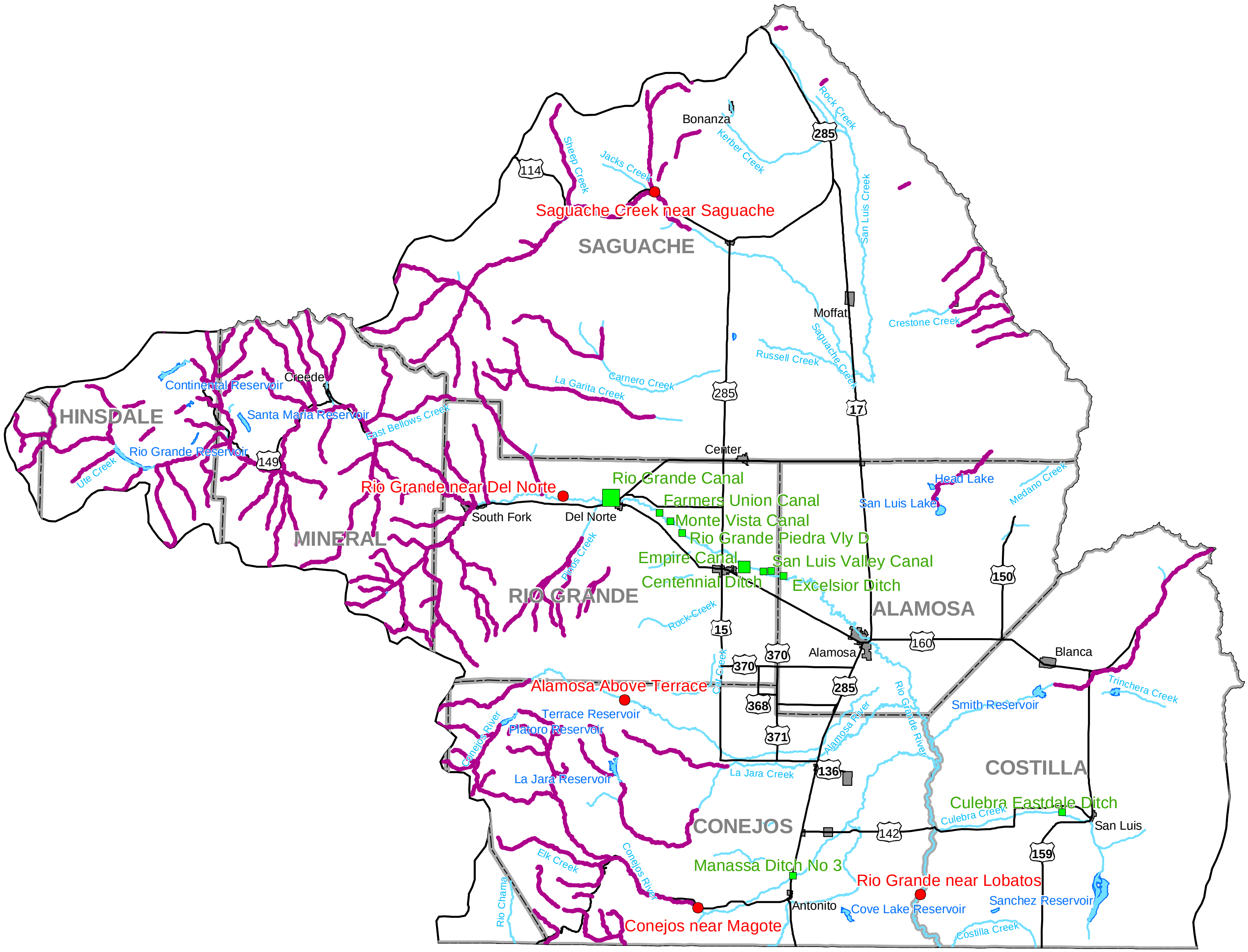

Figure 3-39
Rio Grande Basin Key Diversions and Streamflow Gage Locations

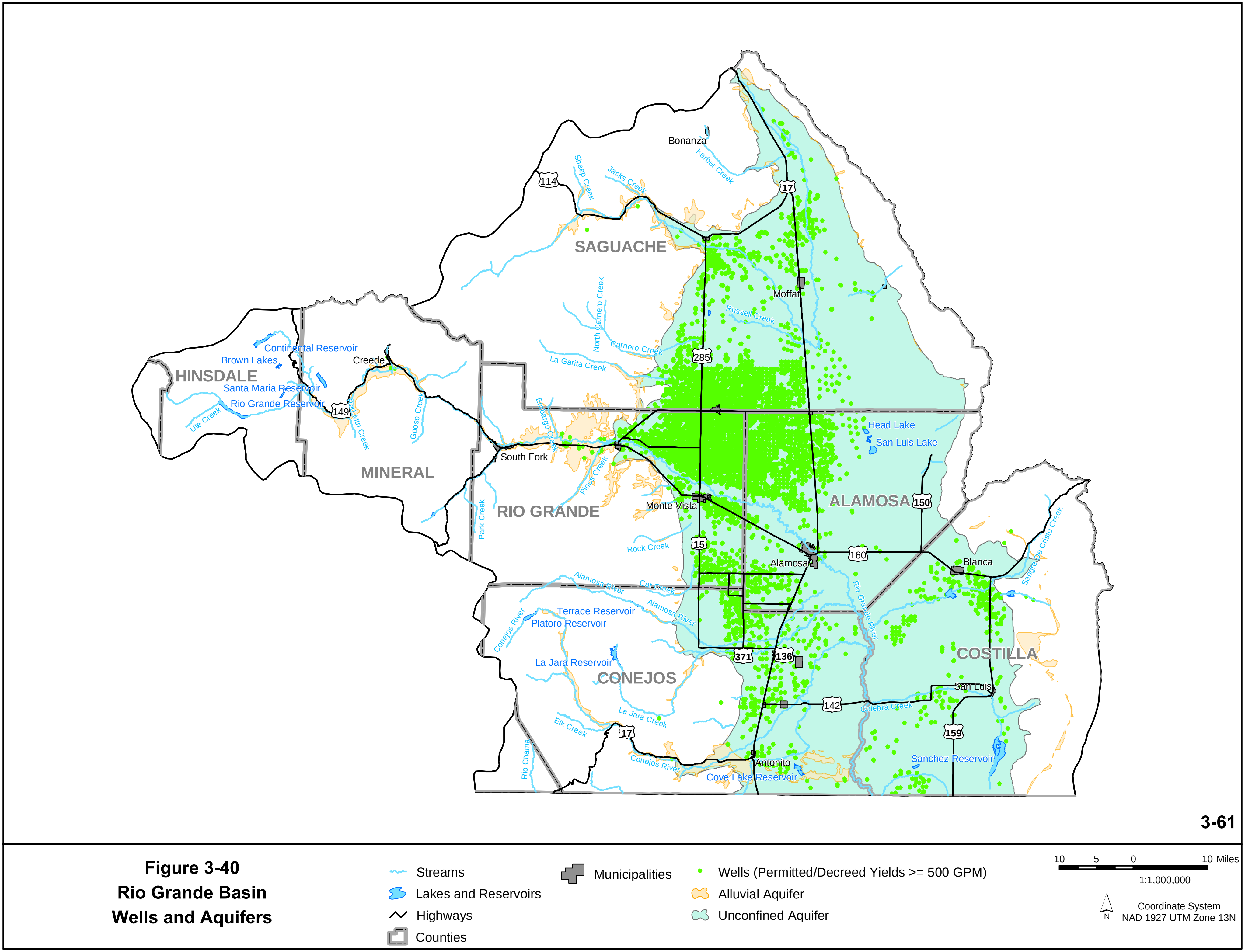

Figure 3-40
Rio Grande Basin
Wells and Aquifers

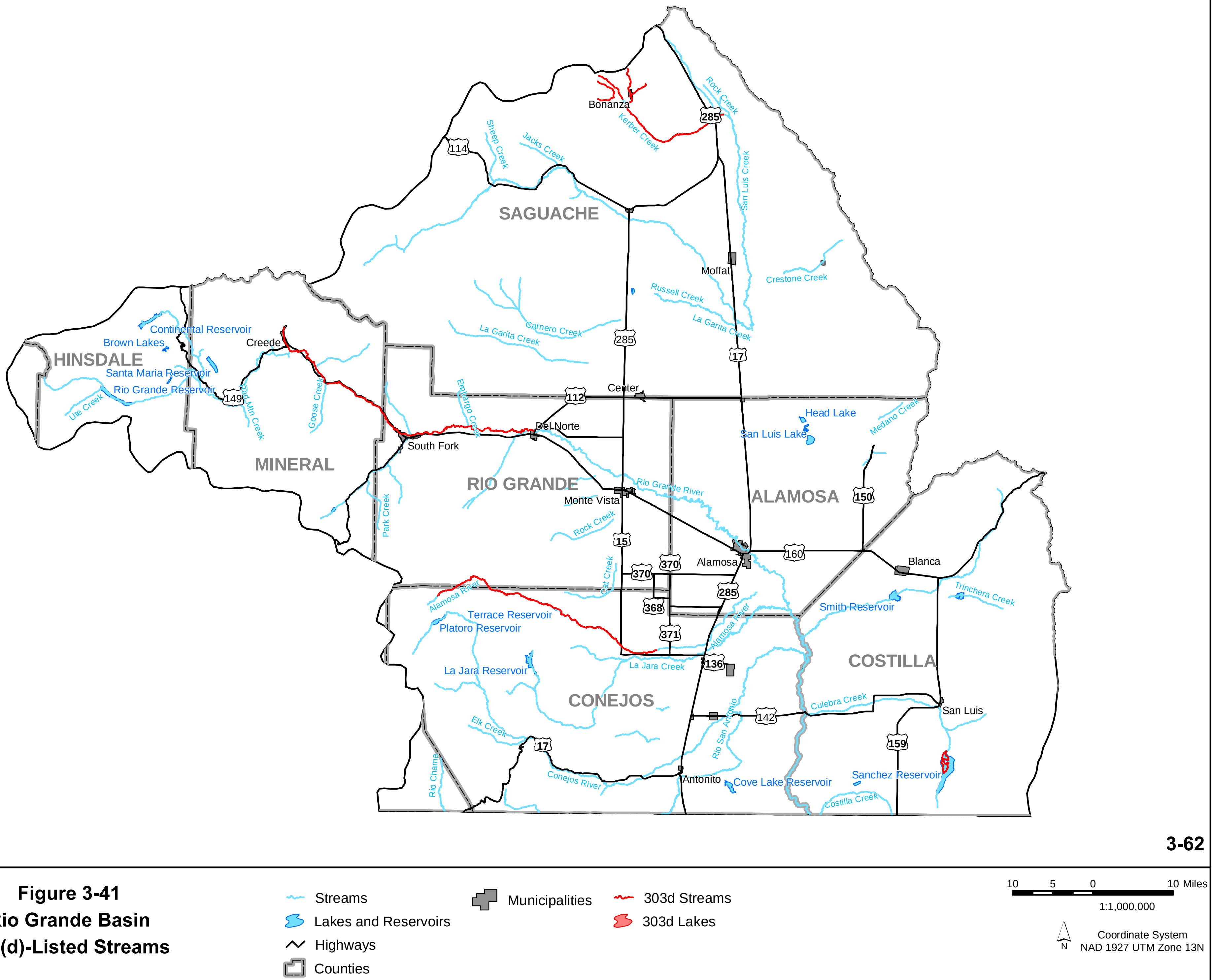

Figure 3-41
Rio Grande Basin
303(d)-Listed Streams

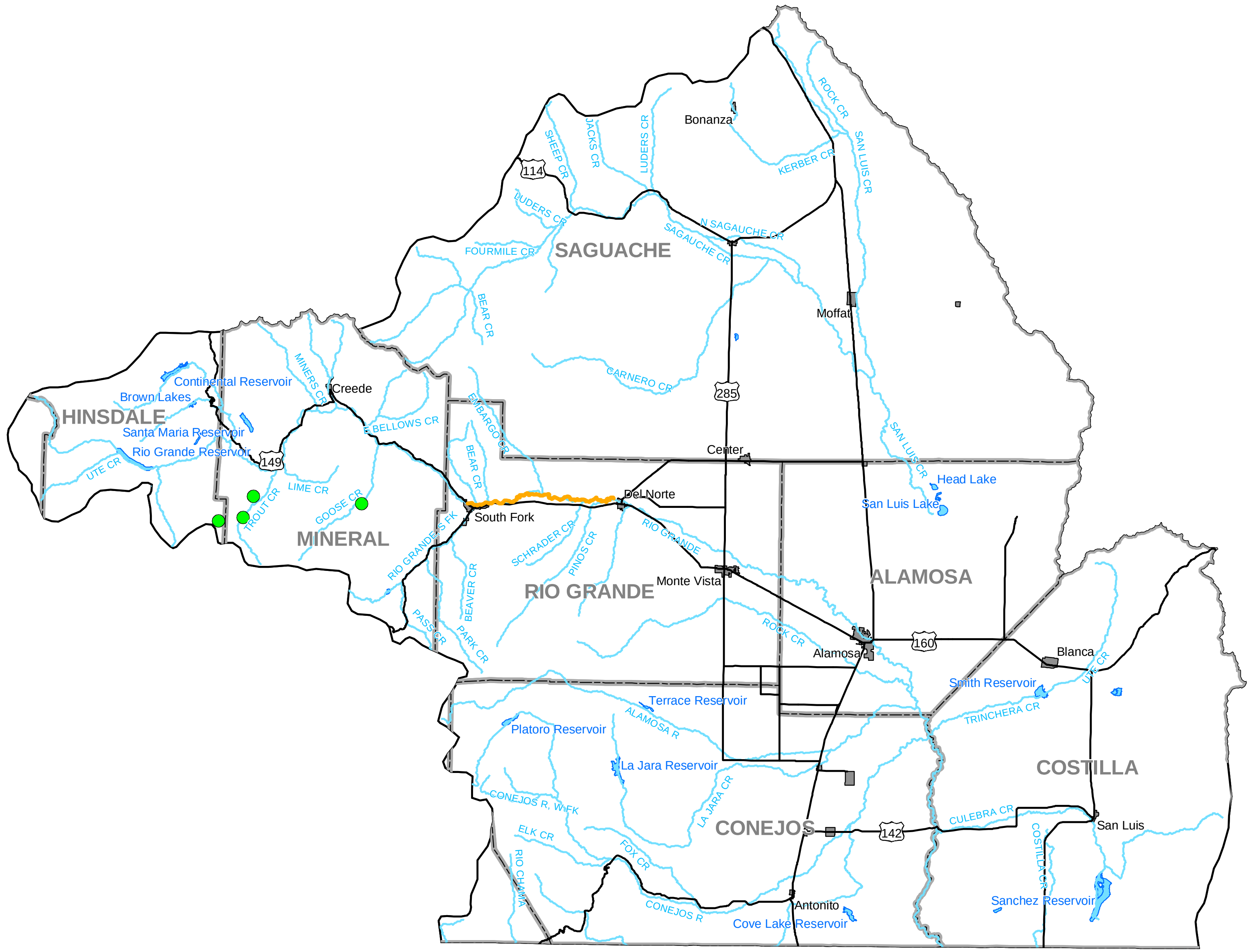

Figure 3-42
Rio Grande Basin
Areas of Environmental Concern

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Boreal Toad Critical Habitat
Gold Medal Trout Stream

The Rio Grande River Basin does not contain any Federally Listed Critical Habitat Streams, Greenback Cutthroat Trout Areas, or Arkansas Darter Areas

7 3.5 0 7 Miles

1:1,000,000

N

Coordinate System
NAD 1927 UTM Zone 13N

data source: Colorado Division of Wildlife

3.8 South Platte Basin

3.8.1 South Platte Basin Geography

The South Platte Basin (including the Republican River Basin) covers approximately 27,660 square miles in northeast Colorado, Figure 3-43. The largest cities in the basin are Denver (population 560,882), Aurora (population 287,216), and Lakewood (population 144,150) (DOLA 2003).

3.8.2 South Platte Basin Climate

The South Platte Basin receives relatively low precipitation, which can be highly variable from year to year. The basin also has widely variable daily and seasonal air temperatures (Woodward-Clyde Consultants 1982). Figure 3-44 shows color-fill contours of the average annual precipitation. The plains region is characterized by small amounts of precipitation averaging between 7 and 17 inches per year. Greater amounts of precipitation accumulate in the mountain region, which receive upwards of 30 inches annually. The foothills of the Front Range, which provide a transition zone between the mountains and the plains, annually receive an average of 17 to 21 inches of precipitation. The potential evapotranspiration exceeds precipitation in the basin in all areas except for the mountain region (CGS 2003).

3.8.3 South Platte Basin Topography

The topographic characteristics of the South Platte Basin are diverse. Elevations in the basin range from over 14,000 feet at the headwaters near the Continental Divide to 3,400 feet at the Colorado/Nebraska state line (CDPHE 2002). The headwaters of the South Platte River originate at an elevation of about 11,500 feet.

3.8.4 South Platte Basin Land Use

Approximately one-third of the basin's land area is publicly owned, and the majority of these lands are forest areas in the mountains. Table 3-13 shows the square miles and percent of total by land cover type.

Figure 3-45 summarizes the land cover by category for the South Platte Basin (USGS 1992). As the figure shows, western portions of the basin and its montane and subalpine areas are primarily forested, while the High Plains region is mainly grassland and planted/ cultivated land.

Table 3-13 Land Cover Data for the South Platte Basin

Land Cover	Basinwide Area (sq. miles)	Basinwide Percent of Total	Statewide Area (sq. miles)	Statewide Percent of Total
Grassland	13,956	50.5%	41,051	39.5%
Planted/ Cultivated	8,526	30.8%	13,737	13.2%
Forest	3,372	12.2%	29,577	28.4%
Shrubland	866	3.1%	16,883	16.2%
Developed	586	2.1%	923	0.9%
Open Water	247	0.9%	590	0.6%
Barren	89	0.3%	1,219	1.2%
Wetland	18	0.06%	80	0.08%
TOTAL	**27,659**		**104,067**	

Source: USGS 1992 NLCD

3.8.5 South Platte Basin Surface Geology

The mountains are comprised of Precambrian age metamorphic and igneous basement rocks. These rocks come into contact with Mesozoic and Paleozoic sedimentary rocks by a fault that runs north and south just west of Denver (CGS 2003). A well-known outcrop is observed along I-70 just west of C-470 revealing the many layers of sedimentary rock that form the Denver Basin.

3.8.6 South Platte Basin Surface Water

The South Platte River emerges out of the mountains southwest of the Denver metro region, flows through the Denver metropolitan urban area, and then enters the High Plains Region (Woodward-Clyde Consultants 1982).

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

The USGS monitors these streamflows with various gages located throughout the basin. Figure 3-46 shows the location of four selected streamflow gages in the South Platte Basin as well as major diversions in the basin and segments with decreed instream flow rights. Table 3-14 summarizes the mean annual streamflow, length of record and drainage area for each selected gage location.

3.8.7 South Platte Basin Groundwater

Groundwater is a substantial resource in the South Platte Basin. Approximately 880,000 acre-feet per year (AFY) of groundwater in the South Platte Basin is used for irrigation, and 100,000 AFY is used to meet municipal, domestic, livestock, industrial, and commercial purposes. These values do not include groundwater pumped from the Ogallala Aquifer. Residents in Phillips, Yuma, Washington, Kit Carson, Cheyenne, Lincoln, and Elbert counties rely almost entirely on groundwater. Those living in the counties of Sedgwick, Morgan, Weld, Adams, and Douglas also use groundwater to meet a large portion of their water demand (CGS 2003).

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

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

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

The reach of the South Platte River that begins southwest of the Denver Metro area and continues downstream to the state line is underlain by valley fill sediment forming the alluvial aquifer. This alluvial aquifer is composed primarily of poorly sorted gravel, sand, and clay. The saturated alluvium increases from 20 feet near Denver to over 200 feet at Julesburg with the thickest section running along the center of the historic river channel (CGS 2003).

The alluvial aquifer is estimated to contain as much as 8.3 million AF in storage and is hydraulically connected to the river (CGS 2003). Therefore, groundwater withdrawals, of which the majority are junior in priority to most surface water rights, can greatly affect the flow of the lower South Platte River. This segment, which is downstream of metro Denver, gives rise to the need for well augmentation plans to protect senior water rights.

In the lower South Platte River alluvium, there are approximately 10,880 permitted wells with yields ranging in capacity from 1 to 3,000 gpm. The average yield is 430 gpm; however, 50 percent of the wells have a yield of 30 gpm or less, which is biased by domestic wells (CGS 2003).

Table 3-14 Summary of Selected USGS Stream Gages for the South Platte River Basin

Site Name	USGS Site Number	Mean Annual Streamflow (AFY)	Mean Annual Streamflow (cfs)	Period of Record (Years)	Drainage (sq. miles)
Poudre	06752000	270,981	374	1881-2002	1,056
South Platte at South Platte	06707500	289,740	400	1896-2002	2,579
South Platte at Kersey	06754000	651,466	900	1901-2002	9,598
South Platte at South Julesburg	06764000	395,314	546	1902-2002	23,193

Source: USGS NWISweb/HydroBase database

The Denver Basin aquifers, which cover approximately 6,800 square miles, are comprised of the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers, are another important water resource for the South Platte Basin. The Denver Basin consists of Tertiary and Cretaceous age sedimentary rocks that supply groundwater for domestic, commercial, municipal, agricultural, and other users (CGS 2003).

There are also five Designated Groundwater Basins in the South Platte Basin, which include the Upper Crow Creek, Camp Creek, Northern High Plains, Lost Creek, and Kiowa-Bijou. Designated groundwater is water that under natural conditions would not be used to recharge or supplement continuously flowing surface streams (Hobbs 2003).

The Northern High Plains aquifer, which includes the Ogallala aquifer located in the Republican River Basin, is found in the eastern edge of Colorado in the High Plains region and is a major source of water for this agricultural region (CDPHE 2002). Groundwater withdrawals have exceeded recharge since the early 1960s. The mean well yield from this aquifer is 373 gpm and the median is 20 gpm (CGS 2003).

3.8.8 South Platte Basin Water Quality

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

The upper South Platte River watershed is an area that has been affected by historic mining districts (i.e., Mosquito Creek), water resource development (i.e., South Park Dams and water diversions), and severe sediment deposition from forest fires such as the recent Hayman, Buffalo Creek and Hi Meadows fires (CDPHE 2002).

The middle reach of the watershed, from below Chatfield Reservoir to the confluence with the Cache la Poudre River, has experienced some of the most intense use and resultant impacts of any river in Colorado. This segment of the river has seen historic mining districts, explosive urban development, stormwater runoff, extensive hydrologic modification, urban and agricultural nutrient loading, and effects of Superfund sites. Pollutants that have impaired the waters of the South Platte Basin include nitrate, ammonia, and copper (CDPHE 2000). Furthermore, the South Platte River through and downstream of the Denver urban area exceeds *E. coli* standards (CDPHE 2002).

The lower reach of the South Platte River, from the Cache la Poudre River to Julesburg, has been affected by upstream urbanization, historic agricultural land use, and waste disposal due to animal feeding operations. Non-point source pollution from pesticide and fertilizer runoff is the primary concern in this segment of the lower South Platte River (CDPHE 2002).

Downstream of the Denver area, groundwater in the alluvial aquifer exceeds the nitrate limit for drinking water standards in some areas. The nitrate contamination not only affects the drinking water supply of several eastern plains cities, but can also be detrimental to certain crops when used for irrigation (CDPHE 2002).

Groundwater in the alluvial aquifer near Denver contains approximately 1,000 ppm TDS. This concentration increases to about 4,000 ppm near Sterling. Surface water at the state line with Nebraska has an average TDS concentration of 1,300 ppm (CGS 2003). These concentrations are of concern because water containing greater than 2,000 ppm TDS is generally considered to be unsuitable for irrigation (CDPHE 2002).

Figure 3-48 identifies the locations of surface waters in the South Platte Basin that have been listed for impairment for one or more parameters on Colorado's 2002 303(d) list. Stream segments proposed for listing via the 2004 303(d) list and the accompanying Monitoring and Evaluation list are described in Colorado WQCC Regulations 93 and 94. The state's 2004 proposed 303(d) list incorporates several additions from the 2002 list. It includes numerous surface waters that span the basin's diverse topography and land uses. Listed segments proposed for the upper South Platte and its tributaries, such as Clear Creek, are primarily listed for metals such as cadmium, copper, and zinc. Certain stream segments in urbanized areas are listed for bacteria and other constituents. A variety of constituents comprises the remainder of the listings for other parts of the basin, including several segments listed for selenium.

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

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

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

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

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

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

Figure 3-49 shows the locations of some of the basin's key aquatic species habitat.

Areas of high recreational value in the basin, including the Mount Evans Wilderness Area, Rocky Mountain National Park, and Chatfield State Park, are discussed in Section 6.

3.8.10 South Platte Basin Energy and Mineral Resources

More than 250 identifiable minerals have been located in deposits in the South Platte Basin. Other important natural resources in the basin include natural gas, petroleum, and coal. Over 130 million tons of coal was produced from the Denver Basin from 1883 to 1978 (Woodward-Clyde Consultants 1982).

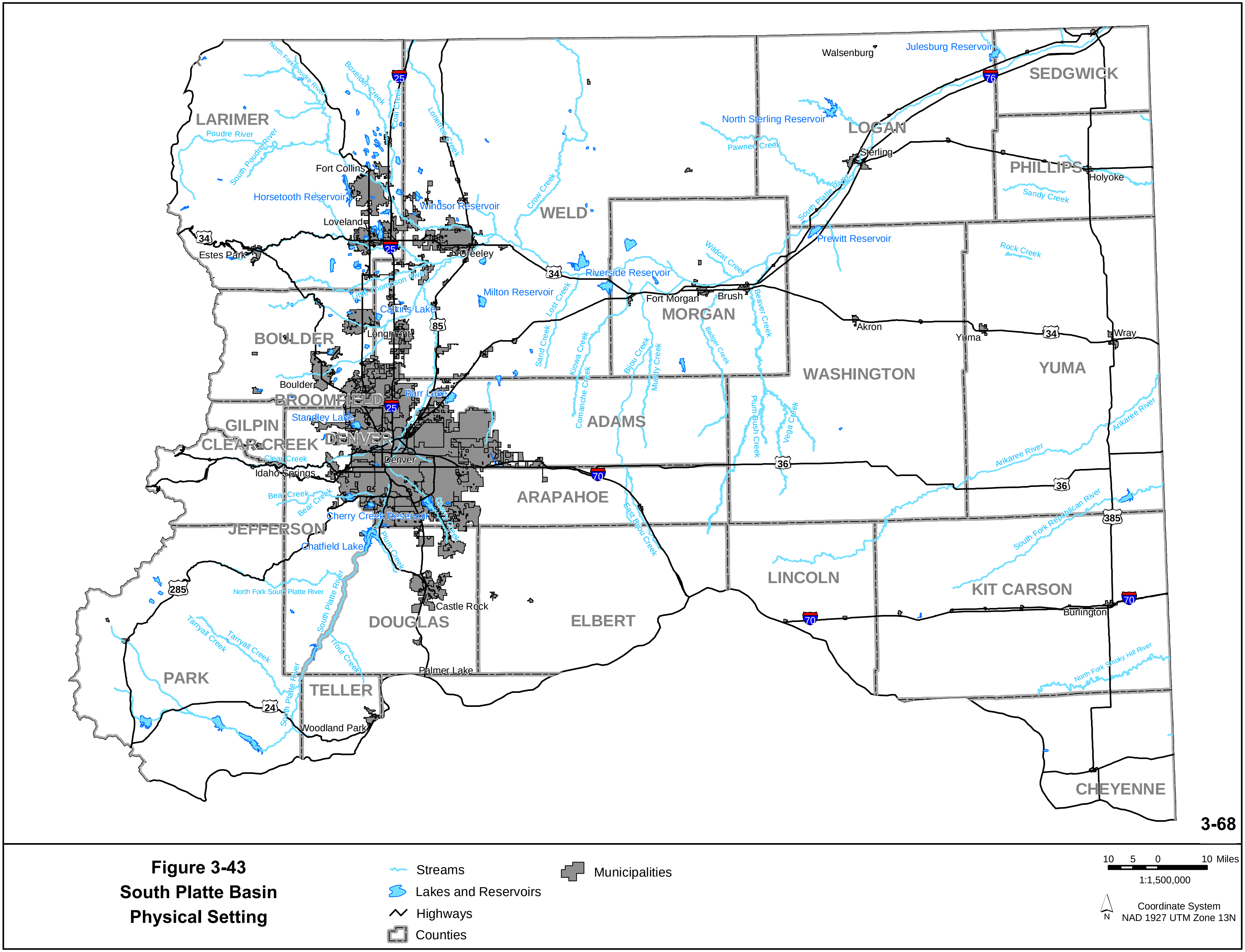

Figure 3-43
South Platte Basin
Physical Setting

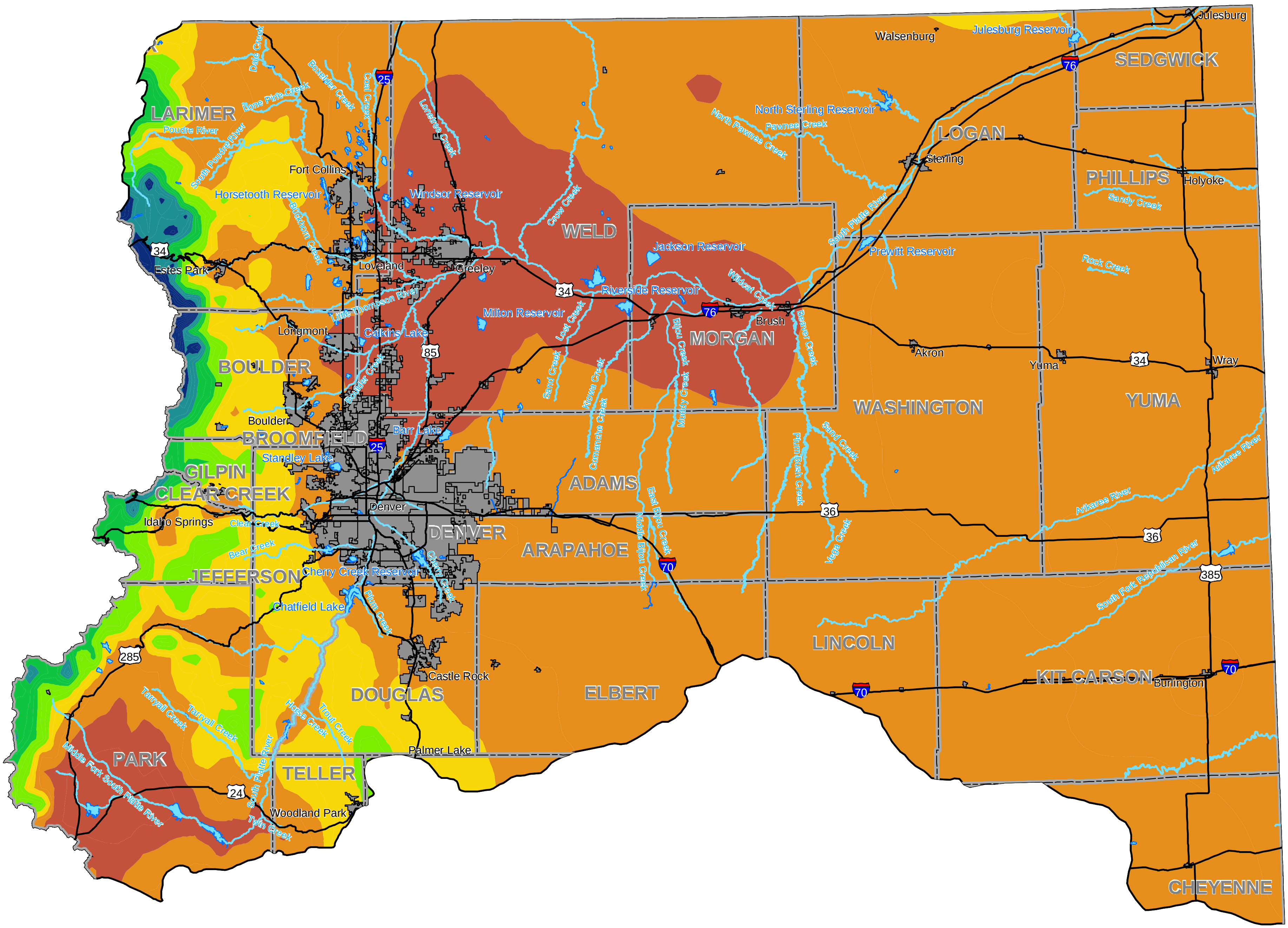

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Figure 3-44
South Platte Basin
Physical Setting

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

Mean Annual Precipitation, Inches
7.0 - 13.0
13.1 - 17.0
17.1 - 21.0
21.1 - 27.0
27.1 - 33.0
33.1 - 39.0
39.1 - 63.0

10 5 0 10 Miles
1:1,500,000
N
Coordinate System
NAD 1927 UTM Zone 13N

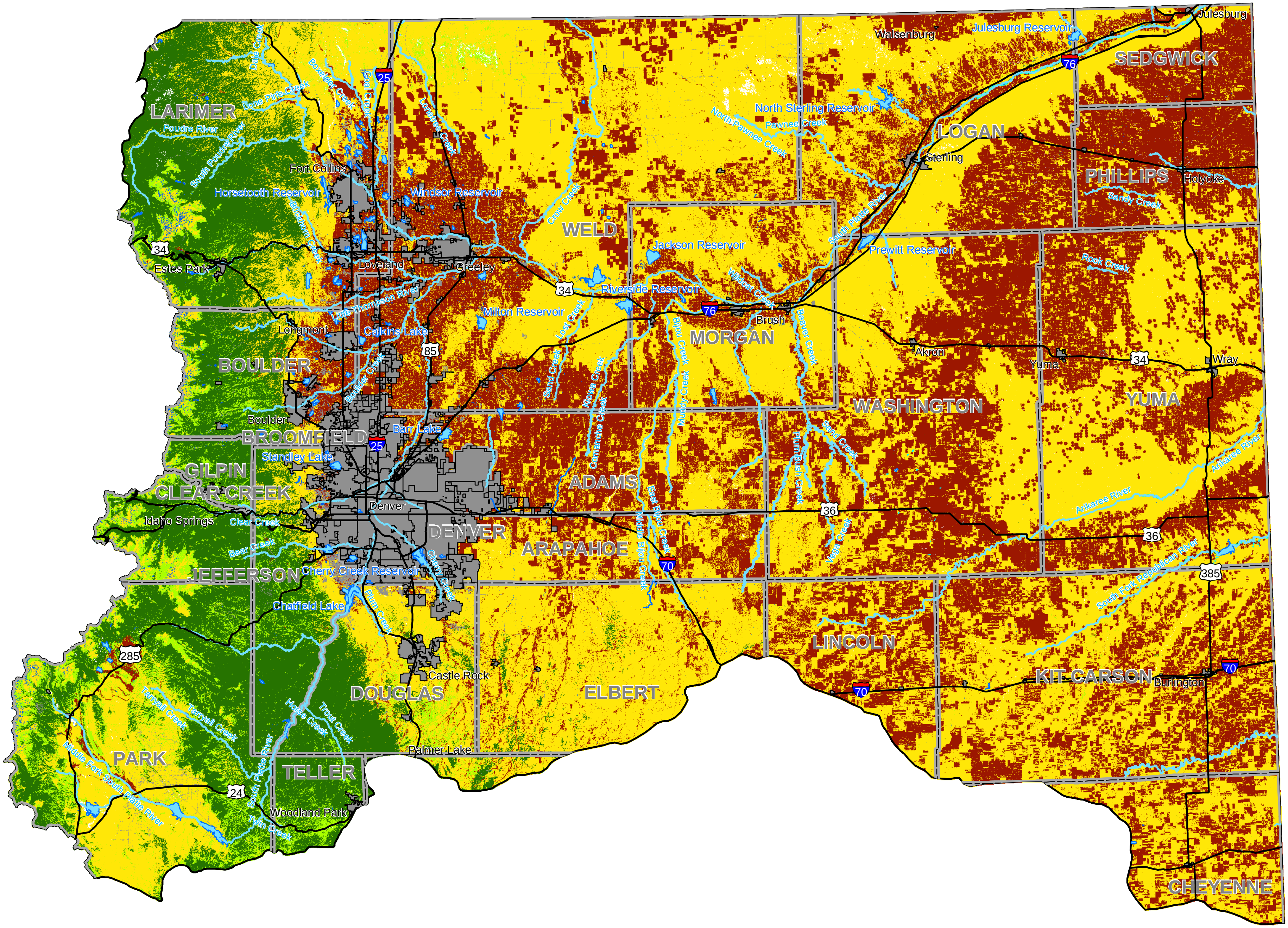

Figure 3-45
South Platte Basin
Land Use

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

Land Cover

- Open Water
- Developed
- Barren
- Forest
- Shrubland
- Orchards/Vinyards
- Grassland
- Planted/Cultivated
- Wetland

9 4.5 0 9 Miles
1:1,500,000

N

Coordinate System
NAD 1927 UTM Zone 13N

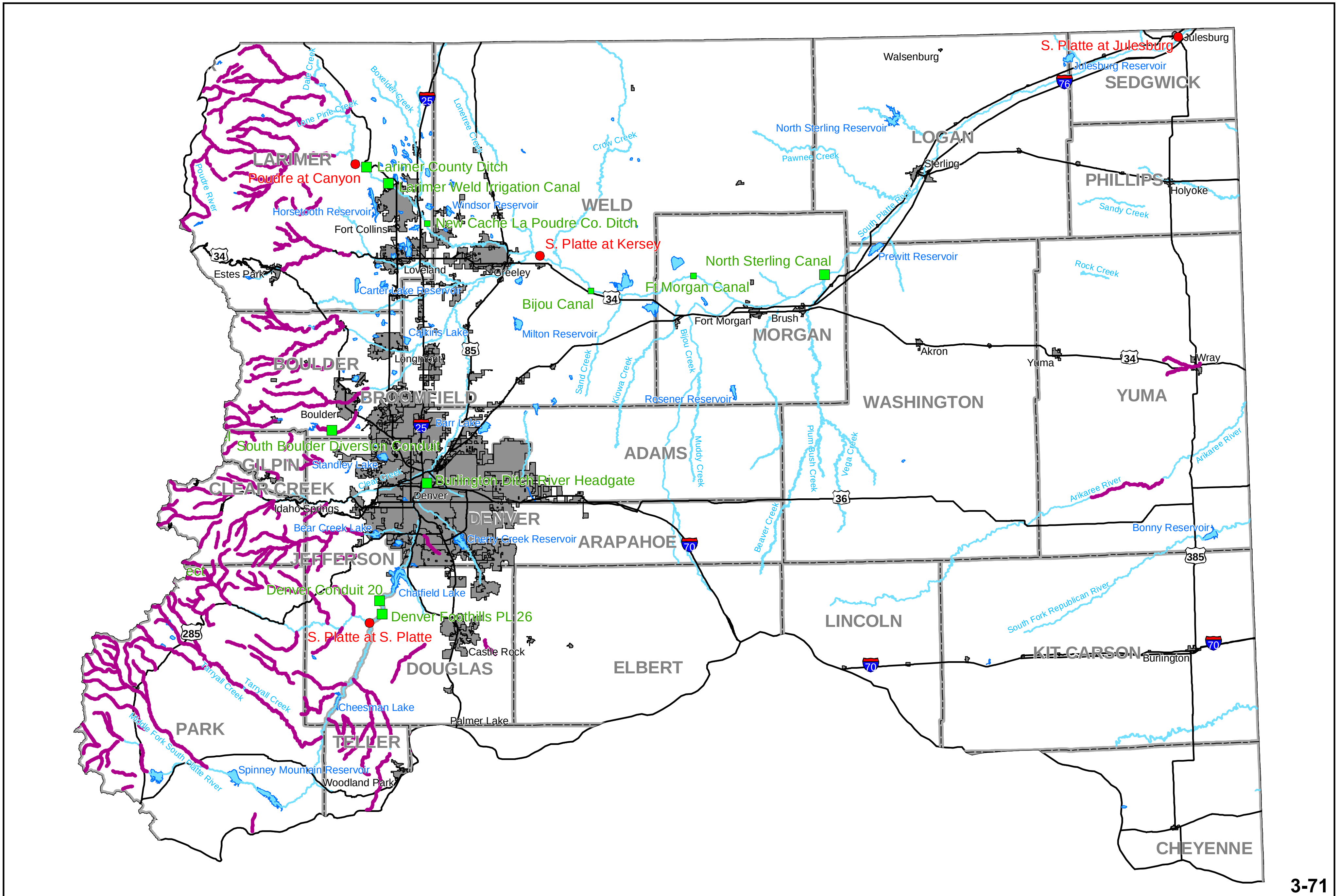

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Figure 3-46
South Platte Basin Key Diversions and Streamflow Gage Locations

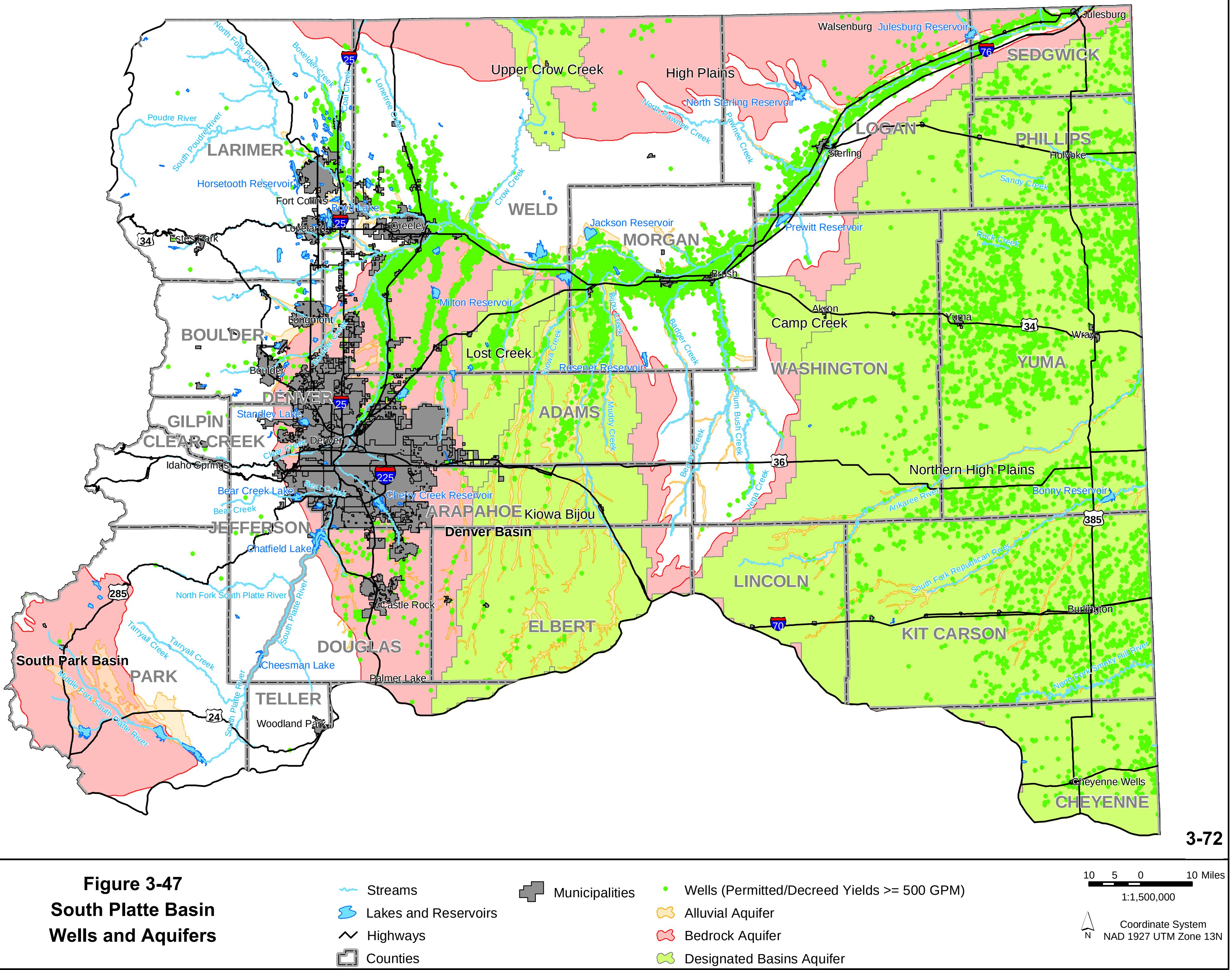


Figure 3-47
South Platte Basin
Wells and Aquifers

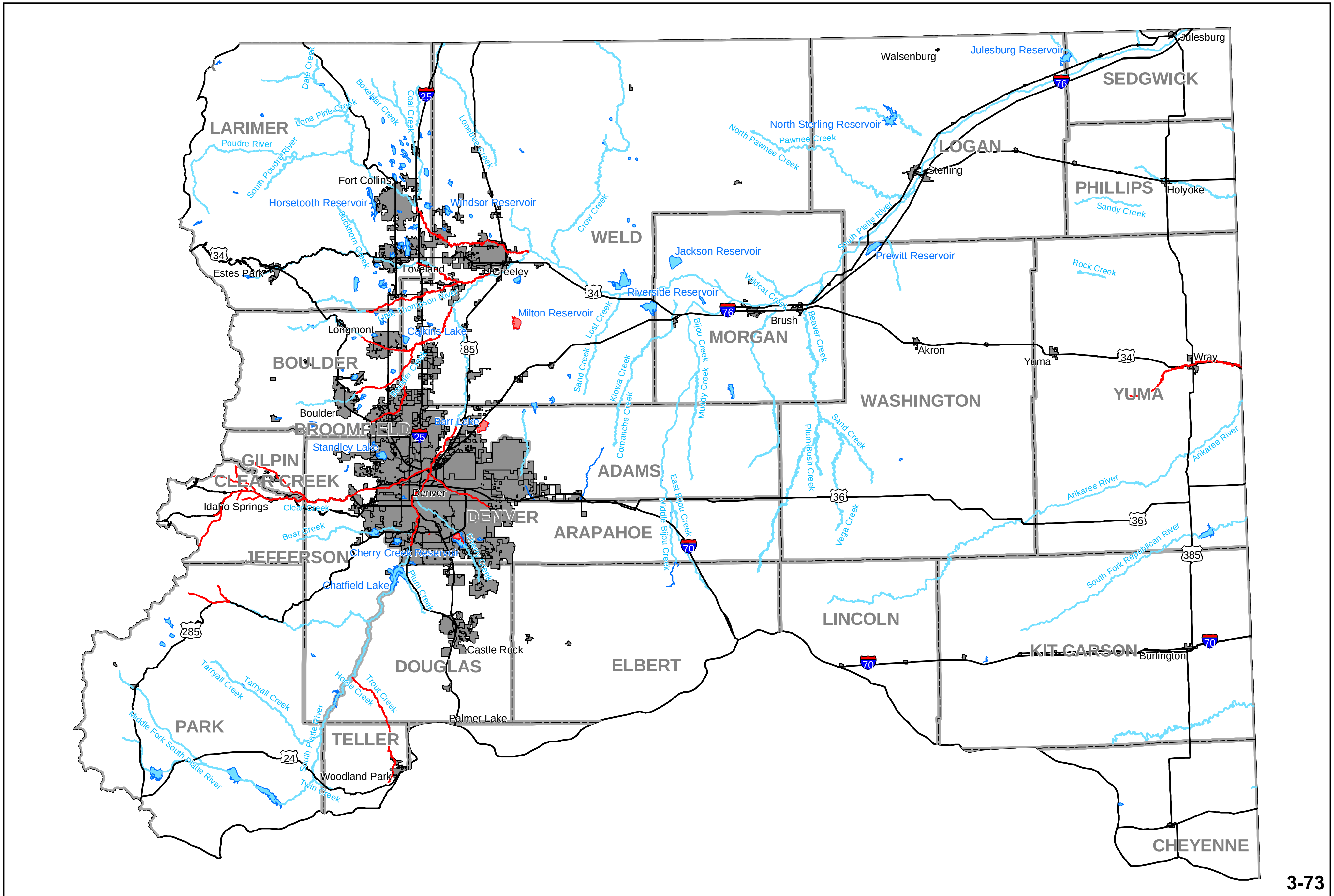


Figure 3-48
South Platte Basin
303(d)-Listed Streams

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
303d Streams
303d Lakes

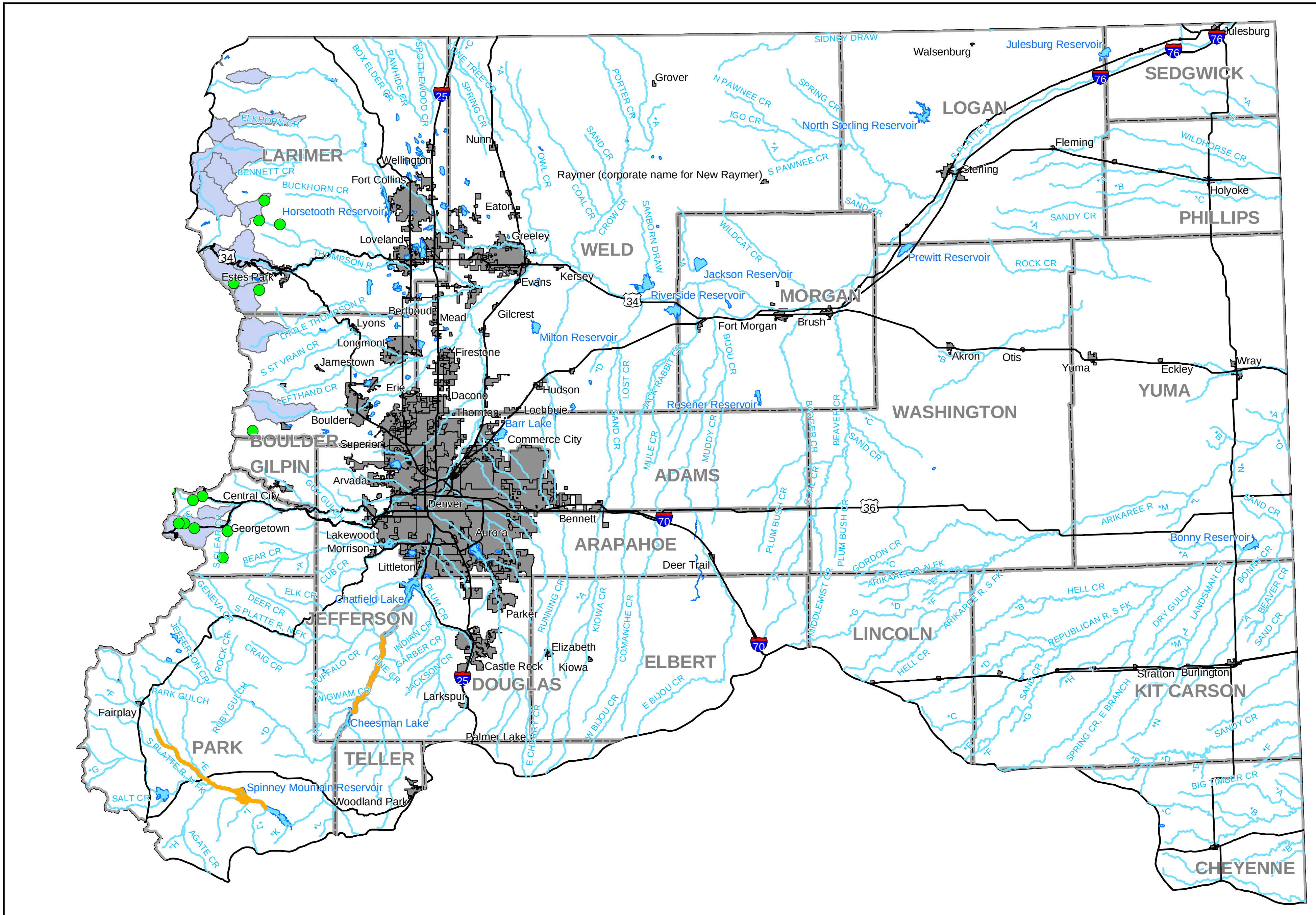


Figure 3-49
South Platte Basin
Areas of Environmental Concern

Streams

Lakes and Reservoirs

Highways

Counties

Municipalities

Boreal Toad Critical Habitat

Gold Medal Trout Stream

Gold Medal Trout Lake

Greenback Cutthroat Trout Areas

9 4.5 0 9 Miles

1:1,500,000

The South Platte River Basin does not contain any Federally Listed Critical Habitat Streams, or Arkansas Darter Areas

N

Coordinate System NAD 1927 UTM Zone 13N

data source: Colorado Division of Wildlife

3.9 Yampa/White/Green Basin

3.9.1 Yampa/White/Green Basin Geography

The Yampa/White/Green Basin covers roughly 10,500 square miles in northwest Colorado and south-central Wyoming (Roehm 2003), as shown in Figure 3-50. The largest cities or towns in the basin are Steamboat Springs (population 10,402) and Craig (population 9,185) (DOLA 2002).

3.9.2 Yampa/White/Green Basin Climate

The Yampa/White/Green Basin climate can be characterized by cool, dry summers and cold winters. Average July temperatures range from 62°F in Steamboat Springs to 73°F in Dinosaur, and average January temperatures range from 15°F in Steamboat Springs to 21°F in Dinosaur (Yampa Valley Partners 2002). Figure 3-51 shows the mean annual precipitation over the Yampa/White/Green Basin. The western edge of the basin averages between 7 and 17 inches of precipitation annually, while the far eastern edge near the Continental Divide averages anywhere between 39 and 63 inches.

3.9.3 Yampa/White/Green Basin Topography

The Yampa/White/Green Basin is defined by the Continental Divide on the east and north and the White River Basin in the south. The elevations in the basin range from 12,200 feet (Mount Zirkel) in the Sierra Madre range to about 5,100 feet at the confluence of the Yampa and Green Rivers at Echo Park within Dinosaur National Monument (Roehm 2003). The basin contains diverse landforms including steep mountain slopes, high plateaus, rolling hills, incised sandstone canyons, and broad alluvial valleys and floodplains.

3.9.4 Yampa/White/Green Basin Land Use

Large portions of the basins are federally owned lands. Livestock, grazing, and recreation are predominant land uses in the basins. Steamboat Springs is a destination ski resort and is likely to experience continued population growth (WQCD 2002).

Figure 3-52 shows the land cover within the Yampa/White/Green Basin (USGS 1992). Near the towns of Craig, Hayden, Steamboat Springs, Yampa, and Meeker, much of the land is dedicated to agricultural use. The mountains are densely covered by forest. The valley and plateaus are mostly covered by shrubland and are also dotted with forest. Table 3-15 also shows the area and percent of total for various land cover types.

Table 3-15 Land Cover Data for the Yampa/White/Green Basin

	Basinwide		Statewide	
Land Cover	Area (sq. miles)	Percent of Total	Area (sq. miles)	Percent of Total
Shrubland	4,411	41.9%	16,883	16.2%
Forest	4,372	41.5%	29,577	28.4%
Grassland	1,289	12.2%	41,051	39.5%
Planted/ Cultivated	320	3.0%	13,737	13.2%
Barren	99	0.9%	1,219	1.2%
Open Water	19	0.2%	590	0.6%
Developed	15	0.2%	923	0.9%
Wetland	3	0.03%	80	0.08%
Orchards/ Vineyards	0	0.00%	5	0.00%
TOTAL	**10,528**		**104,067**	

Source: USGS 1992 NLCD

3.9.5 Yampa/White/Green Basin Surface Geology

The surficial geology in the Yampa/White/Green Basin consists of Precambrian age metamorphic rocks extensively intruded by granitic rocks and quartzite. These rocks are exposed in the central parts of the mountain uplifts. Overlying these rocks are sedimentary rocks of Paleozoic, Mesozoic and Cenozoic age with a net thickness of 25,000 feet (Pearl 1980).

3.9.6 Yampa/White/Green Basin Surface Water

The Yampa River collects water from roughly 8,000 square miles in northwestern Colorado. The headwaters are located west of the Continental Divide in the White River Plateau (Roehm 2003). The Yampa River flows through the town of Yampa, past Steamboat Springs, and then heads west past Craig. The Little Snake River joins the Yampa 5 miles before entering Dinosaur National Monument. In Dinosaur National Monument, the Yampa River flows into the Green River about 5 miles from the Colorado-Utah state line.

Figure 3-50 shows the geographical layout of the rivers and tributaries in the Yampa and White Basins.

The White River flows from its headwaters in the Flat Tops Wilderness Area west to the Town of Buford. It then flows past Meeker and parallels Highway 64 to the Utah state line. In Utah, the White River flows into the Green River, which is a tributary of the Colorado River.

Streamflows are continuously measured at a number of USGS gaging stations in the Yampa/White/Green Basin. Streamflow gages were selected to provide a sample of flow characteristics throughout the basin. Table 3-16 lists gage data from selected locations in the basin. Figure 3-53 shows the locations of these streamflow gages.

3.9.7 Yampa/White/Green Basin Groundwater

The Yampa/White/Green Basin overlays three separate groundwater basins: the Piceance Basin, the Sand Wash Basin, and the Eagle Basin. The aquifers included in these areas include:

- Upper Piceance Basin
- Mahogany confining unit
- Lower Piceance Basin
- Basal confining unit
- Wasatch-Fort Union
- Weber Sandstone
- Maroon and Minturn Formation

Figure 3-54 shows these significant aquifers and also wells with decreed or permitted yields greater than or equal to 500 gpm. In the figure, the aquifers are broken into the alluvial aquifer and the bedrock aquifer. The bedrock aquifer is comprised of the aquifers listed above.

The majority of the White Basin overlies the Piceance Basin. The basin contains four primary layers: Upper Piceance Basin aquifer, Mahogany confining unit, Lower Piceance Basin aquifer, and a Basal confining unit (CGS 2003).

The upper portion of the Yampa River and the Little Snake River, a tributary to the Yampa, overly the Sand Wash Basin (CGS 2003). The confined Tertiary aquifer system (Wasatch-Fort Union aquifer) is the uppermost regional aquifer in the Sand Wash Basin. From the limited available data, this aquifer is estimated to range from less than 1,000 to more than 4,000 feet thick (CGS 2003).

The Eagle Basin, located in the southern portion of Rio Blanco County, is comprised primarily of sandstone aquifers including the Weber Sandstone and Maroon and Minturn Formations. These aquifers are underlain by the Eagle Valley Evaporite confining unit (CGS 2003).

Table 3-16 Summary of Selected USGS Stream Gages for the Yampa/White/Green River Basin

Site Name	USGS Site Number	Mean Annual Streamflow (AFY)	Mean Annual Streamflow (cfs)	Period of Record (Years)	Drainage (sq. miles)
Yampa River at Steamboat Springs	09239500	336,638	465	1910-2002	604
Yampa River near Maybell	09251000	1,134,945	1,568	1916-2002	3,410
Little Snake River near Lily	09260000	417,948	577	1921-2002	3,730
North Fork White River at Buford	09303000	229,899	318	1952-2001	259
White River near Meeker	09304500	451,554	624	1909-2002	755

Source: USGS NWISweb/HydroBase database

3.9.8 Yampa/White/Green Basin Water Quality

Each water body in the Yampa/White/Green Basin has a designated use classification, which is related to water quality. Nearly all waters in the basin fully support their designated use (CDPHE 2002). Headwater segments of both the White and Yampa Rivers have been designated as outstanding waters, which constitutes the highest level of water standards.

Many lower tributaries in the Piceance Creek Basin, located in the central portion of Rio Blanco County, exhibit poor quality due primarily to the streams being fed by groundwater in contact with oil shale. These streams have exceedingly high concentrations of dissolved solids, sulfates, and other minerals associated with oil shale. Other lower elevation streams in the White Basin suffer from high sediment loads due to land management practices on highly erosive soils (CDPHE 2002).

No surface waters in the Yampa/White/Green Basin were listed for impairment on Colorado's 2002 303(d) list. Stream segments proposed for listing via the 2004 303(d) list and the accompanying Monitoring and Evaluation list are described in Colorado WQCC Regulations 93 and 94. The state's 2004 proposed 303(d) list includes listed segments for pH and selenium in Middle Creek and Dry Creek, respectively. Flag Creek in the White Basin is proposed to be listed for selenium.

3.9.9 Yampa/White/Green Basin Areas of Environmental Concern, Special Attention Areas, and Threatened and Endangered Species

Issues of environmental concern in the Yampa/White/Green Basin include protection and recovery of endangered species. For a complete list of federal and/or state listed fish species and other species in the Yampa/White/Green Basin, along with information on RICDs, see Appendix C.

Figure 3-55 shows the locations of some of the basin's key aquatic species habitat.

In addition to impaired areas and those with threatened and endangered species, areas with high environmental or recreational value require special attention when evaluating water supply projects in the Yampa/White/Green Basin.

Areas with recreational value include those designated as Gold Medal waters. Steamboat Lake, located in Steamboat Lake State Park about 30 miles north of Steamboat Springs, has received Gold Medal designation in the Yampa/White/Green Basin. Steamboat Lake offers fishing for rainbow trout, Snake River cutthroats, and brown trout.

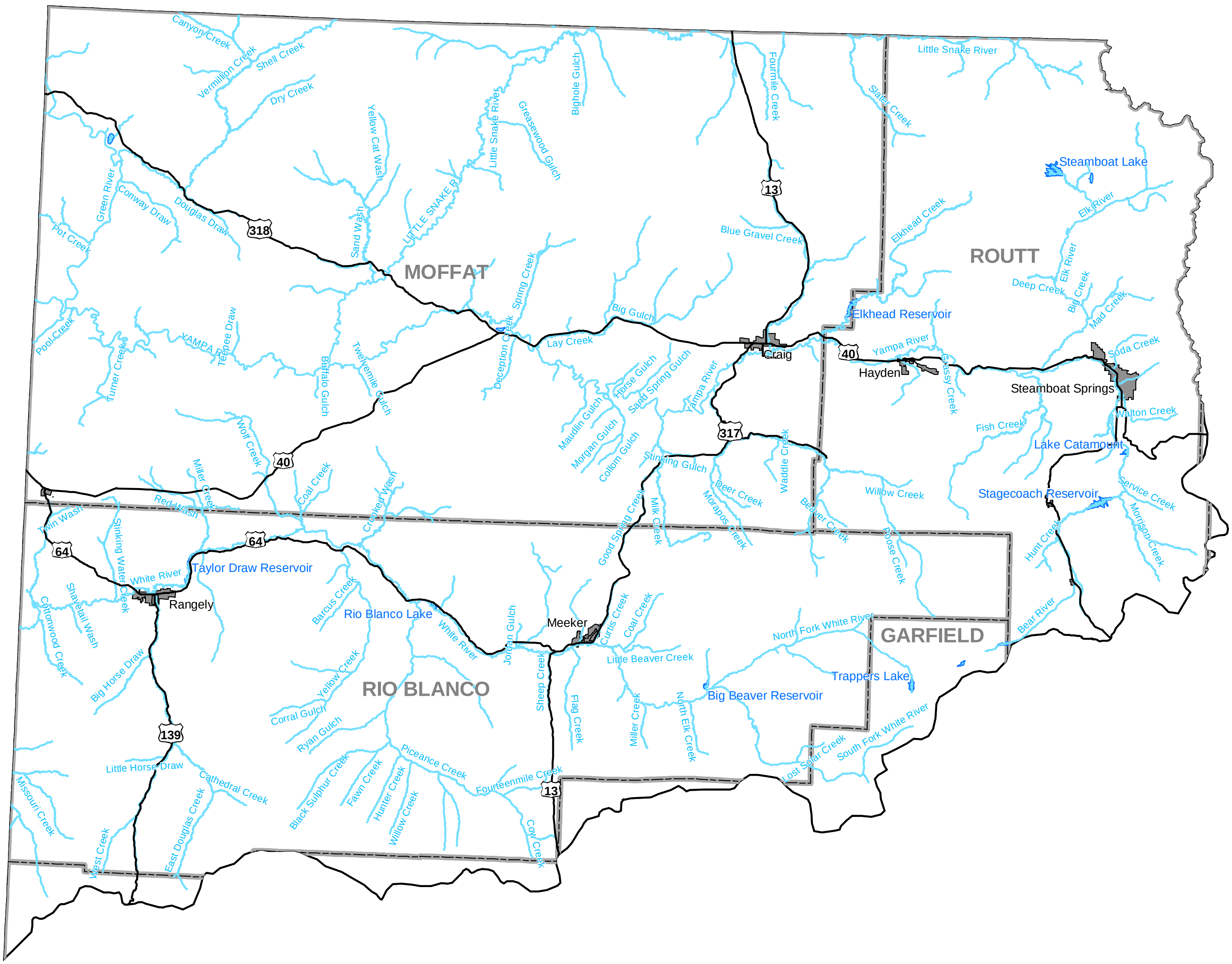
Other areas of high recreational value in the basin, including whitewater reaches of the White and Yampa Rivers, Dinosaur National Monument, and the Mount Zirkel Wilderness area, are discussed in Section 6.

3.9.10 Yampa/White/Green Basin Energy and Mineral Resources

Significant coal and oil shale reserves exist in the Yampa/White/Green Basin. Although coal has been mined in the Yampa River Valley for more than 80 years, coal resources remain substantial. According to broadly defined resources, Yampa River Valley coal reserves are estimated at nearly 29 billion tons (BBC Research and Consulting 1998).

In 1996, Yampa River Valley mines produced about 15 million tons of coal, representing approximately 60 percent of all Colorado coal production. The average annual rate of coal production in the Yampa River Valley increased nearly 8 percent from 1955 to 1996. Yampa River Valley coal is used by utilities throughout the country and also burned locally in the Craig and Hayden power plants (BBC Research and Consulting 1998).

The potential for energy resource development in the basin may represent a significant water quality issue in the future. However, only coal mining and limited soda ash extraction operations in the basins are currently active (CDPHE 2002).



3-78

Figure 3-50
Yampa/White/Green Basin Physical Setting

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

10 5 0 10 Miles
1:1,000,000

N
Coordinate System
NAD 1927 UTM Zone 13N

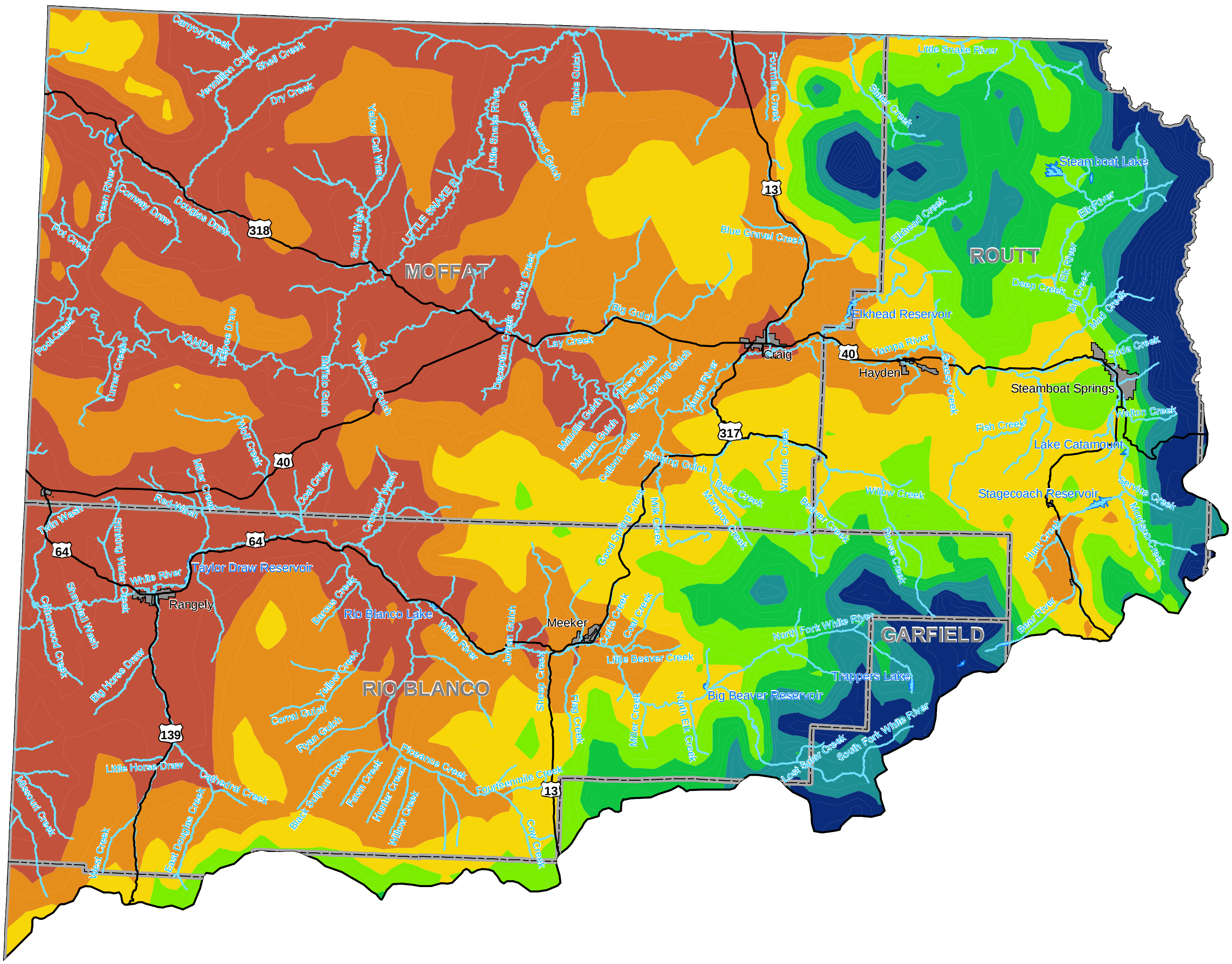


Figure 3-51
Yampa/White/Green Basin
Mean Annual Precipitation

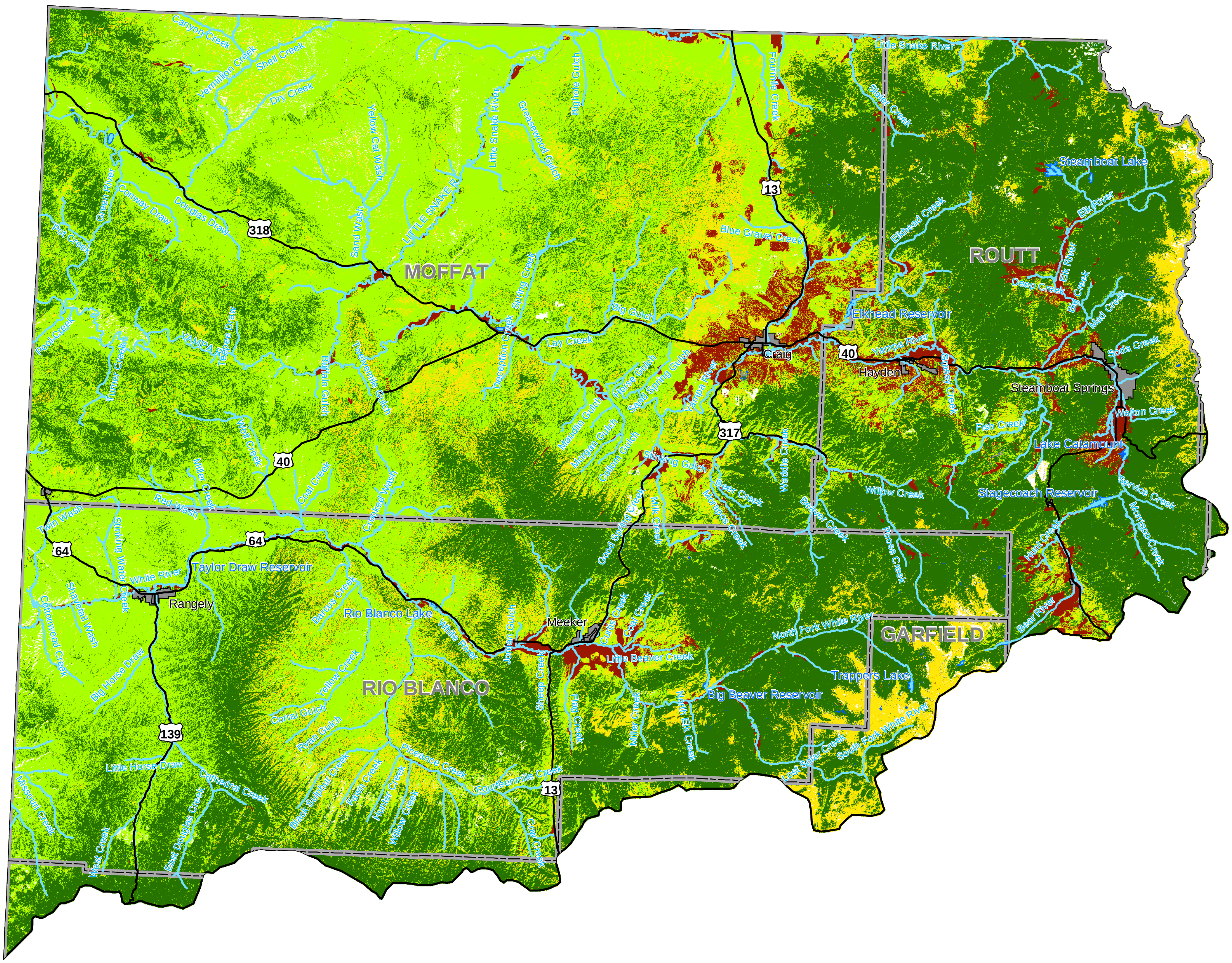


Figure 3-52
Yampa/White/Green Basin
Land Use

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

Land Cover
Open Water
Developed
Barren
Forest
Shrubland
Orchards/Vinyards
Grassland
Planted/Cultivated
Wetland

10 5 0 10 Miles
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Coordinate System
NAD 1927 UTM Zone 13N

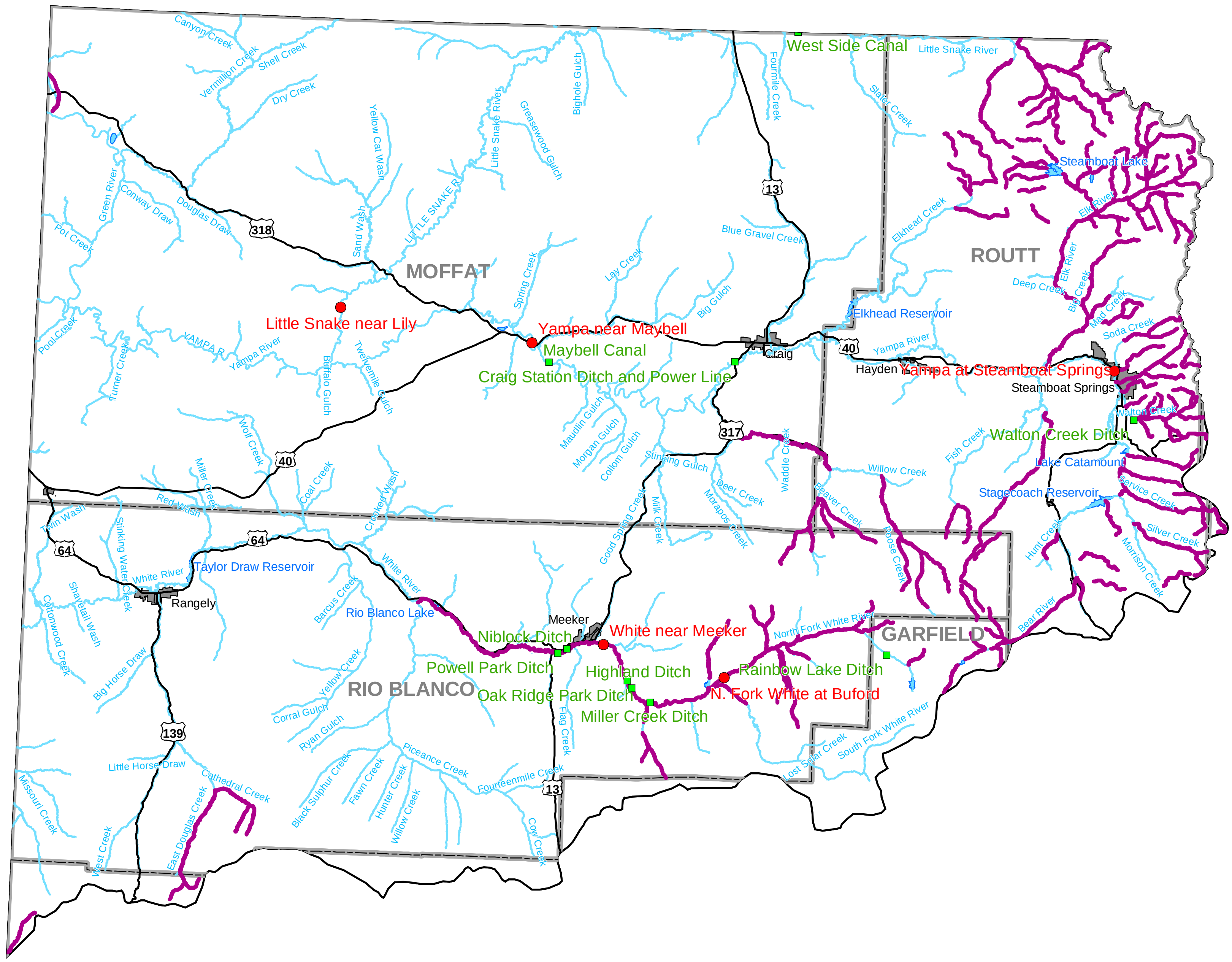

Figure 3-53
Yampa/White/Green Basin Key Diversions and Streamflow Gage Locations

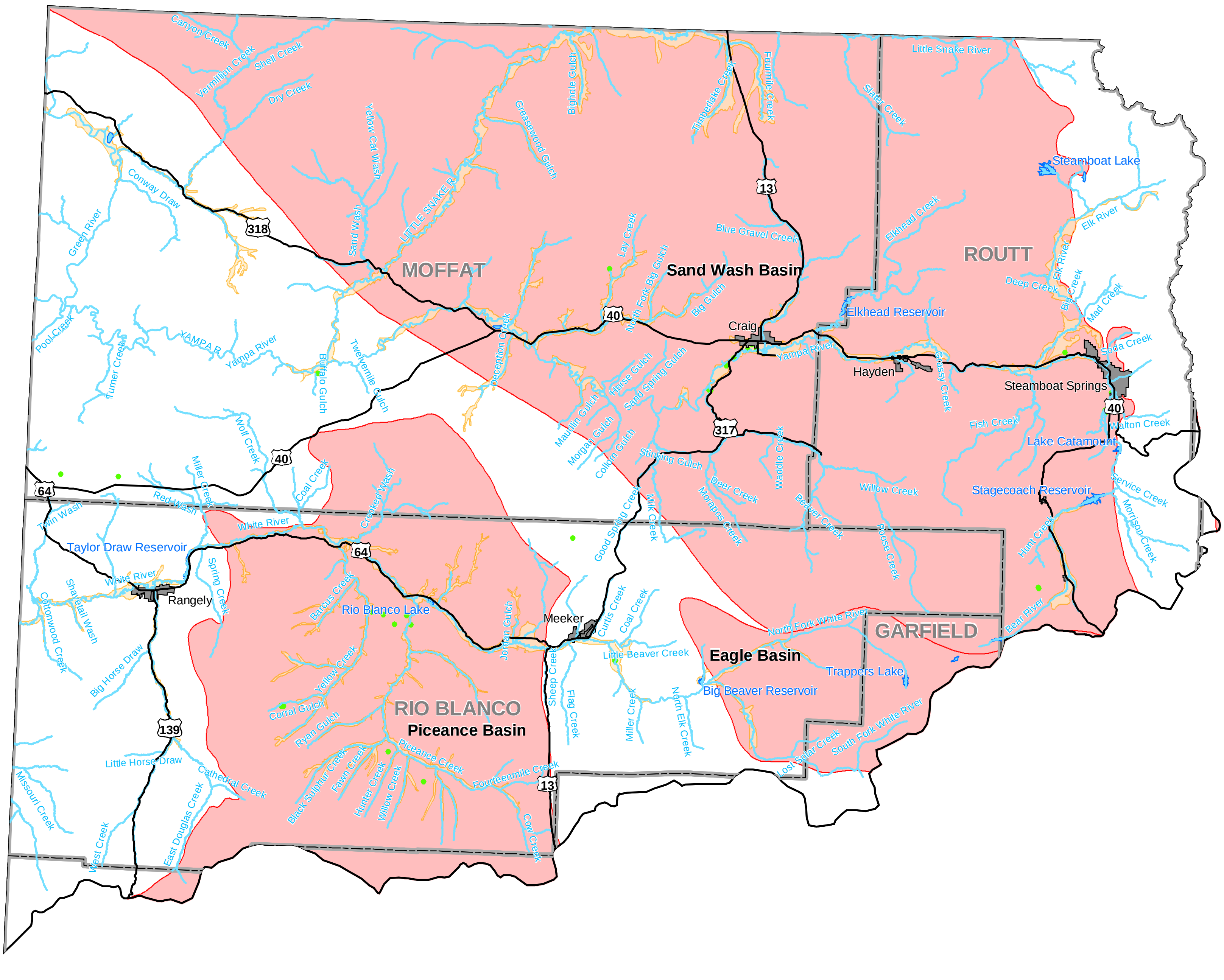

Figure 3-54
Yampa/White/Green Basin Wells and Aquifers

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Wells (Permitted/Decreed Yields >= 500 GPM)
Alluvial Aquifer
Bedrock Aquifer

10 5 0 10 Miles
1:1,000,000
N
Coordinate System
NAD 1927 UTM Zone 13N

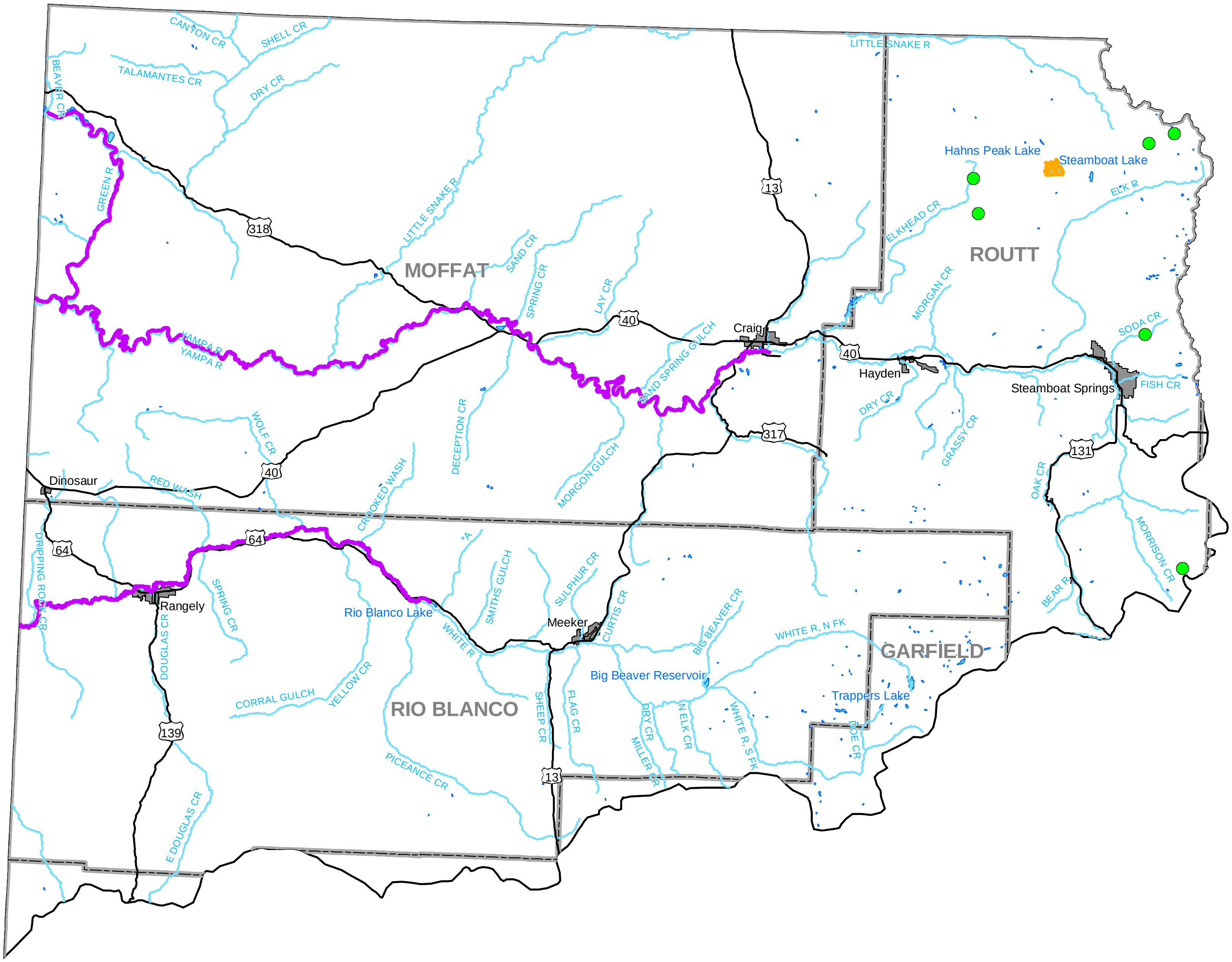

Figure 3-55
Yampa/White/Green Basin
Areas of Environmental Concern

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Boreal Toad Critical Habitat
Federally Listed Critical Habitat
Gold Medal Trout Lake

The Yampa/White River Basin does not contain any Greenback CutthroatTrout Areas, or Arkansas Darter Areas

7 3.5 0 7 Miles

1:1,000,000

N

Coordinate System
NAD 1927 UTM Zone 13N

data source: Colorado Division of Wildlife

Section 4
Legal Framework for Water Use

4.1 Overview of State Water Laws

The following basic overview of Colorado Water Law is derived primarily from Chapter 5 of the CWCB's Drought and Water Supply Assessment Report and the Colorado Foundation for Water Education's Citizen's Guide to Colorado Water Law.[1]

4.1.1 Colorado's Prior Appropriation System

As in most arid western states, the allocation of water in Colorado is governed by the doctrine of "prior appropriation," commonly described as "first in time, first in right."[2] Under this doctrine, rights to water are granted upon the appropriation of a certain quantity of water for a beneficial use.[3] The date of appropriation determines the priority of the water right, with the earliest appropriation establishing the most senior, or superior, right.[4] Thus, the right to use water in Colorado is based on a prior appropriation, rather than by grant from the state.[5] The right to use water is a valuable property right that arises by placing unappropriated water to beneficial use.[6] This right is protected under Colorado law and is rooted in Colorado's Constitution, which establishes that public uses of water in Colorado are subject to the right to appropriate a water right for private use:

> The water of every natural stream, not heretofore appropriated within the State of Colorado, is hereby declared to be the property of the public, and the same is dedicated to the use of the people of the state, subject to appropriation as hereinafter provided. Colo. Const. Art. XVI, § 5.
>
> The right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied. Colo. Const. Art. XVI, § 6.

Like other property rights, vested water rights may not be taken without payment of just compensation, and they may be conveyed separate from the land on which they are used.[7]

As the doctrine of prior appropriation has been interpreted through case law, two major principles regarding the requirement of "beneficial use" and the concept of water as a property right have emerged. First, a water right does not include the right to waste the resource. Second, the right to use water must be sufficiently flexible to accommodate changes of use and the free transferability of water rights in order to allow the maximum use of water. With regard to the former, Colorado courts have required water users to employ an efficient means of diversion, and have limited the amount of water that may be appropriated to the amount necessary for the actual use. With regard to the later – flexible use of water rights – Colorado law recognizes

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1 This overview is general in nature. For additional, more detailed information, see Chapter 5 of the CWCB's Drought and Water Supply Assessment Report; Vranesh's Colorado Water Law (Revised ed. 1999) James N. Corbridge Jr. and Teresa Rice; Citizens Guide to Colorado Water Law, (Revised ed. 2004) Justice Gregory Hobbs, Jr.

2 See Irwin v. Phillips, 5 Cal. 140 (1885)

3 See Colo.Const. Art. XVI, § 6 (The right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied"); see also C.R.S. § 37-92403(3(a) ("Appropriation" means the application of a specified portion of the waters of the state to a beneficial use pursuant to the procedures prescribed by law"); and Board of County comm'rs v. Upper Gunnison River Water Conservancy Dist., 838 P.2d 840 (Cob. 1992) ("To be effective, an appropriation must divert a definite quantity of water with the intent of applying such water to beneficial use").

4 See Colo.Const,. Art.XVI, § 6 ("Priority of appropriation shall give the better right as between those using the water for the same purpose"); Farmers' High Line Canal & Reservoir Co. v. Southworth, 21 p. 1028 (1889) ("Priority of right to water by priority of appropriation is older than the constitution itself, and has existed from the date of the earliest appropriations of water in the boundaries of Colorado").

5 The other major approach to water rights allocation in the United States is known as the "riparian" system, which is prevalent in the water rich states of the eastern United States. Under this system, water is allocated based on land ownership. Most riparian states now have permit statutes, under which an administrative official determines the quantity of water that may be diverted, and the terms and conditions for its use, based on criteria adopted by the legislature to protect public interests in the resource.

6 See Sherwood Irrigation Co. v. Vandewark, 331 P.2d 810 (1958) ("Water is a valuable property right, subject to sale and conveyance"); see also Justice Gregory Hobbs, "Colorado Water Law: An Historical Overview," 1 U. Denv. Water L. Rev. 1 at 2 ("Western prior appropriation water law is a property rights-based allocation and administration system, which promotes multiple use of a finite resource.").

7 See Strickier v. City of Colorado Springs, 26 P. 313, 316 (Cob. 1891) ("A priority to the use of water for irrigation or domestic purposes is a property right and as such is fully protected by the constitutional guaranties relating to property in general").

water storage rights, conditional water rights, augmentation plans, changes of water rights, appropriative rights of exchange, and instream flow rights, all of which allow water users to make the most of a scarce resource. In addition to making efficient beneficial use of water, interstate compacts and equitable apportionment decrees limit the amount of water Colorado can use. These interstate compacts and decrees are discussed in Section 4.2.

4.1.1.1 The Priority System

The priority system of water allocation is designed to cope with water scarcity.[8] Under the doctrine of prior appropriation, if water is insufficient to meet the needs of all water users, those with senior rights can require full or partial curtailment of diversions by junior water users, such that users with later priorities receive less than their allotted amount of water, or none at all.[9] Essentially, this doctrine protects those who first begin using the water from injury by those whose use began later in time.[10] Thus, typically, the more senior the water right, the more valuable it is, particularly in times of drought.

As mentioned above, water rights may be conveyed and changed to a new type, place, and manner of use. As a general matter, municipalities and other water users can satisfy their water needs by appropriating new water rights, including water storage rights, and/or by purchasing senior water rights (typically agricultural use) and changing them to municipal, commercial, or industrial uses according to the statutory procedures for changing a water right.

4.1.1.2 Beneficial Use

The single most important restriction on the appropriation of water in Colorado is the constitutional requirement that water be placed to a "beneficial use."[11] "Beneficial use" is defined in the Water Right Determination and Administration Act of 1969, Section 37-92-101 et seq. (hereafter 1969 Act) as follows:

> Beneficial use is the use of that amount of water that is reasonable and appropriate under reasonably efficient practices to accomplish without waste the purpose for which the appropriation is lawfully made[.][12]

The purpose of the beneficial use requirement is to prevent waste, hoarding, and speculation by appropriators, and to encourage the quick and efficient use of the resource.[13] The beneficial use requirement acts to limit the amount of water that may be appropriated for private use throughout the life of the water right. In order to establish a valid appropriation for an absolute water right, a water user must demonstrate that a certain amount of water has been applied to a beneficial use.[14] The amount decreed is limited to the amount placed to beneficial use.

In order to obtain a conditional water right, a right for water that has not yet been placed to beneficial use, a water user must establish that it "can and will" place a certain amount of water to beneficial use within a reasonable amount of time.[15] A water user may not appropriate more water than it actually needs for its intended use.

Courts have further applied the principle of beneficial use in holding that a water user has no right as against junior appropriators to divert more water than can be used beneficially,[16] regardless of the amount decreed, or to expand its use beyond the amount needed for the decreed use.[17]

A water user that diverts more water than it can place to beneficial use may have its diversions curtailed by the

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8 See James N. Corbridge Jr. and Teresa Rice, Vranesh's Colorado Water Law (Revised ed. 1999) at 2 ("The primary advantage of the appropriation system is the development of methods for the orderly distribution of water in water-short regions by establishing procedures for both the quantification and prioritization of water rights").

9 See CR5. § 37-92-301(3) (requiring the state engineer to distribute water in accordance with the priority system).

10 Application of Hines Highlands Partnership, 929 P.2d 718 (Cob. 1996).

11 See Vranesh, supra, at 43, citing Thomas v. Guiraud, 6 Cob. 530 (Cob. 1883) (referring to the beneficial use requirement as the "true test of an appropriation of water").

12 C.R.5.§ 37-92-103(4) (2002).

13 See Vranesh, snpra, citing, Combs v. Agricultural Ditch Co., 152, 28 P. 966, 968 (Cob. 1892).

14 See CR5. § 37-92-103(a) (this section sets forth Colorado's "anti-speculation doctrine," requiring that an applicant for an absolute or conditional water right show that the proposed appropriation is not based upon the "speculative sale or transfer of the appropriative rights[,]" and that the applicant has "a specific plan and intent to divert, store or otherwise capture, possess, and control a specific quantity of water for specific beneficial uses").

15 See C.R.5. § 37-92-305(9)(b).

16 See, Comstock v. Ramsay, 133 P. 1107, 1110-11 (Cob. 1913).

17 See Weibert v. Rothe Bros. Inc. 618 P.2d 1367,1373 (Cob. 1980).

Division Engineer.[18] If a water right is not placed to beneficial use for an extended period of time, and an intent to abandon the water right is demonstrated, the right may be lost. [19]

Thus, beneficial use limits the quantity of water initially allocated under individual water rights, ensures, through administration, that the amount of water used under a water right over time remains limited to the amount actually needed, and conserves water for other uses and users.

4.1.1.3 Maximum Utilization

Colorado courts have held that water should be allocated and administered in a way that promotes the "maximum utilization" of the resource.[20] This principle was formulated in reliance on Article XVI, Section 6 of the Colorado Constitution, which states "[the right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied."[21] Maximum utilization has been applied by the courts in two ways: (1) to require an efficient means of diversion with the purpose of making more water available to other water users; and (2) to support of the adoption of statutory tools allowing flexible administration, including, for example, augmentation plans, exchanges, and the "futile call doctrine."

Augmentation plans promote maximum utilization by allowing junior appropriators to divert out-of-priority, while protecting seniors from injury by replacing all out-of-priority depletions. [22]

Water exchanges also promote maximum utilization. Under an exchange, a substitute supply of water is made available to a downstream senior appropriator and an equal amount of water is then taken at an upstream point of diversion. Exchanges facilitate the movement of water to promote maximum utilization.

Like augmentation plans, the "futile call doctrine" also allows junior water users to divert out-of-priority under certain circumstances. Under this doctrine, a junior water user will be curtailed only if such curtailment actually makes water available to a senior water user calling for water.[23] This allows juniors to continue diverting in times of scarcity, even if a senior is not receiving its whole entitlement, if curtailment of the junior would not allow any additional water to reach the senior.

4.2 Interstate Compacts, Equitable Apportionment Decrees, and Memoranda of Understanding

Similar to limitations imposed by the prior appropriation system, interstate compacts and equitable apportionment decrees also place limitations on water use in Colorado. Allocation of water supplies among states has been accomplished using compacts (negotiated interstate agreements ratified by Congress and the legislatures of the participating states) or interstate litigation. The following summarize the relevant interstate compacts and decrees for each river basin. Information used in this subsection and additional details on the individual compacts and decrees can be found in Appendix D, A Summary of Compacts and Litigation governing Colorado's Use of Interstate Streams (DWR 2000) and the CWCB website at: http://cwcb.state.co.us/SecD/interstate.htm.

The CWCB actively protects the authority, interests, and rights of the state and its citizens in matters pertaining to

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[18] See § 37-92-502(2)(a) "Each division engineer shall order the total or partial discontinuance of any diversion in his division to the extent that the water being diverted is not necessary for application to a beneficial use[.]"

[19] See City & County of Denver v. Middle Park Water Conservancy District, 925 P.2d 283, 286 (Cob.1996).

[20] See Fellhauer v. People, 447 P.2d 986, 994 (Cob. 1968).

[21] See id. at 994 ("It is implicit in these constitutional provisions that, along with Vested rights, there shall be Maximum utilization of the water of this state") (capitalization in original); see also CR5. § 37-92-102(1)(a) (Under the "basic tenets of Colorado water law," the legislature has codified the doctrine of maximum utilization, declaring that "it is the policy of this state to integrate the appropriation, use, and administration of underground water tributary to a stream with the use of surface water in such a way as to maximize the beneficial use of all of the waters of this state") (emphasis added).

[22] See C.R.S., § 37-92-501.5, requiring the State Engineer to "exercise the broadest latitude possible in the administration of waters under their jurisdiction to encourage and develop augmentation plans and voluntary exchanges of water . . . in order to allow continuance of existing uses and to assure maximum beneficial utilization of the waters of this state."

[23] See CR5., §§ 37-92-102(2)(d) ("No reduction of any lawful diversion because of the operation of the priority system shall be permitted unless such reduction would increase the amount of water available and required by water rights having senior priorities"); and 37-92-502(a) ("Each division engineer shall order the total or partial discontinuance of any diversion in his division. to the extent that the water being diverted is required by persons entitled to use water under water rights having senior priorities, but no such discontinuance shall be ordered unless the diversion is causing or will cause material injury to such water rights having senior priorities").

interstate waters. The CWCB and other representatives appointed by the Governor are engaged in ongoing discussions with federal agencies and other states about water availability and utilization.

4.2.1 Arkansas Basin

Arkansas River Compact of 1948

The Arkansas River Compact apportions the waters of the Arkansas River between Colorado (60 percent) and Kansas (40 percent) based on the inflow to John Martin Reservoir. The Compact established the Arkansas River Compact Administration to prescribe procedures for Compact administration, including three representatives from Colorado (a water user from above and below John Martin Reservoir and the Director of the Colorado Water Conservation Board), three Kansas representatives, and a federal representative.

The 1980 Operating Principles, adopted by the Arkansas River Compact administration, provide for storage accounts in John Martin Reservoir and the release of water from those accounts for Colorado and Kansas water users. If the conservation pool in the reservoir is depleted, Colorado is required to administer water rights priorities in District 67 (downstream from John Martin). During such periods, Water flowing into the reservoir does not accrue to the accounts that are established under the operating principles.

Colorado and Kansas have litigated claims concerning Arkansas River water since the early 20th century. In 1995, Colorado was found to have depleted stateline flows in violation of the Compact. The states are now litigating the nature and extent of the injury before the Supreme Court appointed Special Master. In response to an order of the Court, the Colorado State Engineer promulgated well administration rules to bring Colorado into compliance with the Compact.[24]

4.2.2 Colorado Basin, Dolores/San Juan/San Miguel Basin, Gunnison Basin, and Yampa/White/Green Basin

Colorado River Compact of 1922

The Colorado River Compact divides the Colorado River Basin into the Lower Basin (California, Arizona, and Nevada) and the Upper Basin (Colorado, Utah, New Mexico, and Wyoming) at Lee's Ferry, Arizona. It allocates 7.5 million AF of CU to each basin per year. The Compact allows the Lower Basin to increase its CU by 1 million AFY. It provides that the Upper Basin deliver to the Lower Basin 75 million AF during each 10-year period. The Compact further provides for an allocation to Mexico, first from surplus waters above the 15 million AFY, and secondly splits obligation equally between the basins. The balance of the water supply available to the Upper Basin (approximately 7.5 million AFY) is allocated for use in parts of Arizona, Colorado, New Mexico, Utah, and Wyoming above Lee's Ferry. Lake Powell, located immediately upstream of Lee's Ferry, is operated to annually deliver 7.5 million AF plus any deficiency in the flow required to meet Mexican Treaty obligations.[25]

Upper Colorado River Basin Compact of 1948

Of the water available to the Upper Basin under the Colorado River Compact, the Upper Colorado River Compact further allocates to the Upper Basin CU of Colorado River water as follows:

- Arizona – 50,000 AFY
- Colorado – 51.75 percent
- Utah – 23 percent
- Wyoming – 14 percent
- New Mexico – 11.25 percent

In addition, the State of Colorado may not deplete the flow of the Yampa River below an aggregate of 5 million AF over any 10-year period.

Depending upon the interpretation of the Compacts, other laws, and the amount of water in the river on average, Colorado's right to the CU of water under the Compacts may range from 3.079 million AF to 3.855 million AFY. Colorado currently consumes on average about 2.3 million AFY with facilities in place to use up to 2.6 million AF. Colorado's apportionment has not been divided among the various subbasins within the state. The Yampa and La Plata River Basins have specific delivery obligations under the compacts. The allocation and administration of any surpluses and shortages under the compacts within Colorado will be done according to existing law and subsequent rules and regulations that may be adopted.[26]

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[24] See 37-69-101 to 37-69-106 C.R.S.

[25] See 37-61-101 to 37-61-104 C.R.S.

[26] See 37-62-101 to 37-62-106 C.R.S.

La Plata River Compact of 1922

The La Plata River Compact apportions the La Plata River in the Dolores/San Juan/San Miguel Basin between Colorado and New Mexico. Between December 1 and February 15, each state has unrestricted use of all water within its boundaries. Between February 15 and December 1, the water shall be apportioned as follows: each state has unrestricted use on those days where the interstate station has a mean daily flow of 100 cfs or more; on all other days, Colorado must deliver to the interstate station half of the mean flow at Hesperus for the preceding day, but not more than 100 cfs.[27]

Rio Grande, Colorado, and Tijuana Treaty of 1944 Between the U.S. and Mexico

This treaty guarantees delivery of 1.5 million AF of Colorado River water per year to Mexico. If there is not adequate surplus water to satisfy the obligation, the Upper and Lower Basins are to equally share the burden of reducing uses to make up any deficiencies.

Animas-La Plata Project Compact of 1968

This Compact provides New Mexico with the right to divert and store water from the La Plata and Animas River systems under the Project with the same validity and equal priority as those rights granted by the Colorado courts for Colorado users of Project water, providing such uses are within New Mexico's allocation in the Upper Colorado River Compact.[28]

Pot Creek Memorandum of Understanding

This Memorandum of Understanding between Colorado and Utah for Pot Creek in the Green River drainage of the Yampa/White/Green Basin establishes a schedule of priorities for use in both states and defines a period before which direct flow diversions cannot be exercised, namely May 1 of each year.

4.2.3 Rio Grande Basin

Rio Grande River Compact of 1938

The Rio Grande River Compact establishes Colorado's obligation to ensure deliveries of water at the New Mexico state line and New Mexico's obligation to assure deliveries of water at the Elephant Butte Reservoir, with some allowance for credit and debit accounts. The obligations are calculated based on the amount of flow at indexed stations, which then by schedule in the Compact determines the amount of flow that must be delivered to the downstream state during that year. The Compact establishes the Rio Grande Compact Commission to administer the terms of the Compact. The Commission consists of one representative from each state and a non-voting federal representative.[29]

Amended Costilla Creek Compact of 1963

The Amended Costilla Creek Compact establishes uses, allocations, and administration of the waters of Costilla Creek in Colorado and New Mexico. The Compact makes apportionments and allocations among specific facilities. It is administered by the Costilla Creek Compact Commission, which is composed of the water officials from Colorado and New Mexico.[30]

4.2.4 North and South Platte Basins

South Platte River Compact of 1923

The South Platte River Compact establishes Colorado's and Nebraska's rights to use water in Lodgepole Creek and the South Platte River. Nebraska has the right to fully use water in Lodgepole Creek. Colorado has the right to fully use water in the South Platte River between October 15 and April 1. Between April 1 and October 15, if the mean flow of the South Platte River at Julesburg drops below 120 cfs and water is needed for beneficial use in Nebraska, water rights in Colorado between the western boundary of Washington County and the state line (the "Lower Section") with priority dates junior to June 14, 1897 must be curtailed or augmented through an approved plan.[31]

Republican River Compact of 1942

The Republican River Compact establishes the rights of Colorado, Nebraska, and Kansas to water in the Republican River Basin and makes specific allocations of the right to make beneficial CU of water from identified streams.[32]

Nebraska vs. Wyoming 325 U.S. 665 (1945) and 345 U.S. 981 (1953)

The Nebraska vs. Wyoming U.S. Supreme Court Decree equitably apportions water in the North Platte River between Colorado, Nebraska, and Wyoming. Those

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27 See 37-63-101 and 37-63-102 C.R.S.
28 See 37-64-101 C.R.S.
29 (See 37-66-101 and 37-66-102 C.R.S.
30 See 37-68-101 and 37-68-102 C.R.S.
31 See 37-65-101 C.R.S.
32 See 37-67-101 and 37-67-102 C.R.S.

portions of the decree affecting Colorado limit total irrigation in Jackson County to 145,000 acres and 17,000 AF of storage for irrigation during any one irrigation season. It also limits total water exports from the North Platte River in Colorado to no more than 60,000 AF during any 10-year period.

Wyoming vs. Colorado, 260 U.S. 1 (1922) and 309 U.S. 572 (1940)

The Wyoming vs. Colorado U.S. Supreme Court Decree establishes the right of Colorado and Wyoming to water in the Laramie River Basin. Those portions of the decree affecting Colorado limit total diversions from the Laramie River in Colorado to a total of 39,750 AF, divided among specific water facilities, including 15,500 AF through the Laramie-Poudre Tunnel; 18,000 AF through the Skyline Ditch; and 4,250 AF through various "meadow land appropriations."

Sand Creek Memorandum of Agreement (1939 and revised 1997)

This Memorandum of Agreement between Colorado and Wyoming allocates the waters of Sand Creek between the states in accordance with the priority water rights in each state and provides for certain minimum deliveries to the state line by Colorado, if physically available and needed for irrigation in Wyoming.

4.3 Specific Tools for Addressing Water Needs

There are a number of specific tools within the current legal framework of the Priority System that can be used to address various water supply needs. These specific tools include the following.

4.3.1 Water Storage Rights

There are two different types of water rights – direct flow water rights and storage water rights.[33] Direct flow rights allow a water user to divert water for immediate use, while storage rights allow a water user to divert water and store it to make a beneficial use at a later time. Storage rights, like other water rights, are assigned a priority and must be exercised without injury to other water rights.[34] Storage rights are obviously a very important mechanism for ensuring that water supplies will be adequate in times of drought. Moreover, reservoirs provide year-round water when stream levels drop following the snow melt each year.[35] Over the years, there have been numerous water storage projects undertaken by Colorado irrigation districts, water conservation districts, M&I water providers, and the federal government.[36]

4.3.2 Conditional Water Rights

A conditional water right is defined in the 1969 Act as "a right to perfect a water right with a certain priority upon the completion with reasonable diligence of the appropriation upon which such water right is based."[37] A conditional water right allows an appropriator to secure a place in the priority line before any water is actually applied to beneficial use. To obtain a conditional water right, the applicant must show that the "first step" towards the appropriation has been taken. The "first step" includes the intent to appropriate, plus a demonstration of that intent through "physical acts sufficient to constitute notice to third parties."[38] Once the appropriator actually places the water to beneficial use, an absolute decree may be issued with a priority date relating back to the date the appropriation was initiated through the "first step."

As explained by the Colorado Supreme Court in Public Service Co. vs. Blue River Irrig. Co.,[39] a conditional water right "encourage[s] development of water resources by allowing the applicant to complete financing, engineering, and construction with the certainty that if its development plan succeeds, it will be able to obtain an absolute water right." Conditional water rights are crucial to large-scale development projects, including most transmountain diversions and storage projects, because they allow an appropriator to secure a priority and protect its investment when water cannot immediately be placed to beneficial use.[40] Thus, conditional water rights are a tool that may be used to complete major water projects, including storage reservoirs, transmountain diversion projects, or pipelines to meet water needs.

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[33] CR5. § 37-87-101
[34] Id
[35] See Hobbs, I U. Deny. Water L. Rev. 1 at 13, *supra*
[36] See id. (for discussion of 1902 Reclamation Act and reclamation storage projects in Colorado).
[37] C.R.5.§ 37-92-103(6)
[38] City of Aspen v. Colorado River Water Conservation Dist., 696 P.2d 758, 761 (Cob. 1985).
[39] 753 P.2d 737, 739 (Cob. 1988).
[40] See Vranesh, supra at 99.

4.3.3 Changes of Water Rights

A change of water rights is another tool that allows water users flexibility to maximize the potential use of water. As described in the 1969 Act, a change of water rights includes "a change in the type, place, or time of use, a change in the point of diversion," and changes in the manner or place of storage. A change of water right will not be allowed unless it is approved by the water court,[41] upon a finding that the change "will not injuriously affect the owner of, or persons entitled to use, water under a vested water right or a decreed conditional water right."[42]

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

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

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

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

4.3.4 Leases of Water

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

Another area of potential leasing involves agreements between agricultural and municipal/industrial users for interruptible supplies. Although this approach may require obtaining a change of use decree, it would potentially allow flexibility between agricultural and

[41] See Northern Colo. Water v. Three Peaks Water, 859 P.2d 836 (Cob. 1993).
[42] CR5. § 37-92-305(3).

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

4.3.5 Augmentation Plans

An augmentation plan allows a water user to divert water out-of-priority from its decreed point of diversion, so long as replacement water is provided to the stream from another source, to make up for any deficit to other water users.[43] An augmentation plan, like a change of water right, must be approved by the water court and is also subject to the "no injury rule." Accordingly, the 1969 Act requires substituted water to be "of a quality and quantity to meet the requirements for which the water of the senior appropriator has normally been used[.]"[44]

As explained by the Colorado Supreme Court in In re Application of Midway Ranches v. Midway Ranches Property Owners Association, Inc., [45] "[a]ugmentation plans implement the Colorado doctrine of optimum use and priority administration, which favors management of Colorado's water resource to extend its benefit for multiple beneficial purposes." Augmentation plans provide a statutory mechanism for many different types of water users, big and small, to obtain water when and where they need it, by using other sources of water to replace or "augment" the out of priority depletions that result from their water use. In times of scarcity, an augmentation plan allows a water user to continue diverting even under a relatively junior priority, so long as it can provide replacement water to satisfy the needs of downstream seniors. As noted above, however, under an augmentation plan, a water user is essentially replacing the amount of water consumed with a different source of water. The water user gets credit for the amount of water it diverts that returns to the stream unconsumed. As a result, increased efficiency of use under an augmentation plan potentially reduces the amount of credit a water user receives for water returned to the stream unconsumed.

4.3.6 Instream Flows

Under the 1969 Act, the CWCB is authorized to appropriate water for "minimum stream flows or for natural surface water levels or volumes for natural lakes to preserve the natural environment to a reasonable degree."[46] Appropriations for instream flows may only be made by the CWCB, not by private individuals (however, it is noted that a few private instream flows were obtained in the early 1970s upon initial passage of the statute, but this is no longer allowed under the law), and must be made within the priority system, consistent with the restrictions in Sections 5 and 6 of Colorado's Constitution. The CWCB can also acquire water rights for instream flows "by grant purchase, donation, bequest, devise, lease, exchange, or other contractual agreement." [47]

In recent years, Colorado's legislature has expanded the resources available to the CWCB to protect instream flows. In 2002, the legislature increased the sources of funding that the CWCB may use to acquire water for instream flows, to include "any funds available to it, other than the construction fund created in section 37-60-121, for acquisition of water rights and their conversion to instream flow rights.[48] In 2003, the legislature amended § 37-83-105, C.R.S., which provides for temporary loans or exchanges of water between water users in times of drought without requiring adjudication of a change of water rights, to allow the CWCB to receive loaned water for instream flow purposes on a temporary basis, not to exceed 120 days, in any basin where the Governor has declared a drought or other emergency.[49] Such loans are subject to a determination by the State Engineer that other water users will not be injured.

It is essential that the state be able to acquire water rights for instream flow purposes in order to protect wildlife and the environment in a prior appropriation state during times of drought. Since Colorado water law does not allow the state to consider environmental factors in

43 CR5. § 37-92-305(5).
44 Id.
45 938 P.2d 515,522 (Cob. 1997).

46 CR5. § 37-92-102(3).
47 Id.
48 See id
49 House Bill 03-1320.

allocating or administering water, the only way for the state to ensure protection of stream flows for public purposes is by acquiring water rights, itself, within the priority system. By acquiring a water right with an enforceable priority, the state can place environmental concerns on equal footing with agricultural, commercial, municipal, and other uses of water. This means that in times of scarcity, the state's instream flows will be protected in a manner consistent with their priorities – to the extent the priorities are junior to other water rights, the CWCB's instream flows will be curtailed to make water available to other senior water users, and to the extent the CWCB's priorities are senior, the CWCB may request the Division Engineer to curtail more junior users to protect its instream flows.

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

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

In reaction to various claims for in-channel recreation rights, the General Assembly enacted legislation limiting the right to appropriate RICDs to municipal entities for "minimum streamflow as it is diverted, captured, controlled, and placed to beneficial use between specific points defined by physical control structures for a reasonable recreation experience in and on the water." [50] Applicants for such rights now must forward their application to the CWCB for review.[51] After reviewing the application, the CWCB makes a recommendation to the water court on whether the application should be granted, granted with conditions, or denied. [52]

50 § 37-92-103 (10.3), C.R.S.
51 § 37-92-102(5), C.R.S.
52 Id.

4.3.7 New Appropriations

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

To make an appropriation, one must have a specific intent to divert water for a beneficial use and perform a physical act in furtherance of that intent. Today, new appropriations are often made by filing an Application for a Water Right in the water court. However, no appropriation can be made when "the proposed appropriation is based on the speculative sale or transfer of the appropriative rights."[53] This anti-speculation doctrine prevents individuals or entitles from acquiring water rights solely to sell to others. The waters of Colorado are a public resource and as such are not to be hoarded by those who do not have a present use for the water.

4.3.8 Groundwater Rights

In Colorado, there are four different types of groundwater:

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

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

Tributary groundwater is water that is hydrologically connected to a surface stream.[54] In Colorado, all groundwater is presumed to be tributary to a surface

53 § 37-92-130(3)(a), C.R.S.
54 McClennan v. Hurdle, 33 P. 280 (Colo. 1893).

stream. In the early 1900s, Colorado courts held that tributary groundwater is subject to the prior appropriation system.[55] The court based its decision, in part, on the fact that wells that intercept tributary groundwater actually deplete the stream flow to the detriment of senior surface appropriators.[56]

Non-tributary groundwater is statutorily defined as that groundwater, outside the boundaries of a designated basin, "the withdrawal of which will not, within one hundred years, deplete the flow of a natural stream … at an annual rate greater than one-tenth of one percent of the annual rate of withdrawal."[57] The right to use non-tributary groundwater is purely a function of statute.[58] The General Assembly has recognized that non-tributary groundwater is a finite resource and has specifically declared that "such water shall be allocated…upon the basis of ownership of overlying land.[59] Rights to use non-tributary groundwater are limited to "that quantity of water, exclusive of artificial recharge, underlying the land owned by the applicant or underlying land owned by another" who has consented to the applicant's withdrawal.[60] The annual withdrawal of this type of groundwater is further limited in accordance with a 100-year aquifer life.[61]

Not non-tributary groundwater is groundwater located within one of the Denver Basin aquifers (the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers in the Denver Basin, which extends roughly from Fort Collins to Colorado Springs and from the foothills eastward), but outside the boundaries of a designated basin, the "withdrawal of which will, within one hundred years, deplete the flow of a natural stream…at an annual rate of greater than one-tenth of one percent."[62] Not non-tributary groundwater is also allocated on the basis of land ownership. However, the owner of a not non-tributary well must have a plan for augmentation in place before withdrawing such water.[63]

Designated groundwater is groundwater that would not be available to fulfill surface rights or groundwater that has been the principal water supply for the area for at least 15 years and is not adjacent to a naturally flowing stream.[64] Designated groundwater exists within designated groundwater basins. The Ground Water Commission establishes designated groundwater basins through a notice and hearing procedure when evidence becomes available that groundwater within a specific geographic area meets the above noted criteria.[65] Each designated groundwater basin is administered according to a modified prior appropriation system. Locations of designated groundwater basins are presented in Section 7.

4.3.9 Reuse

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

Thus, water that is brought into a watershed from a source unconnected with the receiving system termed "foreign" water may be reused by its owner.[66] Foreign water includes non-tributary groundwater introduced into a surface stream as well as water imported from an unconnected stream system ("transmountain water").[67] Importers of foreign water enjoy rights of reuse that native water appropriators do not have. Such water is deemed "fully consumable" and can be used and reused to extinction so long as the user maintains dominion and control over the water. Dominion and control in this context refers to the intent to recapture or reuse such water, and is not lost when a municipal provider delivers water to a customer's tap or when consumers use such water to irrigate lawns.[68] Dominion over the water is not lost if the importer intends to reuse such water and has some method to track or recapture the water.

In addition, agricultural water rights that are changed to municipal use may also generate fully consumable water that can be used to extinction. This is because the

55 Comstock v. Ramsay, 133 P. 1107 (Colo. 1913).
56 Id.
57 § 37-90-103(10.5), C.R.S.
58 § 37-90-102(2), C.R.S.
59 Id.
60 § 37-90-137(4)(b)(II), C.R.S.
61 § 37-901-137(4).
62 § 37-90-103(10.7), C.R.S. (emphasis added)
63 § 37-90-137(9)(c)(I), C.R.S.
64 § 37-90-103(6).
65 § 37-90-106.
66 City of Thornton v. Bijou Irr. Co., 926 P.2d 1,66 (Colo. 1996)
67 Id.
68 Public Service Co. v. Willows Water Dist., 856 P.2d 829, 834 (Colo. 1993).

applicant in a change of use proceeding may take credit for, and reuse, the historical CU associated with the prior decreed use. Under this scenario, the amount of water attributable to the historical CU of the senior water right may be used and reused to extinction. Although this is not "foreign water" by definition, it is another source of fully consumable water.

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

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

4.3.10 Conservation Activities

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

Conservation measures can also take the form of increased efficiencies. However, not all water conserved through more efficient uses corresponds to an increase in overall water supply to a water user. For example, a water user could take steps to eliminate certain phreatophytes and thereby "salvage" additional water. That water, however, is owed to the stream and does not necessarily accrue to the benefit of the specific water user conducting the "salvage" activity, since a water user cannot take credit for a "salvage" activity and thereby divert more water.[69] Salvage water is owed to the stream to be diverted by downstream water users pursuant to the priority system.

69 Southeastern Colorado Water Conservancy Dist. v. Shelton Farms, Inc., 187 Colo. 181 (1975).

Section 5
Projected Water Use

Water is managed in Colorado to meet the many important needs of our citizens and our environment, and is vital to Colorado's present and future. Our economy, our quality of life, our recreational opportunities, the environment, and human life itself are all dependent on water. The broad diversity of water uses in Colorado is indicative of the many ways in which we are affected by the water that is available to us and our environment, and how we choose to use it. Severe and continuing drought conditions throughout the state in the early 2000s in conjunction with rapid growth and concern over compact obligations have brought focus to the constraints on our state's water resources and the challenges associated with meeting multiple objectives and needs.

As a significant step toward reaching SWSI's goal of helping Colorado maintain an adequate water supply for our citizens and the environment, SWSI evaluated water use in 2030 in each of the state's major river basins for the following categories of water use (as described in Section 4):

- M&I
- Agricultural
- Recreation and Environmental

A consistent and comprehensive method was developed in SWSI to estimate baseline (year 2000) and future (2030) water uses in the state. M&I and agricultural water projections represent "traditional" uses in water planning, and are generally associated with off-stream uses that have a consumptive component. In order to estimate current and future water needs for these uses, SWSI obtained historical water use data, population projections, and irrigated acreage data for each of the state's major river basins. Decreed CWCB instream flow and RICD water rights were inventoried, and a process for evaluating environmental and recreational uses was initiated – recognizing that these uses differ significantly from M&I and agricultural needs in that they are non-consumptive, flow-related uses. Approaches to defining water needs for environmental and recreational uses are described in Section 6.

Demands on Colorado's water resources are projected to increase dramatically through 2030. In large part, this will be driven by continuing population increases, while agricultural uses remain high, environmental water uses continue, and more people participate in water-based recreational activities. The following sections describe the methods used in determining reconnaissance level water use projections for 2030, and the results of those analyses.

5.1 Overview of Projection Methods

Standard methods were adapted for use in SWSI for projecting future M&I and agricultural uses throughout Colorado, then aggregated by the state's eight major river basins. Because of the unique, in-channel flow and non-consumptive nature of environmental and recreational uses – and some inherent conflicts even between different environmental and recreational uses in the types and timing of flows desired – Colorado's statutory framework for CWCB minimum instream flows was used as the initial basis for estimating future uses for recreation and the environment. Further enhancement of flows was considered in the options analysis phase of SWSI.

The objectives of the SWSI water use analysis efforts were to:

- Develop a reconnaissance-level water use forecast
- Use consistent data and method throughout the state
- Maximize the use of available data

While numerous past evaluations and reports have projected future water use in the state, a standard method for SWSI was deemed important. Past efforts vary widely in their method and demographic projections, and do not provide complete coverage of the state. Nonetheless, past evaluations and databases were referenced in the development of SWSI water use projections to help guide the evaluation and validate results. The estimates developed in SWSI are intended to be reconnaissance-level estimates to guide a discussion of addressing the state's future water needs, and do not supersede demand projections for individual water providers or users.

Water use projections for consumptive use and diversions throughout this report are presented in units of AFY. An AF of water is approximately 326,000 gallons. Non-consumptive water uses are indicated in flow-based units (i.e., the volume of water passing a given point over a certain time step, such as cfs or AF volumes) as described elsewhere in this report.

An overview of the methods used to estimate future water use is provided in the following subsections. Sections 5.2 and 5.3 present the results of the water use analyses.

5.1.1 Method for Estimating Municipal and Industrial Use

In the United States, only Nevada and Arizona grew at a faster rate than Colorado in the 1990s, and State Demographer projections suggest that vigorous increases in population can be expected well into the future. Projecting the water needs that accompany the corresponding municipal, industrial, and commercial uses of water are therefore a key part of addressing the state's future water needs.

5.1.1.1 Overview of Method for Estimating M&I Use

The M&I water use analysis methods employed in SWSI resulted in a summary of baseline water uses (estimated for year 2000) and a forecast of such water uses for the year 2030. In SWSI, all publicly-supplied and self-supplied residential, commercial, institutional, and industrial water uses are identified as M&I water users. In addition, major self-supplied industrial (SSI) water users are also accounted for.

Key terms used in M&I water use projections are presented in Table 5-1.

Table 5-1 Definition of M&I Demand Terms

Demand Terminology	Definition
M&I Demand	All of the water use of a typical municipal system, including residential, commercial, industrial, irrigation, and firefighting
SSI Demand	Large industrial water uses that have their own water supplies or lease raw water from others
M&I and SSI Demand	The sum of M&I demand and SSI
CU Demand	That portion of the water demand for a specific category of water use that is consumed and does not return to the stream system through return flow

This water use analysis included the following components:

- Collection of available statewide water use, demographic, and weather data
- Evaluation of available information to determine factors that influence M&I water use
- Review of M&I water use studies conducted throughout the state
- Preparation of a statewide forecast of future urban water use to the year 2030 by county and by basin
- Assessment of the current level of conservation efforts by county

The method used for estimating urban water demand is based on a sample of water providers throughout the state as described in this section. The estimated per capita water use rates for each county were multiplied by the projected population of each county to estimate current and future municipal water demand (i.e., the residential, commercial, and industrial water use) of each county.

Population projections are summarized in Section 5.1.1.2. Per capita estimates of M&I water use are discussed in Section 5.1.1.3, and SSI uses are discussed in Section 5.1.1.4. The effects of Level 1 conservation measures are reviewed in Section 5.1.1.5. Section 5.1.1.6 provides a discussion of CU factors and estimated CU given the range of data available on the subject. The M&I water use forecasts presented in Section 5.2 represent the baseline SWSI forecasts. Detailed data and results are included in appendices, as noted throughout this section.

5.1.1.2 Population Projections

Future population projections were obtained from the Colorado DOLA, Demography Section. This dataset contains county population projections from 2000 to 2030 in annual increments. Populations for counties that lie within two or more basins were allocated to the respective basins based on estimates from known population centers within each basin. A summary of county and basin population projections is provided in Appendix E.

From 2000 to 2030, Colorado's population is projected to increase by about 2.8 million additional people – a 65 percent increase – to a 2030 population of over 7.1 million. Aggregated basin summaries of the data are presented in Figure 5-1 and Table 5-2. The vast majority of the state's population in 2030 will live in the South Platte and Arkansas Basins.

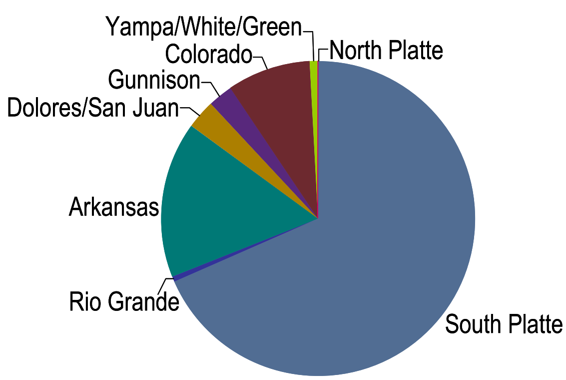


Figure 5-1
Relative 2030 Populations in Each Basin

On a basin level, West Slope growth rates are projected to be the highest, with the Colorado Basin population almost doubling and Gunnison River and Dolores/San Juan/San Miguel Basins' populations increasing by 82 and 89 percent, respectively. However, the population centers along the Front Range will lead the state in increases in the number of residents, with an additional 1.9 million residents in the South Platte Basin and over 450,000 additional residents in the Arkansas Basin by 2030. Thus, growth in many parts of the state will be dramatic with respect to both rates of growth and increases in population. The North Platte Basin is projected to have the lowest growth rate and the fewest additional residents, showing a modest increase in population over the 30-year planning period.

Looking at a county level, 12 of the state's 64 counties are projected to more than double in population between 2000 and 2030. Park, Elbert, and Archuleta Counties are projected to have the state's highest rates of population growth with increases of 482 percent, 191 percent, and 170 percent, respectively. The rural eastern counties of Cheyenne, Kiowa, and Baca are each expected to lose between 15 percent and 18 percent of their population over this 30-year period.

Ten counties are projected to have population increases of more than 100,000 over the 2000 to 2030 period. Front Range counties comprise 9 of those 10 counties. Adams County will add the most population (increase of 343,000) and Weld, El Paso, and Douglas Counties are each projected to add more than 250,000 people over this 30-year period. Twenty-one counties will each have their populations increase by between 10,000 and 100,000, and 30 counties' populations will each increase by less than 10,000 over this period.

Table 5-2 Population Projections by Basin

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 DOLA, Demography Section

5.1.1.3 Estimates of Per Capita M&I Water Use

Numerous factors affect per capita water use rates, and through the course of SWSI, differences in the water use components that are included or excluded from individual entities' per capita estimates clearly affected the resulting values. Per capita water use rates are in large part a function of:

- Number of households
- Persons per household
- Median household income
- Mean maximum temperature
- Total precipitation
- Total employment
- Ratio of irrigated public land areas (e.g., parks) to population in service area
- Level of tourism and/or second homes
- Ratio of employment by sector (e.g., agriculture, commercial, industrial)
- Urban/rural nature of county

Several sources of information were consulted in estimating per capita M&I water use. The CWCB's Drought and Water Supply Assessment study's database was used as an initial data source, and was supplemented in SWSI by sending a follow-up survey to more than 200 water providers. Including the responses to the follow-up survey, the resulting database used in SWSI includes nearly 250 water providers covering most of the state, as indicated in Figure 5-2. Regression analyses of available data indicated that location was the dominant factor in determining the variation of per capita water use among the sample data.

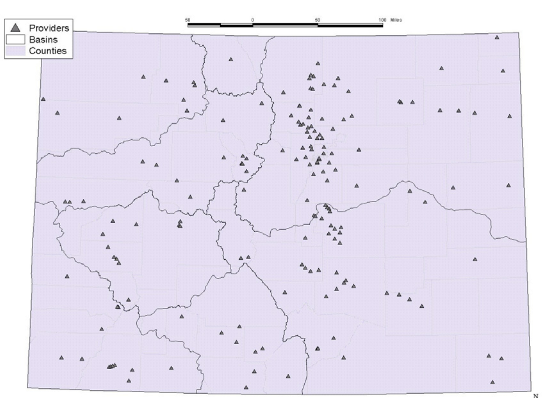


Figure 5-2
Providers in SWSI per Capita Demand Database

The provider per capita values in each county were weighted by their respective populations to produce a weighted average per capita value by county. In addition, the weighted average per capita water use per basin was also calculated. The basin weighted average per capita rate was used for areas of the county that did not have representation in the sample database. The underlying assumption is that water use will be similar throughout the county. The estimated county gallons per capita per day (gpcd) water use rates were multiplied by the county population projections to derive the estimated M&I water forecast for each county. These M&I forecasts are shown in Section 5.2 and the methodology employed is explained in detail in Appendix E.

The sample data provided a per capita water use rate for 58 of the 64 counties within the state. The aggregated basin average per capita water use estimates are depicted in Figure 5-3; county per capita estimates are listed in Appendix E. Overall, the population-weighted average per capita M&I water demand for the state was estimated to be 210 gpcd for the year 2000.

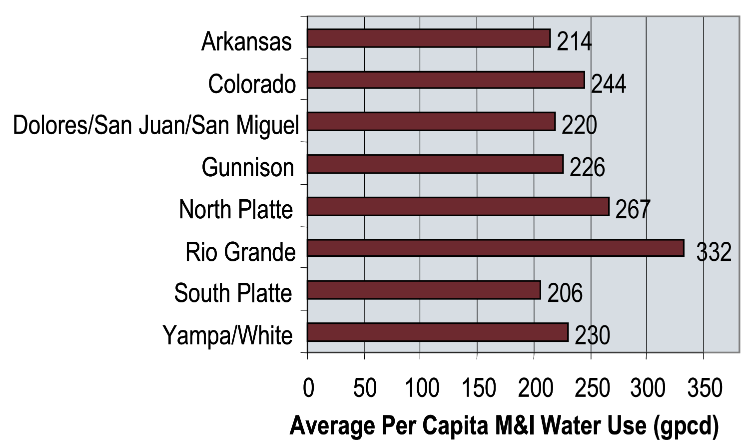


Figure 5-3
Estimated Year 2000 Average per Capita M&I Water Use

This estimation of county per capita water use assumes that all residences, businesses, and industries throughout a county (including most self-supplied users) use water at the same rate as the provider-supplied residences, businesses, and industries as represented in the sample database. Where data were available regarding unique large self-supplied water users in specific counties, these self-supplied water uses were added to the county M&I water demand estimate, as described in the following section.

Due to wide variations in the factors presented above, per capita use rates are 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 supplied through municipal water systems could also drive per capita values upward. 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.

Changes in per capita rates might also be anticipated if a community's park system is essentially "built out" but population growth is still anticipated, or in cases where changes in industrial use do not directly correlate to changes in residential use. Basin Roundtable members and local water providers provided input that can be used to refine the per capita water use estimates for certain counties in future SWSI efforts.

5.1.1.4 Self-Supplied Industrial Use

SSI uses were estimated for baseline and projected future water needs in order to more accurately characterize the state's anticipated increase in water use between 2000 and 2030. The CWCB Drought and Water Supply Assessment database of SSI uses was used as an initial source of information for this analysis. These data were supplemented in SWSI with calls to major industrial water users to verify, update, and expand the information used in the SWSI analyses.

SSI water uses estimated in SWSI include:

- Coal-fired and natural gas power generating facilities that consume significant quantities of water
- Snowmaking facilities
- Other identified industrial facilities with significant water use such as brewing, manufacturing, and food processing

Estimates of baseline and future water use at various power generation facilities in Colorado were sought. Current water use data were obtained for several facilities. These data were for facilities in Adams, Boulder, Denver, Larimer, Mesa, Moffat, Montrose, Morgan, Pueblo, Routt, and Weld Counties. A facility currently under construction in Arapahoe County and assumed to come online in 2005 was determined to have negligible consumptive water use. Data for the Mesa facility were also excluded from the analysis due to the negligible level of CU. Current water use levels for these facilities are assumed constant in future years unless future water use information was obtained. Estimated annual water use for power generation for these counties is shown in Appendix E.

Two dozen regional water use studies were reviewed to identify estimates of current and future projected water use for snowmaking in Colorado counties, with a wide range of conclusions regarding typical rates. Ultimately, the recent Upper Colorado River Basin Study ("UPCO" study) was determined to have the most up-to-date and thorough assessment of snowmaking use at ski areas. Data from this study were used to derive an average snowmaking use per ski area and applied to known or anticipated ski areas in each basin. The estimates for some ski areas were supplemented and refined by directly contacting and interviewing representatives of selected ski areas on an individual basis.

An attempt was made to identify other large self-supplied water users throughout the state. These water users are typically large industrial facilities not associated with municipal or public water supply systems. Quantifiable information was only available for large SSI water users located in Jefferson and Pueblo Counties. The Yampa Valley Water Demand Study (BBC Research & Consulting 1998) provided self-supplied water use estimates for current and future mining and golf course water use. Other SSI water users may exist throughout the state, which were not identified during the Basin Roundtable process or SSI water use evaluations.

5.1.1.5 Effect of Level 1 Conservation

Naturally-occurring water conservation savings are defined as water savings that result from the impacts of plumbing codes, ordinances, and standards that improve the efficiency of water use. These conservation savings are called "passive" savings because water utilities do not actively fund and implement programs that produce these savings. In contrast, water conservation savings resulting from utility-sponsored water conservation programs are referred to as "active" savings. For the purposes of SWSI, passive conservation is also termed Level 1 conservation. Active conservation measures – beyond those currently in place – were evaluated in

SWSI as options toward addressing future water needs in each basin, as part of alternatives developed by the SWSI team in conjunction with Basin Roundtable participants.

The National Energy Policy Act of 1992 set manufacturing standards for improved water efficiency for toilets, urinals, showerheads, and faucets. These standards became effective in 1994. The standards for commercial fixtures became effective in 1997. These standards affect the types of water-using fixtures available for new construction as well as remodeled or renovated facilities, and result in improved indoor water use efficiency. In addition, some municipalities have ordinances that limit turf or irrigated areas, which reduce outdoor water use.

Typically, estimates of Level 1 conservation savings for a given water utility service area, or other planning area, are a function of characteristics of the service area such as the percent of water efficient fixtures present at some base period in time and subsequent new construction and remodeling.

The allocation of total water use among various uses may be seasonal. For example, irrigation is expected to be a larger component of total water use in summer months than in winter months. Locations affected by landscaping ordinances may have a greater impact from Level 1 conservation in the summer months, while locations without landscaping ordinances may find the impact of Level 1 conservation to be more noticeable in winter months.

The estimation of conservation savings requires an initial baseline forecast of water demand without conservation. The baseline water demand forecast is driven by projections of future demographic growth for the study area and does not account for the effects of future water conservation. Impacts of conservation savings can then be determined from the baseline water demand forecast.

Five studies of estimated conservation savings that followed similar methodologies for estimating conservation savings were reviewed in estimating Level 1 conservation savings for SWSI. The average expected percent reduction in baseline water demand from Level 1 conservation savings based on these studies were identified as shown in Table 5-3.

Table 5-3 Anticipated Level 1 Conservation Savings by Year

Year	2000	2010	2020	2030
Expected Savings	2.5%	5.0%	7.0%	8.5%
Increase above 2000	0%	2.5%	4.5%	6.0%

Year 2000 water use data were used to develop the SWSI baseline demand forecast. Thus, the SWSI baseline demand forecast is reflective of water conservation (both passive and active) in effect in the year 2000. Conservation adjustments to the SWSI baseline demand forecast should reflect future impacts of conservation.

The M&I baseline water demand for each county was adjusted by these percent savings factors to account for the impact of Level 1 conservation savings. The resulting estimate is used as the lowest conservation scenario (Level 1).

5.1.1.6 Estimate of M&I CU Rates

Water use can be considered both in terms of gross water needs – the total amount of water delivered to a user – and in CU. Both are important considerations in water planning. The difference between gross and CU is the amount that is realized as return flows (i.e., through wastewater treatment plants and lawn watering). CU is generally higher in arid and semi-arid regions such as Colorado, where more water is used for irrigation and lost to evapotranspiration.

The Colorado River Return Reconnaissance Study (Boyle 2003) cites the source of its CU rates as the Colorado River DSS Consumptive Uses and Losses Application Report (1999), which details the application of the State of Colorado's CU model (StateCU) (for the Colorado River tributaries and the Rio Grande Basin). This document states that for municipal use the CU ratios for urban (36 percent), rural (36 percent), commercial (35 percent), and public (35 percent) use were obtained from the BOR. Note that the BOR urban and rural CU of 36 percent is used in the BOR Gunnison Basin Study (2001).

As part of the Cooperative Agreement regarding endangered species in the Central Platte River in Nebraska, Colorado developed a method for estimating current and future water use. Through this process, a CU rate of 35 percent for M&I uses in the Platte Basin was developed (DNR 1998). It was also noted that while this value is suitable as a basinwide average, variability from one area or city to the next can be expected as a function of the relative mix of water uses, land use density, vegetation, elevation, and climate.

Based on this previous work, SWSI determined that an average M&I CU factor of 35 percent was an appropriate reconnaissance level value for calculating the M&I water demand for each county, and for each scenario. This statewide average CU factor for M&I use is assumed representative of the range of municipal CU that varies by microclimate, development densities, and residential/commercial/ industrial mix throughout most of the state. Routt and Moffat Counties in the Yampa/White/ Green Basin are exceptions due to the presence of high CU thermal-electric power plants that represent a significant percentage of total M&I and SSI water use.

5.1.2 Method for Estimating Agricultural Use

Colorado's DSS was used to estimate existing agricultural water demands in the Colorado, Gunnison, Rio Grande, Dolores/San Juan/San Miguel, and the Yampa/White/Green Basins. DSS modeling tools are described further below. Agricultural use in the Arkansas, North Platte, and South Platte Basins was estimated using a variety of available sources as described below.

Future (2030) agricultural water requirements were estimated using existing requirements and projected future irrigated acreage. In other words, the requirement per irrigated acre is assumed to remain constant and future changes in water requirements are assumed to be linearly related to the projected changes in irrigated acreage. Projected irrigated acreage values represent a range based on feedback from Basin Roundtables and Basin Advisors, an analysis of M&I water acquisition practices, and land development trends in each basin using GIS coverages of irrigated acres, where available. It is usually more meaningful to describe agricultural demands within a basin at the water district rather than county level, since water districts generally follow subbasins. Figure 5-4 shows the water districts throughout the state and this section will refer to water districts for those basins where DSS analyses have been completed.

5.1.2.1 Existing Demands Method: DSS Basins

For the Colorado, Gunnison, Yampa/White/Green, Dolores/San Juan/ San Miguel, and Rio Grande Basins, DSS data sets (specifically for StateCU) were used to quantify the existing conditions. Projections of future agricultural use were made based on existing irrigation practices and water availability conditions, and projected changes in irrigated acreage.

Input data sets include tabulated irrigated acreage and crop types associated with each agricultural diversion structure in the river basin, as well as historical regional weather conditions. Monthly crop irrigation water requirements (IWR) are generated in the model for each diversion structure using these data and the modified Blaney Criddle equation.

IWR values represent the maximum volume of irrigation water, after effective precipitation is taken into account, which would be consumed to grow particular crops. Effective precipitation is the portion of the total precipitation (after surface evaporation plus runoff, deep percolation, etc.) that is stored in the soil and is available to the crops. IWR values do not include farm application losses and conveyance (e.g., ditch) losses. If the IWR can be met with available water supplies, the crops will provide a full yield; otherwise, the crops are "water short." The amount of water that must actually be diverted at the river (or pumped from wells) to meet the crop requirements at the farm will typically exceed the IWR. This is due to canal or other delivery system losses, and the fact that not all of the water delivered to the farm or ranch can be used with 100 percent efficiency. In StateCU, river diversions are assumed equal to the input set of known historical diversions at each structure.

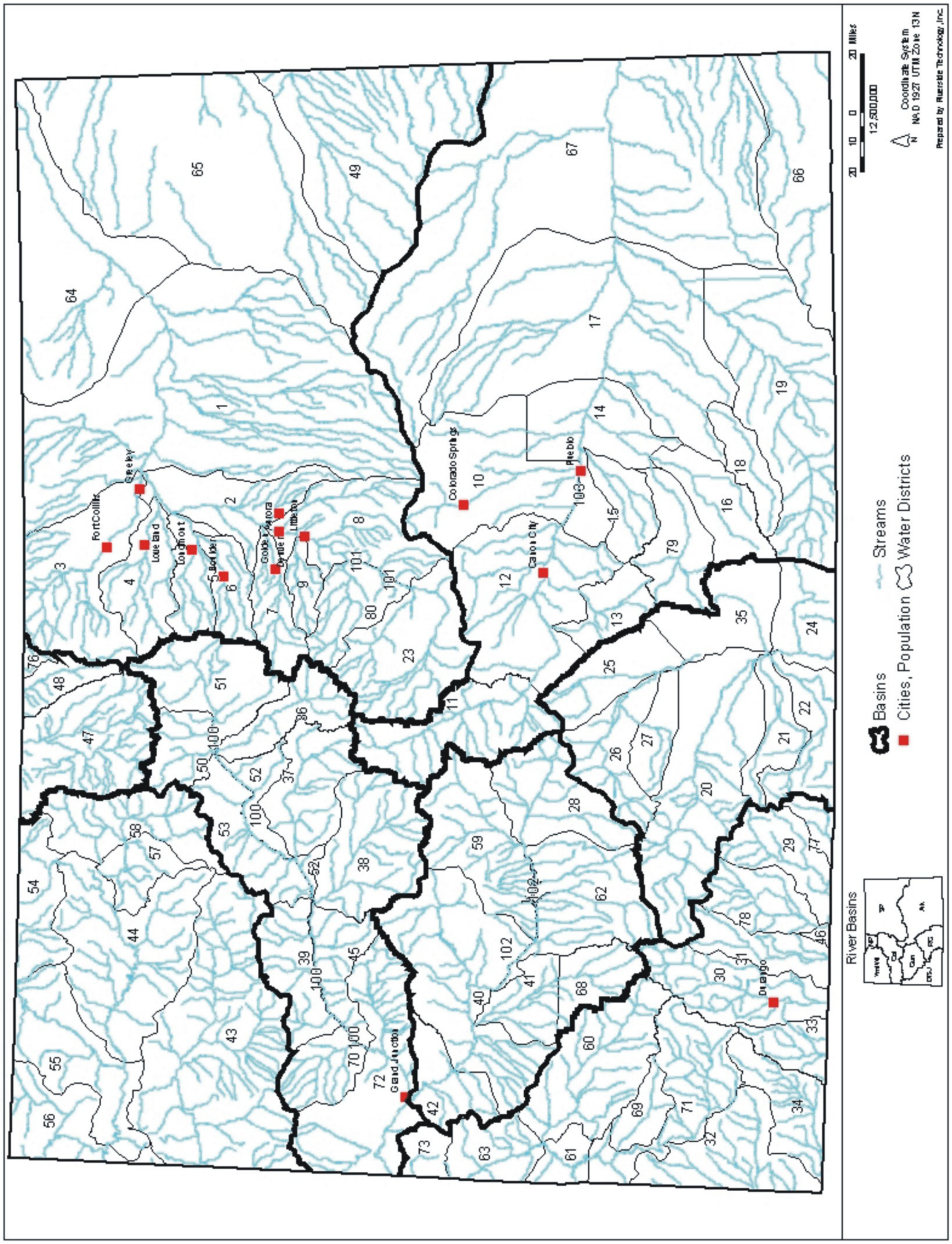


Figure 5-4
Colorado Water District Boundaries

The StateCU model also calculates water supply limited (WSL) crop CU values associated with each diversion structure in the basin. These values represent the net CU of the crops as limited by available water supply and current irrigation practices, and are calculated as functions of historical diversions and soil moisture carryover.

It follows that the IWR values can be viewed as a *demand* associated with the crop requirements, while the WSL values represent the actual flow reaching and being used by the crops (*supply*). In this way, existing shortages in agricultural supply can be estimated as:

$$\textbf{Shortage = IWR – WSL} \qquad \textbf{(5.1)}$$

For this project, annual average IWR and WSL values were aggregated by water district. Existing agricultural water shortages were then calculated for each water district in each basin using Equation 5.1. These results are presented and discussed in Section 5.3.

Table 5-4 summarizes the sources of agricultural demand information for each basin. For the DSS basins, only calendar years 1975 through 2002 were used for the analysis of agricultural use, even though longer periods of record are available. Data associated with years prior to 1975, because of changes in irrigated acreage and historical diversions, are not considered to be well-representative of current conditions.

Table 5-4 Agricultural Demand Information Sources

Basin	Source of Irrigated Acres	Year of Est. of Irrigated Acres	Source of Demand per Acre	Period of Record of Supporting Data
Arkansas	HI Model, DWR, USDA Census of Agriculture	1997-2000	HI Model	1950 - 2000
Colorado	DSS	2000	DSS	1975 - 1990
Dolores/ San Juan/ San Miguel	DSS	2000	DSS	1975 - 1990
Gunnison	DSS	2000	DSS	1975 - 2000
North Platte	CWCB	2001	Preliminary work on DSS	1993 - 2002
Rio Grande	DSS	1998	DSS	1975 - 1997
South Platte	CWCB	2001	Preliminary work on DSS	1993 - 2002
Yampa/ White/ Green	DSS	2000	DSS	1975 - 1990

A more detailed description of the StateCU calculation method can be found at http://cdss.state.co.us/.

5.1.2.2 Existing Demands Method: Basins without DSS Models

For those basins without developed DSS data sets, the Arkansas, South Platte, and North Platte, quantification and characterization of agricultural uses focused on historic diversions, irrigated acreage, and crop type distributions gathered from existing sources and studies.

For the Arkansas Basin, agricultural demands were estimated using IWR values acre-feet per acre per year (AF/Ac/Yr) developed from the State of Colorado's HI Model and irrigated acreages estimated from information provided by CWCB, DWR, and the USDA Census of Agriculture.

For the South Platte and North Platte Basins, agricultural demands were estimated using preliminary estimates of IWR values and irrigated acres developed during preliminary work on the South Platte DSS.

Summaries of the agricultural demand sources for these basins are included in Table 5-4.

5.1.2.3 Future Demands Method

Future (2030) agricultural water requirements were estimated by basin using annual average requirements on a per acre basis, and projected future irrigated acreage. The current requirements (AFY) are normalized to the current irrigated acreages (AF/Ac/Yr) and multiplied by the projected 2030 acreages to arrive at a future total agricultural requirement (AFY). In other words,

2030 Ag Irrigation Water Requirement (AFY) =
Current Average IWR Requirement (AF/Ac/Yr) x
Projected Irrigated Lands (Ac) (5.2)

where

Current Average Requirement (AF/Ac/Yr) =
IWR/Current Irrigated Lands (5.3)

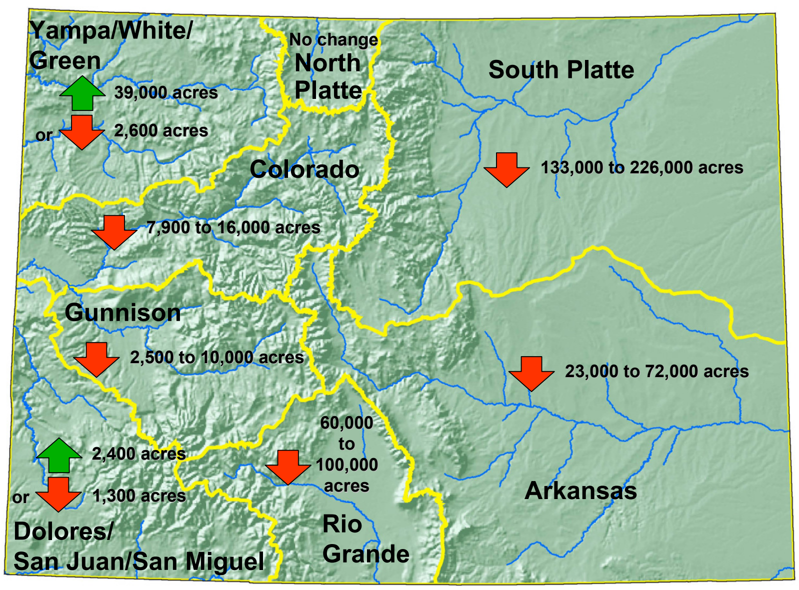
2030 WSL CU; incidental losses, livestock watering, and stock pond evaporation; and gross diversions were estimated using the same approach (Equations 5.2 and 5.3). Projected WSL values represent anticipated crop CU, assuming the ratio of available supply to irrigated acreage stays the same. Incidental losses, livestock watering, and stock pond evaporation represent additional water consumption associated with the projected irrigated acres. Gross diversions reflect the anticipated amount of water actually diverted at the stream to provide this level of combined CU. Basin average annual diversions (averaged over the period of record) were used in Equation 5.2 for these calculations. Results are presented and discussed in Section 5.3.

Projecting future agricultural water demands includes an evaluation of potential changes in irrigated acres, as well as an estimate of agricultural water use per acre.

By 2030, reductions in irrigated acres are expected to occur in most basins as agricultural lands are developed for M&I use and/or water is transferred from agriculture to M&I use to provide for M&I water needs. Additional reductions in irrigated acreage in the South Platte and Arkansas Basins may occur if adequate augmentation sources are not developed for the farms using alluvial groundwater as their primary source of water supply. In the Rio Grande Basin, groundwater pumping in the Closed Basin north of the Rio Grande has resulted in major declines in groundwater levels. Analysis by water users in the Rio Grande Basin suggest that a reduction of up to 100,000 irrigated acres may be required to restore groundwater levels in the basin and achieve long-term sustainability of this resource.

In other areas of the state, localized decreases and increases in agricultural water use are also expected. During the Basin Roundtable process, participants provided input on potential changes in irrigated acres, including the following examples. Several agricultural participants of the Yampa/White/Green Basin Roundtable indicated the desire to irrigate an additional 20,000 to 39,000 acres, if storage could be developed to provide a firm supply of water and funding sources provided. The additional irrigation would occur in Moffat County in Water Districts 44, 54, 55, 56, and 57. The Dolores/San Juan/San Miguel Basin agricultural Basin Roundtable participants indicated plans to irrigate an additional 4,000 acres in Montezuma County through the purchase of existing water rights and storage facilities. The Gunnison Basin indicated the desire to develop storage in the Upper Gunnison and in the Grand Mesa areas and restore lost storage in the Grand Mesa and North Fork areas. These would serve to improve supplies to existing irrigated lands and reduce shortages.

Table 5-5 provides an estimate of the range of potential changes in irrigated acres in each basin. Future changes will be impacted by many factors, including the development of additional storage to provide firm water supplies for agriculture, policies of M&I water users regarding the acquisition of agricultural water rights, M&I growth rates and the location of future growth, and whether there are cost-effective alternative sources of water to meet future M&I water needs. There could be significant additional reductions in irrigated acres in the South Platte and Arkansas Basins beyond the estimates provided in Table 5-5 if water providers are unsuccessful in implementing their identified plans such as developing additional storage to firm existing water supplies. Figure 5-5 illustrates an estimate of potential changes by basin and additional detail on the estimates of potential changes in irrigated acres for each basin are included in Appendix F.



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

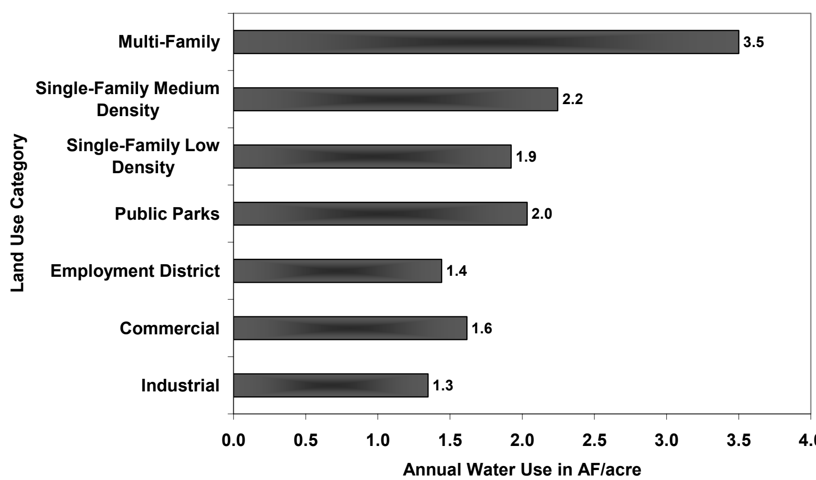
Figure 5-5
Potential Changes in Irrigated Acreage by 2030

Table 5-5 Breakdown of Potential 2030 Changes in Irrigated Acreage

Basin	Potential Decrease in Irrigated Acres resulting from transfers	Potential Decrease in Irrigated Acres resulting from urbanization of irrigated lands	Potential Decrease in Irrigated Acres for other reasons	Potential Increase in Irrigated Acres if additional supplies are developed	Range of Potential Net Change in Irrigated Acres
Arkansas	17,000-59,000	2,300-4,500	4,000-8,000	—	23,000-72,000 Decrease
Colorado	1,200-2,700	6,700-13,000	—	—	7,900-16,000 Decrease
Dolores/ San Juan/ San Miguel	100-200	1,500-3,100	—	2,000-4,000	1,300 Decrease up to 2,400 Increase
Gunnison	300-1,500	2,200-8,500	—	—	2,500-10,000 Decrease
North Platte	No significant change expected	No significant change expected	No significant change expected	No significant change expected	—
Rio Grande	600-1,100	100-200	59,000-99,000	—	60,000-100,000 Decrease
South Platte	40,000-79,000	38,000-57,000	55,000-90,000	—	133,000-226,000 Decrease
Yampa/White/ Green	100-200	1,100-2,400	—	0-40,000	2,600 Decrease up to 39,000 Increase
TOTAL	**59,000-144,000**	**52,000-89,000**	**118,000-197,000**	**2,000-44,000**	**185,000-428,000 Decrease**

As noted, reductions in agricultural irrigated acres may occur due to development, acquisition for M&I needs, dry-up for instream flow purposes, or as a result of lack of long-term supply availability such as lack of augmentation for well pumping or over pumping of groundwater. As described in Section 8, not all of the reduction in agricultural irrigated acres will result in additional supplies available for M&I or other uses. In addition, not all of the development of irrigated agricultural lands for M&I use will result in a reduction of irrigation demands. Some of the development of agricultural irrigated acres will be for large lot residential development of 1 to 5 acres or ranchettes of 5 to 35 acres. For many of these parcels, if the water rights are not sold and transferred at the time of development, there may be some continued irrigation for hay or pasture for domestic animals kept on the properties. Basin Roundtable feedback was mixed on whether new residential owners would tend to irrigate as diligently as the former rancher or farmer and whether overall water demands would change as a result of this new land use.

Typical water use per acre for different types of M&I land use development in the South Platte Basin are shown in Figure 5-6. Generally, as residential densities increase, the gross water use per acre also tends to increase. Figure 5-6 shows that average gross water use can range from 1.3 AF/acre for industrial use to 3.5 AF/acre for higher density residential uses, such as apartments. Agricultural water deliveries and consumptive to historically irrigated lands vary widely and are dependent upon seniority of water rights, physical availability of



Source: Cities of Westminster and Greeley and NCWCD

Figure 5-6
Estimated Gross Urban Water Demands by Land Use (Indoor and Outdoor Use)

supplies, timing of deliveries, delivery losses, and application efficiencies. The ability to use agricultural water rights existing on the land to meet the needs of M&I use as the land is developed is highly dependent upon these factors, plus the need for a portion of the water to be stored to meet non-irrigation M&I demands and to provide for firm yield for below average runoff years. These considerations are explained in greater detail in Section 8.

5.2 Estimated 2000 and Projected 2030 M&I and SSI Use

Of the many factors affecting M&I water use, the projected increases in population clearly drive the increases in M&I use from 2000 to 2030. The effects of Level 1 conservation result in a projected reduction in per capita M&I water use of approximately 6 percent over this 30-year planning period. This reduction is reflected in the 2030 M&I water use projections presented in this section. M&I and SSI water use projections presented in this section represent the gross or total diversion amount, as opposed to the consumptively-used portion as described in Section 5.1.1.6.

To reiterate, M&I projections were developed by multiplying the estimated (2000) or projected (2030) populations by per capita demands for each of the state's 64 counties, then reducing water use associated with Level 1 conservation measures for the 2030 scenario. These results were aggregated on a basin basis, as well as on a subbasin basis for use in the water supply "gap analysis" as presented in Section 6.

Overall, combined **M&I and SSI gross water use is expected to increase statewide by about 53 percent (630,000 AFY) over 2000 levels by 2030**, as shown in Table 5-6. These projections do not include the impacts of water conservation efforts beyond Level 1 that are being implemented or planned by many M&I providers. These future conservation efforts, as described in Sections 6 and 8, are important strategies for meeting future water demands. The increase in M&I and SSI water use over this period by basin, and relative (percent) increase over 2000 M&I water use, are each presented in Figure 5-7. A summary of projected SSI water uses by type of industry and by county is provided in Table 5-7.

Similar to the population patterns described earlier in this section, *rates* of M&I water use increases over the 30-year planning period are generally higher for the West Slope basins than for the Front Range's South Platte and Arkansas Basins. However, the bulk of the increase in water uses *in terms of AFY* will be in the South Platte and Arkansas Basins, which together represent about 80 percent of the total projected increase in Colorado's gross M&I and SSI demands.

Table 5-6 Summary of Combined Gross Water Use for M&I and SSI in 2000 and 2030

Basin	Total Estimated 2000 Gross Demand (AFY)	Total Projected 2030 Gross Demand without Level 1 Conservation (AFY)	Total Projected 2030 Gross Demand with Level 1 Conservation (AFY)	Projected Level 1 Conservation Savings (AFY)	Projected Increase in Gross Demand (AFY)
Arkansas	256,900	373,500	354,900	18,600	98,000
Colorado	74,100	143,800	136,000	7,800	61,900
Dolores/San Juan/San Miguel	23,600	44,800	42,400	2,400	18,800
Gunnison	20,600	37,600	35,500	2,100	14,900
North Platte	500	600	600	—	100
Rio Grande	17,400	23,100	21,700	1,400	4,300
South Platte	772,400	1,250,800	1,182,100	68,700	409,700
Yampa/White/Green	29,400	52,600	51,700	900	22,300
TOTAL	**1,194,900**	**1,926,800**	**1,824,900**	**101,900**	**630,000**

Table 5-7 Estimate of Average Annual SSI Water Use in 2000 and 2030 by County and User Type

County	Power Generation		Snowmaking		Industrial and Mining Processes		Total Estimated Self-Supplied		Increase
	2000	2030	2000	2030	2000	2030	2000	2030	
Adams	9,600	9,600	0	0	NE	NE	9,600	9,600	0
Arapahoe	0	0	0	0	NE	NE	0	0	0
Boulder	2,900	2,900	400	600	NE	NE	3,300	3,600	300
Clear Creek	NE	NE	400	600	NE	NE	400	600	200
Denver	2,400	2,400	0	0	NE	NE	2,400	2,400	0
Eagle	NE	NE	400	600	NE	NE	400	600	200
Garfield	NE	NE	400	600	NE	NE	400	600	200
Grand	NE	NE	1,200	1,900	NE	NE	1,200	1,900	700
Gunnison	NE	NE	300	500	NE	NE	300	500	200
Jefferson	NE	NE	0	0	52,400	52,400	52,400	52,400	0
La Plata	NE	NE	400	600	NE	NE	400	600	200
Larimer	5,200	11,200	0	0	NE	NE	5,200	11,200	6,000
Mesa	NE	NE	400	600	NE	NE	400	600	200
Moffat	11,500	19,100	0	0	2,100	3,900	13,500	23,000	9,500
Montrose	1,900	3,900	0	0	NE	NE	1,900	3,900	2,000
Morgan	5,900	13,900	0	0	NE	NE	5,900	13,900	8,000
Pitkin	NE	NE	2,000	3,200	NE	NE	2,000	3,200	1,200
Pueblo	9,000	17,800	0	0	49,400	49,400	58,500	67,300	8,800
Routt	2,700	7,600	300	600	2,800	5,600	5,800	13,800	8,000
San Miguel	NE	NE	400	600	NE	NE	400	600	200
Summit	NE	NE	1,500	3,700	NE	NE	1,500	3,700	2,200
Weld	3,100	7,400	0	0	NE	NE	3,100	7,400	4,300
TOTAL	**54,200**	**95,800**	**8,100**	**14,100**	**106,700**	**111,300**	**169,000**	**221,400**	**52,400**

NE = no estimate
Note: Counties not shown are not expected to have significant SSI use.

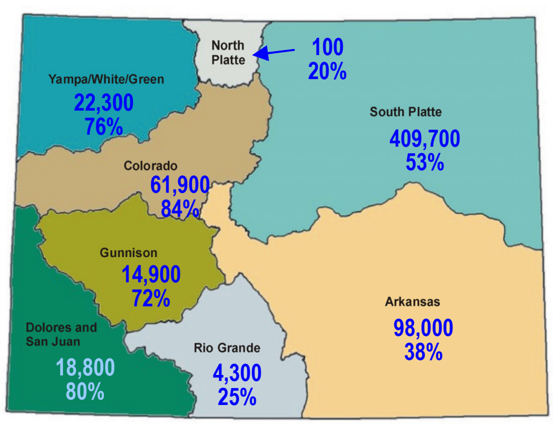


Figure 5-7
Projected Increase in Combined Gross M&I and SSI Demand (AFY) and Percent Increase from 2000 to 2030 by Basin

High and low estimates were also developed around the baseline M&I and SSI water use projections described above. Results of the high and low analysis are presented on a basin basis in Figure 5-8. These values represent the range of demands that might be expected to occur in each basin in 2030, as explained in more detail in Appendix E. Enhanced conservation efforts that could further reduce the "low" water use projections were considered in the options evaluation phase as described in Sections 8 through 10.

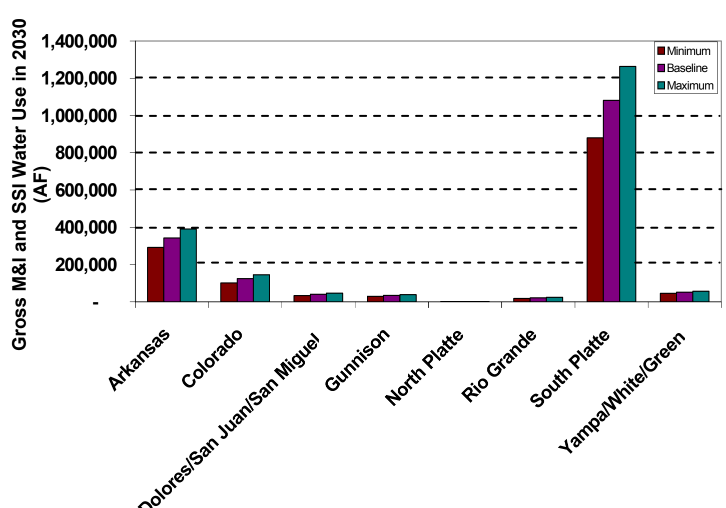


Figure 5-8
Range of Potential Gross M&I and SSI Water Use in 2030

5.3 Projected 2030 Agricultural Demand

Projections of 2030 agricultural demands and supporting data are presented in Table 5-8. As a result of the estimated potential changes in irrigated acres, agricultural demands and their associated gross diversions are shown as decreasing in the Arkansas, Colorado, Gunnison Rio Grande, and South Platte Basins. Demands in the Dolores/San Juan/San Miguel and Yampa/ White Green Basins may have a net increase if additional agricultural supplies are developed to provide for the increase in irrigated acres. Gunnison Basin agricultural demands could increase if additional supplies are developed to reduce shortages on existing irrigated lands. The North Platte Basin is not expected to have a significant change in demands.

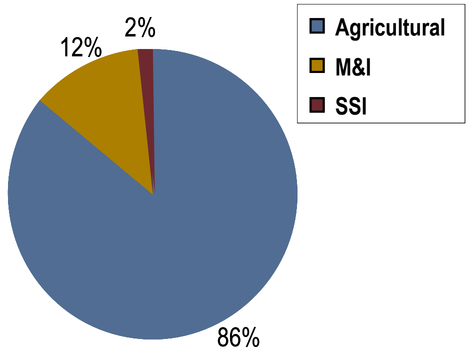


Figure 5-9
Relative Proportions of Agricultural, M&I, and SSI Water Use in 2030

A summary of total projected Colorado agricultural use relative to M&I and SSI demands is shown in Figure 5-9. As can be seen, agricultural use is expected to still comprise the majority of these uses in 2030.

To better anticipate future conditions, it is helpful to examine existing supply and demand. Current agricultural water shortages (crop requirement – supply greater than zero) for the basins with DSS tools have been evaluated. There are a number of factors that impact the calculation of water shortages such as the relative priority of water rights, the physical supply of water available for diversion at any given point, and irrigation practices. These factors are discussed in greater detail below. First, under the Colorado prior appropriation system, water is allocated based on the priority of the water right, so that during times of average to less than average streamflows, some water rights will not be in priority, resulting in a shortage of water to meet irrigation water requirements. The South Platte and Arkansas Basins have many irrigation ditches that are water-short as a result of the extensive appropriation and competition for water in these basins. The development of the Colorado-Big Thompson (CBT) Project in the South Platte and the Frying Pan-Arkansas (Fry-Ark) Project in the Arkansas Basin were developed to address a portion of the water shortages in these basins.

Table 5-8 Current and Range of Potential 2030 Agricultural Demands (AFY)

Basin	Irrigated Acres	Irrigation Water Requirement (IWR)	Water Supply Limited (WSL)	Incidental Losses + Stock Pond Evaporation	Gross Diversions
Current:					
Arkansas	405,000	748,000	619,000	69,000	1,770,000
Colorado	238,000	366,000	319,000	36,000	1,764,000
Dolores/San Juan/San Miguel	255,000	370,000	294,000	33,000	953,000
Gunnison	264,000	473,000	396,000	44,000	1,705,000
North Platte	116,000	96,000	96,000	11,000	397,000
Rio Grande	633,000	1,108,000	776,000	87,000	1,660,000
South Platte	1,027,000	1,798,000	1,541,000	173,000	2,606,000
Yampa/White/Green	118,000	138,000	123,000	14,000	642,000
STATE TOTAL	**3,056,000**	**5,097,000**	**4,164,000**	**467,000**	**11,497,000**
2030 Projections:					
Arkansas	333,000-382,000	616,000-707,000	510,000-584,000	57,000 - 65,000	1,457,000-1,670,000
Colorado	222,000-230,000	342,000-354,000	298,000-309,000	33,000 – 35,000	1,644,000-1,706,000
Dolores/San Juan/San Miguel	252,000-259,000	368,000-373,000	292,000-296,000	33,000 – 33,000	948,000-962,000
Gunnison	254,000-261,000	455,000-468,000	381,000-392,000	43,000 – 44,000	1,640,000-1,689,000
North Platte	116,000	116,000	96,000	11,000	397,000
Rio Grande	533,000-573,000	932,000-1,003,000	653,000-703,000	73,000-79,000	1,398,000-1,503,009
South Platte	801,000-894,000	1,402,000-1,565,000	1,202,000-1,342,000	135,000-150,000	2,033,000-2,269,000
Yampa/White/Green	116,000-158,000	135,000-183,000	120,000-163,000	13,000-18,000	627,000-852,000
STATE TOTAL	**2,726,000-2,932,000**	**4,366,000-4,769,000**	**3,552,000-3,885,000**	**398,000-435,000**	**10,144,000-11,048,000**

Second, the lack of available physical supply can also be a factor that contributes to the calculation of water shortage. For example, a ranch may irrigate hay meadows from a number of small streams running through the ranch. These small streams will normally dry up in late summer, resulting in a lack of available supply even though the water right may be in priority. Additional water supplies could be put to beneficial use if water were available. Shortages as a result of the priority of water rights and the lack of physical supply could potentially be reduced if additional storage were developed to supplement existing supplies.

A third factor that contributes to water shortage calculations results from irrigation practices. These calculated shortages are attributable to farming operational practices, where farmers choose to cease irrigation before the end of the growing season. In other words, the shortages are by choice rather than due to water availability. For example, irrigation may cease for the season in late July or early August, even though water supplies may be available. This is to allow hay to be cut, dried, and baled. The theoretical need for water remains, and additional application of water would result in additional CU. This type of water shortage cannot be reduced through additional water supplies and has not been further evaluated.

For the basins having DSS tools, water districts that have significant water shortages resulting from the relative priority of the water rights or lack of physical supply have been identified. A more detailed description of the methodology for evaluating these shortages can be found in Appendix F. Figure 5-10 shows those basins that have been determined to have significant water shortages as described above. Based on the prevalence of calls throughout the entire Arkansas and South Platte Basins, even during average year streamflow conditions, widespread agricultural water shortages can be expected. In the North Platte Basin, Basin Roundtable participants indicated a need to firm up agricultural supplies. Although there is no DSS for the North Platte Basin, agricultural shortages can be expected.

Generally, the cost of water development exceeds the ability of agriculture to pay for the development of additional water supplies. As a result, it may not be practical or cost-effective to attempt to develop water supply alternatives for areas having agricultural water shortages unless multi-purpose projects could be developed. Section 10 lists potential options for reducing agricultural shortages that have been identified during the process. Funding and ability to pay must be addressed if any of these projects are to be developed.

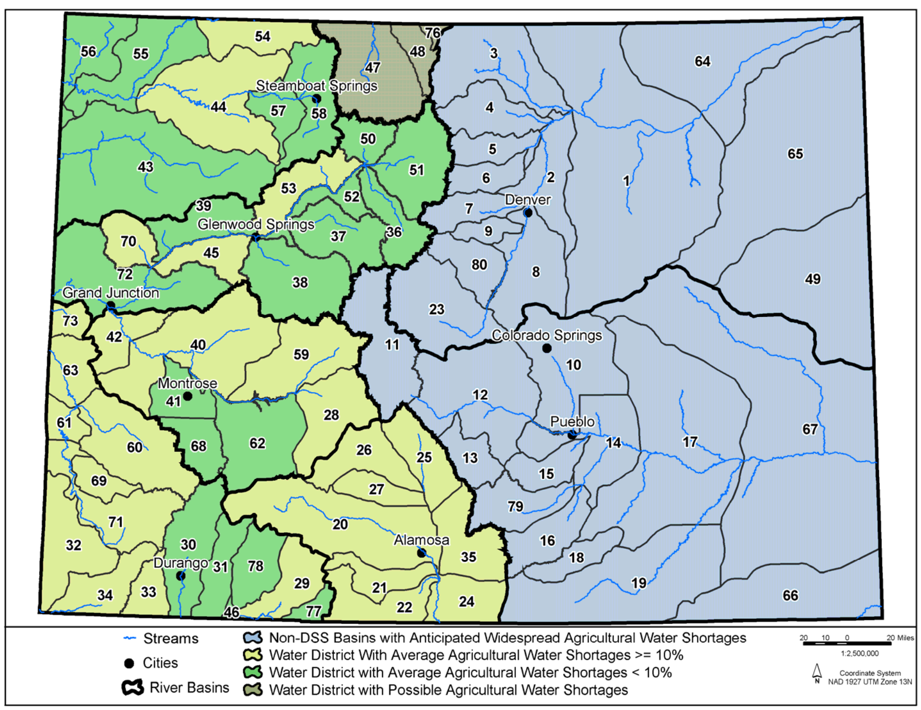


Figure 5-10
Summary of Agricultural Water Shortages by Water District

Section 6
Water Needs Assessment

As described in Section 5, all types of water use, from M&I to agricultural, recreational to environmental, are expected to be significant in 2030. Using input and feedback from the Basin Roundtables as a foundation, SWSI examined how the future water needs of each use and user could be met. Water providers and users, interest groups, organizations, and individuals throughout Colorado have identified a plethora of potential solutions to address future needs. In many cases, water management solutions were more numerous and further developed for M&I uses, while agricultural, recreational, and environmental solutions were fewer or more conceptual in nature. This is partially a result of the technical, planning, and financial resources available to M&I users that allow for more detailed planning and financial resources for implementation.

This section documents the methods employed and results of SWSI's efforts to:

- Catalog and characterize specific water management solutions that are being contemplated around the state for each type of use.
- Identify the amount of water, by basin and subbasin, that will be produced by projects or processes that are expected to move forward with a reasonable degree of certainty by 2030 – called "Identified Projects and Processes" in SWSI.
- Estimate the remaining amount of water needed (the "gap" in supply) in each basin to meet 2030 needs, assuming each of the Identified Projects and Processes completely meets its supply goals.
- Consider the potential implications if a portion of the Identified Projects and Processes are not successfully implemented.

Supply availability is discussed in Section 7. Water management solutions that are less ready for implementation, but could be considered for addressing the remaining "gap" between supply and demands (after subtracting the yields of the Identified Projects and Processes), are described in Section 8.

Key findings of the water needs assessment conducted under SWSI include:

- Most M&I water providers that responded to survey data requests indicated that they either have identified plans or processes underway to meet their estimated demands through 2030.
- It is critical that the Identified Projects and Processes are successfully implemented to meet those future M&I needs or the gap between supply and demand will increase.
- While M&I demands will increase substantially by 2030, as much as 80 percent of that increase could be met through the successful implementation of the Identified Projects and Processes already underway or planned for implementation by M&I water providers.
- Solutions for addressing agricultural, recreational, and environmental water needs are less well-defined and less certain in their implementation due to a number of factors, such as funding constraints, or an inability or mechanism for the beneficiary to contribute financially.
- The CWCB has one of the most proactive and ambitious instream flow programs in the United States. CWCB's instream flow programs have been in existence since 1973 and have protected approximately 8,500 miles of Colorado streams and approximately 500 natural lake levels. The CWCB is authorized to acquire and file water rights to protect the natural environment to a reasonable degree. As part of the SWSI process, many of the Basin Roundtable members expressed the desire to explore other mechanisms beyond CWCB's flow authorities.
- To date, other than through CWCB's instream flow program, there is no coordinated process or widely-accepted method for estimating recreational and environmental flow enhancement goals or prioritizing stream segments or ecological areas for such enhancement.

6.1 Method Employed to Assess Water Needs

6.1.1 Cataloging of Potential Water Management Solutions

Water management solutions were compiled for each basin based on feedback from Basin Roundtable members, Basin Advisors, available reports, studies, plans, and other sources. While any such catalog of solutions is sure to be temporally dynamic, this analysis provided a basis of evaluating future water needs and priorities throughout Colorado. Water management solutions can be virtually any structural or nonstructural action taken to address one or more water users' needs, such as:

- Conservation
- Maximization of existing water rights and water facilities
- Increased reuse of existing or future consumable water supplies
- Rehabilitation, reoperation, or enlargement of existing water supply facilities
- Flow management agreements
- Water transfers
- New water supply projects

Stand-alone water management solutions, referred to as "options" in SWSI, were identified for all uses and users and compiled for each basin. Based on input from project sponsors and the Basin Roundtables, each option was categorized as one of the following:

- **"Identified Projects and Processes"** – those options that are relatively well-defined and can reasonably be expected to be implemented between now and 2030 to address current or increasing water needs. These Identified Projects and Processes are listed in Section 6.2.
- **"Options for Alternatives"** to meet the remaining gap – options that have implementation issues, 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 dialogue – 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 Alternatives – were identified through the Basin Roundtable process as being potentially viable for implementation, but could benefit from implementation assistance or further evaluation as part of a longer-term strategy for meeting needs.

Many of the options identified through the Basin Roundtable process that would benefit agricultural, environmental, or recreational users and uses are categorized as Options for Alternatives – rather than Identified Projects and Processes – because their successful implementation is less certain due to issues such as a lack of suitable funding or payment mechanisms, or an inability to pay for the desired solutions.

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.

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. 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 Colorado's 2030 water needs. Monitoring the implementation progress and success of these projects and processes will be needed to determine whether Colorado has adequate water supplies for our citizens.

6.1.2 Assessment of Future M&I and Agricultural Water Needs

6.1.2.1 M&I Needs

For each basin, 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 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 from 2000 to 2030 for each basin or subbasin, 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). Additional conservation must be carefully evaluated for potential impacts on the reliability of water systems to meet demands during droughts. If water providers rely on temporary water use restrictions to ensure adequate supplies during droughts, then permanent water conservation savings that are allocated to new growth may decrease the ability to achieve the necessary additional reductions in demand during drought periods. This concern, referred to as "hardening of demand" is discussed in Section 8.

SWSI found that, if fully implemented, the Identified Projects and Processes are capable of meeting up to 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 projected increase and demand by 2030 could be addressed with the Identified Projects and Processes, leaving a remaining gap in supply of about 118,200 AF statewide. In many cases, M&I water providers indicated that their entire increase in demand would be satisfied through their own existing supplies and Identified Projects and Processes, meaning that there would be no gap for that provider. Often, this includes conservation measures that will reduce demands beyond the reductions anticipated from Level 1 conservation.

Since water supply projects typically are developed in large increments of yield, many providers may have "excess" supply capacity at any given point in time. That is, it is infeasible for providers to bring on new incremental supplies on a monthly or annual basis to precisely match the progression of increases in demands. Instead, excess supply capacity will be available until demands increase to the point that actions must be initiated to ensure that the next increment of supply available when needed. However, it is important to make the clear distinction between excess supply capacity and actual use – actual use of water supplies will not exceed demands, even if excess capacity is available.

Many of the Identified Projects and Processes being pursued by M&I water providers include one or more of the following:

- Transferring agricultural rights from outside existing or future service areas
- Acquiring agricultural rights through development of irrigated lands or annexation requirements
- Acquiring additional water delivery contracts from the BOR, conservancy districts, or other local or regional water projects
- Maximizing the use of existing water rights
- Enlarging existing storage facilities to firm existing and future water rights
- Continuing, expanding, and developing water conservation programs and public education programs to encourage efficient water use
- Developing additional supplies for well augmentation by acquiring CU supplies from agricultural transfers, new storage, or water delivery contracts
- Developing new storage to firm existing and future rights and capture consumable supplies for later use
- Increased reuse of existing consumable supplies or developing reuse strategies for future consumable supplies including non-potable irrigation of parks and golf courses, exchanges and indirect potable reuse by blending return flows with existing raw water supplies

Each Identified Project and Process has some risk that it will not yield all of the intended water supply. There will be increased competition for future M&I water supplies – especially along the Front Range as many water providers have indicated that they will meet future demands through the development of existing or future conditional storage rights or acquisition of agricultural water rights or water delivery contracts. During the SWSI process, it became apparent that many water providers had identified the same sources of water and there may not be adequate supplies to meet the needs of the various providers. In addition to competition for the same limited water resources, there are risks that permits may never be approved for construction of projects or that mitigation requirements may make a project cost-prohibitive or fail to produce the planned yield. Some providers are pursuing multiple projects simultaneously to account for this risk, while others will need each of their Identified Projects and Processes to meet future demands. Uncertainty associated with the Identified Projects and Processes is discussed in Section 6.2.

A conceptual overview of the M&I gap analysis method is provided in Figure 6-1. In hypothetical Subbasin A, the entire increase in demand can be met by that subbasin's Identified Projects and Processes and existing supplies – meaning there is no remaining gap if all the Identified Projects and Processes are successfully implemented. In contrast, in hypothetical Subbasin B, the Identified Projects and Processes and existing supplies can only address a portion of the increase in M&I demands, so the remaining gap will need to be addressed by Options for Alternatives.

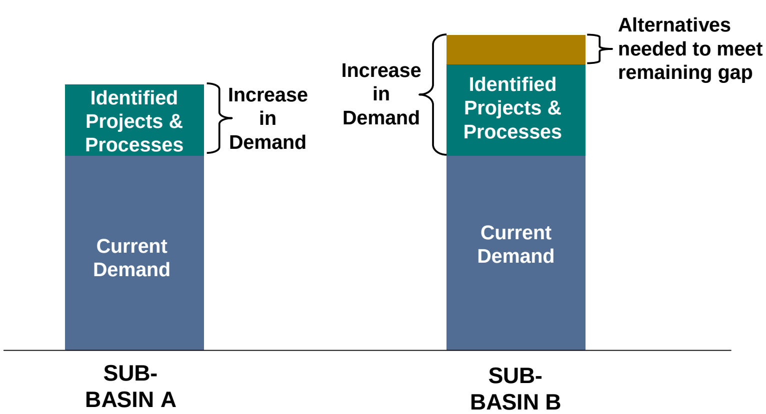


Figure 6-1
Example of Preliminary Gap Analysis

6.1.2.2 Agriculture

The needs for agricultural uses were evaluated through the use of DSS in the Colorado, Dolores/San Juan/San Miguel, Gunnison, Rio Grande, and Yampa/White/Green Basins. The DSS data were supplemented with feedback during the Basin Roundtable process and discussions with the Division Engineers. The Arkansas, North Platte, and South Platte Basins do not yet have a DSS, and evaluation of agricultural needs was determined by feedback during the Basin Roundtable process and discussions with the Division Engineers and water users in the basin.

The reader is encouraged to review Section 5 to more fully understand the approach and methodology used to identify agricultural shortages. Many agricultural water systems in Colorado have evolved to be productive with less than an ideal water supply (see Irrigation Water Requirement). A crop does not have to have water at all phases of its growth in the maximum theoretical amounts. In other words, some shortage can be tolerated and still yield economically acceptable return on investment.

Finally, it should be noted that some agricultural water systems are capable of delivering adequate water to satisfy crop requirements, but still can operate at less than 100 percent water allocation.

For agricultural demands, water districts with current shortages of 10 percent or greater were identified in Section 5. Without solutions to address these shortages, it can be expected that these shortages will continue on through 2030. Figure 5-10 indicates the water districts on the West Slope and Rio Grande where agricultural shortages average greater than 10 percent. Agricultural water shortages are widespread in the South Platte and Arkansas Basins. In the South Platte Basin, shortages are expected to increase as municipal providers become more efficient and increase reuse of return flows that previously were unused and available for use by downstream agricultural users. In the South Platte Basin, the increased use of M&I return flows, together with the well augmentation requirements of Senate Bill 73, are projected to result in increased agricultural shortages and a decrease in irrigated acres. In addition, the continued transfer of CBT units from agricultural to M&I use will reduce agricultural water availability as this supplemental water supply will no longer be available to address agricultural shortages. As indicated in Figure 5-10, a large majority of the state is estimated to have significant agricultural shortages, whereas the Colorado and Yampa/White/Green Basins will have relatively fewer water districts *without* average annual agricultural water shortages.

All basins expressed a need to firm up existing agricultural supplies regardless of changes in irrigated agricultural acreage. However, in many basins agricultural users indicated that acquiring additional water or implementing new or enlarged storage was not economically or technically (due to lack of water availability) feasible. Agricultural users generally cannot pay the cost of acquiring or developing new supplies without subsidy of the water development costs. **Therefore, agricultural shortages will not be addressed through the Identified Projects and Processes (this section) and the Options for Alternatives development (Sections 8 and 10) for all basins unless requested through the SWSI process.** As a result, agricultural shortages have only been addressed in those basins where agricultural users have indicated the potential for acquiring or developing new supplies. In addition, agricultural users in the San Juan Basin under the Dolores Water Conservancy District are in the process of purchasing existing supplies and a reservoir from another irrigation company to irrigate an additional 4,000 acres. In the Yampa Basin, the agricultural Roundtable members indicated the potential to irrigate an additional 20,000 to 39,000 acres, if storage and delivery systems can be permitted, financed, and constructed.

6.1.3 Potential Approaches to Defining Environmental and Recreational Flow Enhancements

Since its implementation in 1973, CWCB's Instream Flow Program has been successful filing water rights to protect the "minimum stream flows or natural lake levels or volumes necessary to preserve the natural environment to a reasonable degree." The recent addition by the State Legislature that granted the CWCB authority to secure instream flows that "preserve or *improve* the natural environment" provides an opportunity to further enhance flows in Colorado's rivers and streams. In addition, through the SWSI process, programs that go beyond CWCB's minimum flow requirements could be implemented where legally, technically, politically, and economically feasible.

Recreational and environmental water needs are generally in-channel flow-based and non-consumptive. These uses have not traditionally been a major part of water planning. Today, much of the work done to address these flow-based needs is tied to agricultural or M&I projects, and much of it is done solely for mitigation of those project impacts. Roundtable and public participants in SWSI expressed significant interest in enhancing flows for recreational and environmental needs beyond legally mandated mitigation levels.

Potential solutions were identified, such as RICDs, re-operation of existing facilities for flow enhancement, or dedicated or multi-use projects. For example, Elkhead Reservoir enlargement in the Yampa Basin will provide for water supply needs as well as a storage pool for releases for endangered species. Wolcott Reservoir in the Colorado Basin, if constructed, is intended to address endangered species needs through the 15-mile reach in the lower part of the Colorado River in Colorado and water supply is another example of a project that can serve multiple needs.

While flow enhancement for environmental and recreational uses was identified by many SWSI participants as being important, few Identified Projects and Processes, aside from river compact deliveries and the CWCB's instream flow program, directly address flow enhancements beyond statutory legal requirements. In support of future options with multi-benefit approaches, several groups provided input to SWSI as to how the state might consider developing a framework for setting goals for these flows. Environmental Defense, Trout Unlimited, and The Nature Conservancy (TNC) provided structured feedback and input on the subject, and suggested that this framework should include parameters such as seasonal variability, which could include occasional flood pulses, high flow periods, and steady base flows, as many aquatic ecosystems benefit from these flow conditions.

This section provides a synopsis of the input received from these groups as a possible starting point for defining environmental and recreational flow goals. Further discussion at the CWCB Board and through the Basin Roundtables or similar groups will be needed to effectively assess whether and how to proceed with incorporating some of these methods for use in Colorado. More specific environmental and recreational options or concepts that could be pursued, as brought forth through the Basin Roundtable process and public input, but that are not included on the list of Identified Projects and Processes, are provided in Section 10.

6.1.3.1 Conserve, Protect, and Restore Approach

One concept for environmental and recreational flow management brought forth by environmental and recreational interest group representatives in SWSI was the "Conserve, Protect, and Restore" (CPR) approach.

The "Conserve" component is centered on keeping currently "healthy" – both in terms of quality and quantity – rivers healthy. This could include the following strategies:

- Acquisitions of interests in water to improve an existing environment via Senate Bill 02-156 authority
- New CWCB instream flow appropriations
- Interruptible water supply agreements
- Leases and other methods

Segments for consideration under the "Conserve" component could include Gold Medal fisheries, wild trout reaches, three-factor (R2 Cross method), intact instream flow reaches, Great Outdoors Colorado Legacy reaches, TNC designated reaches, reaches in wilderness and national parks, and other known high-quality stream segments. The gap between supply and demand might then be measured through ecologically sustainable water management, or other method(s) that fully protect flows, noting that in some cases there may be no gap.

The "Protect" component suggested by the interest groups includes keeping threatened but currently healthy reaches whole, or as close to whole as possible. In addition to the strategies indicated above for the "Conserve" segments, strategies could include integration of permit conditions (federal, state, or local) and agreements such as that contemplated under the ongoing UPCO process. Relevant segments could include any reach that might be affected by future water management actions (e.g., the Identified Projects and Processes or other future actions). The "gap" associated with protecting those identified reaches would then be the difference between current conditions and the minimum (or higher) flow necessary to maintain a functioning, healthy ecosystem.

The "Restore" component suggested by the interest group representatives revolves around restoration of dry, low-flow, or low-quality segments. Project reoperations and ditch lining are two possible strategies that could be employed, in addition to those listed for "Conserve" and "Protect." Possible candidate segments could include truncated instream flow reaches; two-factor instream flow reaches; reaches with endangered, threatened, or sensitive species; Dry Legacy reaches; or others from the Colorado Water Trust maps. Truncated instream flow reaches are those that do not connect habitat, such as portions between tributaries and mainstems, through which fish may not be able to move within a region. Two-factor instream flow reaches are those on which CWCB has used two of the normal three factors in determining minimum flows using the R2 Cross method, often resulting in lower flow criteria and often the result of a lack of water availability on the subject reach. The gap in the "Restore" segments could be considered to be the difference between current conditions and flow goals estimated from this approach, ecologically sustainable water management conditions, or other considerations.

It was noted that the "CPR" approach may differ for environmental versus recreational flow needs.

This approach could be integrated into the Identified Projects and Processes, Options for Alternatives, or as new stand-alone options, as each moves from concept toward implementation.

6.1.3.2 Concepts for Estimating Environmental Flow Needs

Environmental and recreational interest groups suggested that in characterizing environmental water needs, a two-step approach could be implemented:

- Identify and locate critical water-dependent species and natural systems
- Assess the environmental demands (or ecological flow needs) of those systems

Key sources for information for water-dependent species and systems might include:

- CDOW
- Colorado Natural Heritage Program (CNHP)
- Colorado Water Trust
- TNC Ecoregional Plans
- Colorado River Endangered Fish Recovery Programs

It was also suggested that a model could be developed to determine environmental or instream needs of these communities by identifying integral components of the flow regime such as:

- Base flows
- Normal high flows
- Drought and flood conditions
- Interannual variability

6.1.3.3 Approaches to Determining Environmental Flow Needs

TNC proposed the following components to serve as part of an initial method to quantify environmental water demands:

- A coarse statewide characterization
- A select set of pilot projects (two to five) at critical conservation sites
- An evaluation of specific environmental demand after preliminary identification of likely project locations through SWSI

TNC has offered its assistance, along with the Colorado Water Caucus, in data collection and characterization efforts, including gathering a team of experts in riparian and aquatic ecology to work with the CWCB and Basin Roundtable members.

Trout Unlimited suggested that portions of the UPCO Study and other similar approaches be implemented to identify priority stream reaches within each basin that are used for recreational purposes.

Table 6-1 provides a summary of the methods and data sources suggested by these groups for determining environmental and recreational water needs.

Table 6-1 Summary of Suggestions for Determining Environmental and Recreational Needs

Suggested by	Environmental and Recreational Demand Component	Information	Source
Environmental Defense and Trout Unlimited	Determine restoration flow using methodology outlined in Covington and Hubert (2003)[1]	■ Stream gage data ■ Aerial photos ■ Topographic info	■ USGS: http://waterdata/usgs.gov/co/nwis/rt ■ USGS and University of Colorado's Center for the Study of Earth from Space (CSES) ■ USGS topographic quadrangle maps
TNC	Determine water-dependent species and ecosystems	—	■ CDOW ■ CNHP ■ Colorado Water Trust, Documentation of Mapping of Critical Water-Dependent Natural Systems, prepared for CDOW, June 30, 2002 ■ TNC Ecoregional Plans ■ Upper Colorado River Endangered Fish Recovery Program
TNC	Determine environmental or instream needs of the systems	■ Base flows ■ Normal high flows ■ Drought and flood conditions ■ Interannual variability	—
Other information and relevant sources:			
Trout Unlimited	—	■ Instream flow and natural lake level water rights	■ http://cwcb.state.co.us/isf/Database
Trout Unlimited	—	■ Recommendations for instream flow and lake level appropriations	■ CDOW
Trout Unlimited	—	■ Minimum and recommended optimum flow levels for popular kayaking and rafting stream reaches	■ American Whitewater Association: http://www.americanwhitewater.org/rivers/state/CO
Additional reports to consider:			
Trout Unlimited	—	—	■ USFWS, PBO for the BOR's Operations and Depletions, Other Depletions and Funding and Implementation of Recovery Program Actions in UPCO, December 1999
Trout Unlimited	—	—	■ USFWS, Recovery Implementation Program, Flow Recommendations to Benefit Endangered Fishes in the Colorado and Gunnison Rivers, Final Report, July 2003
Trout Unlimited	—	—	■ Hydrosphere Consultants, Inc. Gunnison River - Aspinall Unit Temperature Study, Phase 1, Final Report, for the Endangered Species Recovery Program, March 2002
Trout Unlimited	—	—	■ Roehm, G.W, USFWS, Mountain Prairie Region. A Draft Management Plan for Endangered Fishes in the Yampa River Basin and Environmental Assessment, Denver, 2003
Trout Unlimited	—	—	■ USFWS, UPCO Endangered Fish Recovery Program, Summary of Section 7 Consultations
Trout Unlimited	—	—	■ USFWS, 2002 Red Mesa Ward Reservoir Project Biological Opinion

Table 6-1 Summary of Suggestions for Determining Environmental and Recreational Needs

Suggested by	Environmental and Recreational Demand Component	Information	Source
Trout Unlimited	—	—	■ Annual Letter of Agreement Regarding Arkansas River Flows and Reservoir Releases for the Arkansas River Headwaters Recreation Area, from Executive Director Colorado DNR to the BOR and SECWCD
Trout Unlimited	—	■ Flow requirements for sustaining physical stream habitat and impacts that could result from altered flow regimes in various Metro Denver rivers	■ USACE, Metropolitan Denver Water Supply ES, 1988.
Trout Unlimited	—	■ 1-day and 30-day, and 3-year low flows for stream reaches below wastewater treatment plant	■ Contact plant operators or Colorado Pollution Elimination Discharge Permits for each discharger
Trout Unlimited	—	■ Assessing instream flow needs for streams on National Forest System Lands	■ Various USFS EIS and Environmental Assessments - Ex: Arapahoe Basin Master Development Plan Final EIS, Prepared by the White River national Forest, Dillon Ranger District, September 1999

[1] Covington, J. Scott, and Wayne A. Hubert (2003). Trout Population Responses to Restoration of Streamflows. Environmental Management, 31(1), 135-147.

6.2 Implications of Uncertainty in Identified Projects/Processes and Existing Supplies

In considering the M&I Identified Projects and Processes, the SWSI team and Basin Roundtable members recognized that there may be significant uncertainty in the implementation of many of these projects and processes. That is, any project that is not yet fully implemented could fail to result in the full amount envisioned, for various reasons. Reasons for projects not being fully implemented could include:

- Competition for available water supplies as many providers have identified the same future sources.
- Identified Projects and Processes may yield less or store less than currently envisioned due to permitting constraints or other factors. Some projects may never be permitted or otherwise never be constructed due to implementation constraints.
- The ability to develop water supply projects may be affected by the management of flows and habitat for endangered species as most water supply development projects will require certain federal permits.
- Areas depending on non-renewable, non-tributary groundwater have reliability and sustainability concerns. Continued pumping of non-renewable groundwater to meet existing demands may become problematic due to declining water levels resulting in reduced well yields.
- Agricultural and smaller water providers will have difficulty funding water development projects.

Without judging the merits of any individual water provider or basin's Identified Project 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 fixtures and replace older, higher-flow devices in response to the National Energy Policy Act of 1992. Initial uncertainty levels of 25 percent and 50 percent were applied to the yield of the Identified Projects and Processes to illustrate the importance of currently-identified solutions in meeting Colorado's future water demands.

Figure 6-2 indicates the implications of uncertainty in the Identified Projects and Processes. To any extent that the Identified Projects and Processes fail 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.

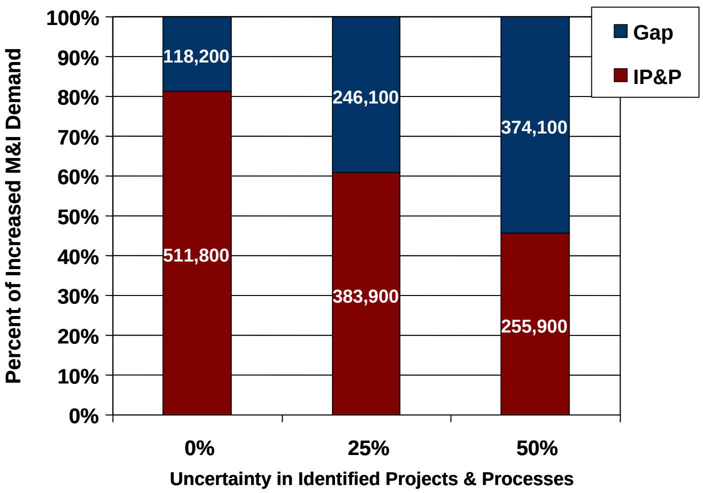


Figure 6-2
Implications of Uncertainty in Identified Projects and Processes on Meeting 2030 M&I and SSI Water Needs

Any yield that would otherwise have come from Identified Projects and Processes for M&I use might likely instead be satisfied with additional permanent agricultural transfers. History has shown that M&I providers will indeed find a way to meet their customers' needs, and agricultural water is the most readily-available source for meeting those needs. As discussed earlier, agricultural transfer will still require storage and infrastructure to move water from its source to treatment facilities and distribution systems.

Thus, it is possible that a failure to implement the Identified Projects and Processes would 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 5-5. The lower end of the range 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 6-3 shows the additional acres of irrigated farm land that might be put out of irrigated production if 25 to 50 percent of the Identified Projects and Processes were not successfully implemented. Agricultural transfers, however, are also not without risk and uncertainty due to the water court process, volume of storage required, and local and federal permits needed for construction of necessary facilities.

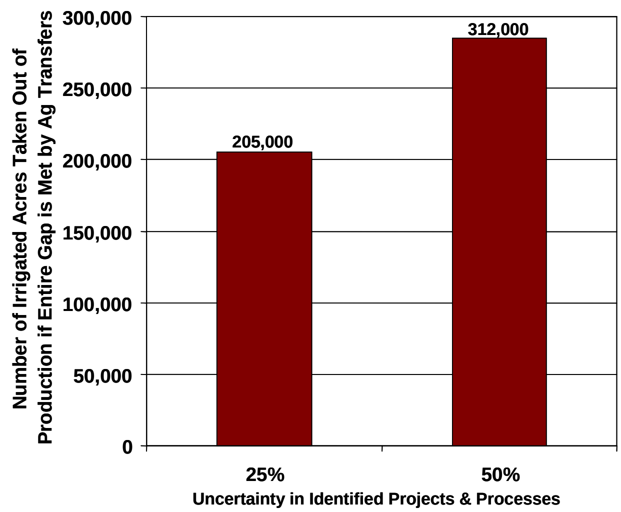


Figure 6-3
Potential Impact on Irrigated Agricultural Acres if Identified Projects & Processes are Not Implemented

Funding and permitting remain the primary challenges in implementing water management solutions in Colorado. Major implementation issues associated with water use in Colorado are discussed in Section 11 of this report.

6.3 Identified Projects and Processes

The catalog of Identified Projects and Processes was summarized by subbasin or county and is presented in this section. Table 6-2 provides a summary of each basin's increased M&I and SSI demands, the amount of that increase provided by the Identified Projects and Processes, and the general locations of the gap.

Table 6-2 Statewide M&I and SSI Gaps in 2030

Basin	Increase in M&I and SSI Demand (AFY)	Estimated Yield of Identified Projects and Processes if Fully Implemented (AFY)	Estimated Remaining M&I/SSI Gap After Identified Projects and Processes (AFY)	Locations of Gap
Arkansas	98,000	80,900	17,100	Upper and Southwestern regions (augmentation credits) and Lower region and unincorporated El Paso County (firm water supply).
Colorado	61,900	58,900	3,000	Garfield, Grand and Summit Counties
Dolores/San Juan/San Miguel	18,800	13,900	4,900	San Miguel (water supply), Dolores (need for augmentation credits) and San Juan (infrastructure to deliver existing and future water supplies).
Gunnison	14,900	12,500	2,400	Crested Butte Mountain Resort, Upper Gunnison and Ouray County (need for augmentation credits) and other unincorporated areas not served by Water Districts.
North Platte	100	100	0	No gap anticipated, but storage required for drought reliability
Rio Grande	4,300	4,200	100	Physical availability of groundwater, but will need augmentation credits for well pumping.
South Platte	409,700	319,100	90,600	South and Denver Metro, Northern, Upper Mountains and Lower Platte.
Yampa/White/ Green	22,300	22,300	0	Concerns over drought reliability due to transit losses. Oil shale development in White River basin could significantly increase demands.
Total	**630,000**	**511,800**	**118,200**	

Figure 6-4 presents this information on a map of the state. In many cases, the Identified Projects and Processes have benefits for multiple users, such as agriculture, recreation, and environmental needs.

A broad range of water management solutions with varying levels of supply are planned for each of the basins. Many water providers are pursuing multiple projects and will need all of these identified projects to meet their increased demand. This is due to the reality that each of the Identified Projects and Processes has risk associated with them and that they may not yield all of the anticipated water supply. Many of these projects and processes will benefit multiple beneficiaries and therefore address a number of objectives concurrently. However, challenges exist in determining funding sources and acquiring water rights to support the multiple uses. The following subsections provide a brief description of the major Identified Projects and Processes in each basin. Due to the number of counties and distinct areas in the Arkansas, Dolores/San Juan/ San Miguel, and South Platte Basins, those basins are summarized by subbasins, whereas each of the other basins is discussed at a county level. Because of the overall volume of demand and the size of the projected gaps in the South Platte and Arkansas Basins, those basins' Identified Projects and Processes lists are more populated than the other basins'. Details of each Identified Project and Process, as available to SWSI, are provided in the tables in the subsections below associated with each basin. Also provided is a basin-by-basin discussion of environmental and recreational flow issues.

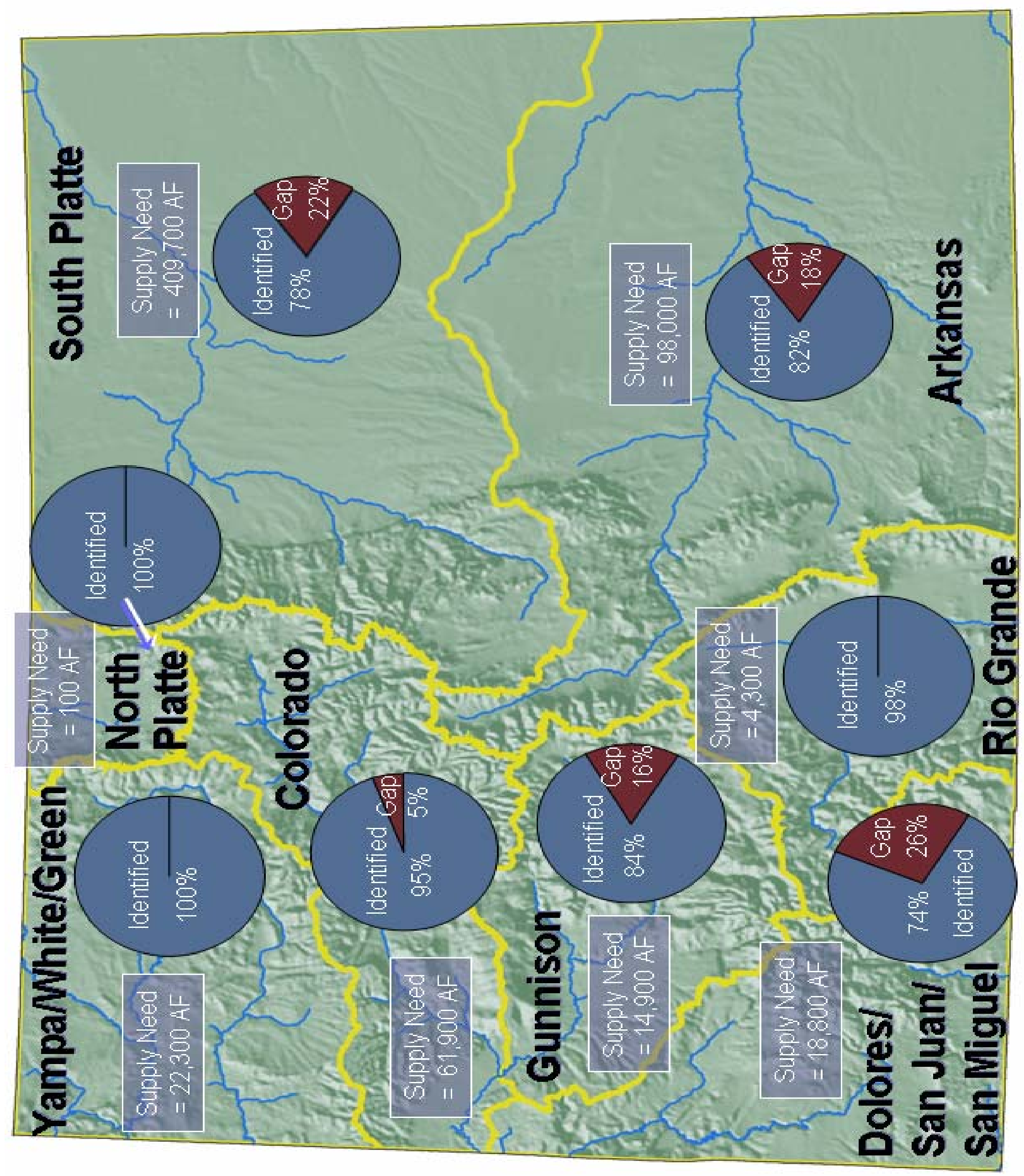


Figure 6-4
Effectiveness of Identified Projects and Processes in Meeting 2030 M&I and SSI Demands

6.3.1 Arkansas Basin

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

Major Identified Projects and Processes for the Arkansas Basin are summarized in Table 6-3. For reference, Figure 6-5 provides a map of subbasins, counties, and major cities in the basin as referenced throughout this discussion.

In the Arkansas Basin, most of the major M&I surface water providers reported that they will be able to meet 2030 needs through existing supplies, projects underway, and future plans and projects. Reuse is being pursued by most providers that have reusable supplies. In most cases in Colorado, reuse is limited to non-native water such as transbasin diversions and the unused first use portion of the CU portion of transfers of agricultural rights. Most of the entities that are planning reuse projects in the Arkansas Basin anticipate using one or more of the following components:

- Augmentation Plans
- Exchanges
- Non-potable use for irrigation of parks and golf courses
- Groundwater recharge
- Gravel lake storage to regulate consumable return flows for exchange or non-potable reuse

While many major providers in the basin currently have identified future water conservation as an identified project and process to meet 2030 demands, they do not anticipate implementing more aggressive levels (Levels 4 and 5) of conservation. In fact, most providers indicated that they would be more likely to acquire additional agricultural rights than to implement aggressive levels of conservation. The various levels of conservation are detailed in Section 8. The urban quality of life associated with irrigated turfgrass and other outdoor watering was cited as an important consideration in promoting reasonable water use and landscaping. Customer acceptance of aggressive, permanent restrictions on irrigated landscaping, rather than temporary drought related bans, was considered to be low. Finally, it was noted that lawn watering can in effect serve as a source of water supply reserve storage, in that that water can be utilized during periods of drought by restricting water use as discussed above in Section 6.1.2.1 and in Section 8.

Moreover, it was estimated that conservation, even at aggressive Level 4 and 5, can reduce, but could not eliminate the Arkansas Basin gap. This is due to the fact that much of the gap is in areas where there are currently inadequate long-term supplies to meet future demands and conserving existing supplies for those users would not meet future water needs. Non-tributary, non-renewable groundwater users need a renewable source of supply and conservation resulting in reduced demand of the non-renewable sources would extend the life of these sources, but not address the ultimate need for renewable sources of water.

Colorado Springs Utilities and the Pueblo Board of Water Works (BOWW) both indicated that they have adequate existing water rights to meet 2030 demands and beyond. Their "surplus" supplies are not available for permanent use by others, since these supplies will eventually be needed by Colorado Springs and Pueblo BOWW. Given the lack of developable new supplies in the Arkansas Basin, agricultural transfers throughout the basin will continue via purchases, developer donations, and development of irrigated lands. Providers in the Southeastern Colorado Water Conservation District (SECWCD), including entities in the Upper Arkansas, Urban Counties, and Lower Arkansas subbasins, are relying heavily on future Fry-Ark allocations and portions of the Preferred Storage Options Plan (PSOP). The PSOP would provide supplies to these areas through its re-operation, reservoir enlargements, and reduction in storage demands due to conservation. The Eastern Plains subbasin will rely on non-tributary groundwater and the Southwestern Arkansas subbasin will rely on augmentation, existing water rights, and agricultural transfers.

Many providers are planning on maximizing the use of their existing transbasin and other consumable supplies. Even though there is no developable additional water in the basin, storage is needed throughout the basin to regulate existing and future supplies, firm the yield of agricultural transfers, provide for augmentation releases, and to capture return flows.

Table 6-3 Major Identified Projects and Processes in Arkansas Subbasins

Subbasin (Counties)	Estimated Demand Met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
Upper Arkansas (Chaffee, Fremont, Lake, Teller)	7,100	■ PSOP – Re-operation of the 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 of 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 (Bent, Crowley, Otero, Prowers)	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 (Baca, Cheyenne, Elbert, Kiowa, Lincoln)	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**	

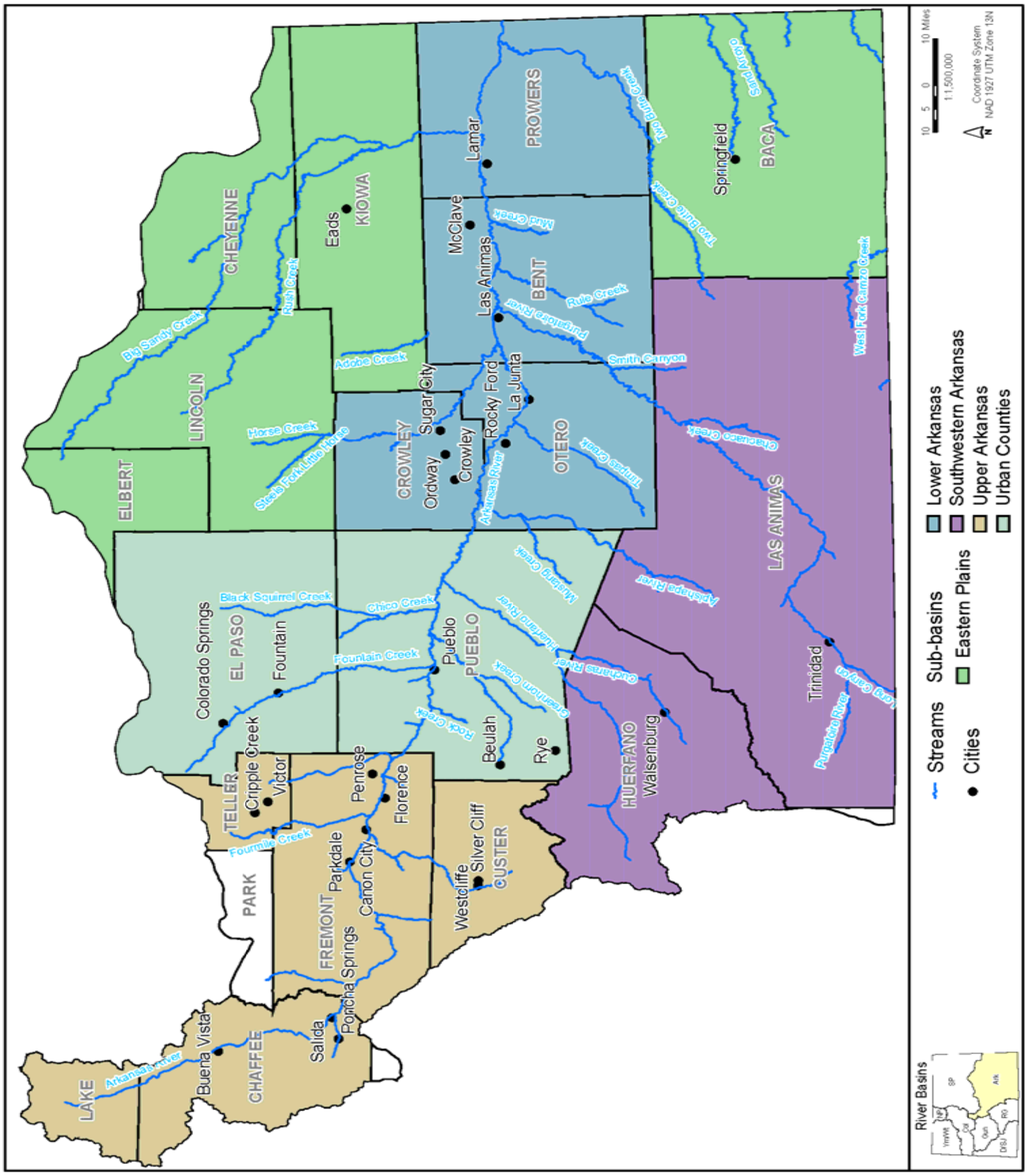


Figure 6-5
Arkansas Basin Location Map

Funding for the Arkansas Valley Pipeline, which would improve drinking water quality and reduce transit losses for the Lower Arkansas Basin communities, is currently being sought at the federal level. The towns along the mainstem of the Arkansas River downstream of the City of Pueblo divert from alluvial wells or from tributary surface water supplies. In addition to local water rights, these towns also have access to Fry-Ark Project allocations and return flows from the use of project water. Stream transit losses are assessed from Pueblo Reservoir to the downstream location and water quality is impacted by minerals and salts in the river channel and return flow as the water flows down the Arkansas River.

Fountain and Security are both participating in the Southern Delivery System with Colorado Springs Utilities to help meet their future demands. In contrast, unincorporated northern El Paso County needs renewable sources to meet future demands as it is currently 100 percent on non-renewable, non-tributary groundwater. If that area's existing non-tributary sources fail or become technically or economically infeasible to continue to use as well yields decline, the amount needed ("the gap" between supply and demand) will become significantly larger in the northern portion of the basin.

The Upper Arkansas Water Conservancy District (UAWCD), which provides augmentation for wells in a portion of the upper basin, will be challenged to develop the CU water rights and storage required to meet the augmentation requirements for these wells. The upper basin, like many headwater areas throughout the state, is projected to experience high growth rates. Augmentation to existing or proposed environmental and recreation water rights, such as CWCB instream flow rights and RICDs and senior agricultural and M&I rights, will likely require the construction of storage in upper areas of tributaries. Economies of scale are generally not present in small reservoir construction and the engineering, permitting, and construction costs will tax the ability to provide for augmentation water at a reasonable cost. The acquisition of agricultural rights will likely be part of the augmentation supplies for the UAWCD due to limits on the availability of Fry-Ark allocations.

Agricultural shortages are prevalent and expected to continue throughout the entire basin, as described in Section 5. Roundtable feedback suggested that these shortages can be very difficult to address, given the water supply limitations outlined in the Arkansas River Compact, a general lack of additional supplies, and the ability of agricultural beneficiaries of projects designed to address their needs to pay for the required infrastructure.

Further detail regarding the Identified Projects and Processes and areas of gap for the Arkansas Basin are provided in Table 6-4.

Table 6-4 Detailed Identified Projects and Processes for the Arkansas Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Baca	Springfield	0	N	Assumed that non-tributary groundwater will meet future needs.	—
Bent	Las Animas	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Bents Fort Water Association	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback

CDM

Table 6-4 Detailed Identified Projects and Processes for the Arkansas Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Bent (cont.)	McClave Water Association	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Unincorporated Bent Co. not served by a water district	100	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
Chaffee	Buena Vista	0	N	No gap.	Terry Scanga, UAWCD
	Salida	500	N	Have existing alluvial and surface water diversions (5.5 cfs in Harrington and 1.6 in Champ Ditches) and augment as necessary with ditch rights and Fry-Ark water. Harrington water rights provide 577 AF of average CU. Champ Ditch water rights are used to recharge an alluvial aquifer and provide approximately 120 AF of CU. Existing CU demands are approximately 500 AF. Can store in Pueblo on if and when basis or in North Fork Reservoir.	Terry Scanga, UAWCD
	Poncha Springs	200	N	Well augmentation. High potential for growth. Contract with UAWCD for 100 AF of storage space. Own several water rights plus use Fry-Ark allocations. McPherson 35 AF of CU and Fry-Ark water and may be acquiring ditch rights. Current demands are 80 AF of CU. Looking for 230 AF of storage.	Terry Scanga, UAWCD
	Unincorporated Chaffee Co.	1,600	N	Need well augmentation through UAWCD. Will seek additional Twin Lakes, Fry-Ark, and agricultural rights. Will need storage to firm yield. Plans to rehabilitate Boss and North Fork and O'Haver Reservoirs. Cottonwood and Rainbow storage sites in Cottonwood drainage.	Terry Scanga, UAWCD
Cheyenne		0	N	Assumed that non-tributary groundwater will meet future needs.	—
Crowley	Olney Springs	0	N	Have existing wells and augmentation plan augmented with Twin Lakes and Fry-Ark. Arkansas Valley Pipeline would improve water quality and reduce transit losses.	Arkansas Valley Pipeline Study, Arkansas Basin Roundtable feedback, and Matt Heimerich, Crowley County Commissioner

Table 6-4 Detailed Identified Projects and Processes for the Arkansas Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Crowley (cont.)	Crowley County Water System including towns of Crowley and Ordway	100	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. PSOP could provide firming of Fry-Ark allocation. Potential increase in prison population would result in a gap. State Demographer population forecast shows minor increase in population.	Arkansas Valley Pipeline Study, Arkansas Basin Roundtable feedback, and Matt Heimerich, Crowley County Commissioner
	Sugar City	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study, Arkansas Basin Roundtable feedback, and Matt Heimerich, Crowley County Commissioner
	Unincorporated Crowley Co. not served by a water system	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study, Arkansas Basin Roundtable feedback, and Matt Heimerich, Crowley County Commissioner
Custer	Round Mountain Water District (Towns of Westcliffe and Silvercliff)	150	N	Alluvial groundwater.	Terry Scanga, UAWCD
	Unincorporated Custer County not in a water district	200	N	Covered by UAWCD when well augmentation plan is filed. Some areas with augmentation will be difficult due to intermittent streams and futile calls. Need Twin Lakes water or agricultural rights since not in SECWCD. Will need storage plus acquisition of water rights.	Terry Scanga, UAWCD
El Paso	Colorado Springs Utilities	0	Y	Colorado Springs has adequate supplies beyond 2030. Member of Fountain Valley Authority. Southern Delivery System (SDS) and PSOP will firm yield and provide delivery infrastructure.	Kevin Lusk, Colorado Springs Utilities
	Security	0	N	Member of Fountain Valley Authority. Has wells in Widefield aquifer and currently leasing Colorado Springs Widefield aquifer water. Will participate in SDS to replace leased aquifer water. PSOP could provide firming of Fry-Ark allocation. Will purchase agricultural rights along Fountain Creek as needed.	Gary Thompson, W.W. Wheeler and Associates
	Fountain	0	N	Member of Fountain Valley Authority. Will participate in SDS. PSOP could provide firming of Fry-Ark allocation. Will drill additional alluvial wells and augment with Fry-Ark and agricultural dry-up along Fountain Creek.	Gary Thompson, W.W. Wheeler and Associates

Table 6-4 Detailed Identified Projects and Processes for the Arkansas Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
El Paso (cont.)	Widefield	0	N	Member of Fountain Valley Authority. PSOP could provide firming of Fry-Ark allocation. Has wells in Widefield and Jimmy Camp Creek aquifers. May construct Reverse Osmosis treatment facility to treat Fountain Creek water to drinking water standards and recharge aquifers. Will purchase agricultural rights along Fountain Creek as needed.	Gary Thompson, W.W. Wheeler and Associates
	Unincorporated El Paso Co. including water districts not listed	8,000	N	Evaluating several options. Currently 100 percent on non-tributary groundwater. Gap could be higher if existing non-tributary groundwater supplies fail to meet existing demand in the future.	Gary Barber, El Paso County Water Authority
	Monument	0	N	Part of Unincorporated El Paso Co. gap.	El Paso County Water Authority Report
	Manitou Springs	0	N	No information on supplies to meet gap.	
Elbert		1,400	N	No information on supplies to meet gap.	
Fremont	Florence	0	N	Part of City of Florence Regional Water System. Oak Creek Reservoir and agricultural transfers are planned to meet future demand.	2002 Regional Water System Study by Martin and Wood Consulting.
	Cañon City	0	Y	Have existing senior water rights but needs storage to firm existing water rights.	Terry Scanga, UAWCD
	Penrose Water District	200	N	May have problems with existing firm yield. Currently using leased water right from Beaver Park Irrigation Company and seeking new acquisitions. Penrose Water District, Beaver Park Irrigation Company, CDOW, Victor and Cripple Creek cooperated on meeting 2002 drought needs.	CDM survey response; Pueblo Chieftain Editorial - "Protecting Our River" - August 2004
	Unincorporated Eastern Fremont Co.	1,500	N	Need well augmentation. Petitioning into UAWCD.	Terry Scanga, UAWCD
	Unincorporated Western Fremont Co.	500	N	UAWCD has developed augmentation supplies for that portion of Fremont County in the UAWCD, including use of Fry-Ark allocation.	Terry Scanga, UAWCD
	Coal Creek	0	N	Part of City of Florence Regional Water System. Oak Creek Reservoir and agricultural transfers are planned to meet future demand.	2002 Florence Regional Water System Study by Martin and Wood Consulting
	Williamsburg	0	N	Part of City of Florence Regional Water System. Oak Creek Reservoir and agricultural transfers are planned to meet future demand.	2003 Florence Regional Water System Study by Martin and Wood Consulting

Table 6-4 Detailed Identified Projects and Processes for the Arkansas Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Fremont (cont.)	Rockvale	0	N	Part of City of Florence Regional Water System. Oak Creek Reservoir and agricultural transfers are planned to meet future demand.	2004 Florence Regional Water System Study by Martin and Wood Consulting
	Park Center Water District	0	N	No gap.	CDM survey response
Huerfano	Walsenburg	0	N	Recently purchased additional water rights (Walsenburg #5 Ditch) and seeking funding for additional storage.	Walsenburg City Clerk
	Gardner	—	—	—	Didn't respond
	La Veta	0	Y	Surface water supplies.	CJ, Town of La Veta
Kiowa	Eads	0	N	Assumed that non-tributary groundwater will meet future needs.	
Lake	Parkville W&S	0	N	Provides water to Leadville and surrounding area. Has adequate water rights, but concern with tunnel and reservoir that provides physical water supply. Reservoir needs rehabilitation or replacement and funding is needed.	Gary Thompson, W.W. Wheeler and Associates
	Unincorporated Lake Co. not served by Parkville Water District	1,100	N	Have filed for a blanket augmentation plan. Created a new augmentation source by obtaining CU from Aurora. Will be in the market to acquire additional water rights and fold into blanket augmentation plans. Sources will Twin Lakes, agricultural transfer or as potential diverter approaches county. Storage is also needed. Box Creek (Aurora) site is a potential. Need to partner.	Jim Felt, Felt, Munson and Culichia
Las Animas	Trinidad	0	N	Existing mountain water system is at capacity. Acquired and transferred agricultural shares and have a storage account and water rights to store in Trinidad Reservoir. Planning to construct a new water treatment facility at Trinidad Reservoir.	Gary Thompson, W.W. Wheeler and Associates
	Unincorporated Las Animas Co.	500	N	Need for well augmentation upstream of Trinidad Reservoir.	Gerry McDaniel, special water counsel to Las Animas
	Aguilar	—	—	—	Didn't respond
Lincoln		0	N	Assumed that non-tributary groundwater will meet future needs.	—
Otero	La Junta	250	N	Constructed Reverse Osmosis Water Treatment Facility. Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback

Table 6-4 Detailed Identified Projects and Processes for the Arkansas Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Otero (cont.)	Fowler	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Manzanola	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Rocky Ford	50	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Hancock Water Company	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Parkdale Water Company	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Swink	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	South Swink W.C.	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Homestead Water Company	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Southside Water Company	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback

Table 6-4 Detailed Identified Projects and Processes for the Arkansas Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Otero (cont.)	Unincorporated Otero County	0	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
Prowers	Lamar	250	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Wiley	50	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	May Valley Water Association	50	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
	Unincorporated Prowers Co.	100	N	Arkansas Valley Pipeline would improve water quality and reduce transit losses. There are concerns over future supplies as Fry-Ark may be oversubscribed, and return flows and firm yield less than planned.	Arkansas Valley Pipeline Study and Arkansas Basin Roundtable feedback
Pueblo	Pueblo BOWW	0	Y	Have existing direct flow, storage, trans-basin, and exchange rights.	Alan Ward, Pueblo Board of Water Works
	St. Charles Mesa	0	N	Will continue to acquire additional agricultural rights as needed and will grow into Bessemer Ditch irrigated acres.	Steve Witte, Division 2 Engineer
	Pueblo West	0	N	Will continue to acquire additional agricultural rights as needed. Acquired water rights outside of service area and own ranch in Upper Arkansas basin.	Steve Witte, Division 2 Engineer
	Boone	—	—	—	Didn't respond
	Avondale W&SD	—	—	—	Didn't respond
	Beulah Water Works District	0	Y	Surface water supplies; 750,000 gallon storage capacity for 163 families; projects are ongoing with grants/loans from Colorado Department of Local Affairs.	Charles Hutchinson, Secretary to the Board of Directors
	Rye	0	Y	Surface water supply from Greenhorn Creek and two wells (one for watering school lawns and other for drinking water); 50,000 gallon storage tank being installed presently; Board not concerned about water supplies.	Town Clerk
	Colorado City	—	—	—	Didn't respond

Table 6-4 Detailed Identified Projects and Processes for the Arkansas Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Teller	Cripple Creek	0	N	Just received a new water right decree. Should be adequate based on recent growth rates continuing into the future, but is evaluating future needs. Penrose Water District, Beaver Park Irrigation Company, CDOW, Victor and Cripple Creek cooperated on meeting 2002 drought needs. Could use more high altitude storage for drought reliability.	Sandy MacDougall, MacDougall, Woldridge and Worley
	Victor	600	N	Town is supplying all of the water it can product to the gold mine. The gold mine has a current shortage of 600 to 1,200 AF per year. Long-term status of gold mining is uncertain. If gold mining ceases, Victor has an excess of supply. CWCB assisted in funding a dam rehab. Colorado Springs upstream collection system limits physical supply. Physical availability a concern in 2002 and Colorado Springs cooperated in bypass of water. Penrose Water District, Beaver Park Irrigation Company, CDOW, Victor and Cripple Creek cooperated on meeting 2002 drought needs. Could use more high altitude storage for drought reliability.	Sandy MacDougall, MacDougall, Woldridge and Worley

* Y = Yes; N = No; U = Unknown

A summary of the gaps for each subbasin are shown on Table 6-5. The greatest gap is in northern El Paso County, where renewable sources of water are needed to replace the current 100 percent reliance on non-tributary groundwater.

Table 6-5 Summary of Gap Analysis for Arkansas Basin

Subbasin	Identified Gross Demand Shortfall (AFY)
Upper Arkansas (Chaffee, Fremont, Lake, Teller)	6,600
Urban Counties (El Paso, Pueblo)	8,000
Lower Arkansas (Bent, Crowley, Otero, Prowers)	800
Eastern Plains (Baca, Cheyenne, Elbert, Kiowa, Lincoln)	1,200
Southwestern Arkansas (Custer, Huerfano, Las Animas)	500
TOTAL	**17,100**

6.3.1.2 Recreational and Environmental Information

6.3.1.2.1 Flow Considerations

There are no CWCB decreed instream flow rights on the mainstem of the Arkansas River. Flow rights on tributaries in the basin can be found at http://cwcb.state.co.us/isf/Downloads/Index.htm.

Above Pueblo Reservoir, the following flow considerations are of note:

Fryingpan-Arkansas Project

Via the Fry-Ark Project's operating plan, a minimum flow of 66.0 cfs was established for the Arkansas River at Granite, which is the only legal minimum flow requirement on the mainstem of the Arkansas (Smith and Hill 2000).

Turquoise Lake and Twin Lakes Management

A Memorandum of Understanding (MOU) was executed with the USFS on July 1, 1976, concerning the transfer of lands acquired by BOR to the USFS at Sugar Loaf Dam and Turquoise Lake. A provision of the MOU states that BOR "…recognizes recreation values on Turquoise Lake and will minimize draw-down during the June 15th through September 15th period. Efforts will be made to maintain a minimum pool elevation of 9,835 feet during this period; however, project needs could dictate further lowering. A minimum pool at elevation 9,776 feet will be maintained for fish habitat and aesthetic purposes." An elevation of 9,835 feet is a target level and equals reservoir contents of 72,505 AF, and an elevation of 9,776 feet equals contents of 9,348 AF (Smith and Hill 2000 pp. 3-63). A Memorandum of Agreement (MOA) was executed with the USFS on April 12, 1984, concerning the transfer of lands acquired by BOR to USFS at Twin Lakes. A provision of the MOA states that BOR "…recognizes public recreation values of Twin Lakes and will attempt to optimize reservoir surface elevations for all reclamation project purposes including public recreation. A minimum pool at elevation 9,168.7 feet will be maintained for power purposes which should enhance the fish habitat and visual resources." An elevation of 9,168.7 feet equals reservoir contents of 72,938 AF (Smith and Hill 2000 pp. 3-63).

Water Exchanges

Water exchanges are used as a management tool for municipal water supplies in the Arkansas Basin. A water exchange is made by diverting water at one location in the river system and replacing it with a like quantity of water at another location. During an exchange, streamflow in the reach between the two exchange locations is decreased by the amount of the exchange.

Exchanges are often limited in these operations; for example, the transmountain return-flow exchange for Colorado Springs and the Rocky Ford Ditch exchange for Aurora are restricted by several legal or voluntary stipulations (Lewis 1999):

- The exchanges must be operated to maintain streamflow in the Arkansas River so as not to interfere with the operation of the Salida wastewater treatment plant and the Fremont Sanitation District wastewater treatment plant. Specifically, the exchanges may not decrease streamflow at the Salida wastewater treatment plant to less than 240 cfs in September through June or to less than 260 cfs in July and August. Exchanges may not decrease streamflow at the outfall of the Fremont Sanitation District wastewater treatment plant to less than 190 cfs throughout the year.
- Exchanges into Twin Lakes Reservoir may not diminish streamflow in Lake Creek downstream from Twin Lakes Reservoir to the confluence with the Arkansas River to less than a minimum instream flow of 15 cfs, as mandated by the CWCB.

Voluntary Flow Management Program

In 1990, BOR and the DNR signed an agreement under which BOR would attempt to provide flows to better support natural resource values. There is no legal obligation upon BOR to provide the flows, and the program must be operated within the context of legally required storage and deliveries for water users. DNR makes flow recommendations via an annual letter to BOR each spring. The DNR flow management goals as of July 2000 for the Arkansas River at Wellsville are outlined below (Smith and Hill 2000):

- The highest priority is the maintenance of a minimum year-round flow of at least 250 cfs to protect the fishery.
- Winter incubation flows (mid-November through April) should be maintained at a level of not more than 5 inches below river height during the spawning period (October 15 to November 15) to protect and incubate brown trout eggs. The optimum flow range is from 250 to 400 cfs, depending on spawning flows, which range from 300 up to 700 cfs.
- To the extent possible, between April 1 and May 15, BOR should maintain flows within the range of 250 to 400 cfs in order to provide conditions favorable to trout egg hatching and fry emergence.
- Deliveries in excess of 10,000 AF should be subject to review and consideration, prior to such deliveries, by BOR and the SECWCD.
- Subject to water availability, BOR should augment flows during the July 1 to August 15 period to 700 cfs to support river rafting through releases from the Fry-Ark Project. Augmentation water may be "recaptured" in Pueblo Reservoir for use by Fry-Ark users. The 700 cfs level is a target; when augmentation occurs, every effort should be made to ensure that flows are as little above, or as little below, 700 cfs as possible. The CDPOR, using funds collected from commercial outfitters, shall be

responsible for replacing evaporative losses caused by summer augmentation.

- BOR should avoid dramatic fluctuations on the river as much as possible throughout the year. When it is necessary to alter flow rates, BOR should limit the daily change to 10 to 15 percent.
- It may be possible to improve feeding conditions for brown trout by reducing flows between Labor Day and October 15 in years when flows would otherwise be higher than those recommended by CDOW. If potential benefits warrant the effort, Arkansas Headwaters Recreation Area managers, CDOW, BOR, and the Division II Engineer should work with the water users to seek opportunities for reducing flows after Labor Day.

Below Pueblo Reservoir, the following flow considerations are of note:

Pueblo Dam Releases:
Releases from Pueblo Dam above 6,000 cfs are rare because the flood control purpose of the reservoir requires that releases be controlled to limit maximum flows at the Avondale gaging station (15 miles below Pueblo Reservoir) to 6,000 cfs.

City of Pueblo Application for Water Rights:
In December of 2001, the City of Pueblo applied for a conditional RICD water right for a series of boat chute control structures on the Arkansas River as it flows through downtown Pueblo that will be constructed as an integral part of the Legacy Project. These structures will be designed to control, concentrate, and direct the flow of the Arkansas River for use by kayaks, canoes, rafts, and other types of recreational water craft, and other purposes. This boating course will be known as Whitewater Park. The Whitewater Park will include a boat chute/fish ladder (Structure 1) to allow kayaks, boats, and other recreational watercraft, as well as native and sport fish, to pass over an existing 13-foot high diversion structure in the river known as the Southern Colorado Power Plant or West Plains Energy diversion dam (the "Power Plant Diversion"). A series of approximately seven smaller, permanent control structures (Structures 2 through 8) will then be constructed in the river between the Power Plant Diversion and the Union Street Bridge to create self-scouring pools and control the flow of the river at specific points to create various wave forms desirable for whitewater kayaking and recreational boating. These structures will be constructed in a reach of the river that is approximately 2,000 feet in length. The Whitewater Park will extend downstream to include a boat chute or chutes (Structure 9) in the Arkansas River at the location of the existing St. Charles Mesa Water District diversion structure, located just downstream from the Santa Fe Street bridge in Pueblo, near Moffat Street (the Moffat Street Chute"). The control structures comprising the Whitewater Park will be numbered consecutively from upstream to downstream, with Structure 1 at the location of the Power Plant Diversion, Structure 8 just upstream from the Union Street Bridge, and Structure 9 at the location of the Moffat Street Chute. The water rights requested are:

- March 15th through November 14th of each year – 500 cfs (conditional)
- November 15th through March 14th of each year – 100 cfs (conditional)

In reviewing the application, the CWCB found that the minimum stream flows necessary to provide a reasonable recreation experience in and on the water are as follows:

- 500 cfs during June and July
- 250 cfs during April, May, and August
- 100 cfs during the remainder of the year

The CWCB also found that the reach of the Arkansas River beginning with Drop Structure 1 and ending at the downstream limit of Pool 8 is an appropriate reach for the RICD; the reach beginning below Pool 8 and continuing downstream to include Drop Structure 9 and any pool below Structure 9 is not an appropriate RICD reach (http://cwcb.state.co.us/isf/ rules/FINALfinalPueblo RecommendationFindings.pdf).

As of March, 2004, the CWCB and City of Pueblo were engaged in discussions to work out a mutually acceptable decree. (Seaholm 2004)

6.3.1.2.2 Water Based Recreation
The Arkansas River Basin offers abundant opportunities for water-based recreation; on the river and its tributaries as well as on numerous reservoirs. Fishing, boating, kayaking, rafting, water skiing, jet skiing, swimming, sailing, sailboarding, and gold panning are all available, as well as hiking, picnicking, camping, hunting, and biking.

A Recreation Area Management Plan for management of recreation use on public lands adjacent to the Arkansas River was completed by the BLM in 1982. While several elements of that original plan were implemented in the form of facility development, maintenance improvements, and visitor information materials, much still remained to be done. A planning process, which began in 1986, was completed in October of 1989 with the finalization of the Arkansas River Recreation Management Plan (ARRMP) as a part of the establishment of the Arkansas Headwaters Recreation Area (AHRA). The AHRA is a partnership between the BLM and CDPOR to manage recreation resources and activities along 148 miles of the river from its headwaters near Leadville down to Pueblo Reservoir. This plan expands the scope of the recreation management partnership to include the USFS and the CDOW. The Arkansas River Recreation Management Plan can be found at: http://www.parks.state.co.us/arkansas/management.asp Key elements of the plan include (CDPOR and BLM):

- Managing recreation resources and activities along 148 miles of the Arkansas River from its headwaters near Leadville to Pueblo Reservoir.
- The Arkansas Headwaters Recreation Area shall be managed to emphasize its natural resources, resource sustainability, and the standards for public land health, recognizing and respecting private property, while embracing numerous recreational, educational, and commercial activities.

The Arkansas Headwaters is one of the nation's premier recreation areas. The area offers abundant and outstanding opportunities for fishing, rafting, kayaking, picnicking, hiking, camping, mountain biking, and sightseeing among deep canyons, broad valleys, and towering mountain peaks. The cities and towns along the river include Leadville, Buena Vista, Salida, Cañon City, Florence, and Pueblo.

The Arkansas River offers fishing opportunities for every type of angler – from the bank or from a boat. The trout population in the Arkansas is 90 percent self-reproducing brown trout and 10 percent Colorado River rainbows, which are introduced as fingerlings. Fish density is about 2,000 fish per mile on the average. The fishing is best when the flows are lower and the water is clear. The river starts to clear up at around 1,200 cfs. Flows will vary during the year with September to April maintaining around 350 to 450 cfs. Runoff generally begins in May and reaches its peak of around 3,000 cfs in mid-June or early July. The flows typically start decreasing in late July as the snow pack in the high country diminishes, and fall back to 700 to 1,000 cfs for July and into August. (http://parks.state.co.us/default.asp?parkID=96&action=park)

Table 6-6 shows the reaches in the Arkansas Basin that are listed for rafting use by American Whitewater.

Table 6-6 River Reaches in the Arkansas River Basin in Colorado Listed for Rafting Use by American Whitewater

Reach Description	Class	Minimum Suggested Flow (cfs)*	Maximum Suggested Flow (cfs)*
Arkansas River from Leadville to Granite	I-II	NA	NA
Arkansas River from Granite to Numbers Launch Site	IV-V	200	2500
Arkansas River from Numbers Launch to Railroad Bridge Launch (The Numbers)	IV	300	3500
Arkansas River from Railroad Bridge Launch to Buena Vista (Fractions / Frogrock / Milkrun)	III	600	3500
Arkansas River from Fisherman's Bridge access to Stone Bridge access (Browns Canyon)	III	600	3500
Arkansas River from Pinnacle Rock Launch to Parkdale Launch (Pinnacle Rock)	III	NA	NA
Arkansas River from Parkdale Launch to Cañon City (Royal Gorge)	III-IV	600	3500
Clear Creek (of the Arkansas) to the Arkansas River	V	NA	NA
Grape Creek from Bear Gulch to Cañon City	IV+	NA	NA
Lake Creek from Graham Gulch to 1/4-mile east of Monitor Gulch	V+	200	1000
Purgatoire River from US 350 TO Highway 109	I-V	NA	NA

Source: http://www.americanwhitewater.org/rivers/state/CO
* Suggested levels of flow; not water rights.

At Pueblo Dam and Reservoir, fish and wildlife and recreation resources are under the management of the Colorado DNR. Recreation at the 9,600-acre park is managed by the CDPOR, Pueblo State Park. Facilities include four campgrounds accommodating approximately 400 campsites and associated facilities such as modern shower and restroom facilities, a recreation information center, two boat ramps, and two marina complexes. A water recreation area, downstream from Pueblo Dam, includes a swim beach and bathhouse area. A state-of-the-art fish hatchery has been constructed downstream from the dam. Approximately 16,500-acre wildlife lands are managed by the CDOW, hiking, and bicycle trails exist as well as facilities for those with physical impairments. Facilities are closed in winter because of ice and snow and adverse weather conditions.

Pueblo State Park is one of the largest water recreation destinations in the state. It is known widely by sun-lovers and water-sports enthusiasts for its 4,646 surface acre reservoir. Plenty of warm water makes the reservoir ideal for boating, sailing, water skiing, fishing, and jet skiing. Regular winds also provide excellent conditions for sailboarding and sailboating.

Visitors to Lake Pueblo may see a wide variety of wildlife. Commonly seen park residents include mule deer, coyote, cottontail rabbit, red and gray fox, beaver, raccoon, skunk, prairie dogs, and badger. Reptile enthusiasts might see bullsnakes, rattlesnakes, sagebrush lizards, coach whips, and box turtles. A rare reptile, the blackneck garter snake, has been identified in the park.

Pueblo Reservoir lies in the Central Flyway for migratory birds and is a popular bird-watching site. Migratory and resident birds include great-blue heron, osprey, marsh hawk, roadrunners, pinyon jay, western meadowlark, and several other species of raptors, waterfowl, and shorebirds. One of the park's most beloved visitors is the majestic Bald Eagle that graces the park each winter. American Peregrine falcons are also occasional visitors.

Lake Pueblo is known as a great fishing destination in Colorado. The CDOW names the Pueblo Reservoir one of the state's fishing "hot spots." Fish inhabiting the reservoir include trout, walleye, large and smallmouth bass, crappie, channel catfish, wiper (a cross between white bass and stripe bass), bluegill, and yellow perch. Lake Pueblo also offers two alternatives to fishing the Pueblo Reservoir. In the Rock Canyon Day-Use area below the dam, the Anticline Fishing Pond (which is stocked regularly) has a handicap pier for easy access, picnic tables, plenty of shade, restroom facilities, and playgrounds. Another fishing option at Lake Pueblo is the challenge of the spillway area and Arkansas River. Fly-fishing on the river is popular in spring and fall (http://parks.state.co.us/default.asp?parkID =85&action=park).

The CDOW awards the Gold Medal designation to waters that have high-quality aquatic habitat, a high percentage of trout 14 inches or longer, and the potential for trophy trout fishing and angling success. There are no Gold Medal designated waters in the Arkansas Basin.

6.3.2 Colorado River Basin

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

Major Identified Projects and Processes for the Colorado Basin are summarized in Table 6-7. For reference, Figure 6-6 provides a map of counties and major cities in the basin as referenced throughout this discussion.

M&I and SSI needs are expected to increase dramatically in the Colorado Basin by 2030. The existing and ongoing UPCO and Eagle River processes were highlighted by Roundtable participants as being critical to meeting the future demands in Eagle, Grand, and Summit Counties. It is expected that augmentation contracts available out of Ruedi, Green Mountain, and Wolford Reservoirs will be a key part of meeting 2030 demands in the basin. There is some uncertainty with the Green Mountain Reservoir contracts due to suspected instability of slopes in the vicinity of Henny, which may result in the permanent reduction of available storage. In addition, agricultural transfers will continue from purchases, developer donations, and development of irrigated lands. Existing supplies will be used in all Colorado Basin counties, and agricultural transfers will be part of the future supplies used to meet increased demands in Eagle, Garfield, and Mesa Counties.

Table 6-7 Major Identified Projects and Processes in Colorado Basin Counties

County	Estimated Demand met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
Eagle	12,500	▪ Existing supplies ▪ Agricultural transfers ▪ Ruedi Reservoir contracts for augmentation of surface or alluvial groundwater diversions ▪ Eagle River process
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
Pitkin	8,500	▪ Existing supplies ▪ Ruedi Reservoir contracts for augmentation of surface or alluvial groundwater diversions
Summit	8,200	▪ Existing supplies ▪ UPCO to identify needs and potential solutions
TOTAL	**58,900**	

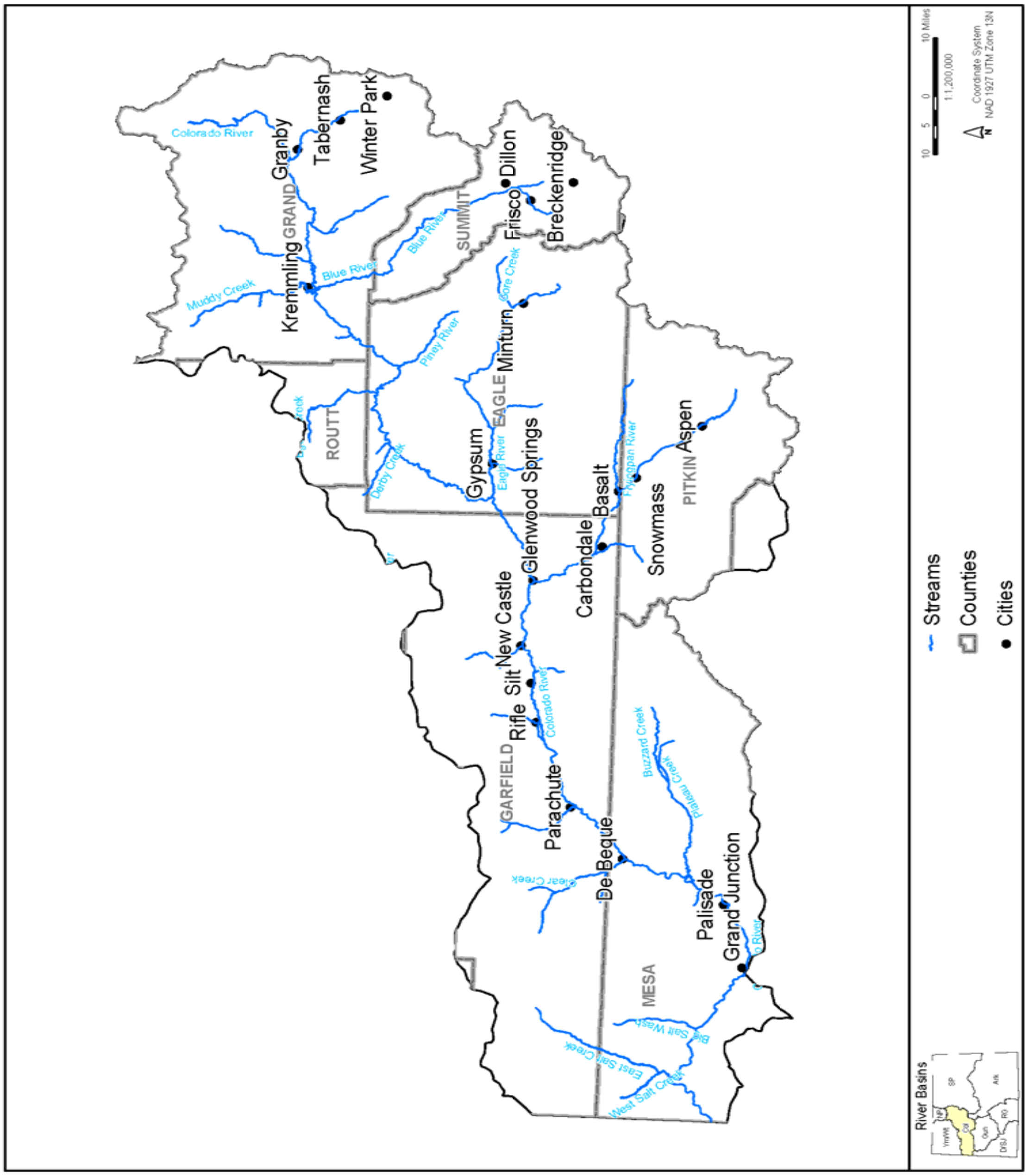


Figure 6-6
Colorado Basin Location Map

CDM

Summit and Grand Counties anticipate significant M&I gaps and environmental and recreational shortages as a result of existing transbasin diversions and planned future increases in transbasin diversions as a result of the Denver North System (Moffat Tunnel) firming project and the Northern Colorado Water Conservancy District (NCWCD) Windy Gap firming project. These two projects have water rights senior to much of the in-basin M&I rights. The UPCO process has outlined potential solutions, but these solutions have a high level of uncertainty and implementation challenges due to lack of physical availability of water and permitting issues for any structural alternatives. As a result, gaps are shown in Grand and Summit Counties. (Upper Colorado River Study 2003).

Some agricultural water shortages are expected to continue for Water Districts 45, 53, and 70. Contract water that is available out of Ruedi, Green Mountain, and Wolford Reservoirs could be used to address this issue for downstream mainstem diverters, but the cost of reservoir contract water generally exceeds the ability to pay for most agricultural users. In addition, much of the agricultural shortages are on side tributaries that are limited by physical supply and new storage developed locally on these side tributaries would be required to carry over water to later in the irrigation season to address these shortages.

Further detail regarding the Identified Projects and Processes and areas of gap for the Colorado Basin are provided in Table 6-8. Gaps for Summit and Grand Counties were extrapolated from the UPCO Study based on SWSI growth projections. SWSI and UPCO growth projections match well for Summit County where 2030 SWSI demand projections are within 5 percent of the UPCO buildout demand. The UPCO buildout demand for Grand County, however, is significantly higher than the 2030 SWSI demands and the UPCO shortages at buildout were pro-rated to the 2030 SWSI demands. As a result, the 2030 gap for Grand County may be overstated, but this gap would occur as demands increase beyond those projected by SWSI (NWCOG 2004).

Table 6-8 Detailed Identified Projects and Processes for Colorado Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Eagle	Eagle River Water and Sanitation	0	U	Provider for Vail, Eagle-Vail, Beaver Creek, Edwards, and Avon.	John Currier
	Gypsum	0	N	Have Storage contracts (Eagle Park, Green Mountain and Wolford Mountain) plus historic consumptive use credits. Working on developing 500 AF of storage above water treatment plant.	Tom Zancanella, consultant to Gypsum
	Mid Valley Metropolitan District	0	U	Serves unincorporated area between Basalt and Carbondale. New developments must bring water – usually Ruedi contracts or agricultural dry-up.	John Currier
	Unincorporated areas in Eagle County not served by a Water District	0	U	Should be able to purchase Ruedi contracts.	John Currier
	Minturn	0	U	New development is required to bring water. This is usually agricultural water that is irrigating the land to be developed.	John Currier
Garfield	Basalt Water Conservancy District	0	U	Provides augmentation water for unincorporated areas, usually via Ruedi and Green Mountain Contracts.	John Currier

Table 6-8 Detailed Identified Projects and Processes for Colorado Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Garfield (cont.)	Battlement Mesa	0	Y	Have adequate water rights for buildout – senior water rights and Ruedi contracts	John Currier
	Carbondale	0	U	Have alluvial Roaring Fork alluvial wells requiring augmentation. Can use existing, unused Ruedi Contracts for future augmentation.	John Currier
	Glenwood Springs	0	U	Existing water rights and unused Ruedi Contracts, if needed.	John Currier
	New Castle	0	U	Recently constructed an intake from the Colorado River. New developments must bring water – usually Ruedi contracts or agricultural dry-up.	John Currier
	Other Garfield County and unincorporated areas	300	N	Some areas will purchase water from Basalt and West Divide Water Conservancy Districts, to the extent available. Other areas will need to dry-up agriculture and develop storage.	John Currier
	Parachute	0	U	Should be able to use Ruedi contracts.	John Currier
	Rifle	0	U	Have Ruedi contracts.	Michael Erion, Resource Consultants
	Silt	0	U	Developers are required to bring water for new development. Any remaining gap should be able to be satisfied by Ruedi contracts.	John Currier
Grand	Columbine Lake Water District	0	U	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Fraser	159	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Granby	5	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Grand County Water and Sanitation	497	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Grand Lake	0	U	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study

Table 6-8 Detailed Identified Projects and Processes for Colorado Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Grand (cont.)	Hot Sulphur Springs	41	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Kremmling	18	Y	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	CDM survey response
	Unincorporated areas in Grand County not served by a water district	200	N	Assumed at 5 percent of increased demand.	
	Silver Creek (Sol Vista)	18	Y	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	CDM survey response
	Winter Park Recreation and Winter Park Water and Sanitation	7	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Winter Park West	19	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
Mesa	Clifton	0	N	Existing water rights and will continue to acquire Grand Valley Canal shares as needed. Some customers use ditch water for irrigation.	Dale Tooker
	Debeque	0	N	Have existing Ruedi Contracts.	Tom Zancanella, Consultant to Debeque
	Grand Junction	0	N	Service area limited by Ute WCD and nearly built out. Have adequate water rights for buildout	CDM survey response
	Palisade	0	U	Cabin Creek Reservoir. Ute WCD will serve most of the Mesa County area.	—
	Ute Water Conservancy District	0	Y	Existing water rights. Also serves Fruita and most of unincorporated Mesa County. Many customers have ditch water for landscape irrigation.	CDM survey response
Pitkin	Aspen	0	U	—	—
	Basalt	0	N	Physical supply met by alluvial groundwater. Have existing consumptive use credits and Ruedi contracts.	John Currier

Table 6-8 Detailed Identified Projects and Processes for Colorado Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Pitkin (cont.)	Snowmass Village	0	U	Have adequate water rights. Would like additional flows for environmental and recreational purposes. Snowmass Creek in stream flow right an issue and may require storage upstream of the instream flow.	John Currier
	Unincorporated Pitkin County	0	U	Can purchase augmentation credits through Basalt WCD. May need small onsite storage to replace depletions to local water rights.	John Currier
Summit	Breckenridge	0	Y	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Dillon	0	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	CDM survey response
	Silverthorne	0	U	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Frisco	0	U	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Blue River	0	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Copper Mountain	0	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Keystone area	0	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	A Basin	0	U	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study

Table 6-8 Detailed Identified Projects and Processes for Colorado Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Summit (cont.)	East Dillon Water District	0	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Snake River Water District	0	N	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Buffalo Mountain /Mesa Cortina	0	U	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study
	Unincorporated areas in Summit County not served by a water district	505	N	Assumed at 5 percent of increased demand.	—
	Eagles Nest	0	U	Existing water rights and UPCO process assumed to provide for future demands. There may be a gap if the UPCO process does not result in new supplies.	UPCO Study

* Y = Yes; N = No; U = Unknown

A summary of the gaps for each county are shown on Table 6-9. The greatest gaps are in Summit and Grand Counties, where supply availability is affected by transbasin diversions.

Table 6-9 Summary of Gap Analysis for Colorado Basin

County	Identified Gross Demand Shortfall (AFY)
Eagle	0
Garfield	300
Grand	800
Mesa	0
Pitkin	0
Summit	1,900
TOTAL	**3,000**

6.3.2.2 Recreational and Environmental Flow Information

6.3.2.2.1 Flow Considerations

In Colorado and Utah, critical habitat for endangered Colorado River fish covers the following stretches of river as shown on Figure 6-7:

- Colorado River from Rifle, Colorado to Lake Powell
- Gunnison River from Delta, Colorado to Grand Junction
- Yampa river from Craig, Colorado to the Green River
- White River from Rio Blanco Dam to the Green River
- Green River from Dinosaur National Monument to Lake Powell

In the Colorado Basin, the ESA is an important regulatory consideration as there are four threatened and endangered fish that are present in parts of the basin or subbasins. All four species are not present throughout the basin. Nevertheless, water projects that require federal permits or involve federal actions are required to comply with the ESA. In the Colorado Basin, a "programmatic approach" is being taken. In general terms, this means that certain management and research actions are being implemented at a programmatic coordinated level to provide benefits to the species. These actions are done to (1) offset the effects of historic water uses, and (2) to allow for future water use and development. Following is a summary of some of the key elements of the Colorado River Endangered Species Recovery Program.

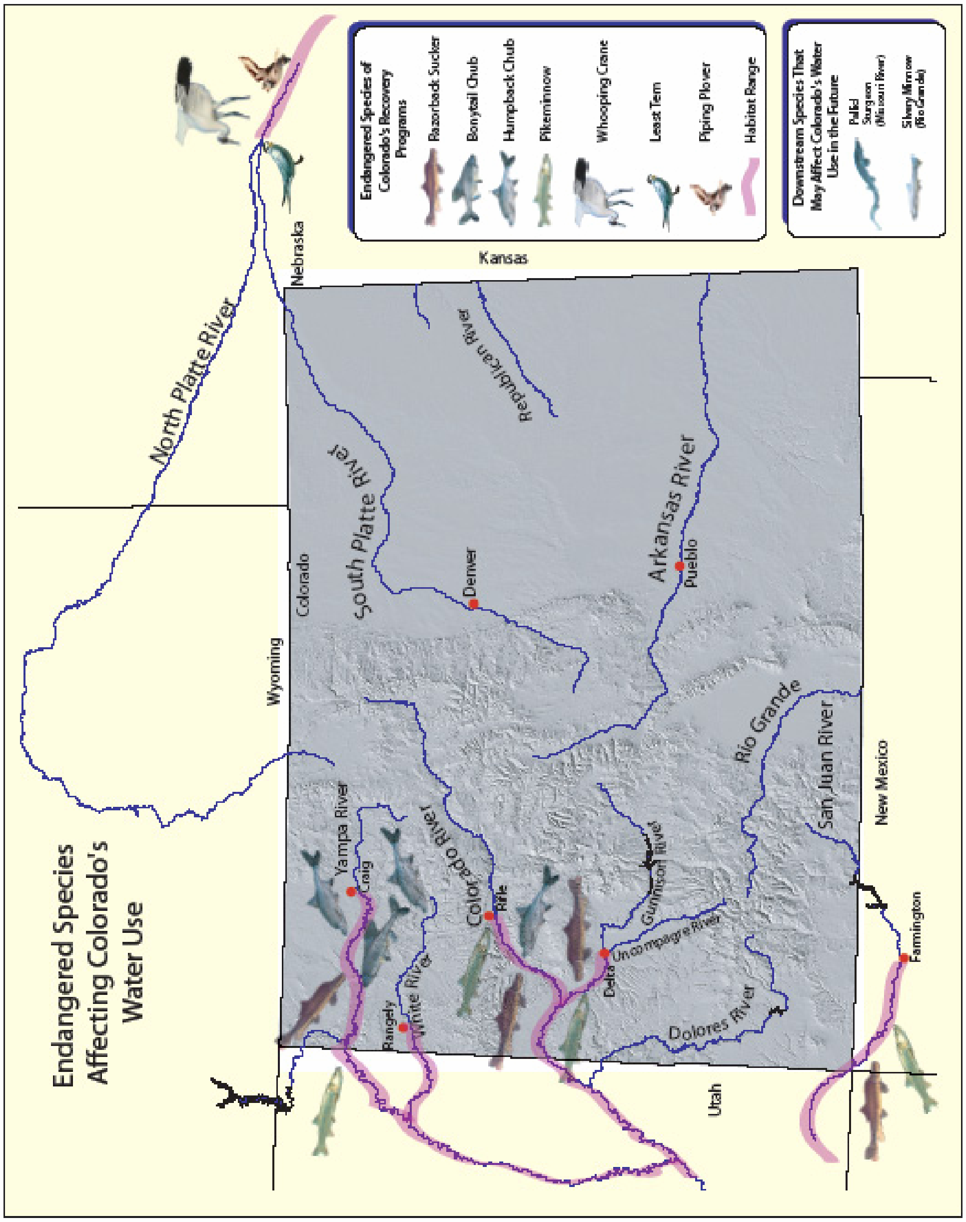


Figure 6-7
Endangered Species Affecting Colorado's Water Use

CDM

Flow recommendations to benefit endangered fish have been developed for the Colorado and Gunnison Rivers (USFWS 2003). It is emphasized that flow recommendations are not monolithic absolute values, and they may be revised from time to time to include the results of research. Flow recommendations may not inhibit the development of Colorado's compact entitlements. The goal of the recommendations is to provide the annual and seasonal patterns of flow in the Gunnison River for the Colorado pikeminnow and razorback sucker (see Section 6.2.4.2 for Gunnison River flow recommendations), and in the Colorado River downstream from the confluence to enhance populations of the four endangered fishes (Colorado pikeminnow, razorback sucker, bonytail chub, and humpback chub). Base flow and peak flow recommendations are provided. The objectives are to allow Colorado the full ability to develop its compact entitlements, while creating and maintaining the variety of habitats used by all life stages of the four endangered fishes:

- Provide habitats and conditions that enhance gonad maturation and provide environmental cues for spawning movements and reproduction
- Form low-velocity habitats for adult staging, feeding, and resting areas during snowmelt runoff
- Inundate floodplains and other off-channel habitats at the appropriate time and for an adequate duration to provide warm, food-rich environments for fish growth and conditioning, and to provide river-floodplain connections for restoration of ecosystem processes
- Restore and maintain in-channel habitats used by all life stages: (1) spawning areas for adults; (2) spring, summer, autumn, and winter habitats used by subadults and adults; and (3) nursery areas used by larvae, young-of-the-year, and juveniles
- Provide base flows that promote growth and survival of young fish during summer, autumn, and winter

Because historical river flows were dependent on water availability, peak flow recommendations were developed for six hydrologic categories that correspond to unregulated April to July inflow based on the 1937 to 1997 period of record: Dry (90 to 100 percent exceedance); Moderately Dry (70 to 90 percent exceedance); Average Dry (50 to 70 percent exceedance); Average Wet (30 to 50 percent exceedance); Moderately Wet (10 to 30 percent exceedance); and Wet (0 to 10 percent exceedance).

Flow recommendations are for the Colorado River near the Colorado-Utah state line (USGS 09163500). Peak-flow recommendations include two components: (1) threshold levels corresponding to 1/2 bankfull discharge and bankfull discharge, and (2) the number of days (duration) that flows should equal or exceed these levels. In addition, recommended durations are presented as a range of days. In general, spring flows recommended for the dry categories provide small peaks used as spawning cues by endangered fish, but contribute little to habitat maintenance; spring flows recommended for average categories promote scouring of cobble and gravel bars and provide localized flooding of short duration; and spring flows for the wet categories promote widespread scouring of cobble and gravel bars, flushing of side channels, removal of encroaching vegetation, and inundation of floodplain habitats.

Base flow recommendations also vary with hydrologic category and are designed to allow fish movement among river segments and to provide maximum amounts of warm, quiet-water habitats to enhance growth and survival of young endangered fish.

The flow recommendations were developed using information currently available; however, it is recognized that uncertainties exist. Biological and physical uncertainties are described in the recommendations, (USFWS 2003) and additional studies are proposed. The recommendations will be implemented using adaptive management. Modifications will be made as more information is gained.

The peak flow recommendations for the Colorado River near the Colorado State Line are shown in Table 6-10 and are one way of achieving the objectives of the program.

Table 6-10 Spring Peak-Flow Recommendations for the Colorado River Near the Colorado-Utah State Line (USGS 09163500)[a]: Number of Days per Year the Flows Should Exceed 1/2 Bankfull Discharge (Q_c = 18,500 cfs) and Bankfull Discharge (Q_b = 35,000 cfs)

Hydrologic Category	Expected Occurrence	Flow Target Duration[b]		Instantaneous Peak Flows (cfs)
		Days/Year ≥ 18,500 cfs	Days/Year ≥ 35,000 cfs	
Wet	10%	80-**100**	30-**35**	39,300-69,800[d]
Moderately Wet	20%	50-**65**	15-**18**	35,000-37,500[e]
Average Wet	20%	30-**40**	6-**10**	≥ 35,000[f]
Average Dry	20%	0-**10**	0	18,500-26,600[e]
Moderately Dry	20%	0-10	0	9,970-27,300[g]
Dry	10%	0	0	5,000-12,100[g]
Long-Term Weighted Average		28-**39**	7.2-**9.1**	

[a] This table represents one possible way of achieving the long-term weighted average for sediment transport.
[b] Lower value in each range is for maintenance, higher (bold) value in each range is for improvement.
[c] Weighted values equal days/year x expected occurrence (the sum of all weighted average values equals the long-term weighted average in days/year).
[d] Instantaneous peak flows within this range have occurred in these hydrological categories since Blue Mesa Reservoir was closed. These observed instantaneous peaks are desired in the future in conjunction with meeting the flow targets. No specific peak flow is recommended to ensure continued variability among years.
[e] Lower number reflects the expected minimum peak flow when recommendations are met and the upper number reflects peak flows that have occurred since Blue Mesa Reservoir was closed. Peak flow is expected to occur within this range, but no specific value is provided to ensure variability among years.
[f] Expected peak flow when recommendations are met. Actual peak may exceed this level, ensuring continued variability among years.
[g] Range of peak flows that have occurred since Blue Mesa Reservoir was closed. Peak flows are expected to continue to fall within this range when Q_c is not reached. No specific recommendation within this range is made to ensure variability among years.

Summer through winter base flow recommendations for the Colorado River, measured at the USGS gage near the Colorado Utah state line (09163500), for the different hydrologic conditions are as follows:

- Wet (10 percent exceedance): 3,000 to 6,000 cfs
- Moderately Wet (10 to 30 percent exceedance) and Average Wet (30 to 50 percent exceedance): 3,000 to 4,800 cfs
- Average Dry (50 to 70 percent exceedance) and Moderately Dry (70 to 90 percent exceedance): 2,500 to 4,000 cfs
- Dry (90-100 percent exceedance): ≥ 1,800 cfs

The base flow period begins after spring runoff is completed and continues through initiation of spring runoff the following year, depending on inflow to the upper Colorado River subbasin. Flows should remain within the bounds specified, but the upper and lower limits are not intended to be targets. The onset of the base flow period will vary considerably – beginning as early as late June in dry years and as late as October in wet years. No specific recommendations are presented for the transition between recommended peak flows and the recommended base flows.

The Colorado River immediately upstream from the confluence with the Gunnison River (15-mile reach) is currently operating under a PBO that provides ESA compliance for 1,000,000 AFY of existing depletions, and up to 120,000 AFY of new depletions additional water development in the upper subbasin in compliance with the ESA, provided that sufficient progress is made toward recovery of the four endangered fishes. This reach of the Colorado River can be seen on Figure 6-4. The PBO provides for coordinated operation of upstream reservoirs to assist in meeting flow recommendations made for the 15-mile reach.

Ultimately, flows in the lower reaches of the upper Colorado River will depend on the combination of (1) flows provided in the Gunnison River following re-operation of the Aspinall Unit, and (2) flows provided in the Colorado River under the PBO. Recommendations at the Colorado-Utah state line do not override recommendations for the upstream reaches and agreements already in place for the upper Colorado River. Therefore, the actual flows at the state line gage for endangered fish are the combination of the flows recommended for the Gunnison (USFWS 2003) and the flows recommended for the 15-mile reach (USFWS

1995), which incidentally contradict the flow recommendations developed for the state line.

Flow recommendations for the 15-mile reach are summarized in Table 6-11 on a mean monthly discharge basis. These recommendations are for the "top of the 15-mile reach." These recommendations take into account and are for a point immediately below the Orchard Mesa Power Plant return and Grand Valley Irrigation Company diversion (USFWS 1995). Recommendations are provided for years of high, above-average, below-average, and low runoff.

The flow recommendations are data specific to the 15-mile reach and relate to adult Colorado pikeminnow habitat preferences, general relationships between stage and habitat quantity and quality, and discharge thresholds for sediment transport. As additional studies are completed, knowledge of the relationship between discharge and fish habitat will continue to evolve and recommendations will continue to be refined.

The CDOW, at the request of CWCB, is conducting research to provide detailed information on the relationship between discharge, habitat availability, and fish population. The CDOW intensively studied several sites on the Yampa and Colorado Rivers to obtain very specific data about the habitat type and quantity and fish abundance and biomass found at various discharges. This more detailed analysis will help decisionmakers maximize the benefits of available water during any particular hydrologic condition. The CWCB and CDOW have requested that the Recovery Program review this work and consider using this more data-intensive methodology for future flow recommendations.

The flow rate is the percent of years that the recommended flows should be provided based on winter snow pack levels. For example, in the wettest 25 percent of years, flows in June should average at least

15,660 cfs; stated another way, this recommendation should be met in 5 of every 20 years. During low-water years, June flows should average no less than 6,850 cfs, and such a minimum should occur at a rate of no more than 4 in 20 years (20 percent).

Numerous instream flow rights have been decreed on major rivers and tributaries in the Colorado River Basin (http://cwcb.state.co.us/isf/Downloads/Index.htm). Some of the decreed rights on major rivers are listed in Table 6-12. These rights are year-round rights containing seasonable variability as reflected in the range of values as shown. Flow rights on smaller tributaries in the basin can be found at the above reference.

Instream flows are maintained as requirements or targets below several BOR projects in the Colorado Basin. A description of these flows is provided in Table 6-13.

6.3.2.2.2 Water-Based Recreation

Numerous river reaches in Colorado are used for whitewater rafting. Table 6-14 shows the reaches in the Colorado basin that are listed for rafting use by American Whitewater.

Table 6-11 Recommended Mean Monthly Flows for the Top of the 15-Mile Reach in cfs (Osmundson 1995)

Rate	Exceedance	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
25%	25%	1,630	1,630	1,630	3,210	10,720	15,660	7,060	1,630	1,630	1,630	1,630	1,630
25%	50%	1,630	1,630	1,630	2,440	9,380	14,250	5,370	1,630	1,630	1,630	1,630	1,630
30%	80%	1,630	1,630	1,630	2,260	7,710	11,350	3,150	1,240	1,240	1,240	1,630	1,630
20%	100%	1,240	1,240	1,240	1,860	7,260	6,850	1,480	810	810	810	1,240	1,240

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Table 6-12 CWCB Instream Flow Rights on Major Rivers in the Colorado River Basin

River	Upper Terminus	Lower Terminus	Range of Flow Rights (cfs)*	Range of Appropriation Dates	Number of Reaches
Blue River	Confluence of Monte Cristo and Bemrose Creeks	Confluence with the Colorado River	1 - 125	March 14, 1986 to Oct. 2, 1987	11
Colorado River	Confluence with Ranger Creek	Confluence with the Gunnison River	20 - 581	July 8, 1980 to Nov. 4, 1994	6
Eagle River	Confluence of the East Fork and South Fork	Confluence with the Colorado River	6 - 130	May 12, 1978 to March 17, 1980	7
Fraser River	Headwaters	Confluence with the Colorado River	2.5 - 30	All Nov. 27, 1990	6
Roaring Fork River	Independence Lake	Confluence with Crystal River	10 - 145	Jan. 14, 1976 to Nov. 8, 1985	5
Williams Fork River	Confluence with McQueary Creek	Williams Fork Reservoir	1 - 38	All May 18, 1979	11

* The range of flows also reflect the fact that there are multiple reaches with different CWCB instream flows specific to each reach.

Table 6-13 Instream Flows below BOR Projects in the Colorado Basin

Project	Instream Flow	Basis
Ruedi Reservoir	Point of compliance at USGS Gage 09080400 – Fryingpan below Ruedi (downstream of Rocky Ford Creek). Release schedule: ■ Lesser of inflow to reservoir or release needed for 39 cfs, November 1 through April 30. ■ Lesser of reservoir inflow or 110 cfs at gage, May 1 through October 30.	Required by operating principles.
Green Mountain Reservoir	Point of compliance at USGS gage 09057500 "Blue River below Green Mountain": ■ 60 cfs minimum release below reservoir in summer ■ 40 cfs is released the remainder of the year	Summer release based on water rights below dam. Release for remainder of the year based on historic practice.
Willow Creek Reservoir	Point of compliance at gage "Willow Creek below Willow Creek Reservoir": Minimum flow 7 cfs or inflow, whichever is less, Oct. 1 through April 30.	
Granby Reservoir	Point of compliance at gage "Colorado River below Granby": 20 cfs from Oct. 1 through April 30. Point of compliance at USGS gage 09010500 "Colorado River near Granby (YMCA gage)": ■ 75 cfs May, June, July ■ 40 cfs August ■ 20 cfs September	Can be reduced on forecast per Secretarial finding
Shadow Mountain Reservoir	■ 20 cfs from Jan. 1 through May 31 ■ 50 cfs from June 1 through July 31 ■ 40 cfs from Aug. 1 through Aug. 31 ■ 35 cfs from Sept. 1 through Oct. 31 ■ 45 cfs from Nov. 1 through Dec. 31	May be reduced based on forecast
Fryingpan Arkansas Diversion	Twelve of the 16 diversions for the Fryingpan Arkansas Project have minimum releases ranging from 1-12 cfs. Four diversions do not have minimum releases.	
Rifle Gap	5 cfs released, or inflow if less, Nov. 1 through April 15	Downstream senior water rights

Source: Personal communication, M. Wilson, BOR, Loveland, 4/22/04 and C. Stanton, BOR, Western Colorado Area Office, 4/23/04.

Table 6-14 River Reaches in the Colorado River Basin in Colorado Listed for Rafting use by American Whitewater

Reach Description	Class	Minimum Suggested Flow (cfs)*	Maximum Suggested Flow (cfs)*
Blue River from Blue River Campground to FR 2400	III-IV	NA	NA
Blue River from Green Mountain Reservoir to Spring Creek Road	III	NA	NA
Buzzard Creek from 64.30 Rd to Collbran	IV	NA	NA
Colorado River from Hot Sulphur Springs to Hwy 40 bridge	IV	400	2000
Colorado River at Gore Canyon	IV-V	700	2000
Colorado River from Pumphouse campground to Rancho Del Rio	III	900	5000
Colorado River from Hanging Lake Exit 125 (I-70) to Grizzly Creek Exit 121 (I-70)	IV-V (V+)	1800	6000
Colorado River from Shoshone Power Plant Exit 123 (I-70) to Grizzly Creek Exit 121 (I-70)	III-IV	500	8000
Colorado River at Cameo Dam	III	18000	25000
Colorado River from Loma launch to Westwater launch	II	NA	NA
Crystal River from Crystal Mill Falls to Crystal Gorge	III-IV (V)	1000	NA
Crystal River from road to Crystal to Beaver Lake	V+	200	350
Crystal River from Marble to Redstone	III-IV	NA	NA
Crystal River from Redstone to Penny Hot Springs	V+	500	NA
Crystal River from Penny Hot Springs to Avalanche Creek	IV-V	500	2000
Crystal River from Avalanche Creek to B.R.B. Campground	III	500	NA
Crystal River, North Fork to the scree slope	V+	NA	NA
Crystal River, South Fork from Schofield Pass to Crystal	V+	250	500
Eagle River from Forest Service Visitor Center to Riverbend bus stop (Dowd Chute)	III-IV (V)	250	4000
Eagle River from Riverbend bus stop to Edwards (Upper Eagle)	III	1000	3000
Eagle River from Edwards to Eagle (Lower Eagle)	II-III	700	5000
Eagle River at Gilman Gorge (Redcliff to Tigiwan Rd [FR 707])	IV-V (V+)	200	800
Fraser River from Tabernash to Branby	III-IV	400	2000
Fryingpan River, upper	IV-V	NA	NA
Fryingpan River from Taylor Creek to Basalt	IV	NA	NA
Gore Creek from East Vail Exit (I-70) to Eagle River	III-IV	300	2000
Grizzly Creek from 1 mile up trail to Grizzly Creek Rest Area	IV-V	NA	NA
Homestake Creek ¼ mile above confluence with Eagle River	V	NA	NA
Piney River from Piney Crossing to State Bridge	V+	NA	NA
Plateau Creek from Hwy 65 to I-70	III-IV	NA	NA
Roaring Fork River from Black Bridge to Veltus Park (Cemetery)	II+ (III)	NA	NA
Roaring Fork River from Upper Woody Creek Bridge to Lower Woody Creek Bridge	III	NA	NA
Roaring Fork River from Lower Woody Creek Bridge to Rte. 82 Bridge	III	NA	NA
Roaring Fork River from Aspen to Upper Woody Creek Bridge (Slaughterhouse)	IV-V	700	NA
Roaring Fork River from Aspen Music School to Slaughterhouse Bridge	IV+	NA	NA
Roaring Fork River from Norrie Colony to Ruedi Reservoir Inlet	IV+	NA	NA
Roaring Fork River from Seven Castles to Basalt 7-11	III+	NA	NA
Roaring Fork River from Weller Lake to Difficult Campground	V+	NA	NA
Rock Creek from Shoe & Stocking Creek Trailhead to Bridge below Quarry	V+	150	400
Sweetwater Creek from Pine Valley Ranch to Anderson Camp	III-IV	NA	NA
Tenmile Creek from Near Copper Mountain Ski Area to Dillon Reservoir	III-IV	600	800
Yule Creek above Marble Quarry	V+	NA	NA

Source: http://www.americanwhitewater.org/rivers/statedrain/CO

* Suggested levels of flow, not water rights.

There are several federal reservoirs in the Colorado Basin. These projects were authorized to serve municipal, industrial, and agricultural needs as their primary purpose. These facilities also provide secondary benefits such as recreation. The following federal project reservoirs in the Colorado Basin offer water-based recreational activities in addition to fulfilling the authorized project purposes:

Vega Reservoir
Vega Dam is located about 10 miles east of the Town of Collbran and provides water for agricultural, M&I, and recreation. Vega State Park is located on the northwest edge of Grand Mesa National Forest. Along with several campgrounds in the park, the lake offers boating, water skiing, and fishing. Excellent ice fishing and snowmobiling have made Vega State Park popular with both winter and summer visitors. Trails are available atop Grand Mesa for hiking, trail biking, and four-wheeling in the summer, and cross-country skiing and snowmobiling in the winter. One-quarter mile south of the dam, the Visitors Center features displays and exhibits describing the history, wildlife, and recreational opportunities available in the area.

The Vega State Park is administered by CDPOR (http://parks.state.co.us/default.asp?parkID=69&action=park).

Horsethief Canyon State Wildlife Area
Horsethief Canyon State Wildlife Area, located just west of Fruita along the Colorado River, is owned by BOR and managed by CDOW. Its primary function is to provide wildlife habitat and rearing ponds for endangered fish. Horsethief Canyon State Wildlife Area has 2,080 acres of land, which offers access to various trails leading to a wilderness area. The area follows the Colorado River. Recreational opportunities include biking, fishing, hiking, horseback riding, hunting, and wildlife viewing (http://www.recreation.gov/ detail.cfm?I D=1020).

Green Mountain Reservoir
Green Mountain Dam and Reservoir are part of the CBT Project and are located 13 miles southeast of Kremmling, Colorado on the Blue River, a tributary of the Colorado River. Green Mountain Dam and Reservoir authorized purposes include agriculture, M&I, and recreation. Recreational developments include 6 campgrounds, 208 campsites, and 2 boat-launch facilities. There is one swim beach. Water surface for fishing is approximately 2,125 acres. Fishing is the primary recreational activity, followed by power boating and camping. Primary sport fish available are brown trout, rainbow trout, and salmon. Campgrounds closed in winter due to snow and ice. Other recreational opportunities include: hunting, picnicking, water sports, winter sports, and wildlife viewing (http://www.recreation.gov/detail.cfm?ID=65).

Lake Granby
Granby Dam is located on the Colorado River about 5.5 miles northeast of Granby and its authorized purposes are for agriculture, M&I, and recreation. Lake Granby and Granby Dam are features of the CBT Project. Developments on Lake Granby include 260 campsites and 3 boat launch ramps. Total water surface available for recreation is approximately 7,250 surface acres. Primary recreation activities are power boating, fishing, and camping. Primary sport fish are rainbow trout, mackinaw trout, and salmon. Facilities closed in winter due to ice and snow conditions. Additional recreational opportunities include hiking, hunting, picnicking, recreational vehicles, and water sports (http://www.recreation.gov/detail.cfm?ID=68).

Willow Creek Reservoir
Willow Creek Dam is located on Willow Creek, a tributary of the Colorado River, about 4 miles north of Granby and provides water for agriculture, M&I, and recreation. Willow Creek Dam and Reservoir are features of the CBT Project. Developments include one campground with 35 campsites and 1 boat launch facility. Total water surface available for recreation is approximately 300 surface acres. Primary recreational activities are fishing, camping, and picnicking. Primary sport fish available are brown trout, rainbow trout, and salmon. Facilities and campground are closed in winter because of ice and snow. Additional recreational opportunities include boating, hunting, recreational vehicles, and water sports (http://www.recreation.gov/detail.cfm?ID=94).

Shadow Mountain Reservoir
Features of the CBT Project, Shadow Mountain Dam and Reservoir are located on the Colorado River below the Grand Lake Outlet and their authorized purposes are for agriculture, M&I, and recreation. Developments include 1 campground with 80 campsites and 2 boat launch ramps. Total water surface available for recreation is approximately 1,346 surface acres with 8 miles of shoreline. Primary recreational activities are camping,

fishing, and power boating. Primary sport fish are brown trout, rainbow trout, and salmon. Facilities close in winter due to ice and snow conditions. Additional recreational opportunities include hiking, picnicking, recreational vehicles, and water sports (http://www.recreation.gov/ detail.cfm?ID=9).

Rifle Gap Reservoir

Rifle Gap Dam authorized purposes are irrigation, recreation, and flood control, and it is located about 5-1/2 miles north of Rifle, at a point where Rifle Creek cuts through the Grand Hogback. The Dam and Reservoir are part of the Silt Project. The clear water at Rifle Gap Reservoir is excellent for scuba diving. Other water activities include boating, fishing, swimming, water skiing, and windsurfing. Fishing enthusiasts can find rainbow and brown trout, walleye, perch, and smallmouth and largemouth bass. Wildlife in the area includes deer, elk, beaver, chipmunks, rabbits, and bobcats. An 18-hole golf course lies adjacent to the area. Winter offers ice fishing, cross-country skiing, and snowmobiling. There are 47 campsites that will accommodate tents, small trailers, and pickup campers. There are some pull-through sites for larger units and day-use picnic areas. Additional recreational opportunities include hunting and picnicking (http://www.recreation.gov/ detail.cfm?ID=60).

Ruedi Reservoir

Ruedi Reservoir, a feature of the Fry-Ark Project, is located on the Fryingpan River about 15 miles east of Basalt. Ruedi Reservoir's authorized purpose provides storage for irrigation, M&I, power, recreation, and flood control. The location provides an exceptionally beautiful background for swimming, boating, water skiing, fishing, sailing, picnicking, camping, and general relaxation. Recreation facilities consist of 4 campgrounds accommodating 81 campsites and 2 boat launching ramps. The water surface available for recreation is 997 acres. Game fish species available include rainbow trout, brown trout, and mackinaw trout. The most common big game species are deer and elk; black bears are seen occasionally. Additional recreational opportunities include hiking, hunting, and recreational vehicles. Facilities close in winter due to ice and snow (http://www.recreation.gov/ detail.cfm?ID=91).

6.3.2.2.2 Upper Colorado River Basin Study

The UPCO River Basin Study was initiated in 1998 to identify and investigate water quantity and quality issues in the study area consisting of Grand and Summit Counties. Phase I of UPCO was the development of the Scope of Work for Phase II. Phase III involves a collaborative effort by the participating parties to seek solutions to the issues identified in the Phase II study report (Hydrosphere 2003).

The primary goal of Phase II of UPCO was to develop the information and analytical tools necessary to understand existing hydrology and water quality conditions in the study area and how increased water diversions may impact those conditions. This information was meant to support discussions and negotiations between the stakeholders as they seek solutions to current and future water supply, reservoir level, instream flow, and water quality issues. Participants in the study were Grand and Summit Counties, Colorado River Water Conservation District (CRWCD), Middle Park WCD, Northwest Colorado Council of Government's Water Quality and Quantity (NCCGWQQ) Committee, NCWCD, Denver Water, and Colorado Springs.

The principal components of the Phase II study were: (1) compilation and analysis of water resources and water supply data for Summit and Grand Counties; (2) expansion of Denver Water's hydrologic and water rights model (Platte and Colorado Simulation Model [PACSM]) to represent individual West Slope water supply systems; (3) development of a data management and display tool to support the analysis of impacts associated with existing and future water supply and demand scenarios; and (4) identification of issues to be addressed in Phase III, the solutions phase, of the study.

The UPCO study compiled information regarding instream flow water rights and water levels necessary for water-based recreational activities. This information was used to evaluate the impact on stream flow and lake levels, and goes beyond just the municipal and domestic water demands of the study area. The study incorporated the following types of information for purposes of evaluation of impacts:

- CWCB instream flow water rights
- Minimum and optimum fish flows
- Low, high, and optimum kayaking flows
- Low, high, and optimum rafting flows
- Reservoir levels necessary for boat ramps and marinas
- Wastewater treatment plant 1-day and 30-day, 3-year flows

The fish, kayaking, and rafting flows and reservoir levels are guidelines that the study established based on information from CDOW and local, established guides and businesses. The flows and reservoir levels represent what the recreation and in-basin communities believe is important to sustain a quality recreational experience.

The UPCO analysis of impacts is based upon the 1947 to 1991 hydrologic record represented in Denver Water's PACSM. This period includes representative wet, dry, and average years but does not include any years that are comparable to drought conditions as severe as what occurred during 2002, when streamflows were the lowest ever recorded.

To develop the in-basin instream water needs, the NCCGWQQ Committee met with local anglers, extrapolated data from various technical reports such as the Metro Denver Water Supply EIS, CDOW, rafting companies, kayak shops, and marina operators. From those discussions, the impact criteria were determined. Marina operators provided information on optimum and minimum reservoir levels for normal operation of their facilities. Information also included the boating season for each reservoir and potential mitigation for future operations under lower reservoir levels.

A summary of the UPCO recommendations on kayaking flows, rafting flows, fish flows, and reservoir levels in Tables 6-15 through 6-18.

Table 6-15 UPCO Recommendations on Kayaking Flows*

River	Segment	Low Water	High Water	Optimum	Comments
Blue River	~8 miles through Rock/Boulder Creek Canyon, from the USFS Rock Creek Campground to Columbine Landing	300 cfs	1,200 cfs	600 to 1,100 cfs	Season is June through July 4, flows permitting. Flows listed are based on USGS gage below Dillon Dam.
Blue River	~3.8 miles in Green Mountain Canyon from Green Mountain Camp (below the dam) to Spring Creek Road	<600 cfs	>600 cfs	500 cfs	Season is late summer, based on downstream call. Due to late summer releases from Green Mountain Reservoir, this segment is one of few late season runs for novices.
Colorado River	~2.6 miles in Byers Canyon from the bridge next to the Riverside Hotel to the bridge near the Road 50 turnoff.	300 cfs	1,000 to 2,000+ cfs	400 to 1,000 cfs	Season is during June runoff.
Fraser River	10.4 miles from Skunk/Crooked Creek in Tabernash to Highway 40 Bridge south of Granby	250 cfs	1,000 cfs	400 to 700 cfs	Season is late May to early June. Optimum flows are rare.
Blue River	Breckenridge Kayak Course (Phases 1 and 2); ~1/4 mile, extending from Breckenridge Recreation Center bike path bridge to above Cemetery Road	100 cfs	NA	500 cfs	Season is May through July. Flows listed are measured at the Four Mile Bridge SEO gage approximately 3 miles downstream from the course.

* References: UPCO River Basin Study, Phase II Final Report, May 29, 2003; UPCO Report on Kayaking Flows (Draft for Discussion), April 18, 2002.

Table 6-16 UPCO Recommendations on Rafting Flows*

River	Segment	Low Water	High Water	Optimum	Comments
Blue River	8 mile segment extending from 2 miles north of Silverthorne at the water plant to the Columbine Landing	550 cfs	2,000 cfs	700 to 1,400 cfs	Season is June through July 4, flows permitting. Flows listed are based on USGS gage below Dillon Reservoir, so actual flows are higher. Under 500 cfs is too low for rafting.
Colorado River	Gore Canyon	400 cfs	>11,000 cfs	2,000 to 3,000 cfs	Most commercial rafting occurs below the UPCO study area, downstream from Gore Canyon. Flows from the UPCO study area are essential for commercial operation in Gore Canyon and downstream. The gage at Kremmling accurately reflects conditions in the Gore Canyon.

* References: UPCO River Basin Study, Phase II Final Report, May 29, 2003; UPCO Report on Rafting Flows, August 20, 2001.

Table 6-17 UPCO Recommendations on Fish Flows[1]

River[2]	Segment	Minimum	Optimum	Comments
Blue River	Below Dillon Reservoir	75 cfs (5/1 - 9/30) 55 cfs (10/1 - 4/30)	100 cfs	Exceptions include releases in the range of 55 to 125 cfs should not increase more than 15 percent over a 24-hour period; above 125 cfs, changes in releases should track with the rate of change in the inflow hydrograph for the reservoir.
Blue River	Below Green Mountain Reservoir	60 cfs (5/1 - 7/15) 140 cfs (7/16 - 9/30) 100 cfs (10/1 - 4/30)	NA	Exceptions include above 140 cfs, changes in releases should track with the rate of change in the inflow hydrograph for the reservoir.
Colorado River	Below Windy Gap, and above Williams Fork	125 cfs	200 cfs	Other recommended flows include 125 cfs minimum and 200 cfs optimum at Hot Sulphur Springs for juvenile and adult brown trout. Recommended rainbow trout optimum flows at Hot Sulphur Springs are as follows: ▪ 300 cfs 4/20 - 6/15 ▪ 125 cfs 6/15 - 7/15 ▪ 175 cfs 7/15 - 10/15 ▪ 200 cfs year-round for adults This may be useful relative to Whirling disease. Temperature in this stretch is a serious issue.
Fraser River	Below Vasquez Creek	9 cfs	12.5 cfs	NA
Colorado River	Below Granby Reservoir	30 cfs	45 cfs	NA
Williams Fork River	Below Williams Fork Reservoir	50 cfs	200 cfs	Maximum flow is 450 cfs

1 References: UPCO River Basin Study, Phase II Final Report, May 29, 2003; UPCO Report on Fish Flows, January 7, 2002. Criteria are based on the protection of brown trout juvenile and adult habitat.

2 General rules that apply to all segments:

A. Late season flows (>10/1) must be stabilized through the winter at the level that occurred during spawning.

B. Changes in stream flows from diversions or releases should not exceed 50 percent spread equally over a 24-hour period. Some segment-specific exceptions apply are described in the table.

C. Stream depths should be a consideration when air temperatures are high and water temperatures are an issue for fisheries. High temperature associated with low flows is one of the bigger concerns.

Table 6-18 UPCO Recommendations on Reservoir Levels*

Reservoir	Location	Minimum	Optimum	Comments
Dillon Reservoir	Frisco Marina	9,012 feet elevation from June to September	9,017 feet with 9,012 feet at the end of September	Season is Memorial Day through October 15
Grand Lake and Shadow Mountain Reservoir	Both waterbodies	8,368 feet elevation	Maximum 1 foot fluctuation in elevation is permissible (8,368 to 8,369)	Season is year-round.
Granby Reservoir	Entire waterbody	NA	NA	Reservoir depth of 221 feet, with fluctuations up to 94 feet permissible.
Wolford Mountain Reservoir	Reservoir and tailwaters	NA	NA	Reservoir is operated to fill by mid-May (timed to match Cameo Peak). Boating activities begin about Memorial Day. Full pool elevation is 7,489 feet ASL. On reservoir fishing year-round, no operational impacts. Downstream fishing occurs, which may be impacted by reservoir releases.

* Reference: UPCO Report on Reservoir Levels (Draft for Discussion), July 25, 2001.

6.3.3 Dolores/San Juan/ San Miguel Basin

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

Major Identified Projects and Processes for the Dolores/San Juan/San Miguel Basin are summarized in Table 6-19. For reference, Figure 6-8 provides a map of subbasins, counties, and major cities in the basin as referenced throughout this discussion.

Numerous Identified Projects and Processes were developed to meet the diverse uses in the Dolores/San Juan/San Miguel Basin and its various subbasins. Both the Dolores Project and the Animas-La Plata Project are considered critical to meeting the gap by Roundtable members. The Dolores Project has been constructed and the Animas-La Plata Project is under construction. The M&I allocations in these projects are projected to be adequate to meet M&I water supply needs in most areas of the San Juan Basin through 2030. However, the infrastructure to deliver Dolores and Animas-La Plata Project water to its end users does not currently exist and must be constructed. This water treatment and delivery infrastructure will be very expensive to construct. It will likely not be financially feasible to serve some unincorporated areas not served by water districts and water hauling is anticipated unless financial assistance is provided to develop the supplies and infrastructure.

M&I users in the Norwood area of the San Miguel subbasin are in need of additional supplies to meet projected growth. The upper areas of the Dolores River upstream of McPhee Reservoir, similar to headwaters areas in other basins, will need augmentation credits above CWCB instream flow rights, or where warranted a finding of de minimus impacts. Users in all counties in the basin will also use existing supplies and water rights to meet their needs.

Average annual agricultural shortages (greater than 10 percent) were identified in many water districts in this Basin. Supplies were identified to irrigate an additional 4,000 acres in Dolores Water Conservancy District through the acquisition of shares in another irrigation company and acquisition of a reservoir. Long Hollow Reservoir on the La Plata River would provide for regulation of flows for the La Plata Compact and maximizing in-basin supplies. This project would help reduce agricultural shortages in the La Plata drainage.

Further details regarding the Identified Projects and Processes and areas of gap for the Dolores/San Juan/San Miguel Basin are provided in Table 6-20.

Table 6-19 Major Identified Projects and Processes in Dolores/San Juan/San Miguel Basin Counties

County	Estimated Demand met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
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**	

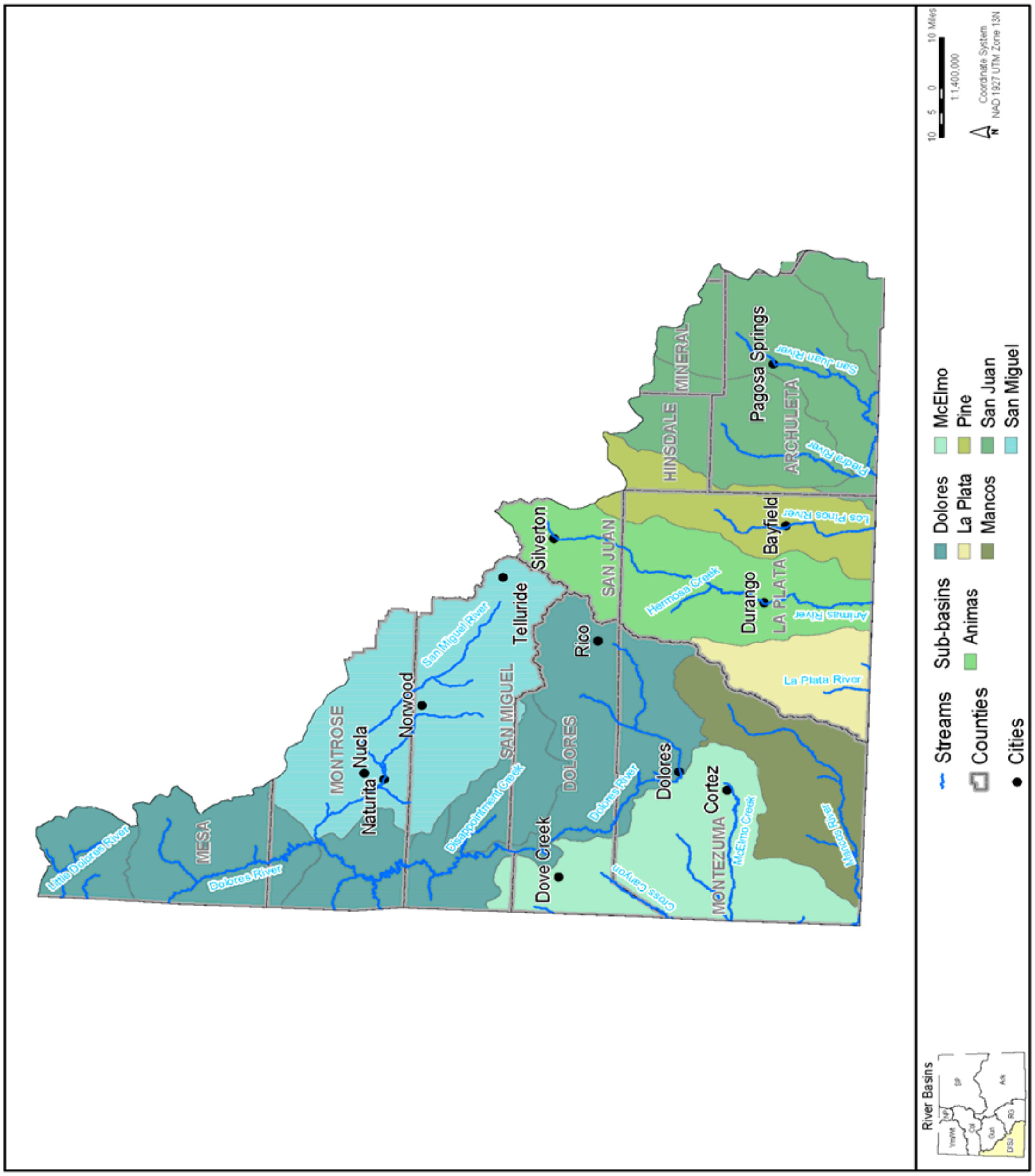


Figure 6-8
Dolores/San Juan/San Miguel Basin Location Map

Table 6-20 Detailed Identified Projects and Processes for Dolores/San Juan/San Miguel Basin

County	Subbasin	Major Provider	Remaining Gross Gap (acre-feet)	Supplies Beyond 2030*	Notes	Source
Archuleta	San Juan	Pagosa Area Water and Sanitation District (PAWSD)	0	Y	Will build Dry Gulch Reservoir and provide raw water to PAWSD. Some financing limitations without teaming.	Harris Engineering Water Supply Study
	San Juan	San Juan Water Conservancy District	0	Y	Will build Dry Gulch Reservoir and provide raw water to PAWSD. Some financing limitations without teaming.	Response to CDM survey
	San Juan	Unincorporated Archuleta County not covered by a water district	366	N	Have assumed 5 to 10 percent of future demand in each county will be in rural area not covered by PAWSD and groundwater or hauling water may be the only options and alternatives will not be developed.	BRT feedback
Dolores	Dolores	Dolores Water Conservancy District	0	Y	CWCB instream flow may limit the ability to provide augmentation above McPhee Reservoir in the future. Alternatives include small storage (10 to 20 AF) or alluvial storage.	Steve Harris, Janice Sheftel and John Porter
	Monument Creek/San Juan	Dove Creek	0	Y	Have right to water from Dolores Water Conservancy District.	Steve Harris, Janice Sheftel and John Porter
	Dolores	Rico	0	N	Instream flow right may be an obstacle in the development of an alluvial well field. Working on coming into Dolores Water Conservancy District. Would need small storage if alluvial well field cannot be developed.	Steve Harris, Janice Sheftel and John Porter
	Mancos/ McElmo	Montezuma Water Company	0	Y	Supplies potable water to rural Dolores and Montezuma Counties.	Steve Harris, Janice Sheftel and John Porter
	Dolores	Unincorporated Dolores County not covered by a water district	17	N	Have assumed 5 to 10 percent of future demand in each county will be in rural area not served by Rico or Dove Creek and groundwater or hauling water will be the only options and alternatives will not be developed.	BRT feedback
La Plata	Animas/San Juan	Durango West Metro District #1	40	N	Potential joint project to construct raw water pump and pipeline among Durango West Metro Districts and Lake Durango Water Company. Other options include the future Animas La-Plata/ Western La Plata rural domestic system or to purchase treated water from the City of Durango.	Steve Harris, Janice Sheftel and John Porter
	Animas/San Juan	Durango West Metro District #2	40	N	Potential joint project to construct raw water pump and pipeline among Durango West Metro Districts and Lake Durango Water Company. Other options include the future Animas La-Plata/ Western La Plata rural domestic system or to purchase treated water from the City of Durango.	Steve Harris, Janice Sheftel and John Porter

Table 6-20 Detailed Identified Projects and Processes for Dolores/San Juan/San Miguel Basin

County	Subbasin	Major Provider	Remaining Gross Gap (acre-feet)	Supplies Beyond 2030*	Notes	Source
La Plata (cont.)	Animas/San Juan	Durango	0	Y	Have adequate water rights and negotiating for Animas-La Plata Project Water to increase overall storage.	Jack Rogers, City of Durango
		Edgemont Ranch Metro District	0	U	May need storage for firming.	Steve Harris
		El Rancho Florida Metropolitan	0	N	Built out.	Steve Harris
	Animas/San Juan	Lake Durango Water Company	300	N	Potential joint project to construct raw water pump and pipeline with Durango West Metro Districts and Lake Durango Water Company. Other options include the future Animas La-Plata/ Western La Plata rural domestic system.	Steve Harris, Janice Sheftel and John Porter
	Pine/San Juan	La Plata - Archuleta Water District	0	U	This District is needed to treat and distribute water. There is a gap if this District is not formed. Options include wells or water hauling.	Steve Harris, Janice Sheftel and John Porter
	Animas/San Juan	Purgatory Metropolitan District	100	N	District has sufficient water now, but is anticipating huge growth, especially at Durango Mountain Resort. The District is looking for more water. Water rights must be deeded to District with inclusion of property within the District. District is looking at all opportunities but does not have any other specific plans.	Janice Sheftel
	Pine/San Juan	Bayfield	0	U	Need storage to firm existing water rights. Only other option is to lease water from Vallecito Reservoir.	Steve Harris, Janice Sheftel and John Porter
	Pine/San Juan	Forest Lakes Metro District	0	Y	Future issue is cost of contract water from Vallecito Reservoir.	Steve Harris, Janice Sheftel and John Porter
	Pine/San Juan	Southern Ute Indian Tribe and Ignacio	0	Y	Source of water and treatment is Southern Ute Indian Tribe water rights. Tribe treats water, but each has own distribution systems.	Steve Harris, Janice Sheftel and John Porter
	Florida/San Jaun	Unincorporated La Plata County in Florida Drainage	100	N	Need for augmentation water. Water could be stored on Edgemont Ranch or institutional changes to Florida Project to allow domestic and augmentation uses.	Janice Sheftel
	Pine/San Juan	Unincorporated La Plata County upstream of Vallecito Dam	0	N	Served by wells.	Steve Harris
	Animas/San Juan	Unincorporated Northern La Plata County not covered by a water system	348	N	North of Durango in Animas River Basin. No single entity that can serve and operating on individual augmentation plans. Durango proposed RICD could impact future water development. Electra Lake is available as a source of augmentation and physical source, but is costly. May be small amounts of ag available to change, but will be expensive.	Steve Harris, Janice Sheftel and John Porter

Table 6-20 Detailed Identified Projects and Processes for Dolores/San Juan/San Miguel Basin

County	Subbasin	Major Provider	Remaining Gross Gap (acre-feet)	Supplies Beyond 2030*	Notes	Source
La Plata (cont.)	La Plata/San Juan	Unincorporated Western La Plata County not covered by a water system	50	N	Have assumed 5 to 10 percent of future demand in each county will be in rural area not served by a water district and groundwater or hauling water from Marble Springs or a municipal system will be the only options and alternatives will not be developed.	Steve Harris, Janice Sheftel and John Porter
	La Plata/ Animas/San Juan	Western La Plata County Water System	0	N	Up to 700 AF of Animas-La Plata water that requires treatment and distribution to deliver the water. Wells are not an option, would require water hauling.	Steve Harris, Janice Sheftel and John Porter
Monte-zuma	Mancos/ McElmo	Mancos	0	Y	Source is Jackson Reservoir and direct flow rights.	Steve Harris, Janice Sheftel and John Porter
	Dolores	Dolores	0	Y	Have water rights and could purchase water from Dolores Project if needed.	John Porter
	Mancos/ McElmo/ San Juan	Mancos Water Company	0	Y	Mancos Water Company is negotiating with the Mancos Water Conservancy District to increase their supply from the Jackson Project.	John Porter
	McElmo	Cortez	0	Y	Have direct flow rights and Dolores Project Water available.	Response to CDM survey
	Mancos	Montezuma County Water District	0	Y	Could purchase water from Dolores Project Water or Montezuma Water Company.	John Porter
	San Juan	Montezuma Water Company	0	Y	Supplies potable water to rural Dolores and Montezuma Counties.	Steve Harris, Janice Sheftel and John Porter
	McElmo	Summit Water District	0	N	Negotiated with Montezuma Water Company for water.	John Porter
	Mancos/ McElmo	Unincorporated Montezuma County not covered by a water district	168	N	Have assumed 5 to 10 percent of future demand in each county will be in rural area not served by a water district and groundwater or hauling water may be the only options and alternatives will not be developed.	BRT feedback
	Mancos/ McElmo	Ute Mountain Ute Indian Tribe	0	N	Current Dolores Project Water allocation may be used by 2030. City of Cortez treats the Tribe's water piped from McPhee. Additional water potentially available from Dolores Project.	Steve Harris, Janice Sheftel and John Porter
Montrose	San Miguel	Nucla	0	U	Mustang Water Authority formed to provide water.	Buckhorn Geotech Report on Mustang Water Authority
	San Miguel	Naturita	0	U	Mustang Water Authority formed to provide water.	Buckhorn Geotech Report on Mustang Water Authority
	San Miguel	Tri-State Power Facility	2000	N	Have adequate water rights for future demands but would need storage to firm the yield if plant is expanded. Need storage options.	Bill Haffner, Tri-State Generating
	San Miguel	Unincorporated Montrose County not covered by a water system	135	N	Have assumed 5 to 10 percent of future demand in each county will be in rural area not served by a water district and groundwater or hauling water will be the only options and alternatives will not be developed.	BRT feedback

Table 6-20 Detailed Identified Projects and Processes for Dolores/San Juan/San Miguel Basin

County	Subbasin	Major Provider	Remaining Gross Gap (acre-feet)	Supplies Beyond 2030*	Notes	Source
San Miguel	San Miguel	Aldaroso Ranch & Homeowners Co	0	N	Have water rights and groundwater.	Helton & Williamsen
	San Miguel	Norwood Water Commission	1000	N	Could also serve some of unincorporated Montrose County in addition to Town of Norwood.	John Porter
	San Miguel	Telluride Ski Area	0	Y	Assumed to have sufficient supplies (per Town of Telluride).	John Porter
	San Miguel	Telluride	0	Y	Existing water rights.	John Porter
	San Miguel	Unincorporated San Miguel County not covered by a water system	195	N	Have assumed 5 to 10 percent of future demand in each county will be in rural area not served by a water district and groundwater or hauling water will be the only options and alternatives will not be developed.	BRT feedback
San Juan	Animas/San Juan	Silverton	0	N	Physical water supply is adequate, but applying for augmentation plan. Will need to expand raw water storage to firm supply. Durango proposed RICD could impact future water development.	Janice Sheftel
	Animas/ San Juan	Cascade Village	0	N	North of Purgatory and supplies water to condominium development. Option is to develop wells. Durango proposed RICD could impact future water development.	Steve Harris
	Animas/ San Juan	Unincorporated San Juan County not covered by a water system	0	N	Minor projected increase in demands.	Steve Harris

A summary of gaps by county are shown on Table 6-21. The largest gap identified is in Montrose County, which is due to the amount of firm yield that would be needed if the Tri-State Power Facility were expanded.

Table 6-21 Summary of Gap Analysis for Dolores/San Juan/San Miguel Basin

County	Identified Gross Demand Shortfall (AFY)
Archuleta	400
Dolores	0
La Plata	1,000
Montezuma	200
Montrose	2,100
San Juan	0
San Miguel	1,200
TOTAL	**4,900**

6.3.3.2 Recreational and Environmental Flow Information

6.3.3.2.1 Flow Consideration

One program that considers flow is the San Juan River Basin Recovery Implementation Program (Implementation Program) was established in 1992. The purpose of the Implementation Program is to protect and recover endangered fishes in the San Juan Basin while water development proceeds in compliance with all applicable federal and state laws. Endangered species include the Colorado pikeminnow (formerly known as the Colorado squawfish) and razorback sucker. It is anticipated that actions taken under this Implementation Program also will provide benefits to other native fishes in the Basin and prevent them from becoming endangered in the future.

The specific goals of this Implementation Program are:

- To conserve populations of Colorado pikeminnow and razorback sucker in the basin consistent with the recovery goals established under the ESA, 16 U.S.C. 1531 et seq.
- To proceed with water development in the basin in compliance with federal and state laws, interstate compacts, Supreme Court decrees, and federal Indian trust responsibilities.

The Implementation Program participants include BOR, Bureau of Indian Affairs, BLM, USFWS, the States of Colorado and New Mexico, Navajo Nation, Southern Ute Indian Tribe, Ute Mountain Ute Indian Tribe, Jicarilla Apache Nation, and non-federal water development interests.

The Implementation Program conducts activities and construction projects designed to achieve recovery goals for the endangered Colorado pikeminnow and razorback sucker in the San Juan Basin. P.L. 106-392 authorizes federal funding of the Implementation Program and recognizes the non-federal cost sharing provided by states and power users. Activities of the Implementation Program include research, monitoring, non-native fish control, re-operation of Navajo Reservoir to provide flows, and stocking of endangered fish. Construction activities include construction of hatchery facilities and fish passages at major diversion structures. In the future, fish screens will be added at major diversion structures, if needed.

In conducting Section 7 consultations on water project depletions, USFWS considers the activities and projects of the Implementation Program as the reasonable and prudent alternatives to avoid jeopardy to the species and adverse modification to critical habitat, and as reasonable and prudent measures to offset incidental take. The Implementation Program has provided ESA compliance on a number of large and small projects in the San Juan Basin, including the Animas-La Plata Project.

Numerous CWCB instream flow rights have been decreed on major rivers and tributaries in the Dolores/San Juan/San Miguel Basin (http://cwcb.state.co.us/isf/Downloads/ Index.htm). Decreed rights on major rivers and streams are listed in Table 6-22. These rights are year-round rights with seasonal variability as reflected in the range of values shown. Flow rights on smaller tributaries in the basins can be found at the above referenced website.

6.3.3.2.2 Water-Based Recreation

Numerous river reaches in Colorado are used for whitewater rafting. Table 6-23 shows the reaches in the Dolores/San Juan/San Miguel Basin that are listed for rafting use by American Whitewater.

Table 6-22 CWCB Instream Flow Rights on Major Rivers in the Dolores/San Juan/San Miguel River Basin

River	Upper Terminus	Lower Terminus	Range of Flow Rights (cfs)*	Range of Appropriation Dates	Number of Reaches
Dolores River	Headwaters	Confluence with the San Miguel River	—	May 1, 1975 to July 13, 1984	5
San Miguel River	Confluence of Bridal Veil and Ingram Creeks	Point immediately upstream of the confluence with Horsefly Creek	6.5 - 93	July 13, 1984 to Jan. 23, 2002	3
La Plata River	Outlet of Upper Lake	Hay Gulch Irrigation Ditch	9	July 13, 1984	1
Piedra River	Confluence with MR and EF Piedra River	Navajo Reservation	20 - 70	March 16, 1978 to March 14, 1979	5

* The range of flows also reflect the fact that there are multiple reaches with different CWCB instream flows specific to each reach.

Table 6-23 River Reaches in the Dolores/San Juan/San Miguel River Basin in Colorado listed for rafting use by American Whitewater

Reach Description	Class	Minimum Suggested Flow (cfs)*	Maximum Suggested Flow (cfs)*
Dolores River from Rico to McPhee Reservoir	II-III	NA	NA
Dolores River from Bradfield Launch (McPhee Reservoir) to Dove Creek Pump Station	II-III	1000	3000
Dolores River from Dove Creek Pump Station to Slickrock	II-III+ (IV)	1000	3000
Dolores River from Slickrock to Bedrock	II+ (III)	1000	3000
Dolores River from Bedrock to Gateway	II+	1000	4000
Dolores River from Gateway to Colorado River (UT)	II+ (IV)	1000	4000
San Miguel River from BB 36 Rd. to Green Truss Bridge	III	700	NA
San Miguel River from Norwood Bridge to Green Truss Bridge	III	1000	NA
San Miguel River from Silverpick Rd. to Fall Creek Rd	III	800	NA
Animas River from Silverton to Tacoma (Upper Animas)	IV-V	1000	4000
Animas River from Tacoma to Rockwood Rail Yard (Rockwood Box)	IV-V	NA	NA
Animas River from Bakers Bridge to Trimble Lane	I-II	NA	NA
Animas River from Trimble Lane to 32nd Street Park	I-II	NA	NA
Animas River from 32nd Street Park to Purple Cliffs	III	NA	NA
Animas River from Purple Cliffs to State line	II-III	NA	NA
Canyon Creek to Animas River	V+	NA	NA
Hermosa Creek from Hermosa Park 16 mi to Dutch Creek, 8 mi to US 550	IV-V	NA	NA
Lime Creek first Gorge	V+	NA	NA
Lime Creek second Gorge	V+	NA	NA
Mineral Creek, South above South Mineral Camp Ground	V+	NA	NA
Navajo River lower 25 miles to San Juan confluence	I-II	NA	NA
Piedra River from Upper Piedra Campground to First Fork Bridge	II-IV	550	1500
Piedra River from First Fork Bridge to Lower Piedra Campground (First Box Canyon)	III-V	NA	NA
Piedra River from Lower Piedra Campground to Navajo Reservation	II-III	NA	NA
Rio Blanco from Highway 84 to San Juan River	II-III	NA	NA
San Juan River – Mesa Canyon	II-III	400	2500
San Juan River – Pagosa Springs Town Run (Conoco Station to Courthouse)	II-III	600	2000
San Juan, East Fork from East Fork to 160 Bridge (East Fork of San Juan)	III-IV	150	500
Vallecito Creek one mile above Vallecito Campground	V+	1.6	2.2
Wolf Creek downstream from Highway 160 Bridge	IV+	NA	NA

* Suggested levels of flow, not water rights.

There are several federal reservoirs in the Dolores/San Juan/San Miguel Basin. These projects were authorized to serve municipal, industrial, and agricultural needs as their primary purpose. These facilities also provide secondary benefits such as recreation. The following federal project reservoirs in the Dolores/San Juan/San Miguel Basin offer water-based recreational activities in addition to fulfilling the authorized project purposes:

McPhee Reservoir

McPhee Reservoir is the principal feature of the Dolores Project and is located on the Dolores River in the San Juan National Forest north of Cortez, Colorado. Its authorized purposes are irrigation, M&I, recreation, hydroelectric power, and flood control. The Lone Dome Recreation Area is located below McPhee Dam and includes over 10 miles of public access to the Dolores River. The reservoir provides recreation and fish and wildlife benefits. Recreational opportunities include biking, boating, camping, educational programs, fishing, hiking, horseback riding, hunting, off-highway and recreational vehicles, picnicking, water sports, winter sports and wildlife viewing (http://www.recreation.gov/detail.cfm?ID=56).

Lemon Dam

Lemon Dam is the principal feature of the Florida project and its authorized purposes are irrigation, recreation, and flood control. The dam is located in southwestern Colorado on the Florida River, approximately 14 miles northeast of the City of Durango in La Plata County. The reservoir provides recreation, fish, and wildlife benefits. Recreational opportunities include biking, boating, camping, fishing, hiking, horseback riding, off-highway vehicles, picnicking, water sports, winter sports, and wildlife viewing (http://www.recreation.gov/ detail.cfm?ID=55).

Jackson Gulch Reservoir
Jackson Gulch Reservoir provides water for irrigation, M&I, and recreation, and is the principal feature of the Mancos Project in southwestern Colorado. The reservoir is located 5 miles north of Mancos, Colorado, and 10 miles from Mesa Verde National Park, a World Heritage Site. The reservoir provides recreation, fish, and wildlife benefits; it has about 36,000 visitors per year. The average elevation is about 7,800 feet above sea level. Recreational opportunities include biking, boating, camping, educational programs, fishing, hiking, horseback riding, off-highway vehicles, picnicking, recreational vehicles, winter sports, and wildlife viewing (http://www.recreation.gov/detail.cfm?ID=54)

Vallecito Reservoir
Vallecito Reservoir is the principal feature of the Pine River Project in southwest Colorado. Its authorized purposes are irrigation, recreation, and flood control. Located on the Pine River in the San Juan National Forest, about 18 miles northeast of Durango, Colorado, the reservoir has a maximum surface area of 2,720 acres. An additional 961 acres of lands are available for recreation. Recreational opportunities include biking, boating, camping, fishing (brown, rainbow, and brook trout), hiking, horseback riding, hunting, picnicking, recreational vehicles, water sports including swimming, winter sports, and wildlife viewing (http://www.recreation.gov/ detail.cfm?ID=63).

San Juan-Chama Project
Reservoirs in the San Juan-Chama Project with recreational opportunities are all located in New Mexico and are not described here.

6.3.4 Gunnison Basin

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

Major Identified Projects and Processes for the Gunnison Basin are summarized in Table 6-24. For reference, Figure 6-9 provides a map of counties and major cities in the basin as referenced throughout this discussion.

In the Gunnison Basin, much of the M&I and SSI needs will be addressed through existing rights. The Tri-County Water Conservancy District, which serves much of Montrose and Delta Counties, holds water rights in the Dallas Creek Project, which will meet the needs of this area beyond 2030. The North Fork of the Gunnison includes Paonia, Hotchkiss, Cedaredge, Orchard City, and other smaller water providers. Many of these providers have identified plans for addressing their needs, which include local storage projects and acquisition of local agricultural water rights.

Table 6-24 Major Identified Projects and Processes in Gunnison Basin Counties

County	Estimated Demand met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
Delta	4,000	▪ Tri-County Water Conservancy District Water Rights ▪ Existing Water Rights ▪ Agricultural transfers ▪ Uncompahgre Project Water Right
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 ▪ Uncompahgre Project Water Right
Ouray	700	▪ Existing Water Rights
TOTAL	**12,500**	

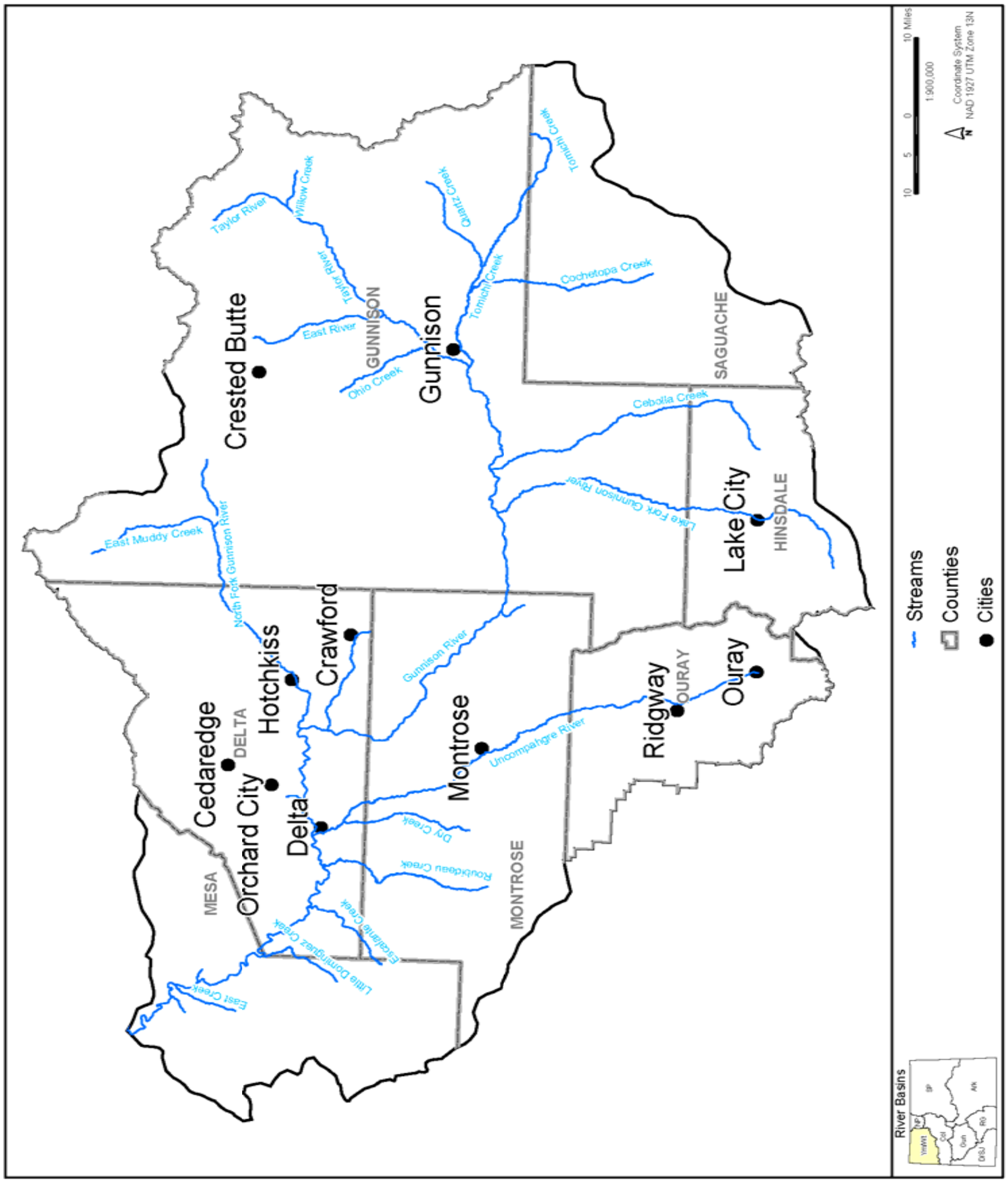


Figure 6-9
Gunnison Basin Location Map

Upper Gunnison Subbasin

The UGRWCD, which provides augmentation for wells in a portion of the upper basin, will be challenged to develop the CU water rights and storage required to meet the augmentation requirements for these wells. The upper basin, like many headwater areas throughout the state, is projected to experience high growth rates. The Crested Butte area may experience significant growth if adequate water supplies for M&I and snowmaking can be developed. Augmentation to existing or proposed environmental and recreation water rights, such as CWCB instream flow rights and RICDs and senior agricultural and M&I water rights, will likely require the construction of storage in upper areas of tributaries. Economies of scale are generally not present in small reservoir construction and the engineering, permit, and construction costs will tax the ability to provide for augmentation water at a reasonable cost.

The UGRWCD has a subordination agreement with the BOR that allows up to 60,000 AF of depletions against the Aspinall Unit (Blue Mesa, Morrow Point, and Crystal Reservoirs and related facilities.) In addition, the UGRWCD has a 500 AF pool in Blue Mesa that can be used to replace depletions to downstream calls. The challenge for UGRWCD will be to develop storage to replace depletions to CWCB instream flows, the Gunnison Whitewater Park RICD, and senior agricultural and M&I water rights upstream of Blue Mesa Reservoir.

Uncompahgre Subbasin

Ouray County will face many of the same challenges as the UGRWCD: high growth rates and the need to augment for new M&I depletions. Like the UGRWCD, there are CU rights available to contract at Ridgway Reservoir for downstream augmentation, but there will be a need to replace depletions to senior agricultural rights upstream of Ridgway Reservoir. The construction of the Biota water bottling facility in the Town of Ouray significantly increases the depletions for the town and augmentation is required when Ouray's water rights are not in priority.

Agricultural shortages are found in certain areas of the basin, even though the total annual average supplies are adequate to meet all needs. Those water districts having annual average shortages greater than 10 percent are generally limited by physical supply, which could be addressed through the construction of additional storage. It will be difficult to address these shortages unless funding mechanisms are developed to assist the agricultural users. The UGRWCD is evaluating funding strategies that would provide for additional financial support for agricultural projects.

As discussed in Section 5, the Gunnison Basin indicated the desire to develop storage in the Upper Gunnison and in the Grand Mesa areas and restore lost storage in the Grand Mesa and North Fork areas. These would serve to improve supplies to existing irrigated lands and reduce shortages.

Further detail regarding the Identified Projects and Processes and areas of gap for the Gunnison Basin are provided in Table 6-25.

Table 6-25 Detailed Identified Projects and Processes for Gunnison Basin M&I Demands

County	Major Provider	Remaining Gross Gap (acre-feet)	Supplies Beyond 2030*	Notes	Source
Delta	Delta (Project 7)	0	Y	Receives treated water via Project 7. Tri-County Water Conservancy District rights will meet future needs.	Project 7 Water Authority and Tri-County Water District
	Cedaredge	0	N	Assume no gap. Have adequate direct flow and storage rights; will acquire water rights if offered at an affordable price.	Jim Hokit, Jim Boyd (Water Commissioner), George Fulton, Cedaredge Public Works Department and Buckhorn Geotech report
	Orchard City	0	U	—	Did not respond
	Hotchkiss	0	N	Have adequate direct flow rights and Overland Reservoir storage.	Jim Hokit

Table 6-25 Detailed Identified Projects and Processes for Gunnison Basin M&I Demands

County	Major Provider	Remaining Gross Gap (acre-feet)	Supplies Beyond 2030*	Notes	Source
Delta (cont.)	Paonia	300	N	Lone Cabin Reservoir Enlargement Identified to meet future water needs.	Final Feasibility Report for Improving Water Supply system of the Town of Paonia, W.W. Wheeler 2/2005
	Crawford	0	U	—	Did not respond.
	Unincorporated Delta Co. not served by a water district	225	N	Assume 5 percent of increased county demand is a gap in unincorporated areas.	Jim Hokit
Gunnison	Town of Gunnison	0	N	Have sufficient water rights for future growth.	Ken Coleman, Gunnison Public Works Director
	Mt. Crested Butte W&SD	300	N	Have adequate existing water rights, investigating new storage sites, will need additional storage to meet future demands.	Frank Glick (Mt. Crested Butte W&SD)
	Crested Butte Mountain Resort	200	N	Additional snowmaking demands if ski area is expanded.	Dale Massey (Crested Butte Mountain Resort)
	Town of Crested Butte	0	N	Have sufficient water rights for future growth. Adequate existing water rights, will develop new supplies as needed.	CDM survey response and John Hess (Town Planner)
	Unincorporated Gunnison Co. not served by a water district	575	N	Need to develop supplies for well augmentation. Additional storage will be needed. UGWRCD believes gap may be higher.	UGRWCD letter 6/14/2004
Hinsdale	Lake City	95	N	Identified need to resolve Lake San Cristobal decreed natural lake level elevation.	UGRWCD letter 6/14/2005
	Unincorporated Gunnison Co. not served by a water district	5	N	Assume 5 percent of increased county demand is a gap in unincorporated areas.	
Mesa	Grand Junction	0	Y	Service area is near buildout and has adequate existing supplies.	CDM survey response
	Ute Water Conservancy District	0	N	Ute Water Conservancy District serves Mesa County in both Colorado and Gunnison Basins and has adequate supplies.	CDM Survey Response
	Unincorporated Mesa Co. in Gunnison Basin not served by a water district	85	N	Assume 5 percent of increased county demand is a gap in unincorporated areas.	Jim Hokit
Montrose	Chipeta Water District (Project 7)	0	Y	Receives treated water via Project 7. Tri-County Water Conservancy District rights will meet future needs.	Project 7 Water Authority and Tri-County Water District
	Montrose (Project 7)	0	Y	Receives treated water via Project 7. Tri-County Water Conservancy District rights will meet future needs.	Project 7 Water Authority and Tri-County Water District
	Menoken Water District (Project 7)	0	Y	Receives treated water via Project 7. Tri-County Water Conservancy District rights will meet future needs.	Project 7 Water Authority and Tri-County Water District

Table 6-25 Detailed Identified Projects and Processes for Gunnison Basin M&I Demands

County	Major Provider	Remaining Gross Gap (acre-feet)	Supplies Beyond 2030*	Notes	Source
Montrose (cont.)	Tri-County Water Conservancy District (Project 7)	0	Y	Receives treated water via Project 7. Tri-County Water Conservancy District rights will meet future needs. Uncompahgre Project Water.	Project 7 Water Authority and Tri-County Water District
	Olathe, Town of (Project 7)	0	Y	Receives treated water via Project 7. Tri-County Water Conservancy District rights will meet future needs.	Project 7 Water Authority and Tri-County Water District
	Unincorporated Montrose Co. in Gunnison basin not served by a water district	320	N	Cimarron is on wells. Assume 5 percent of increased county demand is a gap in unincorporated areas.	Jim Hokit
Ouray	Ouray	150	N	Approx 25 percent of increased demand may require augmentation based on potential downstream calls. Biota water bottling facility now operating.	Bill Ferguson, Ouray County Commissioner and Frank Kugel, Division Engineer
	Ridgway	100	N	Approx 25 percent of increased demand may require augmentation based on downstream calls. Town is in preliminary discussions with Tri-County WCD on cooperative venture.	Bill Ferguson, Ouray County Commissioner and Frank Kugel, Division Engineer and Jim Hokit
	Unincorporated Ouray Co. not served by a water district	50	Y	Assume 5 percent of increased county demand is a gap in unincorporated areas.	—

* Y = Yes; N = No; U = Unknown

Table 6-26 provides a summary of gaps by county for the Gunnison Basin. The largest demand in the basin is in Gunnison County where additional storage and well augmentation will be needed to meet future demands.

Table 6-26 Summary of Gap Analysis for Gunnison Basin

County	Identified Gross Demand Shortfall (AFY)
Delta	500
Gunnison	1,100
Hinsdale	100
Mesa	100
Montrose	300
Ouray	300
TOTAL	**2,400**

6.3.4.2 Recreational and Environmental Flow Information

6.3.4.2.1 Flow Considerations

Flow recommendations to benefit endangered fish have been developed for the Gunnison River (Figure 6-6) (USFWS 2003). It is emphasized that flow recommendations are not monolithic absolute values, and they may be revised from time to time to include the results of research. Flow recommendations may not inhibit the development of Colorado's Compact entitlements. The goal of the recommendations is to provide the annual and seasonal patterns of flow in the Gunnison River for the Colorado pikeminnow and razorback sucker, and in the Colorado River downstream from the Gunnison confluence to enhance populations of the four endangered fishes (Colorado pikeminnow, razorback sucker, bonytail chub, and humpback chub). Base flow and peak flow recommendations are provided. The objectives are to create and maintain the variety of habitats used by all life stages of the four endangered fishes:

- Provide habitats and conditions that enhance gonad maturation and provide environmental cues for spawning movements and reproduction

- Form low-velocity habitats for adult staging, feeding, and resting areas during snowmelt runoff
- Inundate floodplains and other off-channel habitats at the appropriate time and for an adequate duration to provide warm, food-rich environments for fish growth and conditioning, and to provide river-floodplain connections for restoration of ecosystem processes
- Restore and maintain in-channel habitats used by all life stages: (1) spawning areas for adults; (2) spring, summer, autumn, and winter habitats used by subadults and adults; and (3) nursery areas used by larvae, young-of-the-year, and juveniles
- Provide base flows that promote growth and survival of young fish during summer, autumn, and winter

Because historical river flows were dependent on water availability, peak flow recommendations were developed for six hydrologic categories that correspond to unregulated April to July inflow based on the 1937 to 1997 period of record: Dry (90 to 100 percent exceedance); Moderately Dry (70 to 90 percent exceedance); Average Dry (50 to 70 percent exceedance); Average Wet (30 to 50 percent exceedance); Moderately Wet (10 to 30 percent exceedance); and Wet (0 to 10 percent exceedance). Flow recommendations are for the Gunnison River at the USGS river gage near Grand Junction, Colorado (09152500). Peak-flow recommendations include two components: (1) threshold levels corresponding to 1/2 bankfull discharge and bankfull discharge and (2) the number of days (duration) that flows should equal or exceed these levels. In addition, recommended durations are presented as a range of days. In general, spring flows recommended for the dry categories provide small peaks used as spawning cues by endangered fish, but contribute little to habitat maintenance; spring flows recommended for average categories promote scouring of cobble and gravel bars and provide localized flooding of short duration; and spring flows for the wet categories promote wide-spread scouring of cobble and gravel bars, flushing of side channels, removal of encroaching vegetation, and inundation of floodplain habitats.

The flow recommendations were developed using information currently available; however, it is recognized that uncertainties exist. Biological and physical uncertainties are described in the recommendations (USFWS 2003), and additional studies are proposed. The recommendations will be implemented using adaptive management. Modifications will be made as more information is gained.

The peak flow recommendations for the Gunnison River are shown in Table 6-27 and are one way of achieving the objectives of the program. The flow recommendations in Table 6-27 are included because the recommended flows at the state line gage are the combination of the flows recommended for the Gunnison River and the flows recommended for the 15-mile reach.

Table 6-27 Spring Peak-Flow Recommendations for the Gunnison River Near Grand Junction (USGS 09152500)[a]: Number of Days per Year the Flows Should Exceed 2 Bankfull Discharge (Q_c = 8,070 cfs) and Bankfull Discharge (Q_b = 14,350 cfs)

Hydrologic Category	Expected Occurrence	Flow Target Duration[b]		Instantaneous Peak Flows (cfs)
		Days/Year ≥ 8,070 cfs	Days/Year ≥ 14,350 cfs	
Wet	10%	60-**100**	15-**25**	15,000-23,000[d]
Moderately Wet	20%	40-**60**	10-**20**	14,350-16,000[d]
Average Wet	20%	20-**25**	2-**3**	
Average Dry	20%	10-**15**	0	≥ 8,050[e]
Moderately Dry	20%	0-**10**	0	≥ 2,600[f]
Dry	10%	0	0	-900-4,000[g]
Long-Term Weighted Average[c]		20-**32**	4-**7**	

[a] This table represents one possible way of achieving the long-term weighted average for sediment transport.
[b] Lower value in each range is for maintenance, higher (bold) value in each range is for improvement.
[c] Weighted values equal days/year x expected occurrence (the sum of all weighted average values equals the long-term weighted average in days/year).
[d] Instantaneous peak flows within this range have occurred in these hydrological categories since Blue Mesa Reservoir was closed. These observed instantaneous peaks are desired in the future in conjunction with meeting the flow targets. No specific peak flow is recommended to ensure continued variability among years.
[e] Lower number reflects the expected minimum peak flow when recommendations are met and the upper number reflects peak flows that have occurred since Blue Mesa Reservoir was closed. Peak flow is expected to occur within this range, but no specific value is provided to ensure variability among years.
[f] Expected peak flow when recommendations are met. Actual peak may exceed this level, ensuring continued variability among years.
[g] Range of peak flows that have occurred since Blue Mesa Reservoir was closed. Peak flows are expected to continue to fall within this range when Q_c is not reached. No specific recommendation within this range is made to ensure variability among years.

Summer through winter base flow recommendations for the Gunnison River, measured at the USGS gage near Grand Junction (09152500), for the different hydrologic conditions are as follows:

- Wet (0 to 10 percent exceedance) and Moderately Wet (10 to 30 percent exceedance): 1,500-2,500 cfs
- Average Wet (30 to 50 percent exceedance) and Average Dry (50 to 70 percent exceedance): >1,050 to 2,000 cfs
- Moderately Dry (70 to 90 percent exceedance): >750 to >1,050 cfs
- Dry (90 to 100 percent exceedance): >750 to >1,050 cfs

The base flow period begins after spring runoff is completed and continues through initiation of spring runoff the following year. Depending on inflow to the Gunnison Basin, flows should remain within the ranges specified, but the upper and lower limits are not intended to be targets. The onset of the base flow period will vary considerably – beginning as early as late June in dry years and as late as October in wet years. No specific recommendations are presented for the transition between recommended peak flows and the recommended base flows.

Although base flows may vary among years and hydrologic conditions, a minimum flow of at least 1,050 cfs is recommended at the USGS gage near Grand Junction during summer, autumn, and winter in all but dry and moderately dry years (USFWS 2003).

The flow recommendations were developed using information currently available; however, it is recognized that uncertainties exist. Biological and physical uncertainties are described in the recommendations, (USFWS 2003) and additional studies are proposed. The recommendations or a reasonable alternative will be implemented using adaptive management. Modifications will be made as more information is gained.

Recommended instream flows below Redlands Diversion Dam for endangered fish are 300 cfs for the period of July 1 to October 30. This flow provides passage and "attraction flows" to attract fish to the fish ladder for endangered fish that was constructed by the Upper Colorado River Endangered Fish Program at Redlands Diversion Dam. Water for this instream flow is released from the Aspinall Unit (BOR 2003).

The CWCB holds an instream flow right on the mainstem of the Gunnison River from USGS gage 09128000 (Gunnison River below Gunnison Tunnel) to the confluence of the North Fork of the Gunnison River for 300 cfs on a year around basis. The appropriation date is December 10, 1965.

Numerous instream flow and natural lake rights have been appropriated on tributaries to the Gunnison River. A listing of these rights is available from the CWCB at http://cwcb.state.co.us/isf/downloads/index.htm.

The DOI and the State of Colorado entered into an agreement regarding federal reserve water rights for the Black Canyon National Park. The agreement would settle instream flow right for the Black Canyon of the Gunnison National Park between the Gunnison Diversion Dam through the Black Canyon to the confluence with the north fork of the Gunnison River (DOI 2003).

The proposed settlement of instream flow rights was divided into two parts:

1. A Federal Reserve right of 300 cfs, or natural flow, whichever is less with a 1933 priority date. The federal water right would satisfy the CWCB's existing instream flow decree but improve the priority date by 32 years.
2. A new instream flow water right under Colorado law with a 2003 priority date that would allow the CWCB to protect flows available beyond those already controlled by the Aspinall Unit.

For the 2003 instream flow right, if Blue Mesa Reservoir fills and spills by July 31 in any year, water beyond that which satisfies present and future obligations of the authorized purposes of the Aspinall Unit shall be held by the CWCB for decreed instream flow purposes with a 2003 priority date.

Pursuant to the agreement, the CWCB filed an application for an instream flow right in December 2003. Several statements of opposition were filed. The CWCB is working to resolve issues associated with the statements of opposition. However, litigation with some environmental interests in federal court could delay final settlement for several years (Kowalski 2004).

On March 29, 2002, the UGRWCD filed for a RICD in District Court Water Division No. 4 (Case No. 02-CW38) for a Gunnison River White Water Park near the City of Gunnison, which is one-quarter mile in length. The application is for water rights for specified semi-monthly time periods as provided in Table 6-28.

Table 6-28 Water Rights Application for Gunnison White Water Park

Time Period	Water Right (cfs)
May 2 - 15	570
May 16 - 31	1,190
June 1 - 15	1,460
June 16 - 30	1,500
July 1 - 15	1,100
July 16 - 31	530
August 1 - 15	460
August 16 - 31	390
September 1 - 15	300
September 16 - 30	270

The recommendations of CWCB submitted to the court find that the reasonable recreation experience in and on the water could be attained if the streamflow amounts were 250 cfs during May through September. CWCB adopted the applicants' recommendation that RICD not be in effect or exercised during the time when the hydrograph would permit the Redlands Power canal water rights or the Gunnison Tunnel water rights to call for their senior water rights.

The water court issued a decree for the instream flow right in December 2003. The decree was generally consistent with the request for flows by the UGRWCD. The CWCB filed a notice of appeal to the Colorado Supreme Court in February 2004. Arguments are expected to take place before the Supreme Court in late 2004, with a ruling by the court sometime thereafter (Kowalski 2004).

Bypass flows are maintained as requirements or targets below several BOR projects in the Gunnison Basin. A description of these flow bypasses is provided in Table 6-29.

Table 6-29 Bypass Flows Below BOR Projects in the Gunnison Basin

Project	Flow	Basis
Silver Jack Dam	17 cfs	Release needed to meet senior water rights requirements at times; releases targeted at 17 cfs at other times to maintain fishery
Ridgway Reservoir	75 cfs - May 17 - Oct 31; 45 cfs Nov. 1 - 15; 30 cfs Ridgway Dam to Cow Creek - year around	NEPA requirement
Paonia Reservoir	15 cfs for 1/2 mile downstream to confluence with Muddy Creek	Target flow no legal requirement
Taylor Park Reservoir	Unknown	Instream flow rights held by both CWCB private parties under Colorado water law (Bayer rights)
Fruit Growers Reservoir	None	
Crawford Reservoir	None	
Aspinall Unit	See Section 3.3.3	

Source: Personal communication, Cole Stanton, USBR, Grand Junction 4/2/04

In 2004, the BOR initiated the Aspinall Unit Operations EIS, which will describe effects of operation changes at the Aspinall Unit related to compliance with the ESA. Work should be completed by the end of 2007. The EIS will develop and analyze alternative operating criteria and guidance for future reservoir operations to help meet recommended flows for endangered fish while continuing to maintain the authorized purposes of the Aspinall Unit.

The authorization of the Aspinall Unit embraces a variety of purposes including:

- Regulating the flow of the Colorado River
- Storing water for beneficial CU
- Providing for the reclamation of arid and semi-arid land
- Providing for the control of floods
- Allowing the Upper Basin states to develop Colorado River Compact apportioned waters
- Providing for the generation of hydroelectric power; secondarily in accordance with the primary purposes

- Providing for fish and wildlife enhancement and public recreation; secondarily in accordance with the primary purposes

Various other authorities, contracts, and documents also relate to the Unit.

The EIS will develop alternatives to address the flow recommendations and will analyze environmental effects of these alternatives. The following purposes and goals will be addressed in alternatives (BOR 2004):

- Assist the National Park Service in protecting resources of the Black Canyon of the Gunnison National Park (Black Canyon)
- Help the State of Colorado protect/use its compact entitlement
- Operate alternatives within state water law
- Satisfy as many needs as possible with same water releases
- Protect recreation at Unit reservoirs and in the Gunnison Gorge and Lower Gunnison River
- Protect tailwater and reservoir fisheries
- Provide needed hydropower flexibility
- Provide flood control
- Provide for public input and public information concerning operations of the Unit
- Allow for adaptive management as new scientific data becomes available through monitoring of endangered fish responses

6.3.4.2.2 Water-Based Recreation

Numerous river reaches in Colorado are used for whitewater rafting. Table 6-30 shows the reaches in the Gunnison Basin that are listed for rafting use by American Whitewater:

Table 6-30 River Reaches in the Gunnison River Basin in Colorado Listed for Rafting Use by American Whitewater

Reach Description	Class	Minimum Suggested Flow (cfs)*	Maximum Suggested Flow (cfs)*
Anthracite Creek, Ruby Fork from Bridge to Erikson Springs Campground	V+	600	1,000
Cebolla Creek from Hwy 149 to Blue Mesa Reservoir	II	NA	NA
Cimarron River from Big Cimarron Campground to Cimarron Rd. bridge	V+	600	NA
Cimarron River from Cimarron to Gunnison River	V	300	NA
Daisy Creek from 40-foot Waterfall to Confluence with Slate River	V	400	2,000
East River from Gothic Bridge to above Stupid Falls	IV	600	3,000
Escalante Creek from Escalante Forks to Captain Smith's Cabin	V	NA	NA
Gunnison River from Almont to Blue Mesa Reservoir	II	NA	NA
Gunnison River from Crystal Dam to Chukar (Black Canyon)	IV-V	400	3,000
Gunnison River from Chukar to N. Fork (Gunnison Gorge)	IV	500	NA
Gunnison River, North Fork from Paonia Reservoir to below Somerset	III	1,000	NA
Henson Creek from above Nellie Creek to half a mile from Lake City	IV-V	NA	NA
Kannah Creek from Kannah Creek Trailhead to Girl Scout Camp Bridge	V	NA	NA
Kannah Creek from Rte. 50 to Rte. 141 (Gunnison River)	III	NA	NA
Lake Fork of the Gunnison at Lake City Town Run	III	300	2,000
Lake Fork of the Gunnison at Redbridge	IV-V	400	2,000
Oh Be Joyful Creek from Ankle Breaker to Beaver Ponds	V	400	2,000
Slate River from Beaver Ponds to Oh Be Joyful Campground	V	400	2,000
Taylor River from Taylor Park Reservoir to Almont	II-IV	280	1,000
Uncompahgre River from Ouray to KOA Campground	V+	NA	NA

Source: http://www.americanwhitewater.org/rivers/statedrain/CO

* Suggested levels of flows, not water rights.

The following federal project reservoirs in the Gunnison Basin offer water-based recreational activities in addition to other authorized project purposes:

Silver Jack Dam and Reservoir
The USFS developed recreation facilities at Silver Jack Reservoir as part of the Cimmarron project under a cooperative arrangement with the BOR. It provides water for irrigation, recreation, and flood control. Facilities include access roads, campgrounds, a boat dock, trails, fences, landscaping, and an administration site. Recreational opportunities at Silver Jack Reservoir include boating, camping, fishing, hiking, hunting, picnicking, recreational vehicles, and wildlife viewing (http://www.usbr.gov/ dataweb/ html/bostwickpark.html and http://www.recreation.gov/ detail.cfm?ID=61).

Ridgway Reservoir
Ridgway State Park is located about 12 miles north of Ouray and is part of the Dallas Creek Project under a cooperative arrangement with the BOR. Ridgway is known as one of the nation's most accessible recreation areas for people with disabilities. Its authorized purposes are irrigation, M&I, recreation, and flood control. Recreational development includes facilities for picnicking, camping, boating, hiking, and enjoyment of the scenic setting. Additional recreational opportunities include biking, fishing, hunting, recreational vehicles, scuba diving, water skiing, windsurfing, swimming, winter sports, and wildlife viewing. Measures to protect and enhance the fish and wildlife resources have been incorporated into the project plans. They include minimum flows in the Uncompahgre River, a deer fence along a relocated highway, and acquisition of a wildlife range to offset losses associated with the reservoir. The Ridgway Recreation Area is administered by the CDPOR under agreement with the BOR (http://www.usbr.gov/ dataweb /html/dallascrk.html and http://www.recreation.gov /detail.cfm?ID=59)

Paonia Reservoir
Paonia Dam and Reservoir provides water for irrigation, recreation, and flood control, and are located about 16 miles northeast of Paonia and are part of the Paonia project under a cooperative arrangement with the BOR. Recreational opportunities include boating, fishing, camping, hunting, picnicking, recreational vehicles, water sports, and wildlife viewing. Recreation facilities are administered by the CDPOR under agreement with the BOR (http://www.usbr.gov/ dataweb/html/paonia.html and http://www.recreation.gov/detail.cfm?ID=57).

Taylor Park Reservoir
Taylor Park Dam and Reservoir are located about 10 miles north of Gunnison and is part of the Uncompahgre project under a cooperative arrangement with the BOR. Its authorized purposes are irrigation, recreation, and flood control. Free camp and picnic grounds have been provided by the USFS at the Reservoir. Cabins are available at privately owned resort developments in the area. Camping, picnicking, swimming, and boating are popular activities, and fishing is good for rainbow, brown, and mackinaw trout; some brook and native trout also are caught (http://www.usbr.gov/dataweb/html/uncomp.html and http://www.recreation.gov/detail.cfm?ID=62).

Fruitgrowers Reservoir
Fruitgrowers Dam and Reservoir are located about 3 miles north of Austin and provides water for irrigation, recreation, and flood control. Other than hunting and hiking, Fruitgrowers Reservoir receives very little recreation use; however, bird-watching is becoming increasingly popular. The reservoir is a major migration stop and nesting site for a variety of shorebirds and waterfowl. In the spring, Fruitgrowers Reservoir wildlife viewing area offers a spectacular sight with thousands of sandhill cranes stopping over on their way north. The reservoir hosts the largest nesting colony of western grebes in Colorado and more than 200 species of birds have been sighted. Also, a variety of mammals (i.e., mule deer, fox, and mink) and reptiles make the area their home. No water contact activities are allowed. The site has only primitive facilities and no onsite manager or law enforcement (http://www.usbr.gov/ dataweb/ html/ fruitgrower.html and http://www.recreation.gov/ detail.cfm?ID=53).

Crawford Reservoir
Crawford Dam and Reservoir are located about 1 mile south of Crawford. Its authorized purposes are irrigation, recreation, and flood control. Recreational opportunities include biking, boating, camping, educational programs, fishing, hiking, horseback riding, picnicking, recreational vehicles, water sports, winter sports (ice fishing, cross-country skiing, snowmobiling), and wildlife viewing. There are 45 campsites with hookups and 21 without. Showers and flush toilets are available. A fishing trail with

platforms and an accessible dock are also available. Recreation at Crawford Reservoir is administered by the CDPOR (http://www.usbr.gov/dataweb/html/ smithfork.html and http://www.recreation.gov/ detail.cfm?ID=50).

Wayne N. Aspinall Unit, also referred to as the Curecanti National Recreation Area

The project was constructed for the purposes outlined in Section 6.3.4.2.1. Three reservoirs, named for the corresponding dams on the Gunnison River, form the heart of Curecanti National Recreation Area. Blue Mesa Reservoir is Colorado's largest body of water, and is the largest Kokanee Salmon fishery in the United States. Morrow Point Reservoir is the beginning of the Black Canyon of the Gunnison and below, Crystal Reservoir is just upstream of the Gunnison Diversion Tunnel, a National Historic Civil Engineering Landmark. Recently discovered dinosaur fossils, a 5,000-acre archeological district, a narrow gauge train, and traces of 6,000-year-old dwellings further enhance the offerings of Curecanti. Water activities at Morrow Point Reservoir include fishing and boating (pack-in boats). A concessionaire provides guided fishing opportunities and a scenic guided boat tour (1.5 miles) May 1 to October 1. Both Morrow Point and Crystal require a vigorous hike to reach the reservoirs. Blue Mesa Reservoir's water activities include boating, fishing, sail-boarding, water skiing, and swimming. Ice fishing and cross-country skiing are some winter activities. Additional recreational opportunities include camping, educational programs, hiking, hunting, picnicking, recreational vehicles, water sports, and wildlife viewing. Blue Mesa, Morrow Point, and Crystal recreation areas are administered by the National Park Service (http://www.usbr.gov/dataweb/ html/crsp.html and http://www.recreation.gov/ detail.cfm?ID=2651 and http://www.nps.gov/cure/).

The 26-mile reach of the Gunnison River from the upstream boundary of the Black Canyon of the Gunnison National Park to the North Fork of the Gunnison River has been awarded Gold Medal designation. This section of the Gunnison is the best trout water in the state for large numbers of 16- to 25-inch rainbows and browns, with fish over 5 pounds not uncommon.

6.3.5 North Platte Basin

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

The North Platte River headwaters in Colorado are a relatively small portion of the overall North Platte Basin. Farming and ranching are the predominant economic base. The North Platte Basin is expected to see a relatively small increase in M&I and SSI demands (about a 100 AF increase between 2000 and 2030), so major Identified Projects and Processes were not brought forth for formal cataloging in SWSI. It is anticipated that this increase in demand will be met primarily via the application of existing supplies and water rights.

6.3.5.2 Recreational and Environmental Information

No CWCB instream flow rights have been decreed on the North Platte River. Decreed rights on tributaries in the basin can be found at http://cwcb.state.co.us/isf/ Downloads/ Index.htm.

There are no reaches in the North Platte Basin in Colorado that are listed for rafting use by American Whitewater.

The North Platte River from the Routt National Forest boundary downstream to the Colorado-Wyoming line (5.3 miles) has received Gold Medal designation. The predominant fish in the North Platte River are brown trout and rainbow trout.

One of the three lakes in the Delaney Butte Lakes State Wildlife Area, North Delaney Butte Lake, is an extremely productive lake that grows trophy brown trout, and has received Gold Medal designation. This wildlife area is located about 10 miles west of Walden.

6.3.6 Rio Grande Basin

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

Major Identified Projects and Processes for the Rio Grande Basin are summarized in Table 6-31. For reference, Figure 6-10 provides a map of counties and major cities in the basin as referenced throughout this discussion.

In the Rio Grande Basin, agricultural shortages and needs dominated much of the Basin Roundtable's discussions and efforts. There is minor growth projected for M&I needs and no new major SSI users were identified. It was estimated that sufficient groundwater is physically available for most anticipated M&I growth, but augmentation of groundwater pumping will be required. All counties will make use of existing water rights and groundwater. Augmentation will be provided by the San Luis Valley Water Conservancy District and other local water providers. As described in Section 7, there are no reliable water supplies that can be developed under the Rio Grande Compact. Augmentation of M&I well pumping will be provided form a variety of sources including existing transbasin water rights diverted from the San Juan Basin and existing and future agricultural transfers. Transbasin water diversions are shown in Section 7. In addition, demand will be reduced by additional conservation measures such as metering.

Water levels in the unconfined aquifer north of the Rio Grande have experienced significant declines. The confined aquifer has also experienced localized declines in water levels. It has been estimated by the Rio Grande Water Conservation District that up to 100,000 acres may be needed to be removed from irrigation to reach a sustainable level of groundwater pumping. Discussions are currently underway among water users to develop a plan to reduce irrigated acres and restore the aquifers to sustainable levels. As noted in Section 5, there are existing agricultural shortages, but these will be difficult to address given the over pumping of the aquifer and compact limitations. As a result, no Identified Projects and Processes, except for the reduction in the amount of current irrigated agricultural land, have been proposed.

Further detail regarding the Identified Projects and Processes and areas of gap for the Rio Grande Basin are provided in Table 6-32.

Table 6-31 Major Identified Projects and Processes in Rio Grande Basin Counties

County	Estimated Demand met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
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**	

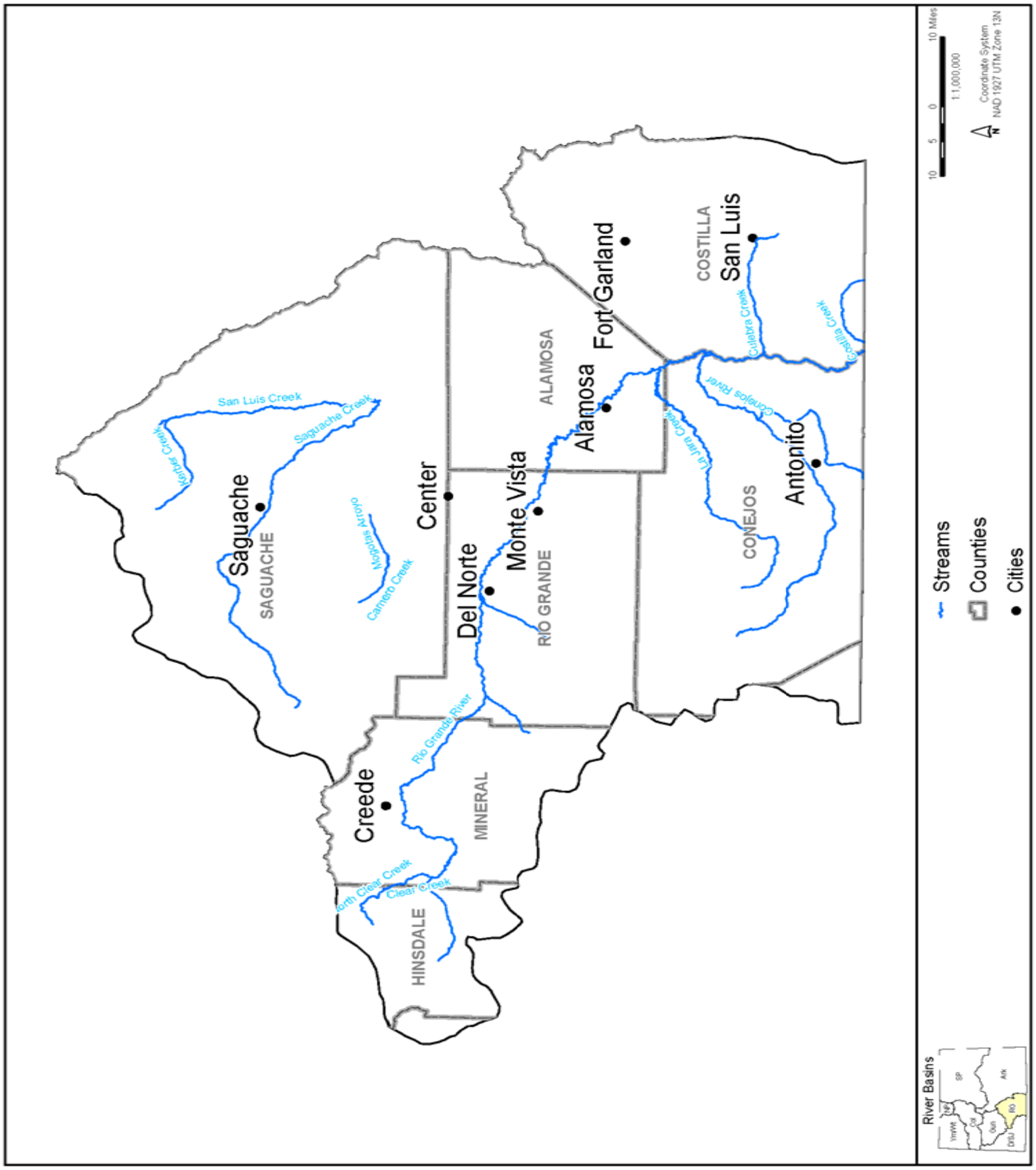


Figure 6-10
Rio Grande Basin Location Map

Table 6-32 Detailed Identified Projects and Processes for Rio Grande Basin

County	Major Provider	Remaining Gross Gap (acre-feet)	Supplies Beyond 2030*	Notes	Source
Alamosa	Alamosa, City of	0	Y	Evaluating its water supply options; has a relatively new well in place; surface supply via diversions from a drainage slough and six confined aquifer wells (1,000 feet deep). City recently acquired East Alamosa Water District and its water rights.	BRT2 feedback and Hydrosphere memo 7/8/99
	Unincorporated Alamosa County not served by a water district - San Luis Valley Water Conservancy District augmentation	0	Y	Augmentation of new wells required for parcels < 35 acres. San Luis Valley Water Conservancy District augmentation water available.	Mike Gibson, San Luis Valley Water Conservancy District
Conejos	Antonito, Town of	0	Y	Conejos River surface diversion plus one well at 500 feet.	Rio Grande DSS documentation memo 7/8/99
	Manassa, Town of	0	Y	Have two wells in confined aquifer (800 feet deep).	Rio Grande DSS documentation memo 7/8/99
	Romeo, Town of	0	Y	Have one well in confined aquifer (689 feet deep). Installing water meters to conserve water and operate within 100 AFY well water right withdrawal limitation.	
	Sanford, Town of	0	N	Have two wells in confined aquifer (±900 feet deep). Present water rights permit withdrawal of 250 AFY. Usage is exceeding water rights. Town is in process of acquiring additional water rights.	
	Unincorporated Conejos County not served by a water district	0	U	Assumed to have wells in confined aquifer. Augmentation required. Agricultural dry-up primary source of augmentation water.	
Costilla	Town of Blanca	0	U	Have one well in unconfined aquifer.	
	Fort Garland Water and Sanitation District	0	U	Have two wells in unconfined aquifer.	
	Costilla County Conservancy District	0	U	Assumed to have wells in unconfined aquifer. Augmentation required. Agricultural dry-up primary source of augmentation water.	
	San Luis Water & Sanitation District	0	U	Have two wells in unconfined aquifer.	
	Costilla County Water & Sanitation District	±50	N	Served by ±6 wells in unconfined aquifer.	
	Unincorporated Costilla County not served by a water district	0	U	Assumed to have wells in confined aquifer. Augmentation required. Agricultural dry-up primary source of augmentation water.	
Mineral	Creede, Town of	0	Y	Has two alluvial wells. Well water right withdrawal limitation is ±470 AFY. Have existing rights and have policy for new developments bring in augmentation water.	Mike Gibson, San Luis Valley Water Conservancy District

Table 6-32 Detailed Identified Projects and Processes for Rio Grande Basin

County	Major Provider	Remaining Gross Gap (acre-feet)	Supplies Beyond 2030*	Notes	Source
Mineral (cont.)	Unincorporated Mineral County not served by a water district - San Luis Valley Water Conservancy District augmentation	0	U	Augmentation of new wells required for parcels < 35 acres. San Luis Valley Water Conservancy District augmentation water available if owner petitions for inclusion.	Mike Gibson, San Luis Valley Water Conservancy District
Rio Grande	Monte Vista, City of	0	U	Have five wells in confined aquifer (800 to 1,000 feet deep).	Rio Grande DSS documentation memo 7/8/99
	Center, Town of	0	U	Have two wells in confined aquifer (785 feet deep).	Rio Grande DSS documentation memo 7/8/99
	Del Norte, Town of	0	U	Have two wells 300 feet deep and a Piños Creek surface water right back-up.	Rio Grande DSS documentation memo 7/8/99
	Unincorporated Rio Grande County not served by a water district - San Luis Valley Water Conservancy District augmentation	0	U	Augmentation of new wells required for parcels < 35 acres. San Luis Valley Water Conservancy District augmentation water available.	Mike Gibson, San Luis Valley Water Conservancy District
Saguache	Baca Subdivision Water System	0	U	Assumed to have wells in confined aquifer. Augmentation required. Agricultural dry-up primary source of augmentation water.	
	Saguache, Town of	0	U	Assumed to have wells in unconfined aquifer. Augmentation required. Agricultural dry-up primary source of augmentation water.	
	Crestone, Town of	0	U	Assumed to have wells in confined aquifer. Augmentation required. Agricultural dry-up primary source of augmentation water.	
	Unincorporated Saguache County not served by a water district - San Luis Valley Water Conservancy District augmentation	0	Y	Augmentation of new wells required for parcels < 35 acres. Included in San Luis Valley Water Conservancy District but may need to construct recharge pits for augmentation water for areas not tributary to Rio Grande.	Mike Gibson, San Luis Valley Water Conservancy District

* Y = Yes; N = No; U = Unknown

A summary of the gap analysis by county is shown in Table 6-33. Costilla County was the only area with an identified gap due to six wells that are located in an unconfined aquifer.

Table 6-33 Summary of Gap Analysis for Rio Grande Basin

County	Identified Gross Demand Shortfall (AFY)
Alamosa	0
Conejos	0
Costilla	100
Mineral	0
Rio Grande	0
Saguache	0
TOTAL	**100**

6.3.6.2 Recreational and Environmental Information

6.3.6.2.1 Flow Considerations

Numerous instream flow rights have been decreed on major rivers and tributaries in the Rio Grande Basin (http://cwcb.state.co.us/isf/Downloads/Index.htm). Decreed rights on major rivers are listed in Table 6-34. These rights are year-round with seasonable variability as reflected in the range of values shown. Flow rights on smaller tributaries in the basins can be found at the above reference.

6.3.6.2.2 Water Based Recreation

Numerous river reaches in Colorado are used for whitewater rafting. Table 6-35 shows the reaches in the Rio Grande Basin that are listed for rafting use by American Whitewater.

Table 6-34 CWCB Instream Flow Rights on Major Rivers in the Rio Grande Basin

River	Upper Terminus	Lower Terminus	Range of Flow Rights (cfs)*	Range of Appropriation Dates	List of Segments
Alamosa River	Confluence Treasure and Cascade Creeks	Confluence Wightman Fork	7 - 15	Oct. 7, 1982	1
Conejos River	Confluence North Fork and Middle Fork Conejos River	USGS gage near Mogote	10 - 90	Oct. 7, 1982	5
Rio Grande River	Headwaters	Confluence with South Fork Rio Grande	8 - 160	Aug. 16, 1982	6
Saguache Creek	Confluence Middle Fork and South Fork Saguache Creek	Headgate Star Ditch	5 - 14	Oct. 7, 1982	2

*The range of flows also reflect the fact that there are multiple reaches with different CWCB instream flows specific to each reach.

Table 6-35 River Reaches in the Rio Grande Basin in Colorado listed for rafting use by American Whitewater

Reach Description	Class	Minimum Suggested Flow (cfs)*	Maximum Suggested Flow (cfs)*
Conejos River from Platoro Reservoir to South Fork Conejos (The Pinnacles)	II-IV	200	130
Rio Grande from Rio Grande Reservoir to 12 miles above Creede (Upper Rio Grande)	III-IV	NA	NA
Rio Grande from Wagon Wheel Gap to South Fork	II	NA	NA

Source: http://www.americanwhitewater.org/rivers/statedrain/CO

* Suggested levels of flow, not water rights.

The following federal project reservoirs in the Rio Grande Basin in Colorado offer water-based recreational activities in addition to the authorized project purposes:

Platoro Reservoir
Platoro Dam and Reservoir provides water for irrigation and recreation, and are part of the San Luis Valley Project in the south-central portion of the State of Colorado. Platoro Dam is on the Conejos River about 1 mile above the Town of Platoro, Colorado. The reservoir is located in a high mountain valley with broad vistas of the San Juan Mountains. A wilderness area is located to the south of the reservoir area. Since the recreation season is short and the location remote, use is low to moderate. Recreational opportunities include biking, boating, cultural/historic sites, camping, fishing, hiking, horseback riding, hunting, picnicking, recreational vehicles, and wildlife viewing (http://www.recreation.gov/detail.cfm?ID=58 and http://www.usbr.gov/dataweb/html/sanluis.html).

6.3.7 South Platte Basin

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

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

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

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

While additional conservation is a part of most water providers' plans to meet future water supply needs, most providers do not foresee or propose to implement levels of conservation such as severe limitations or bans on grass lawns. As in the Arkansas Basin, many providers cite the following as their reasons not to move toward aggressive conservation measures:

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

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

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

Table 6-36 Major Identified Projects and Processes in South Platte Subbasins

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

CDM

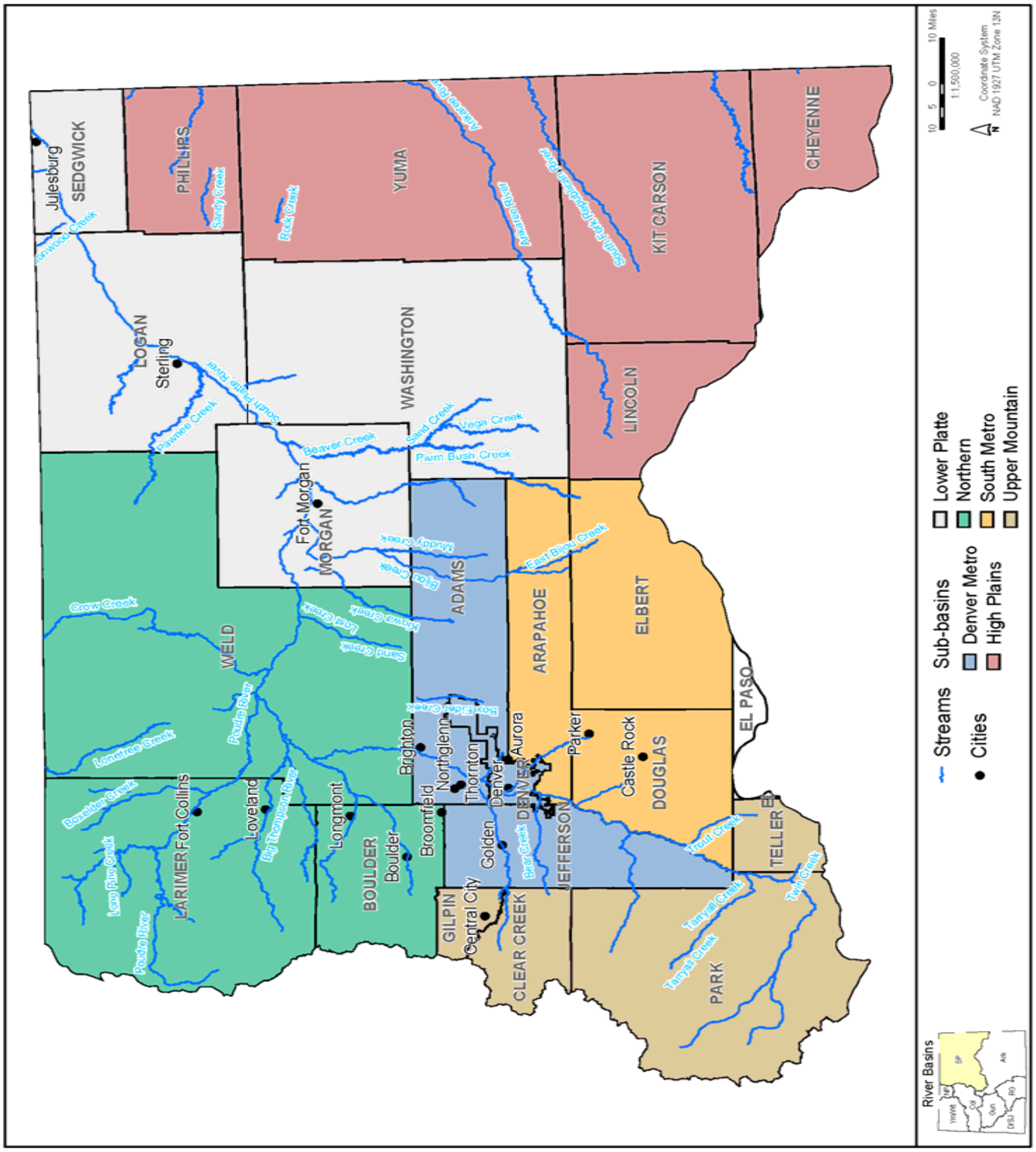


Figure 6-11
South Platte Basin Location Map

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

Denver Metro

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

South Metro

The South Metro area has a projected future increased demand of 88,000 AFY. Among the major water providers in this area, Aurora is embarking on its long-range plan to meet future needs as its key Identified Process. This plan will rely heavily on the recapture and reuse of its return flows and agricultural transfers from downstream of the Denver Metro area. The East Cherry Creek Valley Water and Sanitation District is implementing a similar program and the Parker Water and Sanitation District has recently received a permit for the construction of Reuter-Hess Reservoir. The South Metro Water Supply Study included many of the water providers in Arapahoe and Douglas Counties that currently rely primarily on non-tributary, non-renewable groundwater. As noted in the South Metro Study, the costs of continued reliance on non-renewable Denver Basin aquifer water will increase dramatically as well yields decline and additional wells and infrastructure are needed to maintain current level of groundwater pumping. These costs will not resolve the issue of the long-term reliability of the resource and the ultimate need to develop a renewable source of water. To continue to use as well yields decline, the amount needed ("the gap" between supply and demand) will become significantly larger in the northern portion of the basin. The South Metro Study identified potential solutions including the development of a CU project, where surface water would be diverted, stored, and treated in wet years to reduce the reliance on groundwater pumping. The South Metro users' needs of approximately 40,000 AF would increase by an additional 40,000 AFY if non-tributary wells fail or become technically or economically infeasible to continue current levels of groundwater pumping in the future. As noted in Section 7, there are no reliable surface water supplies that can be developed from the South Platte using surface water diversions as the sole water supply source. The South Metro Water Providers have indicated that additional alternatives need to be developed for meeting future South Metro water needs.

High Plains

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

Lower South Platte

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

Upper Mountain

The Upper Mountain areas primarily rely on groundwater for M&I demands. These areas will have the challenge of the limited physical availability of groundwater. Much of the groundwater is in fractured bedrock and well yields can be highly variable and decline as additional growth occurs. Certain areas in the basin may have self-limiting growth due to the lack of sufficient groundwater and the inability to deliver surface water supplies. Many of these areas already experience reduced well production. Park County has approximately 25,000 pre-1972 platted lots, which are not required to provide augmentation (James 2004). Many of these lots are platted with high densities. These approved densities may impact well yields, trucked water or onsite storage tanks may be required to meet peak demands for some in-home domestic uses if additional development occurs. Jefferson County is in the process of regulating densities in certain mountain areas in order to prevent over development of the limited groundwater resources.

Agriculture

Based on discussions with South Platte Basin Roundtable members, it is expected that agricultural transfers will continue to occur to meet a portion of the basin's growing M&I needs. This will likely manifest itself through outright purchases, developer donations, and development on irrigated lands. However, not all agricultural acquisitions can be transferred to existing water intakes. As a result, the use of dual water systems delivering local ditch water through pressurized non-potable water lines will increase.

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

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

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

Agricultural shortages are prevalent and expected to continue throughout the entire basin, as described in Section 5. The CBT Project was designed to reduce agricultural shortages in the northern area, but the transfers of CBT shares from agricultural to M&I use will increase shortages. The need for augmentation sources for alluvial agricultural wells along the South Platte has become a critical need. As M&I demands increase and providers turn to increased use of their reusable supplies and agricultural transfers, the availability of augmentation supplies for agricultural users decreases and agricultural users cannot compete with M&I providers on the price of augmentation water. Also, the increased use of reusable supplies and potential reduction in return flows from M&I water conservation efforts may result in reduced flows, decreasing available supplies for downstream agricultural users. Significant reductions in irrigated lands will occur in the South Platte unless augmentation supplies are developed for agricultural well augmentation and alternative sources of M&I water are identified.

Further details regarding the Identified Projects and Processes and areas of gap for the South Platte Basin are provided in Table 6-37.

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

Table 6-37 Detailed Identified Projects and Processes for South Platte Basin

Subbasin	Major Provider	Notes	Source
Denver Metro	Arvada	Adding gravel lake storage to firm existing water rights and Denver raw water contract.	Dick Stenzel
	Aurora (Adams County portion)	Aurora Long range plan assumed to meet gap: Lower South Platte Project, Homestake II, Arkansas River ag transfers.	Lisa Darling, City of Aurora
	Brighton	Need additional augmentation water and building storage.	Dick Stenzel
	Consolidated Mutual	Building additional storage and transferring ag rights.	Dick Stenzel

Table 6-37 Detailed Identified Projects and Processes for South Platte Basin

Subbasin	Major Provider	Notes	Source
Denver Metro (cont.)	Denver Water	Denver IRP including North system (Moffat) firming and reclaimed water.	Denver IRP
	Golden	Has constructed Guanella Reservoir.	Response to CDM survey
	North Table Mountain W&SD	Has raw water contract with Denver Water.	Dick Stenzel
	Northglenn	Existing gap on firm yield, need storage to firm existing water rights. Would like to enlarge Standley Lake.	Dale Kralicek, City of Northglenn
	South Adams County W&SD	Constructing dual water system and has acquired augmentation and storage.	Jim Jones, South Adams County W&SD
	Thornton	Will develop Water Supply and Storage water rights and advanced water treatment for its existing South Platte and Lower Clear Creek rights, including Aurora agreement.	response to CDM survey
	Unincorporated Adams County and other small eastern county towns	Existing and future developments reliant on non-trib groundwater and ability to irrigate lawns is limited. No reliable source of surface water immediately available.	Dick Stenzel
	Unincorporated Jefferson County and small towns	Existing and future mountain developments reliant on trib and non-trib groundwater. Small towns diverting from low headwater creeks and alluvial wells with poor drought yields.	Dick Stenzel
	Westminster	Building additional gravel storage to firm exchanges. Will expand reclaimed system and continue transferring ag rights.	response to CDM survey
South Metro	Arapahoe County WWA	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report
	Aurora (Arapahoe County portion)	Aurora Long rang plan assumed to meet gap.	Lisa Darling, City of Aurora
	Castle Pines North	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies .	South Metro Report
	Castle Rock	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report
	Centennial	Currently on both surface water and non-renewable groundwater. Implementing aquifer storage and recovery. Part of the South Metro effort to develop additional renewable water supplies.	South Metro Report
	Cottonwood	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report
	East Cherry Creek Valley	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report
	Englewood	Service area near buildout. Has adequate existing supplies for buildout demands.	Response to CDM survey
	Franktown	Not in South Metro Group.	
	Inverness	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report
	Meridian	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report
	Parker	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report

Table 6-37 Detailed Identified Projects and Processes for South Platte Basin

Subbasin	Major Provider	Notes	Source
South Metro (cont.)	Pinery	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report
	Roxborough	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report
	Stonegate	Currently on non-renewable groundwater. Part of the South Metro effort to develop renewable water supplies.	South Metro Report
	Unincorporated Douglas County not in water district	Existing and future developments reliant on non-trib groundwater. No reliable source of surface water.	South Metro Report
	Eastern Arapahoe County	Existing and future developments reliant on non-trib groundwater. No reliable source of surface water.	South Metro Report
	Elbert County	Existing and future developments reliant on non-trib groundwater. No reliable source of surface water immediately available.	Dick Stenzel
Upper Mountain	Black Hawk	Decreed Aug Plan will meet needs. Could use additional raw water storage.	Dick Stenzel
	Central City	Decreed Aug Plan will meet needs.	Dick Stenzel
	Empire		Dick Stenzel
	Georgetown		Dick Stenzel
	Idaho Springs		Dick Stenzel
	Unincorporated Clear Creek County	Will need to acquire additional augmentation water. Source will be City of Golden agreement or ag transfers.	Dick Stenzel
	Unincorporated Gilpin County	Will need to acquire additional augmentation.	Dick Stenzel
	Park County	There are over 25,000 pre-1972 platted lots that will not require augmentation of wells. Decreed aug plans available for some post 1972 lots. Bargas Ranch water rights acquired with Centennial Water and Sanitation District and will provide additional augmentation source. Park County is in discussion with Denver Water on potential enlargement of Antero Reservoir.	Lynda James, Park County Land & Water Trust Fund
High Plains	Numerous small towns	High Plains aquifer assumed to meet future needs.	Dick Stenzel
Northern	Berthoud	Northern Integrated Supply Project, CBT and ag rights and annexation policies.	Dick Stenzel
	Boulder	Windy Gap Firming, CBT and ag rights.	Dick Stenzel
	Broomfield	Windy Gap Firming, CBT and ag rights and annexation policies. Constructing reclaimed system.	Dick Stenzel
	Calpine Power Plant	Aurora raw water lease expires in 2013 and will need a source of water. The plant has an estimated life of 40 years.	Dick Stenzel
	Central Weld County Water District (includes Johnstown, Kersey, LaSalle, Gilcrest, Frederick, Firestone, Dacono, Milliken and Platteville)	Northern Integrated Supply Project, reservoir enlargement, CBT and ag rights and annexation policies. There is expected to be a limitation on the ability to transfer water to its water treatment plant and non-potable systems using local ditch water may be required.	Dick Stenzel
	Tri-Districts (East Larimer, Fort-Collins Loveland and North Weld County Water Districts and includes Ault, Windsor and Eaton)	Northern Integrated Supply Project, Halligan Reservoir enlargement, CBT and ag rights and annexation policies. There is expected to be a limitation on the ability to transfer water to its water treatment plant and non-potable systems using local ditch water may be required.	Dick Stenzel
	Erie	Windy Gap Firming, CBT and ag rights and annexation policies.	Dick Stenzel

Table 6-37 Detailed Identified Projects and Processes for South Platte Basin

Subbasin	Major Provider	Notes	Source
Northern (cont.)	Estes Park	Windy Gap Firming and CBT.	Dick Stenzel
	Fort Collins	Windy Gap firming, Northern Integrated Supply Project, reservoir enlargement, CBT and ag rights and annexation policies.	response to CDM survey
	Fort Lupton	Windy Gap firming, Northern Integrated Supply Project, reservoir enlargement, CBT and ag rights.	Dick Stenzel
	Greeley	Windy Gap firming, reservoir enlargement, CBT and ag rights and annexation policies.	response to CDM survey
	Hudson	Will need well augmentation.	response to CDM survey
	Lafayette	Windy Gap firming, CBT and ag rights.	Dick Stenzel
	Lefthand WD	Northern Integrated Supply Project, CBT and ag rights.	Dick Stenzel
	Lochbuie	Will need well augmentation.	Dick Stenzel
	Longmont	Windy Gap firming, Union Reservoir enlargement, CBT and ag rights and annexation policies.	response to CDM survey
	Louisville	Windy Gap firming, CBT and ag rights.	Dick Stenzel
	Loveland	Windy Gap firming, CBT and ag rights and annexation policies. Green Ridge Glade recently enlarged.	Dick Stenzel
	Lyons		Dick Stenzel
	Platte River Power Authority	Windy Gap firming.	Dick Stenzel
	Superior	Windy Gap firming, CBT and ag rights.	Dick Stenzel
	Xcel Fort St. Vrain Power Facility	Facility is not expected to increase capacity.	Dick Stenzel
	Unincorporated Boulder County (mountains and small towns)	Augmentation for growth in Nederland and mountain subdivisions.	Dick Stenzel
	Unincorporated Larimer County (mountains)	Will need augmentation for mountain subdivisions.	Dick Stenzel
Lower Platte	Brush	Will need well augmentation.	Dick Stenzel
	Fort Morgan	Buy CBT and well augmentation.	Dick Stenzel
	Julesburg	Will need well augmentation.	Dick Stenzel
	Sterling	Will need well augmentation.	Dick Stenzel
	Xcel Pawnee Power Facility	Will need consumptive use water for additional power generation.	Gary Thompson, W.W. Wheeler & Associates

Table 6-38 provides the South Platte Basin gap analysis by subbasin. The largest gap is in the South Metro subbasin where current supplies are non-renewable groundwater.

Table 6-38 Summary of Gap Analysis for South Platte Basin

County	Identified Gross Demand Shortfall (AFY)
Denver Metro	12,500
South Metro	50,300
Upper Mountain	1,400
High Plains	0
Northern	18,400
Lower Platte	8,000
TOTAL	**90,600**

6.3.7.2 Recreational and Environmental Information

6.3.7.2.1 Flow Considerations

In January 2004, the USFS released a Wild and Scenic River Study Report and Final EIS for 99.5 miles of river including the North Fork of the South Platte River and segments of the South Platte River. All of the South Platte River study corridor and much of the North Fork of the South Platte River study corridor lie within the boundaries of the Pike National Forest (National Forest). Both areas, however, include many private and local government inholdings. The study corridors also contain a 6.6-mile stretch of the North Fork of the South Platte River that lies outside the National Forest boundary. This section is mostly in private ownership but includes some public lands managed by Denver Water and Jefferson County Open Space.

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

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

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

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

After the USFS, Denver Water is the next largest land manager or owner in the area. Denver Water's lands are managed for water delivery, dispersed recreation, summer home rentals, and resource protection to ensure high water quality. Over many years, Denver Water had acquired most of the non-federal land along the South Platte from Deckers to the North Fork confluence, and along the North Fork from the confluence to Ferndale, in anticipation that these lands would be inundated by its planned Two Forks Reservoir (USACE 1988). Plans for the Two Forks Project were abandoned indefinitely, however, after a 1989 ruling by EPA that the project would violate the CWA.

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

The purpose of the SPPP is to protect the ORVs identified by the USFS and preserve water supply functions without designating the river under the Wild and Scenic Rivers Act. These values are historical, fishery, geological, recreational, scenic, and wildlife resources. The SPPP also recognizes that Colorado's Front Range communities rely heavily upon the South Platte for drinking water supply and other M&I uses and that agriculture throughout northeastern Colorado depends heavily on South Platte flows. The ORVs must be protected in the context of preserving these functions as well. The interests of all these communities can be maintained through common dialogue toward an approach in which the many values on the river – habitat, ecosystem, and human-based – can all be addressed in coordination and balance with one another. Mutual respect for the many important uses is central to the SPPP. It creates a cooperative management structure of local, state, and federal agencies. The underlying principle is no loss of existing or future water supply. The major components of the SPPP are:

- Protect canyons.
- A streamflow management plan, including: no loss of existing or future water supply; minimum outflows from Spinney Mountain, Elevenmile, and Cheesman Reservoirs; ramping (changing gradually) outflow changes from Elevenmile and Cheesman Reservoirs and the Roberts Tunnel; new valves, monitors, and gages; channel work on North Fork to be coordinated with CDOW; public input to annual operating plans; stream channel maintenance and improvement; designation of desirable outcomes; and goals for water suppliers to use as guidance in their operating decisions as follows:
  - Operate Spinney Mountain, Elevenmile, and Cheesman Reservoirs to release stored water to maintain minimum outflow when inflow is low.

- Operate Spinney Mountain, Elevenmile, and Cheesman Reservoirs for outflows in an optimum range the remainder of the year.
- Operate Elevenmile and Cheesman Reservoirs outflow for optimum temperatures and ramping of daily temperature fluctuations to benefit fisheries below the dams.
- Consideration of whitewater and fisheries in Roberts Tunnel discharges, within the limitations described in the Streamflow Management Plan.
- Revise annual operating plans to limit fluctuations when the potential exists to harm vulnerable life stages of brown or rainbow trout.

Future water projects, especially those that would significantly extend bank-full stream conditions, would require an analysis by the project proponent of channel capacity related to adequate protection of fisheries habitat and populations, channel stability, and maintenance of the ecosystem.

- A Management Partnership for Recreation, Wildlife, Scenery, and Other Values.
- Cooperative water quality initiatives would be implemented through the Coalition for the Upper South Platte (CUSP), which is composed of interested local governments, agencies, and parties in the basin. This coalition was originally known as the Upper South Platte Watershed Protection Association.
- Endowment. Front Range local governments and water suppliers would contribute at least $1 million to be spent on the values identified by the USFS.
- Enhancement Board. A coordinating forum, the Friends of the South Platte River, Inc., would provide comments and responses on activities such as land use or land management planning decisions, as well as deciding expenditures from the endowment.
- Withdrawal of 1986 applications for conditional storage rights. Both Denver Water and the Metropolitan Denver Water Authority would withdraw Water Court applications for 780,000 AF of additional storage at the Two Forks Reservoir site.
- Alternative to development of Denver's rights-of-way. Denver Water and environmental groups have proposed a working relationship that could lead to alternative projects and allow Denver Water later to relinquish its 1931 rights-of-way on the South Platte at the Two Forks site. As a demonstration of good faith in pursuing alternative projects, Denver Water would voluntarily impose a moratorium on applications for development of the rights-of-way for a period of 20 years from formal acceptance of the SPPP.
- Provision for limited development. In addition, Denver Water and other present and future water suppliers would continue to have access to the river for operational and maintenance purposes.

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

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

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

CWCB holds numerous instream flow rights for the major rivers and tributaries in the South Platte Basin (http://cwcb.state.co.us/isf/ Downloads/ Index.htm). Decreed rights on major rivers and streams are listed in Table 6-39. These rights are year-round with seasonal variability as reflected in the range of flows shown.

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

6.3.7.2.2 Water Based Recreation

Table 6-40 shows the reaches in the South Platte Basin that are listed for rafting use by American Whitewater. There are no reaches listed in the Republican River Basin.

Table 6-39 CWCB Instream Flow Rights on Major Rivers in the South Platte River Basin

River	Upper Terminus	Lower Terminus	Range of Flow Rights (cfs)*	Range of Appropriation Dates	Reaches
Big Thompson River	Confluence with Dry Gulch	Dille Tunnel Diversion	15 - 50	All Nov. 14, 1989	3
Boulder Creek	Confluence of North and Middle Boulder Creeks	75th Street Bridge	0.45 - 15	Nov. 15, 1859 to Nov. 10, 1993	2
Cache la Poudre River	Confluence with La Poudre Pass Creek	Wild & Scenic terminus	16 - 55	Nov. 8, 1985 to Dec. 11, 1987	4
Clear Creek	Headwaters	Confluence with South Clear Creek	10	July 13, 1984	1

* The range of flows also reflect the fact that there are multiple reaches with different CWCB instream flows specific to each reach.

Table 6-40 River Reaches in the South Platte River Basin in Colorado Listed for Rafting Use by American Whitewater

Reach Description	Class	Minimum Suggested Flow (cfs)*	Maximum Suggested Flow (cfs)*
Bear Creek from Idledale to Morrison	III-IV	NA	NA
Big Thompson from Idyllwilde Dam to Canyon Mouth	IV-V	250	1500
Boulder Creek from Gun Shy to Jasper Creek (The Source)	V	NA	NA
Boulder Creek from Mile Marker ? to Mile Marker ? (Upper Canyon Run)	IV-V(V+)	150	300
Boulder Creek from Mile Marker ? to Eben G Fine Park (Canyon Run)	IV+	150	500
Boulder Creek from Eben G Fine Park to CU Greenhouse (Town Run)	II-III	150	500
Boulder Creek, North – from Switzerland Park to Boulder Falls (Dream Canyon)	V+	NA	NA
Boulder Creek, South – from Rollinsville to Pinecliffe (Alto-Alto)	III-IV	NA	NA
Boulder Creek, South – from Pinecliffe to Gross Reservoir (USB)	V+	NA	NA
Boulder Creek, South – from Gross Reservoir to Eldorado State Park (Lower South Boulder Creek)	IV(V+)	NA	NA
Boulder Creek, South – Eldorado Canyon (Eldo)	V+	NA	NA
Cache la Poudre from Long Draw Reservoir to Big South Campground (Big South)	V+	NA	NA
Cache la Poudre from Big South Campground to Tunnel Picnic Ground (Spencer Heights)	V+	650	1300
Cache la Poudre from Home Moraine to Indian Meadows Bridge (White Mile Run/Upper Rustic)	III-IV	650	2300
Cache la Poudre from Indian Meadows Bridge to Narrows Picnic Ground (Grandpa's Gorge)	III-IV	650	2300
Cache la Poudre from Narrows Picnic Ground to Steven's Gulch Access (The Narrows)	IV-V+	NA	NA
Cache la Poudre from Steven's Gulch Access to Mishawaka Inn (Upper Mishawaka)	III-IV	NA	NA
Cache La Poudre from Mishawaka Inn to Poudre Park Picnic Ground (Lower Mishawaka)	III	NA	NA
Cache La Poudre from Poudre Park Picnic Ground to below Pine View Falls (Poudre Park)	IV	NA	NA
Cache La Poudre from just below Pine View Falls to Mile Marker 114.7 (Bridges)	III-IV	NA	NA
Cache La Poudre from below Filter Plant to Picnic Rock Access (Filter Plant)	II-III	NA	NA
Cache La Poudre, N. Fork – from Cherokee Park Rd (near Trails End) to Halligan Reservoir (upper)	IV-V	NA	NA
Cache La Poudre, N. Fork – from Livermore Bridge to Main Stem (lower)	II-III	NA	NA
Cache La Poudre, S. Fork – from Fish Creek Trailhead to Main fork (South Fork)	IV-V	NA	NA
Clear Creek from Loveland Ski Area to Silverplume (BFE)	IV(V+)	NA	NA
Clear Creek from Silverplume to Georgetown	V+	NA	NA
Clear Creek from Lawson to Idaho Springs (Dumont)	III-IV	NA	NA
Clear Creek from Kermit's to Green Bay Rock (Upper Clear Creek)	IV	NA	NA
Clear Creek from Green Bay Rock (mile 262.9) to Rigor Mortis (mile 267.2) (Black Rock)	IV-V(V+)	500	1000
Clear Creek from Rigor Mortis (mile 267.2) to Golden (Lower Clear Creek)	IV	500	1000
Clear Creek, West Fork from Coors Falls to Gunshot (West Fork)	V	100	250
Jasper Creek from Class II to Boulder Creek	V+	NA	NA
Joe Wright Creek from County Rd. 103 bridge to Big South Campground	V	NA	NA
Left Hand Creek from the intersection of 81st and 94th to Buckingham Park	IV	NA	NA
Saint Vrain Creek, North – from Peak to Peak Hwy to Buttonrock Preserve (Upper NSV)	V+	150	500
Saint Vrain Creek, North – from Buttonrock Preserve to CR 80 (Middle NSV)	IV(V)	NA	NA

Table 6-40 River Reaches in the South Platte River Basin in Colorado Listed for Rafting Use by American Whitewater

Reach Description	Class	Minimum Suggested Flow (cfs)*	Maximum Suggested Flow (cfs)*
Saint Vrain Creek, North – from County Road 80 to Lyons (Lower NSV)	III	NA	NA
Saint Vrain Creek, South – from confluence to 1 in 5 Rapid (SSV)	V+	150	400
South Platte from Eleven Mile Reservoir to Lake George (Eleven Mile Canyon)	III-IV(V+)	NA	NA
South Platte from Lake George to Cheesman Reservoir (Cheesman/Wildcat Canyon)	V	300	700
South Platte from Cheesman Reservoir to Deckers (Deckers)	IV	NA	NA
South Platte from Deckers to confluence with North Fork (Chutes)	I-III	NA	NA
South Platte from confluence to Strontia Springs Reservoir (Waterton Canyon)	III-IV	NA	NA
South Platte near Union Avenue Union Chutes)	III	NA	NA
South Platte at confluence of Cherry Creek and South Platte (near Speer Blvd) (Effluent Park)	II-III	200	5000
South Platte from Brighton City Park to Fort Lupton	I-II	NA	NA
South Platte, North Fork from Bailey to Pine (Bailey)	IV-V+	250	NA
South Platte, North Fork from Buffalo Creek to South Platte (Foxton)	III-IV	300	NA
Williams Fork from Horseshoe Campground to Williams Fork Reservoir	II-IV	NA	NA
Woods Creek from Reservoir to confluence with West Fork Clear Creek	V	200	NA

* Suggested levels of flow, not water rights.

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

Bonny Reservoir

Bonny Dam and Reservoir provides water for recreation and flood control and are on the South Fork of the Republican River near Hale, Colorado just west of the Kansas border in Yuma County. They are features of the Armel Unit, Upper Republican Division, Pick-Sloan Missouri Basin Program. The reservoir has approximately 2,095 surface acres. Fishing is well known and excellent. Fishing season is year-round. Camping, hunting, hiking, picnicking, and wildlife viewing can be enjoyed at Bonny Lake State Park. With seasonably warm waters, dependable winds, and sandy beaches, Bonny Lake State Park is a destination for swimmers, water skiers, and windsurfers. Other recreational opportunities include boating and recreational vehicles. Recreation at the site is managed by the CDPOR for the BOR (http://www.recreation.gov/detail.cfm?ID=48 and http://www.usbr.gov/dataweb/html/armel1.html).

Carter Lake

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

Flatiron Reservoir

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

Horsetooth Reservoir

Horsetooth Reservoir is located in the foothills about 5 miles west of Fort Collins in the South Platte Basin. It provides water for irrigation, M&I, and recreation. The reservoir is at an elevation of 5,430 feet. As part of the CBT Project, it furnishes the main water supply for the Poudre Valley. The reservoir is 6.5 miles long. Developments include 4 campgrounds, 111 campsites, and 7 boat launch ramps. A concession-operated public marina is located at the Inlet Bay area. A concession-operated restaurant is located in the South Bay. A developed public swim beach is located on the west side of the lake. Total water surface available for recreation is approximately 1,900 surface acres, surrounded by 2,000 acres of public land. Primary recreation activities include fishing, power boating, water skiing, and camping. Primary sport fish include rainbow trout, crappie, smallmouth bass, white bass, wiper, largemouth bass, and walleye. Additional recreational opportunities include hiking, picnicking, and wildlife viewing. The reservoir is open year-round. Recreation is managed by Larimer County Parks and Open Lands (http://www.co.larimer.co.us/parks/Horsetooth.htm and http://www.recreation.gov/detail.cfm?ID=66).

Lake Estes

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

Marys Lake

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

Pinewood Lake

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

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

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

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

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

6.3.8 Yampa/White/Green Basin

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

Major Identified Projects and Processes for the Yampa/White/Green Basin are summarized in Table 6-41. For reference, Figure 6-12 provides a map of counties and major cities in the basin as referenced throughout this discussion.

In the Yampa/White/Green Basin counties of Moffat, Rio Blanco, and Routt, existing supplies and water rights including reservoir storage in Stagecoach, Elkhead, and Yamcolo Reservoir will be used to meet existing agricultural and future M&I demands. High transit losses in delivering storage water downstream to the locations of use were experienced during the recent dry years and firm yields may be much lower than anticipated, requiring additional water supply development to meet dry year needs. Basin Roundtable participants identified that the Elkhead and Stagecoach Reservoir enlargements are critical to meeting the basin's projected water needs. SSI demands associated with power generation in the Craig and Hayden areas are projected to increase significantly. Due to unknowns such as international markets, national security, and proprietary processing methods, the rate of potential development of energy resources such as oil shale and the level of associated water demands is not known but could have a significant demand on the basin's water resources, increasing annual demands by more than 100,000 AF. The probability, timing, and extent of such demands are unknown at this time.

Significant agricultural shortages (greater than 10 percent) were identified in Water Districts 44 and 54. The agricultural Basin Roundtable members identified additional irrigable land that could be irrigated if storage could be developed to provide reliable supplies. A range of 20,000 to 40,000 acres of potentially irrigable lands were identified. The development of additional water storage projects would require subsidies or partnering with other users in order to make such development feasible.

Further detail regarding the Identified Projects and Processes and areas of gap for the Yampa/White/Green Basin are provided in Table 6-42.

Table 6-41 Major Identified Projects and Processes in Yampa/White/Green Basin Counties

County	Estimated Demand met by Identified Projects and Processes and Additional Conservation (AFY)	Identified Projects and Processes
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**	

Table 6-42 Detailed Identified Projects and Processes for Yampa/White/Green Basin

County	Major Provider	Remaining Gross Gap (AF)	Supplies Beyond 2030*	Notes	Source
Routt	Hayden	0	N	Recently acquired water rights in Stagecoach and Yamcolo. Expect minor growth and will have adequate supplies.	Frank Fox, Hayden PW
	Hayden Power Generating Facility (Xcel)	0	N	Increase in demand will be met through existing rights and Elkhead Reservoir enlargement.	Basin Roundtable Feedback
	Morrison Creek W&S District	U	U	—	—
	Mt. Werner W&SD (Steamboat Springs)	0	Y	—	Response to CDM survey
	Oak Creek	0	Y	No gap indicated through Basin Roundtable discussions.	Response to CDM survey
	Unincorporated Routt County	0	N	There may be need for augmentation sources and storage depending upon location of depletions in relation to augmentation supplies.	
	Yampa	0	U	No gap indicated through Basin Roundtable discussions.	Basin Roundtable Feedback
Moffat	Craig	0	Y	Will have adequate supplies for growth beyond 2030.	Response to CDM survey
	Craig Power Generating Facility (tri-State Generating and others)	0	N	Increase in demand will be met through existing rights, Yamcolo and Elkhead Reservoirs and Elkhead Reservoir enlargement.	Basin Roundtable Feedback
	Dinosaur	0	U	Expect small increase in demand.	Basin Roundtable Feedback
	Unincorporated Moffat Co and other small towns	0	U	There may be need for augmentation sources and storage depending upon location of depletions in relation to augmentation supplies.	—
Rio Blanco	Rangely	0	U	Expect small increase in demand.	Basin Roundtable Feedback
	Meeker	0	U	Expect small increase in demand.	Basin Roundtable Feedback
	Mesa View Water District	0	U	Expect small increase in demand.	—
	Unincorporated Rio Blanco County and other small towns	0	U	There may be need for augmentation sources and storage depending upon location of depletions in relation to augmentation supplies.	—

* Y = Yes; N = No; U = Unknown

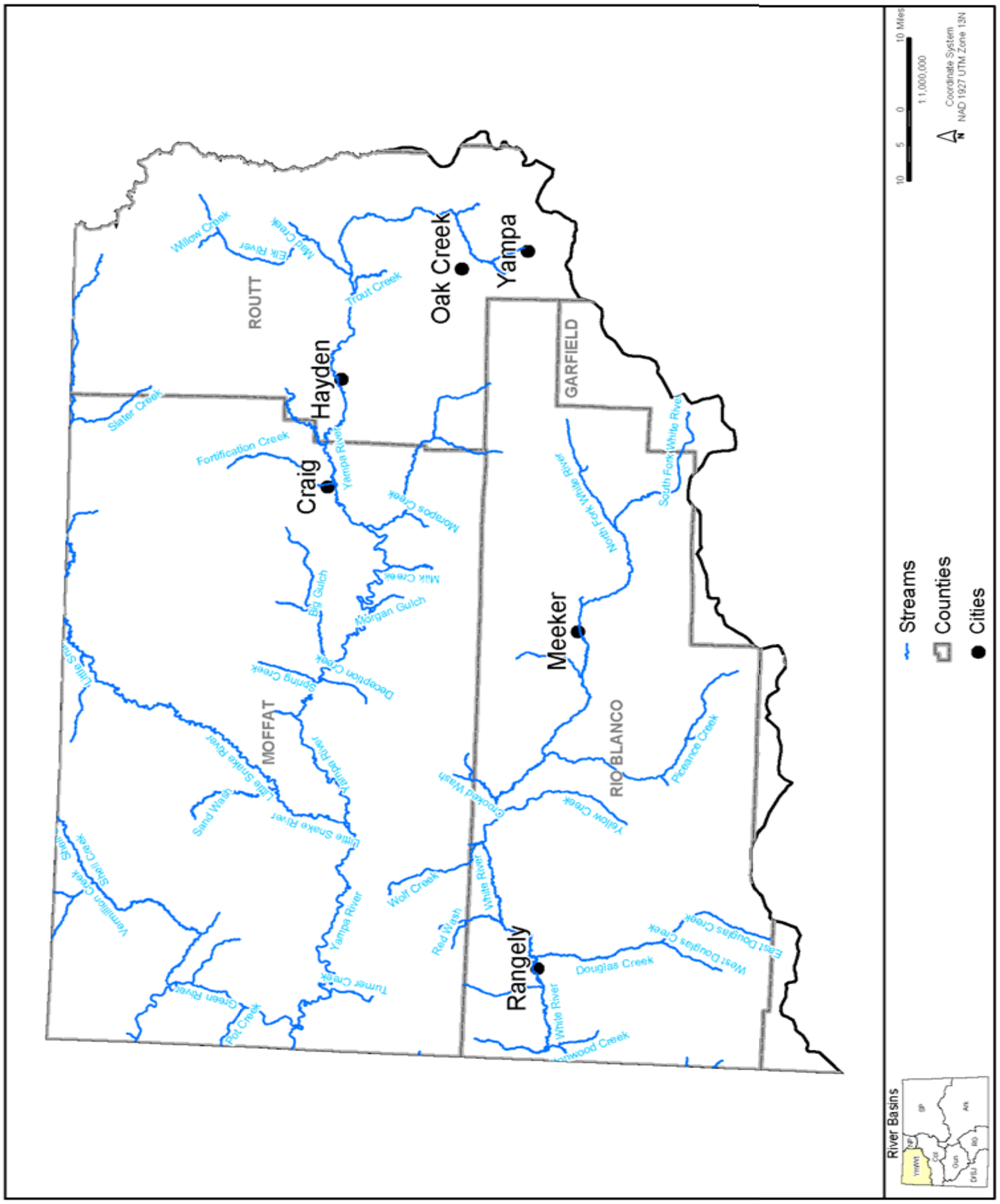


Figure 6-12
Yampa/White/Green Basin Location Map

CDM

Table 6-43 shows that there are no identified gaps for any counties in the Yampa/White/Green Basin.

Table 6-43 Summary of Gap Analysis for Yampa/White/Green Basin

County	Identified Gross Demand Shortfall (AFY)
Moffat	0
Rio Blanco	0
Routt	0
TOTAL	**0**

6.3.8.2 Recreational and Environmental Information

6.3.8.2.1 Flow Considerations

On January 21, 2004 the City of Steamboat Springs filed for a RICD in District Court Water Division No. 6 (Case No. 6-03CW86) for the City of Steamboat Springs Boating Park. The application is for water rights for two in-channel diversion structures, which capture and control the flow of the Yampa River to create features that provide recreation experience for all boating recreational uses. The Boating Park extends approximately 630 feet within the channel of the Yampa River. The application seeks a water right for specified time periods as provided in Table 6-44.

Table 6-44 Water Rights Application for Steamboat Boating Park

Time Period	Flows (cfs)
April 15 - 30	500
May 1 - 15	800
May 16 - 31	1,200
June 1 - 15	1,700
June 16 - 30	800
July 1 - 15	300
July 16 - Oct. 31	120

The above amounts claimed are limited to the hours of 6:00 a.m. to 9:00 p.m., except during nighttime competitive events when the hours may be extended.

The appropriation date requested is December 16, 2003.

(http://cwcb.state.co.us/isf/rules/ RICDapp.htm and http://cwcb.state.co.us/isf/rules/ steamboat.pdf)

On May 26 and 27, 2004, the CWCB held a hearing in Steamboat Springs. CWCB recommended that the water court deny the entry of a decree for this RICD (http://cwcb.state.co.us/isf/rules/SteamboatdraftRecommendationandFindings.pdf).

The Management Plan for Endangered Fishes in the Yampa River Basin assists in the recovery of four endangered fish species as water depletions from the Yampa River Basin continue to serve human water needs in Colorado and Wyoming. The plan anticipates that depletions will increase to meet projected future human needs. The plan quantifies current depletions, as well as future depletions projected through 2045. The plan describes specific management actions to promote recovery of the listed species in the face of these depletions and criteria by which to measure the success of management actions (USFWS 2004).

The plan recommends that daily average base flows in the Yampa River not fall below 93 cfs at Maybell from August through October at any greater frequency, magnitude, or duration in the future than had occurred historically. Historical records show that base flows at Maybell occasionally have fallen below the 93 cfs flow target in July, as well. Therefore, the base flow period was expanded to include July. Moreover, uncertainty with respect to the winter flow needs of the fishes prompted the USFWS to extend the base-flow period through the winter months (November through March) with a 33 percent buffer added to the 93 cfs flow target (i.e., 124 cfs) during this period, which is consistent with observed hydrologic patterns. The plan proposes to augment base flows in accordance with these recommendations to compensate for impacts to base flows due to depletions. Hydrologic modeling demonstrated that 7,000 AF would satisfy base flow needs in all but the driest years.

Numerous instream flow rights have been decreed on major rivers and tributaries in the Yampa/White/Green Basin (http://cwcb.state.co.us/isf/Downloads/ Index.htm). Decreed rights on major rivers are listed in Table 6-45. These rights are year-round with seasonable variability as reflected in the range shown. Flow rights on smaller tributaries in the basin can be found at the above reference.

6.3.8.2.2 Water-Based Recreation

Numerous river reaches in Colorado are used for whitewater rafting. Table 6-46 shows the reaches in the Yampa/White/Green Basin that are listed for rafting use by American Whitewater:

There are no federal project reservoirs in the Yampa-White-Green Basin in Colorado offering water-based recreational activities.

Steamboat Lake, located in Steamboat Lake State Park about 30 miles north of Steamboat Springs, has received Gold Medal designation. Steamboat Lake offers fishing for rainbow trout, Snake River cutthroats, and brown trout.

Table 6-45 CWCB Instream Flow Rights on Major Rivers in the Yampa/White/Green Basin

River	Upper Terminus	Lower Terminus	Range of Flow Rights (cfs)	Range of Appropriation Dates	Number of Reaches
White River	Confluence of the North and South Forks of the White River	Confluence with Piceance Creek	200	Nov. 15, 1977	1
Yampa River	Confluence with Morrison Creek	Confluence with Elkhead Creek	25 - 200	May 15, 1968	1

Table 6-46 River Reaches in the Yampa/White/Green Basin in Colorado Listed for Rafting Use by American Whitewater

Reach Description	Class	Minimum Suggested Level (cfs)	Maximum Suggested Level (cfs)
Upper Green River from Gates of Lodore to Split Mountain Campground	II-IV	NA	NA
Elk River from 2 miles above Mad Creek to Mad Creek	I-II	NA	NA
Elk River from Box Canyon Campground to Glen Eden Bridge	III	NA	NA
White River from North-South Fork confluence to Green River	I-II	NA	NA
White River, North Fork from Mirror Lake to South Fork	III	NA	NA
White River, South Fork from National Forest Campground to North Fork	III-IV	NA	NA
Willow Creek from National Forest Campground to Reservoir	II	NA	NA
Yampa River from Yampa River Park to 12th Street (Steamboat) (Steamboat town run)	III	NA	NA
Yampa River from 85 Rd. to Deer Lodge Park Road (Cross Mountain Gorge)	IV(V)	700	13,000
Yampa River from Deerlodge Park to Split Mountain Campground (Dinosaur)	II-III(IV)	700	20,000

Source: http://www.americanwhitewater.org/rivers/statedrain/CO

* Suggested level of flows, not water rights.

Section 7
Availability of Existing Water Supplies

7.1 Methods and Tools Employed to Evaluate Surface Water Supply Availability

The availability of surface water and groundwater supplies for each basin are summarized in this section. Physical availability of surface and groundwater resources must be carefully evaluated against the legal right to divert, pump, or consume these resources. Surface water supply availability was estimated at selected points in each major river basin in Colorado. Colorado's DSS surface water allocation model, StateMod, and supporting datasets were the primary tools used for this analysis when available. StateMod simulates daily or monthly hydrologic water availability in a river basin based on a stream's water rights, structures, and operating rules (http://cdss.state.co.us). For those basins without StateMod datasets, alternative sources and studies were used to summarize available water to the extent possible.

7.1.1 Decision Support Systems

StateMod simulates three types of flow: physically available, legally available, and naturalized. These terms are described below. The primary data sources used in the development of the StateMod input files include USGS and DWR streamflow measurements, SEO diversion records, reservoir storage records, basin studies and reports, and interviews with water administrators and project owners. Much of the model input data is stored in HydroBase, the DSS central database. HydroBase contains historical water rights, stream gage locations, and real-time and historical stream flows.

- **Physically Available Water:** The actual or observed amount of water flowing in the stream. This flow is measured at a gage or calculated as a function of historical hydrology less current water uses, and the effects of storage and conveyance structures. Existing storage and conveyance capacities are used.
- **Legally Available Water:** The portion of physically available flow that is unappropriated, or water that could be developed without injury to other water rights or compacts. The water must be first physically available, and then the legal restrictions to that water must be assessed (e.g., downstream calls, compact requirements, etc.). As with physically available flow, this calculated flow is a function of historical hydrology combined with current water use, etc. Water that is legally available can serve multiple purposes. For example, water that must be delivered to a downstream senior right or compact requirement could provide environmental benefits.
- **Naturalized Streamflow:** The undepleted, unregulated total water supply that would have been available absent all human intervention (e.g., diversions, storage and releases, return flows, CU). This calculated flow is the primary input dataset used for making physically and legally available flow simulations in StateMod and is often referred to as "base case." Naturalized flow is also known as natural, native, or virgin flow.

StateMod runs consist of baseline datasets that were used to describe water availability in this section. Irrigation demands that have been included in the DSS baseline runs described in the individual river basins reflect 1993 irrigated acreage and crop types for the Western Slope basins, and 1998 irrigated acreage and crop types in the Rio Grande Basin. "Current" M&I demands for all DSS models, except the Rio Grande Basin, reflect 1996 levels of use, corresponding to the end-date of the current model study period. In the Rio Grande Basin, the M&I demand reflects 1998 levels of use. During the SWSI process, M&I demands for 2000 and 2030 were developed that can be incorporated into future analyses. While it is important to update M&I demands for the DSS basins, the incorporation of 2000 water demands will not significantly affect the supply availability shown in this section. Section 7.4 includes estimates of 2000 and 2030 depletions and supply that can be developed under the Colorado River Compact.

Additional information on the DSS models can be found at: http://cdss.state.co.us/ .

7.1.2 Data Sources

Table 7-1 summarizes the sources of supply data used in this study to evaluate surface water supply availability. The Colorado, Gunnison, Yampa, White, Rio Grande, San Juan, and Dolores Basins have existing DSS datasets and models. StateMod was therefore used for estimating available supply in these basins. For those basins without developed DSS datasets – Arkansas, South Platte, and North Platte – information for physically and legally available flows were gathered from existing sources and studies. For example, USGS flow gages were used to help quantify physically available flows for all three of these basins. The Republican River basin was not studied in SWSI because of ongoing interstate litigation concerns. Additionally, legally available flows were quantified in the SECWCD Hydrologic Analysis Study (2000) for the Arkansas Basin, and in the Denver Water Chatfield Reservoir Reallocation PACSM modeling effort, the CWCB Lower South Platte Water Management and Storage Sites Reconnaissance Study, and the NCWCD NISP for the South Platte Basin.

Table 7-1 Summary of SWSI Sources of Data: Supply Availability

Basin	Sources of Data
Arkansas	SECWCD Hydrologic Analysis (2000), USGS flow gages
Colorado	DSS/StateMod
Dolores/San Juan/ San Miguel	DSS/StateMod
Gunnison	DSS/StateMod
North Platte	USGS flow gages
Rio Grande	DSS/StateMod
South Platte	PACSM model (Denver Water), NISP study (NCWCD), Lower S. Platte Water Management and Storage Sites Reconnaissance Study (CWCB)
Yampa/White/Green	DSS/StateMod

* Republican not studied

For each basin where DSS StateMod runs were available, modeled flows were summarized at 4 to 10 key locations. Locations were chosen to provide a good spatial coverage across a given basin. These locations also generally correspond to downstream ends of delineated subbasins (counties and water districts). The simulated flows at these locations are therefore representative of total subbasin available flows and provide useful information for analyzing options at a subbasin level (Section 10).

7.1.3 Firm Yield Analysis

The concept of "firm yield" is a common term used in water supply planning. The firm yield, as defined below, is analyzed for several locations to illustrate the storage to yield ratios under certain planning criteria. For these analyses, firm yield is defined as the maximum annual supply that can be reliably provided every year for the period of record with no monthly shortages.

This firm yield definition is based on no monthly shortages for the period of record. The appropriate period of record to be used for firm yield analysis as well as the willingness to accept some shortages can significantly affect the firm yield analysis. Individual water planning agencies may have different criteria for the critical period of record that should be used. In addition, the planning agencies may determine that it is more cost-effective to manage infrequent shortages with demand modifications than to design the water system to deliver full supplies with no shortages over the critical period or period of record.

As part of the supply availability summaries presented in this section, curves of firm yield versus total storage ("yield curves") are provided for one location in most basins. These curves were generated using Water Supply Investigation Tool (WatSIT), a screening-level reservoir and water supply model developed for this project. The model simulates the filling of a reservoir by a time series of monthly available river flows and the simultaneous emptying of the reservoir according to a user-defined monthly demand pattern. For a given reservoir size, firm yield is therefore calculated as the maximum total annual demand that can be met without shortages over the full period of record of river flows. A detailed description of WatSIT is provided in Appendix F.

Firm yield calculations can be inaccurate for short periods of record, because assumed starting reservoir conditions affect calculated firm yields (Lester and Couch 2000). Starting reservoir conditions affect firm yields when the reservoir simulation fails to include at least one period of partial depletion followed by full recovery (to full capacity) before entering the critical hydrologic period (Zarriello 2002). Firm yields presented in this section were not affected by assumed starting conditions for any of the basins except the Rio Grande and the South Platte Basins (which had shorter periods of record than the others). As described below, for the Rio Grande Basin analysis, starting reservoir conditions were set equal to the maximum wet-weather predicted storage volume. For the South Platte Basin, the analysis was terminated at the point at which yields showed a dependence on starting conditions (at high total storage values).

Example yield curves for the Yampa River below Craig are shown in Figure 7-1. Modeled demands for these analyses follow typical monthly patterns of M&I use, based on an analysis of monthly water demands from several municipal water providers.

WatSIT also has an option for assuming agricultural demand patterns, rather than M&I (i.e., assuming the water is being used for agriculture rather than M&I). As shown in Figure 7-1, for the Yampa River, assuming agricultural patterns of use rather than M&I, results in a small increase to the calculated firm yields. This increase in firm yield is the result of greater agricultural demands during the runoff period, allowing more direct diversions during this period and less reliance on storage. Also shown in Figure 7-1 is a yield curve corresponding to the same set of assumptions as the original curve, except that the criteria for firm yield are relaxed. For this curve, some shortages (> 20 year return period) are accepted. Small increases in firm yield (9,000 to 100,000 AFY) for the same storage volume are predicted. These increases may be more dramatic for different systems or for accepting more frequent shortages (a shorter return period). Finally, it is expected that firm yields would increase significantly if the storage water was used in a conjunctive use project with non-tributary groundwater. In other words, non-tributary groundwater could firm up yields by supplementing shortages in surface water supplies in dry years, pushing the yield curves upward.

7.2 Overview of Groundwater Supplies and Availability including Designated Groundwater Basins and Non-tributary Aquifers

Groundwater is present throughout the state. It is found in a variety of aquifers, from unconsolidated sand and gravel in the floodplains of the major rivers to bedrock deposits buried deep below the surface. The key aquifers in the state are located primarily in the unconsolidated deposits. These include the alluvial aquifer systems of the Arkansas, South Platte, Gunnison, Colorado, and North Platte Rivers. In addition, there is a significant aquifer located in unconsolidated deposits in the San

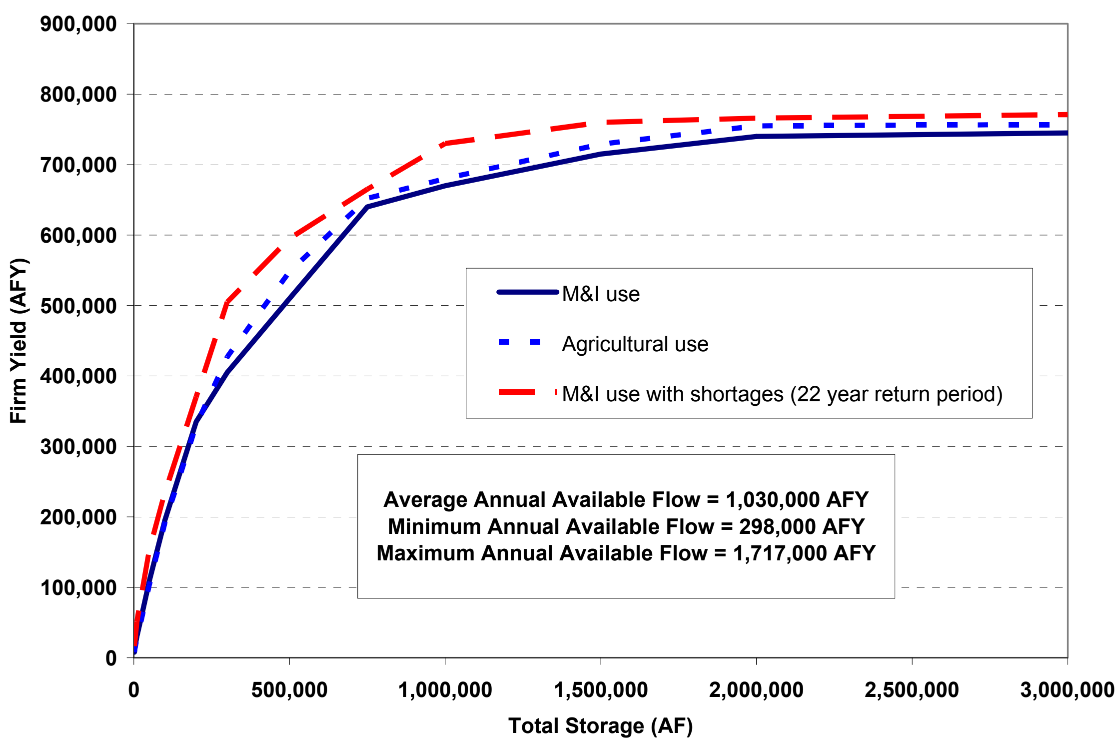


Figure 7-1
Reservoir Yield Curve
Yampa River below Craig (1909-1999)

Luis Valley in south central Colorado within the Rio Grande Basin. Of the many aquifer systems located in bedrock deposits, the most significant of these are the aquifers of the Denver Basin, located east of the Front Range, and the Ogallala (High Plains) aquifer located in eastern Colorado.

7.2.1 Definition of Groundwater Resources

Groundwater is administered by the State DWR to regulate and manage its use. Section 4 provides additional information on water rights as it affects groundwater resources. To reiterate, Colorado recognizes four types of groundwater and has separate sets of rules for each. These are based on interaction with surface water and/or on geographic location:

- **Tributary** - groundwater that is hydrologically connected to a natural stream.
- **Non-tributary** – groundwater located outside of a designated basin, the withdrawal of which will not, within 100 years, deplete the flow of a stream at an annual rate greater than one-tenth of 1 percent of the annual rate of withdrawal.
- **Designated Basin** – groundwater in areas not adjacent to a continuously flowing stream or required to fulfill decreed surface water rights, and located within the boundaries of a designated basin as defined by the legislature.
- **Denver Basin** – groundwater located outside of a designated basin and located within the boundaries of the Denver basin aquifers as defined in 1985.

Tributary and non-tributary groundwater supplies are located throughout the state, while Denver Basin and designated basin groundwater are located in specified areas in eastern Colorado.

Tributary groundwater occurs in the shallow alluvial aquifers adjacent to streams. This type of groundwater is administered under the Prior Appropriation System of water rights as are surface water supplies. In most basins, groundwater use is junior to surface water and so its use is allowed only if augmentation plans have been filed with the State Engineer that describe how the predicted depletions of stream flow due to the groundwater usage are offset.

Non-tributary groundwater occurs in deeper bedrock aquifers. This type of groundwater is administered based on ownership of the land overlying the aquifer, independent of the Prior Appropriation System. Permits limit annual usage to depleting a certain percentage of the computed aquifer volume, usually 1 percent.

In many cases the groundwater supplies are limited either by their physical or legal availability. The physical availability is the amount of water an aquifer can produce. The legal availability is the amount of groundwater that can be extracted from an aquifer under the water rights system that is present for the specific groundwater basin.

The amount of groundwater that each of these aquifers can produce is difficult to determine. This is due to several factors including uncertainty about the transmissivity, porosity, thickness of an aquifer, its extent, and locally, the effects of pumping that draws down the groundwater supply.

The transmissivity of an aquifer describes its potential to provide water. An aquifer with high transmissivity can provide a large amount of water per foot of aquifer drawdown. Transmissivity is a product of the aquifer saturated thickness and its water-bearing properties. Both of these aspects vary naturally throughout an aquifer. The aquifer saturated thickness and the extent of an aquifer usually are estimated based on a review of driller's logs of the subsurface and mapping of the permeable aquifer zones. An aquifer is composed mostly of soil or rock particles, with the groundwater existing in the porous void spaces in between. Soil and rock strata of both aquifer and non-aquifer materials change in composition due to how the strata were deposited, so the void spaces also vary. The water-bearing properties of an aquifer, defined as its hydraulic conductivity, are related to the size, number, and interconnectedness of the void spaces. It can vary by several orders of magnitude due to natural variations in the aquifer materials. Estimates of hydraulic conductivity can be made from the aquifer grain size and from aquifer pumping tests. The natural variation in porosity affects the ability to accurately estimate the amount of groundwater in storage in an aquifer. The range in porosity also can be up to several orders of magnitude for consolidated bedrock deposits and by a factor of 2 or 3 and for unconsolidated deposits. Due to the natural variations of these aquifer properties, any estimates of the amount of groundwater in storage and its availability will have a larger amount of uncertainty associated with them than will estimates of surface water availability.

The groundwater resources in each basin have been characterized based on published reports and data for the major aquifer systems.

7.2.2 Denver Basin Bedrock Aquifers

The Denver Basin contains four major aquifer units. These cover an area of approximately 6,700 square miles extending from Greeley south to Colorado Springs and from Limon west to the edge of the foothills. The aquifers consist of layers of sedimentary rocks that are, from youngest to oldest, the Dawson, Denver, Arapahoe, and Laramie-Fox Hills. Figure 7-2 shows a cross-section of the aquifer through the center of the basin.

There have been several estimates of the available water in storage. One of the early estimates of water availability was from the USGS (Robson 1987). In this study, information from driller's logs, laboratory tests of core samples, aquifer pumping tests, water level measurements, and groundwater flow modeling were used to delineate the configuration and storage coefficients of each aquifer, from which estimates of the available volume were made. The USGS study concluded that approximately 467 million AF of water existed in the Denver Basin aquifers, and of this approximately 269 million AF of water could be recovered. In 1985 the Colorado General Assembly promulgated Senate Bill 5, which set forth criteria for management of these bedrock aquifers. As part of this Bill, the storage coefficient was determined for each aquifer. The total amount of recoverable groundwater was estimated to be 295 million AF.

The aquifer storage coefficient has a strong influence on the estimated volume of water contained in an aquifer. Detailed studies conducted on core samples from a borehole located in the center of the basin near Kiowa (Lapey 2003) indicated that the storage coefficient might be as much as 30 percent lower than previously thought. This translates into a possible 30 percent reduction in the amount of recoverable water in storage, to approximately 206 million AF.

Even the lower estimates of the amount of available water in storage in the Denver Basin aquifers are quite large. Unfortunately, the sediments that make up each of the aquifers tend to be relatively fine grained and include many interlayered clay and shale units that have very low permeability. As a result, the water-bearing ability of the Denver Basin bedrock aquifers is relatively low. This leads to large drawdown in water levels from pumping of these aquifers. In the Arapahoe aquifer, water levels have declined by as much as 30 feet per year. In addition, some areas of the Denver Basin aquifers have declined by over 250 feet and this decline has been seen over a 10-square-mile area. Figures 7-3 and 7-4 show recent groundwater level trends for the significantly impacted aquifers (Arapahoe and Laramie-Fox Hills). Non-tributary groundwater rights and withdrawal volumes are linked to the surface land area ownership. Thus, the amount recoverable may be less and the cost of recovery increased than previously estimated.

Water levels are still above the physical top of each aquifer in most parts of the Denver Basin, thus exhibiting confined aquifer conditions. As water levels continue to drop, there are concerns about loss in well yield, increases in pumping costs, and aquifer subsidence. Well yield will likely decrease as the height of water in an aquifer declines. There are also concerns about a loss in well yield if water levels drop below the top of existing well screens. Air would then enter the system and cause minerals to precipitate and possibly bacteria to form on the well screens.

Pumping costs are likely to increase because, with declining water levels, there is a greater pump lift required so existing pumps must run longer or more powerful pumps will be needed. Eventually, wells would need to be deepened or replaced with deeper wells. Higher pumping costs are also likely when, due to declining yields, there will be a need to install and operate more wells to achieve the same production rates. **In the South Metro Denver area, it is anticipated that aquifer production will decline by 40 to 85 percent by the year 2050, and that municipal wells in this part of the Denver Basin that can produce even 100 gpm will be considered to be a good producing well. Current production rates average 540 gpm for the Arapahoe aquifer and 120 gpm for the Lower Dawson. To maintain current production, an increase in number of wells would be needed. It is estimated that it will cost $2.7 to $4 billion for infrastructure by 2050 for supplies provided by the non-tributary groundwater source**

within its service area. Conjunctive use of available surface water supplies would reduce this cost and, more importantly, decrease the annual demand on the aquifers by approximately 50 percent (Black and Veatch 2004).

As water levels continue to decline, water pressure will drop and the possibility exists that the saturated rocks will no longer be able to support the weight of the overlying strata. Compaction will occur and, if significant enough, could lead to subsidence that propagates upwards to the land surface. This phenomenon has been seen in many urban areas where groundwater pumping is concentrated and can lead to considerable damage to existing streets, buildings, and infrastructure.

The available supply in the Denver Basin bedrock aquifers is further governed by the legal availability of the water. The legal availability is determined in part by the location in the basin and in part by the well age. Approximately the eastern half of the Denver Basin aquifers are part of one of four designated basins (Kiowa-Bijou, Lost Creek, Upper Big Sandy, and Upper Black Squirrel). In the western half of the Denver Basin, wells that have been permitted since 1973 and do not have an affect on the overlying surface streams are considered non-tributary and have been allowed to withdraw 1 percent of the water per year based on how much water is underlying the land owned or controlled by the appropriator, thus providing for at least a 100-year life for the aquifer.

7.2.3 Designated Groundwater Basins

Designated basin groundwater is located in eight specified areas in eastern Colorado, as shown in Figure 7-5. Designated basin groundwater is administered by the Colorado Groundwater Commission, with daily management typically given to the Ground Water Management District or districts within the basin. Rules governing usage differ by basin but typically distinguish between tributary and non-tributary aquifers, if both are present, and permit usage based on aquifer volume within an allowed radius and a specified annual rate of aquifer depletion.

7.2.3.1 Designated Basins Other Than the High Plains

There are six designated basins in this category, including four that comprise the eastern part of the Denver Basin geologic region (Lost Creek, Kiowa-Bijou, Upper Big Sandy, and Upper Black Squirrel) and two that exist elsewhere within the lower South Platte Basin (Camp Creek, Upper Crow Creek).

The alluvial aquifer in the Lost Creek, Kiowa-Bijou, and Upper Black Squirrel designated basins has been determined by the State Engineer to be overappropriated and, therefore, no new large capacity well permits will be granted.

The remaining aquifers in these designated basins, including the alluvial aquifer in the Upper Big Sandy, Camp Creek, and Upper Crow Creek, the bedrock aquifers within the Denver Basin region (Dawson, Denver, Arapahoe, and Laramie-Fox Hills), plus Camp Creek, and parts of Upper Crow Creek. In these areas, groundwater is subject to appropriation by high capacity wells provided the appropriation does not unreasonably impair existing water rights. The Colorado Groundwater Commission determines whether a proposed new well will cause an unreasonable impairment of existing rights.

7.2.3.2 High Plains Aquifer

The High Plains aquifer exists in the eastern portion of the state. It consists of the Ogallala aquifer, which extends from Texas to South Dakota, plus the overlying alluvial deposits of the Republican River Basin. This aquifer system is administered under the Northern and Southern High Plains Designated Basin rules and regulations. High capacity wells are allowed in both designated basins, with wells in the Northern High Plains designated basin being limited to a maximum allowable pumping rate such that 40 percent of the water in storage within the saturated materials can be depleted within 100 years.

It has been estimated that there is approximately 12.4 million AF of economically recoverable groundwater in the Southern High Plains designated basin (McLaughlin Water Engineers 2002). **Current withdrawal rates are approximately 220,000 AFY, leading to an estimated life of this portion of the High Plains aquifer of approximately 56 years.** Water levels have been declining in this basin at an average rate of approximately 5.4 feet per year over the past 10 years.

In the Northern High Plains designated basin there was an estimated 48 million AF of recoverable water in storage (Woodward-Clyde 1966) before the onset of large-scale pumping that occurred starting in the 1970s. At the time of the analysis, an estimated 160,000 acres were irrigated by groundwater pumping. This number grew rapidly to over 520,000 acres by 1975 and has averaged approximately 550,000 acres since the mid-1980s. The larger well production for irrigation has led to declines in water levels of over 10 feet in large areas of Phillips, Yuma, Kit Carson, and Cheyenne Counties where the High Plains aquifer exists (CGS 2003). The saturated thickness of the aquifer in this region is commonly over 100 feet (CGS 2003).

7.3 Available Surface Water and Alluvial Groundwater Supply in Each Basin

Legally and physically available flows, as well as naturalized flows, are summarized below at select locations for each basin to the extent possible given the available datasets. Naturalized flow is not calculated at all locations by StateMod. Therefore, in some cases, flows calculated for nearby locations were used in the summaries presented here. Calculated naturalized and physically available flows were not available for basins without StateMod datasets (Arkansas, North Platte, and South Platte). Alluvial groundwater supplies that are considered tributary to the major river systems are also summarized.

Historical flows at key gages in all river basins are monitored by the SEO. This map, commonly referred to as the "Snake Diagram" is a useful tool for illustrating the volume of flows throughout the state. The snake diagram is shown in Figure 7-6. It is important to note that the snake diagram does not include consideration of Colorado's commitments under compacts and decrees. Therefore, only a portion of the flows that are shown are available to Colorado.

There are numerous factors that may affect the physical and/or legal availability of surface water supplies. Some of the factors that are specific to individual basins are listed in the basin subsections below. General factors that must be considered when evaluating the availability of supply are listed in Table 7-2. As can be seen in the table, it is difficult to characterize supply availability without stating which factors have or have not been included in some fashion in the analysis.

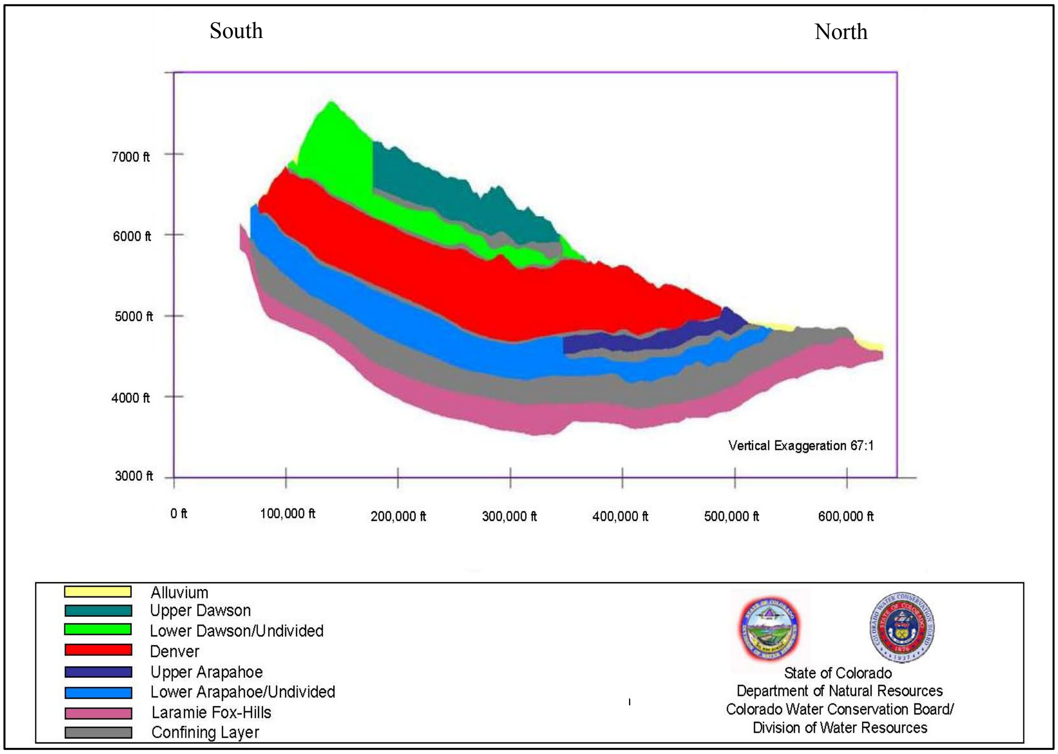


Figure 7-2
Denver Basin Aquifer South-North Cross Section
South Platte Basin
(Source: CWCB South Platte DSS)

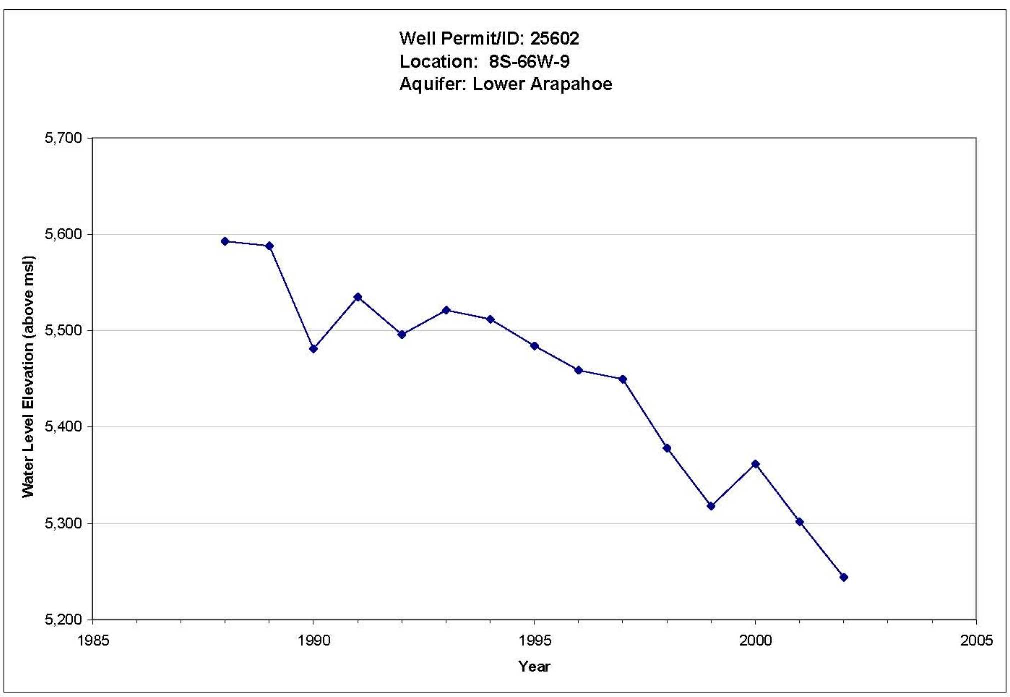
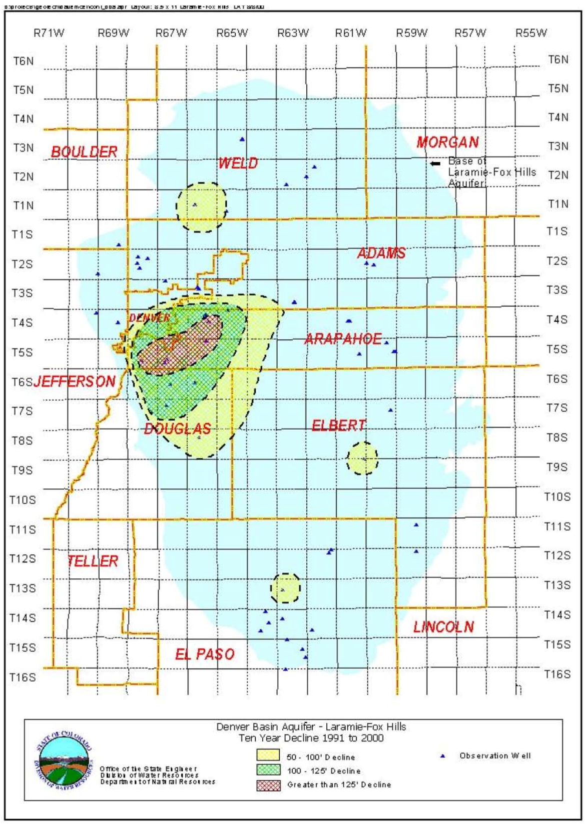


Figure 7-3
Lower Arapahoe Aquifer Water Elevation



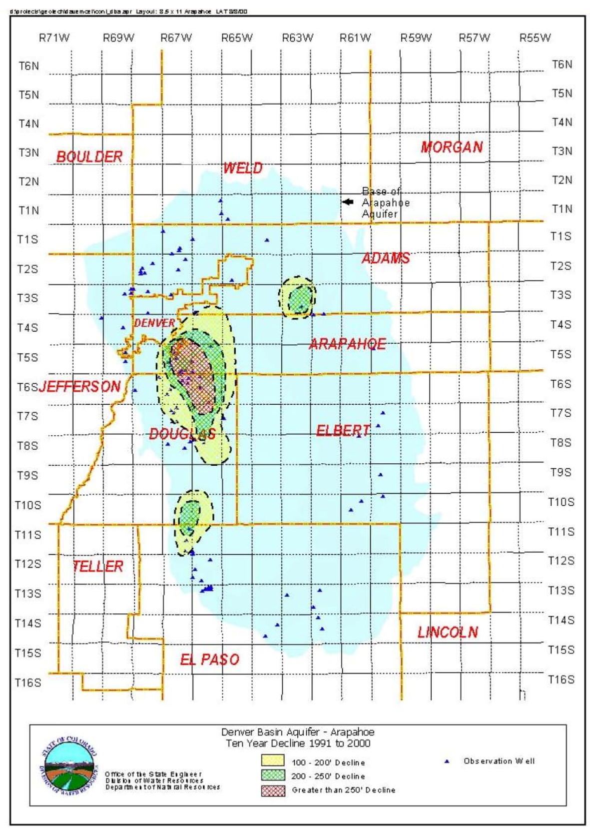


Figure 7-4
Arapahoe and Laramie-Fox Hills Aquifer Groundwater Level Decline (1991-2000)

Designated Ground Water Basins

Crow Creek & Camp Creek Basins

Irrigation and Domestic water is from both **Alluvial and Bedrock Aquifers. No surface water supply.**

Lack of precipitation may result in increased pumping and lowing of the water table. This would lead to higher energy and production costs.

Kiowa-Bijou

Irrigation water supply is from the **Alluvial Aquifer, No surface water supply.** Domestic supply from both **Alluvial and Bedrock Aquifers.**

Lack of precipitation may result in increased pumping and lowing of the water table. This would lead to higher energy and production costs.

Lost Creek

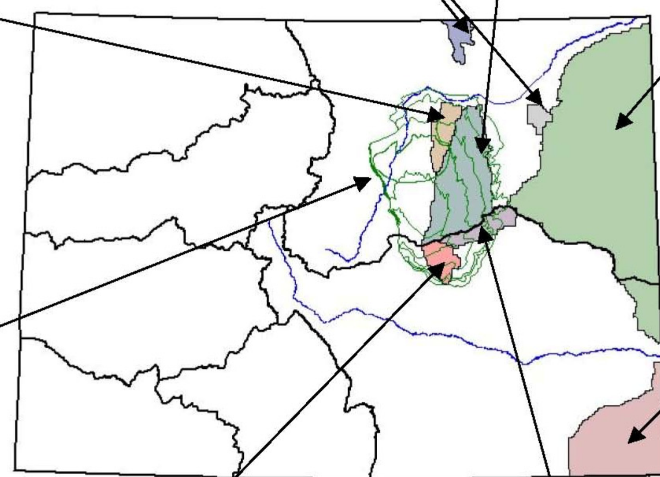
Irrigation and Domestic water is from both **Alluvial and Bedrock Aquifers. No surface water supply.**

Lack of precipitation may result in increased pumping and lowing of the water table. This would lead to higher energy and production costs.

Northern High Plains

Irrigation and domestic water supply is from the **Ogallala Aquifer. No surface water supply.**

Lack of precipitation may result in increased pumping and lowering water levels. This would lead to higher energy and production costs.



Southern High Plains

Irrigation and domestic water supply is from the **Ogallala, Dakota, Cheyenne and Docum Aquifers. No surface water supply**

Lack of precipitation may result in increased pumping and lowering water levels. This would lead to higher energy and production costs.

Denver Basin

Ground water supply is from the four major Denver Basin Bedrock Aquifers, **Dawson, Denver, Arapahoe and Laramie-Fox Hills.** The aquifers are not part of the surface system and are not affected by drought conditions. However, in times of shortages in the surface water supply, increased use of ground water from the basin can result in accelerated water level declines

Upper Black Squirrel

Irrigation water supply is from the **Alluvial Aquifer, No surface water supply.** Domestic water supply from **Denver Basin Aquifers**

Lack of precipitation may result in increased pumping and lowing of the water table. This would lead to higher energy and production costs.

Upper Big Sandy

Irrigation water supply is from the **Alluvial Aquifer, No surface water supply.** Domestic supply from **Alluvial and Bedrock Aquifers.**

Lack of precipitation may result in increased pumping and lowing of the water table. This would lead to higher energy and production costs.

Figure 7-5
Designated Groundwater Basins: Eastern Colorado

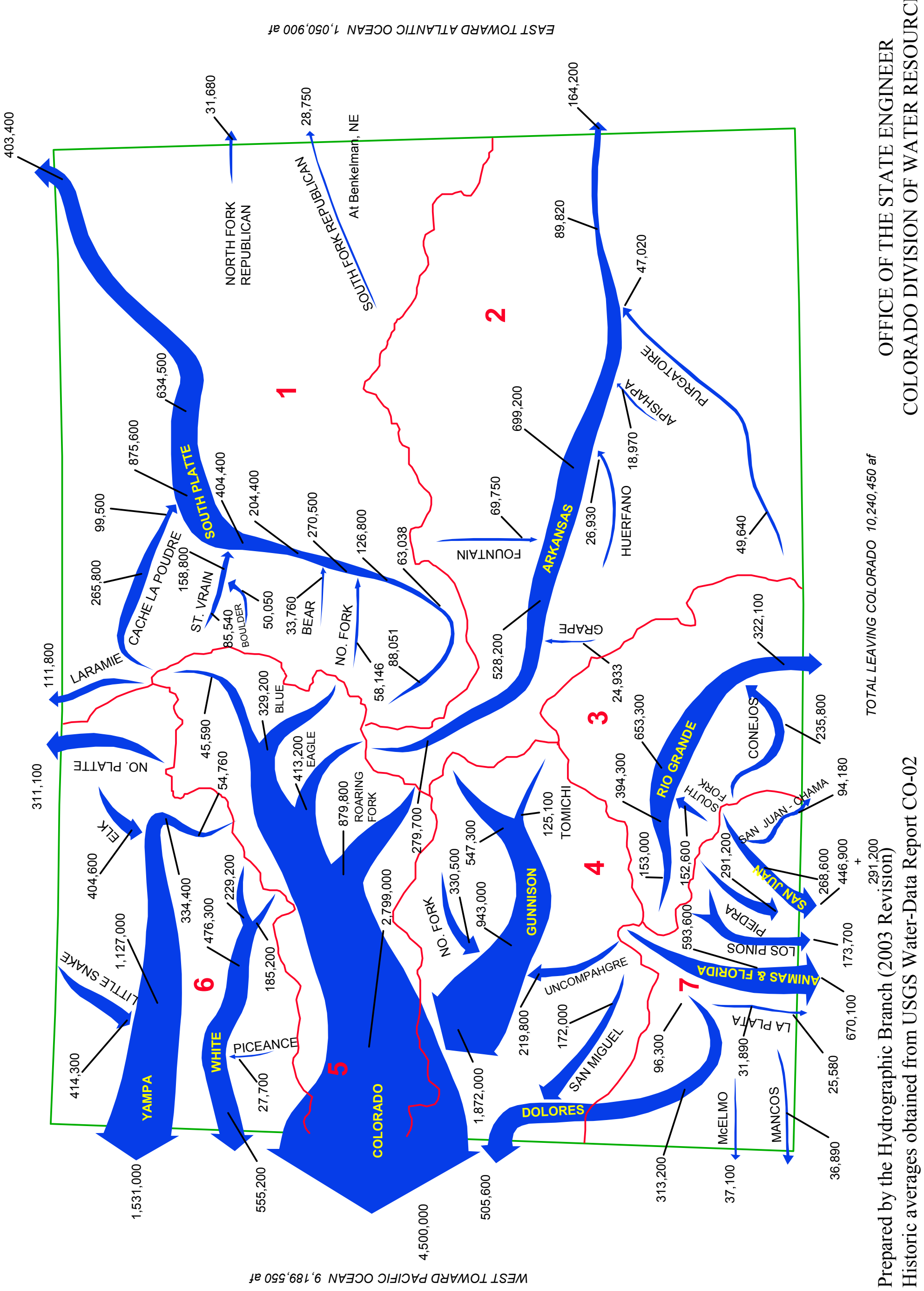


Figure 7-6
Colorado "Snake Diagram"

Table 7-2 Factors that May Affect Future Availability (Legal and/or Physical) of Supplies in Each Basin

Factors That May Decrease Availability of Water Supplies	Factors That May Increase Availability of Water Supplies
Increases in M&I and Self-Supplied Industrial CUs	Reduction in M&I and Self-Supplied Industrial CUs such as reducing lawn areas and industrial process improvements
Evaporation from new or enlarged reservoirs	Return flows from CU agricultural transfers that cannot be recaptured and reused
Increased reuse of existing consumable return flows	Unused CU yields from an agricultural transfer that cannot be stored by M&I or SSI users
New or increased transbasin diversions out of the basin	Increase in transbasin imports
Increase in agricultural CU ▪ Increase in irrigated lands ▪ Development of additional supplies to reduce or eliminate agricultural shortages ▪ Changes in irrigation efficiency such as conversion to sprinklers ▪ Changes to higher CU crops ▪ Diversion by downstream agricultural users of increases in M&I return flows	Decrease in agricultural CU ▪ Reduction in irrigated lands to lack of supplies for well augmentation ▪ Transfer of agricultural rights for dedication to in stream flows (increase in availability below the instream flow reach) ▪ Changes to lower CU by crops ▪ Changes in crop types
Development of irrigated lands resulting in a net increase in CU (increased depletions per acre)	Development of irrigated lands resulting in a net decrease in CU (decreased depletions per acre)
Additional flow requirements for species protection (e.g., endangered species)	Runoff from increase in impervious areas
RICDs and instream flow water rights filings (decrease in legal availability above the water right)	Return flows from increased non-tributary groundwater pumping (to the extent not reused)
Increase in coverage of phreatophytes or change in type of phreatophytes	Flow Management Agreements and/or Coordinated Reservoir Operations (increase in environmental or recreational flows for the specific reach at specific times)
Additional bypass flow requirements for existing projects	Endangered species recovery by means other than flows (stocking, habitat improvements, etc.)
Increase in coverage of phreatophytes or change in type of phreatophytes	Reduction in coverage of phreatophytes or change in type of phreatophytes
Hydrologic variability (e.g., climate change resulting in reduced runoff or extended droughts)	Hydrologic variability (e.g., climate change resulting in increased runoff or extended wet periods)

7.3.1 Arkansas Basin

7.3.1.1 Arkansas Basin Surface Water Supplies

StateMod datasets are not available for the Arkansas Basin. There are, however, a number of USGS flow gages, with extensive periods of record, located throughout the basin. Three of these gages, shown in Figure 7-7, were used to characterize historical physically available flow in the basin. These flows are measured and reflect actual historical diversions and demands, which may or may not reflect current conditions. The period of record varies by gage, spanning the time period 1890 to 2002 (full calendar years). The selected gage locations are:

- Arkansas River at Cañon City (1890 to 2002)
- Arkansas River at Las Animas (1940 to 2002)
- Arkansas River at Lamar (1914 to 2002)

Minimum, median, and maximum annual measured flows are summarized for each location in Figure 7-8. To better represent the effects of seasonal and year to year hydrologic variation, monthly summaries and annual time series of historical physical flows are shown in Figures 7-9 through 7-14. Median annual flows and 3-year running averages are also included on the annual time series plots. The monthly analyses highlight the fact that physical flows vary greatly with season, with the greatest amounts of water present in the spring and summer runoff months and a sharp decline in flows in the autumn and winter. The annual time series plots also show large variation with notable extended drought periods in the late 1950s, throughout the 1970s, and in the mid-1990s. Extended wet periods appear to have occurred in the 1920s and 1940s.

The interpretation above is in general agreement with the CWCB Drought Study (HDR 2003), which summarized the history of drought in Colorado and identified significant drought periods in the last 100 years. The Drought Study notes that the most recent drought analyzed for years 2000 to 2003 exceeds many of the drought records established during the 20th century.

A recent hydrologic analysis (SECWCD 2000) showed very little legally available flow in the basin (Figure 7-15). The analysis used hydrologic data from 1966 to 1995. **Native Arkansas River flows were available for a junior water right in only 3 of the 30 years evaluated. This interpretation was confirmed during the Arkansas Basin Roundtable Technical Meetings where there was consensus that there are no reliable available water supplies for development, but that there are infrequent very wet periods where water would be available.** These flows could be developed for use in a conjunctive use project where non-tributary groundwater could be used as a drought backup.

The 1948 Arkansas River Compact plays a major role in the limited supply availability in the basin. The Compact apportions the waters of the Arkansas River between Colorado (60 percent) and Kansas (40 percent), as administered by the Arkansas River Compact Administration.

Another factor that may affect supply availability in the basin, now or in the future, is the need and/or desire to maintain or enhance recreational and environmental flows. Environmental and recreational considerations are further developed in Sections 6 and 10 of this report. For example, a number of renowned whitewater rafting reaches are located in the basin, particularly along the Arkansas River upstream of Pueblo Reservoir. Additionally, as shown in Figure 3-8, the federally-listed Arkansas Darter is present in the Arkansas River and tributaries, and requires special attention with respect to habitat conditions. The City of Pueblo has filed for a RICD for a kayak course in the Arkansas River at the City of Pueblo, which, if approved, may impact water supply management alternatives for M&I and agricultural users.

7.3.1.2 Arkansas Basin Alluvial Aquifer

The alluvial aquifer that is associated with the Arkansas River is limited to the area near the river and its tributaries. Alluvium in the upper Arkansas Basin is typically discontinuous due to areas where the river has cut down to bedrock. This is seen in areas like the Royal Gorge and Brown's Canyon (CGS 2003). Once the river passes Pueblo Reservoir, the alluvial aquifer exhibits more continuity and continues uninterrupted to the Colorado-Kansas state line.

The alluvial aquifer has a maximum thickness of 250 feet on the valley floor. The alluvium in the tributary streams ranges from 0 to 50 feet (Byler et al. 1999). Like the South Platte River alluvial aquifer, this aquifer has a high hydraulic conductivity in its lower reach downstream of Pueblo Reservoir and is very productive. It is replenished by return flows from irrigation of adjacent lands and is considered a renewable resource. However, the groundwater in this aquifer is considered tributary to the Arkansas River and users of this resource are administered under the Prior Appropriation System. Except for domestic or other low-volume exempt uses, the use of groundwater in this aquifer requires a water court-approved augmentation plan that describes how depletions to the river will be offset to avoid injury to senior appropriators and to comply with the interstate compact with Kansas. Rulemaking by the State Engineer in 1996 requires all wells to have meters installed so that total amounts withdrawn can be better regulated. This may have the effect of reducing future withdrawals to comply with the interstate compact.

The location and extent of alluvial aquifer in the Arkansas Basin is shown in Figure 3-6.

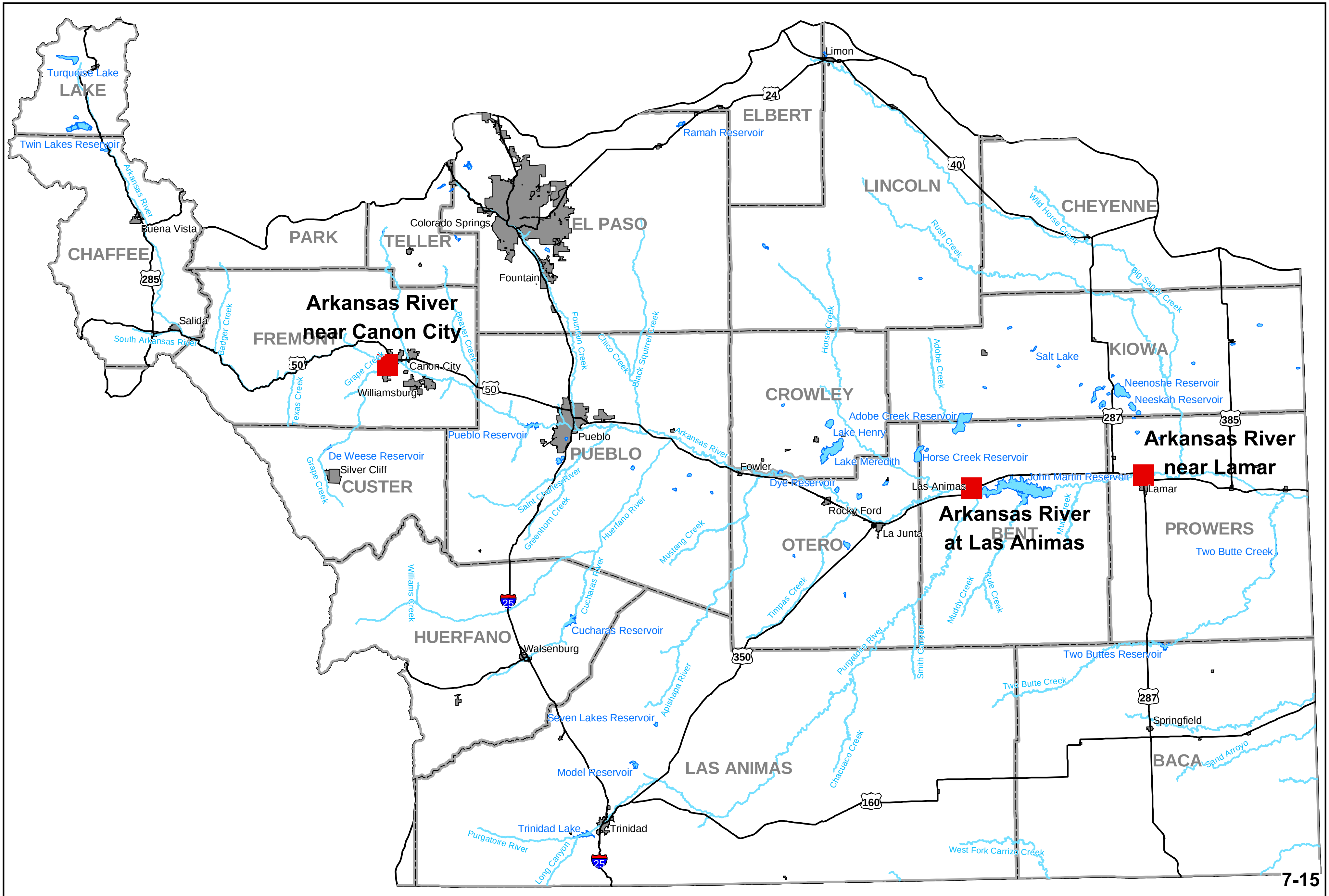


Figure 7-7
Arkansas Basin
Selected Locations, Water Supply Availability

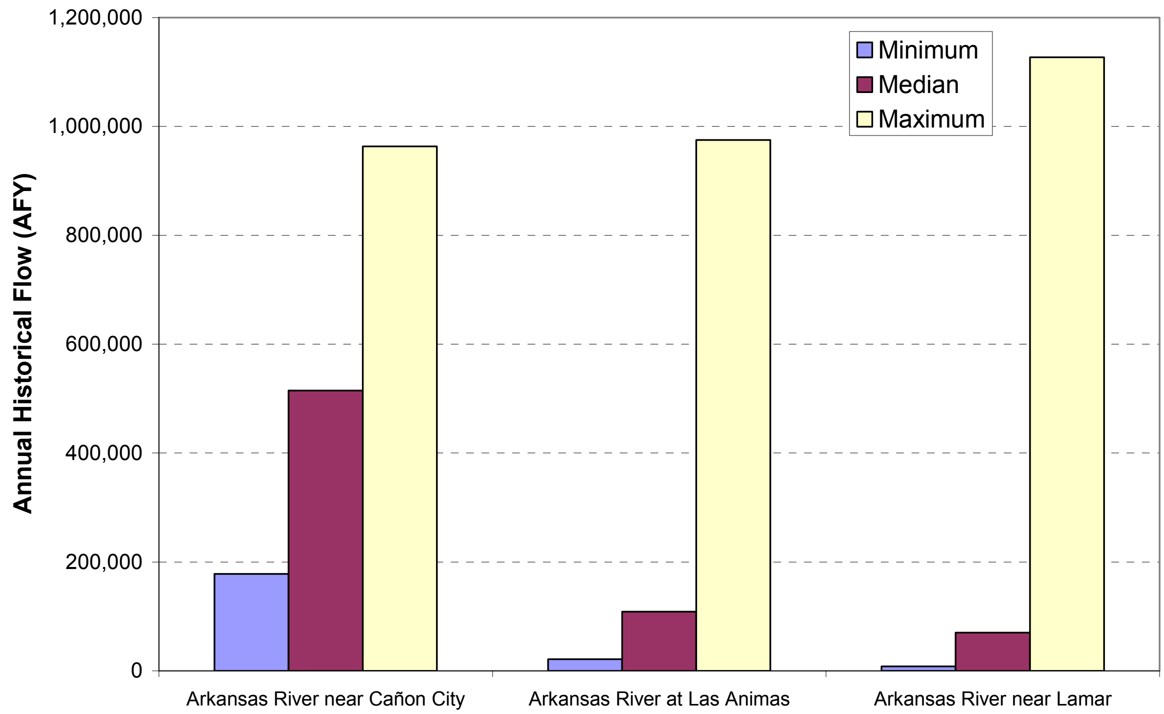


Figure 7-8
Minimum, Median, and Maximum Annual Historical Flows
Arkansas Basin

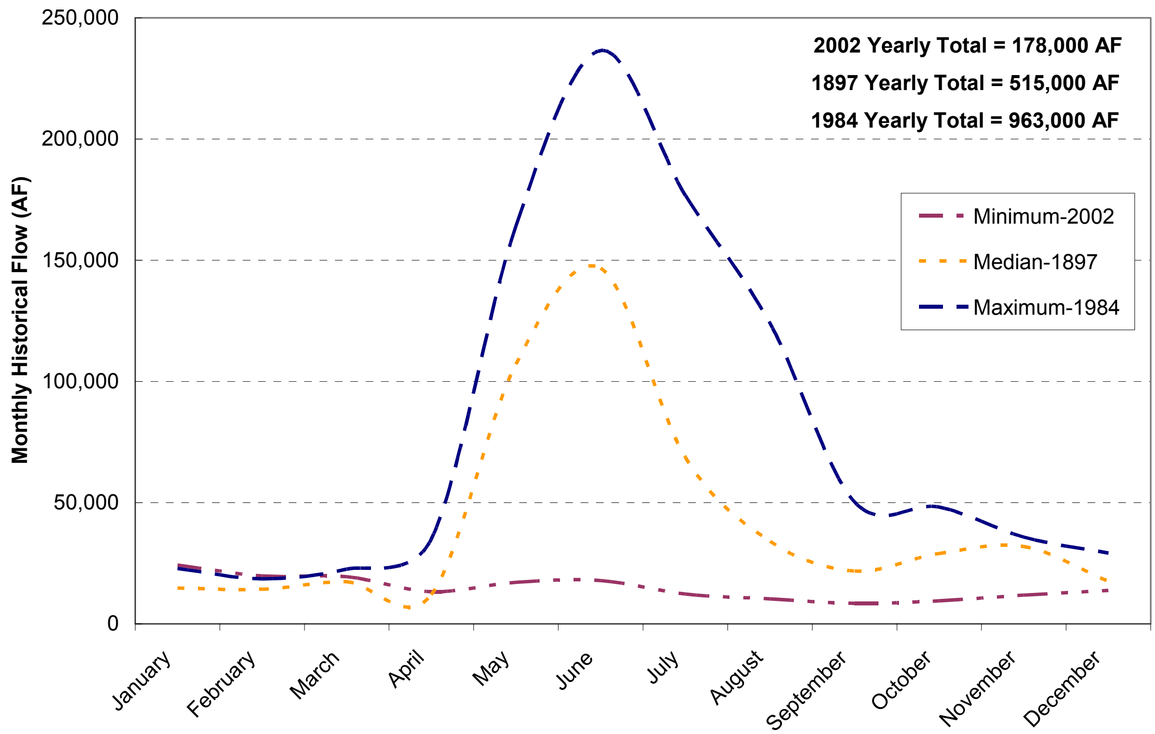


Figure 7-9
Monthly Historical Flow
Arkansas River Gage at Cañon City (1890-2002)

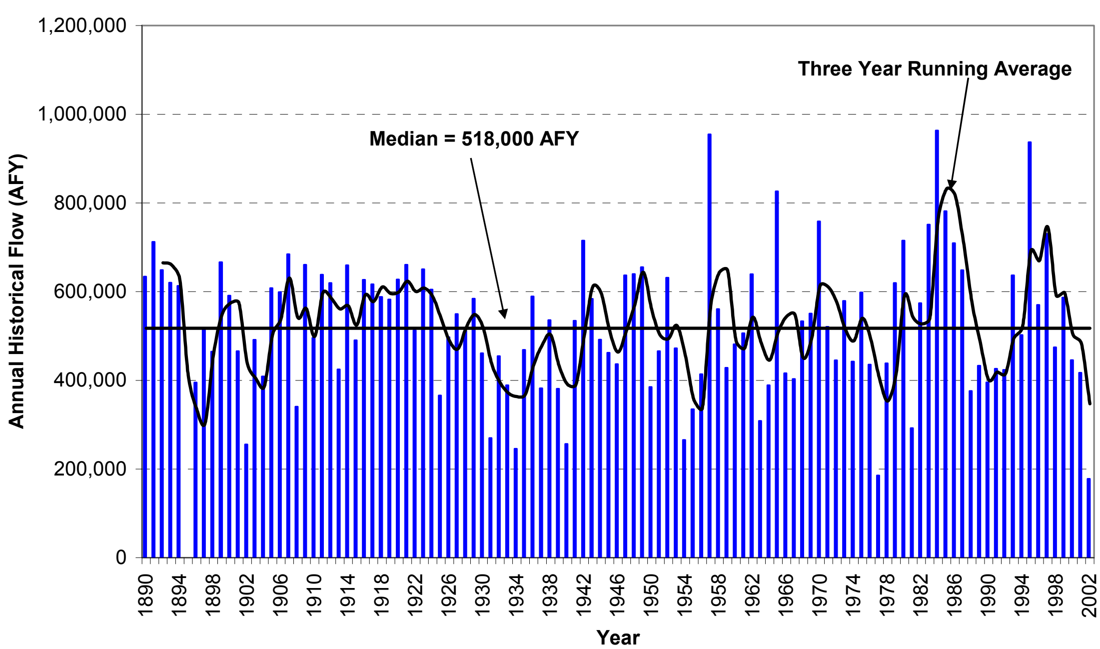


Figure 7-10
Annual Historical Flow
Arkansas River Gage at Cañon City (1890-2002)

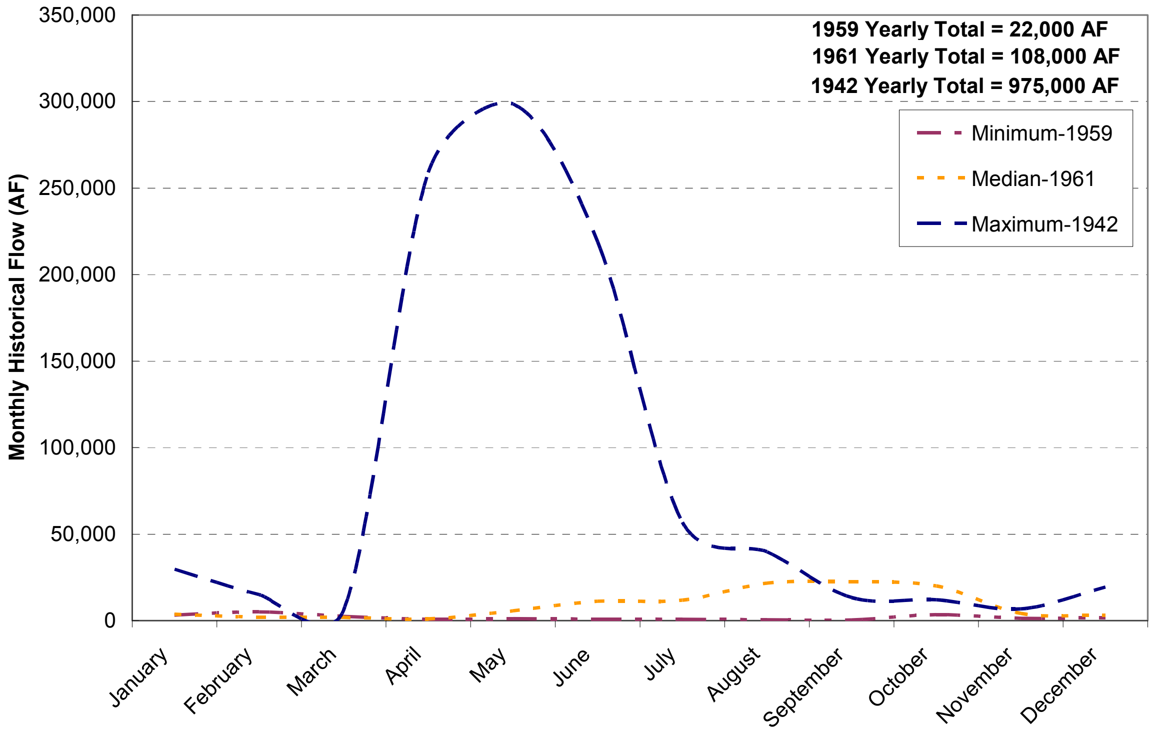


Figure 7-11
Monthly Historical Flow
Arkansas River Gage at Las Animas (1940-2002)

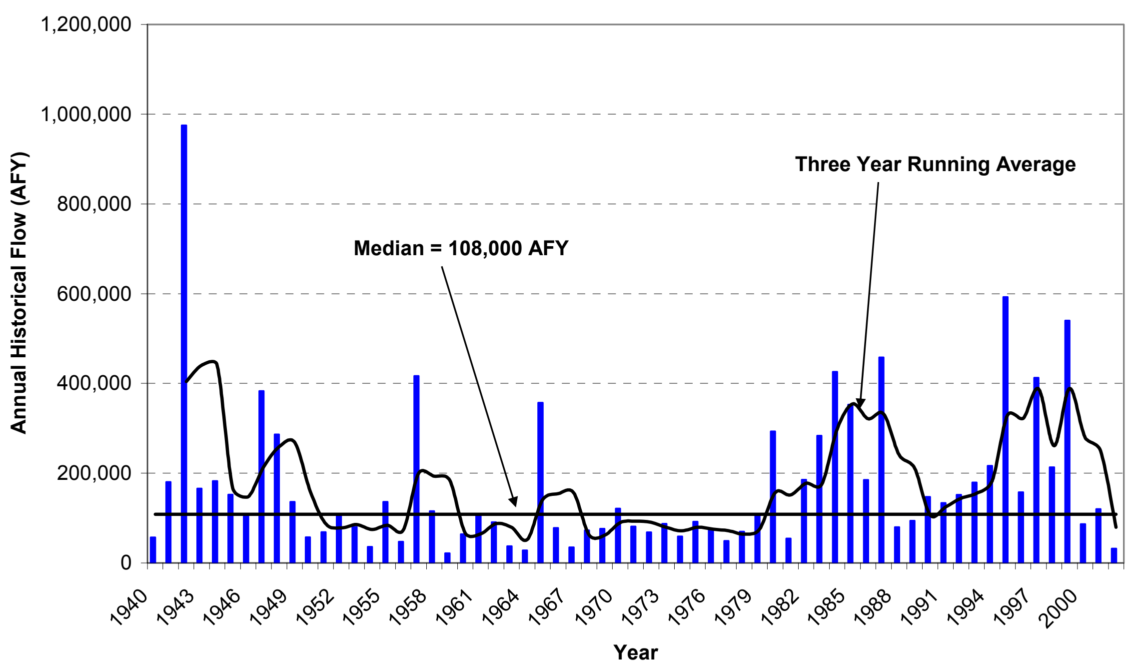


Figure 7-12
Annual Historical Flow
Arkansas River Gage at Las Animas

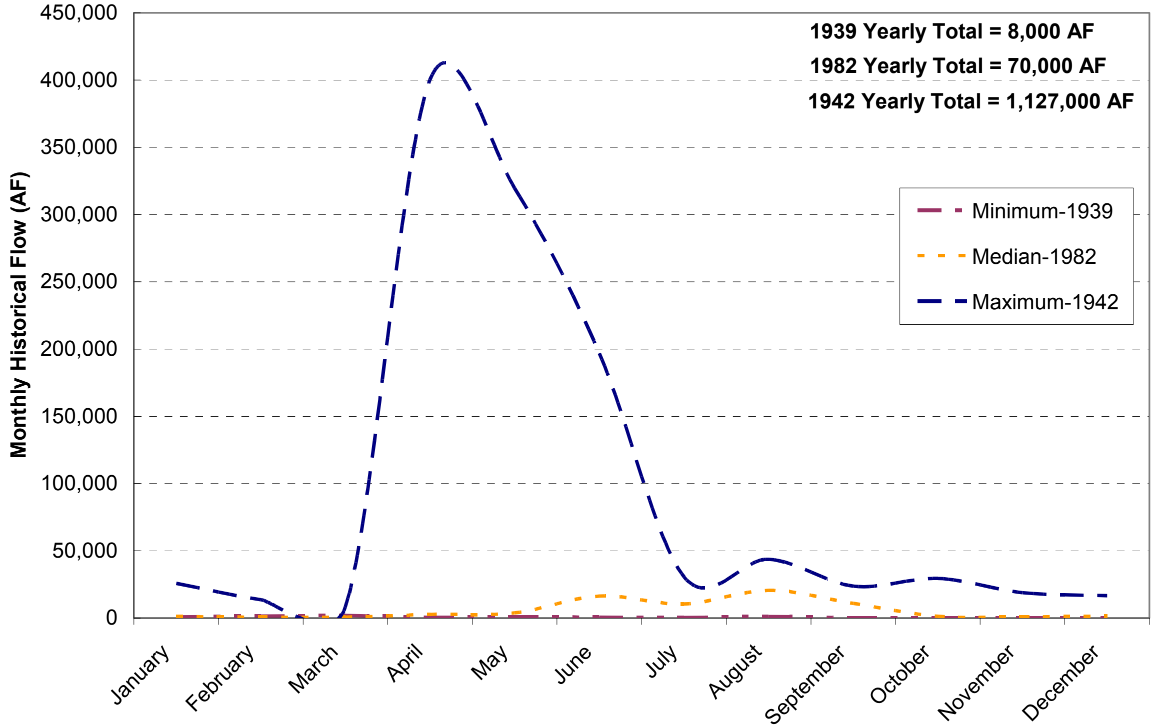


Figure 7-13
Monthly Historical Flow
Arkansas River Gage at Lamar (1914-2002)

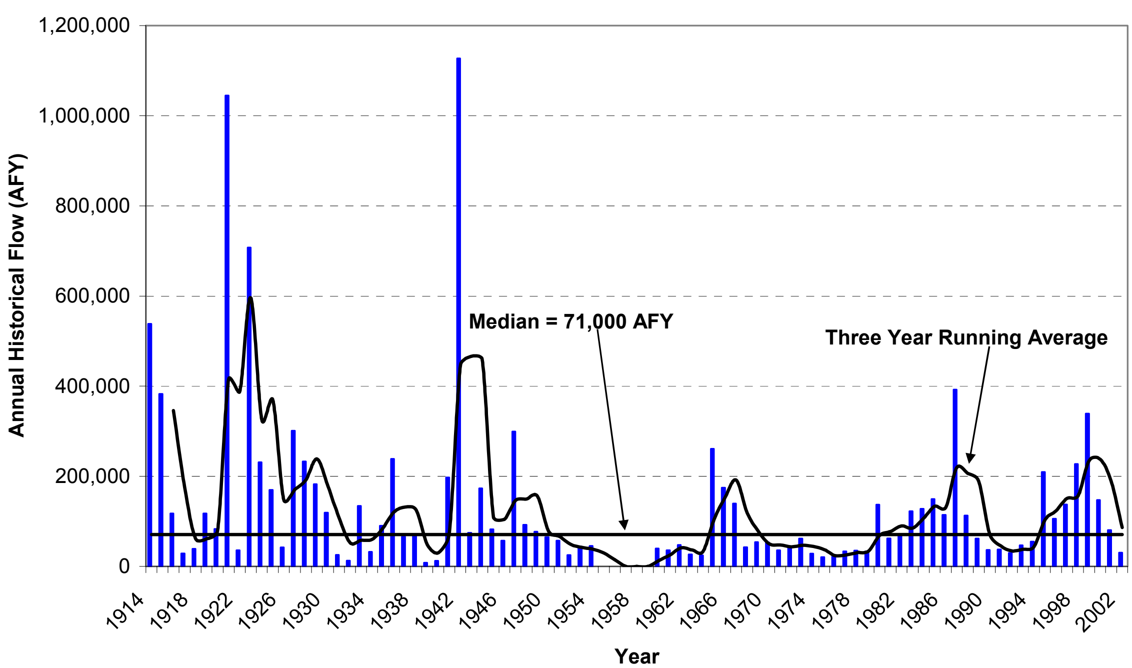


Figure 7-14
Annual Historical Flow
Arkansas River Gage at Lamar (1914-2002)

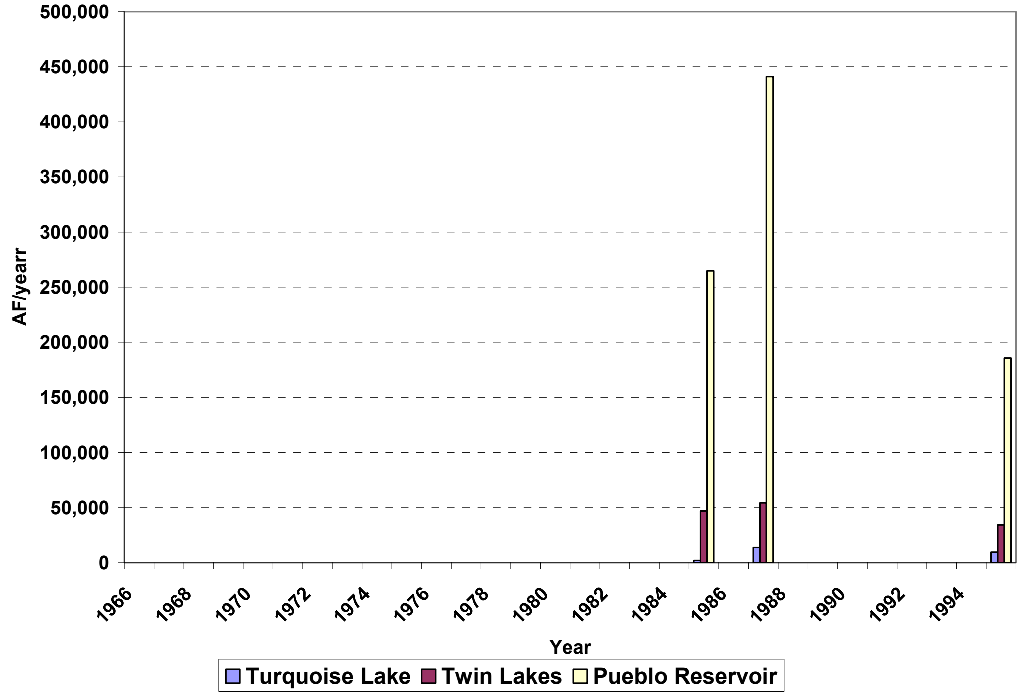


Figure 7-15
Estimate of Available Water for Fry-Ark Project Diversions
Arkansas River Junior Water Rights

7.3.2 Colorado Basin

7.3.2.1 Colorado Basin Surface Water Supplies

Six locations were selected for the Colorado basin to characterize surface water supply availability using StateMod datasets. The period of record for the Colorado StateMod datasets is 1909 to 1995 (full calendar years). The selected locations, shown in Figure 7-16 are:

- Blue River below Green Mountain Reservoir
- Roaring Fork River near Glenwood Springs
- Colorado River near Kremmling
- Colorado River near Dotsero
- Colorado River near Debeque
- Colorado River at the state line

Median annual legally available, physically available, and naturalized flows are summarized for each location in Figure 7-17. Differences between legally and physically available flows indicate that much of the physically available flow at upstream locations may not be available for development due to senior downstream water rights. Figure 7-18 shows minimum, median, and maximum annual legally available flows for the period of record. The wide range of annual flows at the locations between wet and dry periods and an analysis of potential reservoir yields indicate that firm yield supply is significantly less than average yield supply.

To better represent the effects of seasonal and year to year hydrologic variation, monthly (for minimum, maximum, and median years) and annual time series of legally available flows for the periods of record are shown in Figures 7-19 through 7-30. The median annual flow and 3-year running averages are also included on the annual time series plots. The monthly analyses highlight the fact that available flows vary greatly with season, with the greatest amounts of water available in the summer months and a sharp decline in flows in the autumn and winter. The annual time series plots also show large variation with a notable extended drought period from the late 1980s to the early 1990s and more acute droughts in the mid-1930s, 1950s, and late 1970s. Extended wet periods evident in these figures include the late 1920s and the mid-1980s.

The interpretation above is in general agreement with the CWCB Drought Study (HDR 2003), which summarized the history of drought in Colorado and identified significant drought periods in the last 100 years. The Drought Study notes that the most recent drought analyzed for years 2000 to 2003 exceeds many of the drought records established during the 20th century. It should be noted that the drought period of the past few years is not yet included in the StateMod datasets, and therefore, not represented in the available flow numbers presented here.

Finally, Figure 7-31 is provided to further quantify the impacts of seasonal and year to year hydrologic variation and to illustrate the difference between average annual available flow and the potential annual firm yield. This chart shows firm yield as a function of total available storage for legally available flows at the Colorado River near Dotsero, where even with very large volumes of storage, the maximum annual firm yield is approximately 65 percent of the average annual available flow. The curve reaches an asymptotic value of 350,000 AFY at approximately 2,000,000 AF total storage, beyond which no significant gains in firm yield can be achieved with increased storage. At the asymptotic value, all excess water is captured, stored, and used, but supply is still limited (below the average annual) by the *timing* of the available flows and reservoir evaporation and seepage. The critical (limiting) periods for this analysis are the late 1970s for smaller storage volume yields, and the early 1990s for larger storage volume yields. Note that yields would likely be significantly higher if some value or frequency of shortages, greater than zero, were acceptable. Potential limitations to the projected supply availability as a result of the Colorado River Compact are evaluated in Section 7.4. The Compact includes potential limitations for the Colorado, Gunnison, Dolores/San Juan/San Miguel, and Yampa/White/Green Basins combined as well as additional limitations on certain subbasins.

In addition to the Colorado River Compact, there are other factors not reflected in the data presented that may further limit future supply availability as summarized below. The future development of existing conditional water rights are not included in the DSS datasets. These water rights could eventually be developed resulting in less available water for the rest of the basin. Development of conditional rights, however, must be applied to beneficial use and meet a water need. Conditional water rights, by basin, are summarized in Section 10.

Since the current Colorado DSS dataset covers the period from 1909 to 1995, once the current drought has ended, the DSS dataset for the Colorado should be extended, including updated irrigated acres and M&I demands. A new StateMod model run should be conducted with the updated dataset to determine if the recent drought is a new critical period.

Maintaining or enhancing recreational and environmental flows could also affect future supply availability. Environmental and recreational considerations are further developed in Sections 6 and 10 of this report. For example, a number of endangered fish species, such as the Razorback Sucker and the Humpback Chub, are present in the Colorado River and tributaries, and require special attention. The Colorado River immediately upstream from the confluence with the Gunnison River (15-mile reach) is currently operating under a PBO that may affect the amount of allowable depletions in this upper subbasin to help promote the recovery of four endangered fish species. Coordinated reservoir operations, habitat improvement, stocking, and control of non-native species are other options that can help meet the needs of endangered species.

Water is available for future demands out of contract pools in Green Mountain, Ruedi, and Wolford Mountain Reservoirs. There is approximately 10,000 AFY available from Green Mountain, 21,000 AF from Ruedi, and 7,500 AF from Wolford Mountain Reservoirs. Existing and future supply availability out of Green Mountain Reservoir may be affected by minimum storage restrictions recently placed on the reservoir. Historic movement of landslides in the adjacent Town of Heeney are a concern during low water storage levels such as occurred during the recent drought period and caused storage restrictions. If it is determined that the reservoir must maintain these minimum storage levels long term, and storage is not replaced elsewhere, there may be a permanent loss of firm yield for the users of Green Mountain Reservoir.

Finally, in addition to future in-basin demands, there will likely be additional diversions through existing transbasin facilities (such as Denver Water's Roberts and Moffat Tunnels and NCWCD's CBT and Windy Gap firming projects) as these transbasin diverters grow into their Colorado Basin water rights and firm existing water rights with east slope storage. These increased transbasin diversions are not included in the present DSS analysis, but will affect future supply availability in the Colorado Basin. SWSI recognizes the need to evaluate future available supply in the headwaters of the Colorado Basin. This will be evaluated in more detail as part of SWSI's ongoing work in 2005 to 2006. The Denver Water Northern Firming and the NCWCD's Windy Gap Firming Projects, if implemented, could increase average annual diversions from the Colorado to the South Platte by up to 48,000 AFY. The proposed Homestake II or Wolcott Reservoir Projects could also potentially increase transbasin diversions. Historical transbasin diversions from the Colorado Basin are shown in Figure 7-32. Transbasin diversions averaged 482,728 AFY from 1971 to 2003. The locations of transbasin diversions from the Colorado, Gunnison, and Dolores/San Juan/San Miguel Basins are shown in Figure 7-33.

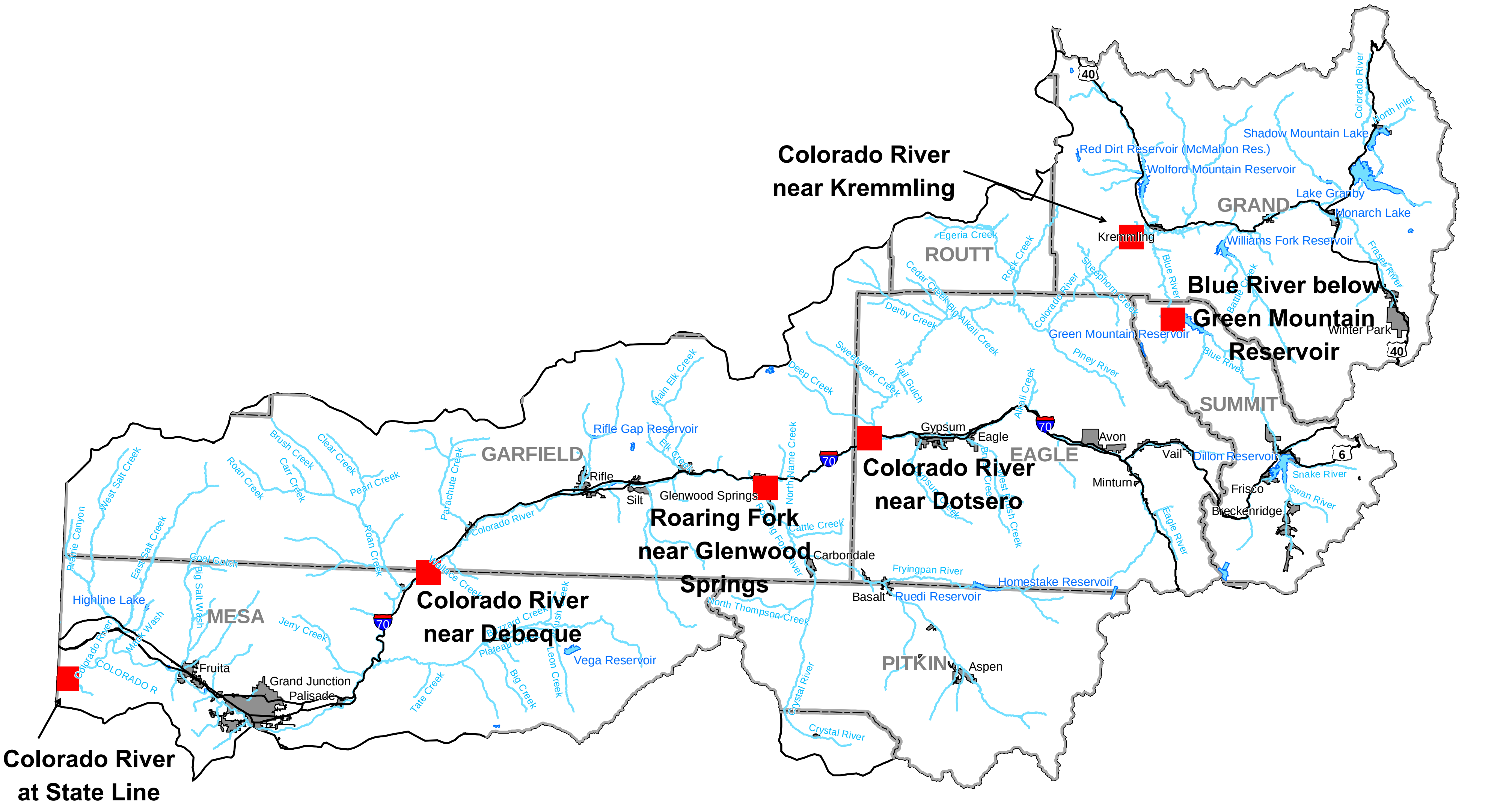
7.3.2.2 Colorado Basin Alluvial Aquifer

The distribution of alluvial deposits in the Colorado Basin varies greatly from one reach to the next. The alluvial deposits, as mapped by USGS geologic quadrangle maps, are primarily located near the Towns of Eagle and Gypsum, along the Roaring Fork River, Roan Creek, and from the Town of Palisade to the Colorado-Utah state line. Alluvium is very limited or non-existent in the canyon sections of the Colorado River where the bedrock is exposed (CGS 2003).

The saturated thickness of the alluvium in the basin is represented by the interval from the water table to the underlying bedrock. Welder (1987) reported that test holes in the alluvium of Roan and Parachute Creeks penetrated 80 feet and 70 feet, respectively, of saturated permeable sand and gravel. For the Fraser River, Apodaca and Bails (1999) report alluvial saturated thickness ranging from 14 to 45 feet, averaging 21 feet in the spring, and ranging from 7 to 20 feet in the fall with an average of 15 feet.

The alluvial groundwater in the Colorado Basin is considered tributary to the Colorado River and users of this resource are administered under the Prior Appropriation System. Except for domestic or other low-volume exempt uses, the use of groundwater in this aquifer requires a water court-approved augmentation plan that describes how depletions to the river will be offset to avoid injury to senior appropriators and to comply with the interstate compact.

The location and extent of alluvial aquifer in the Colorado River Basin is shown in Figure 3-13.



7-23

Figure 7-16
Colorado Basin Selected Locations, Water Supply Availability

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Model Node

10 5 0 10 Miles
1:1,200,000

N
Coordinate System
NAD 1927 UTM Zone 13N

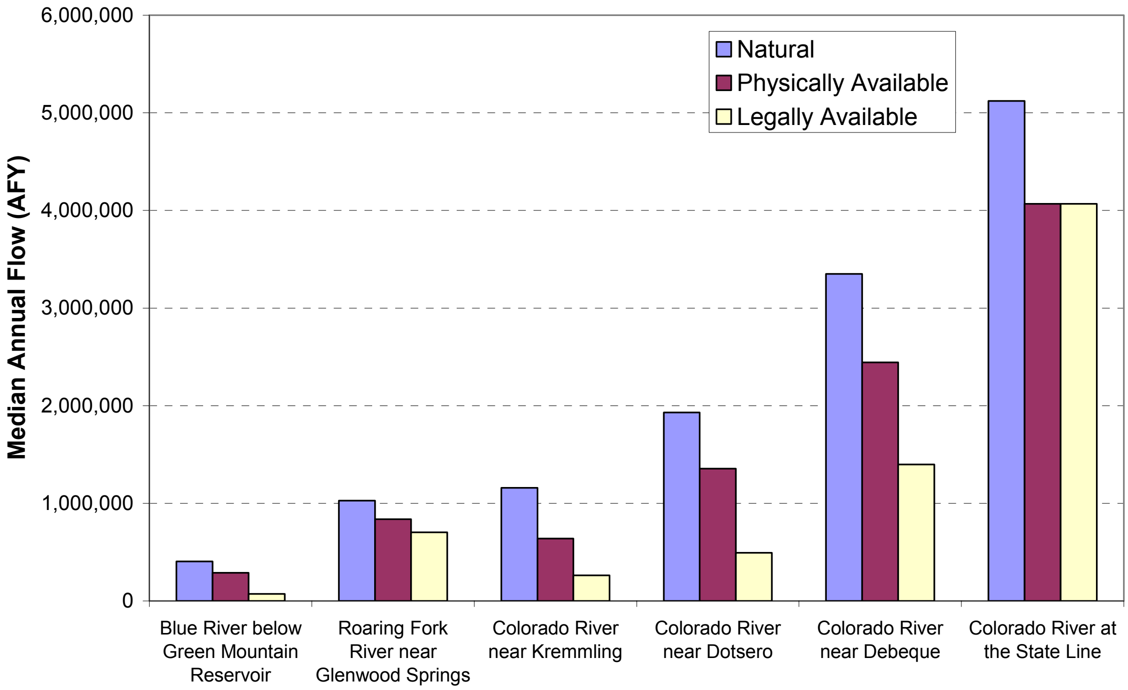


Figure 7-17
Median Annual Natural, Physically Available, and Legally Available Flows
Colorado Basin

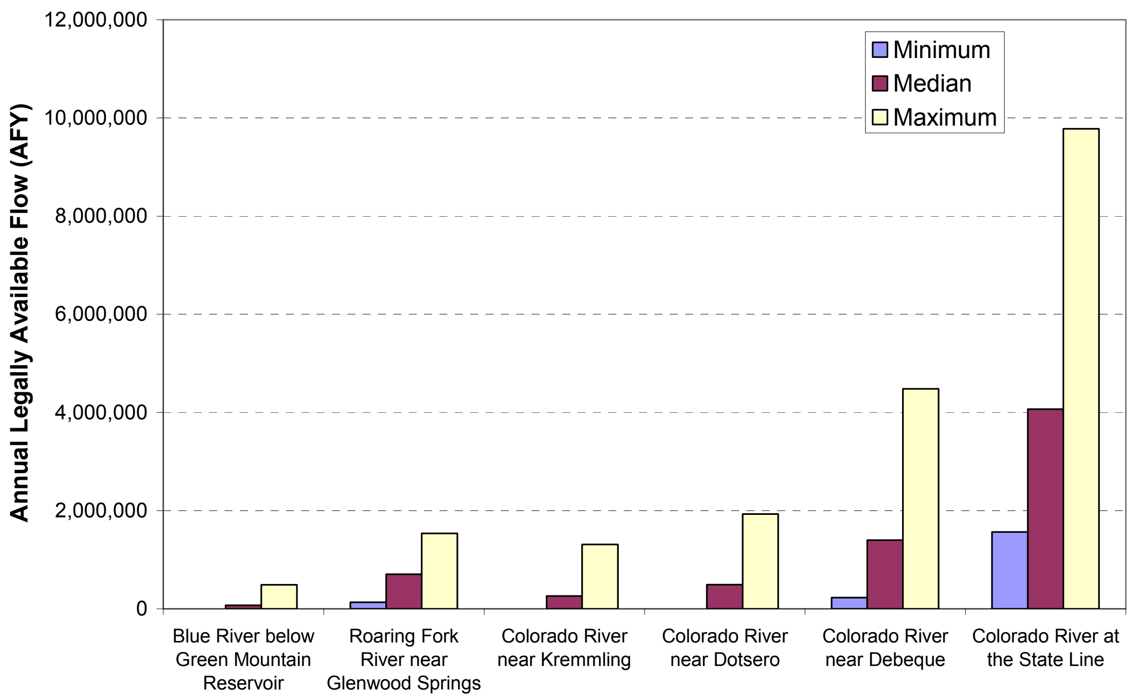


Figure 7-18
Minimum, Median, and Maximum Annual Legally Available Flows
Colorado Basin

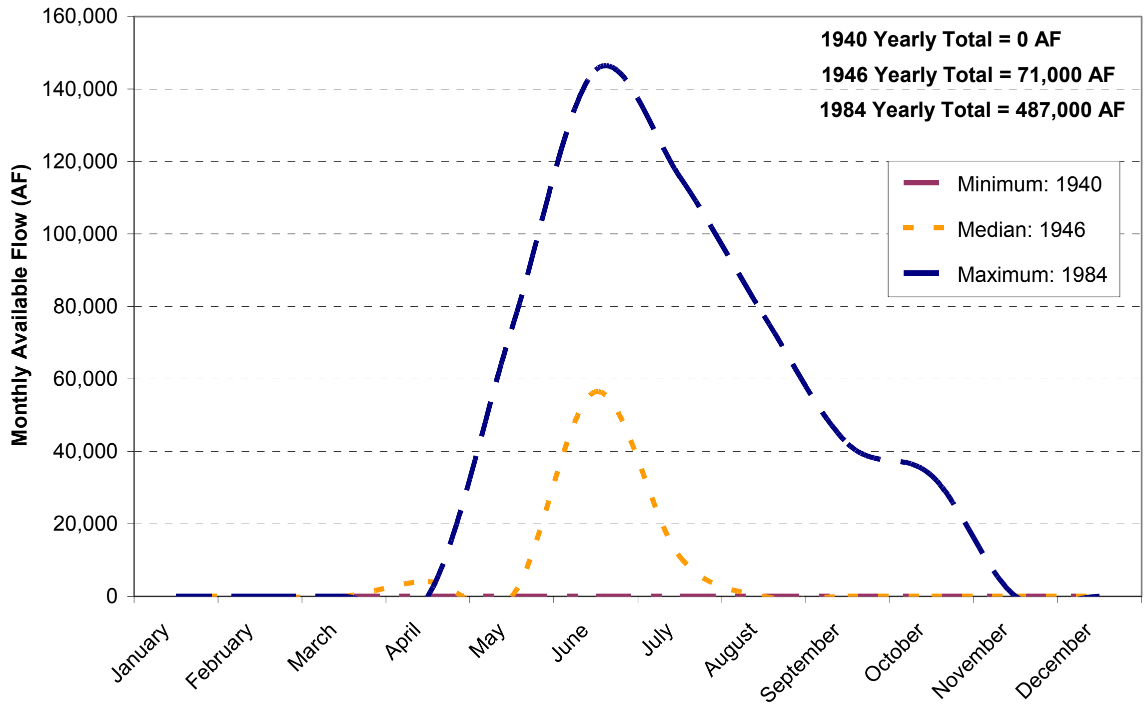


Figure 7-19
Monthly Legally Available Flow
Blue River below Green Mountain Reservoir (1909-1995)

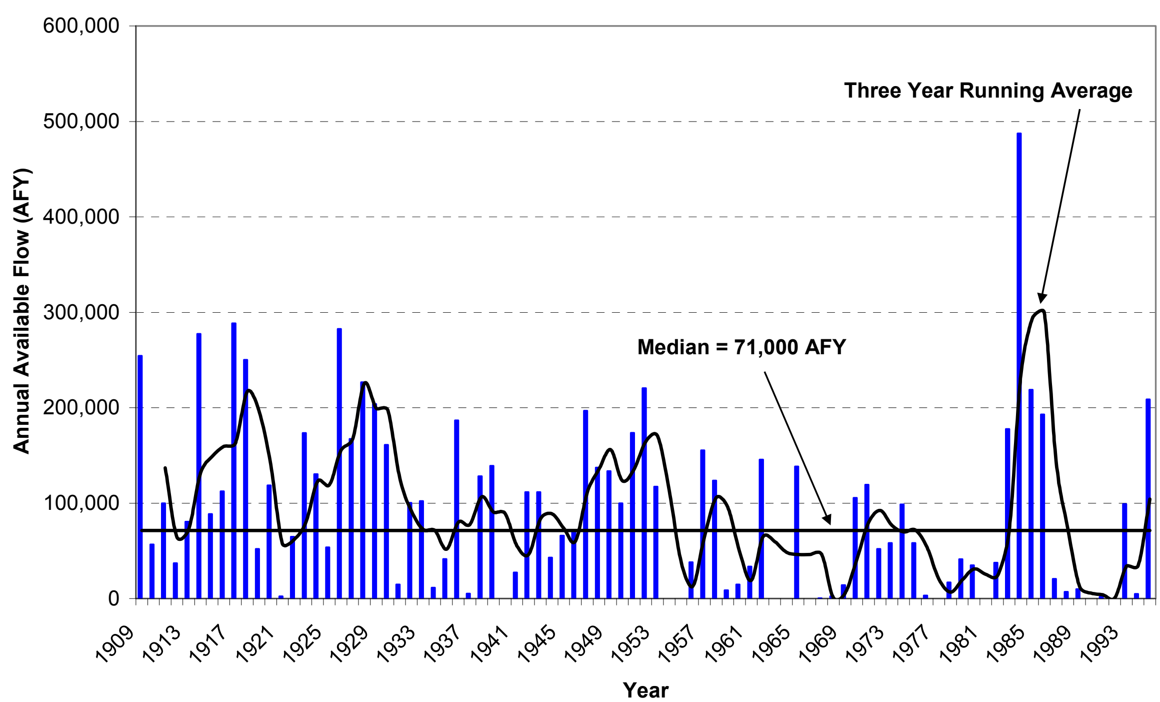


Figure 7-20
Annual Legally Available Flow
Blue River below Green Mountain Reservoir (1909-1995)

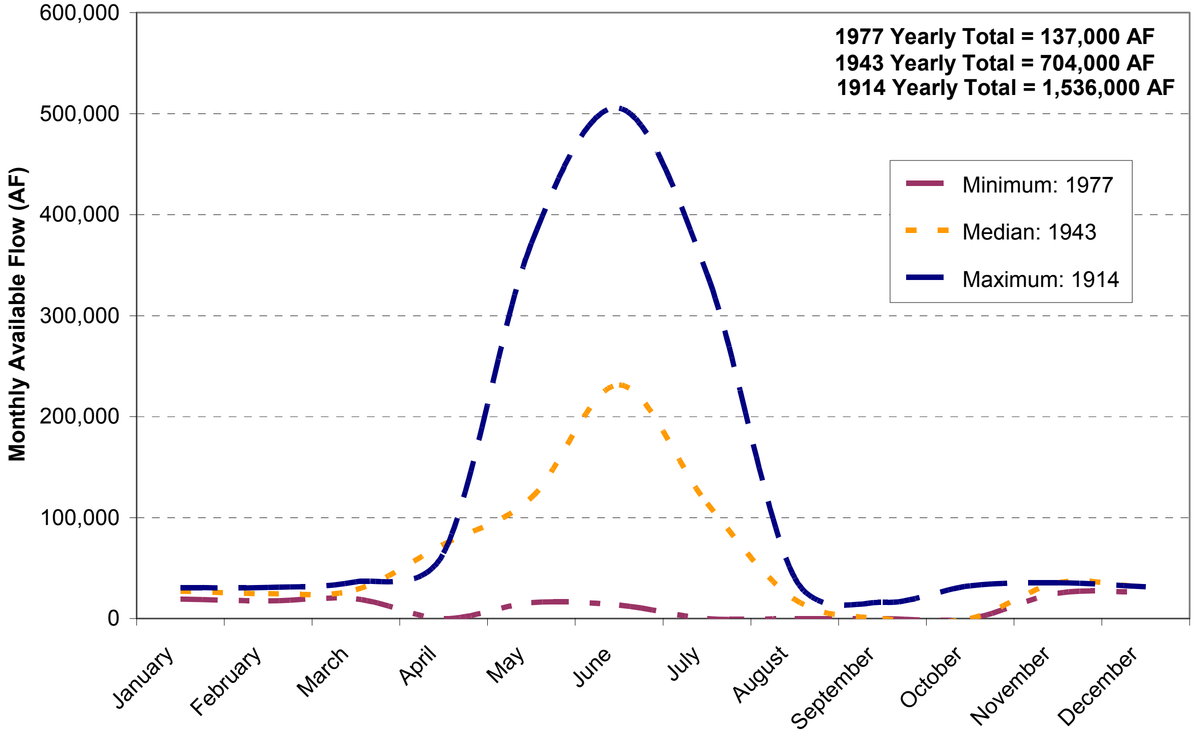


Figure 7-21
Monthly Legally Available Flow
Roaring Fork River near Glenwood Springs (1909-1995)

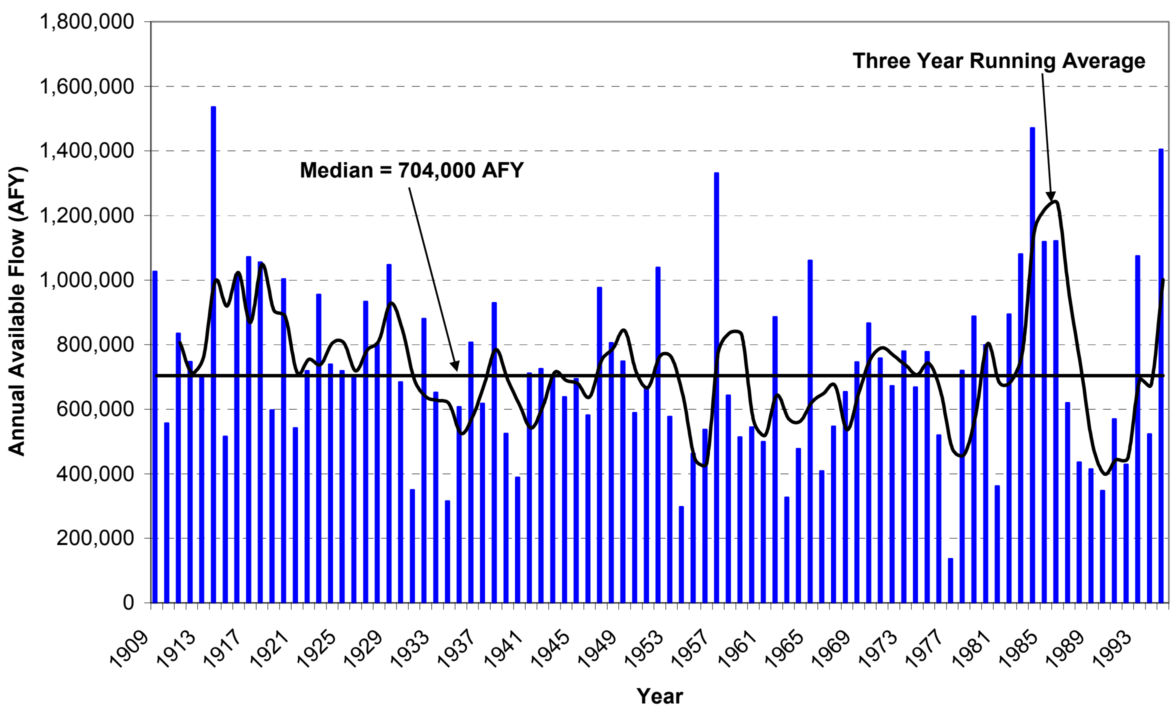


Figure 7-22
Annual Legally Available Flow
Roaring Fork River near Glenwood Springs (1909-1995)

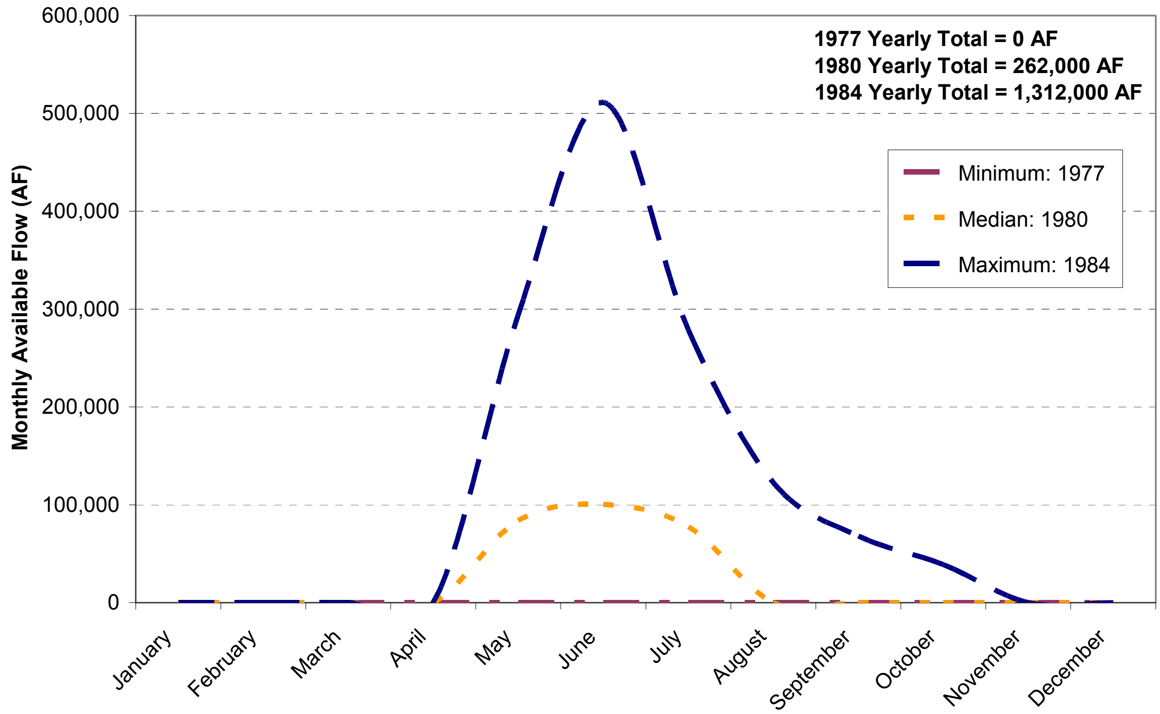


Figure 7-23
Monthly Legally Available Flow
Colorado River near Kremmling (1909-1995)

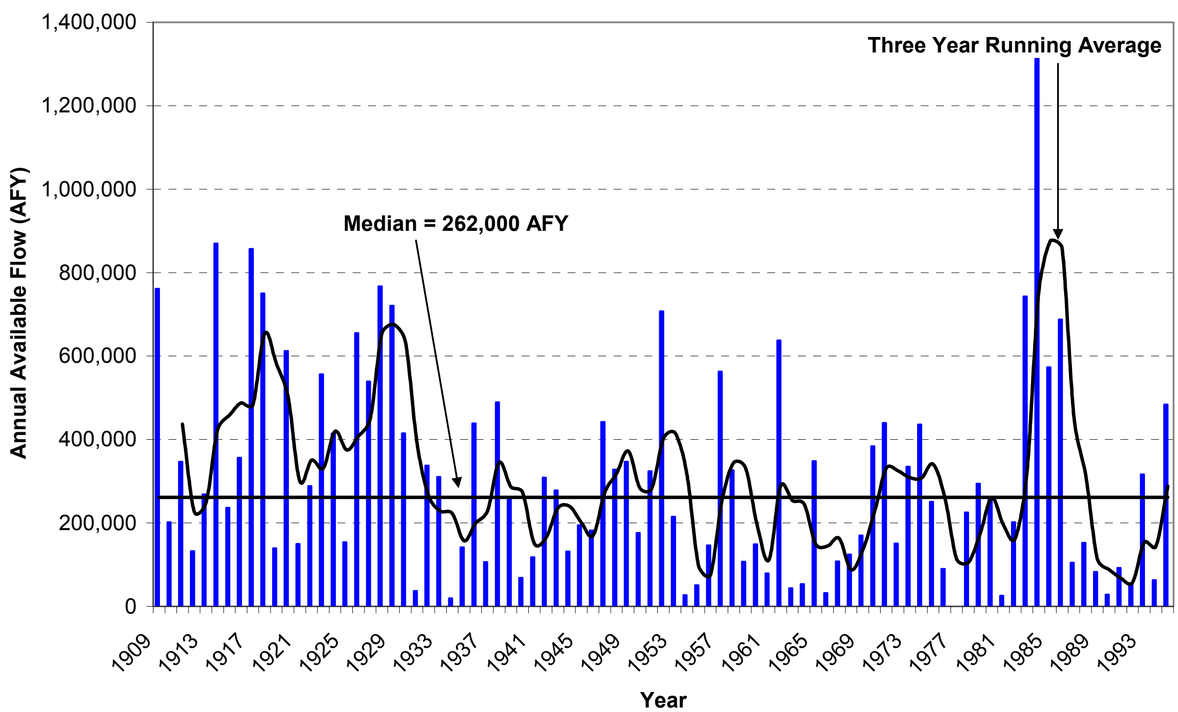


Figure 7-24
Annual Legally Available Flow
Colorado River near Kremmling (1909-1995)

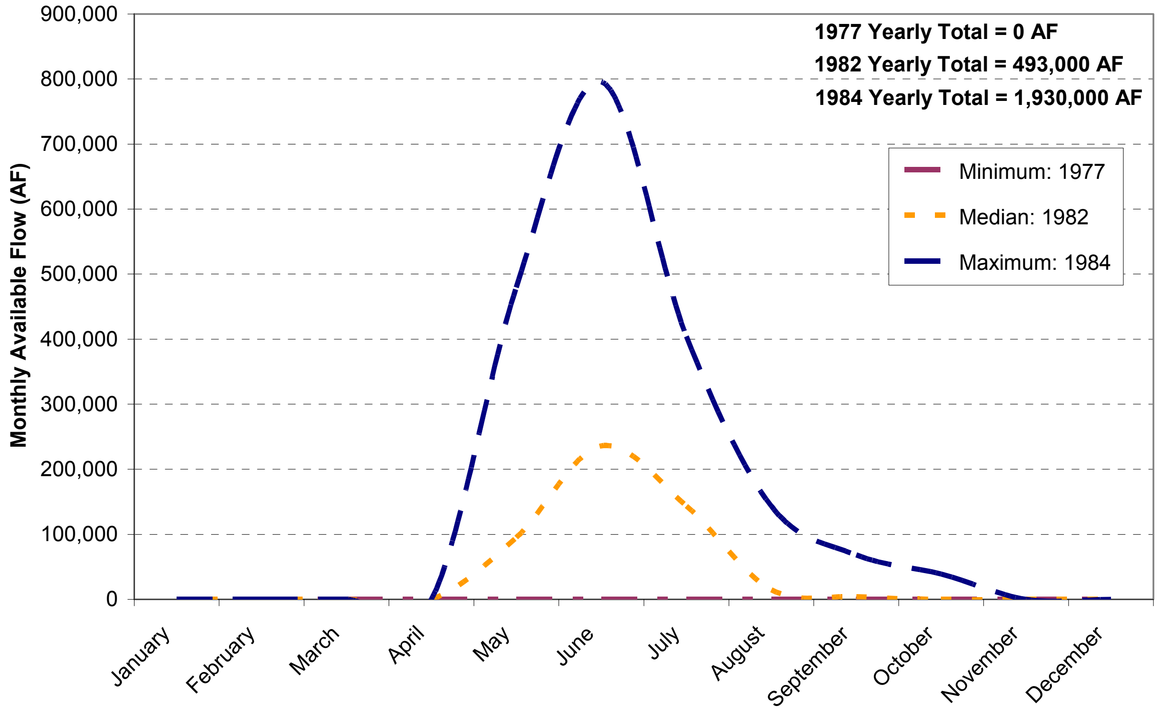


Figure 7-25
Monthly Legally Available Flow
Colorado River near Dotsero (1909-1995)

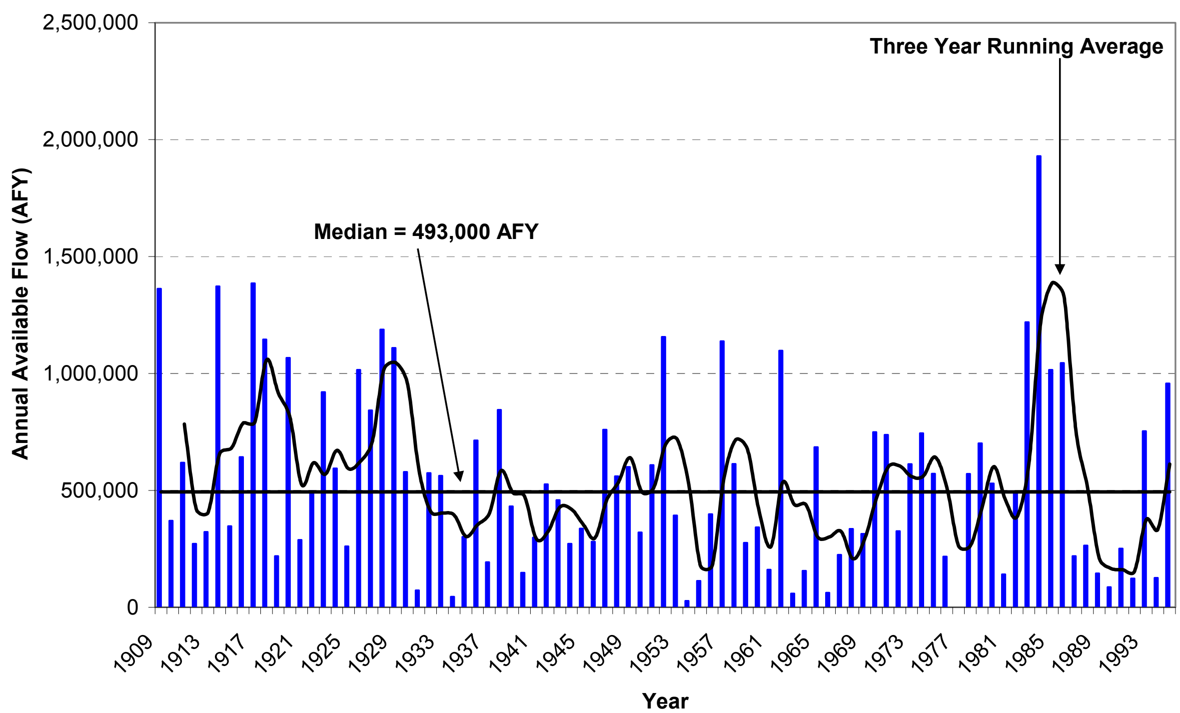


Figure 7-26
Annual Legally Available Flow
Colorado River near Dotsero (1909-1995)

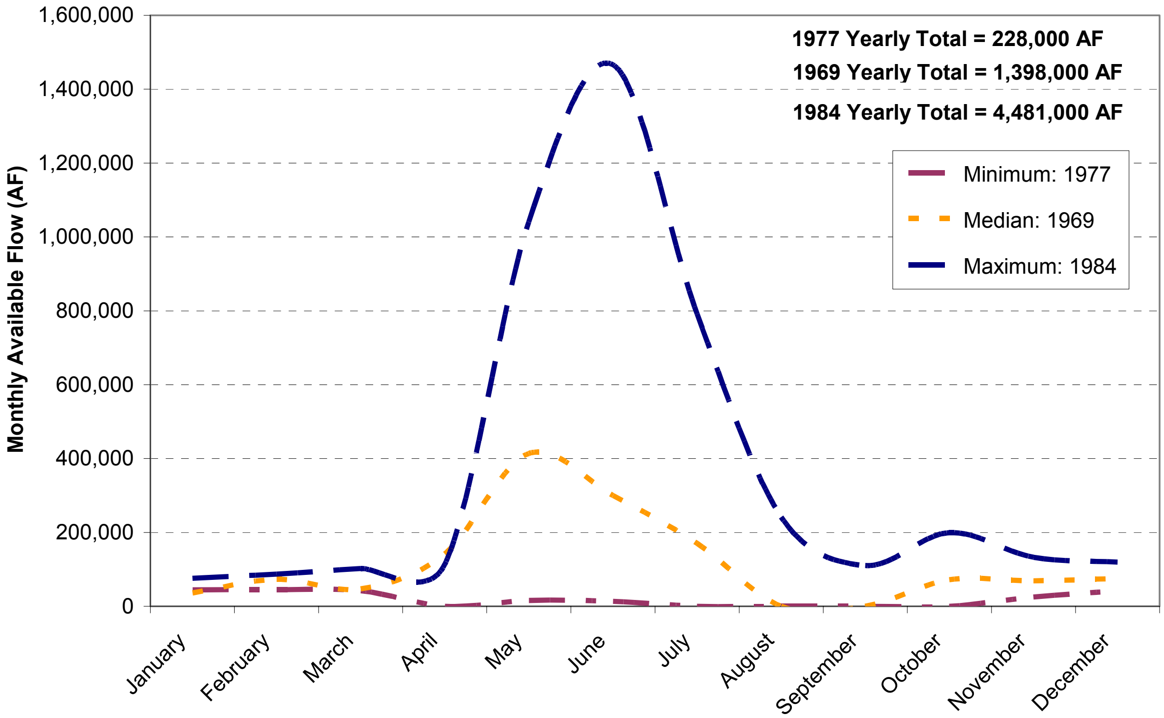


Figure 7-27
Monthly Legally Available Flow
Colorado River near Debeque (1909-1995)

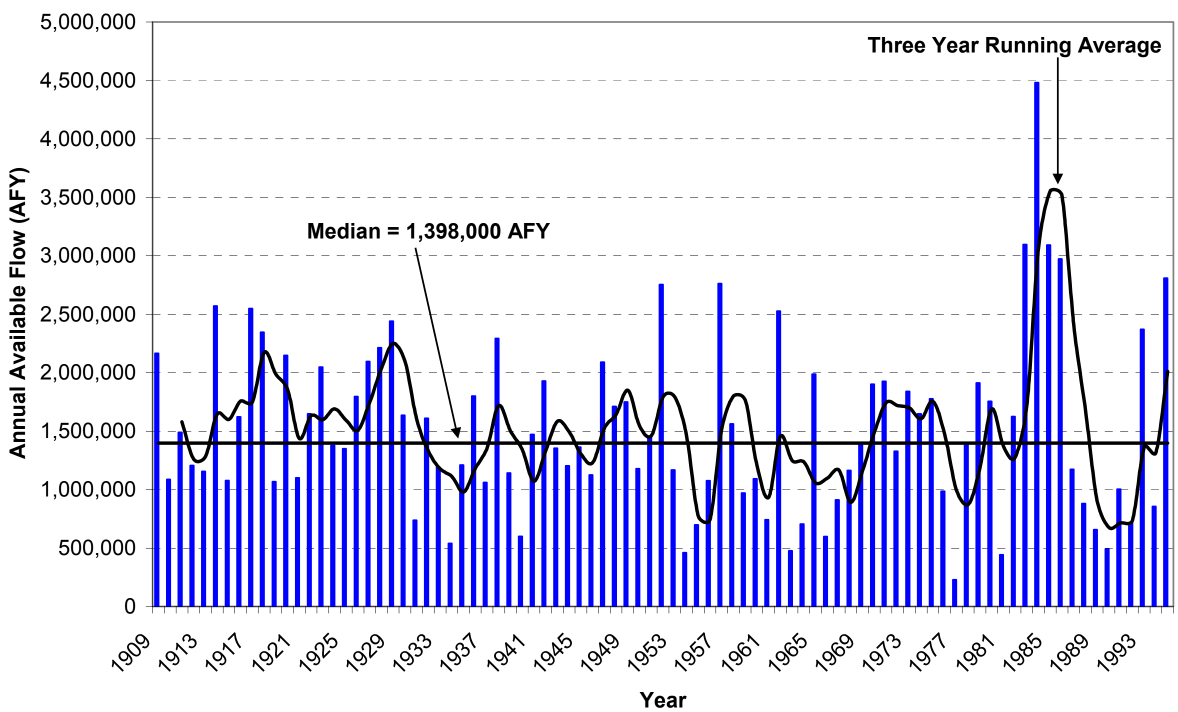


Figure 7-28
Annual Legally Available Flow
Colorado River near Debeque (1909-1995)

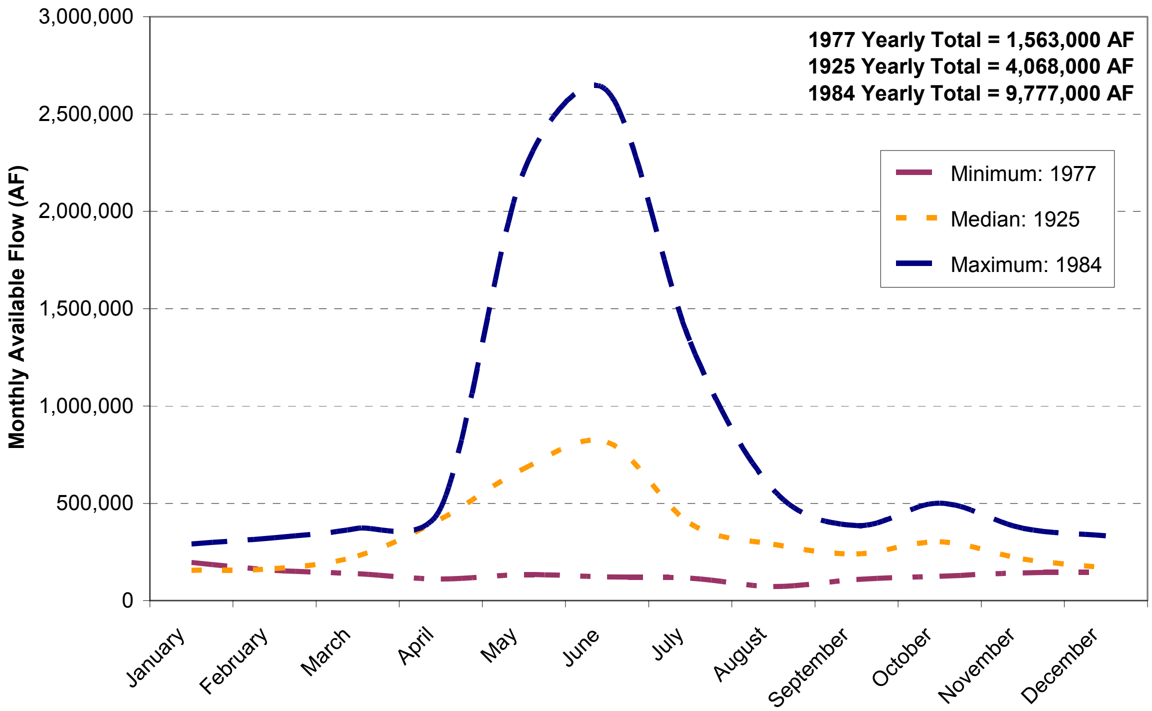


Figure 7-29
Monthly Legally Available Flow
Colorado River at the State Line (1909-1995)

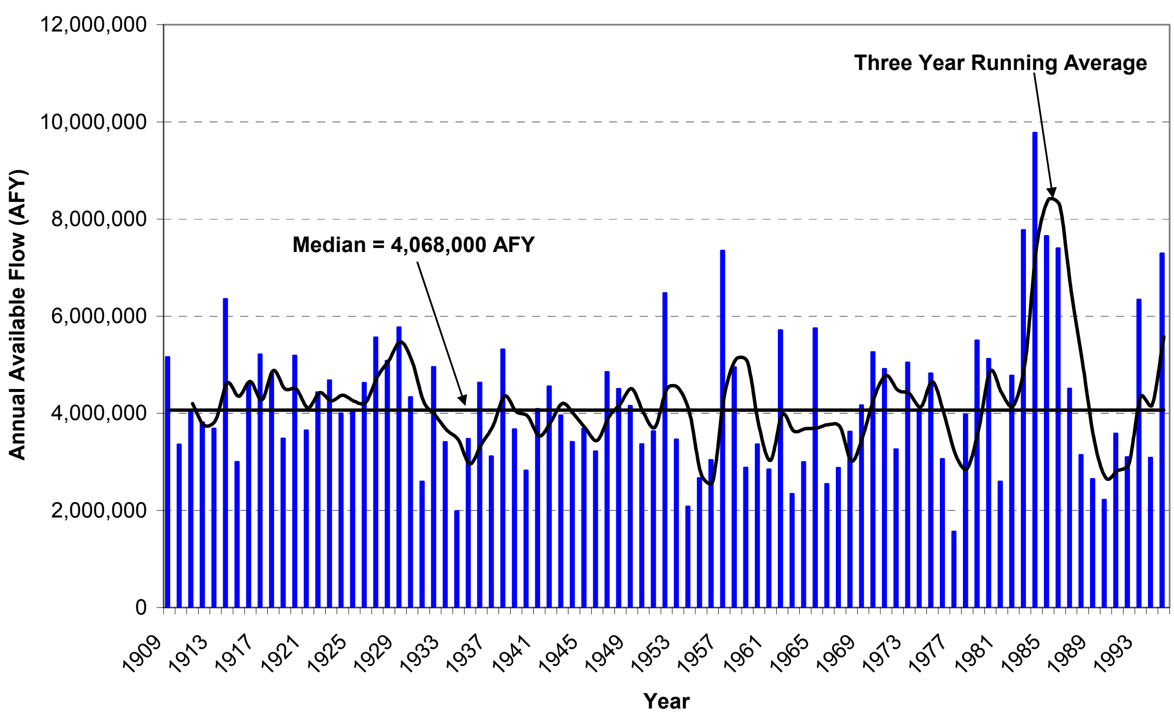


Figure 7-30
Annual Legally Available Flow
Colorado River at the State Line (1909-1995)

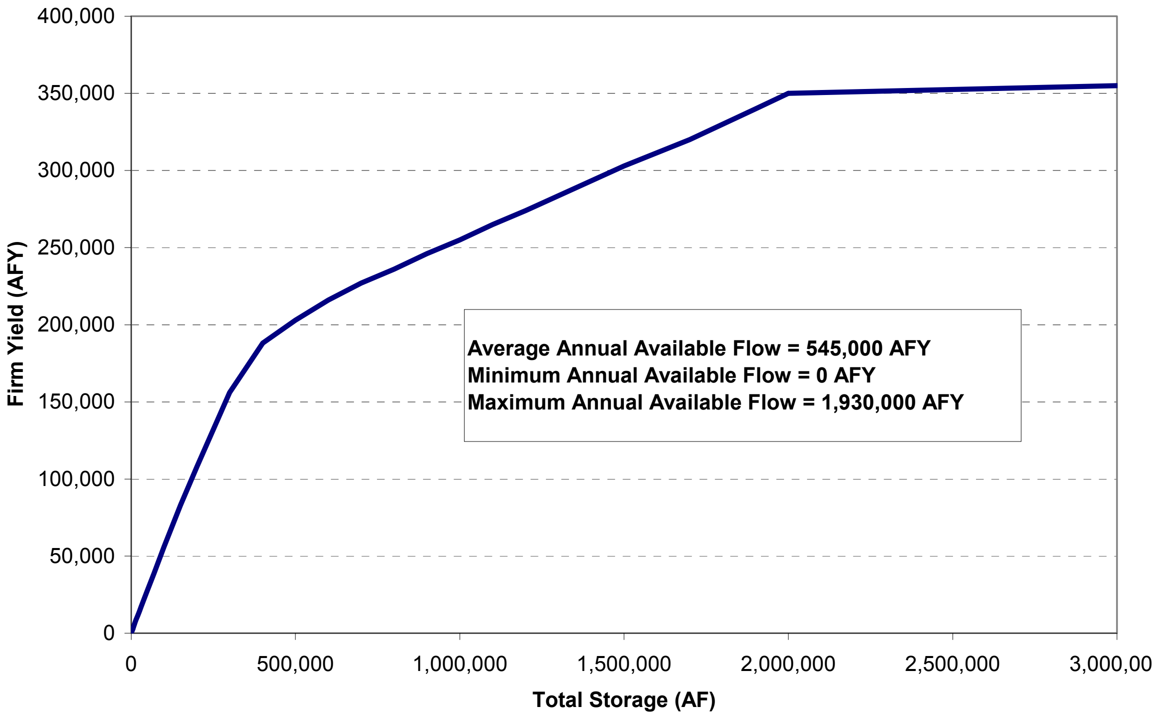


Figure 7-31
Reservoir Yield Curve
Colorado River near Dotsero (1909-1995)

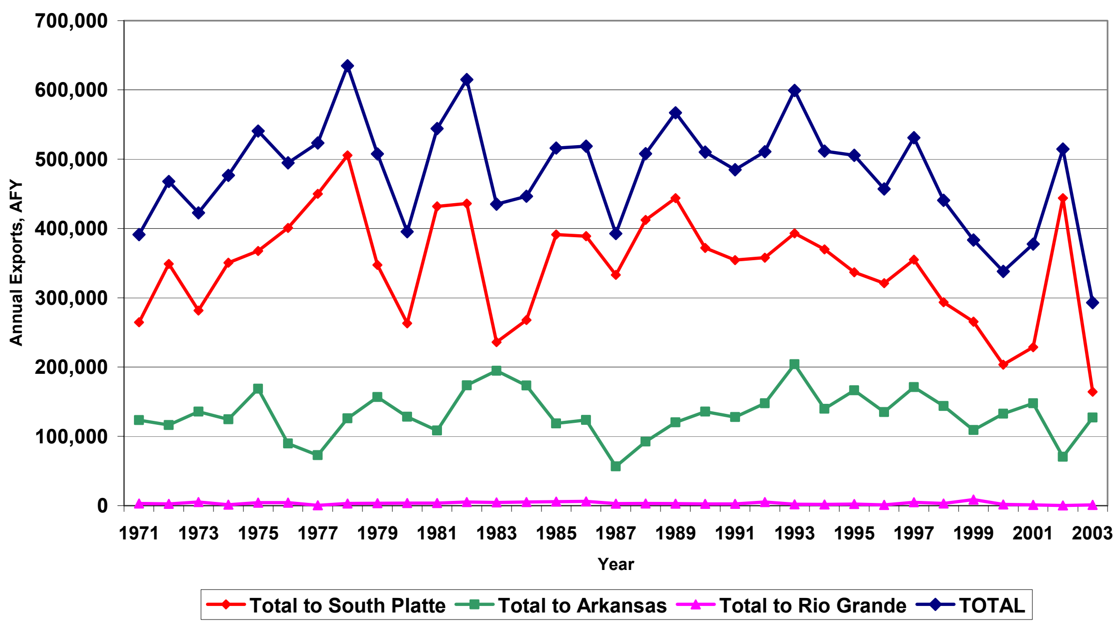


Figure 7-32
Annual Exports from the West Slope
to the South Platte, Arkansas, and Rio Grande Basins (1971-2003)

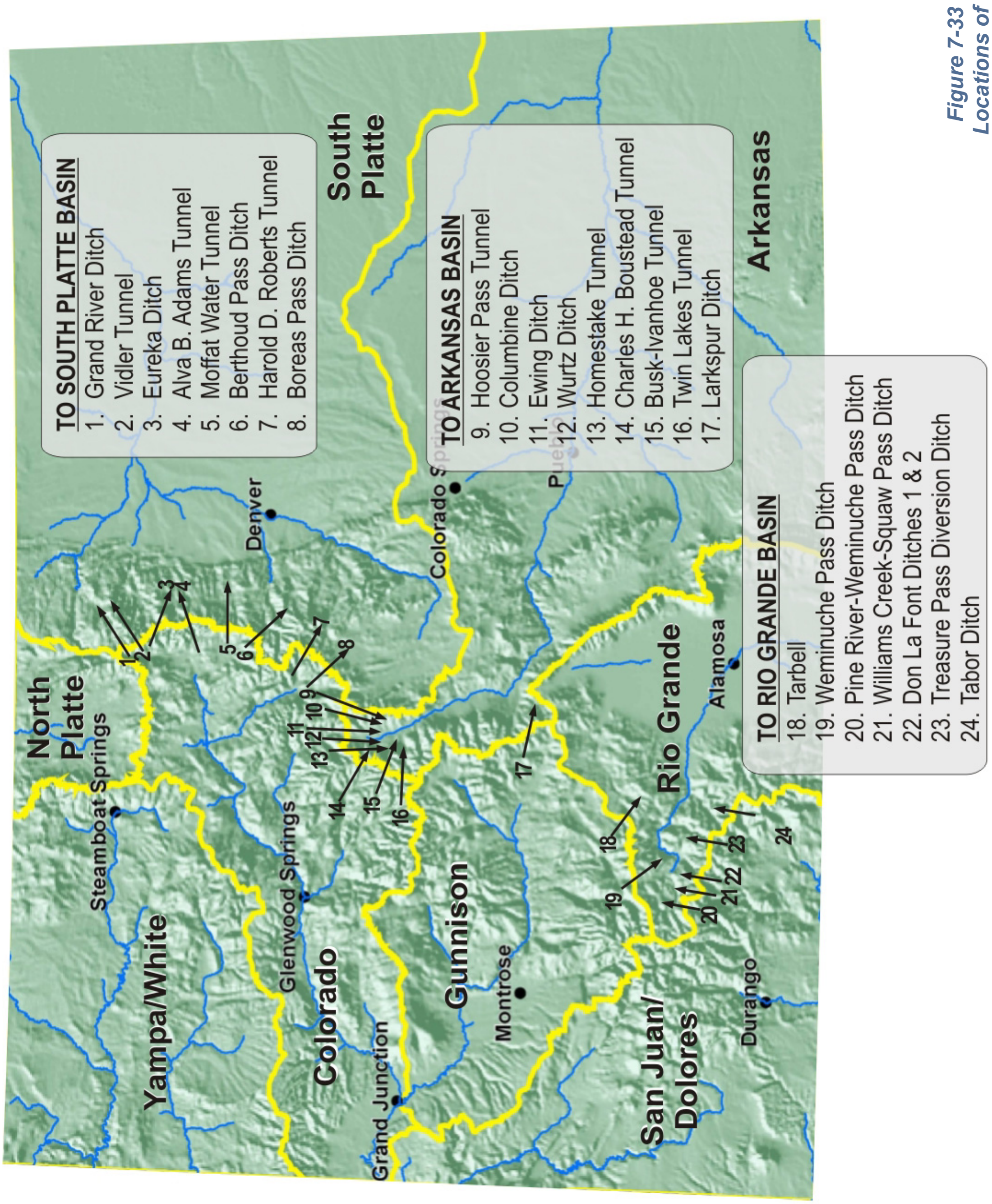


Figure 7-33
Locations of Transbasin Diversions

7.3.3 Dolores/San Juan/San Miguel Basin

7.3.3.1 Dolores/San Juan/San Miguel Surface Water Supplies

The Dolores/San Juan/San Miguel basin StateMod dataset incorporates the La Plata Compact, an interstate compact that governs the distribution of water on the La Plata River between Colorado and New Mexico. Administration of the compact is dependent on the stream flow at two USGS gaging stations: Hesperus Station and Interstate Station. Colorado's allocation of water per the Compact becomes limited if flow at Interstate Station falls below 100 cfs between February 16 and November 30, with the required downstream delivery on the following day equal to one-half of the mean flow at Hesperus. The DSS simulates compact restrictions according to these rules.

Ten locations were selected for the Dolores/San Juan/San Miguel basin to characterize supply availability using StateMod datasets. The period of record for the Dolores/San Juan/San Miguel StateMod datasets is 1909 to 1999 (full calendar years).

The selected locations, shown in Figure 7-34 are:

- San Juan River at Navajo
- Piedra River at Arboles
- Los Pinos River at Boca
- Animas River at the state line
- La Plata River at the state line
- Mancos River at Towaoc
- Dolores River near Dolores
- Dolores River near Bedrock
- San Miguel River near Placerville
- San Miguel River near Uraven

Median annual legally available, physically available, and naturalized flows are summarized for each location in Figure 7-35. Differences between legally and physically available flows indicate that much of the physically available flow at upstream locations may not be available for development due to senior downstream water rights With respect to the San Juan River and its tributaries, it should be noted that approximately 85 percent of the San Juan's flow originates in Colorado, and yet Colorado must assure that adequate water passes the state line for use in New Mexico. Consistent with the Colorado River Compact, New Mexico's allocation under the Compact cannot be satisfied by other Colorado compact rivers that do not flow into New Mexico. For some of the locations, however, such as the Dolores River near Dolores, downstream priority calls are minimal.
Figure 7-36 shows minimum, median, and maximum annual legally available flows for the period of record. A wide range of annual flows at the locations indicates that firm yield supply may be significantly less than average yield supply.

To better represent the effects of seasonal and year to year hydrologic variation, monthly (for minimum, maximum, and median years) and annual time series of legally available flows for the periods of record are shown in Figures 7-37 through 7-56. The median annual flow and 3-year running averages are also included on the annual time series plots. The monthly analyses highlight the fact that available flows vary greatly with season, with the greatest amounts of water available in the summer months and a sharp decline in flows in the autumn and winter. The annual time series plots also show large variation. For most of the locations, a notable extended drought period is evident from the late 1980s to the early 1990s, with more acute droughts in the mid-1930s, 1950s, and late1970s. Extended wet periods evident in these figures include the early 1940s and the mid-1980s.

The interpretation above is in general agreement with the CWCB Drought Study (HDR 2003), which summarized the history of drought in Colorado and identified significant drought periods in the last 100 years. The Drought Study states that the most recent drought analyzed for years 2000 to 2003 exceeds many of the drought records established during the 20th century. It should be noted that the drought period of the past few years, which may not yet be over, is not yet included in the StateMod datasets, and therefore, not represented in the available flow numbers presented here.

Finally, Figure 7-57 is provided to further quantify the impacts of seasonal and year to year hydrologic variation and to illustrate the difference between average annual available flow and the potential annual firm yield. This chart shows firm yield as a function of total available storage for legally available flows at the San Miguel River near Placerville. For the San Miguel River near Placerville, even with very large volumes of storage, the maximum annual firm yield is only approximately 77 percent of the average annual available flow. The curve reaches an asymptotic value of 125,000 AFY at approximately 300,000 AF total storage, beyond which no significant gains in firm yield can be achieved with increased storage. At the asymptotic value, all excess water is captured, stored, and used, but supply is still limited (below the average annual) by the timing of the available flows and reservoir evaporation and seepage. The critical (limiting) period for this analysis is the late 1970s. Note that yields would likely be significantly higher if some value or frequency of shortages, greater than zero, were acceptable.

Potential limitations to the projected supply availability as a result of the Colorado River Compact are evaluated in Section 7.4. The Compact includes potential limitations for the Colorado, Gunnison, Dolores/San Juan/San Miguel, and Yampa Basins combined as well as additional limitations on certain subbasins.

The future development of existing conditional water rights, including the Animas-La Plata Project, are not included in the Colorado DSS datasets. These water rights could eventually be developed resulting in less available water for the rest of the basin. Development of conditional rights, however, must be applied to beneficial use and meet a water need. Conditional water rights by basin are summarized in Section 10. Since the current Dolores/San Juan/San Miguel DSS dataset covers the period from 1909 to 1999, once the current drought has ended, the DSS dataset for the basin should be extended, including updated irrigated acres and M&I demands. A new StateMod model run should be conducted with the updated dataset to determine if the recent drought is a new critical period.

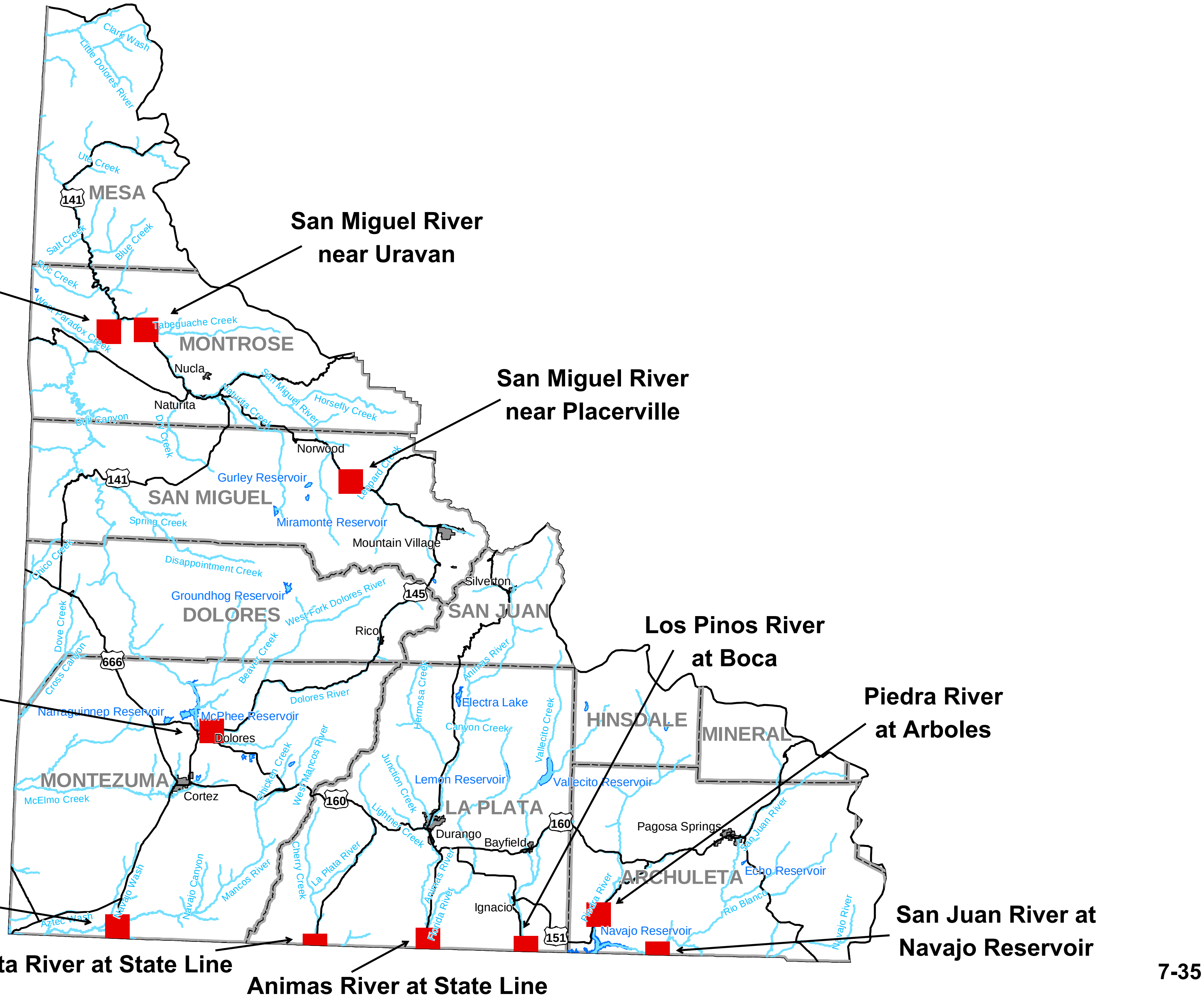
Maintaining or enhancing recreational and environmental flows could affect current and future supply availability. Environmental and recreational considerations are further developed in Sections 6 and 10 of this report. For example, a number of endangered fish species, such as the Razorback Sucker and the Pikeminnow, are present in the Dolores/San Juan/San Miguel Basin, and require special attention with respect to minimum instream flows. Reoperation of Navajo Reservoir, stocking, and habitat improvement are options that can help meet the needs of endangered species in this basin.

Finally, discussions with basin stakeholders have noted that the impacts of CBM water extractions on supply availability, particularly in the Pine and Florida River systems, are unknown and are not included in the StateMod dataset.

There are minor transbasin diversions from the Dolores/ San Juan/San Miguel to the Rio Grande Basin averaging 1,873 AF from 1971 to 2003 (Upper Colorado River Commission 2004).

7.3.3.2 Dolores/San Juan/San Miguel Alluvial Aquifers

No significant alluvial aquifers have been identified. There are domestic wells in the basin that are recharged by agricultural return flows and the long-term viability of these wells is dependent upon the continued pattern of irrigation return flows.



7-35

Figure 7-34
Dolores/San Juan/San Miguel Basin
Selected Locations, Water Supply Availability

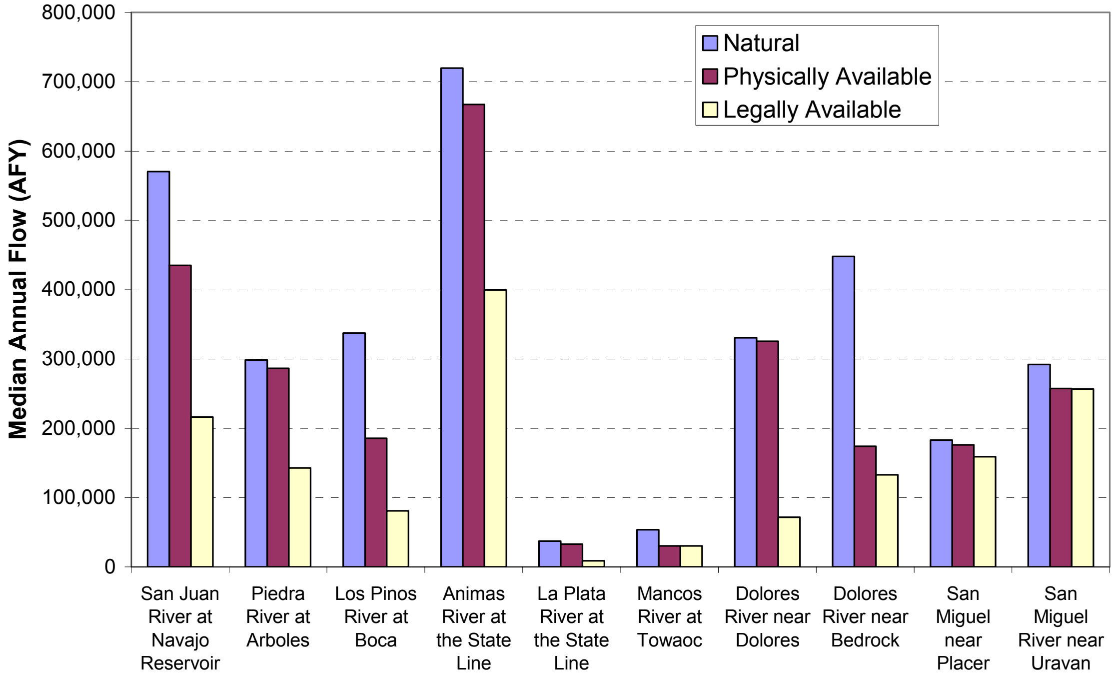


Figure 7-35
Median Annual Natural, Physically Available, and Legally Available Flows
Dolores/San Juan/San Miguel Basin

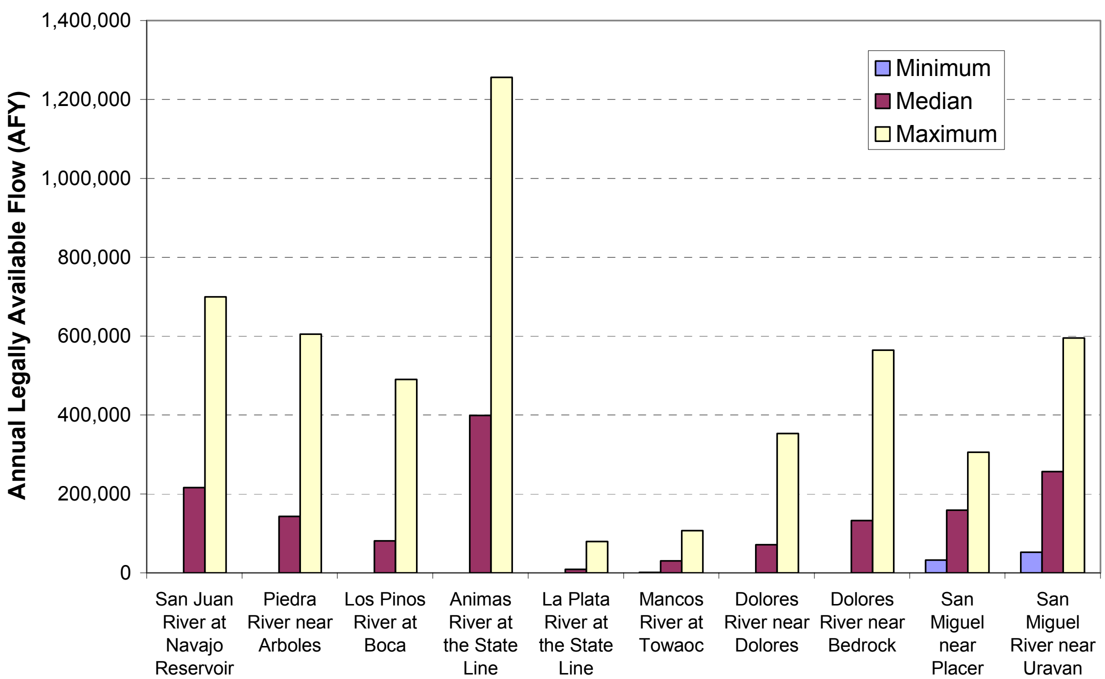


Figure 7-36
Minimum, Median, and Maximum Annual Legally Available Flows
Dolores/San Juan/San Miguel Basin

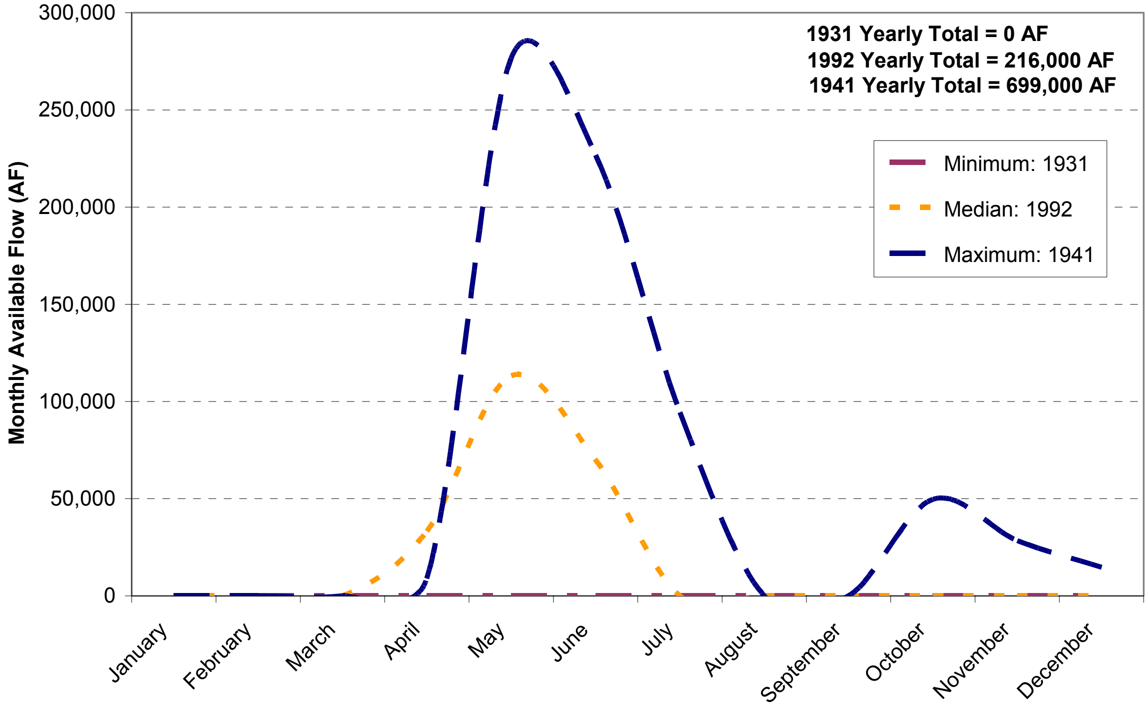


Figure 7-37
Monthly Legally Available Flow
San Juan River at Navajo Reservoir (1909-1999)

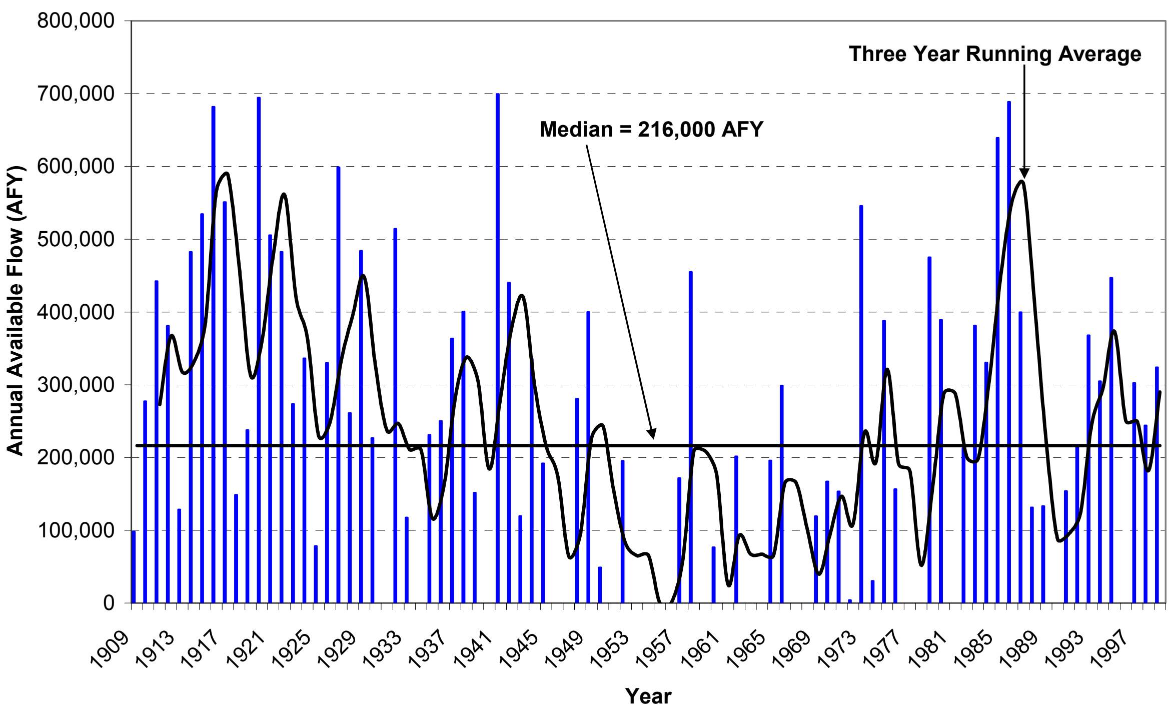


Figure 7-38
Annual Legally Available Flow
San Juan River at Navajo Reservoir (1909-1999)

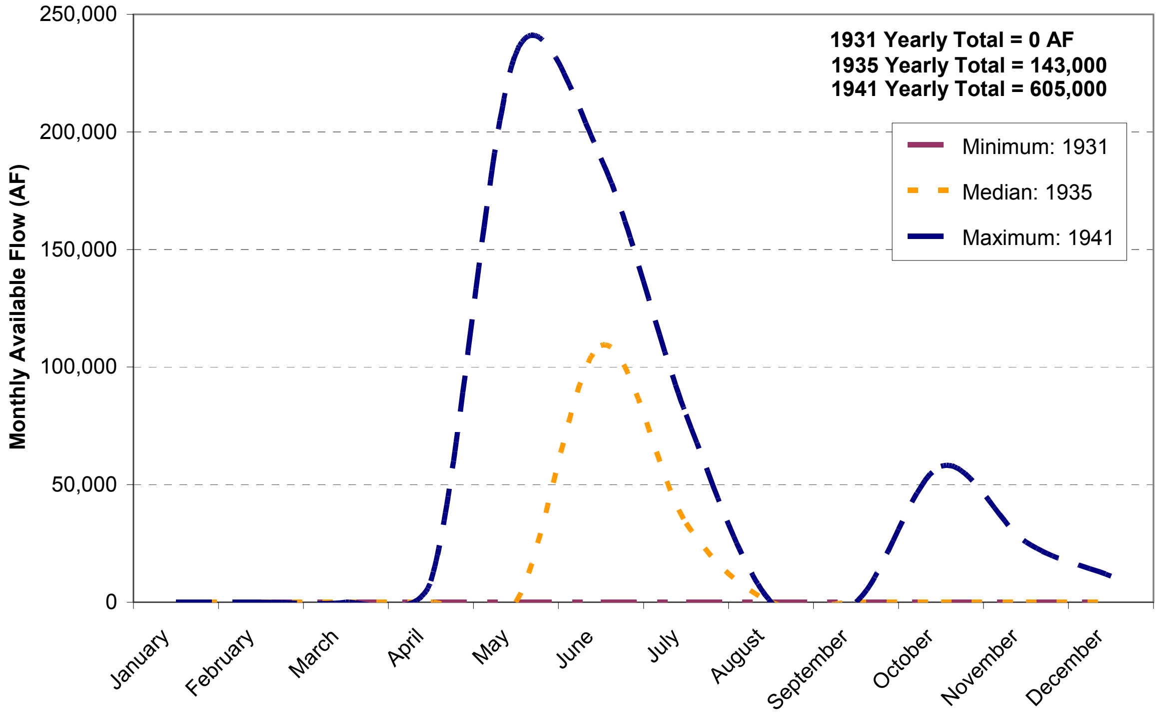


Figure 7-39
Monthly Legally Available Flow
Piedra River near Arboles (1909-1999)

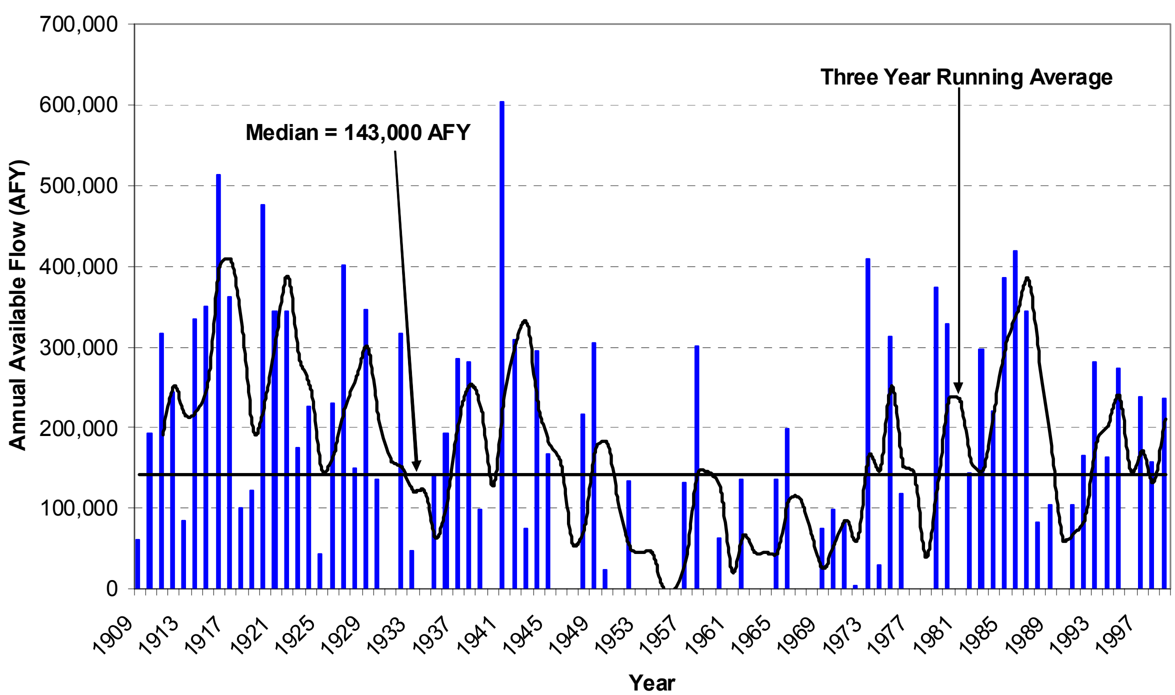


Figure 7-40
Annual Legally Available Flow
Piedra River near Arboles (1909-1999)

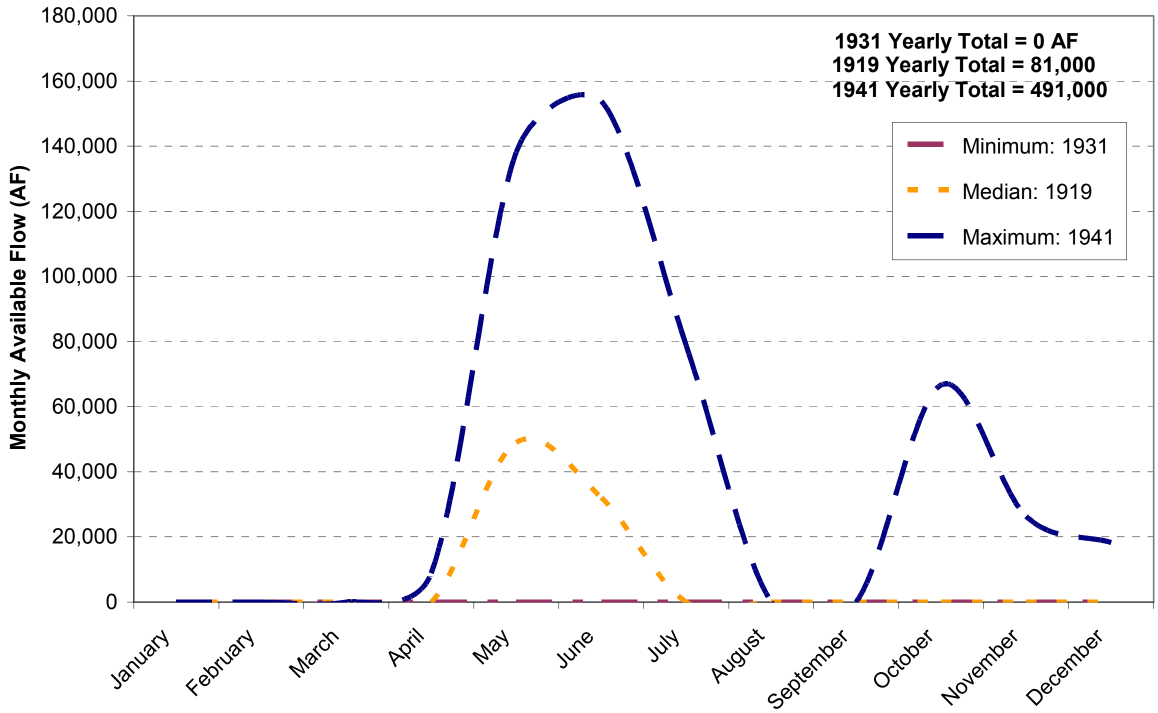


Figure 7-41
Monthly Legally Available Flow
Los Pinos River near Boca (1909-1999)

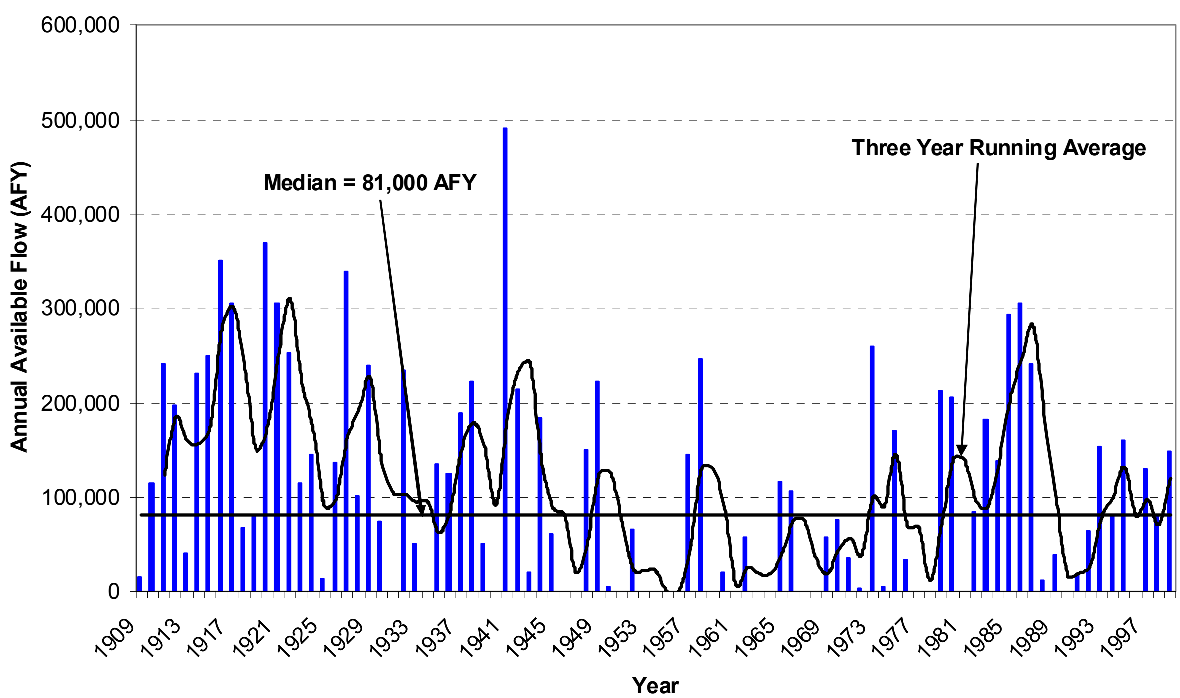


Figure 7-42
Annual Legally Available Flow
Los Pinos River near Boca (1909-1999)

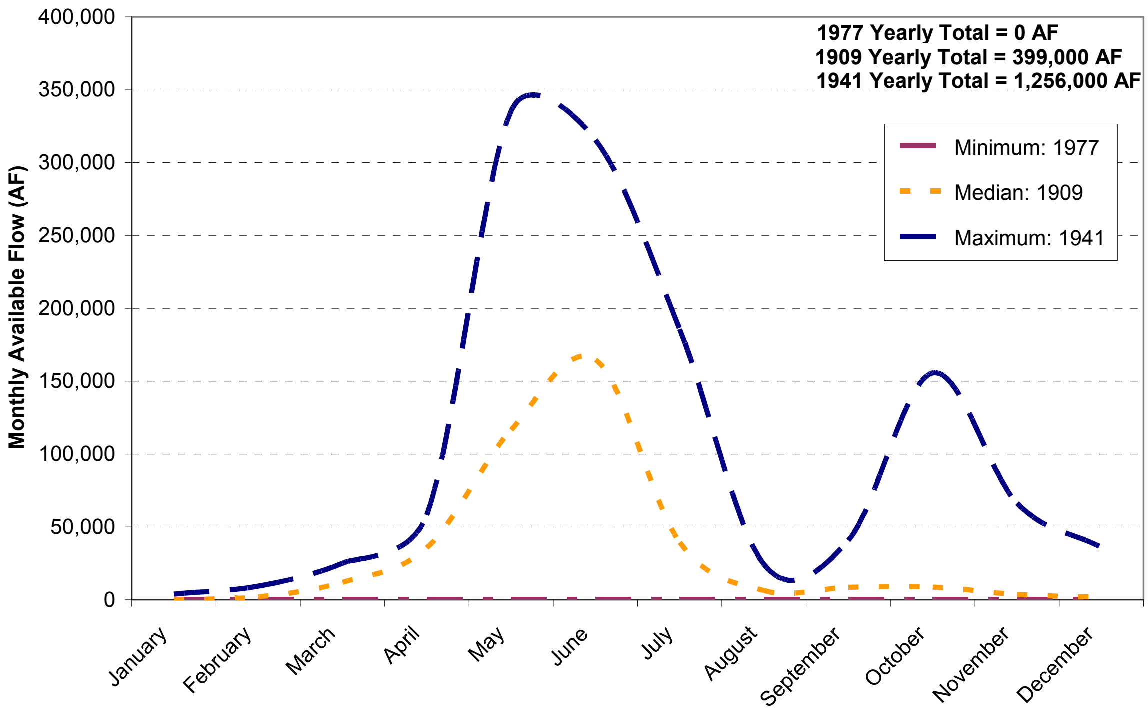


Figure 7-43
Monthly Legally Available Flow
Animas River near the State Line (1909-1999)

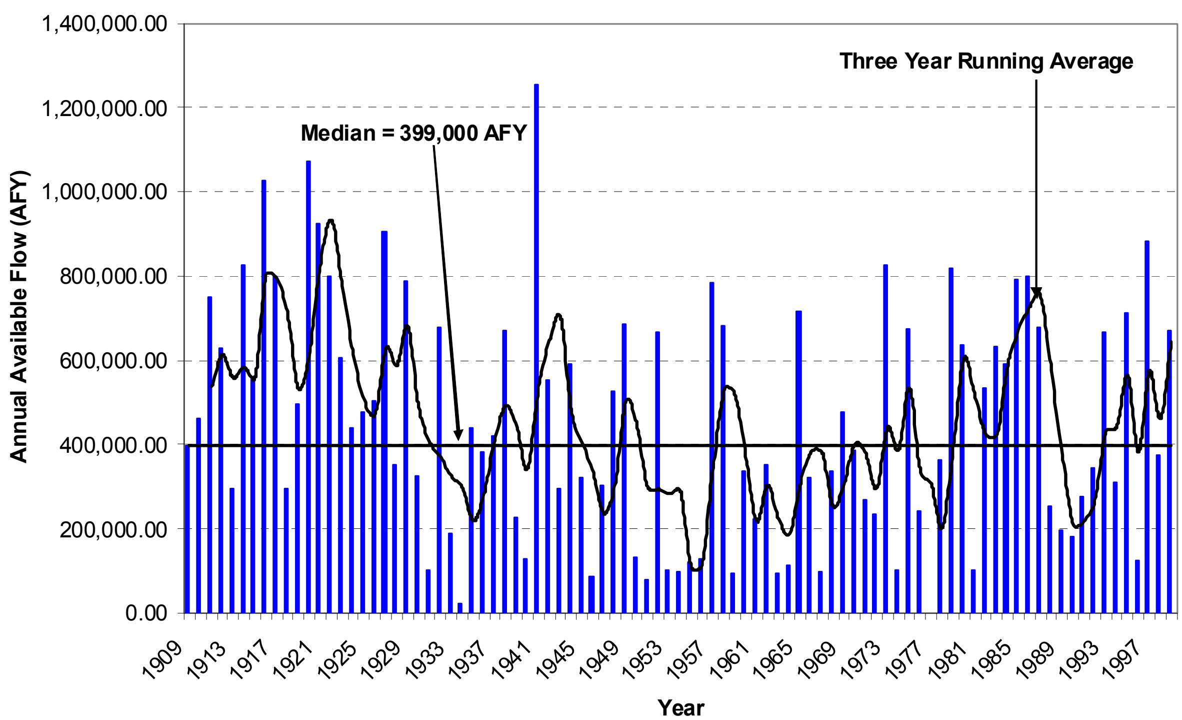


Figure 7-44
Annual Legally Available Flow
Animas River near the State Line (1909-1999)

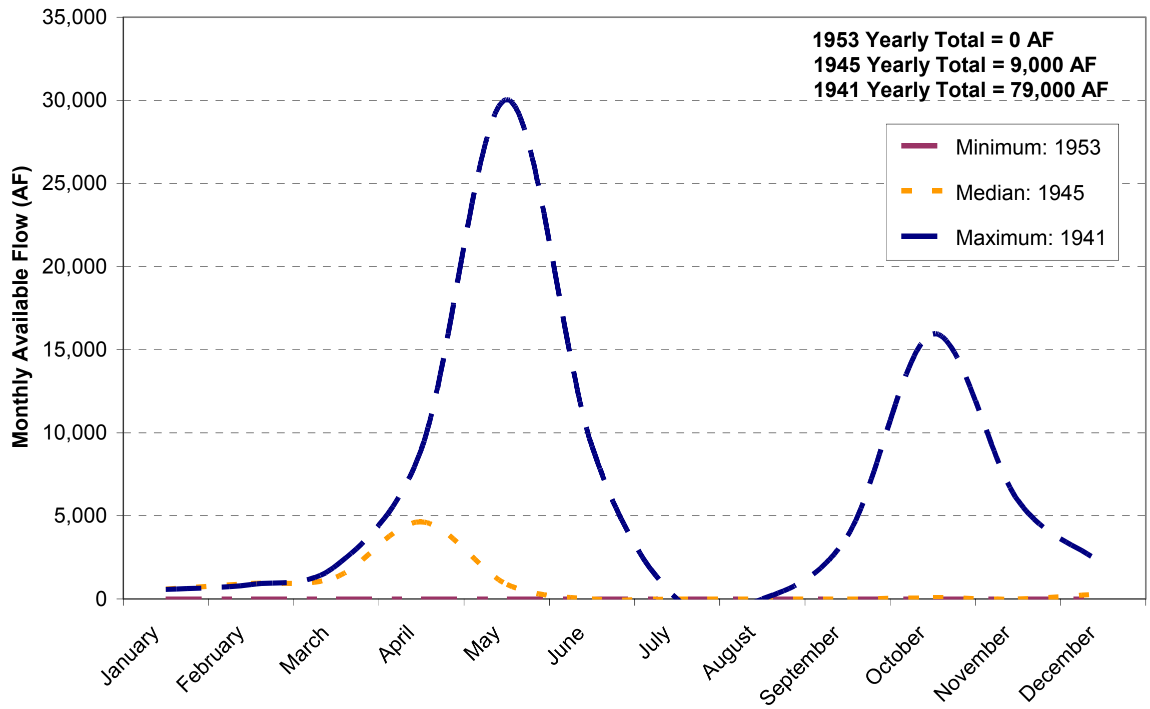


Figure 7-45
Monthly Legally Available Flow
La Plata River near the State Line (1909-1999)

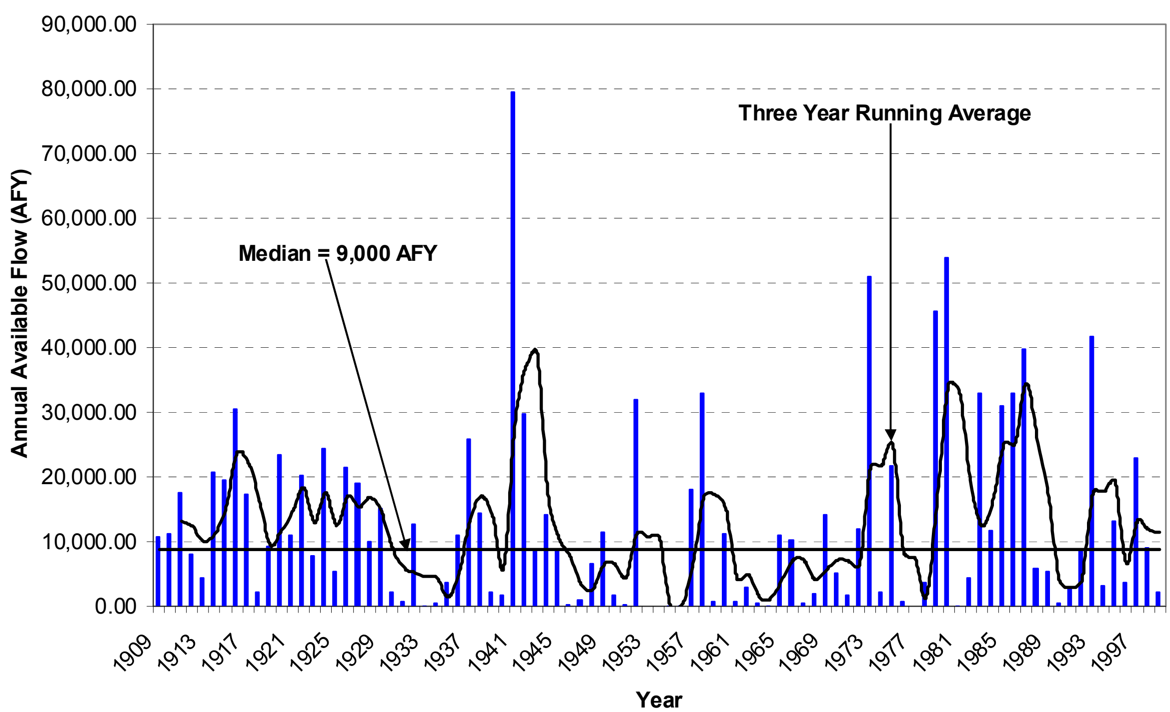


Figure 7-46
Annual Legally Available Flow
La Plata River near the State Line (1909-1999)

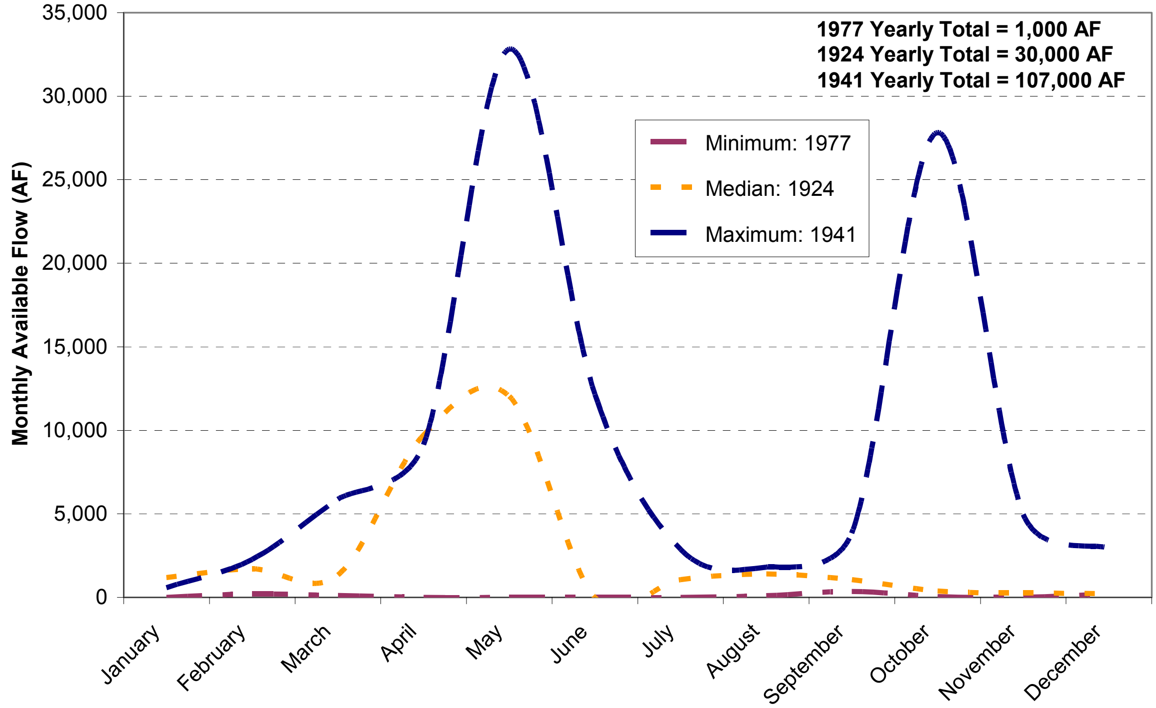


Figure 7-47
Monthly Legally Available Flow
Mancos River near Towaoc (1909-1999)

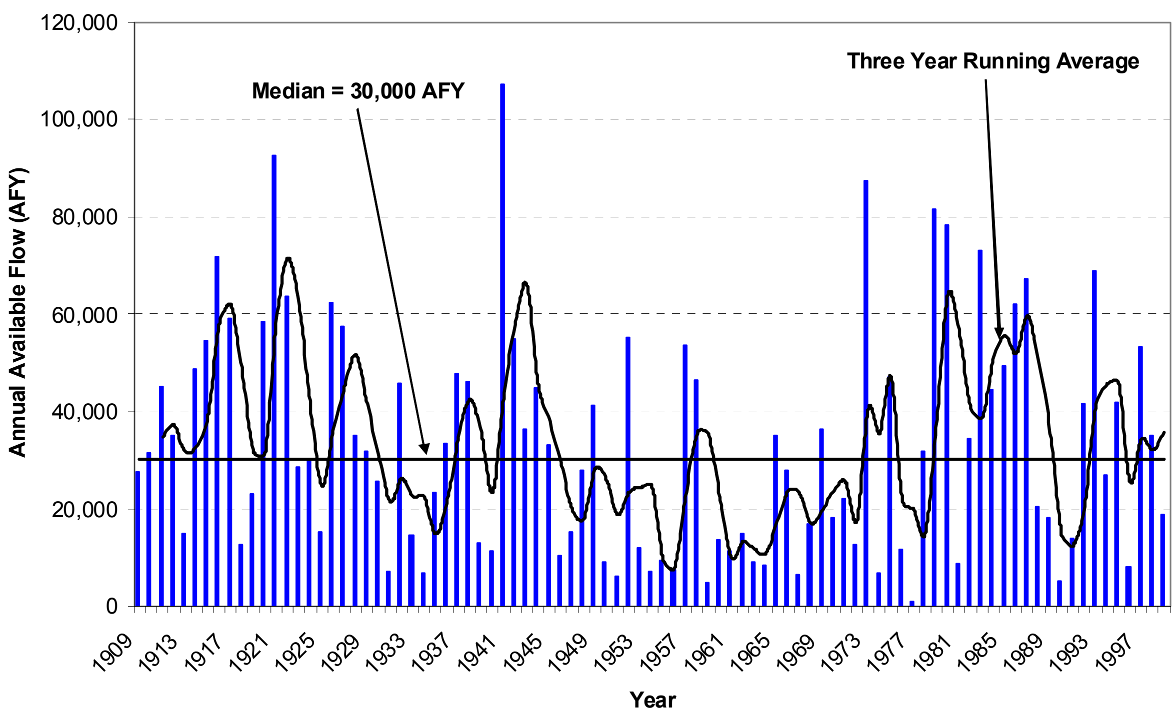


Figure 7-48
Annual Legally Available Flow
Mancos River near Toawoc (1909-1999)

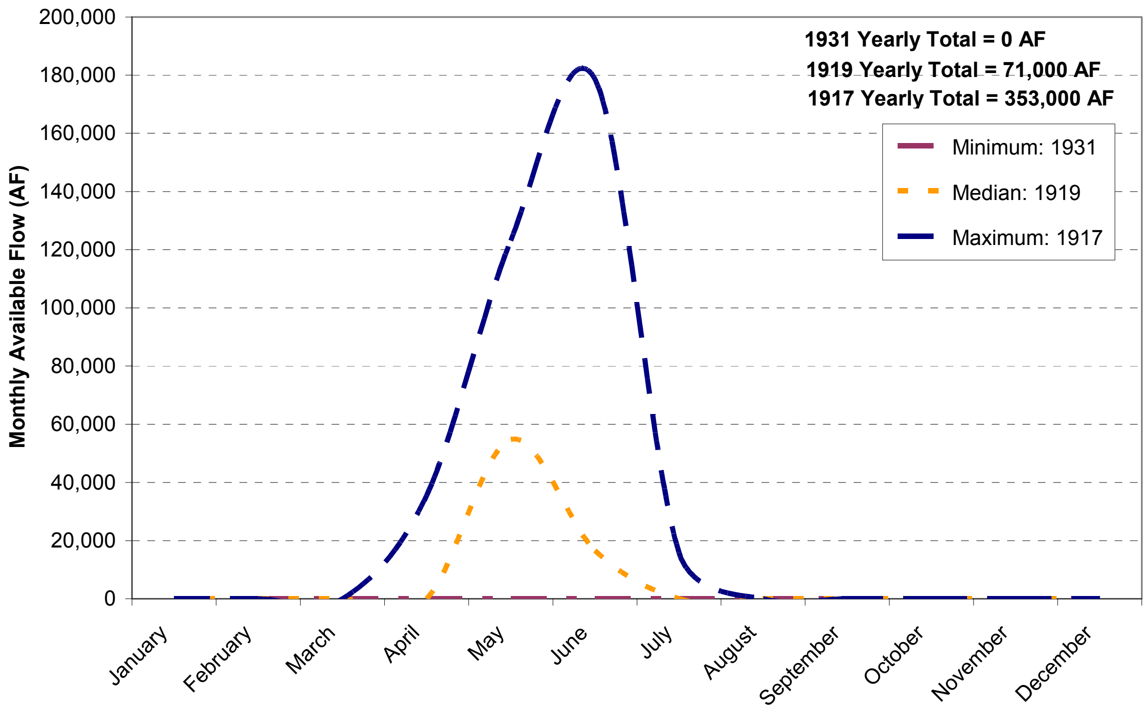


Figure 7-49
Monthly Legally Available Flow
Dolores River near Dolores (1909-1999)

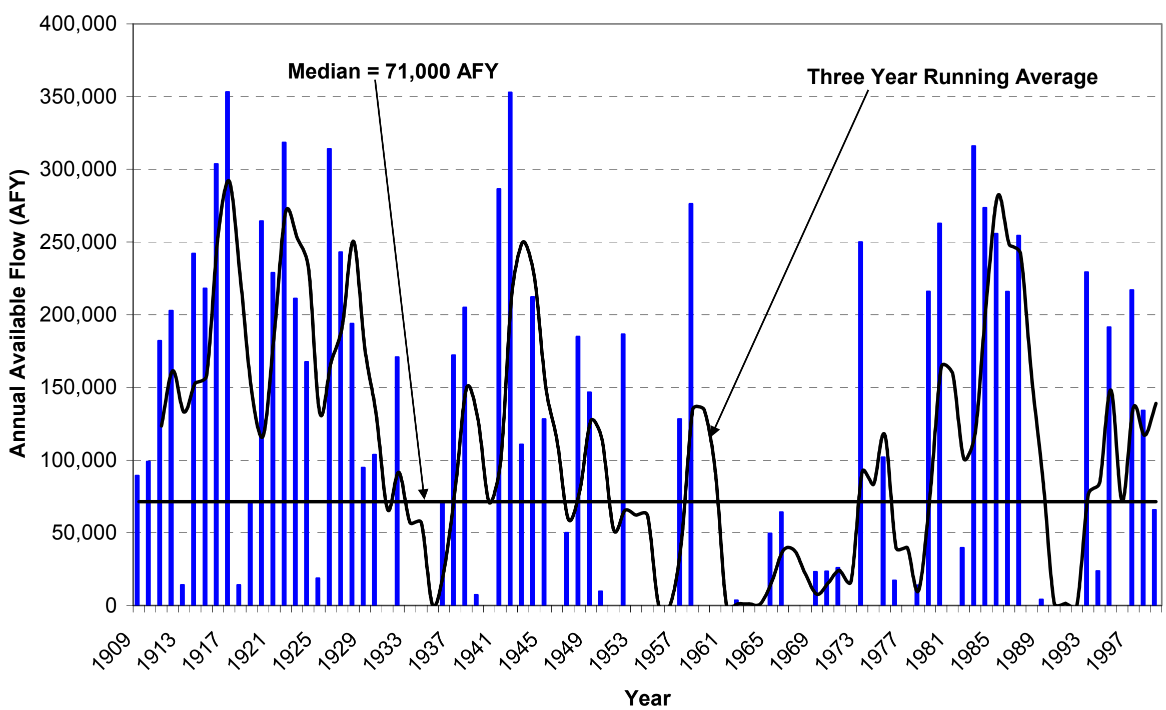


Figure 7-50
Annual Legally Available Flow
Dolores River near Dolores (1909-1999)

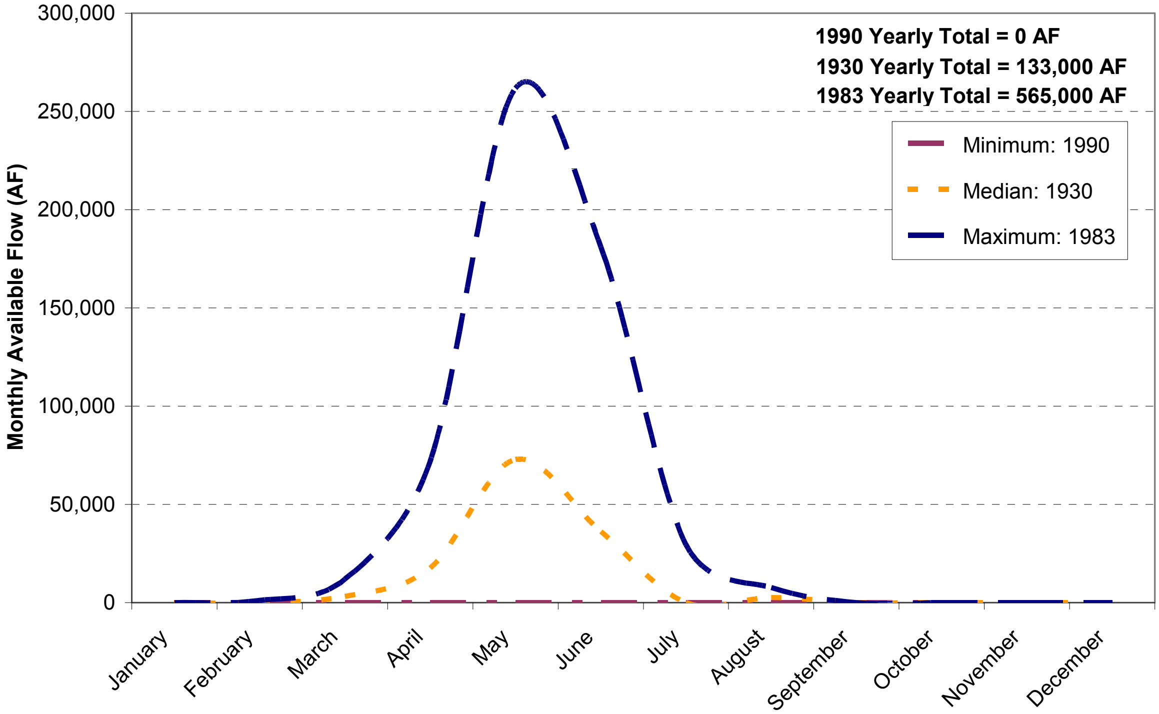


Figure 7-51
Monthly Legally Available Flow
Dolores River near Bedrock (1909-1999)

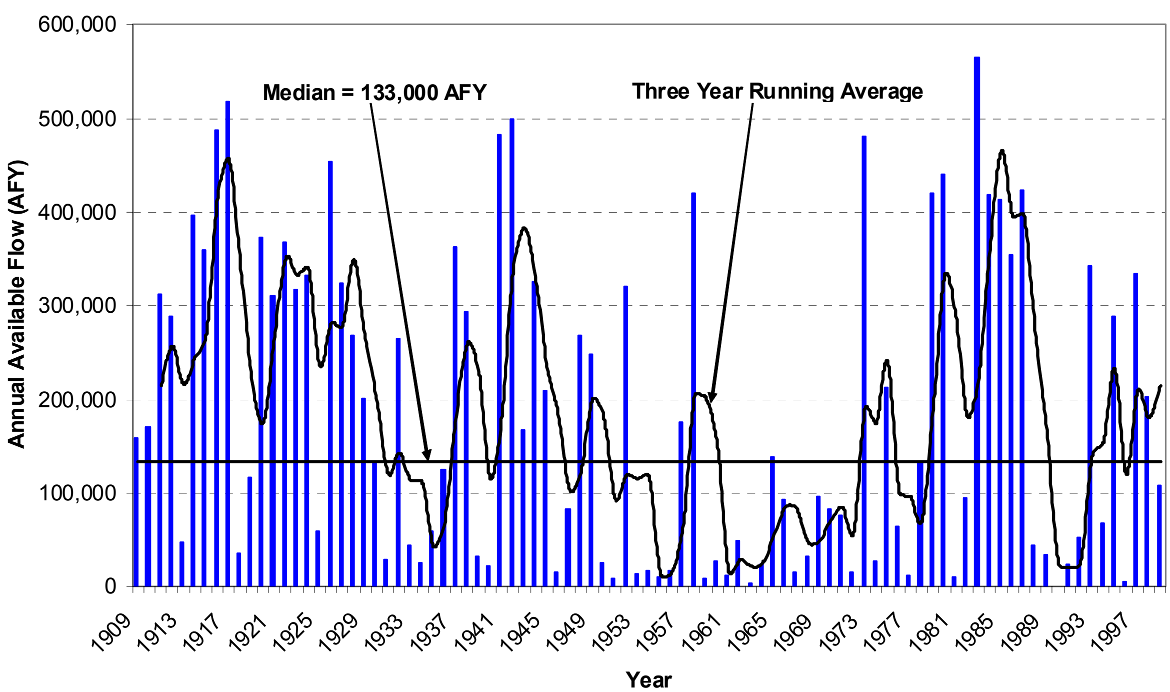


Figure 7-52
Annual Legally Available Flow
Dolores River near Bedrock (1909-1999)

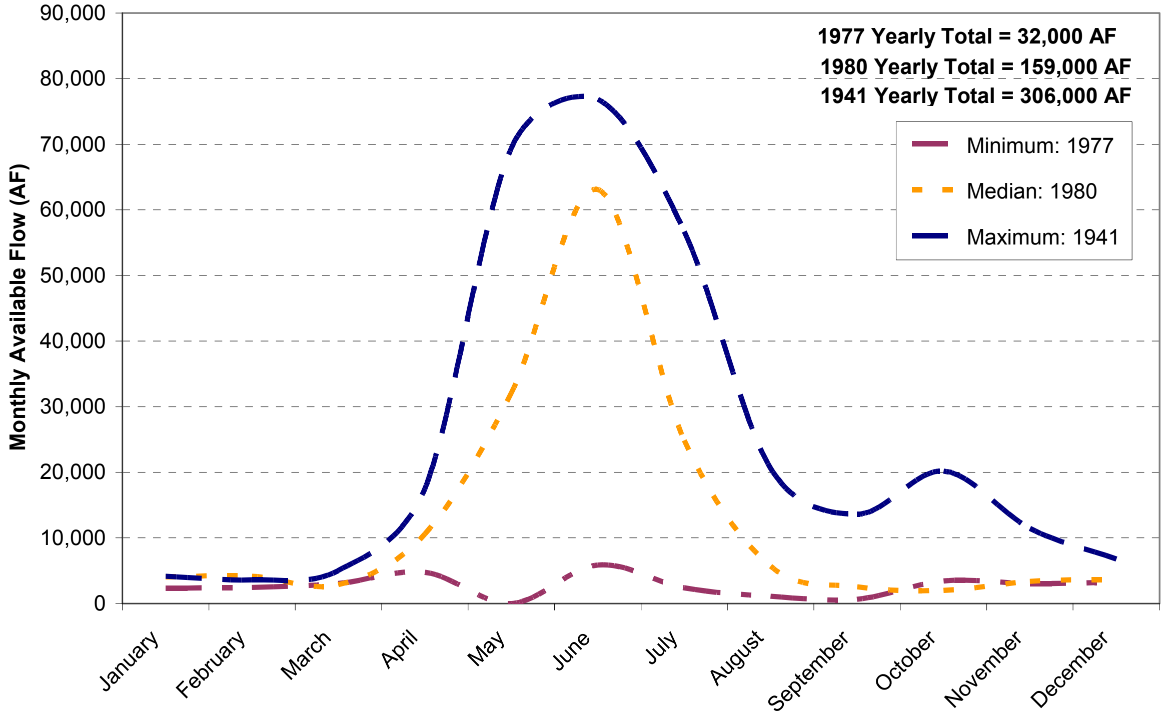


Figure 7-53
Monthly Legally Available Flow
San Miguel River near Placerville (1909-1999)

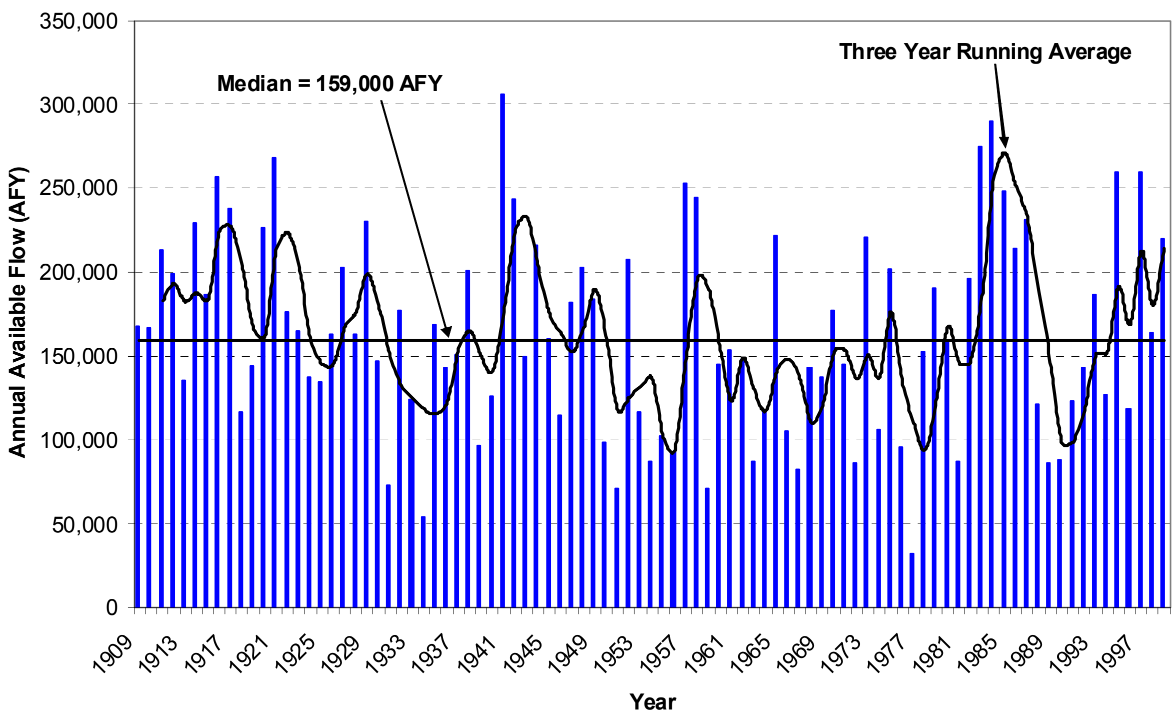


Figure 7-54
Annual Legally Available Flow
San Miguel River near Placerville (1909-1999)

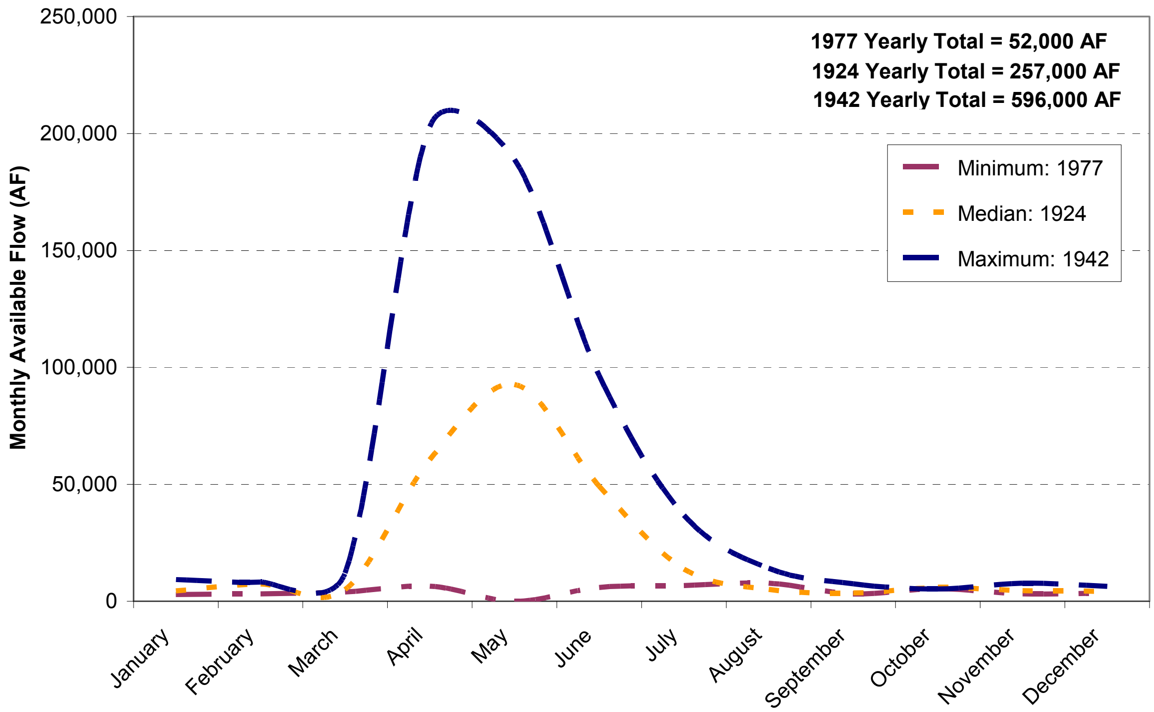


Figure 7-55
Monthly Legally Available Flow
San Miguel River near Uravan (1909-1999)

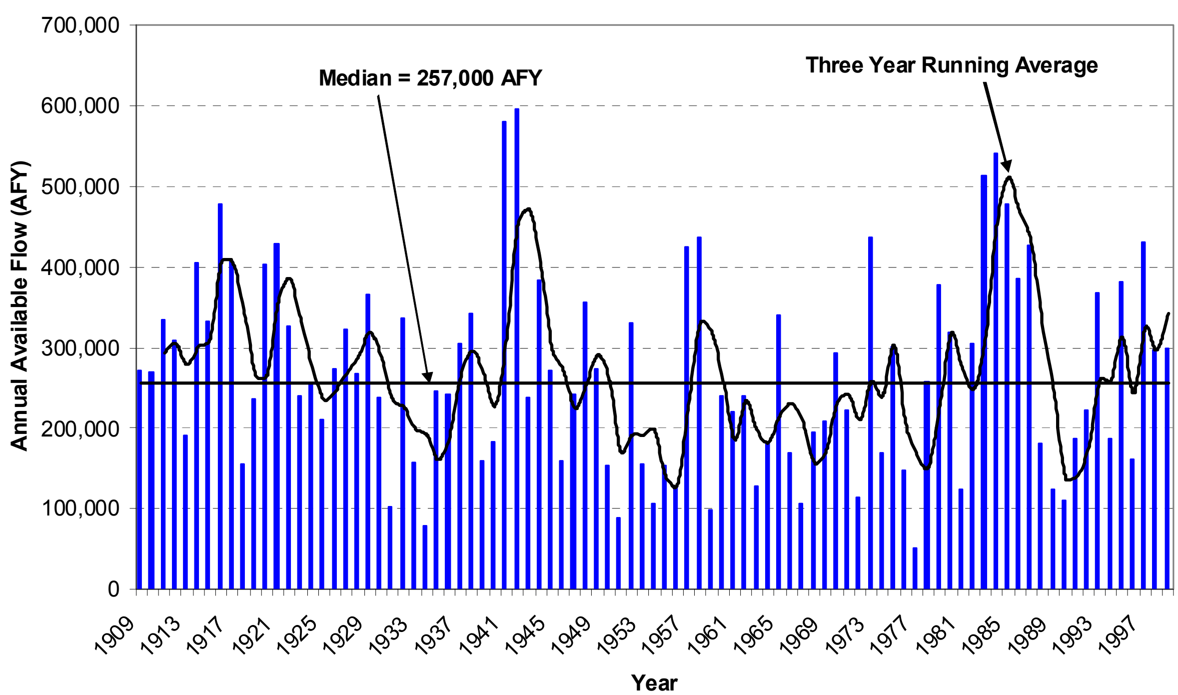


Figure 7-56
Annual Legally Available Flow
San Miguel River near Uravan (1909-1999)

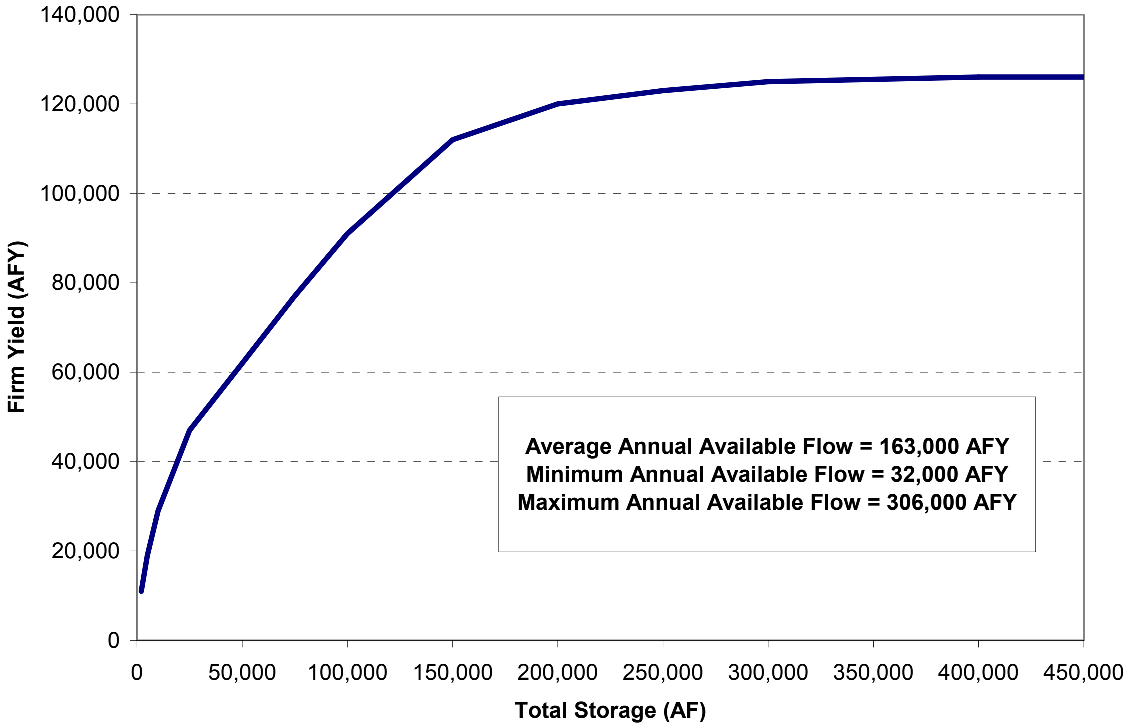


Figure 7-57
Reservoir Yield Curve
San Miguel River near Placerville (1909-1999)

7.3.4 Gunnison Basin

7.3.4.1 Gunnison Basin Surface Water Supplies

Six locations were selected for the Gunnison basin to characterize supply availability using StateMod datasets. The period of record for the Gunnison StateMod datasets is 1909 to 2001 (full calendar years).The selected locations, shown in Figure 7-58 are:

- Tomichi Creek at Gunnison
- Gunnison River at Gunnison
- Gunnison River below Gunnison Tunnel
- Gunnison River at Delta
- Uncompahgre River at Colona
- Gunnison River near Grand Junction

Median annual legally available, physically available, and naturalized flows are summarized for each location in Figure 7-59. Differences between legally and physically available flows indicate that much of the physically available flow at upstream locations may not be available for development due to senior downstream water rights. Figure 7-60 shows minimum, median, and maximum annual legally available flows for the period of record. A wide range of annual flows at the locations evaluated indicates that firm yield supply is significantly less than average yield supply.

To better represent the effects of seasonal and year to year hydrologic variation, monthly (for minimum, maximum, and median years) and annual time series of legally available flows for the periods of record are shown in Figures 7-61 through 7-72. The median annual flow and 3-year running averages are also included on the annual time series plots. The monthly analyses highlight the fact that available flows vary greatly with season, with the greatest amounts of water available in the summer months and a sharp decline in flows in the autumn and winter. The annual time series plots also show large variation with a notable extended drought period in the mid-1950s and the late 1980s and an acute single year drought in 1977. Extended wet periods evident in these figures include the 1910s to early 1920s, and the early to mid-1980s.

The interpretation above is in general agreement with the CWCB Drought Study (HDR 2003), which summarized the history of drought in Colorado and identified significant drought periods in the last 100 years. The Drought Study states that the most recent drought analyzed for years 2000 to 2003 exceeds many of the drought records established during the 20th century. It should be noted that the drought period of the past few years, which may not be over, is not yet included in the StateMod datasets, and therefore, not represented in the available flow numbers presented here.

Finally, Figure 7-73 is provided to further quantify the impacts of seasonal and year to year hydrologic variation and to illustrate the difference between average annual available flow and the potential annual firm yield. This chart shows firm yield as a function of total available storage for legally available flows at the Gunnison River below the Gunnison Tunnel. For the Gunnison River below the Gunnison Tunnel, even with very large volumes of storage, the maximum annual firm yield is approximately 71 percent of the average annual available flow. The curve reaches an asymptotic value of 405,000 AFY at approximately 2,500,000 AF total storage, beyond which no significant gains in firm yield can be achieved with increased storage. At the asymptotic value, all excess water is captured, stored, and used, but supply is still limited (below the average annual) by the *timing* of the available flows and reservoir evaporation and seepage. The critical (limiting) period for this analysis is the mid-1950s. It should be noted that the period of record for this analysis has recently been extended through water year 2002. Note that yields would likely be significantly higher if some value or frequency of shortages, greater than zero, were acceptable. The potential benefits of Aspinall reoperations, which could increase firm yield at this location, are not included.

Potential limitations to the projected supply availability as a result of the Colorado River Compact are evaluated in Section 7.4. The Compact includes potential limitations for the Colorado, Gunnison, Dolores/San Juan/San Miguel and Yampa/White/Green Basins combined as well as additional limitations on certain subbasins.

The future development of conditional water rights are also not included in the DSS datasets. These water rights could eventually be developed resulting in less available water for the rest of the basin. Conditional water rights would meet a water need. Conditional water rights, by basin, are summarized in Section 10.

Water is available for certain users from the contract pools in Blue Mesa Reservoir and Ridgway Reservoir. The UGRWCD has a subordination agreement with the

BOR that allows up to 60,000 AFY of depletions against the Aspinall Unit water rights (40,000 AFY above Blue Mesa Dam, 10,000 AFY between Blue Mesa and Morrow Point Dams, and 10,000 AFY between Morrow Point and Crystal Dams). In addition, the UGRWCD has a 500 AF pool in Blue Mesa that can be used to replace depletions to downstream calls. In the economic justification report for the Aspinall Project, approximately 750,000 AFY was identified as needing to be run through the turbines at the reservoirs to generate power to justify the project. The availability of a "marketable pool" or yield from the Aspinall Unit available for contracting by water users in Colorado was discussed in the Colorado Supreme Court Decision in the Union Park Reservoir case (No. 98SA327). In regards to the issue of a marketable pool, the Court stated "The court finds that Congress intended the Colorado River Storage Project (CRSP) Act to serve as a mechanism for Upper Basin states to develop their water resources and still meet their Colorado River Compact obligations. CRSP Act projects and participating projects allow Colorado to develop its water resources while ensuring that adequate water remains in storage to help meet the Compact obligations in dry years. Historically, the BOR has applied the water afforded by the Aspinall Unit decrees to full beneficial use through hydropower generation, flood control, fish and wildlife, and recreation purposes. Therefore, Arapahoe County may not appropriate the Aspinall Unit water for its own use. The court also finds that the water court's decision correctly implemented Congress's intent to subordinate 60,000 AF to in-basin water users while providing a 240,000 AF marketable pool for contractual use by future in-basin and transbasin water users."

Since the current Gunnison DSS dataset covers the period from 1909 to 2001, once the current drought has ended, the DSS dataset for the basin should be extended, including updated irrigated acres and M&I demands. A new StateMod model run should be conducted with the updated dataset to determine if the recent drought is a new critical period.

Maintaining or enhancing recreational and environmental flows could also affect current and future supply availability. Environmental and recreational considerations are further developed in Sections 6 and 10 of this report. For example, a number of endangered fish species, such as the Razorback Sucker and the Colorado Pikeminnow, are present in the Gunnison River and tributaries, and require special attention with respect to minimum instream flows. Critical habitat has been designated in the Gunnison River between the confluence with the Uncompahgre River and the confluence with the Colorado River. Coordinated reoperation of the Aspinall unit, stocking, and habitat improvement are options that can help meet the needs of endangered species in the basin.

There are minor transbasin diversions from the Gunnison Basin to the Arkansas and Rio Grande Basins averaging 1,678 AF from 1971 to 2003 (Upper Colorado River Commission 2004.)

7.3.4.2 Gunnison Basin Alluvial Aquifer

Groundwater in the Gunnison Basin is obtained from unconsolidated alluvial aquifers. Alluvial deposits range in thickness from less than 10 feet to rarely more than 200 feet. Typically, they are less than 100 feet along major streams and less than 30 feet thick in tributary valleys (Lewis-Russ 1999).

The alluvium in the Gunnison Basin consists of clay, silt, sand, and gravels. The alluvial deposits in the Gunnison Basin area are found primarily along Ohio Creek down to Gunnison, throughout the Uncompahgre valley, and the lower portion of the North Fork River according to the Montrose, Colorado and Moab, Utah geologic quadrangle.

Over 1,500 wells withdraw water from this alluvial aquifer, although the withdrawal rate from most wells is relatively low, at less that 35 gpm (DWR 2004). The majority of these wells are for irrigation purposes, but approximately 25 alluvial wells are used for public water supply (CDPHE 2001). The groundwater in this aquifer is considered tributary to the Gunnison River and users of this resource are administered under the Prior Appropriation System. Except for domestic or other low-volume exempt uses, the use of groundwater in this aquifer requires a water court-approved augmentation plan that describes how depletions to the river will be offset to avoid injury to senior appropriators.

The location and extent of alluvial aquifer in the Gunnison River basin is shown in Figure 3-27.

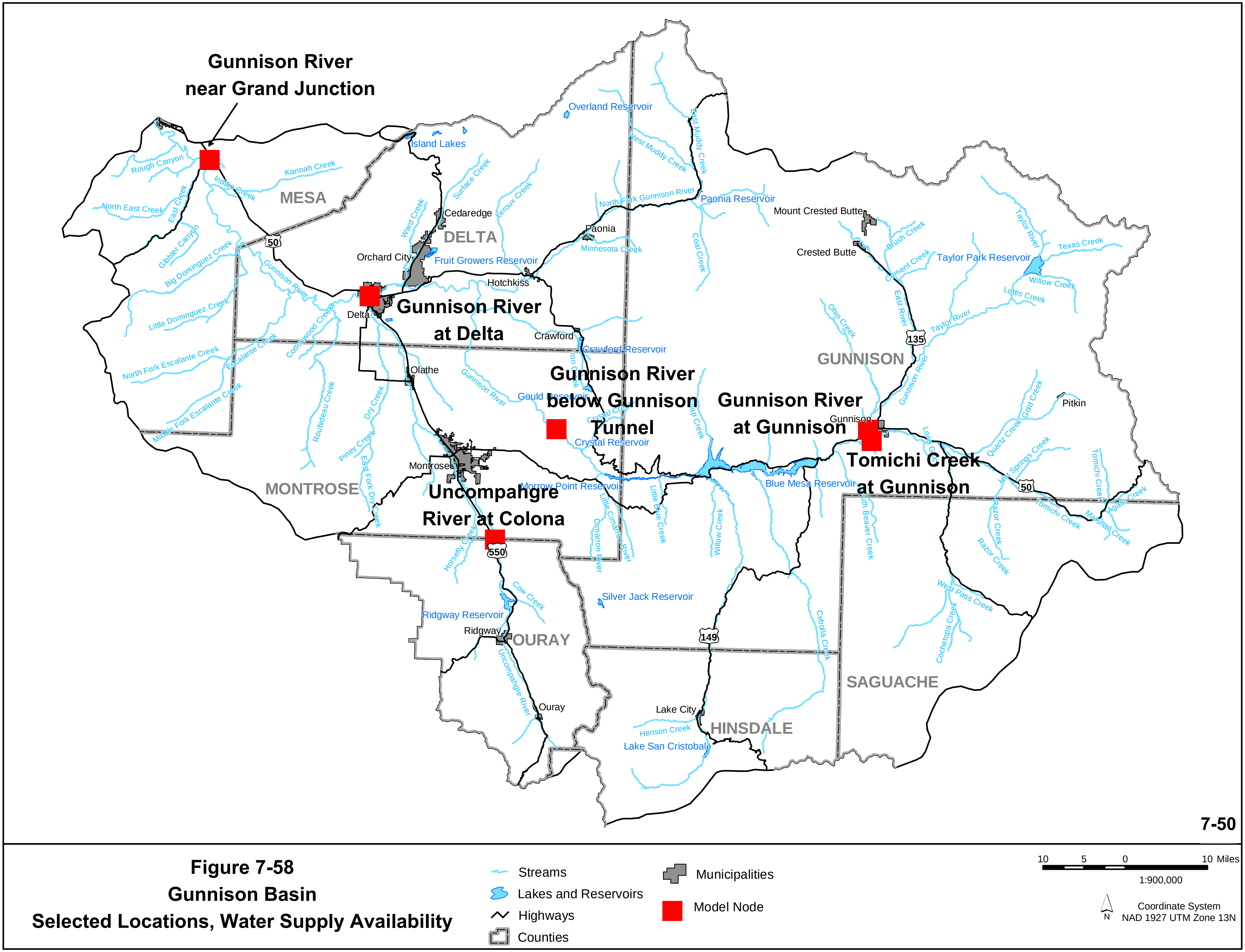


Figure 7-58
Gunnison Basin
Selected Locations, Water Supply Availability

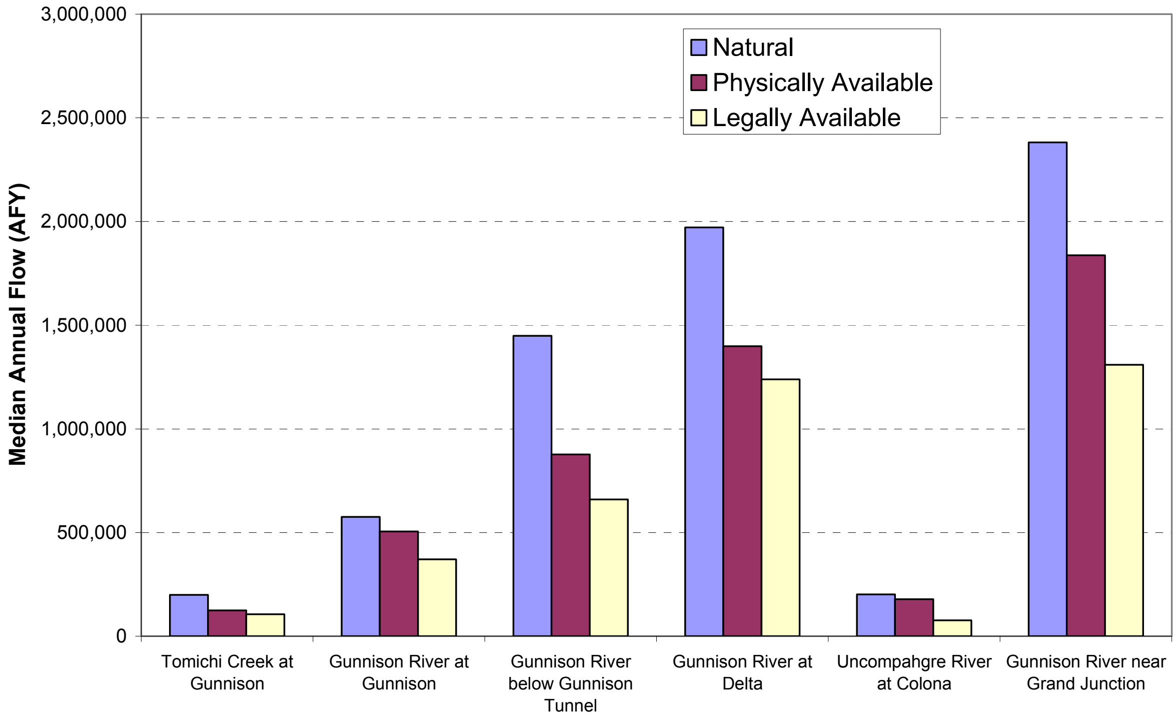


Figure 7-59
Median Annual Natural, Physically Available, and Legally Available Flows
Gunnison Basin

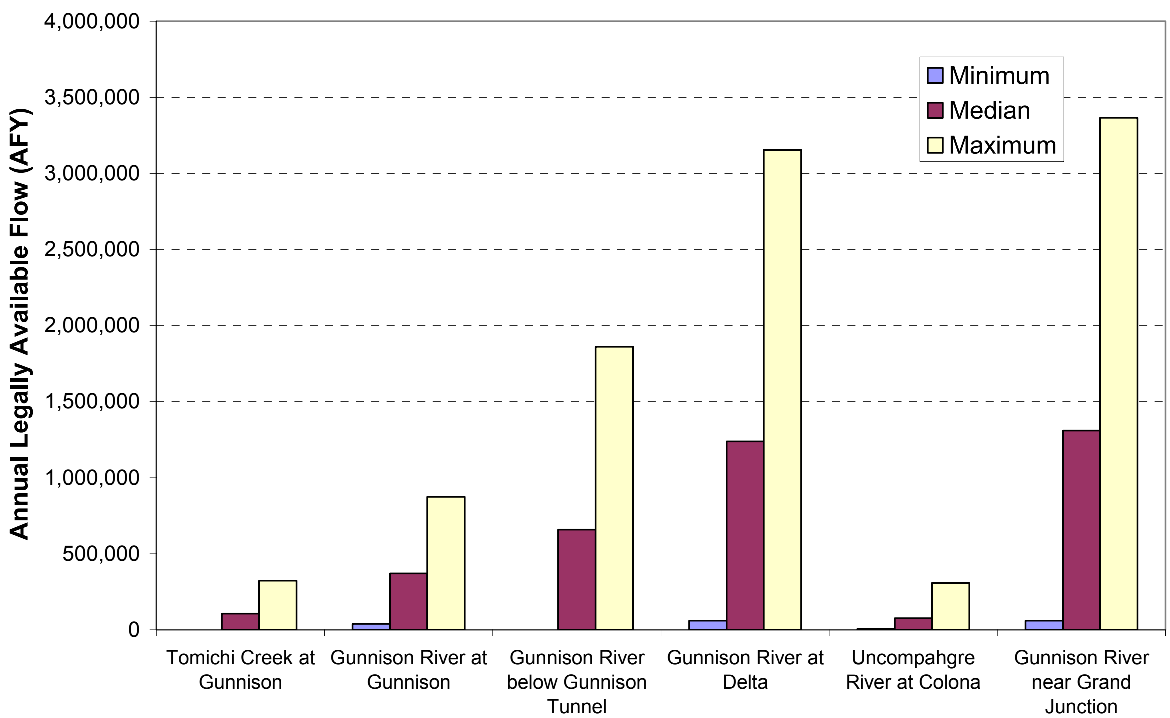


Figure 7-60
Minimum, Median, and Maximum Annual Legally Available Flows
Gunnison Basin

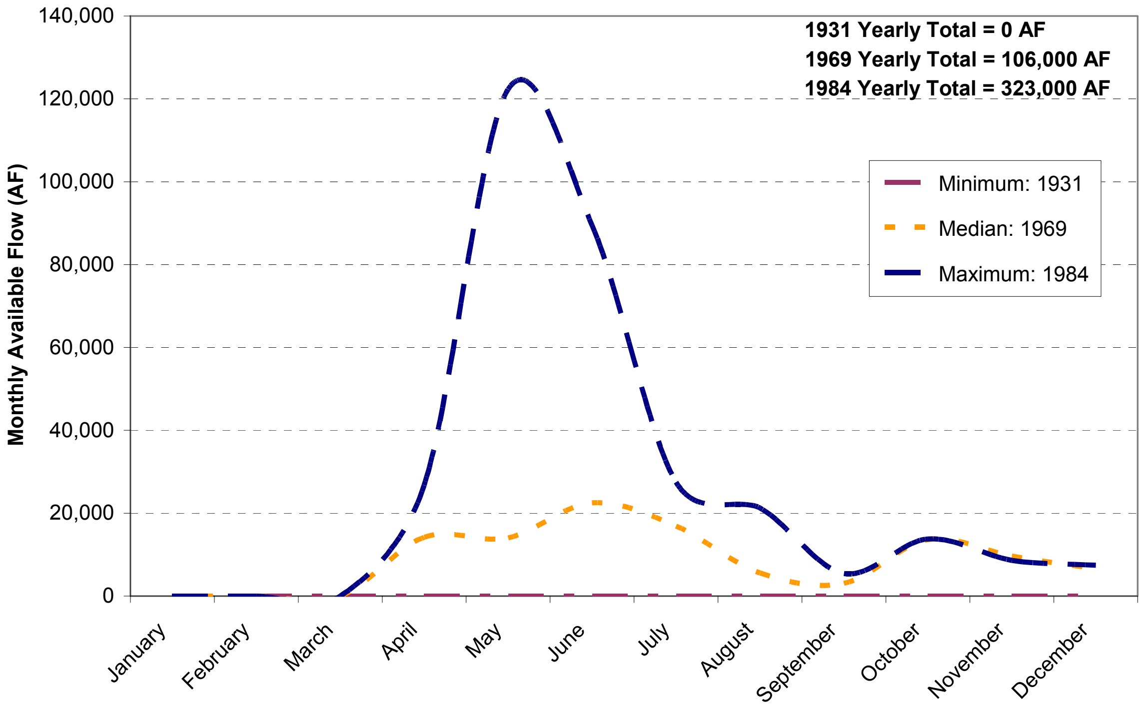


Figure 7-61
Monthly Legally Available Flow
Tomichi Creek at Gunnison (1909-2001)

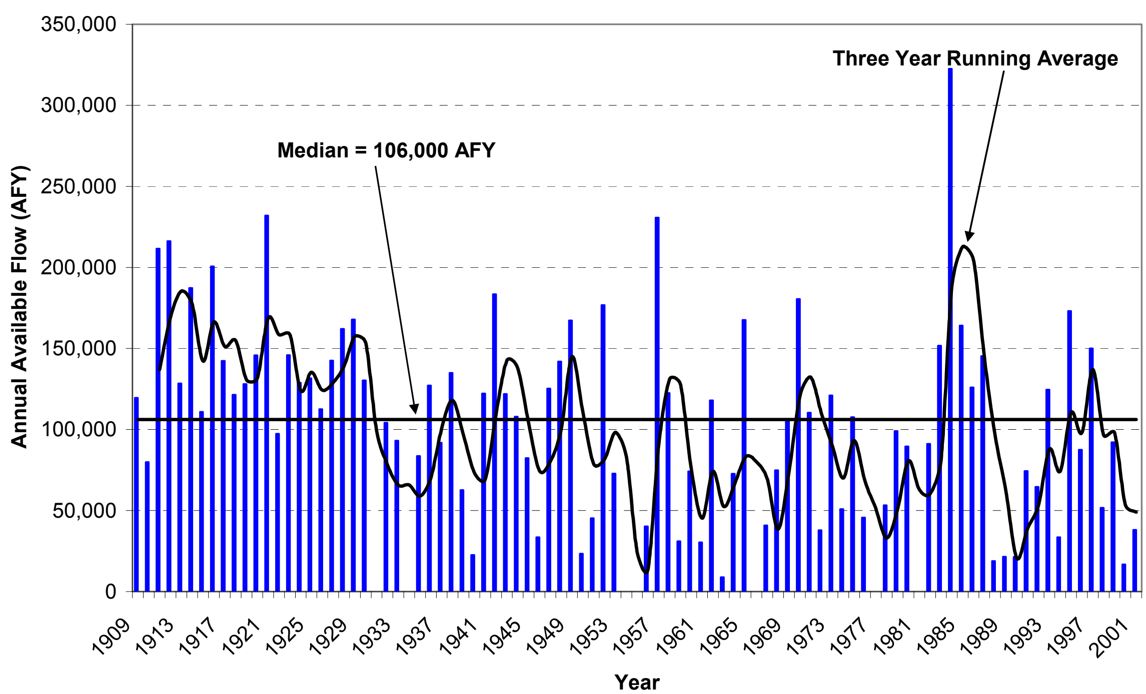


Figure 7-62
Annual Legally Available Flow
Tomichi Creek at Gunnison (1909-2001)

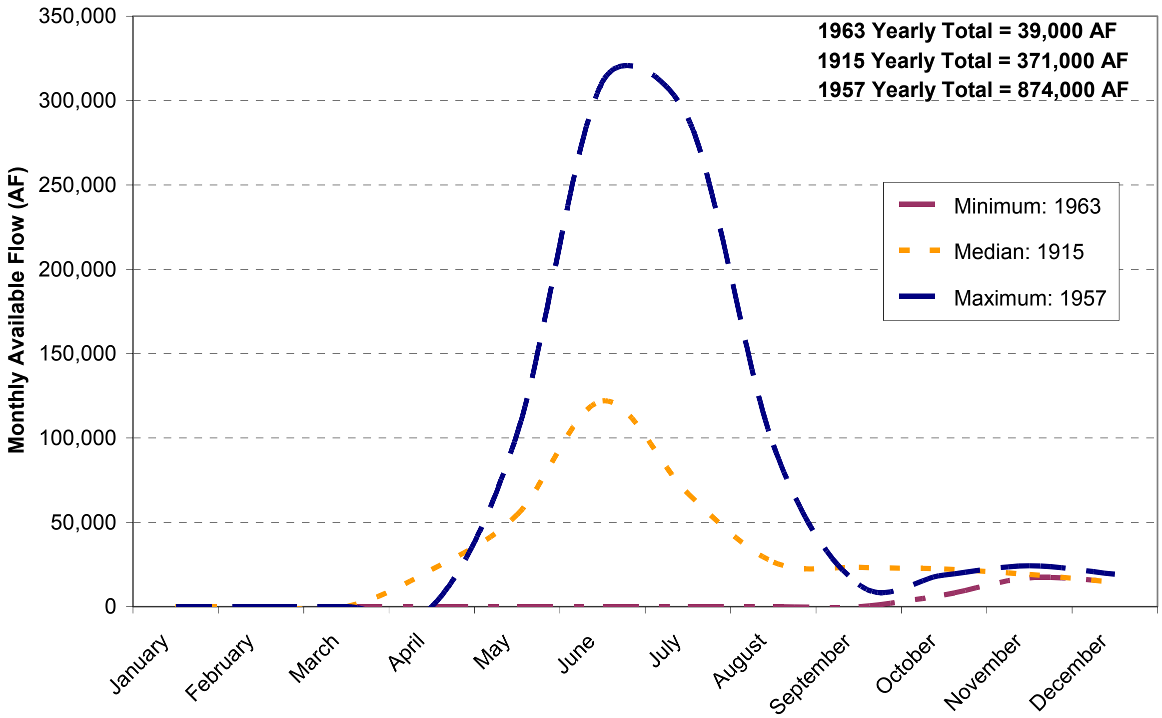


Figure 7-63
Monthly Legally Available Flow
Gunnison River at Gunnison (1909-2001)

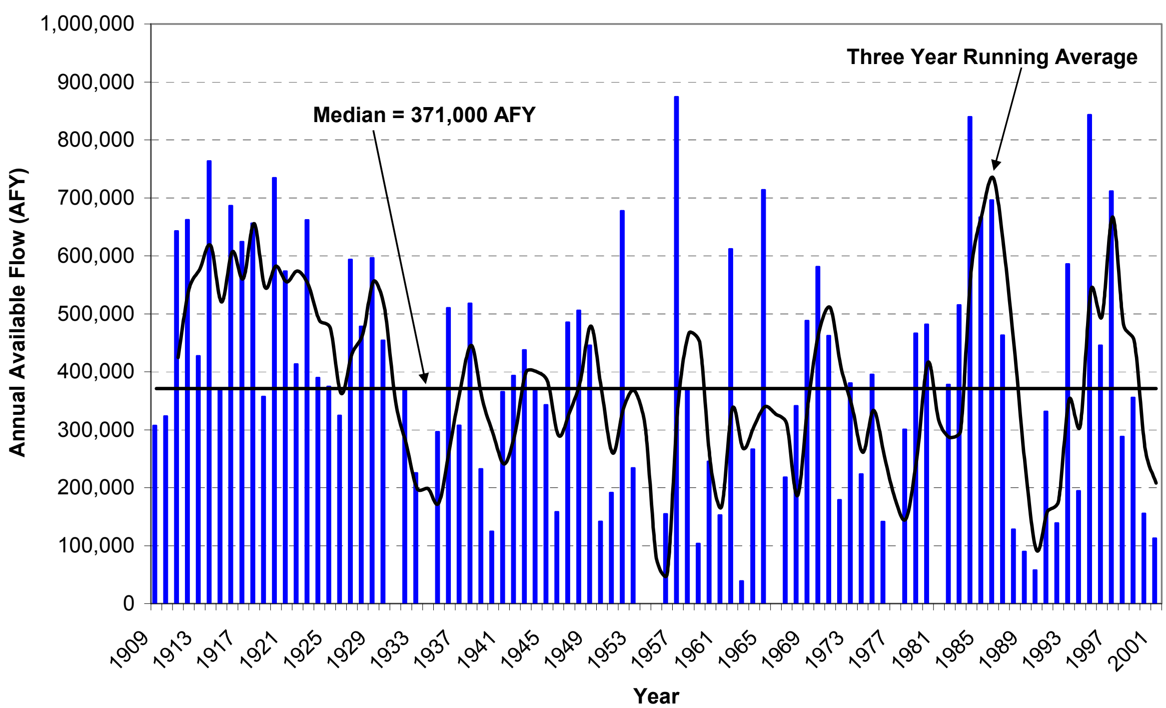


Figure 7-64
Annual Legally Available Flow
Gunnison River at Gunnison (1909-2001)

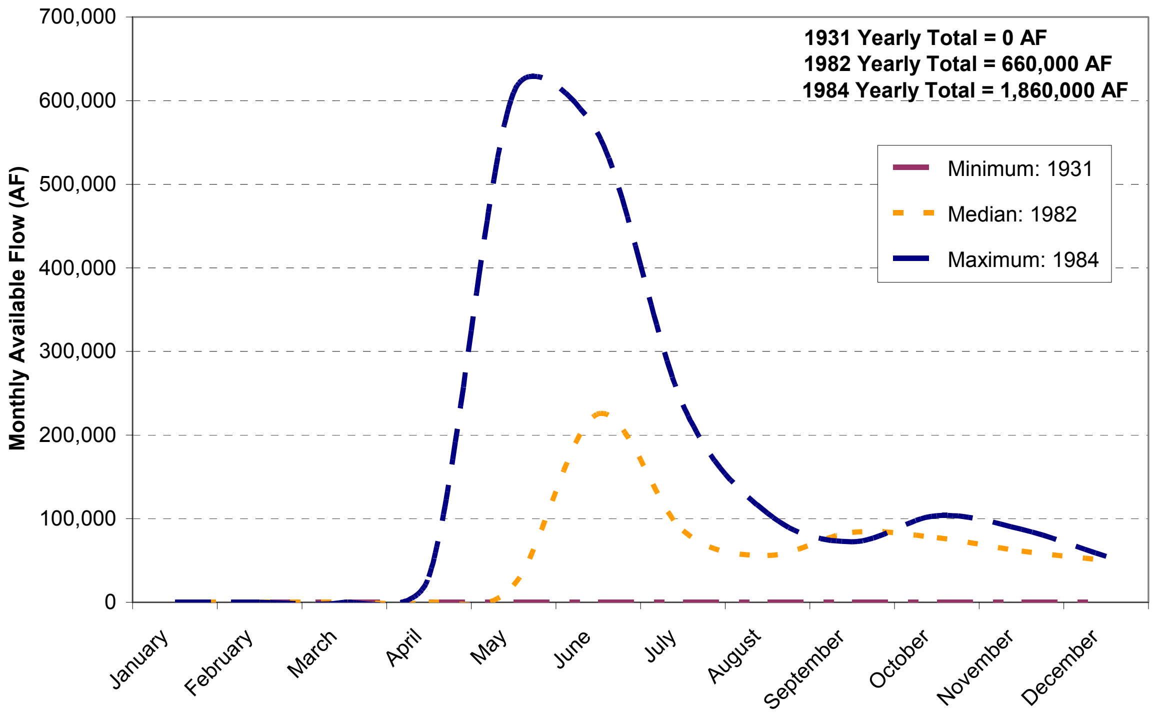


Figure 7-65
Monthly Legally Available Flow
Gunnison River below Gunnison Tunnel (1909-2001)

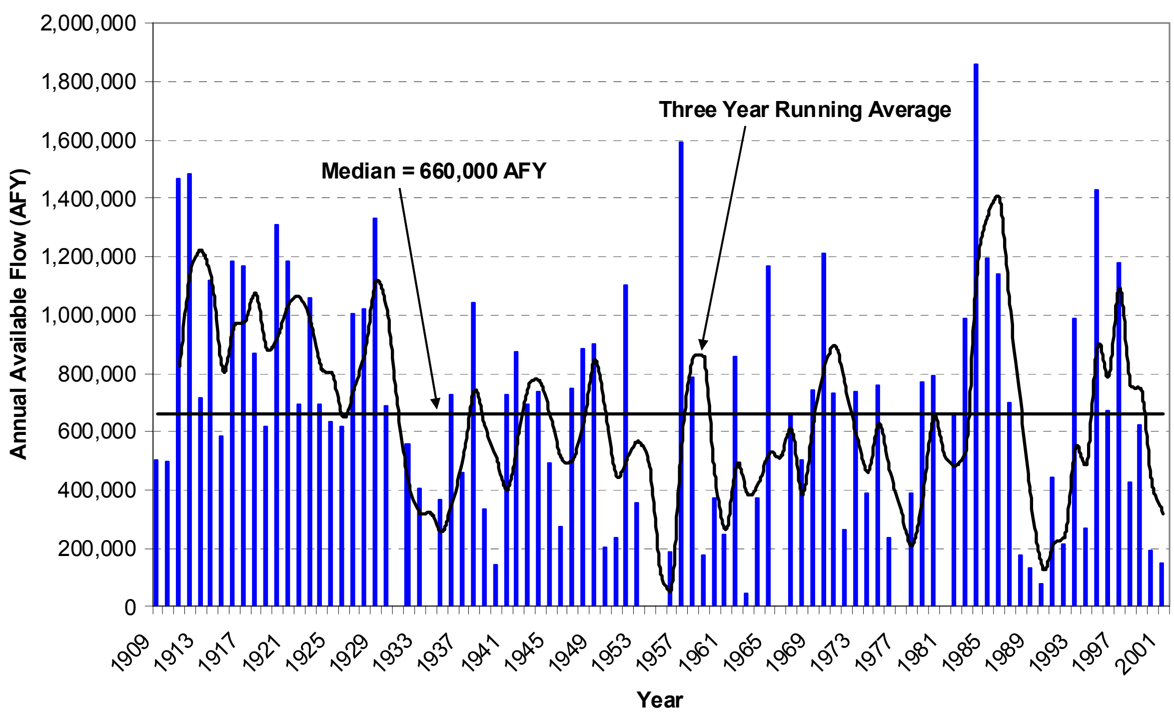


Figure 7-66
Annual Legally Available Flow
Gunnison River below Gunnison Tunnel (1909-2001)

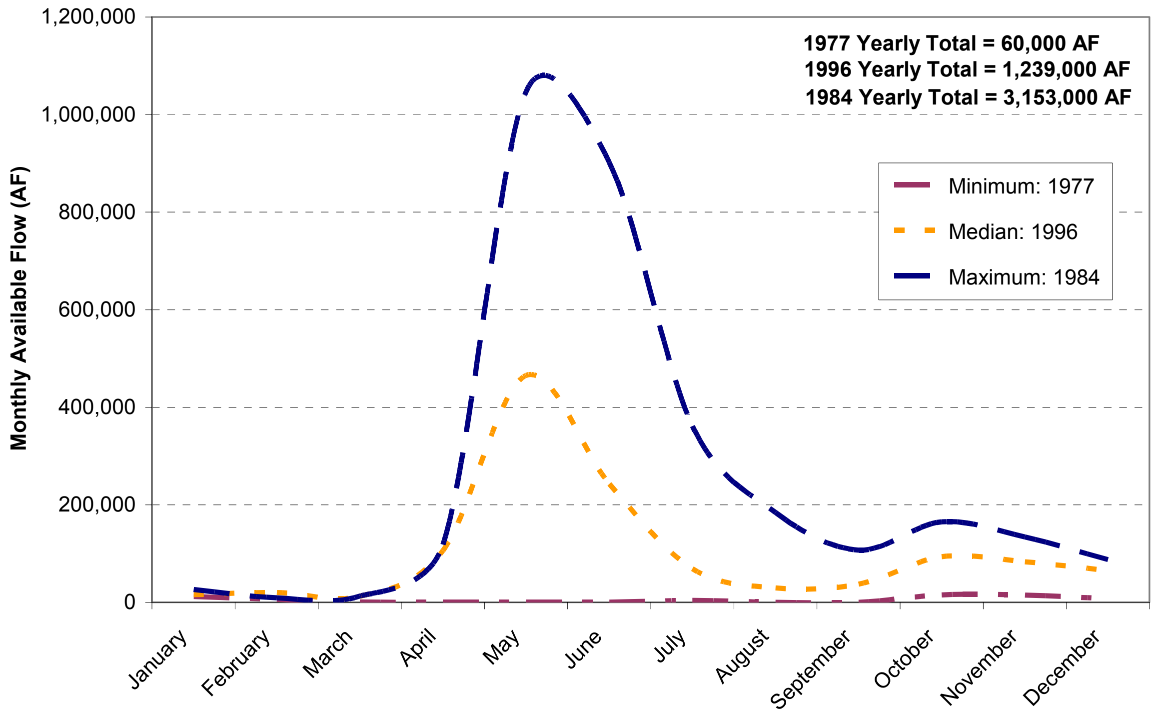


Figure 7-67
Monthly Legally Available Flow
Gunnison River at Delta (1909-2001)

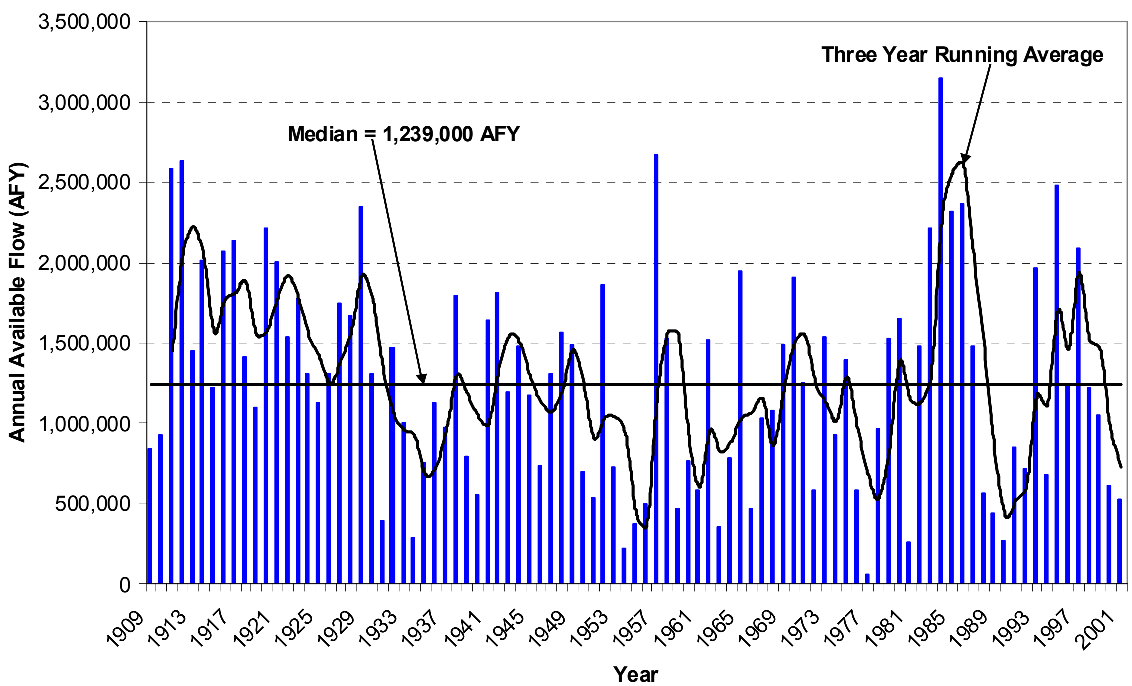


Figure 7-68
Annual Legally Available Flow
Gunnison River at Delta (1909-2001)

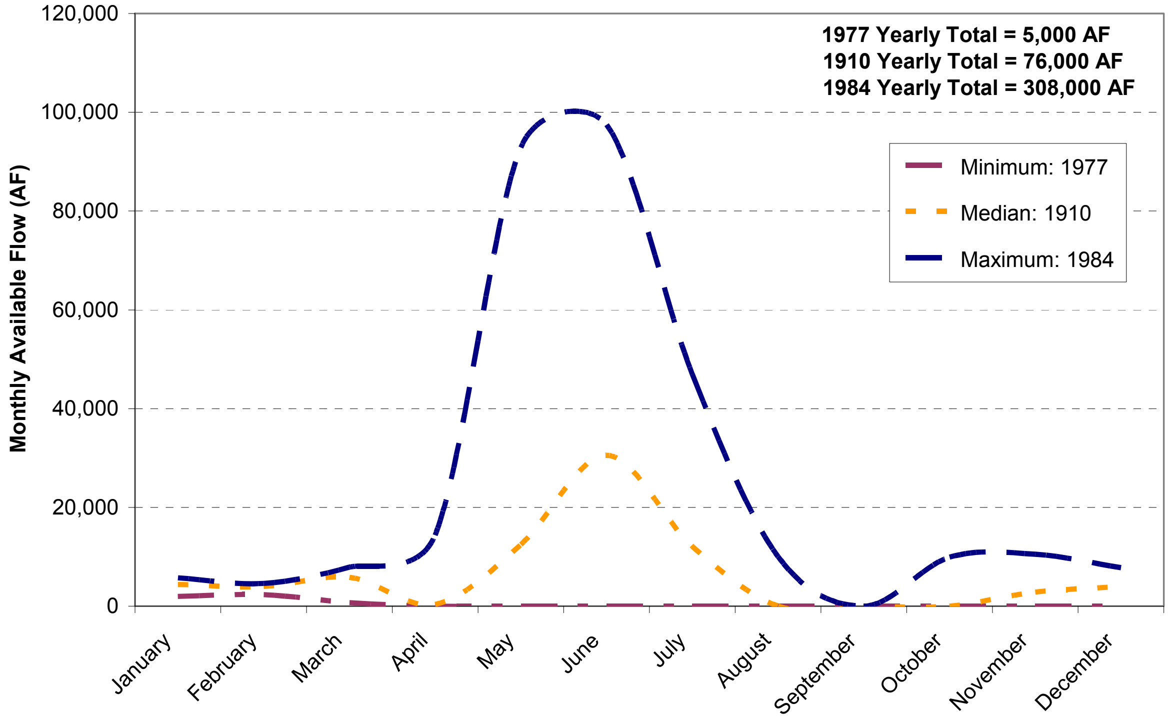


Figure 7-69
Monthly Legally Available Flow
Uncompahgre River at Colona (1909-2001)

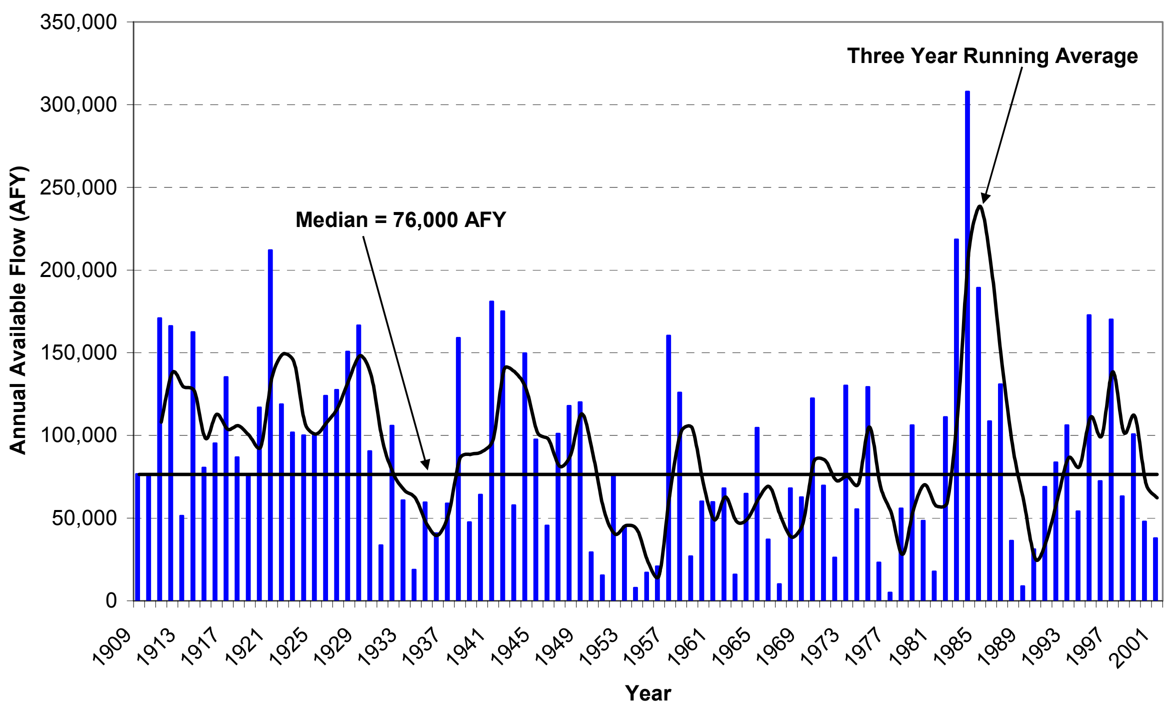


Figure 7-70
Annual Legally Available Flow
Uncompahgre River at Colona (1909-2001)

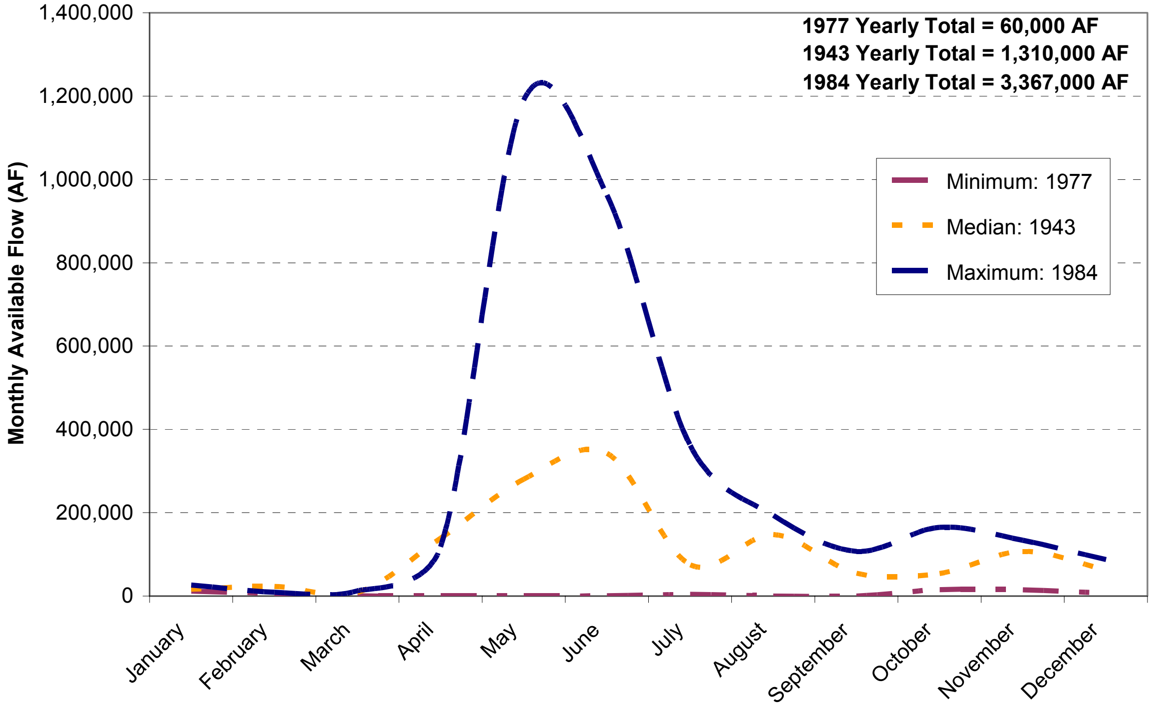


Figure 7-71
Monthly Legally Available Flow
Gunnison River at Grand Junction (1909-2001)

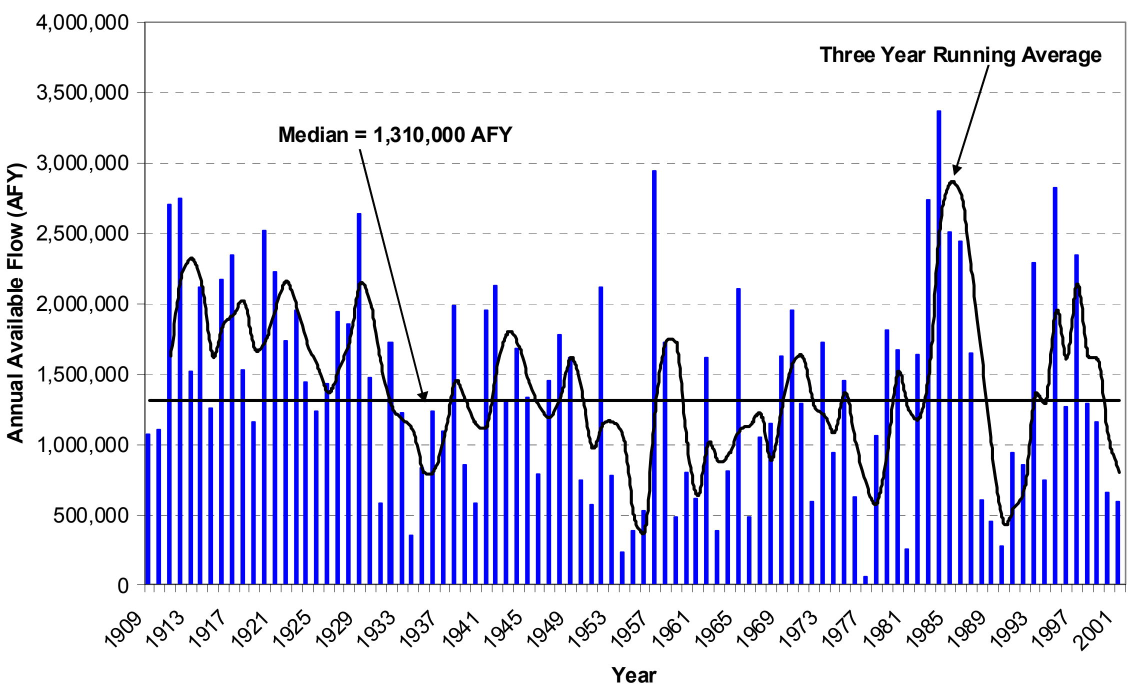


Figure 7-72
Annual Legally Available Flow
Gunnison River at Grand Junction (1909-2001)

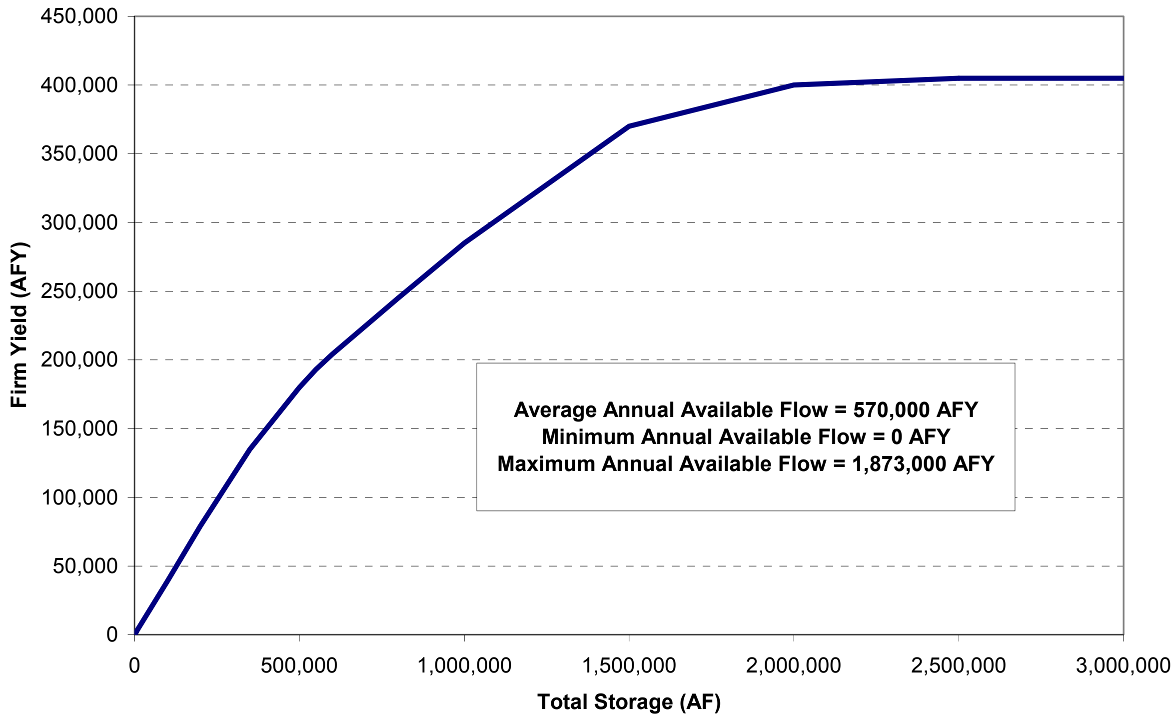


Figure 7-73
Reservoir Yield Curve
Gunnison River below Gunnison Tunnel (1909-2002)

7.3.5 North Platte Basin

7.3.5.1 North Platte Surface Water Supplies

StateMod datasets are not available for the North Platte Basin. There are, however, a number of USGS flow gages, with extensive periods of record, located throughout the basin. Two of these gages, shown in Figure 7-74, were used to characterize historical physically available flow in the basin. These flows are measured and correspond to actual historical, rather than current, diversions and demands. The period of record varies by gage, spanning the time period 1915 to 2001 (full calendar years). The selected gage locations are:

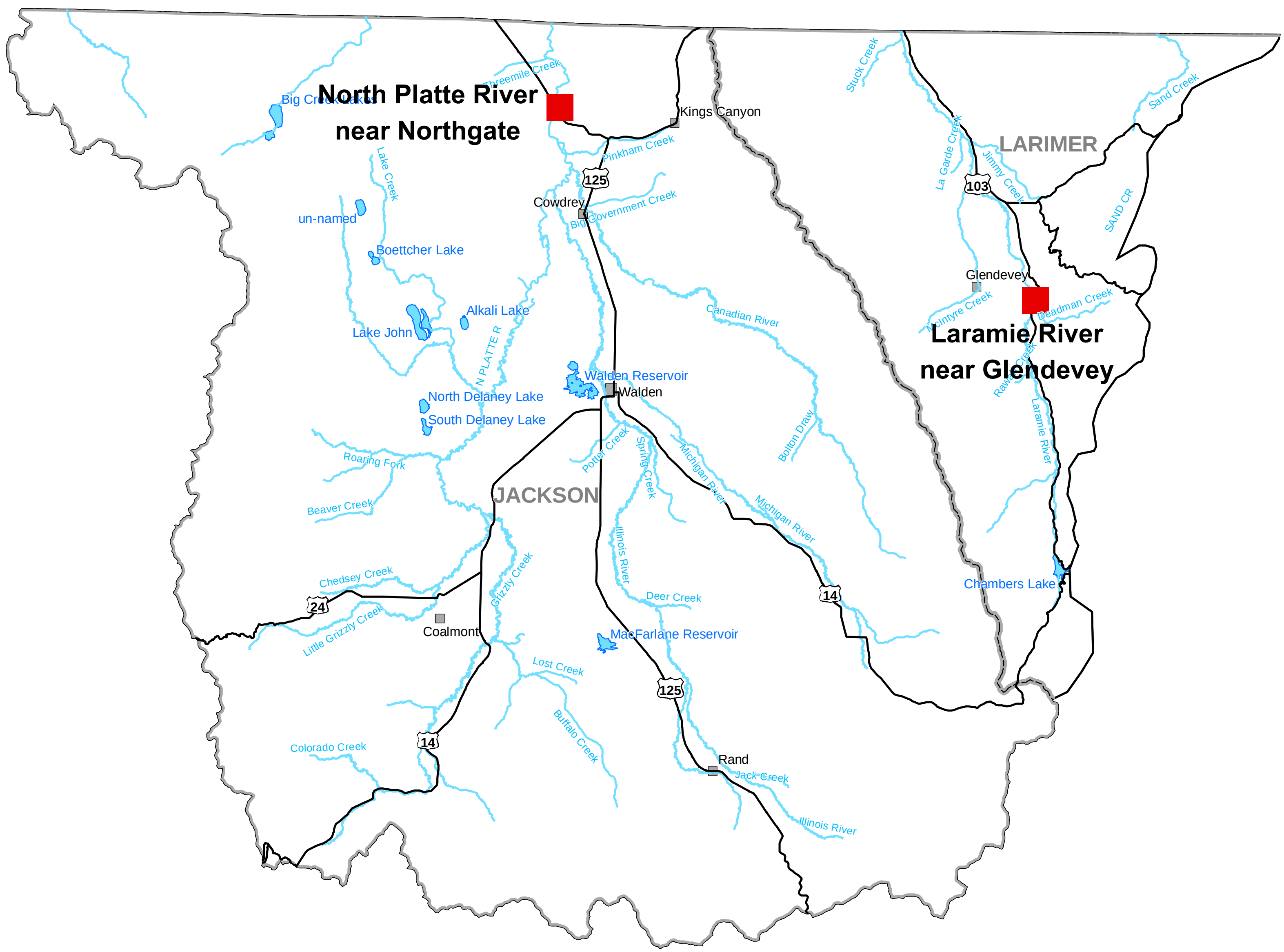
- North Platte River near Northgate (1916-2001)
- Laramie River near Glendevey (1915-1981)

Minimum, median, and maximum annual measured flows are summarized for each location in Figure 7-75. To better represent the effects of seasonal and year to year hydrologic variation, annual time series, and monthly summaries of historical physical flows are shown in Figures 7-76 through 7-79. Median annual flows and 3-year running averages are also included on the annual time series plots. The monthly analyses highlight the fact that physical flows vary greatly with season, with the greatest amounts of water present in the summer months and a sharp decline in flows in the autumn and winter. The annual time series plots also show large variation with a notable extended drought periods in the mid-1950s and the early 1990s. Extended wet periods appear to have occurred in the mid-1980s and mid-1990s.

The interpretation above is in general agreement with the CWCB Drought Study (HDR 2003), which summarized the history of drought in Colorado and identified significant drought periods in the last 100 years. The Drought Study states that the most recent drought analyzed for years 2000 to 2003 exceeds many of the drought records established during the 20th century.

The North Platte River Basin Decree is a Supreme Court decree that limits the total number of acres that can be irrigated in the North Platte Basin. The decree also limits the amount of water that can be stored for irrigation and the amount of water than can be exported out of the basin. This decree is described in Section 4. Currently, Colorado is not maximizing its allocation of water rights available under the decree. Estimates indicate that there is the potential to irrigate additional acres based on hydrologic conditions from 1975 to 2002. Transbasin diversions have also not been maximized per the Decree over the period of record. Transbasin diversion limits are limited on a running ten year total to 60, 000 AF. Recent diversions have averaged 44,600 AF for the most recent 10-year period (Leonard Rice Consulting Water Engineers 2004).

Another factor to be considered when assessing supply availability in the basin is the need and/or desire to maintain or enhance environmental flows. Environmental considerations are further developed in Sections 6 and 10 of this report.



7-60

5 2.5 0 5 Miles
1:500,000

N
Coordinate System
NAD 1927 UTM Zone 13N

Figure 7-74
North Platte Basin
Selected Locations, Water Supply Availability

Streams
Lakes and Reservoirs
Highways
Counties

Cities, Population
0 - 100
101 - 1000

Streamflow Gage

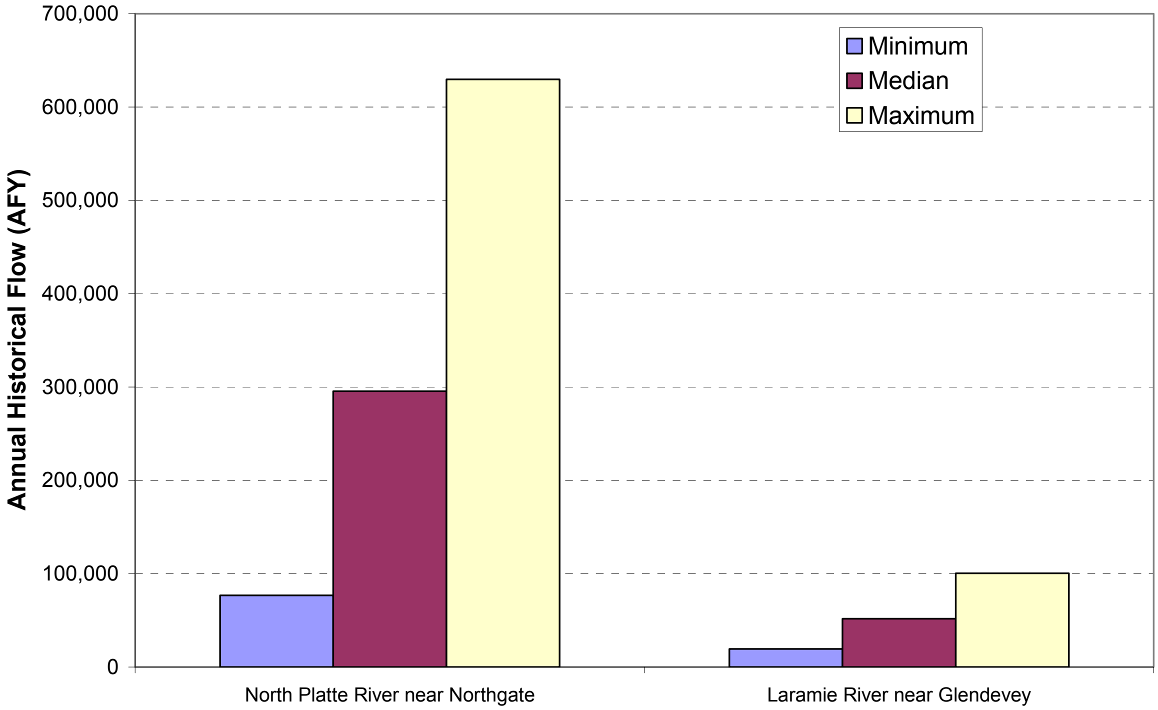


Figure 7-75
Minimum, Median, and Maximum Annual Historical Flows
North Platte Basin

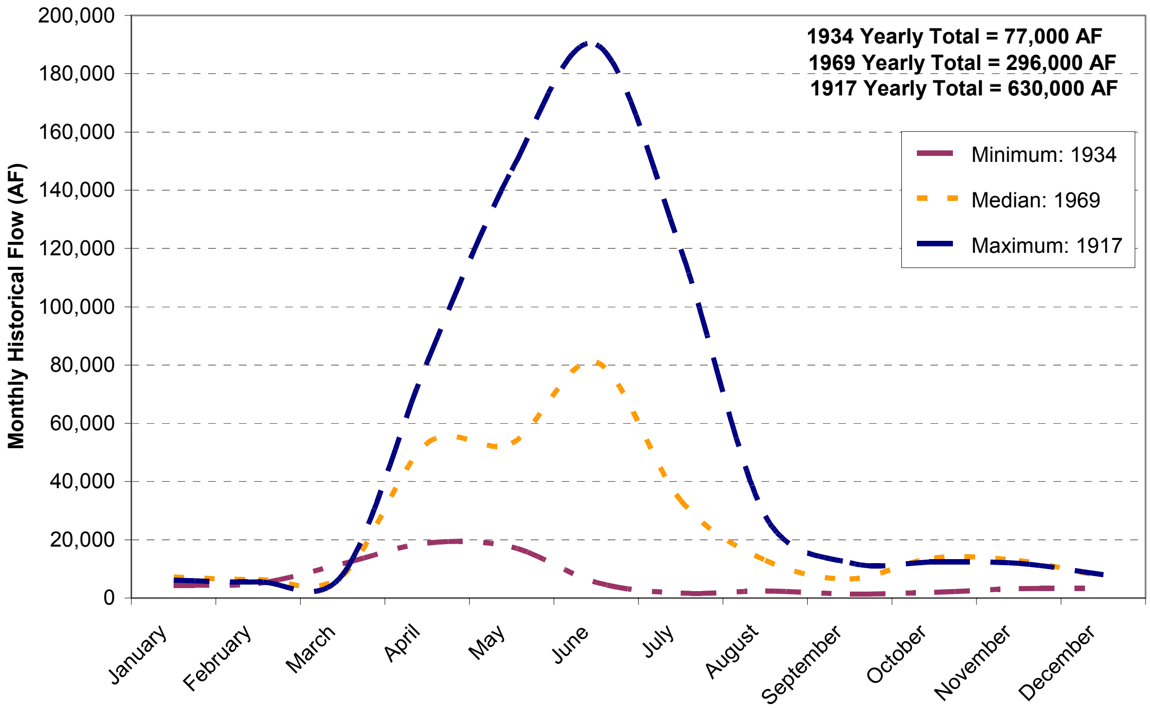


Figure 7-76
Monthly Historical Flow
North Platte River near Northgate (1916-2001)

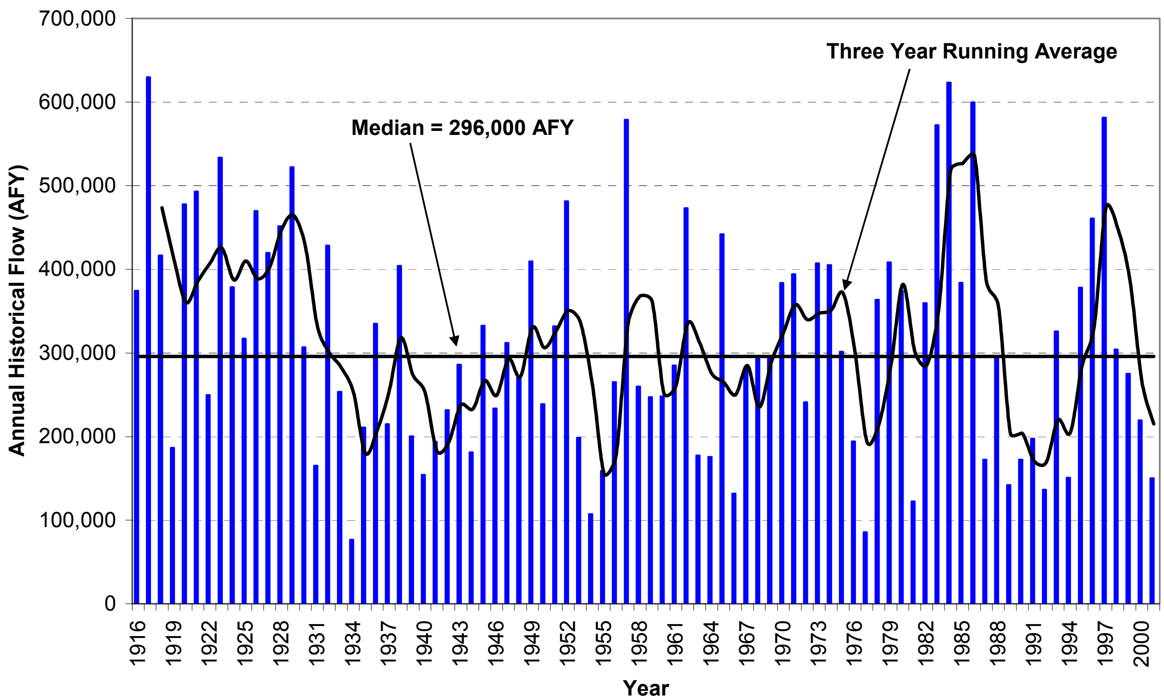


Figure 7-77
Annual Legally Available Flow
North Platte River near Northgate (1916-2001)

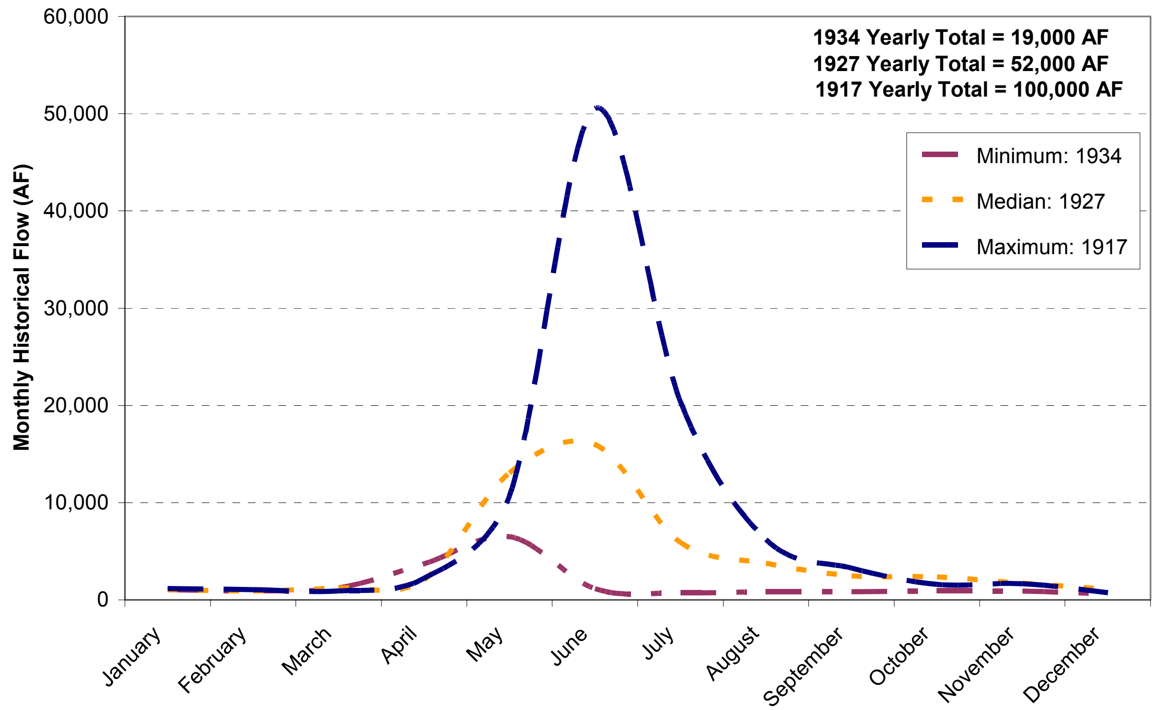


Figure 7-78
Monthly Historical Flow
Laramie River near Glendevey (1915-1981)

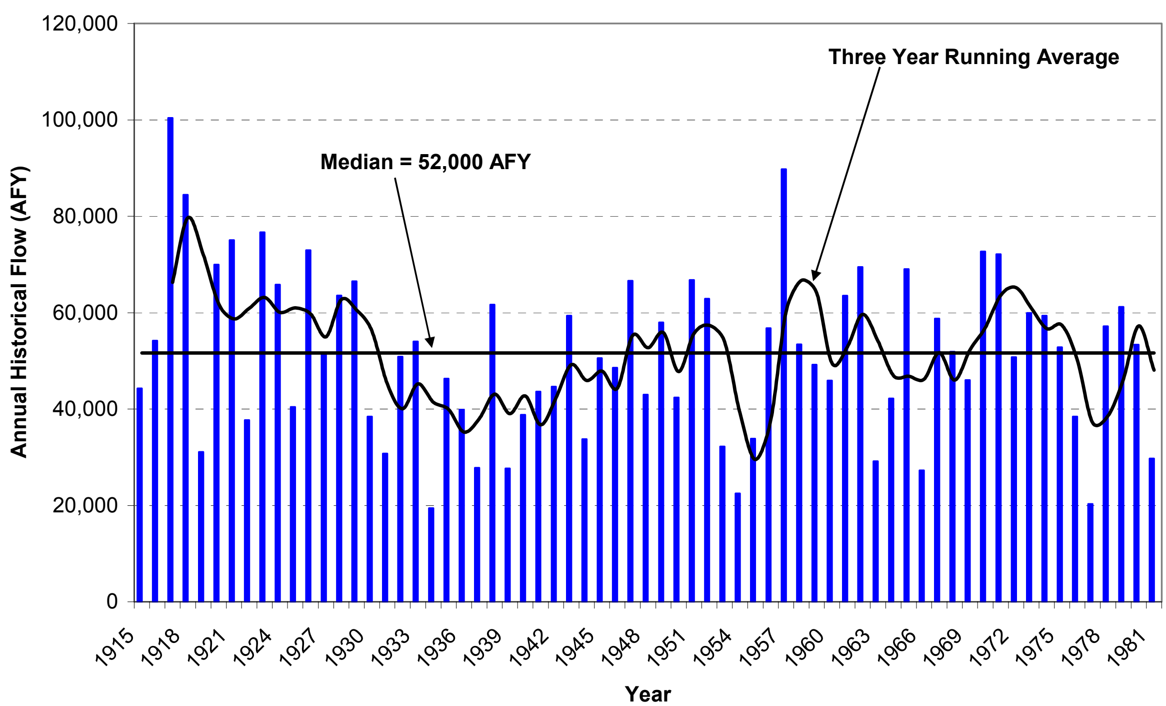


Figure 7-79
Annual Historical Flow
Laramie River near Glendevey (1915-1981)

7.3.6 Rio Grande Basin

7.3.6.1 Rio Grande Basin Surface Water Supplies

The Rio Grande Compact of 1938 establishes that Colorado shall annually deliver a portion of the waters of the Conejos River and the Rio Grande to the New Mexico state line and New Mexico's obligation to assure deliveries of water at the Elephant Butte Reservoir, with allowance for credit and debit accounts in Elephant Butte. This generally has to be accomplished by partially curtailing diversions on the two rivers to provide water to meet Colorado's annual obligation (Wolfe 2003). Colorado's obligation is generally harder to meet in wet years because the delivery obligations are greater than in dry years. Section 4 has additional information on the compact.

The Rio Grande DSS and Basin Roundtable feedback support the assessment that, as a result of compact limitations, there is very infrequent available flow in the Rio Grande for use in Colorado and that these flows, as in the Arkansas, do not provide a reliable source for new supply development. The following description summarizes the Rio Grande StateMod analysis of available flows (Leonard Rice Consulting Water Engineers 2004.)

1. Colorado attempts to meet Compact obligations each year, with little or no surplus or deficit. This is accomplished through regularly "curtailing" Colorado water users in order to meet state line delivery requirements.

2. Slight over- or under-delivery from year to year is carried forward in the Colorado "account" and affects administration in subsequent years.

3. In the Baseline DSS run, there are 2 years out of 48 when Colorado reaches the 100,000 AF credit allowed by the Compact. During these 2 years, an average of 17,781 AF of delivery at the state line was not credited to Colorado; therefore, it could have been available for development.

4. When Elephant Butte Reservoir spills, Colorado's credit and surplus on Compact deliveries are canceled. Elephant Butte Reservoir spilled six times between 1950 and 1997, i.e., 6 out of 48 years. Following Elephant Butte spills, Compact requirements are canceled for that year. The deliveries, however, help achieve a spill condition in subsequent years. In other words, if all available water during spill years was developed in Colorado, it would likely reduce or eliminate the number of subsequent spill years.

7. During periods when Colorado has not reached its Compact credit limit, and there is not a spill at Elephant Butte, there is no available flow. This occurred 72 of the 78 years (83 percent of the model period) in the Baseline model.

Four locations were selected for the Rio Grande Basin to characterize supply availability using StateMod datasets. The period of record for the Rio Grande StateMod datasets is 1950 to 1997 (full calendar years). The selected locations, shown in Figure 7-80 are:

- Rio Grande at Wagon Wheel Gap
- Rio Grande near Del Norte
- Rio Grande at Alamosa
- Rio Grande near Lobatos

Median annual legally available, physically available, and naturalized flows are summarized for each location in Figure 7-81. Median annual legally available flows are zero for each location for reasons discussed above. The fact that significant volumes of water are physically available at these locations, but not legally available, highlights the compact requirements discussed above. Figure 7-82 shows minimum, median, and maximum annual legally available flows for the period of record. Both the minimum and median legally available flows are zero. The maximum flow plot shows that when there is actually legally available flow in the basin (6 out of 48 years), it can be significant.

To better represent the effects of seasonal and year to year hydrologic variation, monthly (for minimum, maximum, and median years) and annual time series of legally available flows for the periods of record are shown in Figures 7-83 through 7-90. The median annual flow and 3-year running averages are also included on the annual time series plots. The monthly analyses highlight the fact that available flows, when non-zero, vary with season, with the greatest amounts of water available in the summer months and a sharp decline in flows in the autumn and winter. The annual time series plots show non-zero available flows in only 6 out of 48 years, as discussed above: 1985, 1986, 1987, 1988, 1994, and 1995. The mid-1980s has been identified in the analyses for other basins as an extended wet period.

Finally, Figure 7-91 is provided to further quantify the impacts of seasonal and year to year hydrologic variation and to illustrate the difference between average annual available flow and the potential annual firm yield. This chart shows firm yield as a function of total available storage for legally available flows in the Rio Grande at Alamosa. This curve was generated using WatSIT. Firm yield is defined as the maximum annual supply that can be reliably provided every year for the period of record (no monthly shortages). The model assumes typical seasonal patterns of M&I use. As described above, the available inflow period of record was not long enough to eliminate model sensitivity to starting reservoir conditions. Therefore, for this exercise, starting conditions were set equal to the maximum simulated wet-weather volume (occurring in the mid-1980s). In other words, the model assumes that a period of wet weather and high available flow occurs just after the storage is brought online.

For the Rio Grande at Alamosa, even with very large volumes of storage, the maximum annual firm yield is less than 5 percent of the average annual available flow. This large discrepancy between annual firm yield and average annual available flow is due to the fact that, during most years, the available flow is zero. The curve reaches an asymptotic value of 590 AFY at approximately 450,000 AF of total storage, beyond which no significant gains in firm yield can be achieved with increased storage. At the asymptotic value, all excess water is captured, stored, and used, but supply is still limited (below the average annual) by the *timing* of the available flows and reservoir evaporation. The above analysis indicates that there are no significant reliable new supplies that can be developed in the Rio Grande Basin.

There are a number of other factors that may further limit future supply availability. For example, conditional water rights are also not included in the DSS datasets. These water rights could eventually be developed resulting in less available water for the rest of the basin. Due to the limited availability of water in the Rio Grande and compact limitations on post-compact reservoir storage, significant development of conditional rights in not anticipated. Conditional water rights, by basin, are summarized in Section 10.

An additional consideration is that there has been significant pumping of the unconsolidated (confined and unconfined) aquifers in the basin and that a reduction in irrigated acreage may be required to return aquifer levels to a sustainable level. As a result, there does not appear to be reliable additional supplies that could be developed given the Compact limitations and the current levels of irrigation in the basin, though a portion of the infrequent available flows could be diverted to groundwater recharge if there were capacity in the diversion structures canals and recharge areas.

Maintaining or enhancing recreational and environmental flows could affect current and future supply availability. Environmental and recreational considerations are further developed in Sections 6 and 10 of this report. For example, the Rio Grande Sucker, Rio Grande Chub (state species of concern), and the Rio Grande Cutthroat Trout (petitioned for federal listing) are present in the Rio Grande River and tributaries, and require special attention. Coordinated reservoir operations, stocking, and habitat improvement are options that can help meet the needs of endangered species.

7.3.6.2 Rio Grande Basin Aquifers

In the Rio Grande basin, the most pronounced hydrological feature is the San Luis Valley. The San Luis Valley is approximately 100 miles long and 50 miles wide (Pearl 1980).

The groundwater system in this basin consists of two principal aquifers. The shallower of these aquifers, the unconfined aquifer, consists of a water-saturated layer of sand and gravel, down to a depth of about 100 feet across most of the valley. Below the unconfined aquifer in the central part of the valley are a number of clay layers that serve to separate the unconfined aquifer from deeper water-bearing layers of sand, gravel, and fractured volcanic rocks. The deeper layers, of which there are many, together make up the confined aquifer because of the overlying and confining clays. Water flows from many wells completed in the confined aquifer due to natural artesian pressure (DWR 2003).

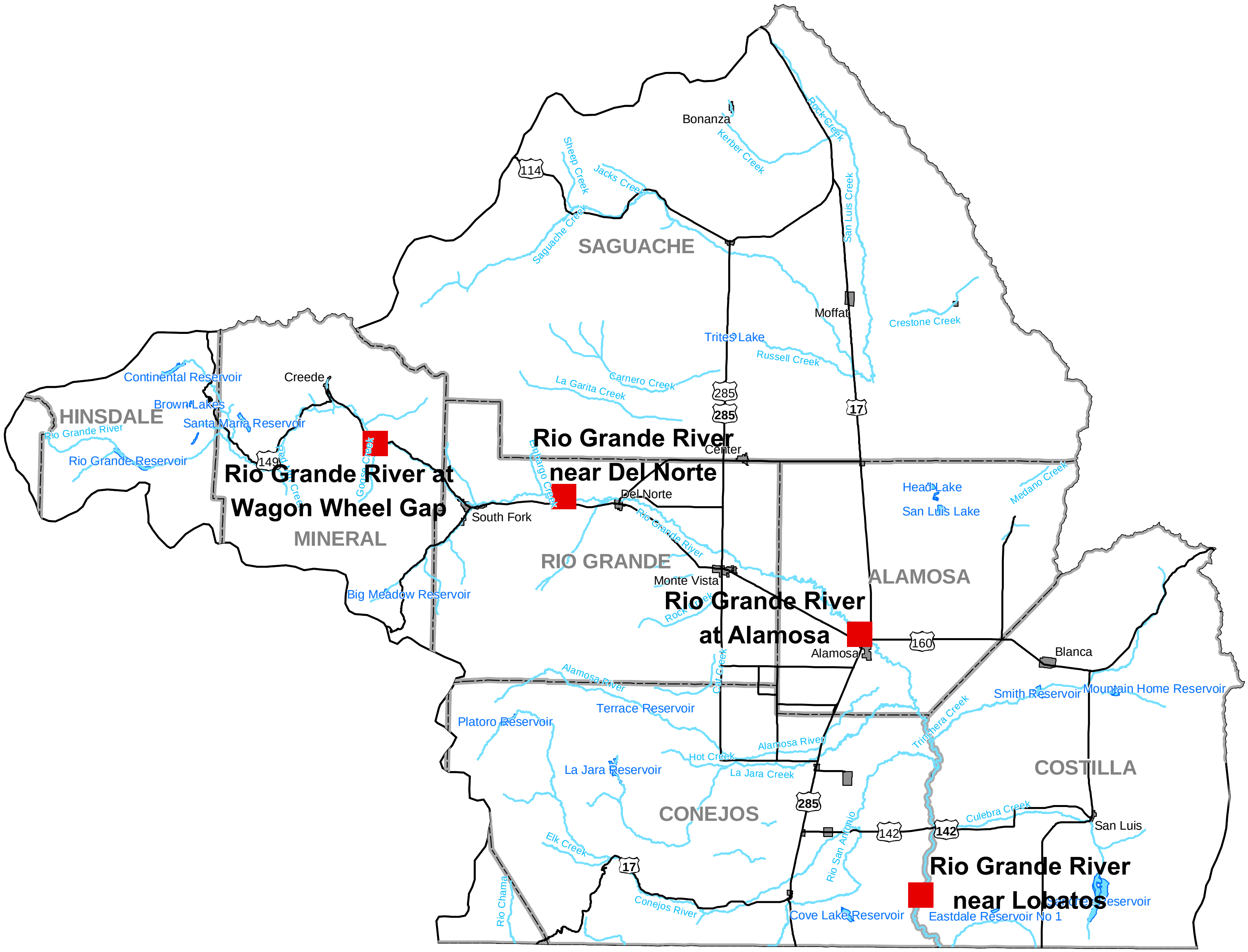
The volume of storage in the combined aquifer system of the valley is significant, with estimates of over 140 million AF estimated to be recoverable (Pearl 1974). Recent studies indicate that the deepest economically recoverable groundwater in the confined aquifer is 2,000 to 4,000 feet. At these depths, groundwater use is limited by poor water quality, reduced hydraulic conductivity due to compaction and lithification, and high well completion and water pumping costs (DWR 2003).

The unconfined aquifer functions similar to a surface reservoir with a pattern of rising levels in the spring and early summer caused by recharge from streams, canals, and early irrigation season return flows. Water levels decline in the late summer and fall as the streamflow decreases and groundwater is pumped largely for agricultural purposes. In contrast, water levels declined 20 to 40 feet in the confined aquifer in the northern portion of the San Luis Valley between 1970 and 1997, with larger declines seen in recent years near the Town of Center (CGS 2003). Groundwater modeling being undertaken as part of the Rio Grande DSS will help quantify the impacts of pumping on the confined aquifer.

The well depths and water levels in wells in all aquifers in the San Luis Valley generally do not exceed 150 feet with 90 percent of an estimated 9,980 wells being less than 400 feet deep (CGS 2003). The majority of wells have yields of less than 100 gpm.

The groundwater in this aquifer system generally is considered tributary to the Rio Grande River and users of this resource are administered under the Prior Appropriation System. Because of the hydraulic connection between surface water and both the unconfined and confined aquifers, the SEO has restricted well permits for irrigation wells since the 1970s. Further restrictions on groundwater use may occur as a result of the pending rules for new wells in the confined aquifer. These rules are intended to maintain confined aquifer water levels to those observed in the 1978 to 2000 time period (DWR 2004.) As noted, it is possible that up to 100,000 acres may need to be retired from irrigation if groundwater levels are to return to historical levels.

The location and extent of unconsolidated unconfined aquifer in the Rio Grande Basin is shown in Figure 3-40.



7-67

Figure 7-80
Rio Grande Basin Selected Locations, Water Supply Availability

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Model Node

10 5 0 10 Miles
1:1,000,000
N
Coordinate System
NAD 1927 UTM Zone 13N

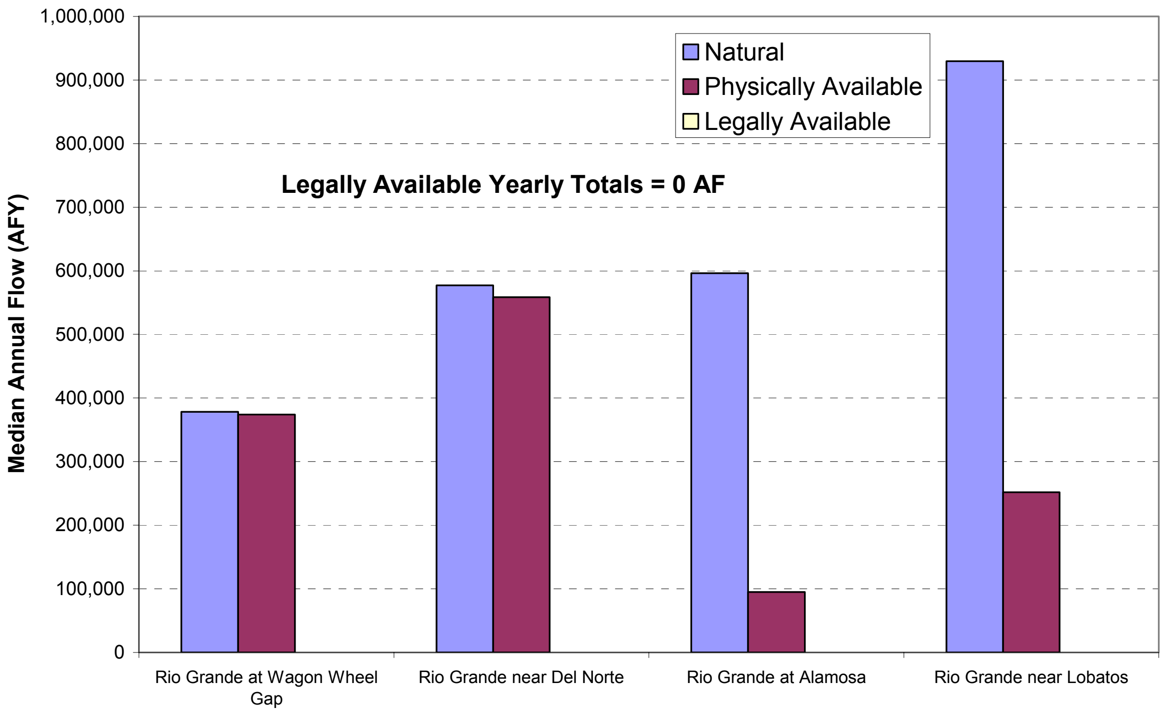


Figure 7-81
Median Annual Natural, Physically Available, and Legally Available Flows
Rio Grande Basin

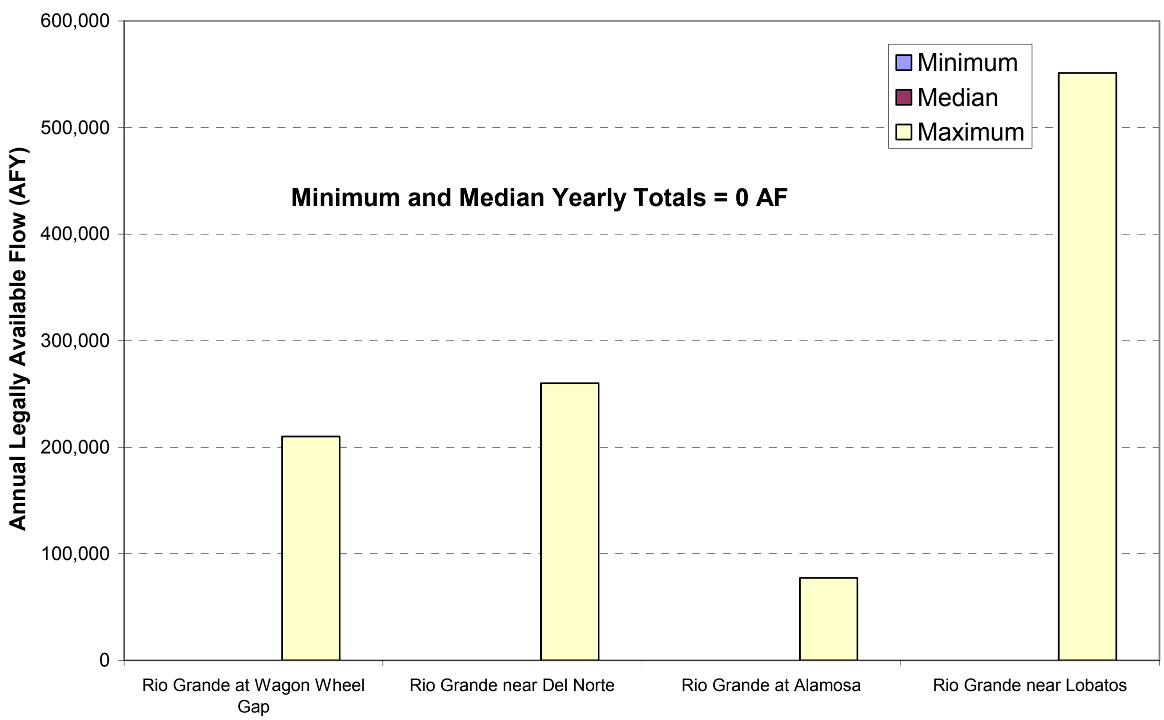


Figure 7-82
Minimum, Median, and Maximum Annual Legally Available Flows
Rio Grande Basin

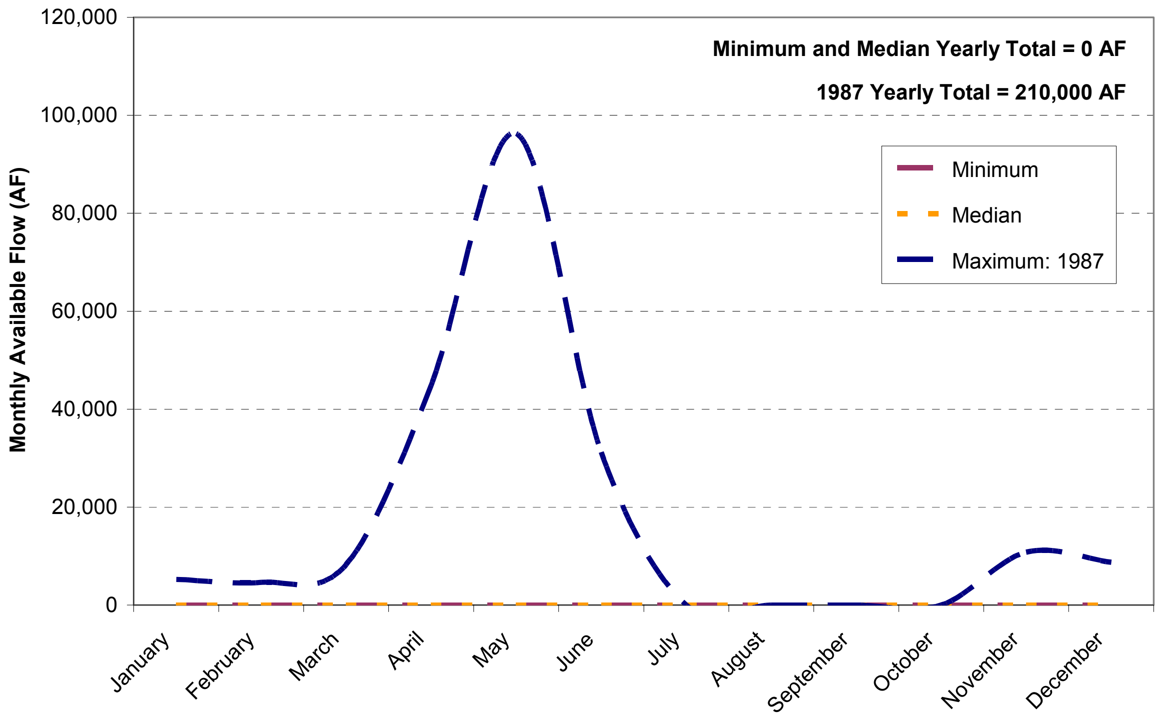


Figure 7-83
Monthly Legally Available Flow
Rio Grande at Wagon Wheel Gap (1950-1997)

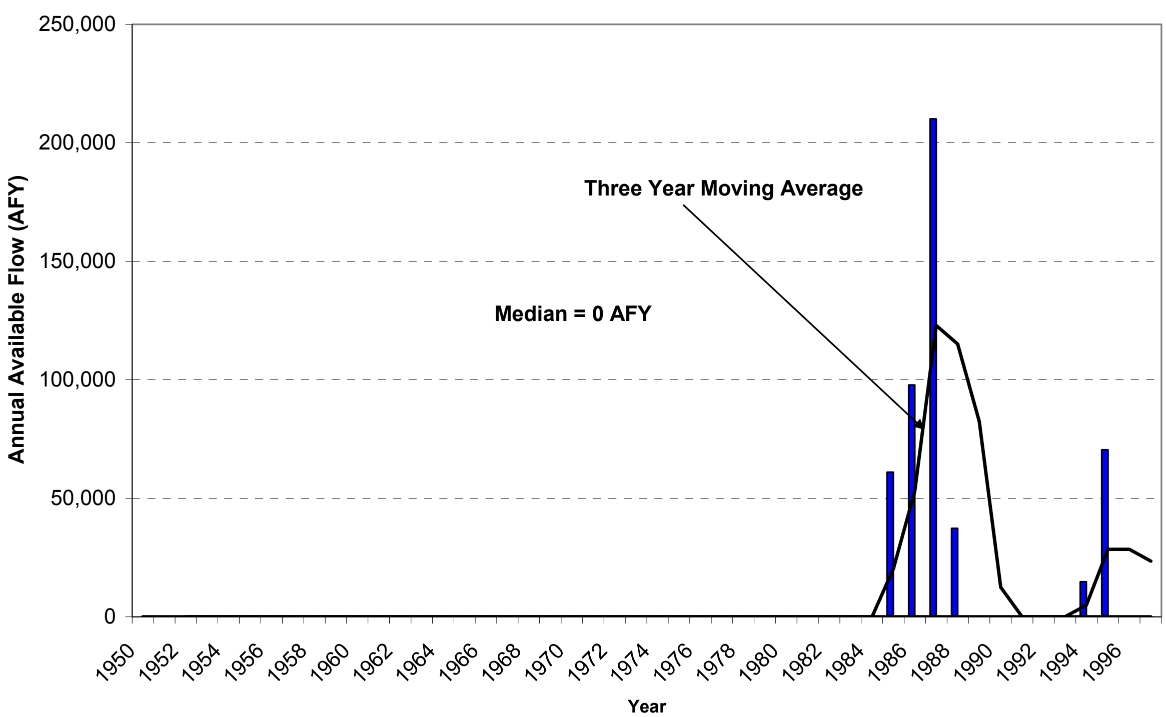


Figure 7-84
Annual Legally Available Flow
Rio Grande at Wagon Wheel Gap (1950-1997)

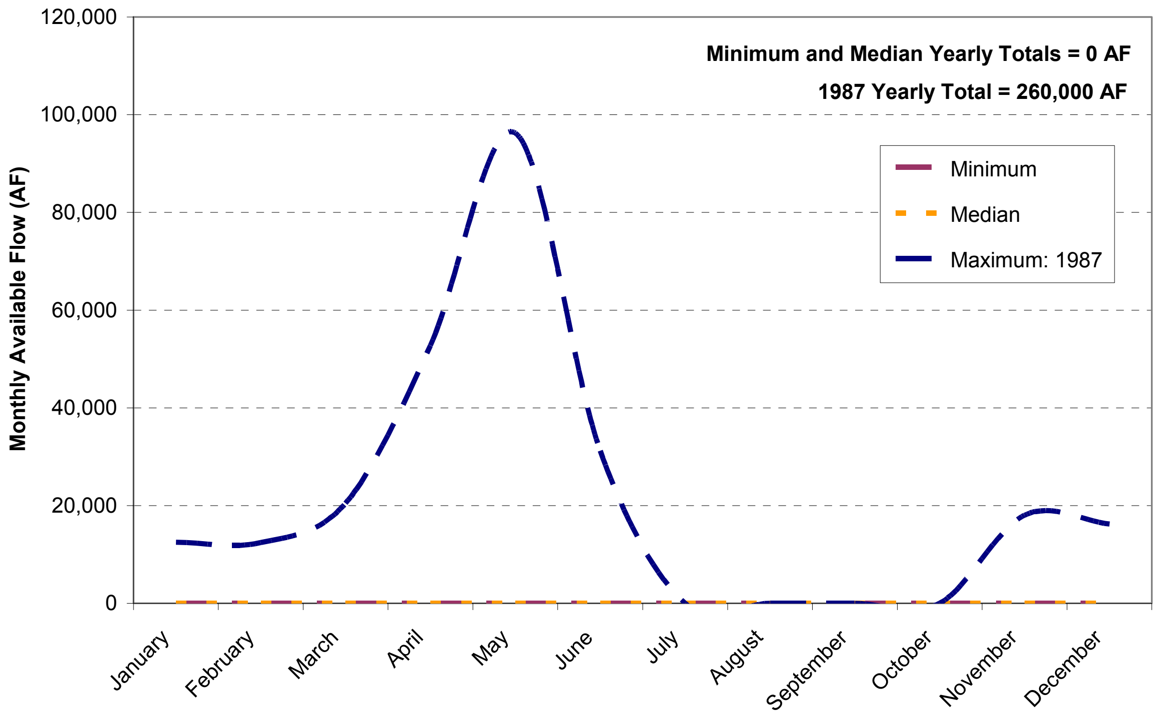


Figure 7-85
Monthly Legally Available Flow
Rio Grande near Del Norte (1950-1997)

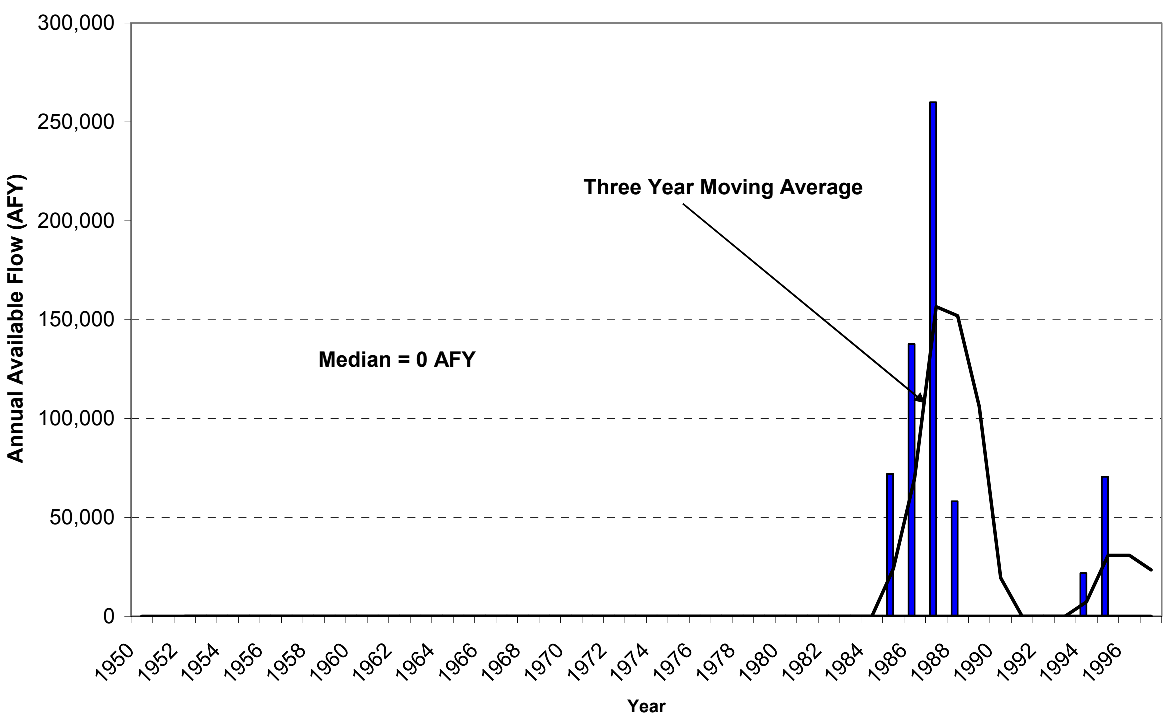


Figure 7-86
Annual Legally Available Flow
Rio Grande near Del Norte (1950-1997)

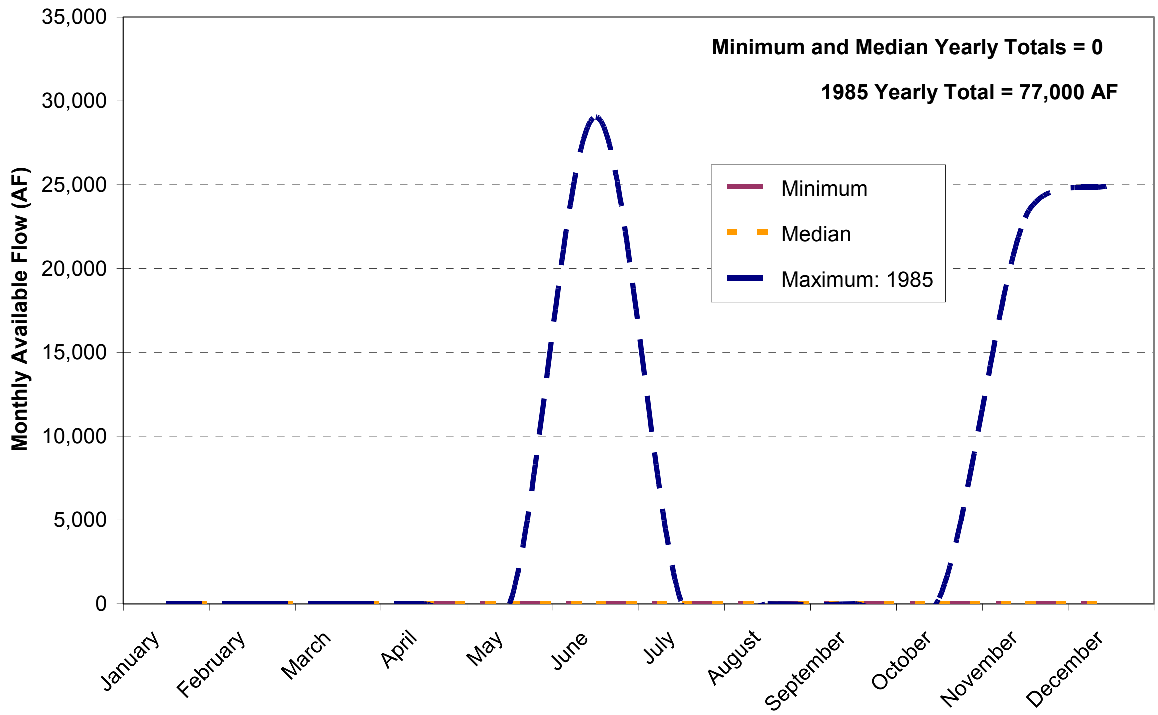


Figure 7-87
Monthly Legally Available Flow
Rio Grande at Alamosa (1950-1997)

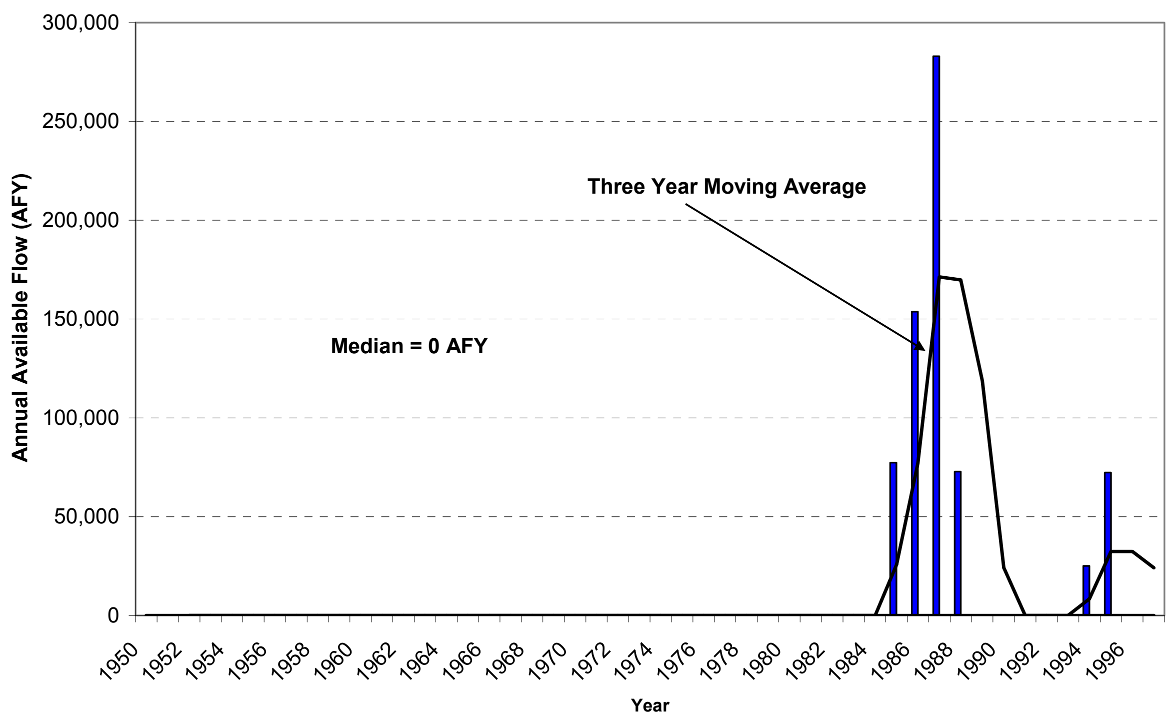


Figure 7-88
Annual Legally Available Flow
Rio Grande at Alamosa (1950-1997)

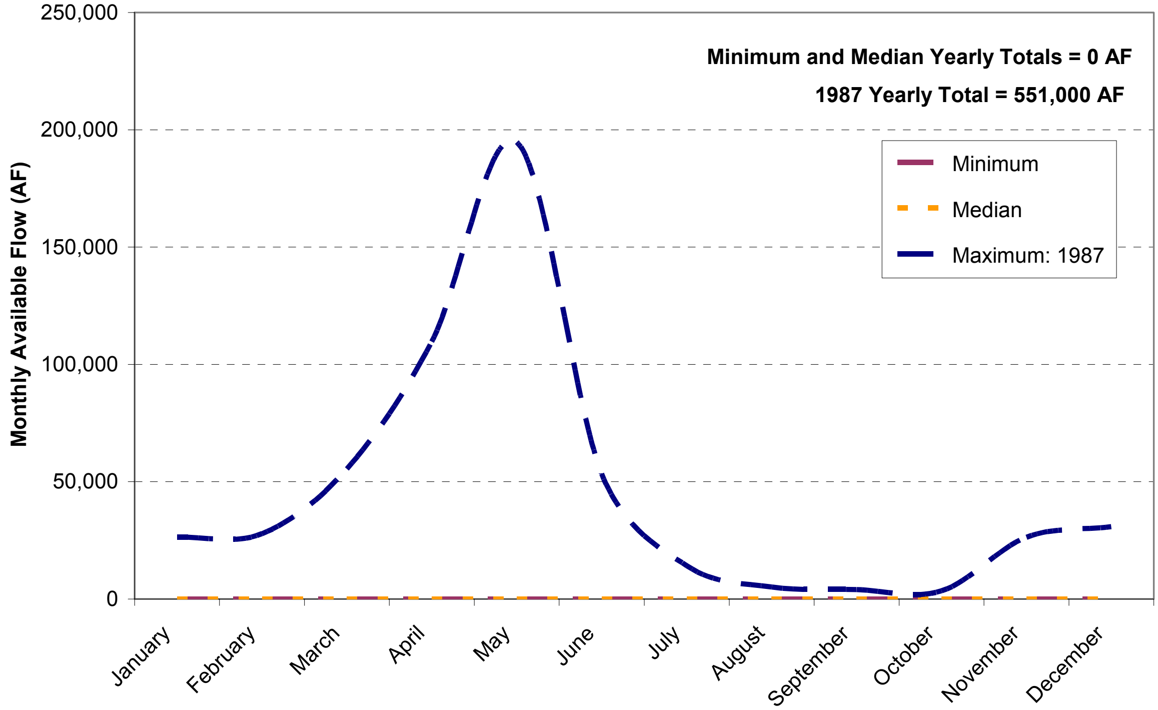


Figure 7-89
Monthly Legally Available Flow
Rio Grande near Lobatos (1950-1997)

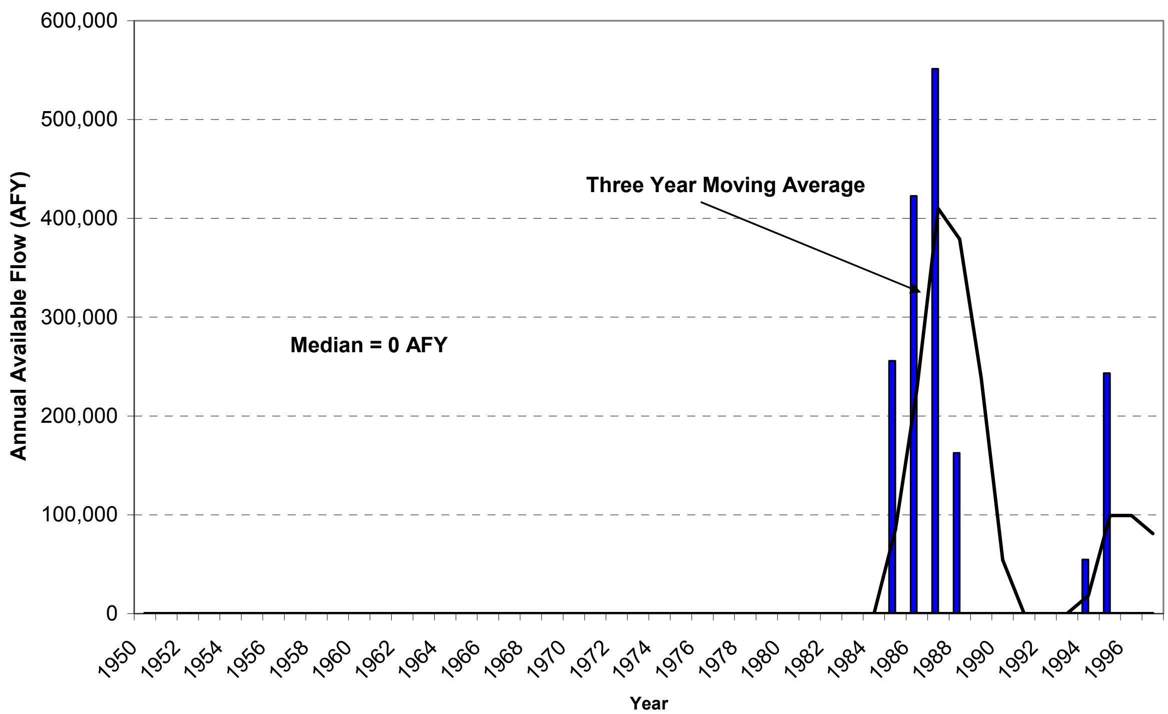


Figure 7-90
Annual Legally Available Flow
Rio Grande near Lobatos (1950-1997)

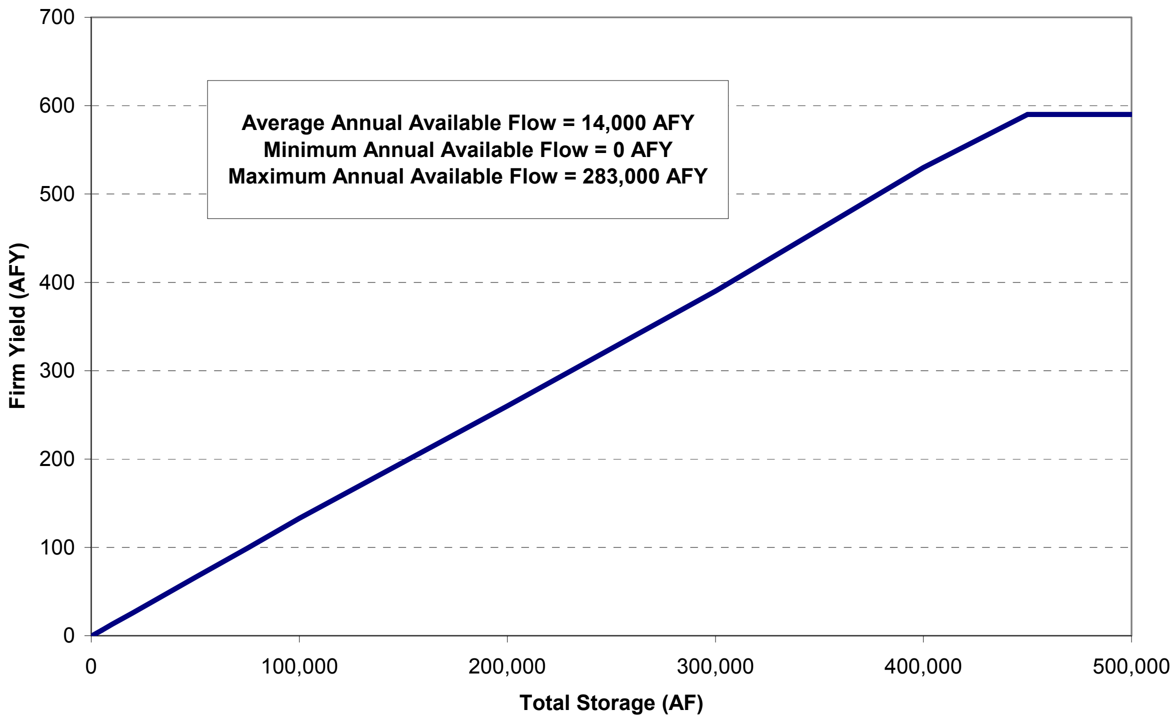


Figure 7-91
Reservoir Yield Curve
Rio Grande at Alamosa (1950-1997)

7.3.7 South Platte Basin

7.3.7.1 South Platte Surface Water Supplies

Legally available flows for the South Platte Basin were summarized for three locations based on the results of recent studies. The locations (Figure 7-92) and sources of data are:

- South Platte River below Chatfield (Denver Water Data)
- South Platte River at Kersey (NCWCD 2001)
- South Platte River at Sedgwick (GEI 2001)

The periods of record for these analyses are: 1942 to 2002 (Chatfield), 1950 to 2001 (Kersey), and 1944 to 1997 (Sedgwick). Median annual legally available flows are summarized in Figure 7-93. Median annual historical measured flows from USGS gages at the given locations are also provided for reference. Significant differences between legally available and measured physical flows are indicative of large downstream senior water rights. Figure 7-94 shows minimum, median, and maximum annual legally available flows for the period of record. A wide range of annual flows at the locations indicates that firm yield supply is significantly less than average yield supply.

To better represent the effects of seasonal and year to year hydrologic variation, monthly (for minimum, maximum, and median years) and annual time series of legally available flows for the periods of record are shown in Figures 7-95 through 7-100. The median annual flow and 3-year running averages are also included on the annual time series plots. The monthly analyses highlight the fact that available flows vary greatly with season, with the greatest amounts of water available in the summer months and a sharp decline in flows in the autumn and winter. The annual time series plots also show large variation with a notable extended drought period in the 1950s. Apparent drought periods are also evident in the late 1970s and late 1980s to the early 1990s.

The interpretation above is in general agreement with the CWCB Drought Study (HDR 2003), which summarized the history of drought in Colorado and identified significant drought periods in the last 100 years. The Drought Study states that the most recent drought analyzed for years 2000 to 2003 exceeds many of the drought records established during the 20th century. It should be noted that the drought period of the past few years is not included in any of the analyses used here.

Finally, Figure 7-101 is provided to further quantify the impacts of seasonal and year to year hydrologic variation and to illustrate the difference between average annual available flow and the potential annual firm yield. This chart shows firm yield as a function of total available storage for legally available flows at the South Platte River below Chatfield. This curve was generated using WatSIT. Firm yield is defined as the maximum annual supply that can be reliably provided every year for the period of record (no monthly shortages). The model assumes typical monthly patterns of M&I use. As described above, the available inflow period of record was not long enough to eliminate model sensitivity to starting reservoir conditions at high total storage volumes. Therefore, for this exercise, calculations were ceased at the point at which firm yields became sensitive to starting reservoir conditions (at 325,000 AF of storage).

For the South Platte River below Chatfield, even with very large volumes of storage (325,000 AF), the annual firm yield is only approximately 27 percent of the average annual available flow. This low firm:average yield ratio is a result of the variability of annual available flows shown in Figure 7-96. While the available flows indicate that developing a firm annual supply at this location is questionable, the available flows could be developed for use in a conjunctive use project where non-tributary groundwater could be used as a drought backup with a resulting increase in firm annual yield. The critical (limiting) periods for this analysis are the mid-1960s for higher storage yields and variable (e.g., mid-1950s, late 1970s, and early 1990s) for lower storage yields. Note that yields would likely be significantly higher if some value or frequency of shortages, greater than zero, were acceptable.

There are a number of factors not reflected in the data presented that may further limit future supply availability. For example, a number of recharge plans have been filed along the lower South Platte River in the past few years that will eventually divert high flows during periods that were historically free river. Additionally, many M&I providers have reservoir enlargement plans that will help them fully utilize existing rights and allow development of existing conditional water rights. Another factor will be the increased reuse of existing consumable M&I return flows that have been unused for many years. As M&I providers develop gravel lake storage to capture these consumable return flows and develop non-potable irrigation systems, the removal of these flows that have been in the river will affect future water supply availability. A factor that could increase supply availability would be the return flows from future expanded non-tributary well pumping and transbasin diversions that have not yet been imported into the South Platte. These potential increases would require that there is not reuse of these consumable return flows by the original diverters. Many different scenarios can be evaluated in the future when the South Platte module of the DSS is completed.

Finally, maintaining or enhancing recreational and environmental flows could affect current and future supply availability. Environmental and recreational considerations are further developed in Sections 6 and 10 of this report. For example, federal threatened or endangered fish species, such as the Greenback Cutthroat Trout, and state species of concerns such as the Plains Top Minnow, are present in the South Platte River and tributaries, and require special attention.

7.3.7.2 South Platte Basin Alluvial Aquifer

The South Platte River valley-fill aquifer extends in Colorado from where the river flows out of the foothills onto the plains upstream of Denver to downstream at the border with Nebraska near Julesburg. Saturated valley fill deposits underlie more that 4,000 square miles of the South Platte basin in Colorado (Hearne et al. 1987).

The saturated thickness of the South Platte alluvium is close to 20 feet near Denver and increases to nearly 200 feet downstream near Julesburg (CWCB 2004). The aquifer is composed of unconsolidated sand, silt, gravel, and clay that occur within the valleys of the South Platte River and its tributaries. These deposits generally have a large hydraulic conductivity, resulting in a very productive aquifer with well yields often greater than 1,000 gpm. Based on DWR records, well depths in the Lower South Platte alluvium average about 75 feet. Estimates of the volume of water in this aquifer vary widely and range up to 25 million AF (Pearl 1980). The aquifer is replenished by return flows from irrigation of adjacent lands and is considered a renewable resource. However, the groundwater in this aquifer is considered tributary to the South Platte River and users of this resource are administered under the Prior Appropriation System. Except for domestic or other low-volume exempt uses, the use of groundwater in this aquifer requires a water court-approved augmentation plan that describes how depletions to the river will be offset to avoid injury to senior appropriators and to comply with the interstate compact.

The location and extent of alluvial aquifer in the South Platte River Basin is shown in Figure 3-47.

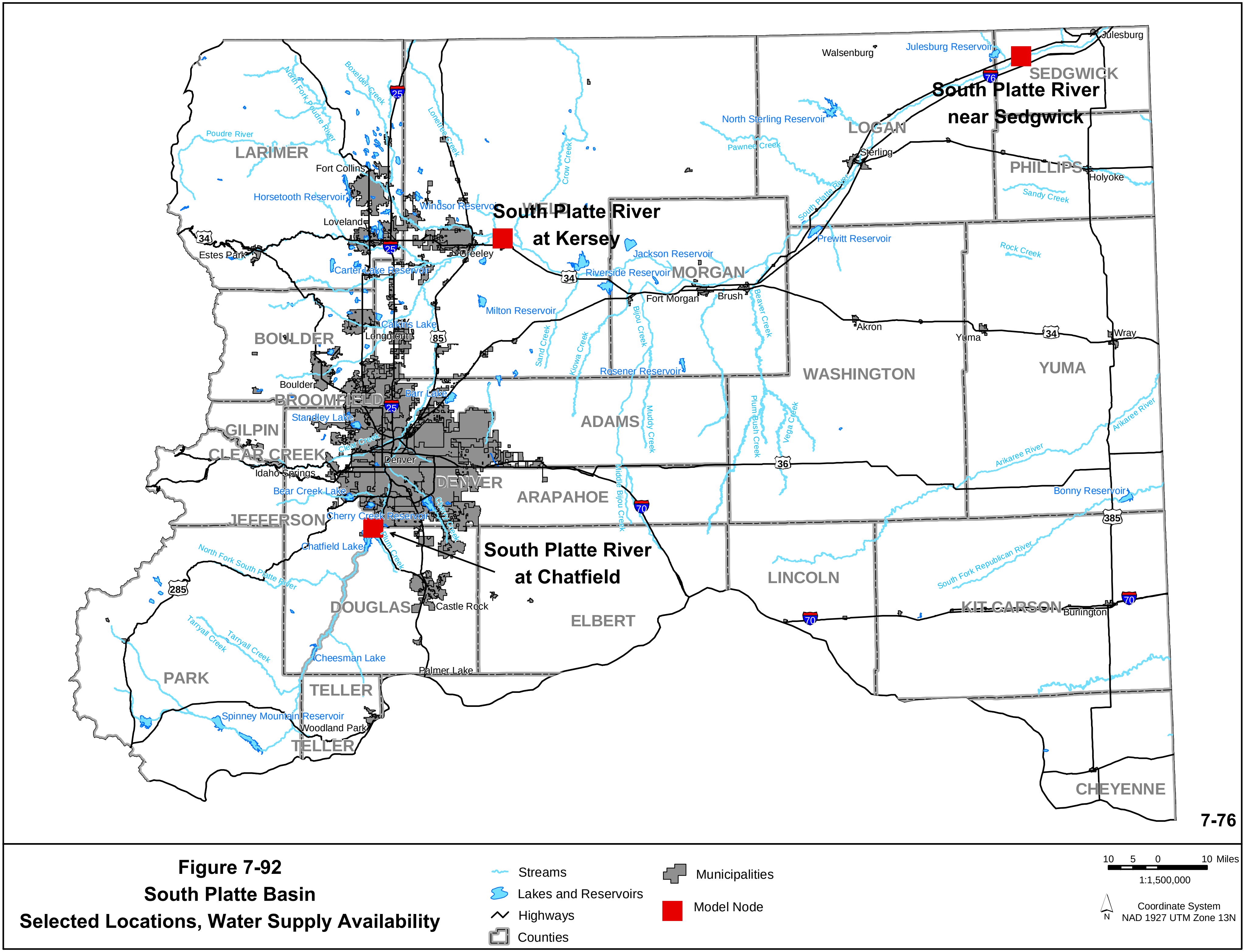


Figure 7-92
South Platte Basin
Selected Locations, Water Supply Availability

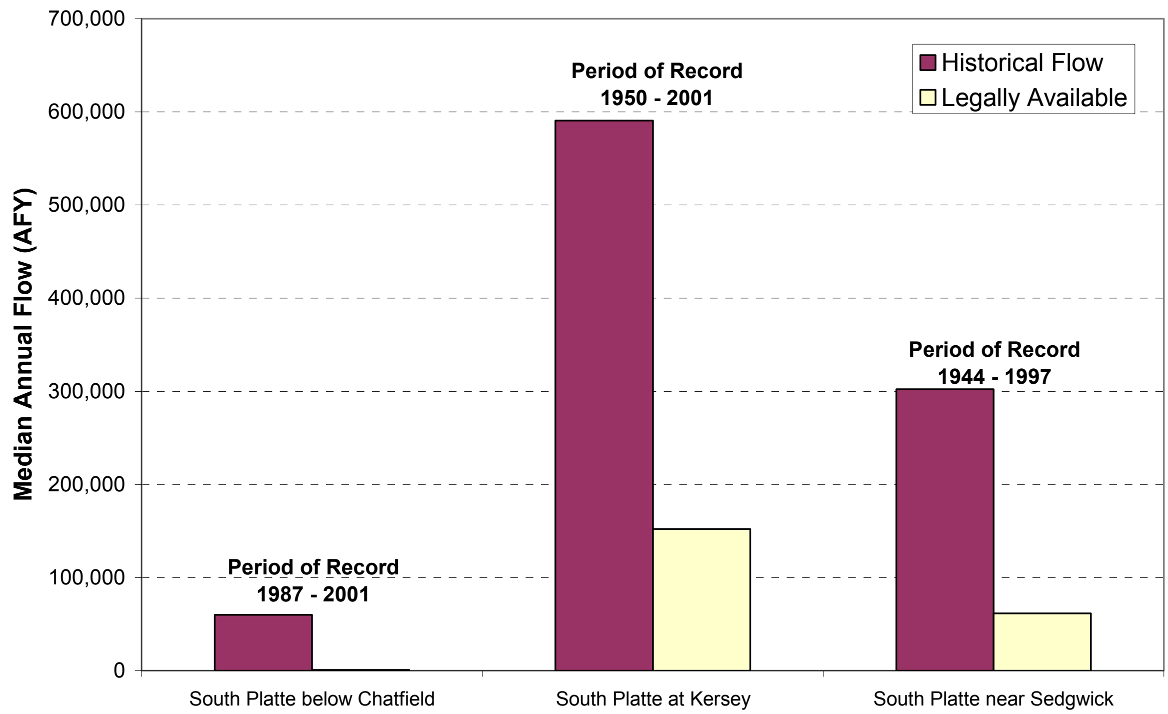


Figure 7-93
Historical and Legally Available Flows
South Platte Basin

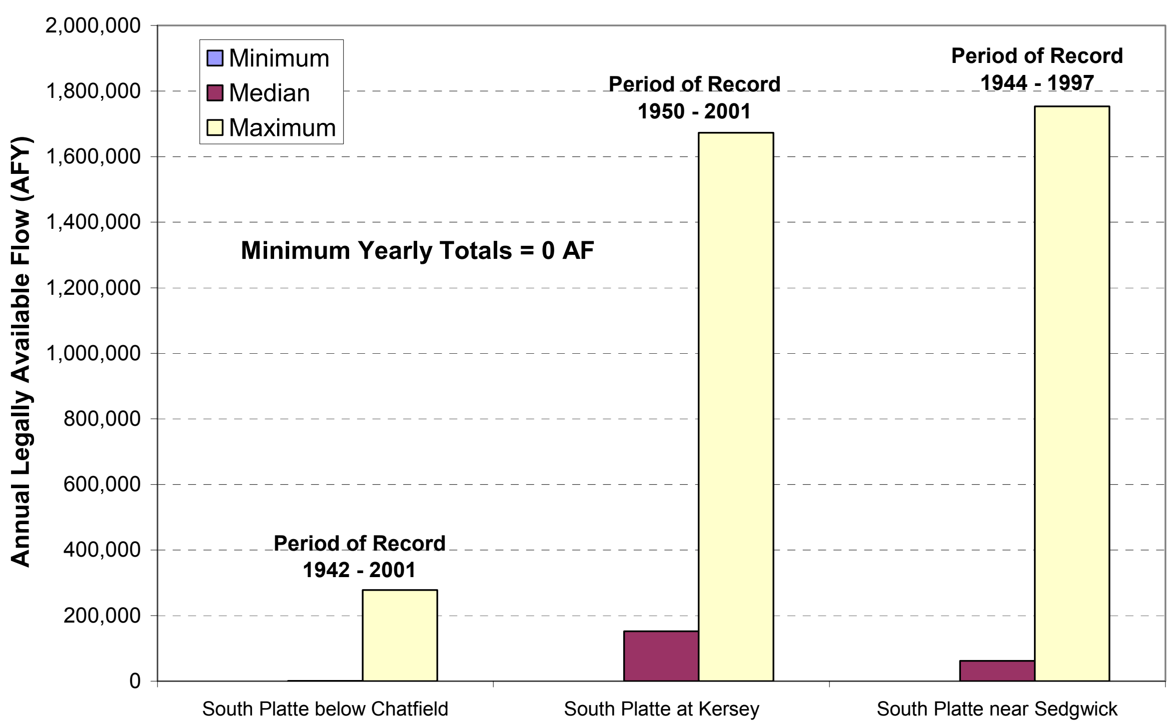


Figure 7-94
Minimum, Median, and Maximum Annual Legally Available Flows
South Platte Basin

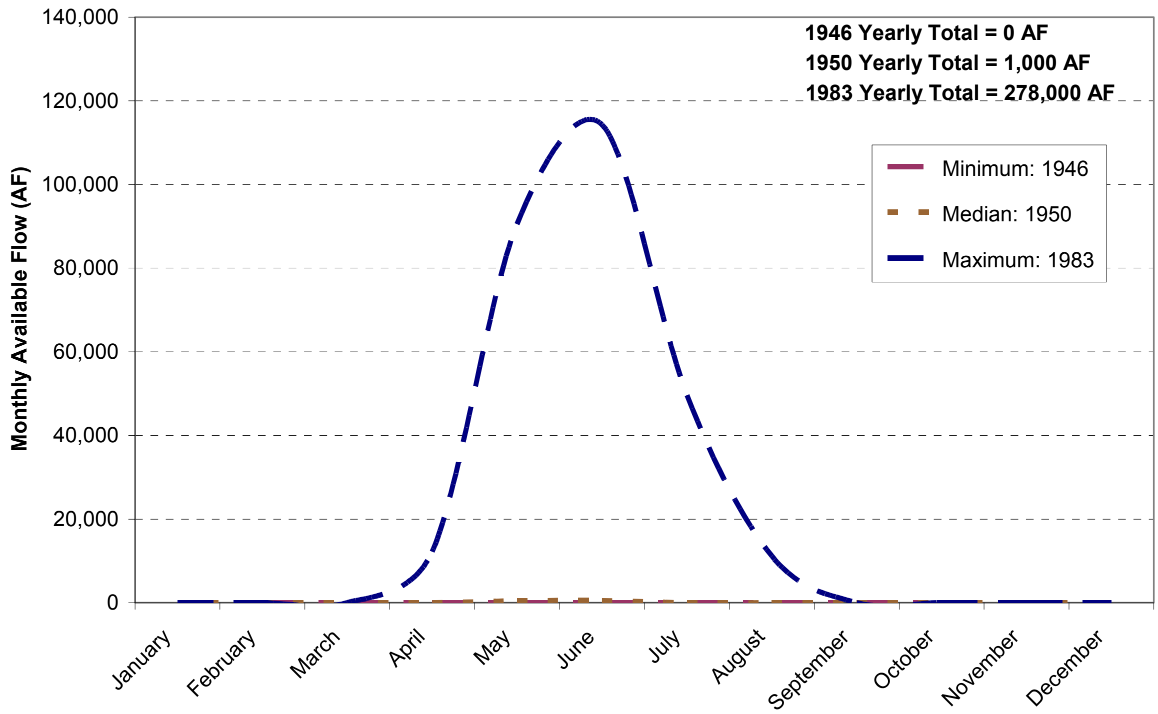


Figure 7-95
Monthly Legally Available Flow
South Platte River below Chatfield Reservoir (1942-2001)

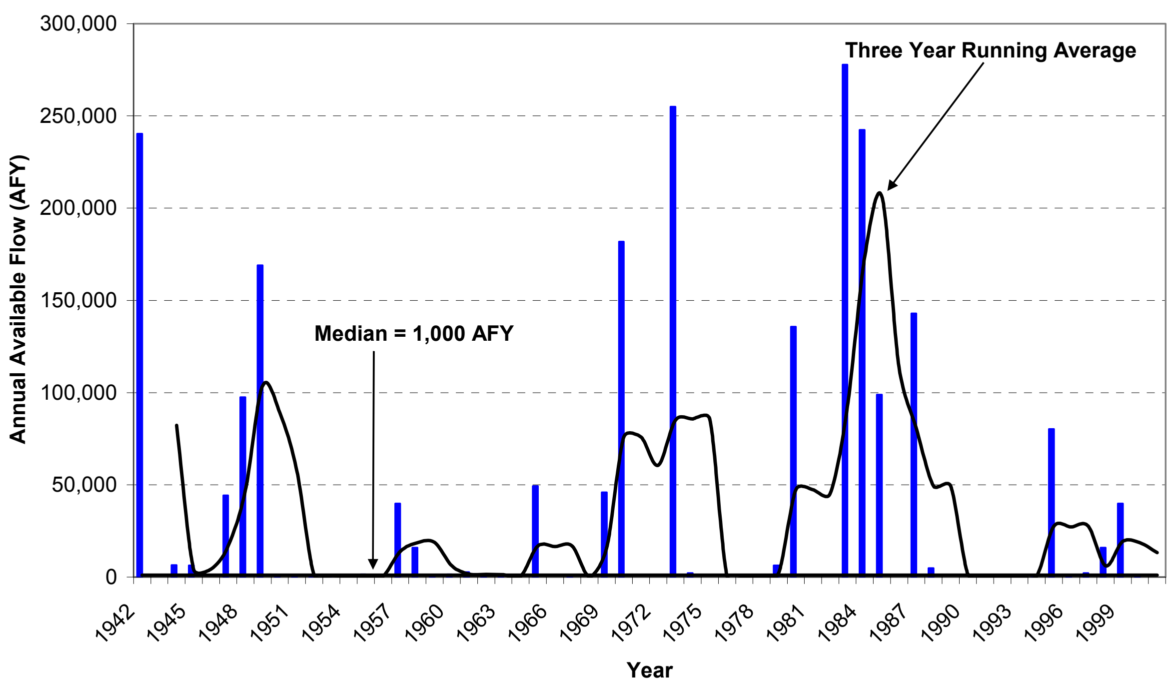


Figure 7-96
Annual Legally Available Flow
South Platte River below Chatfield Reservoir (1942-2001)

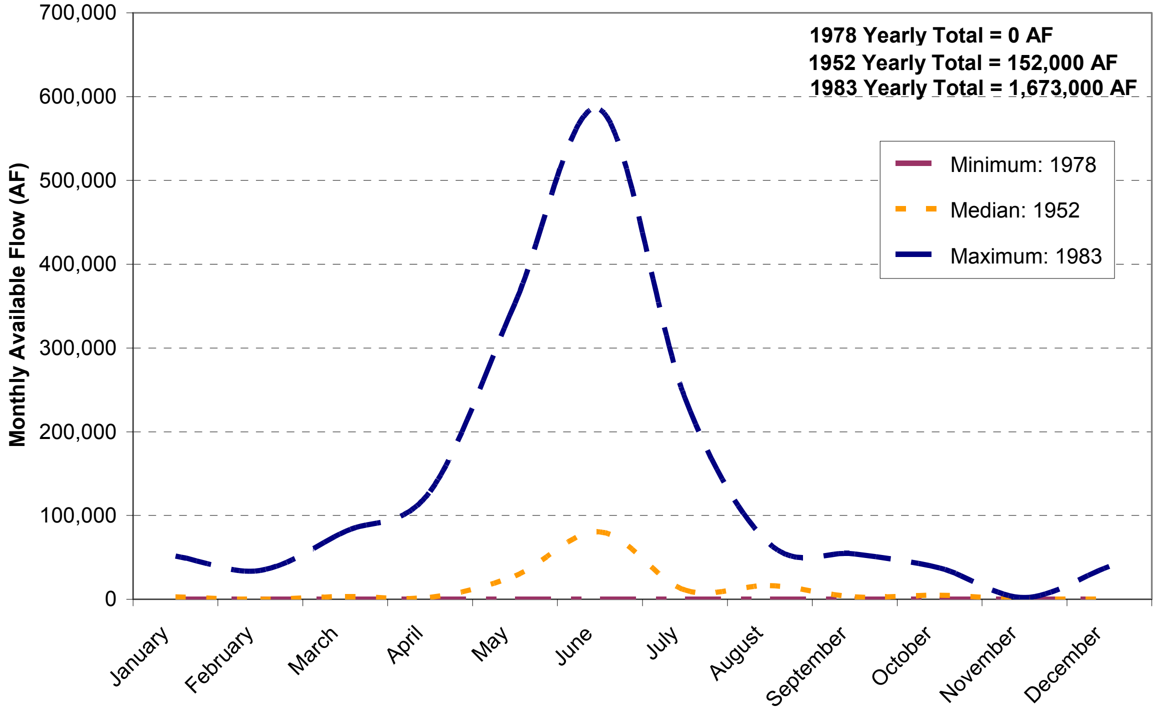


Figure 7-97
Monthly Legally Available Flow
South Platte River at Kersey (1950-2001)

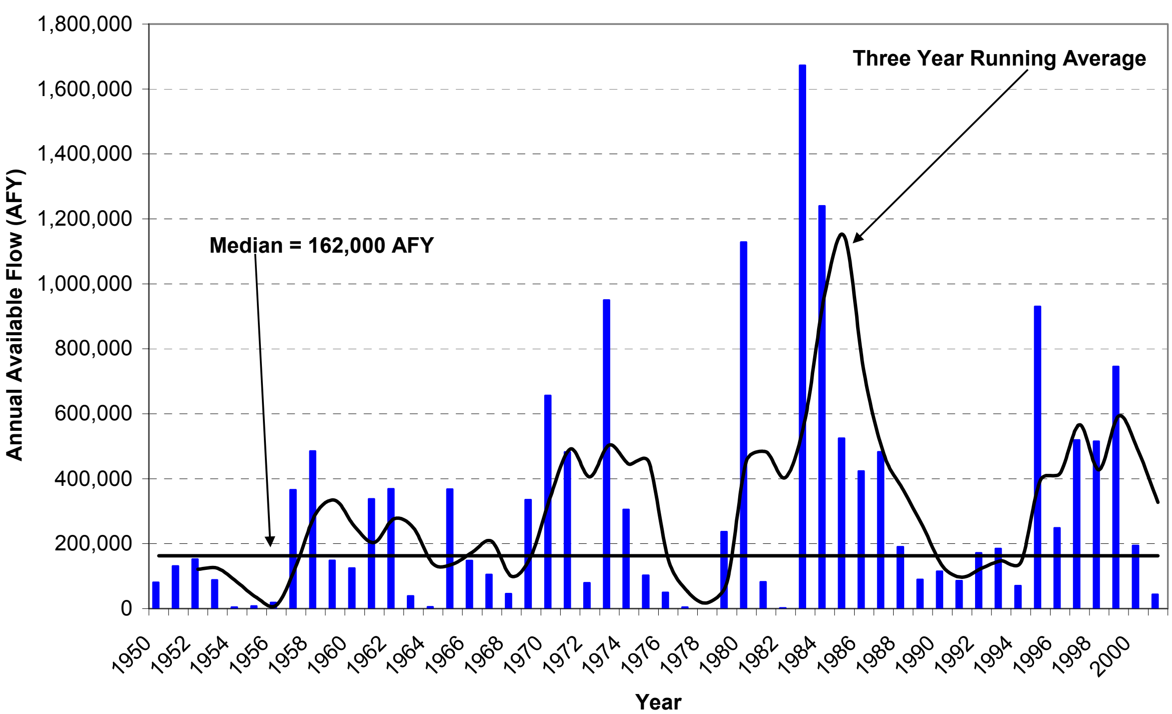


Figure 7-98
Annual Legally Available Flow
South Platte River at Kersey (1950-2001)

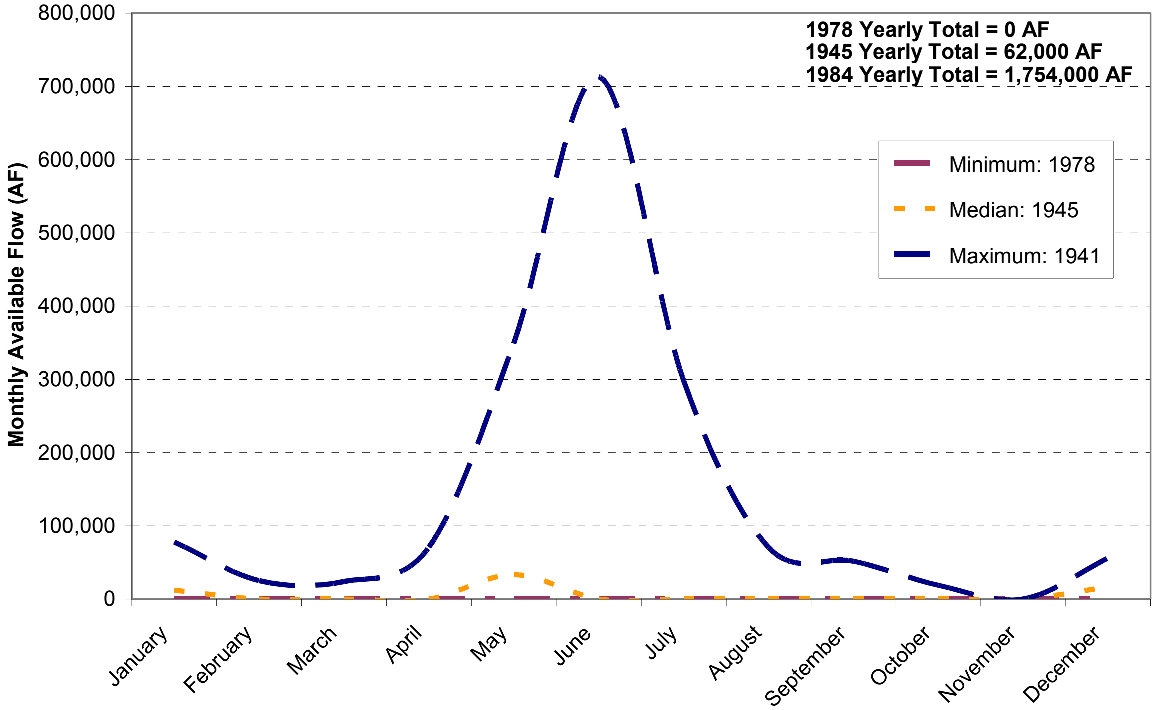


Figure 7-99
Monthly Legally Available Flow
South Platte River near Sedgwick (1944-1997)

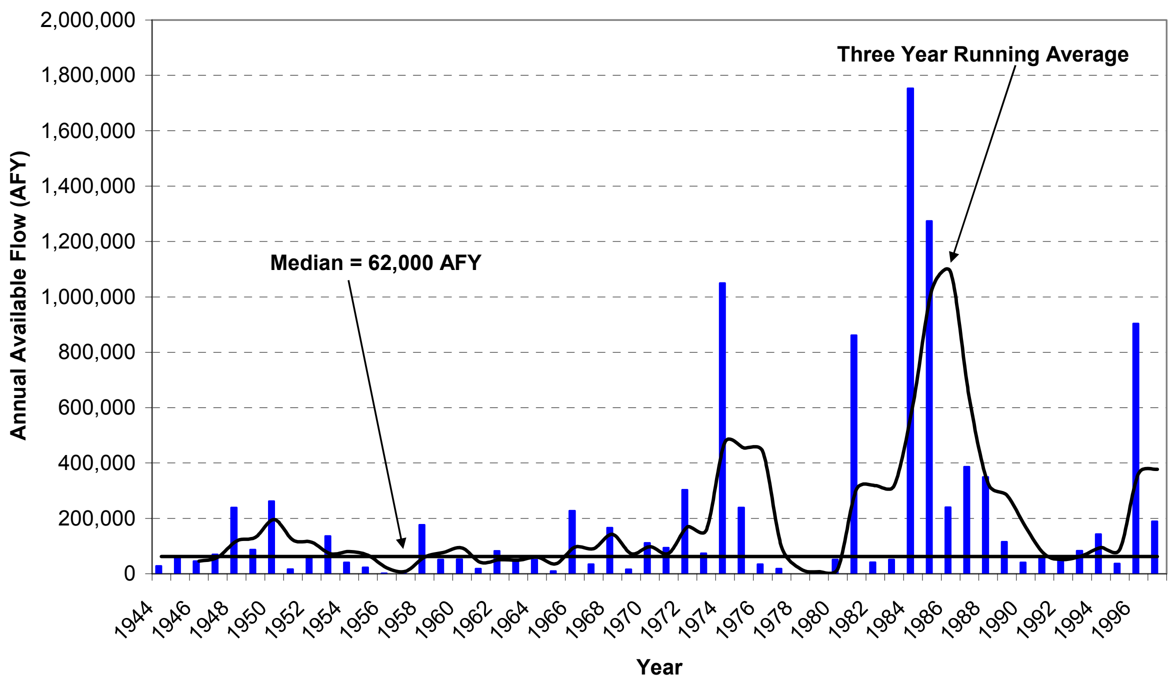


Figure 7-100
Annual Legally Available Flow
South Platte River near Sedgwick (1944-1997)

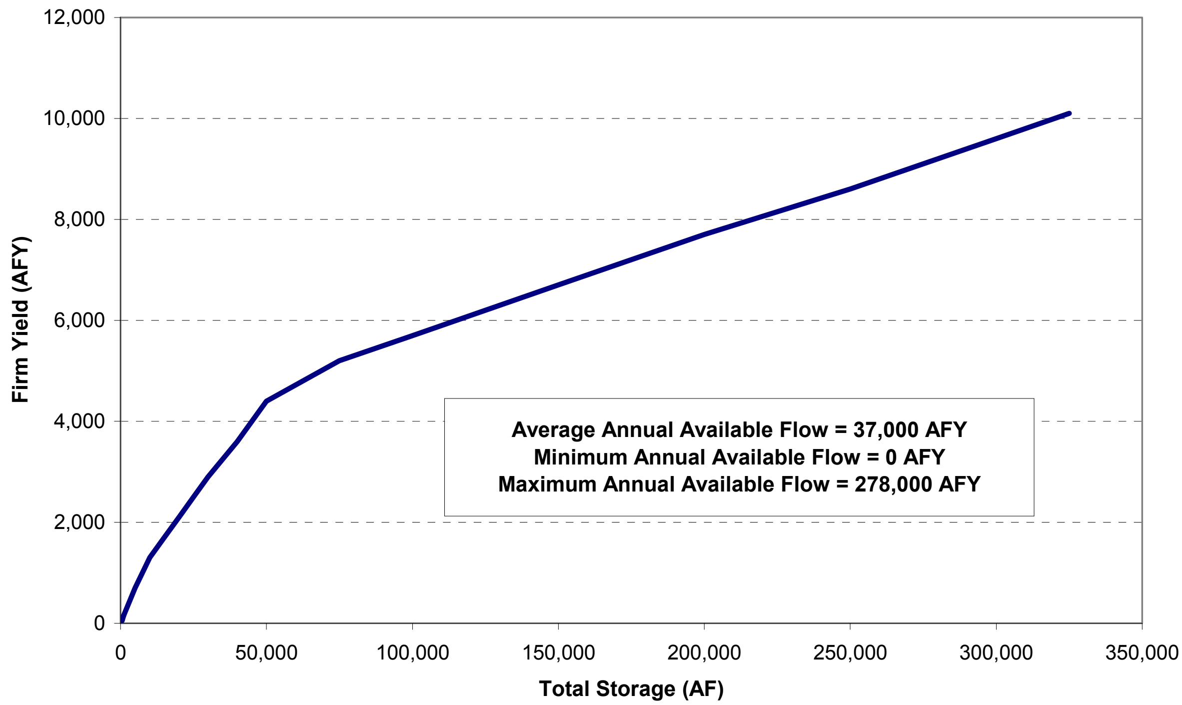


Figure 7-101
Reservoir Yield Curve
South Platte River below Chatfield Reservoir (1942-2001)

7.3.8 Yampa/White/Green Basin

7.3.8.1 Yampa/White/Green Basin Surface Water Supplies

Two separate StateMod datasets are simulated for the Yampa/White/Green Basin. One dataset covers just the Yampa and Green Basins, and one covers the White Basin. Four locations were selected for the Yampa and Green River Basins and two for the White Basin to characterize supply availability in this region. The period of record for the Yampa Basin dataset is 1909 to 1999 (for full calendar years). The period of record for the White Basin dataset is 1975 to 1990 (full calendar years). The selected locations, shown in Figure 7-102, are:

- Yampa River near Steamboat Springs
- Yampa River below the Elk River
- Yampa River below Craig
- Yampa River above the Green River
- White River above Meeker
- White River near the state line

Median annual legally available, physically available, and naturalized flows are summarized for each location in Figure 7-103. As can be seen, only one small difference exists between legally and physically available flows at the locations, indicating that the majority of the water in the stream is available for development without injury to downstream priority users. Figure 7-104 shows minimum, median, and maximum annual legally available flows for the period of record. A wide range of annual flows at the locations indicates that firm yield supply is significantly less than average yield supply.

To better represent the effects of seasonal and year to year hydrologic variation, monthly (for minimum, maximum, and median years), and annual time series of legally available flows for the periods of record are shown in Figures 7-105 through 7-116. The median annual flow and 3-year running averages are also included on the annual time series plots. The monthly analyses highlight the fact that available flows vary greatly with season, with the greatest amounts of water available in the summer months and a sharp decline in flows in the autumn and winter. The annual time series plots also show large variation with a notable extended drought period from the late 1980s to the early 1990s and more acute droughts in the mid-1930s, 1950s, and late1970s.

The interpretation above is in general agreement with the CWCB Drought Study (HDR 2003), which summarized the history of drought in Colorado and identified significant drought periods in the last 100 years. The Drought Study states that the most recent drought analyzed for years 2000 to 2003 exceeds many of the drought records established during the 20th century. It should be noted that the drought period of the past few years is not yet included in the StateMod datasets, and therefore, not represented in the available flow numbers presented in the following figures. Extended wet periods evident in these figures include the late 1920s, the mid-1980s, and the late 1990s.

Finally, Figure 7-117 is provided to further quantify the impacts of seasonal and year to year hydrologic variation and to illustrate the difference between average annual available flow and the potential annual firm yield. This chart shows firm yield as a function of total available storage for legally available flows at the Yampa River below Craig. This curve was generated using WatSIT. Firm yield is defined as the maximum annual supply that can be reliably provided every year for the period of record (no monthly shortages). The model assumes typical monthly patterns of M&I use. For the Yampa River below Craig, even with very large volumes of storage, the maximum annual firm yield is approximately 70 percent of the average annual available flow. The curve reaches an asymptotic value of 750,000 AFY at approximately 2,500,000 AF total storage, beyond which no significant gains in firm yield can be achieved with increased storage. At the asymptotic value, all excess water is captured, stored, and used, but supply is still limited (below the average annual) by the *timing* of the available flows and reservoir evaporation and seepage. The critical (limiting) periods for this analysis are the early to mid-1930s for low storage yields and the early 1990s or mid-1950s for high storage yields. Note that yields would likely be significantly higher if some value or frequency of shortages, greater than zero, were acceptable.

There are a number of factors not reflected in the data presented that may further limit future supply availability. For example, neither the Colorado River Compact nor the Upper Colorado River Compact are included in the DSS analysis. The Compact places an upper limit on total CU of Colorado River and tributary (e.g., Yampa) water within the state. The Upper Colorado River

Compact apportions the flow of the Yampa at Maybell which must not fall below 5 million AF for any consecutive 10-year period. Predicting the potential for future downstream Colorado River Compact calls is a complex issue, dependent on, among other things, downstream hydrologic and climate conditions. Therefore, neither the DSS datasets nor the SWSI process, attempt to precisely quantify the potential impacts of the Compact on supply availability. Potential limitations to the projected supply availability as a result of the Colorado River Compact are evaluated in Section 7.4.

Conditional water rights are also not included in the Colorado DSS datasets. These water rights could eventually be developed resulting in less available water for the rest of the basin. Conditional water rights, by basin, are summarized in Section 10.

Maintaining or enhancing recreational and environmental flows could affect current and future supply availability. The City of Steamboat Springs has filed for a RICD, which could limit future upstream development if decreed. Environmental and recreational considerations are further developed in Sections 6 and 10 of this report. For example, a number of federal endangered fish species, such as the Colorado Pikeminnow and the Humpback Chub, are present in the Yampa Basin, and require special attention with respect to target flows for endangered species protection and recovery. Coordinated reservoir operations, stocking, control of non-native species, and habitat improvement are options that can help meet the needs of endangered species.

7.3.8.2 Yampa/White/Green Basin Alluvial Aquifers

No significant alluvial aquifers have been identified. There are domestic wells in the basin that are recharged by agricultural return flows and the long-term viability of these wells are dependent upon the continued pattern of irrigation return flows.

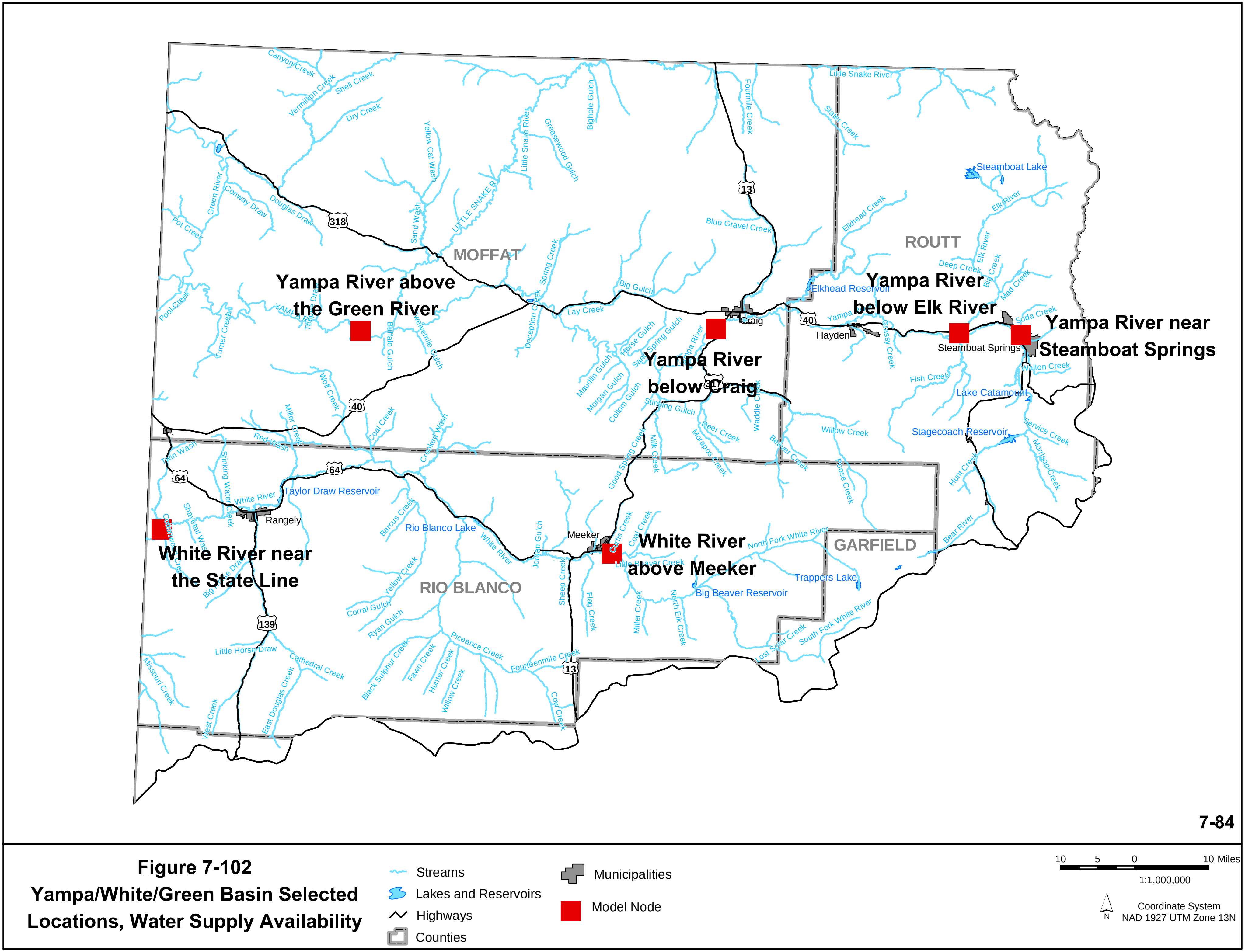


Figure 7-102
Yampa/White/Green Basin Selected Locations, Water Supply Availability

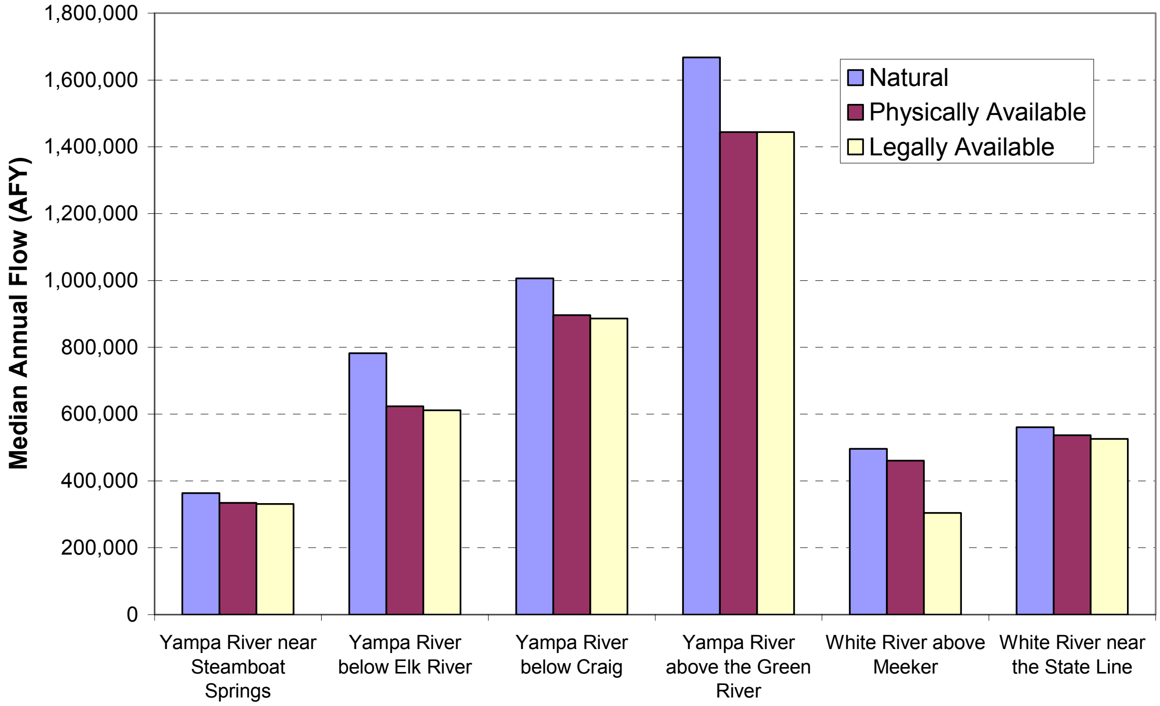


Figure 7-103
Median Annual Natural, Physically Available, and Legally Available Flows
Yampa/White/Green Basin

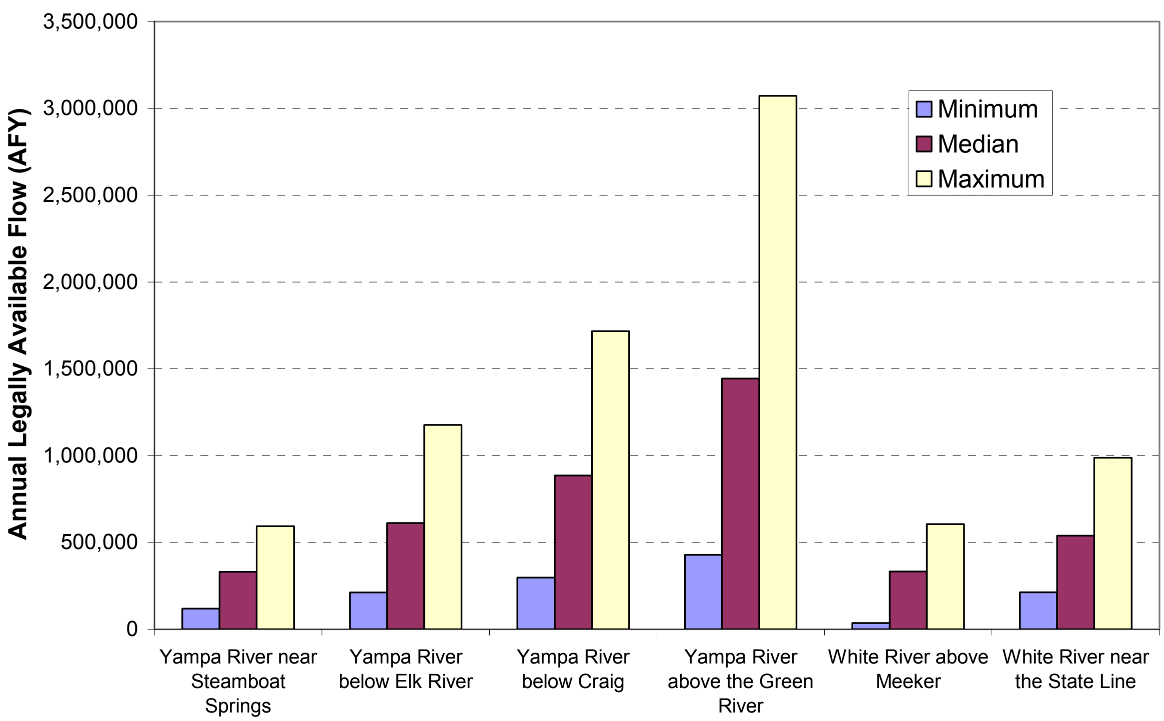


Figure 7-104
Minimum, Median, and Maximum Annual Legally Available Flows
Yampa/White/Green Basin

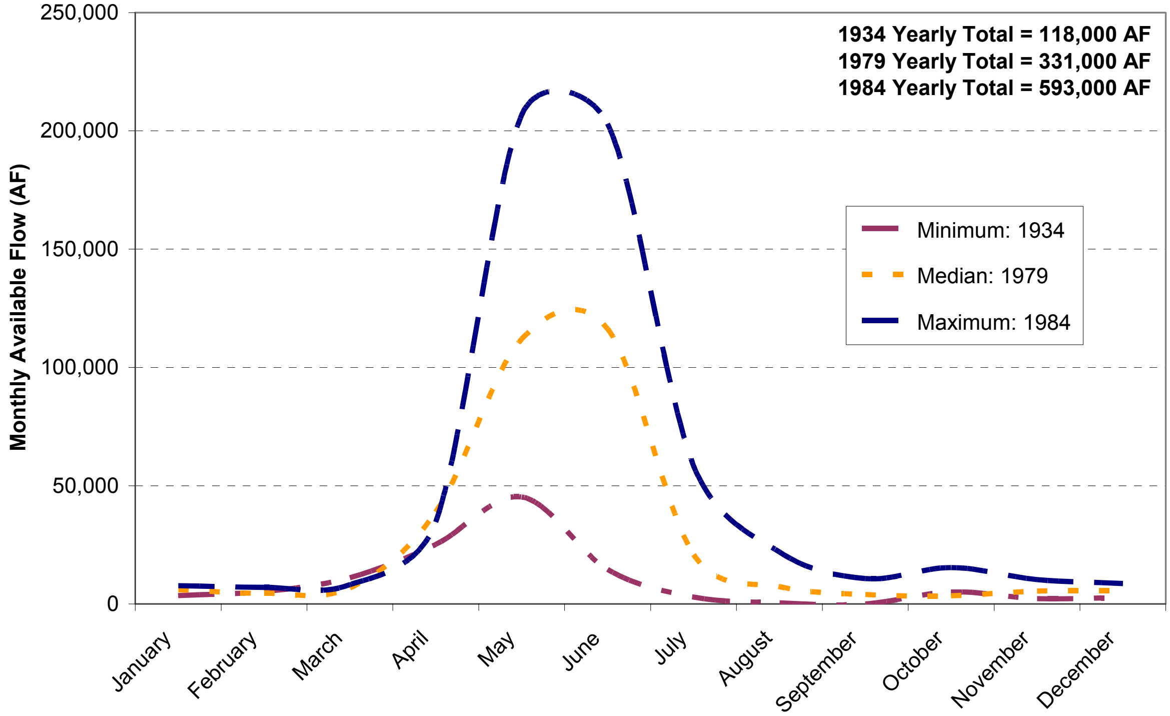


Figure 7-105
Monthly Legally Available Flow
Yampa River near Steamboat Springs (1909-1999)

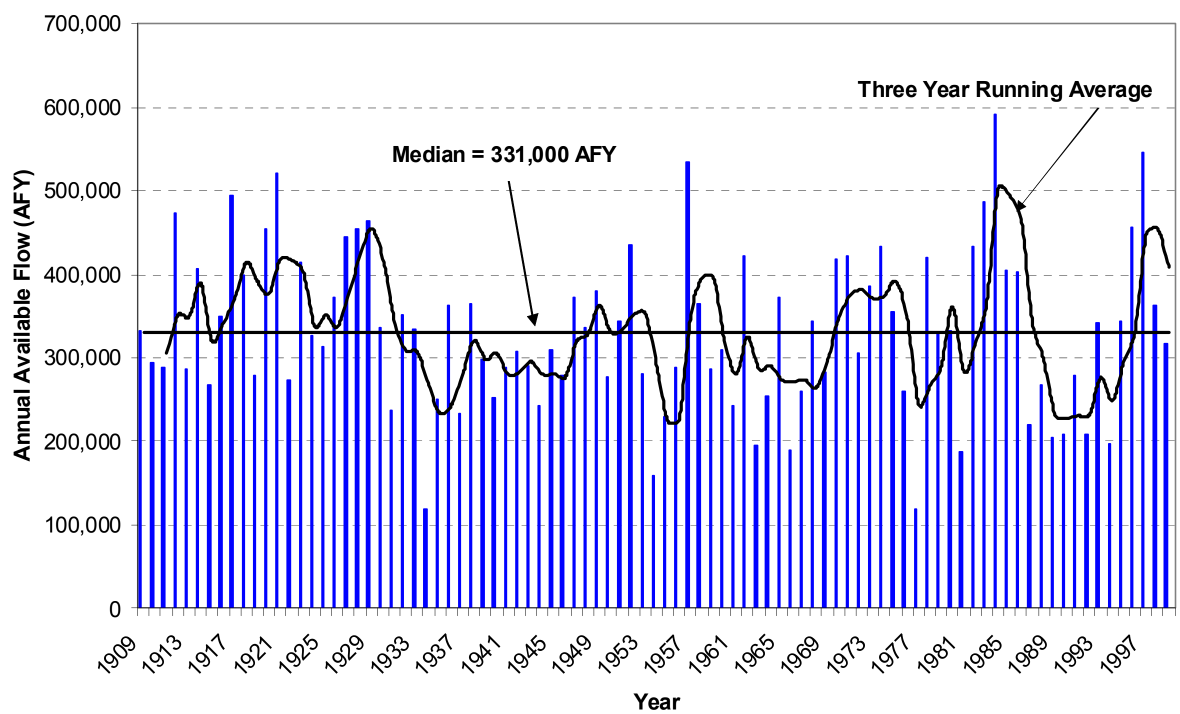


Figure 7-106
Annual Legally Available Flow
Yampa River near Steamboat Springs (1909-1999)

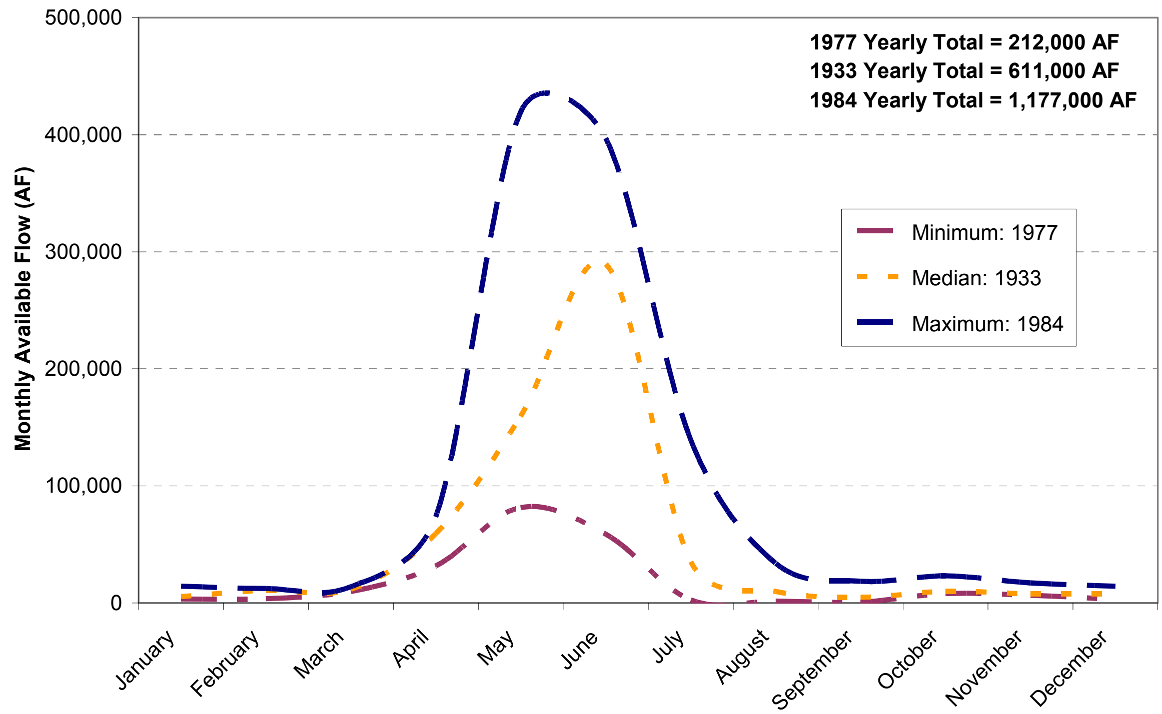


Figure 7-107
Monthly Legally Available Flow
Yampa River below Elk River (1909-1999)

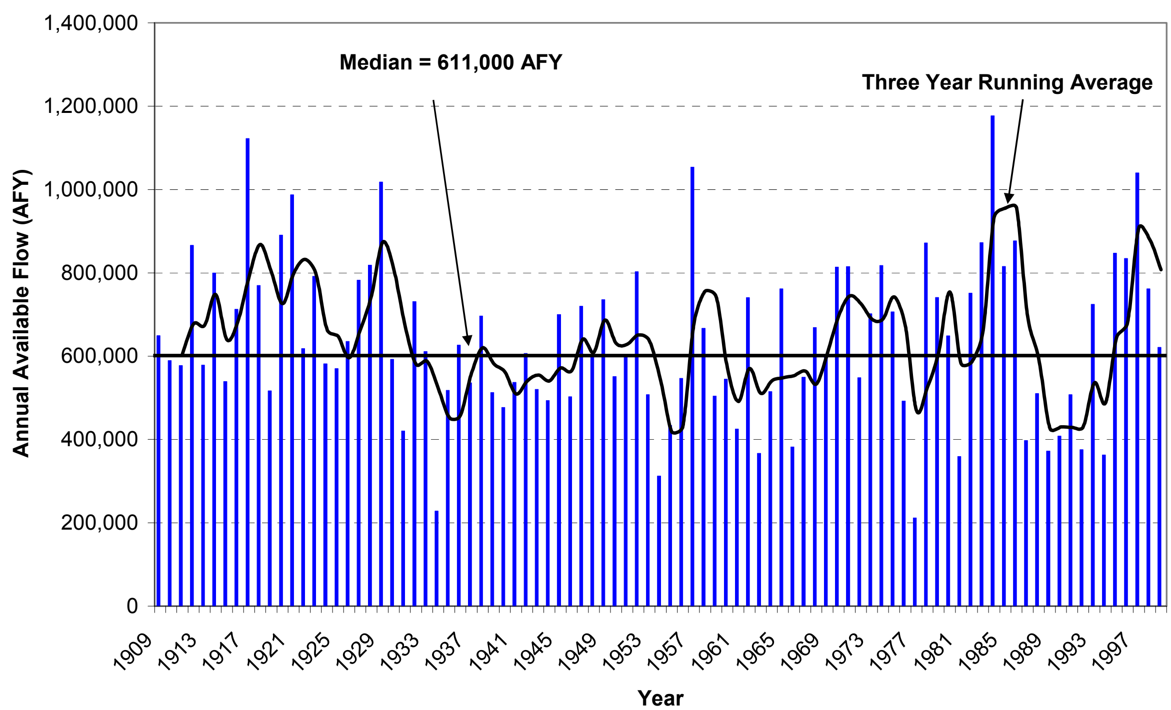


Figure 7-108
Annual Legally Available Flow
Yampa River below Elk River (1909-1999)

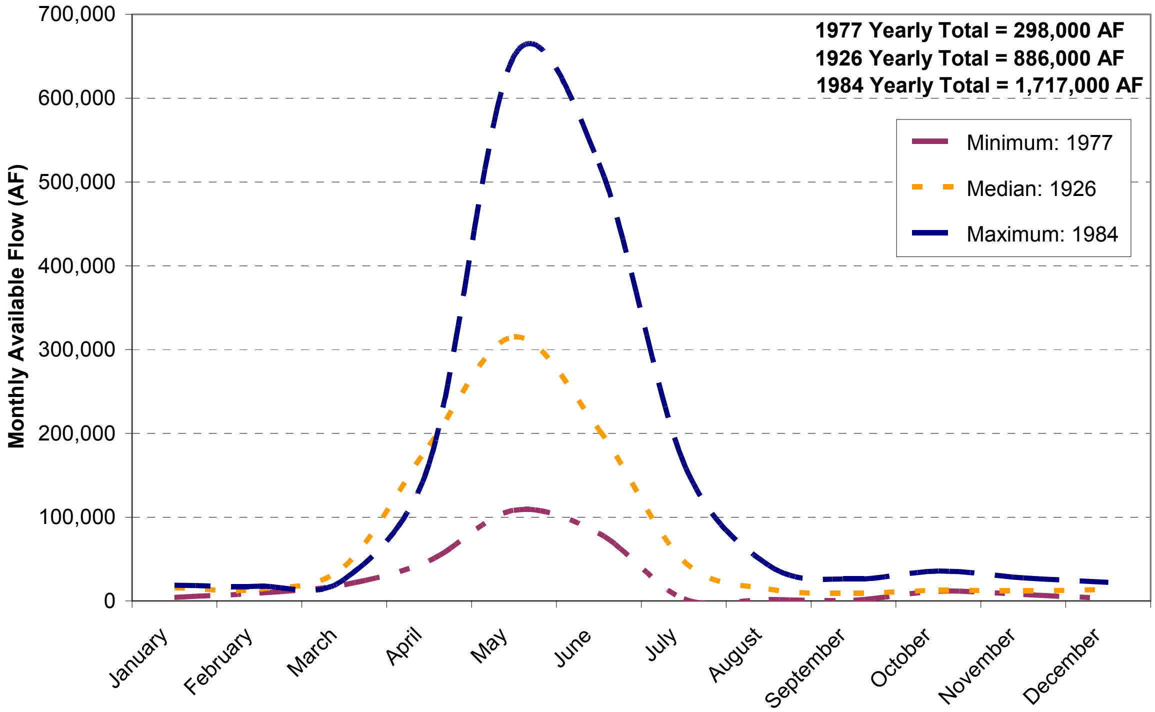


Figure 7-109
Monthly Legally Available Flow
Yampa River below Craig (1909-1999)

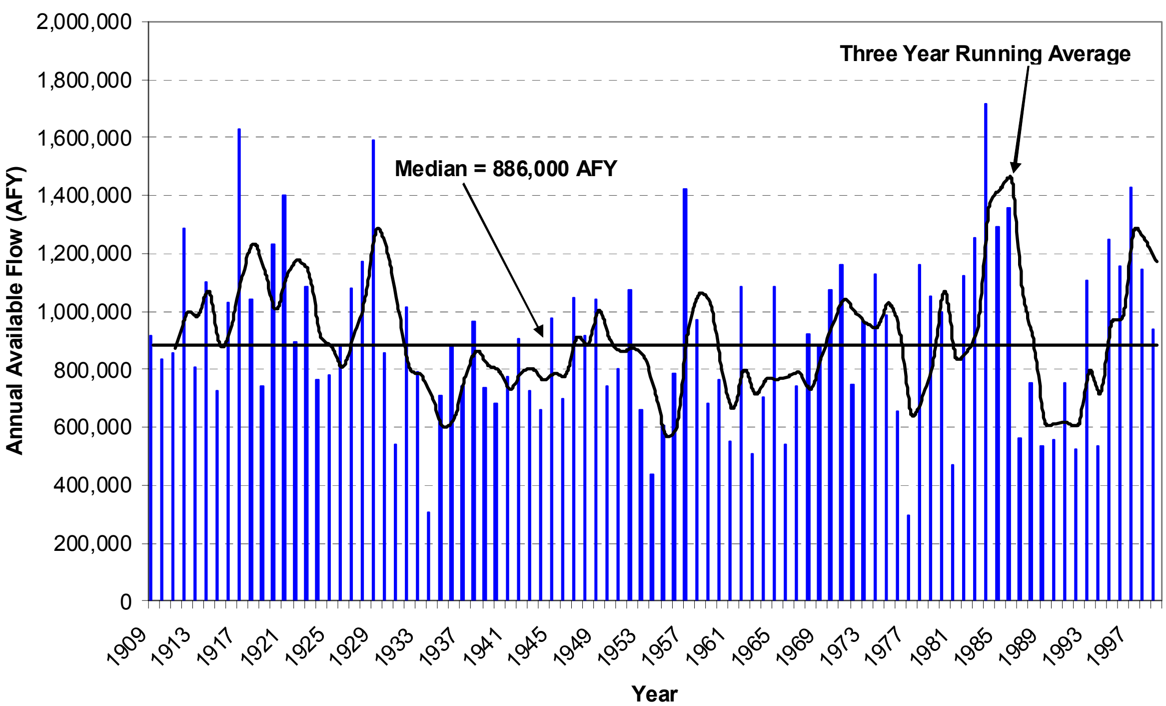


Figure 7-110
Annual Legally Available Flow
Yampa River below Craig (1909-1999)

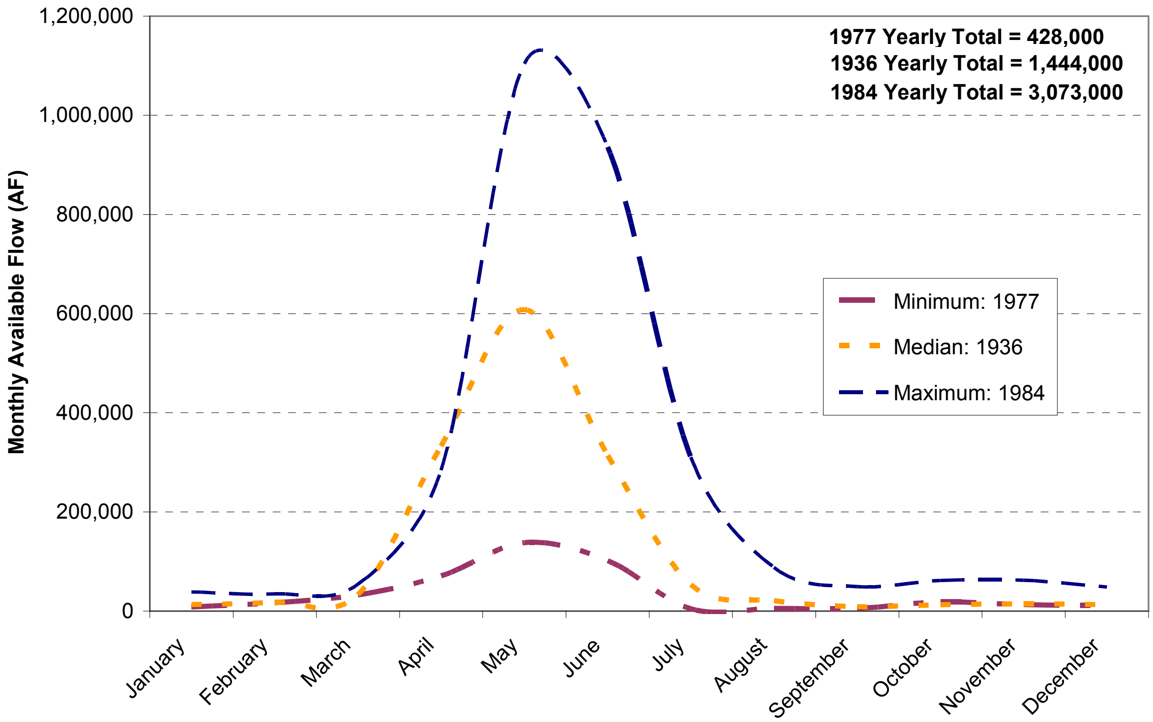


Figure 7-111
Monthly Legally Available Flow
Yampa River above the Green River (1909-1999)

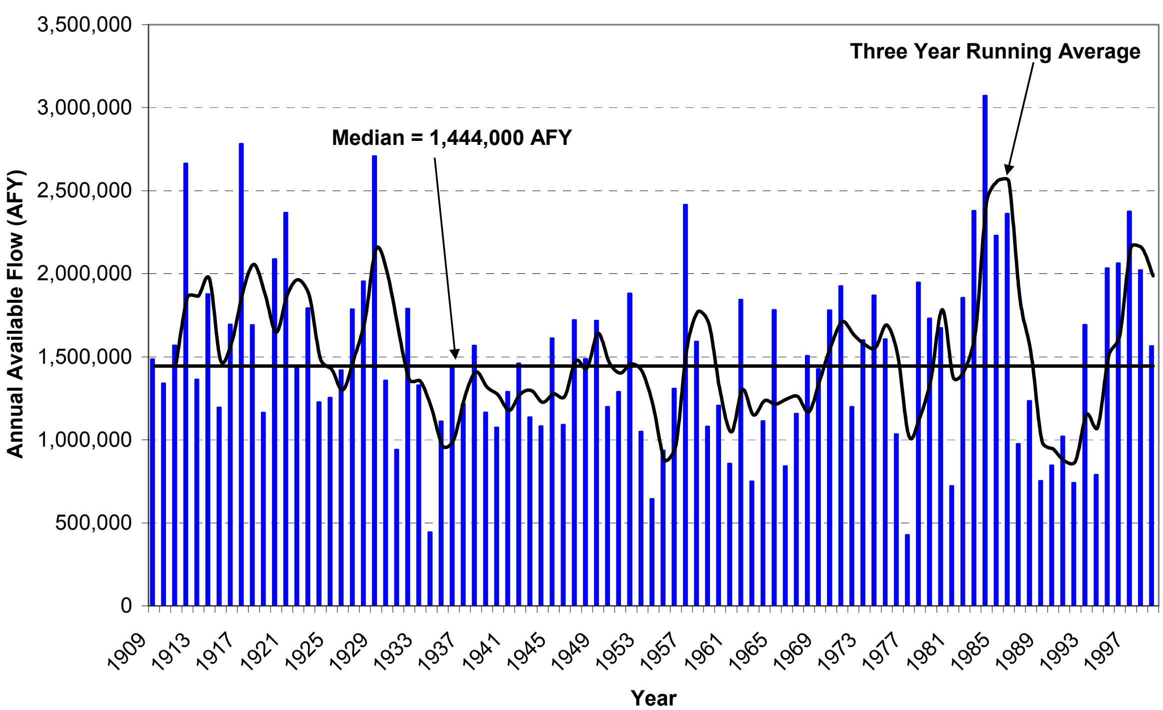


Figure 7-112
Annual Legally Available Flow
Yampa River above the Green River (1909-1999)

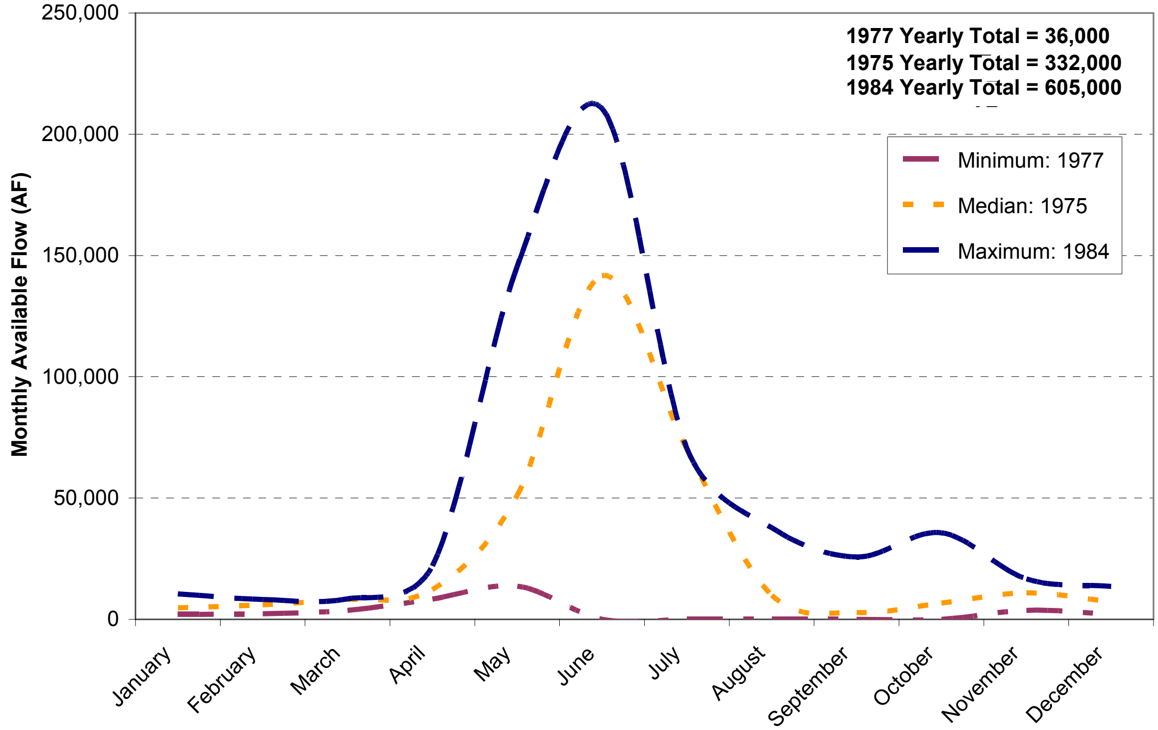


Figure 7-113
Monthly Legally Available Flow
White River above Meeker (1975-1990)

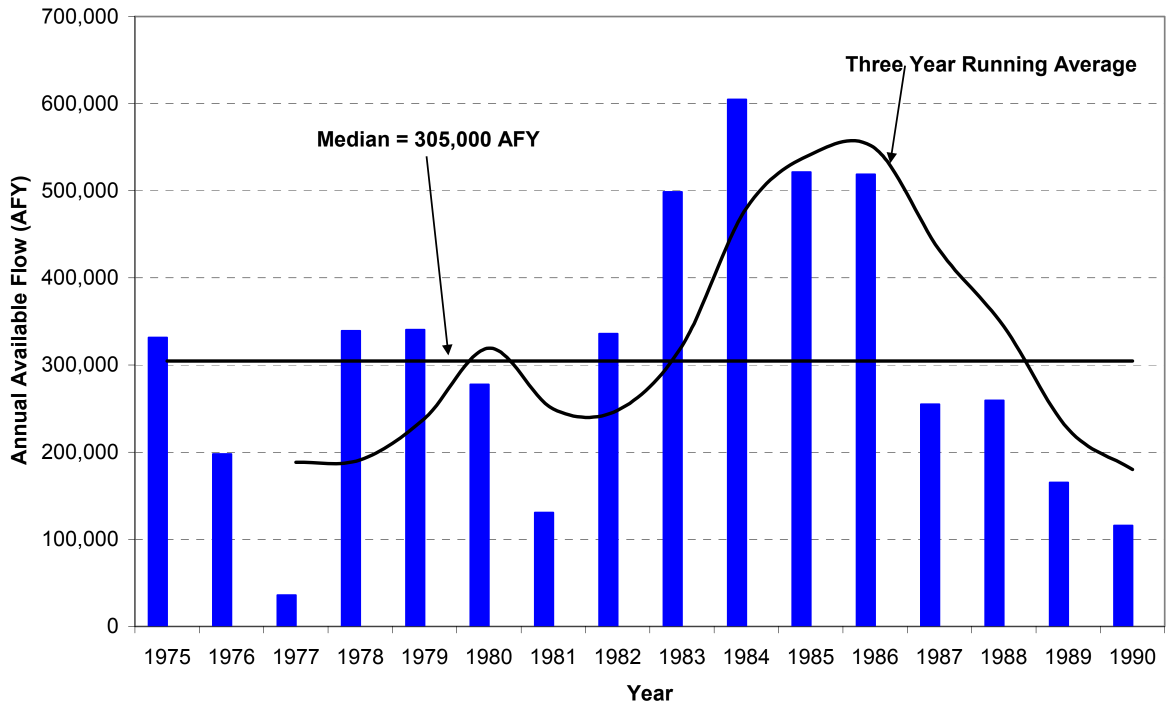


Figure 7-114
Annual Legally Available Flow
White River above Meeker (1975-1990)

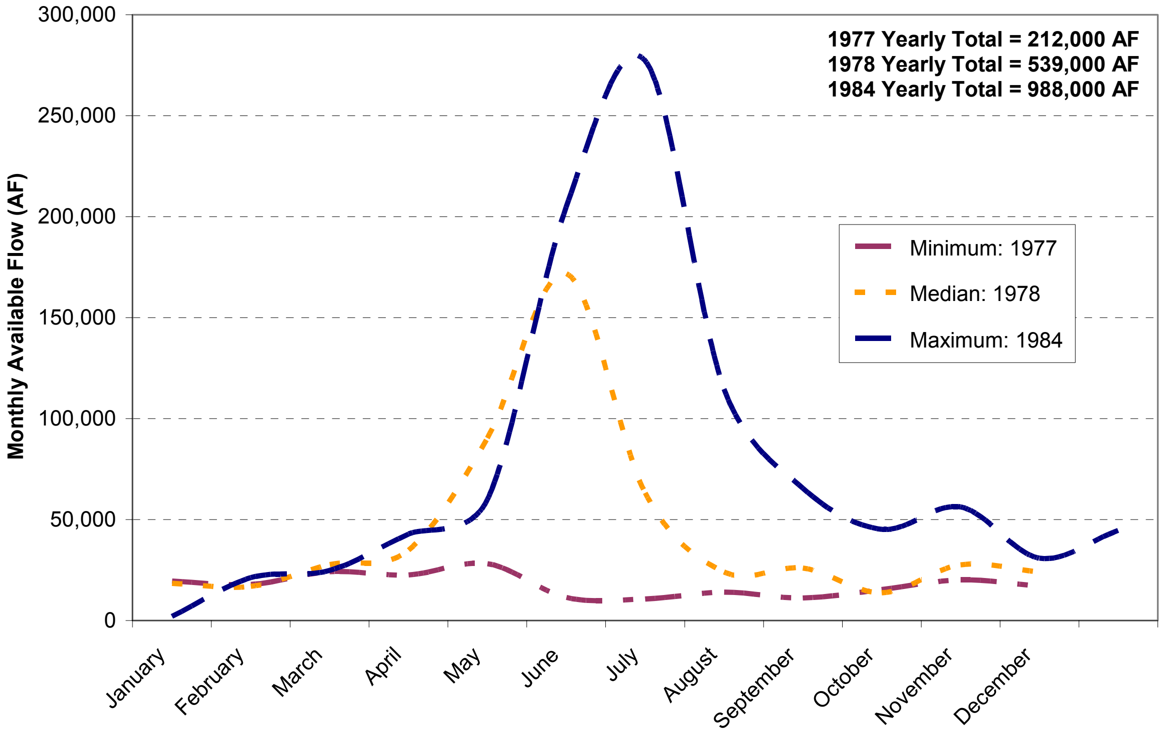


Figure 7-115
Monthly Legally Available Flow
White River near the State Line (1975-1990)

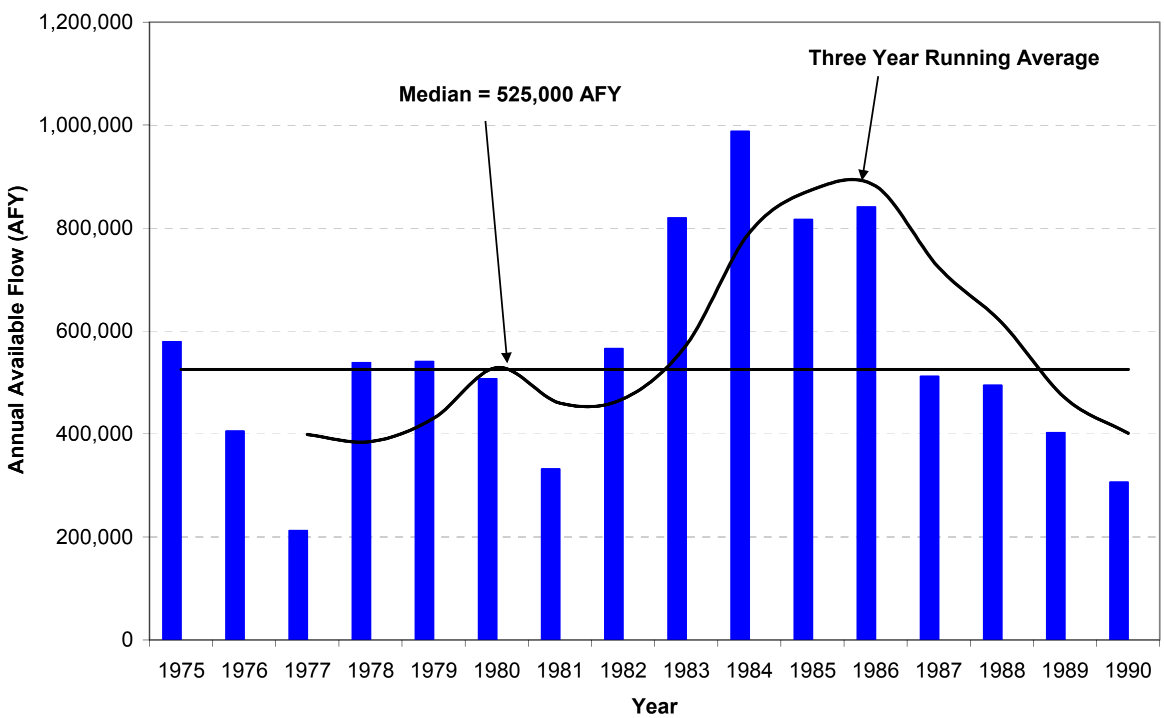


Figure 7-116
Annual Legally Available Flow
White River near the State Line (1975-1990)

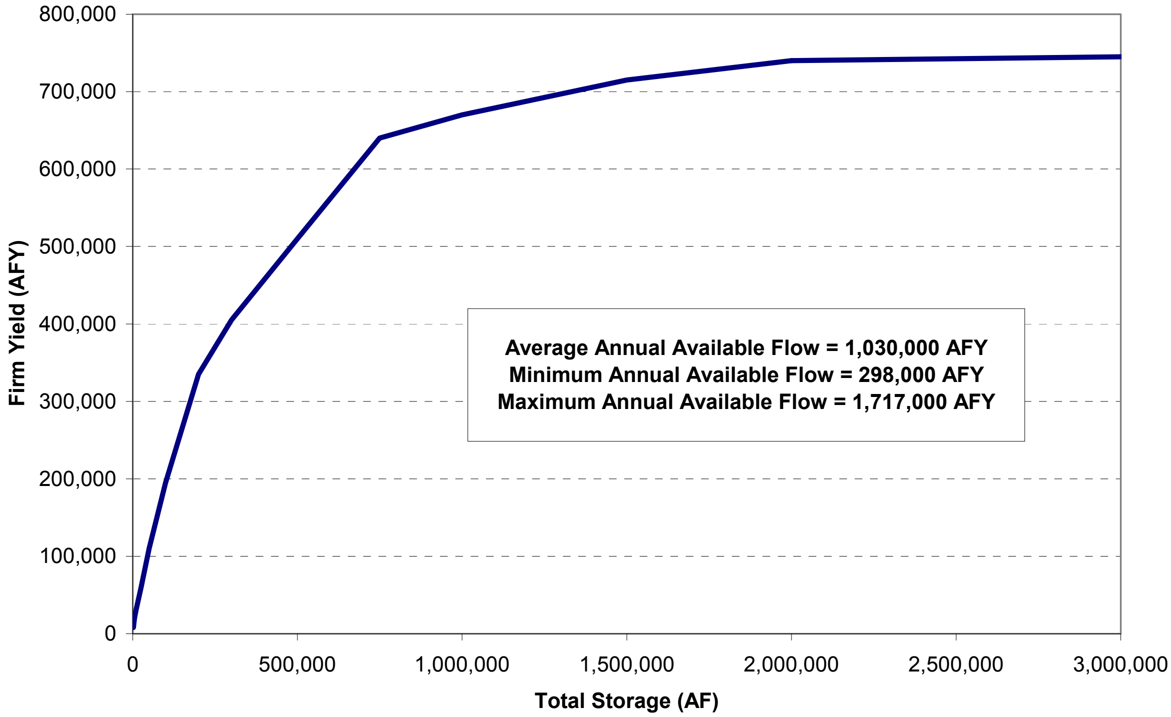


Figure 7-117
Reservoir Yield Curve
Yampa River below Craig (1909-1999)

7.4 Availability for Water Supply Development under Interstate Compacts and Decrees

Colorado has entered into and is affected by nine interstate compacts, two equitable apportionment decrees, and one international treaty. These agreements establish how water is apportioned between states and the Country of Mexico and have a significant effect on how Colorado can develop our future water supply as shown in Table 7-3. As noted in Section 7.3, there are no reliable additional water supplies that can be developed in the Arkansas and Rio Grande Basins, though water may be available in very wet years. The North Platte has the ability to increase irrigated acres consistent with the North Platte Decrees, but during the Basin Roundtable process, this was not proposed due the inability of agricultural users to pay for the infrastructure. The South Platte and those basins that are part of the Colorado River Compact (Colorado, Dolores/San Juan/San Miguel, Gunnison, and Yampa/White/Green) have legal and physical availability of supplies for development. An analysis of interstate compact and other issues related to development of supplies under the South Platte and Colorado River Compacts are discussed in this section.

Table 7-3 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	—

7.4.1 Colorado River Compact Analysis and Potential for Development of Additional Supplies

The Colorado River Compact places an upper limit on total CU of Colorado River and its tributaries within the state. Predicting the amount of water available for future water supply development in Colorado is a complex issue and is dependent upon the assumed hydrologic and climate conditions in the Upper Colorado River Basin states (Colorado, Wyoming, Utah, and New Mexico), estimates of physical supply and depletions in Colorado and other issues unrelated to the compact such as endangered species.

Colorado's compact entitlement to a portion of the approximately 11 million AFY of native (natural) flow generated in Colorado from the Colorado River and its tributaries (Dolores/San Juan/San Miguel, Gunnison and Yampa/White/Green) is a function of the water supply available at Lee Ferry, Arizona. Of the 11 million AF of average annual natural flow, nearly 9 million AF flow out of the state. Details on the compacts are provided in Section 4 and Appendix D. Based on the assumption in the Colorado River Compact of long-term average annual native flow at Lee Ferry of 15 million AF, the Upper Basin's apportionment is 7.5 million AF. Colorado's right to CU of water is 3.855 million AFY. Depending upon the interpretation of the Compacts, other laws, and the amount of water in the river, Colorado's right to the CU of water under the Compacts may range from 3.079 to 3.855 million AF per year (Colorado River Compact Water Development Workshop 1995). The lower estimate of water available for consumption in Colorado is based on a hydrologic determination conducted by the BOR in 1988 that considered the critical drought period between 1954 and 1966 (BOR 1988). During this critical period, the average annual available flow available for consumption by the Upper Basin states was estimated at 6.0 million AF, with Colorado's share equal to 3.079 million AF.

It is important to note the role of storage in Lake Powell and other Upper Basin Colorado River Storage Project Reservoirs such as Navajo, Blue Mesa, and Flaming Gorge to assist in providing for deliveries to the Lower Basin states during below average runoff. Storage releases from these reservoirs provide the ability for Upper Basin states to continue to maintain depletions during periods of below average native flow available at Lee Ferry.

Concerns over the recent drought and level of Lake Powell have led to the concern over the possibility that curtailment of water rights in the Upper Basin states may be needed in order to maintain the required deliveries to the Lower Basin states as required by the Colorado River Compact. It has been suggested that long-term climate change or extended drought periods estimated from tree ring studies may result in periods where long-term flow available for Colorado may be less than the hydrologic determination. **SWSI relies on BOR's hydrologic determination as a reasonable planning standard. The method used by BOR for estimating the critical period is similar to municipal planning standards for most Colorado M&I water providers that rely on a historical drought period (usually 1950s drought) for evaluating supplies. Droughts more severe than the historical planning period are anticipated and will be managed through temporary water management strategies, such as water restrictions and temporary leases from agricultural users.**

The Upper Colorado River Commission also has prepared an estimate of historical and virgin flow at Lee Ferry. The long-term 10-year running averages of historical and virgin (natural or native) flow at Lee Ferry are shown in Figure 7-118. The lowest 10-year running average of 11.8 million AF for the period 1896 through 2003 (water years ending September 30) occurred during the 1954 to 1966 critical period. (Note that the BOR Hydrologic Determination Report estimates that the lowest 10-year running average was 12.1 million AF. At the end of 2003, the 10-year running average was 13.9 million AF, indicating that at least through 2003, the recent drought was not yet as severe as the period used for the hydrologic determination.)

Estimates of annual historical and virgin flow are shown in Figure 7-119. This graph shows that annual releases from Lake Powell have resulted in maintaining deliveries at Lee Ferry at a minimum of 8.3 million AF despite the most recent drought years. On a 10-year running average, the Upper Basin states delivered over 102 million AF through 2003, significantly in excess of the required deliveries under the Compact.

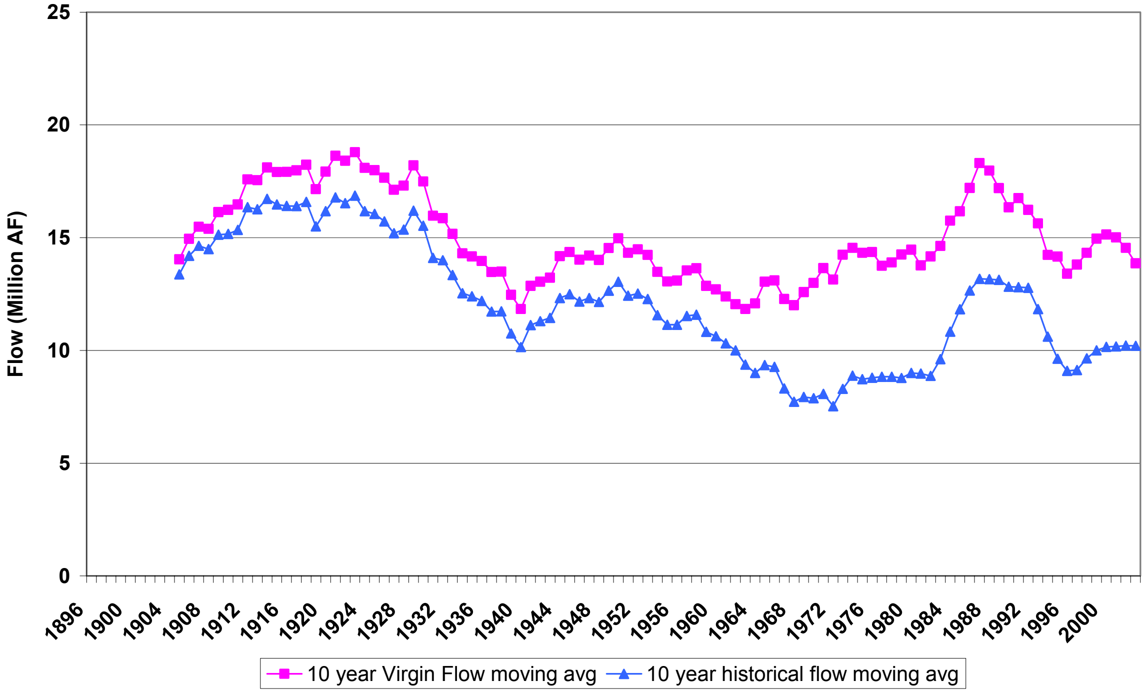


Figure 7-118
Estimated Natural and Historical Flow at Lee Ferry
(Source: Upper Colorado River Commission)

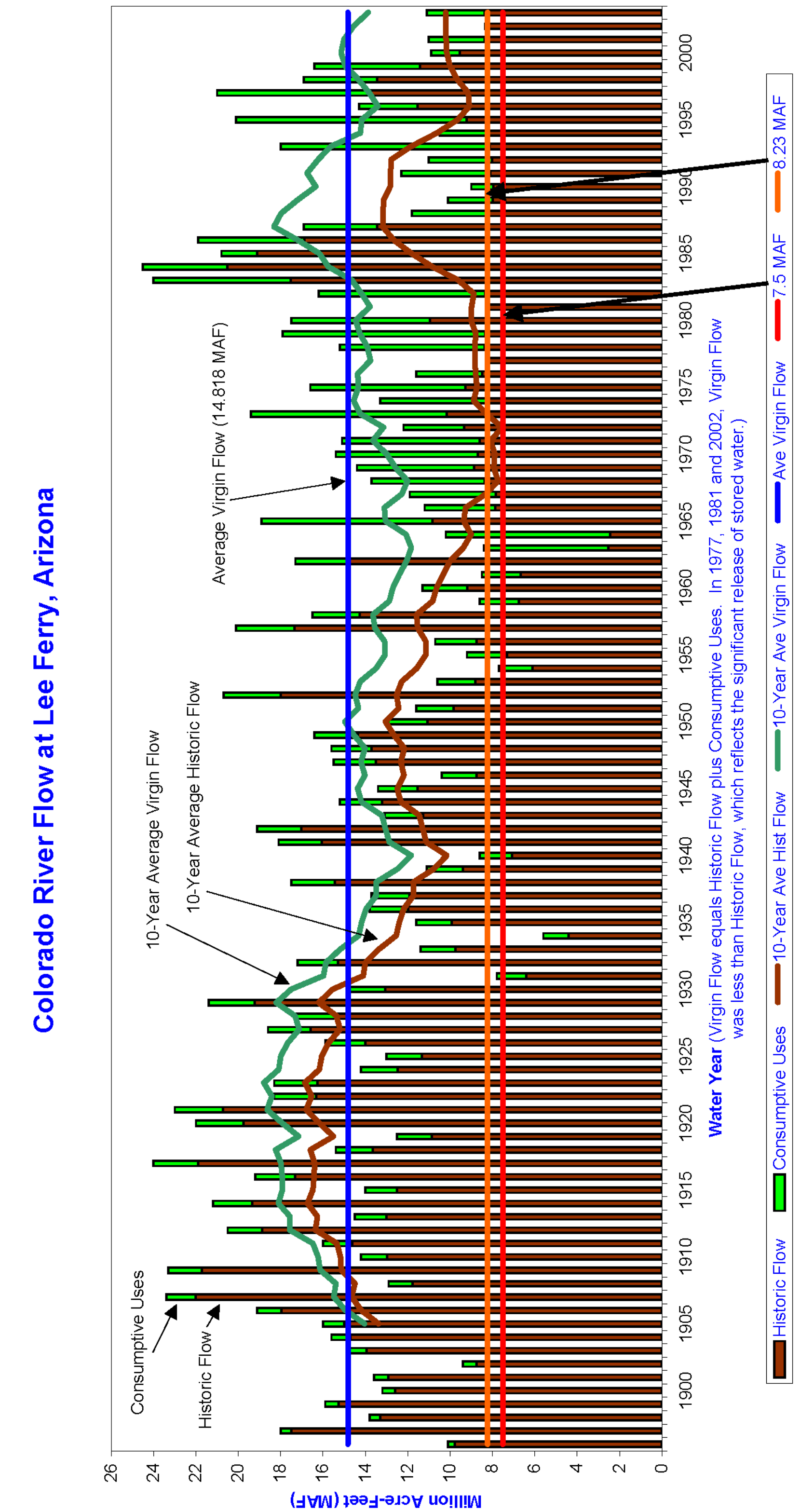


Figure 7-119
Estimated Natural and Historical Flow at Lee Ferry
(Source: Upper Colorado River Commission and CWCB)

The BOR has prepared Colorado River Basin Consumptive Uses and Losses Reports for the period from 1971 through 2000, in 5-year increments. These reports estimate CU by category, including reservoir evaporation, irrigation, stockpond evaporation and livestock, mineral resources, thermal-electric power, and exports (CWCB 2004). In addition, potential depletion schedules were proposed in the 1990s by the Upper Colorado River Commission.

The CWCB also has prepared estimates of CUs and losses and comparisons with the BOR estimates (Leonard Rice Consulting Water Engineers 2004.) For the most recent period, 1996 to 2000, the BOR estimates of CUs and losses averaged 2.048 million AF as compared to the CWCB estimate of 1.987 million AF. This difference of 65,000 AF is attributable to differences in the calculation of agricultural CU shortages and discussions are ongoing to resolve the differences. CWCB is providing supporting information the BOR. Based upon their review, the BOR may prepare an updated estimate of CUs and losses to reflect the latest data and information. The addition of Colorado's share of average CRSP reservoir evaporation during this period of 354,000 AF results in total CUs and losses of 2.402 million AF (BOR) or 2,341 million AF (Leonard Rice Consulting Water Engineers 2004). Both of these estimates are well below the 3.855 million AF contemplated by the Colorado Compact and the 3.079 million AF under the hydrologic determination, indicating that on average approximately 450,000 to 1,200,000 AF is available for development beyond the 1996 to 2000 average CUs and losses.

There are four key sources of information that were examined to reflect the range of interpretation on Colorado's water use and available supply.

1. **Upper Colorado River Commission Future Depletion Schedule** – the Upper Colorado River Commission has developed a depletion schedule to assist the BOR in determining power and repayment rates and for other planning purposes.

2. **BOR Estimate** – these are prepared by the BOR to estimate water use in the Upper Basin states of the Colorado River.

3. **CWCB DSS Estimate** – this estimate is based on detailed analysis of irrigated acreage, available supply, calculated agricultural shortages, and water use data.

4. **SWSI Estimate** – an estimate of projected and potential additional CUs and losses was prepared using SWSI M&I and agricultural demand projections. Since other CUs and losses, such as reservoir evaporation, were not evaluated during the SWSI process, estimates were made of potential changes in these CUs and losses.

Table 7-4 shows the range of projected and potential additional depletions from 2000 to 2030. This table also shows the Upper Colorado River Commission, BOR, and DSS estimates of depletions for the 1996 to 2000 period. A comparison of current estimates is shown in Figure 7-120. (Note: these estimates are based on an average for the years 1996 to 2000 for both the BOR and CWCB DSS estimates and the year 2000 for Upper Colorado River Commission and SWSI. The SWSI estimate uses the same data as the CWCB DSS, the difference in values is simply the result of single year data point versus a multi-year average.) The SWSI 2030 anticipated depletions for agricultural, M&I, and power/industrial are based on the range of potential demands described in Section 5. The estimate of anticipated exports is based on an assumption that existing transbasin diversion facilities have the capacity to divert an additional 115,000 AFY and that firming projects and increased demands can potentially increase exports by this amount. Reservoir evaporation was estimated assuming that additional storage would be constructed within the basin. This table also includes potential depletions that would be in addition to the anticipated depletions. Potential depletions are only included in the SWSI 2030 high demand. Additional potential depletions were estimated for additional agricultural firming projects, energy development such as oil shale, a potential multi-basin project, and additional reservoir evaporation associated with storage developed to meet these additional depletions. These estimates are included to indicate how these possible anticipated and potential depletions would impact the availability of Colorado's compact entitlement under the BOR hydrologic determination.

As noted earlier, a number of federal endangered fish species are present in the Colorado basins in Colorado and require special attention. Coordinated reservoir operations, stocking, control of non-native species, and habitat improvement are options that can help meet the needs of endangered species.

The location of available flows must also be examined when evaluating the potential for development of additional supplies. As noted throughout this report, the potential for development of supplies in headwater areas is limited due to physical availability, instream flow rights, RICDs, and environmental and recreational needs and permitting requirements.

In addition, development of Colorado's Compact entitlement must ensure that the requirements of other relevant compacts regulating flows or depletions in the Yampa, La Plata, and other tributaries be met.

Table 7-4 Comparison of Estimated and Projected Depletions under Colorado's Share of the Colorado River Compact

	Upper Colorado River Depletion Schedule			BOR Estimate	CWCB DSS Estimate	SWSI Estimate			
Item	1991-1995	2000 Projected	2030 Projected	1996-2000 Average	1996-2000 Average	2000	2030 Demand with No Change in Irrigated Acres	2030 High Demand	2030 Low Demand
Current Depletions									
Agricultural - Irrigation and Stock	1500	1500	1500	1430	1345	1259	1259	1259	1259
Municipal/Domestic	19	19	19	35	27	42	42	42	42
Power/Industrial	35	35	35	19	18	22	22	22	22
Minerals	21	21	21	4	4	0	0	0	0
Exports	606	606	606	480	476	520	520	520	520
Reservoir Evaporation	84	84	84	82	117	117	117	117	117
TOTAL	**2265**	**2265**	**2265**	**2048**	**1987**	**1960**	**1960**	**1960**	**1960**
Anticipated Depletions									
Agricultural - Irrigation and Stock	0	20	52	0	0	0	0	32	-46
Municipal/Domestic	0	18	82	0	0	0	33	38	24
Power/Industrial	0	40	73	0	0	0	20	20	20
Minerals	0	0	32	0	0	0	0	0	0
Exports	0	45	162	0	0	0	115	115	115
Reservoir Evaporation	0	2	2	0	0	5	20	30	10
TOTAL	**0**	**125**	**403**	**0**	**0**	**5**	**188**	**235**	**124**
Potential Depletions									
Agricultural - Irrigation and Stock	0	1	5	0	0	0	0	25	0
Municipal/Domestic	0	0	1	0	0	0	0	0	0
Power/Industrial				0	0	0	0	0	0
Minerals	0	0	1	0	0	0	0	50	0
Multi-basin Project				0	0	0	0	150	0
Reservoir Evaporation				0	0	0	0	15	0
TOTAL	**0**	**1**	**7**	**0**	**0**	**0**	**0**	**240**	**0**
Summary of Depletions	2265	2391	2675	2048	1987	1965	2148	2436	2084
Evap-Storage Units	295	295	295	354	354	348	341	341	341
TOTAL DEPLETIONS	**2560**	**2686**	**2970**	**2402**	**2341**	**2313**	**2489**	**2777**	**2425**
Colorado Allocation	3079	3079	3079	3079	3079	3079	3079	3079	3079
Remaining Available	519	393	109	677	738	766	590	302	654
Percent of State Share Unused	17%	13%	4%	22%	24%	25%	19%	10%	21%

7.4.2 South Platte River Compact Analysis and Potential for Development of Additional Supplies

The South Platte River Compact provides that Colorado has the right to fully consume water in the South Platte River between October 15 and April 1. Between April 1 and October 15, if flows in the South Platte River at Julesburg drop below 120 cfs, water rights junior to June 14, 1897 may be curtailed between the western boundary of Washington County and the state line unless such diversions are replaced or augmented. The South Platte Compact allows additional development of water in Colorado as average annual flows at the state line currently exceed the Compact criteria.

The development of additional supplies to meet M&I needs in the South Platte is impacted by the physical availability of water in relation to M&I water needs. As noted in Section 7.3.7.1, there are no reliable supplies to be developed under a **new water right** at or above Chatfield Reservoir. As in most basins, available supplies increase as the river flows downstream. The South Platte is similar to the Arkansas and different from the other basins in the state in that M&I return flows, primarily from wastewater discharges and landscape irrigation are significant contributors to the increased flows. Flows in the South Platte are greatest in the section of the river where the return flows from the South Metro, Denver Metro, and Northern regions combine near the Kersey gage. Examination of the State Engineer's snake diagram (Figure 7-6) illustrates this return flow pattern.

Section 6 outlined the Identified Projects and Processes that South Platte water providers intend to implement to help meet 2030 demands. The increased use of existing water rights, enlargement of existing reservoirs, and new reservoir construction are in-basin solutions that will use much of the available, higher quality supplies available at existing M&I intakes located in the headwaters or canyon mouths. The limitations of available higher quality at existing M&I intakes will lead to the expansion of non-potable reuse for irrigation and indirect potable reuse, which will reduce the available flows downstream of urban areas to the extent these flows have been in the river. Recharge plans filed by agricultural users in the lower South Platte may divert additional flows. Water supply availability in the South Platte will be enhanced by return flows from potential expanded non-tributary well pumping and transbasin diversions that have not yet been imported into the South Platte. By 2030, it is anticipated that reliable available supplies will have been developed and supplemented by agricultural transfers.

Federal threatened or endangered fish species, such as the Greenback Cutthroat Trout, and state species of concerns such as the Plains Top Minnow, are present in the South Platte River and tributaries, and require special attention.

Under the proposed Platte River Endangered Species Program, Colorado has agreed to "balance" our water depletions for the next 13 years, which is the first increment of the proposed program. Colorado will "balance" our depletions by ensuring that as population grows, the sources of water needed to meet this growth will be "balanced" between net accretive and net depletive water development. Accretive development includes non-tributary groundwater, agricultural transfers, and transbasin imports. Depletive development includes new native basin storage and reuse.

Section 8
Options for Meeting Future Water Needs

8.1 Developing Options for Future Water Needs

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

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

8.2 Families of Options

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

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

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

A brief description of water use in Colorado can help put in context the limitations of some of these alternatives that would produce additional water supplies through increasing the efficiency of water uses. More detail regarding basic provisions of Colorado water law can be found in Section 4. At the start of the SWSI Basin Roundtable process, the overriding objective of compliance with the Colorado water rights system and interstate compacts provided the framework for evaluating potential strategies for meeting future water needs. A primary tenet of Colorado water law applicable to water rights change of use is that return flows resulting from beneficial use of water under an appropriation are "owed" to the stream, where they provide water for subsequent appropriators. This tenet derives from the fact that typically not all the water diverted from the stream is 100 percent consumed. For example, when irrigating crops, water may seep into the ground as it is conveyed through the irrigation canal or infiltrate into the ground once it is applied to the field. Much of this infiltrated water makes its way back to a surface water stream and is then diverted by downstream water users.

Figure 8-1 is a schematic of the return flows from agricultural water use. Under water law, appropriators have a legal right to rely on the continuation of stream conditions in effect when they made the appropriation, including return flows to the stream from diversions made by other appropriators. The result of this pattern of water use is that water in Colorado can be diverted and used and then subsequently rediverted and used many times, as return flows from one irrigator's use of water form the supply for a downstream user's water right. Other benefits of these return flows include the recharge of aquifers. Many domestic and irrigation wells would dry up if groundwater recharge from historical irrigation practices were not maintained. Return flows can also result in improved riparian habitat and more even stream flows, which help maintain year-round fisheries that would otherwise not exist. Thus, for example, many of the small urban creeks that flow through urban areas support riparian habitat and aquatic species as a result of return flows from lawn irrigation and other urban water uses.

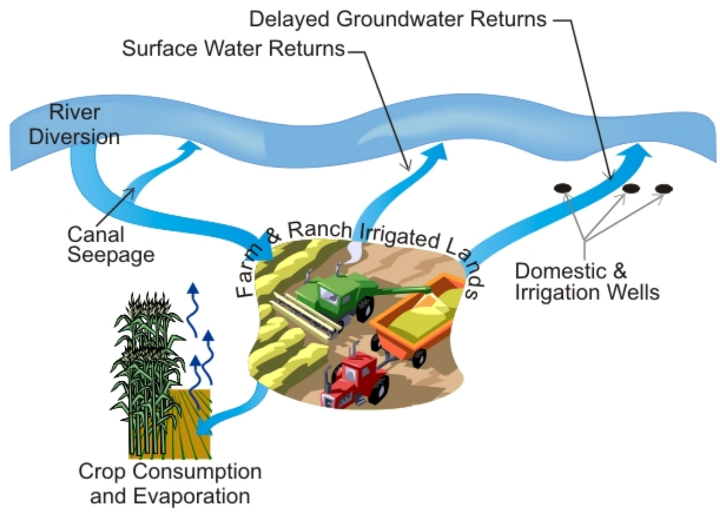


Figure 8-1
Return Flows from Agricultural Use of Surface Water

8.2.1 Conservation

8.2.1.1 Municipal and Industrial Water Conservation

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

Table 8-1 summarizes five levels of water conservation developed during SWSI. Each level shows examples of water conservation programs that a utility or water provider might implement at the given level of conservation effort. In addition, the table indicates an estimated percent reduction in total M&I demand that might result from each level of conservation; and a generalized cost of the water savings at each level. Such generalized savings and costs may vary with the program implementation conditions of each water provider. The percent savings and generalized costs of each level of water conservation effort are described in detail in Appendix E (SWSI Water Demand Forecast Report).

- **Level 1 Water Conservation Savings:** This level is defined as water savings that result from the impacts of plumbing codes, ordinances, and standards that improve the efficiency of water use. These conservation savings are sometimes termed "passive" savings because water utilities do not actively fund and implement the programs that produce these savings. These savings occur as new construction and remodeled buildings become more water efficient over time. In addition, landscaping ordinances contribute to these passive savings. Level 1 conservation is included in the SWSI baseline water demand forecast.

In contrast, water conservation savings resulting from utility-sponsored water conservation programs are referred to as "active" savings. The options included as potential future options for SWSI in terms of M&I conservation, correspond to the different levels of active conservation (Level 2 through 5) are described below.

Table 8-1 Active Conservation Matrix

Level	Types of Programs	Percent Reduction in Future M&I Demand				Cost $ per AF
		2000	2010	2020	2030	
1	Plumbing codes	n/a*	2.5%	4.5%	6%	$0
	Fixture standards from National Energy Policy Act					
2	Metering	n/a*	4%	4%	4%	$100
	Leak detection		(6.5%)	(8.5%)	(10%)	
3	All of the above (Level 2)	n/a*	5%	8%	10%	$500
	Education		(7.5%)	(12.5%)	(16%)	
	Rebates for toilets and washers					
	Audits: residential and commercial					
	Landscape audits					
	Increasing rate structure					
4	All of the above (Level 3)	n/a*	10%	15%	20%	$1,000
	Steep pricing rate and surcharges		(12.5%)	(19.5%)	(26%)	
	Rebate for landscape changes					
	Turf replacement & restrictions					
	Rebates for irrigation sensors & controllers					
	Sub-metering of master-meter properties					
	Fixture retrofit upon sale of property					
	Ordinance eliminating single-pass cooling					
5	All of the above (Level 4)	n/a*	15%	25%	35%	$2,000
	Replacement of all inefficient water fixtures & appliances		(17.5%)	(29.5%)	(41%)	
	Eliminate leakage by all customers					
	Eliminate high-water using landscape					
	Install non-water using urinals by non-residential customers					

n/a* The 2000 level of water use implicit in the county gpcd values includes "current" conservation savings.
The percent reduction indicated for Levels 2 through 5 is "above and beyond" the Level 1 reduction; the cumulative percent reduction is shown in parentheses.

Note that emergency conservation programs and short-term drought-response restrictions are not included among these long-term water conservation programs. 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 the lawn or 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, it was reported that mandatory restrictions resulted in short-term water demand reductions of 20 to 30 percent (Kenny and Klein 2004).

- **Level 2 (Basic) M&I Conservation:** This level of conservation consists of programs for metering and leak detection, and can generally achieve about a 4 percent water demand reduction in addition to the passive conservation reductions. It is assumed that water providers would continue to fund programs to maintain this level of savings in future years, thus the estimated percent reduction is a steady percent.
- **Level 3 (Moderate) M&I Conservation:** This level of conservation typically includes programs for metering and leak detection, education, rebates for water-efficient toilets and washers, and a rate structure that promotes effective water use. This level of effort generally corresponds with implementation of the nine water conservation measures recommended by the CWCB for consideration in Colorado water conservation plans. This level of conservation can generally achieve about 5 percent water demand reduction in the short- to mid-term (10 years).
- **Level 4 (Aggressive) M&I Conservation:** This level of conservation typically includes programs above and beyond moderate conservation, including steep pricing rate and surcharges, rebate for landscape changes, residential and commercial audits, turf replacement and restrictions, rebates for irrigation sensors and controllers, sub-metering of master-meter properties, and fixture retrofit upon sale of properties. This level of conservation can generally

achieve about 10 percent water demand reduction in the short- to mid-term (10 years).

- **Level 5 M&I Conservation:** Program savings are influenced by the level of participation and compliance with a given program. The prior levels of conservation effort (2 through 4) assume a reasonable level of program participation. Level 5 assumes total participation by all customers and is intended to represent a maximum level of effort in water use efficiency. Such a level of conservation is estimated to achieve about 15 percent water demand reduction in the short- to mid-term (10 years).

It is important to note that the matrix shown in Table 8-1 shows *future* conservation potential. The SWSI baseline county water use values of gpcd are based upon year 2000 data and therefore implicitly include the "current" level of conservation effort. One cannot simply apply an assumed level of conservation to a county demand number and expect the referred percent savings, because water providers may be at or above the assumed level of conservation.

It is also important to note that the *realistic* level of future water demand varies by location given the currently implemented or budgeted water conservation programs. For example, Level 3 conservation represents a set of conservation programs similar to what Denver Water has already implemented, as of the base year 2000. Continued implementation of Level 3 programs will further increase market saturation and enhance program savings. Therefore, the future water demand for Denver County should be further reduced by the Level 3 percentages to reflect the future impacts of continuing the *currently* implemented conservation programs. Furthermore, Denver Water is considering for future implementation a set of programs commensurate with Level 4. Thus, if the additional programs are implemented, it would be realistic to further reduce the Denver County demand projections by the difference between Level 3 and Level 4 (i.e., simply apply the Level 4 percent reduction). This would provide a realistic projection of future water demand for Denver County. However, the base period of the SWSI analysis is 2000. Therefore, the level of conservation in the year 2000 is assumed for the *current* conservation level.

In order to develop a more realistic assessment of future water demand throughout the state, the appropriate *current* (year 2000) level of conservation was identified for each county. The classification of the level of effort for each county is subjectively based on a review of available water conservation plans submitted by water providers to the CWCB and survey results collected by the Colorado Municipal League. The resulting classification of each county is summarized in Table 8-2. It is estimated that these current active conservation programs will result in water demand savings ranging from 3 to 14 percent by basin, or an estimated 231,000 AF, by 2030 if the current level of effort is sustained into the future. More detail on the estimated M&I conservation savings is provided in Appendix E.

Table 8-2 Current Level of Water Conservation Effort

County	Level of Current Conservation Effort - 2000				
	1	2	3	4	5
Adams			✓		
Alamosa		✓			
Arapahoe			✓		
Archuleta		✓			
Baca		✓			
Bent			✓		
Boulder			✓		
Broomfield		✓			
Chaffee		✓			
Cheyenne	✓				
Clear Creek	✓				
Conejos	✓				
Costilla	✓				
Crowley		✓			
Custer	✓				
Delta	✓				
Denver			✓		
Dolores		✓			
Douglas			✓		
Eagle			✓		
El Paso		✓			
Elbert		✓			
Fremont		✓			
Garfield			✓		
Gilpin	✓				
Grand		✓			
Gunnison		✓			
Hinsdale	✓				
Huerfano	✓				
Jackson	✓				
Jefferson			✓		
Kiowa	✓				
Kit Carson	✓				
La Plata			✓		
Lake	✓				
Larimer			✓		
Las Animas			✓		
Lincoln		✓			

Table 8-2 Current Level of Water Conservation Effort (cont.)

County	Level of Current Conservation Effort - 2000				
	1	2	3	4	5
Logan		✓			
Mesa			✓		
Mineral			✓		
Moffat		✓			
Montezuma		✓			
Montrose		✓			
Morgan			✓		
Otero		✓			
Ouray	✓				
Park	✓				
Phillips	✓				
Pitkin			✓		
Prowers		✓			
Pueblo		✓			
Rio Blanco	✓				
Rio Grande	✓				
Routt		✓			
Saguache	✓				
San Juan	✓				
San Miguel	✓				
Sedgwick			✓		
Summit		✓			
Teller			✓		
Washington	✓				
Weld		✓			
Yuma		✓			

Source: survey by Colorado Municipal League.

8.2.1.2 Evaluating New Supply from M&I Water Conservation

The ability to develop new supplies from water conservation or to carry over conserved water for later use is dependent on the type of water rights used. The potential for conservation must be evaluated on an individual M&I water provider basis, considering the types of water rights owned and the return flow obligations that apply to these water rights. Figure 8-2 illustrates the M&I return flow cycle for surface water diversions. The benefits of water conservation include:

- Implementation costs can be significantly lower than new water supply development or other alternatives.
- There are no permitting requirements to implement water conservation.
- Implementation is within the control of the local water provider and does not require approval of other entities.
- No new diversions are required from rivers or streams.
- Existing water supplies can be stretched to supply demands of new growth.
- Lesser environmental impacts than new water storage development.
- Can reduce water and wastewater treatment, distribution, collection, capital, and operations and maintenance costs.

Some of the issues involved in evaluating the net available water supply produced from M&I water conservation are:

- M&I direct flow water rights cannot be stored or carried over for drought periods (absent a change of use proceeding in water court), thus conserving water and reducing the demand on direct flow rights may not create reliable supply to meet new demands (for example for new growth.)
- CU water rights, such as transbasin, non-tributary, groundwater, or CU agricultural transfers, on the other hand, can be stored. If the overall demands on CU supplies can be reduced, the "saved" water can be used to meet the demands of new growth, improve reliability or both, if adequate storage is available to carry over the conserved water for use in drought periods.
- Many M&I water users have substantial agricultural rights that provide for the diversion of the entire historical amount of irrigation use as long as CU is not increased and historical return flows are maintained.

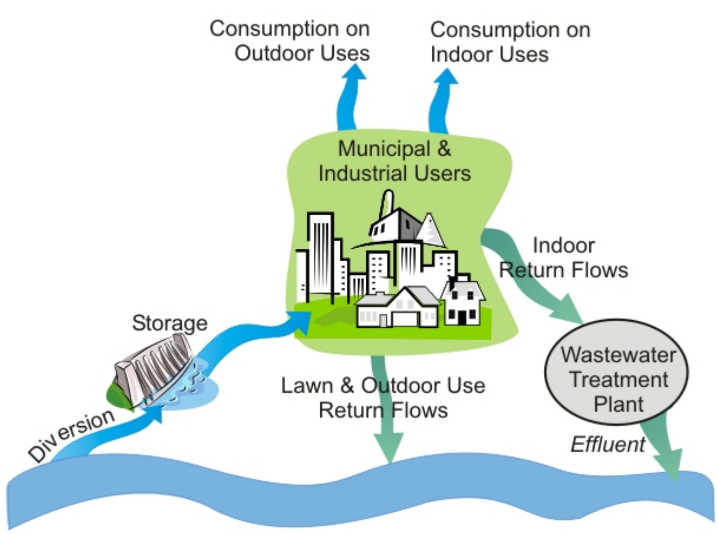


Figure 8-2
Return Flows from M&I Use of Surface Water

In these instances, wastewater returns and return flows from lawn irrigation have been quantified and may be used to maintain historical return flows such that historical CU is not increased. Conservation that results in reduced volumes of wastewater or lawn return flows can require M&I users to acquire additional water supplies to maintain these historical returns.

- Augmentation plans can be developed that account for wastewater and lawn return flows, and only require that the M&I CU be replaced. As a result, conservation would not result in an increase in supply unless the M&I CU is reduced, such as through the reduction in total irrigated areas of lawn. The assumed CU is usually decreed in an augmentation plan and as a result, any attempt to use conserved water would require a re-opening of the augmentation decree to re-quantify CU. This action would likely be costly and could present a high level of risk to the water provider.
- M&I landscape irrigation return flows, in addition to satisfying downstream rights, also creates delayed return flows than can have instream and riparian environmental benefits, and maintains aquifers for domestic and irrigation wells.

8.2.1.3 Agricultural Conservation (Efficiency Improvements)

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

Table 8-3 shows the range of expected application efficiencies for different types of irrigation practices and the approximate costs to install these irrigation delivery systems.

Table 8-3 Estimated Efficiencies and Costs for Irrigation Methods

Type of Irrigation	Range of Efficiency	Average Capital Cost/Acre	Average Annual Cost/Acre
Flood	30-50%	—	—
Furrow	40-60%	$37	$30
Gated Pipe	~60%	$178	$51
Center Pivot Circle	~85%	$433	$64
Center Pivot with Corner	~85%	$568	$80

The benefits of agricultural efficiency measures include:

- Increased ability to deliver water to the crops can stretch existing supplies. This benefit would apply to water short irrigators that would benefit if additional water could be delivered to their crops. If the irrigator that has water short crops typically experienced 50 percent losses, reducing those losses will result in an increased delivery to the water short crops and a resulting increase in crop CU.
- Agricultural efficiency may reduce non-crop CU. Some of the CUs and losses may be due to tailwater from irrigation ponding at the end of fields and evaporating, rather than returning as surface or groundwater return flows.
- There may be potential water quality benefits. Canal seepage and/or flood or furrow irrigation may result in the leaching of minerals from the soils that result in impacts to the water quality of the return flows. Lining canals or the installing sprinklers may reduce the leaching of these minerals. This must be examined on a site-specific basis, as some irrigated fields may require periodic flushing of salts and minerals that accumulate in the soils in order to remain productive. The benefits of these improvements accrue to many, and programs like the Colorado River Salinity Control Program exist to encourage these types of improvements.
- No new diversions are required from rivers or streams.
- Permits are not required for implementation.

There are a number of potential issues and conflicts that must be evaluated for the potential implementation of agricultural efficiency measures.

- Historical agricultural return flows are a vital part of the flows in all basins and downstream surface water diverters and downstream states have relied on these return flows.

- These return flows, in addition to satisfying downstream water rights, also create delayed flows that can have instream and riparian environmental benefits and maintain aquifers for domestic and irrigation wells.
- Typically, any water that is saved by efficiency measures such as canal lining or the conversion of irrigation practices and technology from flooding to gated pipe, center pivot circle, and center pivot with corner can only be used on lands for which the appropriation was originally made. Selling or delivering "saved" water to other users would constitute an improper expansion of use.

8.2.2 Agricultural Transfers

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

Section 4 of this report describes the general background of agricultural transfers. The total water available under a change of agricultural water rights typically depends on the historical CU of the water for agricultural purposes: this is a measure of the water right for transfer. In addition, the yield of an agricultural water right may depend upon the location of the new use of the water. For example, in general, if the water is to be diverted through the same ditch system as historically, a transfer to M&I use may allow diversions of all of the water previously diverted at the historical farm headgate though the historic CU cannot be increased. The water that may be diverted on a transfer of water from an agricultural use to one out of the basin will be limited to the historical CU. Meanwhile the historical return flows must be maintained; storage may be needed to ensure that other water rights that historically relied on return flows are protected. After the historical return flows have been replicated, it is legal for the transferred "consumable" water to be used and reused to extinction. A graph illustrating the yield from an agricultural transfer project, shown in conjunction with the reuse of a portion of the return flows used for M&I irrigation of landscaping, is provided in Figure 8-3.

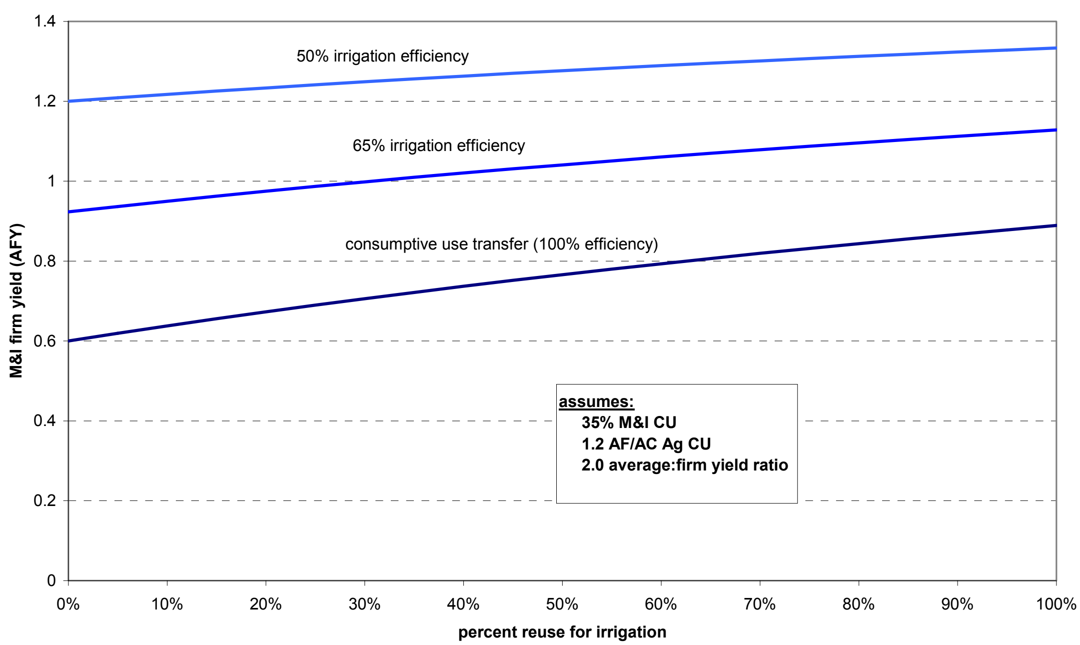


Figure 8-3
Firm Yield to M&I User from the Dry Up and Transfer of 1 Acre of Irrigated Agricultural Water Use

In some areas of the state, and particularly the Front Range, agricultural transfers are commonly used to develop supplies to meet M&I needs, and are important options included in the SWSI process. Three types of agricultural transfers are discussed: permanent, interruptible, and rotating.

8.2.2.1 Permanent Agricultural Transfers

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

The benefits of permanent agricultural transfers include:

- A permanent water right is acquired and future uncertainty over future water supply availability is reduced.
- Agricultural water rights generally have more senior priorities; these senior rights provide a more reliable supply since the water right will be in priority for longer periods than a junior or new water rights filing. Less storage is required to produce a firm annual yield than from new in-basin water supply development projects with junior water rights.
- Permitting may be simpler for such transfers than for development of a new water supply project, since the agricultural water to be acquired has already been diverted from the stream system and a portion consumed. This can result in a higher level of certainty than construction of a new reservoir storing junior water rights, where environmental issues and the effects of new depletions will be evaluated.
- Overall basin depletions are not increased.
- Return flows from the historic CU are consumable and can be reused.
- Lesser environmental impacts than a new water storage project.

Permanent agricultural water transfers, though widely practiced in certain areas of the state as a water supply option for M&I users, have several potential issues and conflicts:

- Localized socio-economic impacts result from dry-up of agricultural lands. Irrigation of agricultural lands has historically resulted in the development of a local economy. In addition to supporting the farmer or rancher, associated economic benefits of the irrigated agriculture may form the basis of the entire economy of the local community. Permanent dry-up of lands may have a significant negative effect on the local community unless the irrigated lands are converted to other uses such as residential, commercial, or industrial.
- Dry land has a substantially lower assessed value than irrigated agricultural land. In Colorado, unless the farm or ranch has development potential, much of the value of a farm or ranch may be derived from the water rights. Once the water rights are transferred and the land no longer irrigated, the assessed value is reduced significantly. This results in a significant loss of tax base to the local governments and school districts.
- A water court procedure is required to change the use of agricultural water rights. This procedure can be a very lengthy and expensive process, and is not without risk.
- Revegetation of formerly irrigated lands is required by law under certain circumstances. Colorado statue, in some instances, requires that an entity transferring and permanently drying up irrigated lands ensure that the land is revegetated with plants not requiring supplemental irrigation. This can be a difficult and costly process.
- Continued agricultural use of lands maintains the open space nature of the property to the benefit of the general public. If water is transferred from irrigated lands, the land may be more susceptible to development for other uses, since agricultural use will be harder to support.
- There is a potential loss of wetlands and riparian habitat. Return flows from irrigated agriculture often result in the creation of local wetlands and riparian habitat.
- Approximately 2 to 3 AF of storage is required to produce 1 AF of firm annual yield for M&I use. Agricultural transfer yields are not, by themselves, firm since they are typically seasonal and susceptible to drought conditions. Storage is needed to carry over agricultural supplies from the irrigation season to the non-irrigation months and to ensure that adequate water can be stored in average to above average runoff years for use in below average years.
- Return flows from agricultural lands may provide important seasonal instream flow benefits, the timing of which may be altered by a transfer. Flood irrigation

of mountain meadow hay fields often result in delayed return flows of high quality, cold water, supporting aquatic habitat in the late fall and winter months.

- There is a potential impact on groundwater tables and wells in the area unless historical returns are made in the exact location. Many domestic and irrigation wells are kept viable by the return flows from irrigation.

8.2.2.2 Interruptible Agricultural Transfers

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

Interruptible agricultural transfers offer several benefits:

- A permanent transfer of agricultural water rights may not be needed, avoiding some of the negative impacts of a permanent dry up of agricultural lands.
- Interruptible agreements are useful during below average runoff conditions, when the available supplies to meet M&I, environmental, or recreational needs are reduced. The need to construct significant volumes of new storage to carry over water from average to above average runoff years for use in below average years can be minimized.
- Since agricultural water rights are often more senior, the temporary transfer of this water to other uses can result in meeting an M&I, environmental, or recreational need during critical dry periods without the expense and issues of a permanent agricultural transfer or the development of storage or an expensive new water supply project.
- A better or more stable income to agricultural users can be assured, since during a drought supplies may not be adequate to produce a crop, even if the agricultural water right were used for irrigation and the net income from an interruptible arrangement can exceed the revenue that would be realized from farming that year.

There are numerous potential issues and conflicts with interruptible transfers that may limit the usefulness of this option as a tool for meeting future water needs:

- One premise of an interruptible supply arrangement is that the agricultural water right will remain in irrigation in perpetuity. An interruptible arrangement will be of very limited benefit to meet long-range water supply needs unless the interruptible supply arrangement is permanent and the farmer is bound to keep the water in agricultural use.
- Interruptible agreements must be evaluated on a case by case basis, as not all agricultural rights can be transferred to M&I water use. For example, interruptible transfers are very limited in the Denver Metro and South Metro subbasins of the South Platte, where there is very little agricultural water use that can be interrupted on an annual basis and transferred to existing M&I intakes.
- The agricultural rights involved in the interruptible transfer must have dry year yields. Many agricultural water users also experience significant shortages during below average runoff conditions and these supplies may be of little benefit in a dry year.
- The determination of the transferable amount can be complicated; as in a water transfer the rights of those other water users must be protected. There must be a mechanism to ensure that the transfer does not result in an increase of historical CU and return flows are maintained during the temporary interruption. CRS 37-9-309 allows the State Engineer to approve and administer interruptible transfers under certain conditions. Otherwise a change of water right will be required.
- Soil, weed, labor, and equipment management issues must be considered during those periods when the interruptible transfer is occurring and there is no irrigation. A farm operation involves not only the planting, irrigating, and harvesting of crops, but the hiring of labor and maintenance of equipment. In addition, the management of soil erosion and weed growth will be issues on irrigated fields that are temporarily dried up.
- Some agricultural crops, such as orchards, vineyards, and some hay crops are difficult to fallow and may not be appropriate for an interruptible transfer.

8.2.2.3 Rotating Agricultural Transfers with Storage to Firm Agricultural Demands

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

The benefits of this rotating agricultural transfer approach include:

- M&I reliability is improved since there is a guaranteed additional supplemental supply of water each year.
- A better or more stable income can be provided to agricultural users, since an income would be guaranteed during the fallowing year and the firming of agricultural yield will result in a more predictable farm yield during a drought.
- A permanent transfer of agricultural water rights may not be needed, avoiding some of the negative impacts of a permanent agricultural transfer.
- Maximizes the benefits of a non-tributary groundwater conjunctive use program. Non-tributary, non-renewable groundwater has a firm annual yield that does not vary from wet to dry years as long as the resource is not significantly depleted. The life of this groundwater resource could be extended by relying on a rotating agricultural fallowing program in average to above average years and pumping groundwater only during below average years. In these below average years, the yield from the rotating fallowing can be used to firm the yield of the agricultural users that are irrigating during those years.

Potential issues and conflicts with rotating agricultural transfers include:

- As for other interruptible supply arrangements, the lands involved remain in irrigation in perpetuity. The agricultural users would need to bind themselves to continue agricultural irrigation use and to fallow the land for a year as required.
- This may be more expensive approach than a permanent agricultural transfer. Incentives would need to be significant to induce an agricultural user to forego the right to sell the water in the future. Annual payments would be required for the agricultural users that are fallowing each year. In addition, the transaction costs to assemble a suitable program could be significant.
- Some agricultural crops, such as orchards, vineyards, and some hay crops are difficult to fallow and may not be appropriate for a rotating fallowing program.
- Agricultural supplies under a rotating program may not be in the needed location or of sufficient quantity. The water from the fallowed lands must be transferred to the M&I water supply intakes if the yield is to be used for this purpose rather than instream needs.
- A change of use from agricultural to M&I or other uses would likely be required. Determination of the transferable amount can be complicated and other water users must be protected. Legal and engineering costs will be incurred.
- Soil, weed, labor, and equipment management issues must be considered for the fallowed lands. A farm operation involves not only the planting, irrigating, and harvesting of crops, but the hiring of labor and maintenance of equipment. In addition, the management of soil erosion and weed growth will be issues on irrigated fields that are temporarily dried up.
- Storage would be required to firm the yield for all parties. M&I users would need storage to carry irrigation season water over to the non-irrigation months and storage will be needed to firm the agricultural supplies and provide for the replacement of delayed return flows from the fallowed lands.

8.2.2.4 Water Bank

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

The benefits of water banks include:

- Water supplies are improved for users acquiring water from the water bank.

- Agricultural use can be preserved by allowing alternative uses on an interim basis, without a permanent dry up.
- A better or more stable income to agricultural users can be provided, since the net income from a lease can exceed the revenue that would be realized from farming in a dry year.
- Provides for flexibility in water management, as there is a free market mechanism through which water supplies can be transferred within a basin.

The potential issues and conflicts with the use of water banks for meeting future water needs include:

- Water may not be available from the water bank when needed. There is no guarantee or requirement for a party to place its water in a bank.
- 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.
- Challenges in starting a market. An entity needs to be responsible for implementing advertising and maintaining the Bank.

8.2.3 Development of Additional Storage

Storage projects capture water during high flow years and seasons to be used during low flow periods. These storage projects include the construction of new reservoirs, enlargement of existing reservoirs, or rehabilitation of existing reservoirs that have reduced storage volumes due to various structural problems (e.g., spillways unable to meet the current probable maximum flood criteria, etc.). Storage options included in the SWSI process include the construction of new storage facilities to capture legally available flows under a new water rights appropriation, the construction of new storage facilities to maximize the yields of existing water rights, including exchange priorities and conditional storage rights, and the enlargement of existing reservoirs. The rehabilitation of existing reservoirs that are under voluntary or mandatory storage restrictions was evaluated during the Basin Roundtable process. It was determined that while there are many reservoirs with restricted capacities, the total potential storage to be gained from rehabilitation efforts is small in comparison to Colorado's overall need. This issue is discussed in greater detail in Section 10.

8.2.3.1 New Storage Projects

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

The benefits of developing new storage projects include:

- Water sources will be diversified if the water to be stored is from a new source. This can reduce the risk of supply shortfalls as not all water sources may experience shortages at the same time.
- The development of storage to capture unappropriated water can potentially reduce the pressure to transfer water from existing uses (i.e., agricultural water) to meet future water needs.
- The reliability of the overall water supply system can be increased and the risks reduced. The development of additional new storage can help protect against potential water shortages due to structural failures such as storage restrictions or the temporary inability to use a supply due to water quality concerns such as those associated with a forest fire in the watershed.
- Existing water rights are not affected if the water to be stored is under a new water right.
- The development of storage for unappropriated water captures an unused resource.
- The development of storage maximizes compact entitlements for beneficial use within the State of Colorado.
- Overall system efficiencies are increased by minimizing system spills.
- The yields of exchanges and non-potable reuse for irrigation are increased. Maximizing the reuse of consumable return flows requires storage, since return flows occur year-round, but reuse for irrigation only occurs during the summer months.
- Storage is required to firm the yield of transfers of agricultural water rights. If storage is not constructed,

additional agricultural water rights will be needed to ensure adequate supply during below normal runoff conditions.

- New reservoirs provide flat water recreation opportunities. Boating, swimming, and lake fishing opportunities are increased.
- Storage often provides consistent flows below the storage facility that can provide ideal cold water fishery habitat. Many of the Gold Medal fisheries in Colorado are below storage facilities.
- There is the potential for hydropower generation.

The potential issues and conflicts in developing new storage projects include:

- There may be environmental impacts to the aquatic and terrestrial environment. These impacts are likely to be more significant than those resulting from enlarging existing storage facilities.
- Loss of recreation associated with free-flowing streams, such as fishing, rafting, and kayaking.
- Water quality impacts can be associated with impounded water.
- Cultural impacts associated with inundation of lands.
- Permitting and mitigation can be more expensive and lengthy than other water supply options and have 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.

8.2.3.2 Expansion of Existing Storage Facilities

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

The expansion of existing storage facilities has several benefits including:

- There are likely to be less environmental and recreational issues than for new storage, since the reservoir already exists.
- Permitting and mitigation requirements may be less difficult than for construction of a new storage facility.
- Existing water rights are not affected if the water is to be stored under a new water right.
- The expansion of storage to capture unappropriated water can potentially reduce the pressure to transfer water from existing uses (i.e., agricultural water) to meet future water needs.
- The expansion of storage for unappropriated water captures an unused resource.
- The expansion of storage helps to maximize compact entitlements for beneficial use within the State of Colorado.
- Overall system efficiencies are increased by minimizing system spills.
- The yields of exchanges and non-potable reuse for irrigation are increased. Maximizing the reuse of consumable return flows requires storage, since return flows occur year-round, but the demand for irrigation is seasonal.
- Storage is required to firm the yield of transfers of agricultural water rights. If additional storage is not constructed, additional agricultural water rights will be needed to ensure adequate supply during below normal runoff conditions.

The potential issues and conflicts in expanding existing reservoirs include:

- Environmental and recreation impacts can also occur here depending on the size of facility.
- Expanding existing storage facilities does not diversify water sources and the risks of structural failures or water quality catastrophes are not reduced.
- Permitting and mitigation, though typically less difficult than that for new storage, can still be expensive and lengthy with an uncertain outcome.
- A significant amount of storage may be required to produce an acre-foot of firm yield. The amount of storage required will be basin and water rights specific.
- There are a limited number of reservoirs that can be enlarged. Many reservoirs are not cost-effective to enlarge.
- There is a limited volume of increased storage available through reservoir enlargements.
- The enlargement of existing reservoirs may not be cheaper than new storage. The original dam embankments and spillways, in many instances, were

not designed or constructed to current engineering standards. Upgrading the existing facilities to be compatible with an enlargement may not be cost-effective.

8.2.4 Conjunctive Use of Surface Water and Groundwater

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

In the context of water supply, aquifers can be categorized as being renewable or non-renewable. Aquifers that are located adjacent to rivers in the alluvial floodplain deposits usually have a hydrologic interaction with those rivers, and dynamically get water from or discharge water to the rivers throughout their reaches. Aquifers of this type are referred to as tributary aquifers. They usually are unconfined aquifers that are relatively shallow. Tributary aquifers are considered to be a renewable source of water since they are hydrologically linked to renewable supplies such as precipitation and infiltration of surface water.

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

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

8.2.4.1 Bedrock Aquifer Conjunctive Use

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

The benefits of bedrock aquifer conjunctive use storage and recovery include:

- Maximizes the benefits of bedrock aquifers and extends their long-term reliability. The use of surplus surface water supplies can reduce the need to withdraw non-renewable groundwater. The recharge of the aquifer extends the life of the groundwater reserve.
- Evaporation is minimized. Once the water has been recharged, there is no additional evaporation as compared to surface water storage.
- There may be fewer environmental impacts than surface reservoir storage.
- Requires less surface area for water storage.
- The permitting process is simpler than for developing surface water storage.
- Existing infrastructure designed for peak demands can be used during non-peak demand periods. Existing wells developed to meet peak demands can be used as injection wells during non-peak periods.
- Potable quality water can be withdrawn. Most bedrock aquifers are of potable water quality and do not require water treatment except for disinfection.

- Fewer risks of contamination and disruption of supply. Being far below the surface insulates the supply from contamination and since aquifer supplies would typically be extracted using multiple wells there is redundancy built into the system.
- Significant volumes of potential aquifer storage are available. Most of the major bedrock aquifers in Colorado have significant volumes of storage.

Issues and conflicts with implementation of bedrock aquifer conjunctive use include:

- Surface water supplies must be available for recharge.
- The surface water diverted for recharge to a bedrock aquifer must be treated both to potable water quality and must be chemically compatible with the native aquifer groundwater so that dissolved constituents do not precipitate and clog the aquifer.
- All of the recharged water may not be recoverable.
- Recharge rates for non-tributary aquifers often are low.
- High energy costs are incurred for aquifer recharge and pumping.
- May require the construction of specialized wells or refitting of existing wells that can be used to both inject and pump water. Such wells are referred to as aquifer storage recovery wells, or ASR wells.
- There may be a need for additional infrastructure (wells, surface water storage, and water treatment) constructed to meet peak demands.
- Additional surface storage may be needed to capture peak surface water flows that would be used later to recharge the aquifer. Surplus supplies are normally available during peak runoff periods, which can be when water demands are highest and existing wells will not be available for recharge.

8.2.4.2 Alluvial Aquifer Conjunctive Use

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

- Maintains high groundwater levels, benefiting wetlands, nearby streams and other nearby surface water features.
- Evaporation is minimized. Once the water has been recharged, there is no additional evaporation as compared to surface water storage.
- There may be fewer environmental impacts than for surface reservoir storage.
- Often requires less land for water storage.
- The permitting process is simpler than developing surface water storage.
- Streamflows can be diverted and recharged without additional treatment costs.
- Existing structures can often be used for recharge, such as river diversion structures and canals.
- Recharge can occur with low capital and operating costs since the recharge can occur through ditch or pond seepage as opposed to pumped injection.
- Tributary aquifers usually have a high recharge rate.
- Significant volumes of potential aquifer storage are available.
- Can be used to regulate streamflows for environmental enhancements. Timing the stream accretions from alluvial recharge can occur so that the water is accreted to the stream to benefit the environment.
- Can be used to augment agricultural well pumping. Timing the accretions from alluvial recharge can occur so that the water reaches the stream to match and augment depletions from agricultural well pumping.

Issues and conflicts with implementation of alluvial aquifer conjunctive use and storage and recovery include:

- Surface water supplies must be available for recharge.
- May lead to high water table conditions, which could reduce infiltration rates and be potentially damaging to nearby structures.
- The water quality may be degraded during recharge as additional salts and minerals may be leached during the infiltration.
- Advanced water treatment may be required if the recovered water is used for potable purposes. Alluvial

aquifers are also recharged by agricultural and urban return flows and may be high in salts, minerals and nitrates. Advanced water treatment techniques, such as reverse osmosis, are commonly used to treat alluvial aquifer water for M&I use. The disposal of the waste streams from reverse osmosis treatment can be very expensive.

- The recharged water will eventually return to the river system if not used or recaptured, and so may not be recoverable when needed.
- Additional wells may need to be constructed to meet peak demands.
- Storage may need to be developed to capture peak surface water flows that are used for later recharge.
- A water court approval process, which may be lengthy and expensive, is required.

8.2.5 Municipal and Industrial Reuse

M&I reuse involves a second or consecutive uses of consumable water supplies that have first been used to meet municipal or industrial needs but not fully consumed. The first aspect important to understand in reuse projects is the consumptive and non-consumptive components of water use. Water use is generally divided into CU (i.e., water that is in effect consumed and eliminated from the system) and non-CU (i.e., water returning to the system after use by infiltration into the ground, or water returning to the system as effluent from wastewater treatment plants after use in households). Reuse projects seek to recycle that portion of the water not consumed.

M&I consumable return flows can be reused through several methods. Three general types of reuse projects were included for consideration in the SWSI process: water rights exchanges, non-potable reuse and indirect potable reuse.

8.2.5.1 M&I Reuse by Water Rights Exchanges

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

The non-CU water can be reused multiple times, theoretically to extinction, with the total available water reduced with each application, since each time the water is diverted for reuse, a portion of it is consumed by the use. A schematic illustrating the exchange of consumable return flows is shown in Figure 8-4.

The increases in yield that can be achieved through the successive use and reuse of the return flows to extinction are shown in Figure 8-5. For example, if there are no return flows from the use of 1 AF of consumable water, then there is no additional yield and the total yield is one acre-foot. If 50 percent of the return flows from an M&I use of consumable water were exchanged and the return flows from each successive use used to extinction, the total yield realized from 1 AF of consumable water is 1.6 AF. This is based on an assumed M&I CU of 35 percent and return flows of 65 percent.

Potential benefits of exchanging reusable flows include:

- Improves M&I reliability by providing for additional yields.
- Maximizes water use through successive uses.
- Maximizes beneficial use of water.
- May not require additional diversion structures or other facilities.
- Lesser environmental impacts than a new water supply project.

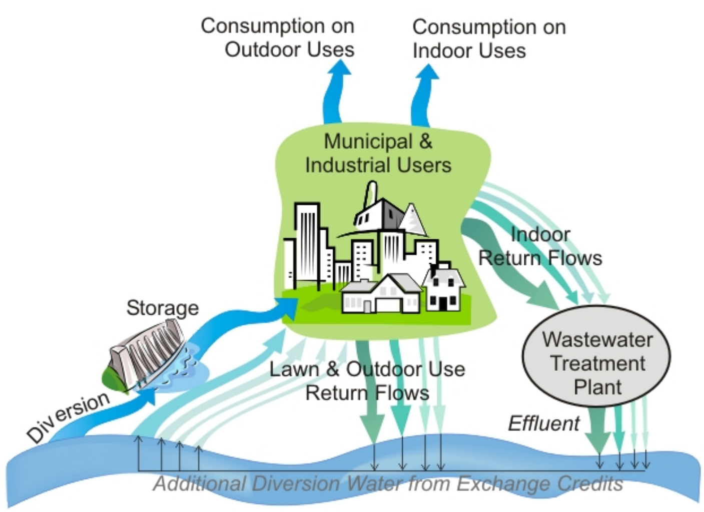


Figure 8-4
M&I Water Rights Exchange

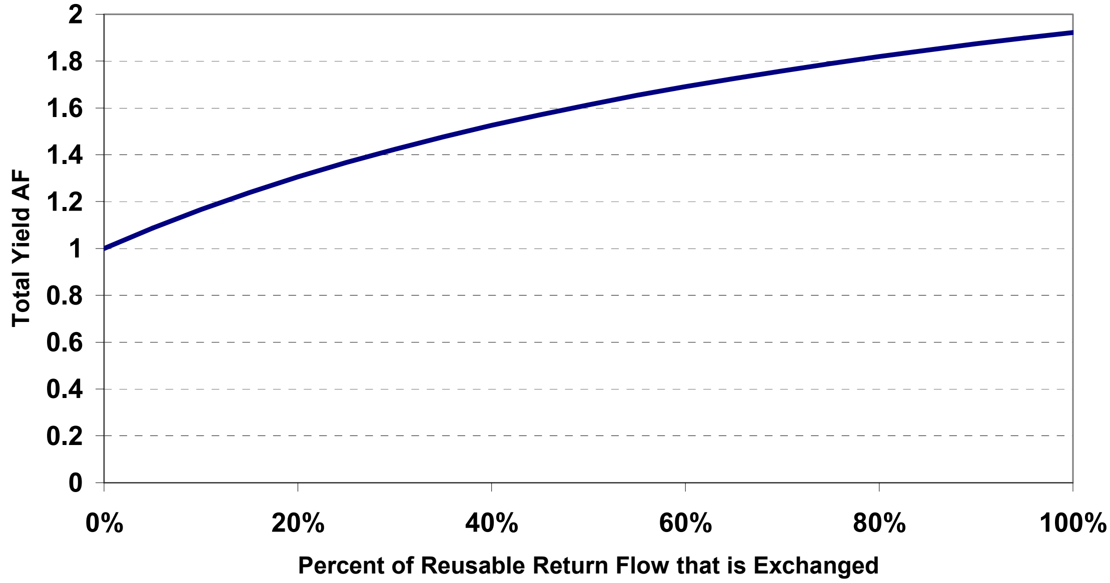


Figure 8-5
Total Yield from Exchange of 1 AF of Consumable Water Based on Reuse to Extinction

Potential issues and conflicts involving reuse by exchange include:

- There must be adequate exchange potential (physical supply) available at the upstream point of diversion.
- The substitute supply (the reusable water that is used to replace the water diverted by exchange) must be suitable for downstream water uses as required by statute.
- There may be water quality objections from downstream users. The substitute supply may be of a different water quality from what the downstream user would have received absent the exchange. A water court procedure allows these issues to be addressed.
- Storage may be needed to regulate year round effluent return flows. The timing of return flows may not match the times when there is exchange potential. For example, winter effluent may need to be stored for exchange to agricultural users during the irrigation season.
- Previously unused reusable effluent historically resulted in reduced or more junior river calls controlling the river.
- As water availability decreases, M&I users are looking to develop or expand the reuse of existing reusable return flows via water rights exchanges. To the extent these reusable flows have been returning to the rivers, they have been used by downstream water users.
- As reusable supplies that have been historically used by downstream users are reused, river calls may become more senior, impacting all users.

8.2.5.2 Non-potable Reuse

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

As noted, it is infeasible to capture return flows from landscape irrigation, though additional yield could be achieved if the landscape irrigation return flow points and amounts are identified and exchanged to upstream points. A schematic illustrating non-potable reuse for landscape irrigation is shown in Figure 8-6.

Figure 8-7 shows how the total yield from 1 AF of consumable water based on the percent of the effluent return flows that are used for landscape irrigation can be increased. For example, if 50 percent of the effluent return flows from an M&I use of consumable water were reused for landscape irrigation the total yield realized from 1 AF of consumable water is 1.25 AF.

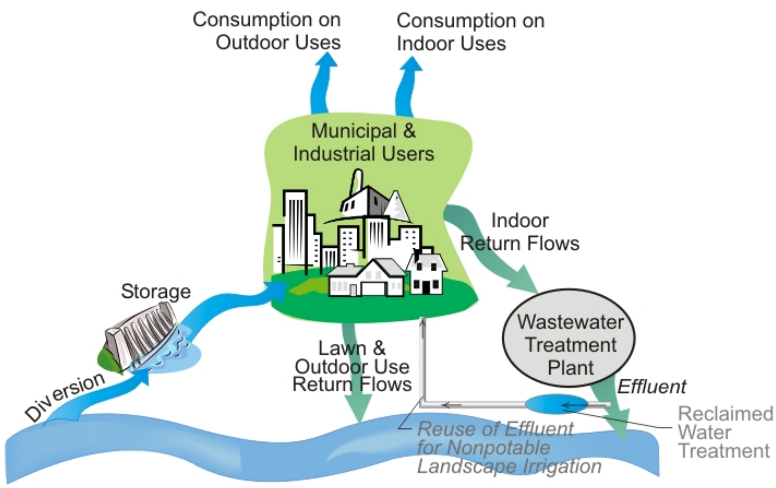


Figure 8-6
Irrigation Reuse

- Does not use higher quality drinking water for irrigation.

Potential issues and concerns include:

- Can be very expensive.
- Must have consumable effluent to reuse or identified return flows.
- Wastewater treatment plant needs to be near irrigation demands.
- Must have storage to regulate year round effluent flows and meet demands during irrigation season.
- As M&I users develop or expand the reuse of existing reusable return flows via water rights exchanges less water may be available to downstream users.
- 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.

Potential benefits of non-potable reuse include:

- 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.

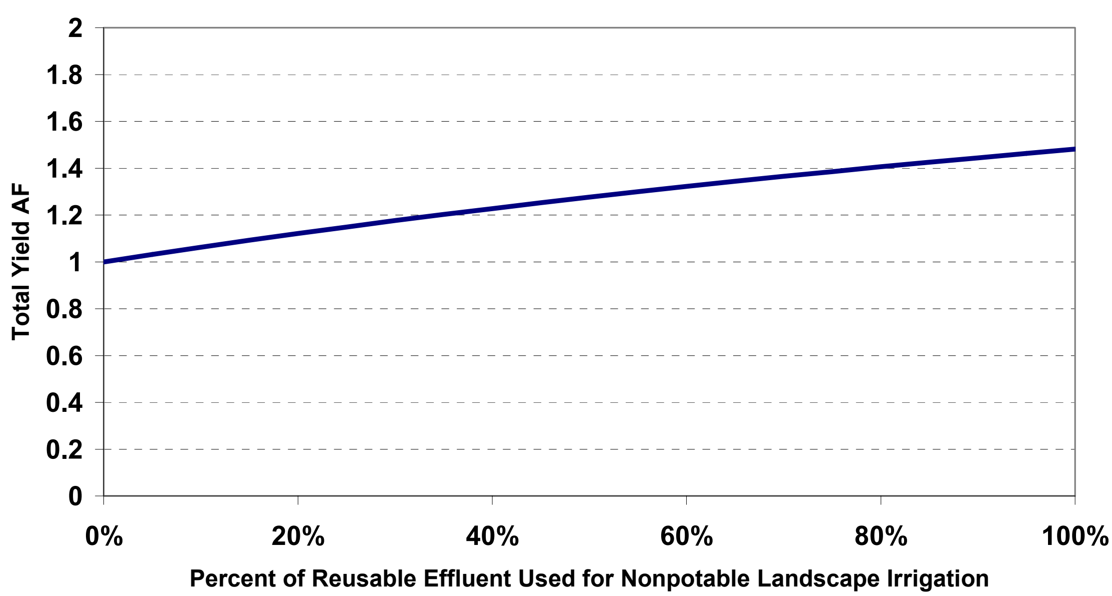


Figure 8-7
Total Yield from Non-potable Reuse of 1 AF of Consumable Water Based on One-time Reuse for Landscape Irrigation

8.2.5.3 Indirect Potable Reuse

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

Potential benefits of indirect reuse include:

- Improves M&I reliability.
- Maximizes use through successive use.
- Maximizes beneficial use of water.
- Lesser environmental impacts than a new water supply project.
- May not require new diversion structures.

The potential issues and conflicts of indirect potable reuse are:

- Can be very expensive. Infrastructure and operations and maintenance costs will be high.
- Must have consumable effluent to reuse.
- Raw water treatment plant and/or pump back station needs to be constructed. Infrastructure is required to divert and store return flows, pump back to raw water supply storage and additional treatment.
- Existing and future regulatory compliance concerns. SDWA regulations have to be met at a minimum. Concerns over disinfection byproducts and pollutants in captured return flows can result in expensive, advanced water treatment processes.
- The disposal of water treatment waste products is becoming increasingly problematic and costly.
- Previously unused reusable effluent historically resulted in reduced or more junior river calls controlling the river.
- As M&I users develop or expand the reuse of existing reusable return flows via water rights exchanges less water may be available to downstream users.
- River calls may become more senior, impacting all users.
- Public acceptance of the reuse of return flows for drinking water must be achieved.

8.2.6 Control of Non-Native Phreatophytes

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

Potential benefits of non-native phreatophyte control are:

- Benefits all users: M&I, Agriculture, Environment, and Recreation in accordance with water right priorities.
- Reduces non-beneficial consumption of water.
- Creates additional supplies without new water storage or other infrastructure.

Potential conflicts or issues associated with non-native phreatophytes are:

- 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.
- It is not clear that the vegetation that replaces the non-native species will use less water.

Section 9
Evaluation Framework

A water supply gap analysis was conducted for each of the eight river basins as described in Chapter 6. This analysis concluded that the planned water supply projects (the "Identified Projects and Processes") that have been formulated by water providers and users across the state, if completely successful, will provide about 80 percent of the projected M&I water needs by 2030. There is also uncertainty associated with these numbers. Significant M&I gaps were identified in the following basins:

- Arkansas Basin
- Dolores/San Juan/San Miguel Basin
- Gunnison Basin
- South Platte Basin

Gaps between water demand or need and available supplies are also anticipated for other types of water use in virtually all basins, and the gaps in each basin could be significantly larger if the Identified Projects and Processes are not successfully and fully implemented.

As such, Section 8 describes families of future water supply options based on: (1) projects and other solutions identified through the Basin Roundtable discussions; (2) projects and other solutions identified from existing reports and studies; and (3) concepts identified by the SWSI team.

To explore the merits of these potential water supply options, an evaluation framework was needed. The purpose of the evaluation framework was to ensure that projects could be analyzed in a consistent, transparent, and understandable manner. SWSI has identified and considered a broad range of options.

Families of options were described in Section 8 and are evaluated in this section. Section 10 describes specific options that could be used in developing portfolios of options. Any remaining gap not addressed by the Identified Projects and Processes could be addressed via these options.

Subsequent SWSI work can build on this information and work toward consensus developing and evaluating combinations or "portfolios" of options that would form basinwide or statewide alternatives for comparison and possible implementation.

This section presents the following:

- An overview of the stakeholder process
- An overview of the method used in evaluating ways to address each basin's future water needs, or evaluation framework
- The specific water management objectives, sub-objectives, and associated performance measures
- The method and results used to gauge individual Basin Roundtable members' preferences – the importance each member placed on each objective and sub-objective
- The evaluation method that was employed to evaluate the families of options and the results

9.1 Stakeholder Process

SWSI was designed to emphasize local input at the basin/local level, reaching out to municipal water providers, agricultural interests, business interests, governmental agencies, environmental interests, recreation interests, and the public at large. These different interests represent the major stakeholders for water use in Colorado. In total, over 40 Basin Roundtable Technical Meetings and Public Information Meetings were held throughout the state to solicit and exchange information and ideas.

The SWSI stakeholder process was made up of three elements (Figure 9-1):

- Colorado Water Conservation Board
- Basin Roundtables
- Public Outreach

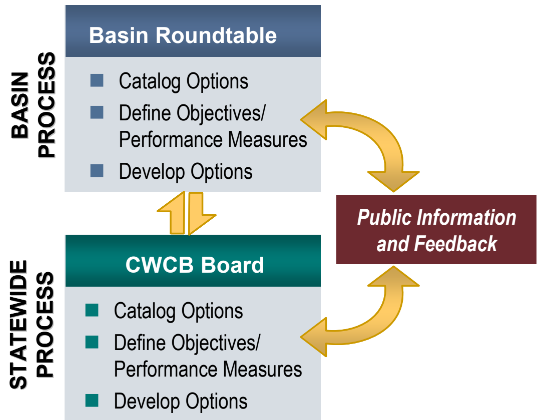


Figure 9-1
SWSI Stakeholder Process

Colorado Water Conservation Board (CWCB) – The CWCB includes representatives from each river basin, as well as key state policy makers. CWCB reviewed information from the Basin Roundtable Technical Meetings and Public Information Meetings, and provided crucial input on the development of planning objectives and strategies for achieving the objectives and implementing solutions.

Basin Roundtables – Basin Roundtable Technical Meetings provided a forum for local interests (municipal water providers, agricultural water districts, local governments, state and federal governments, and environmental and recreational interest groups) to review and present water demand and supply information, help guide the development of water management objectives and performance measures, and exchange ideas on how to meet the water needs of the region. The focus of these Basin Roundtables, which met up to four times in each river basin, was to develop consensus on specific water resources issues. Basin Roundtable members' input was used as the primary means of identifying, developing, and evaluating water management solutions in SWSI.

Public Outreach – The SWSI public outreach program provided a forum specifically for presenting information to the general public, and for obtaining feedback on the process and conclusions. A series of Public Information Meetings was held within each of the river basins near the beginning of SWSI. A second round of Public Information Meetings was held in conjunction with the last round of Basin Roundtable Technical Meetings. In addition, public comments were received at each Basin Roundtable Technical Meeting and at each CWCB Board Meeting.

The members of the Basin Roundtables are shown in Section 1.6, while Appendix B contains the Basin Roundtable meeting schedules, agendas, and meeting summaries. Appendix B also contains the Public Information Meeting schedules and meeting summaries, and contains the SWSI-related CWCB Board meeting presentations.

9.2 Overview of Evaluation Framework

The following terms were used to ensure that stakeholders had a common language during the planning process.

Objectives	The overarching interests in water management – they define major goals of water users in clear, understandable terms
Preferences	Stakeholder values, specifically the weights that they assign to each objective, relative to the other objectives
Performance Measures	Indicators of how well the objectives are being achieved
Options	The individual water supply projects or management strategies that could be implemented to meet the objectives
Family of Options	A grouping of similar types of options, as described in Section 8
Alternatives	Combinations of options that appear to best meet water management objectives, which may be developed in subsequent phases of SWSI

The overall evaluation framework is summarized in Figure 9-2. This framework was conducted for each of the eight basins.

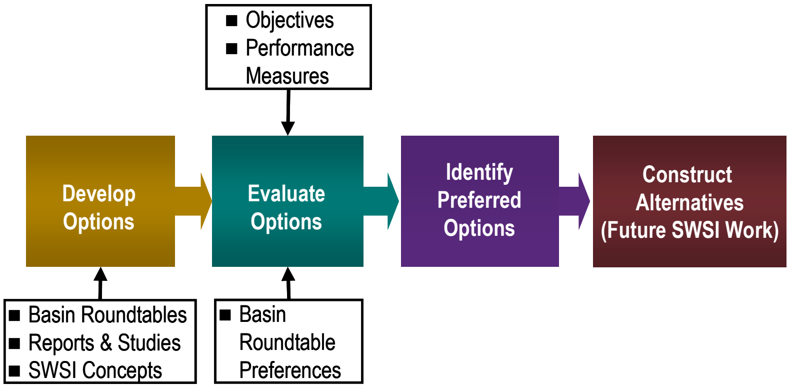


Figure 9-2
Overview of Evaluation Framework

The approach to developing alternatives for each basin in subsequent phases of SWSI could be based on the use of options – individual projects or solutions – as "building blocks" for basinwide alternatives. Alternatives could be developed using options that have the likelihood of being preferred by the stakeholders in each basin, as described more specifically below. This approach consists of the following steps:

- Develop options based on Basin Roundtable Technical Meeting discussions
- Group options into families of options, as described in Section 8
- Evaluate families of options against objectives and sub-objectives using performance measures and Basin Roundtable member preferences
- Identify preferred families of options and use them (with specific options from those families as available/appropriate to the basin) to construct alternatives to meet the demand gaps for each basin in subsequent phases of SWSI

These options were evaluated against a set of performance measures, developed by the SWSI team and confirmed by CWCB and Basin Roundtable members. Stakeholder preferences (weights of importance assigned to each objective) were also factored into the evaluation as described below.

The unique aspect of this approach for SWSI is that the preferences (or objective weights) for each individual Basin Roundtable member are maintained. In other words, this evaluation method was applied to all of the participating stakeholders. This helps allow for discovery of common ground through facilitated discussion, rather than a strictly numeric or "voting" approach (Keeney 1992).

Quantitative scoring provides guidance to decisionmakers, but it is not intended to "make" the decision. Depending on the weights placed on the objectives, the quantitative comparison will differ from person to person and illuminate the tradeoffs associated with each option.

Figure 9-3 illustrates the overall evaluation framework used in SWSI. By deliberately first analyzing the objectives (our goals in water management) separately from the options (specific projects or solutions intended to meet those goals), we are better able to draw out interests over positions, illustrate tradeoffs, and identify creative solutions that might otherwise not come forward. Additional discussion about interest-based dialogue versus position-based debate is provided in Section 9.4.

The "why" portion outlines which aspects of water management are important to someone, as illustrated through the objectives. The "how" portion describes how one addresses a water management need – specific projects or ways in which the objectives could be accomplished.

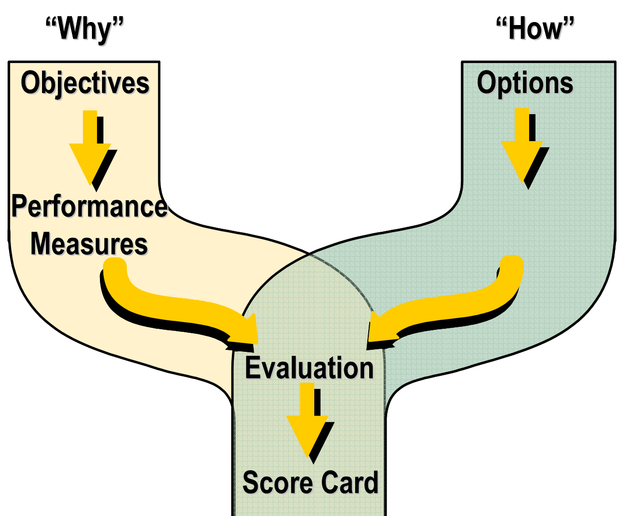


Figure 9-3
Evaluation "Road Map"

9.3 Defining Objectives and Performance Measures

The first step in the evaluation framework was to define the water management objectives for Colorado water users and uses and the associated performance measures. These form the evaluation criteria that options and alternatives can be compared against.

A draft list of water management objectives was developed by the SWSI team. These objectives were modified significantly based on comments provided by the CWCB, the Basin Roundtables, and public input.

The final set of water management objectives is shown in Figure 9-4, not listed in any particular order. Each Basin Roundtable member was asked to provide his or her own relative preference for each objective, as described in Section 9.4.

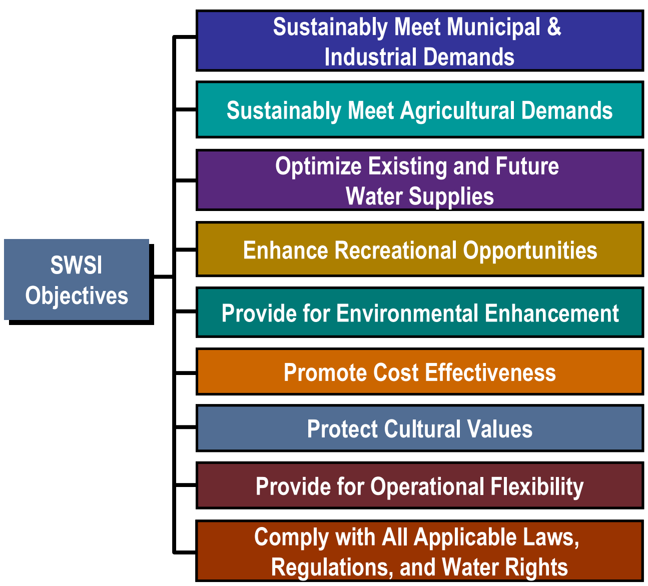


Figure 9-4
SWSI Water Management Objectives

Each of these objectives has one or more sub-objectives that help further define the goal. Once the objectives were defined, performance measures were developed to indicate how well the objective and its sub-objectives were being achieved. These performance measures were used to score and rank the options before alternatives can be built.

Termed "Comply with All Applicable Laws, Regulations, and Water Rights," the ninth water management objective, was developed based on input from the Basin Roundtable Technical meetings. Each option developed under SWSI will comply with applicable laws and regulations, the water rights system, and individual rights. This ninth objective was thus included as a baseline requirement but was not used to compare options. It instead represents a minimum condition or "gate" that all alternatives must pass through to be considered for implementation.

Recognizing that SWSI is a reconnaissance-level process and that feasibility studies would likely be needed before implementation of the options evaluated, two sets of performance measures were developed.

The first set of performance measures was developed to evaluate options for consideration in SWSI. These are qualitative performance assessments that were made based on engineering judgment, using the best available information.

The second set of performance measures could be used as projects move toward implementation, for more detailed feasibility-level planning in which specific options will be evaluated prior to implementation. These performance measures are more quantitative and would rely more heavily on the state's DSS and other more refined data and information.

Table 9-1 summarizes the water management objectives, sub-objectives, and associated performance measures for SWSI.

Table 9-1 SWSI Water Management Objectives and Performance Measures

Objectives/Sub-objectives	Reconnaissance Level Performance Measures Used in SWSI	Future Feasibility Level Performance Measures
1. Sustainably Meet Municipal & Industrial Demands		
■ Meet M&I demands during drought	On a scale of 1 to 5: 1 does not have the ability to reliably provide additional supply during 1950s drought; and 5 has the most ability to reliably provide additional supply during 1950s drought.	Amount of additional supply provided during 1950s drought on a basinwide level as aggregated from County demands; and percent of major water providers that have shortages during 1950s drought.
2. Sustainably Meet Agricultural Demands		
■ Meet agricultural demands when and where needed	On a scale of 1 to 5: 1 does not have the ability to reliably provide additional supply during 1950s drought; and 5 has the most ability to reliably provide additional supply during 1950s drought.	Amount of additional supply provided during 1950s drought on a basinwide level; and amount of identified agriculture shortage reduced by alternative.
3. Optimize Existing and Future Water Supplies		
■ Minimize non-beneficial consumption (e.g., evaporation, phreatophytes)	On scale of 1 to 5: 1 has high evaporation; and 5 has low evaporation.	Qualitative score based on reservoir surface area and phreatophyte control water applied to crops that is not being consumed.
■ Maximize successive uses of non-tributary groundwater and other legally reusable water	On scale of 1 to 5: 1 impacts successive uses of agriculture water; and 5 does not impact successive uses of agriculture.	Amount of additional municipal reuse (acre-ft/year); and Qualitative score that is based on projects that could impact successive uses such as canal lining and higher efficiency irrigation practices.
■ Maximize use of existing and new in-basin supplies	Not used for Reconnaissance Level screening	Percent of existing in-basin water supplies and water rights that are fully used plus the percent of existing trans-basin rights that are fully reused.
4. Enhance Recreational Opportunities		
■ Provide adequate water for recreation when and where needed	On scale of 1 to 5 for river based recreation reaches, the number of months of river based recreation will be the indicator: 1 is lower months of river based recreation; and 5 is higher months of river based recreation.	Qualitative score based on estimate of sustained high flows in commercial rafting reaches.
■ Encourage the cooperative multiple use of water to enhance recreational and wildlife opportunities	Not used for Reconnaissance Level screening	Qualitative score based on guarantee of minimum pool or stream flows during 1950's drought.
5. Provide for Environmental Enhancement		
■ Provide adequate water for environment when and where needed	On scale of 1 to 5 using existing environmental coverages: 1 reduces in-stream flows; 3 maintains current in-stream flows; and 5 increases in-stream flows.	Qualitative score based on measurement of instream flows in current environmental coverages which contain habitat areas consisting of gold metal trout areas and cold/warm water fisheries.
■ Avoid/mitigate environmental impacts of new projects	Not used for Reconnaissance Level screening	Qualitative score that examine flows in relation to allowed depletions for areas within Programmatic Biological Opinions.
■ Protect and improve water quality	On scale of 1 to 5: 1 degrades water quality; 3 maintains water quality; and 5 improves water quality.	A qualitative evaluation of water quality and flow on a basinwide basis.

Table 9-1 SWSI Water Management Objectives and Performance Measures

Objectives/Sub-objectives	Reconnaissance Level Performance Measures Used in SWSI	Future Feasibility Level Performance Measures
6. Promote Cost Effectiveness		
■ Allocate cost to all beneficiaries fairly	Not used for Reconnaissance Level screening	All alternatives will address this in implementation based on allocation of costs.
■ Achieve benefits at lowest cost	On scale of 1 to 5: 1 is highest unit cost; and 5 has lowest unit cost.	Estimate of capital and O&M costs over the life of the project/alternative
■ Provide for funding eligibility	On scale of 1 to 5: 1 has low chance for federal funding; and 5 has high chance for federal funding.	Qualitative score based on if project qualifies for federal funding.
■ Mitigate for third-party economic impacts	Not used for Reconnaissance Level screening	All alternatives will address this in implementation.
7. Protect Cultural Values		
■ Maintain quality of life unique to each basin	For urban areas, on scale of 1 to 5: 1 is a loss of current irrigation and landscape practices, such as bluegrass lawns; and 5 maintains the ability to landscape as desired and water at an affordable price. For rural areas, on a scale of 1 to 5: 1 is a loss of the current economy and related quality of life; and 5 maintains the current economy and quality of life.	Cultural values may be specific to subbasins. Qualitative score will reflect the specific issues unique to each basin.
■ Maintain open space	On a scale of 1 to 5: 1 is a loss of open space; and 5 is no (or minimal) loss of open space.	Estimate of lost open space (in acres).
8. Provide for Operational Flexibility		
■ Provide for short-term transfer of water to different users/uses, while protecting water rights	On scale of 1 to 5: 1 does not produce interruptible supply options; and 5 does produce interruptible supply options.	Amount of water produced by interruptible water supply options such as water banks or short-term leases (acre-feet/yr).
9. Comply with All Applicable Laws, Regulations, and Water Rights		
■ Baseline requirement for all alternatives; not used in comparison of alternatives	Not applicable	Not applicable

9.4 Individual Preferences

Individual Basin Roundtable members' preferences were solicited for each of the river basins in order to determine the region-by-region values and interests. To solicit preferences, each of the participating members of the Basin Roundtables was asked to complete a weighting exercise for the water management objectives. An approach called *Pair-Wise Comparison* was used for this effort.

In Pair-Wise Comparison, a person must indicate their preference between two objectives, compared to each other. For example, which objective is more important to you, Enhance Recreational Opportunities or Protect Cultural Values? Basin Roundtable members were told that although both objectives might be important to them, they must choose which is *more* important. Each possible pair of objectives – 28 combinations in all – was put before each of the Roundtable members. Individual results were maintained, but anonymous to the other Roundtable members. Appendix G shows the weighting form that Basin Roundtable members were asked to fill out.

The Pair-Wise Comparison is not a voting process. Rather, it was used to identify and illustrate the values and preferences different individuals place on goals and objectives for water management in Colorado for use in SWSI. By exploring these different preferences, discovery of common ground or consensus is more likely. This helps move the process from "position-based" debates to "interest-based" dialogue.

A position-based debate is one where stakeholders lay down positions, such as "new reservoirs are absolutely needed" or "water conservation is the only way to solve our water needs." Both of these positions are intractable – often leading to stalemate. Any alternative that has a new reservoir will surely be seen as adversarial to the stakeholder desiring water conservation, for example.

An interest-based dialogue, in contrast to position-based debate, is where stakeholders identify their preferences (or interests) for well understood and accepted objectives. For example, the stakeholder whose *position* was "water conservation is the only way to solve our water needs" may have an *interest* to protect the environment (which is likely shared by many other stakeholders, but in varying degrees). And the stakeholder whose *position* was "new reservoirs are absolutely needed" may have the *interest* in reliably meeting municipal demands during a drought (which is also likely shared by many other stakeholders, but with varying degrees).

Moving from positions to interests, and understanding how stakeholders value these interests, allows solutions to be identified that can achieve multiple interests. This is how consensus and common ground can be discovered. This report illustrates how different families of options can address the state's water needs while meeting multiple objectives (Section 8); subsequent SWSI work can continue this process for the development and assessment of portfolios of options, described in this process as "alternatives." **Over the last 18 months, the SWSI team met with the Basin Roundtables on four occasions. This was a short timeframe to address all the technical data in the basins, and to have Basin Roundtable members achieve consensus. Developing more trust and further exploration of water resource management solutions that meet multiple interests appears to be warranted.**

The results of the individuals' objective preferences (weighting) were plotted for each river basin. What is shown on the following graphs is the weight (expressed as a percentage based on Pair-Wise Comparison results) that Basin Roundtable members gave to each of the objectives shown in Figure 9-4. By design, the maximum weight that any Basin Roundtable member could give an objective is 25 percent. For each individual, the total of the weights for all objectives adds up to 100 percent. The red line indicates the range of weights that the entire group of participants gave to a particular objective. If the red line starts at zero, this means that at least one participant assigned a zero percentage weight to that objective. If the red line goes up to 25, then at least one participant assigned a 25 percentage weight to that objective.

The black diamond on each red line indicates the average weight of all the participants within the river basin for that objective.

Also plotted on the red line are the average weights for three interests, under which the majority of Basin Roundtable members were grouped: (1) municipal water providers – as indicated by blue circles; (2) agricultural/ ranching – as indicated by yellow triangles; and (3) environmental/recreational – as indicated by green squares. Some members did not fall into any of these groups, but are reflected in the overall group averages.

It is important to note that the average weightings for each Basin Roundtable and certain subsets thereof are presented here only to illustrate the overall tenor of each group. However, in no case was the average weight used in evaluating options. Rather, each individual's objective weighting was used to develop and track their individual ranking of options.

9.4.1 Basin Roundtable Members' Individual Preferences

Arkansas Basin

The results for the Arkansas Basin are shown in Figure 9-5.

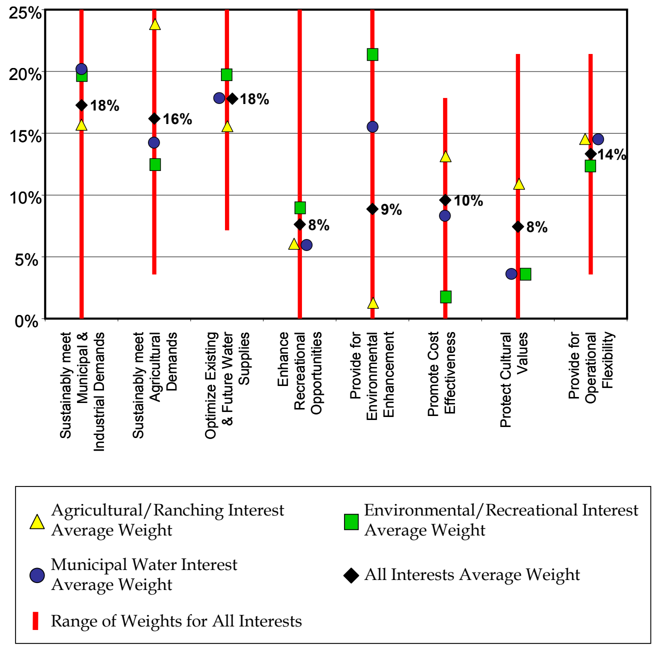


Figure 9-5
Arkansas Basin Objective Weights

The following observations can be made for the Arkansas Basin:

1. For the group as a whole, the highest weighted objectives are: Meet Municipal & Industrial Demands; Optimize Existing & Future Supplies; and Meet Agricultural Demands, which vary between 16 to 18 percent. Objectives Enhance Recreational Opportunities and Protect Cultural Values were weighted lowest, at 8 percent.

2. The agricultural interest average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Agricultural Demands, Promote Cost Effectiveness, and Protect Cultural Values; while they are *lowest* for Provide for Environmental Enhancement; and about *average* for Meet Municipal & Industrial Demands, Optimize Existing & Future Supplies, Enhance Recreational Opportunities, and Provide for Operational Flexibility.

3. Municipal interest average weights are *highest* for objectives such as Meet Municipal & Industrial Demands and Provide for Environmental Enhancement; while they are *lowest* for Protect Cultural Values; and about *average* for Meet Agricultural Demands, Optimize Existing & Future Supplies, Enhance Recreational Opportunities, Promote Cost Effectiveness; and Provide for Operational Flexibility.

4. Environmental and recreational interest average weights (when compared against the overall group averages) are highest for objective Provide for Environmental Enhancement; while they are lowest for Promote Cost Effectiveness and Protect Cultural Values; and about average for Meet Municipal & Industrial Demands, Meet Agricultural Demands, Optimize Existing & Future Supplies, Enhance Recreational Opportunities, and Provide for Operational Flexibility.

Colorado Basin

The results for the Colorado Basin are shown in Figure 9-6.

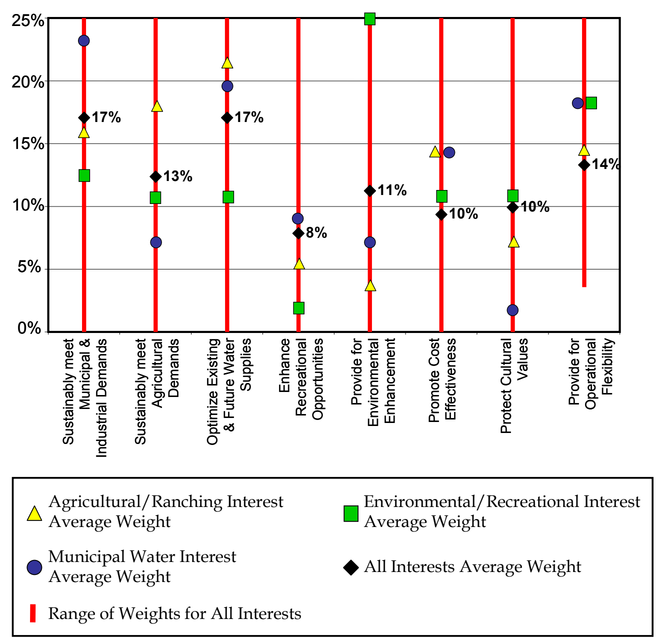


Figure 9-6
Colorado Basin Objective Weights

The following observations can be made for the Colorado Basin:

1. For the group as a whole, the highest weighted objectives are: Meet Municipal & Industrial Demands; Optimize Existing & Future Supplies; and Provide Operational Flexibility, which vary between 14 to 17 percent. The objective Enhance Recreational Opportunities was weighted lowest, at 8 percent.

2. The agricultural interest average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Agricultural Demands, Optimize Existing & Future Supplies, and Promote Cost Effectiveness; while they are *lowest* for Provide for Environmental Enhancement; and about *average* for Meet Municipal & Industrial Demands, Enhance Recreational Opportunities, Protect Cultural Values, and Provide for Operational Flexibility.

3. The municipal interest group average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Municipal & Industrial Demands, Optimize Existing Supplies, Promote Cost Effectiveness, and Provide for Operational Flexibility; while they are *lowest* for Meet Agricultural Demands, Provide for Environmental Enhancement, and Provide for Cultural Values; and they are about *average* for Enhance Recreational Opportunities.

4. Environmental and recreational interest average weights (when compared against the overall group averages) are *highest* for objectives such as Provide for Environmental Enhancement and Provide for Operational Flexibility; while they are *lowest* for Meet Municipal & Industrial Demands, Optimize Existing & Future Supplies, and Enhance Recreational Opportunities; and about *average* for Meet Agricultural Demands, Promote Cost Effectiveness, and Protect Cultural Values.

Dolores/San Juan/ San Miguel Basin

The results for the Dolores/San Juan/San Miguel Basin are shown in Figure 9-7.

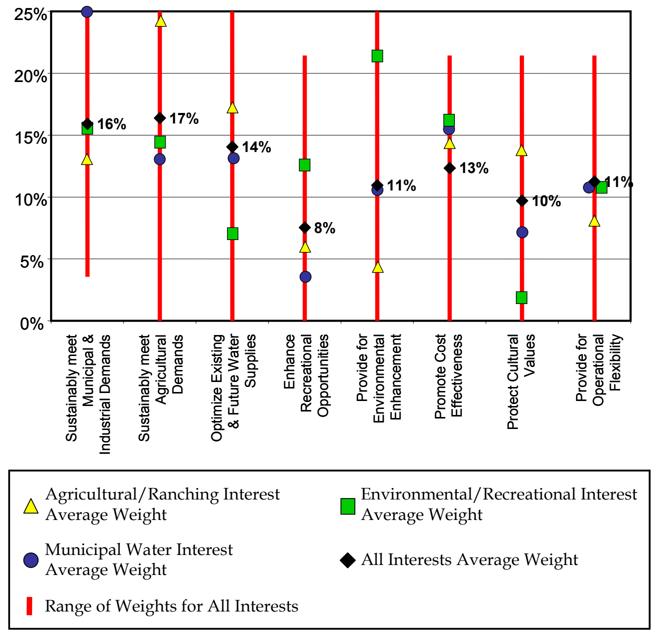


Figure 9-7
Dolores/San Juan/ San Miguel Basin Objective Weights

The following observations can be made for the Dolores/San Juan/San Miguel Basin:

1. For the group as a whole, the highest weighted objectives are Meet Agricultural Demands, Meet Municipal & Industrial Demands, and Optimize Existing Water Supplies, which vary between 14 and 17 percent. The lowest weighted objective is Enhance Recreational Opportunities at 8 percent.

2. The agricultural interest average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Agricultural Demands, Optimize for Existing & Future Supplies, and Protect Cultural Values; while they are *lowest* for Meet Municipal & Industrial Demands, Provide for Environmental Enhancement, and Provide for Operational Flexibility; and about *average* for Enhance Recreational Opportunities and Promote Cost Effectiveness.

3. The municipal interest group average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Municipal & Industrial Demands and Promote Cost Effectiveness; while they are *lowest* for Meet Agricultural Demands, Enhance Recreational Opportunities and Protect Cultural Values; and they are about *average* for Optimize Existing & Future Supplies, Provide for Environmental Enhancement, and Provide for Operational Flexibility.

4. Environmental and recreational interest average weights (when compared against the overall group averages) are *highest* for objectives such as Enhance Recreational Opportunities, Provide for Environmental Enhancement, and Promote Cost Effectiveness; while they are *lowest* for Optimize Existing & Future Supplies and Protect Cultural Values; and they are about *average* for Meet Agricultural Demands and Provide for Operational Flexibility.

Gunnison Basin

The results for the Gunnison Basin are shown in Figure 9-8.

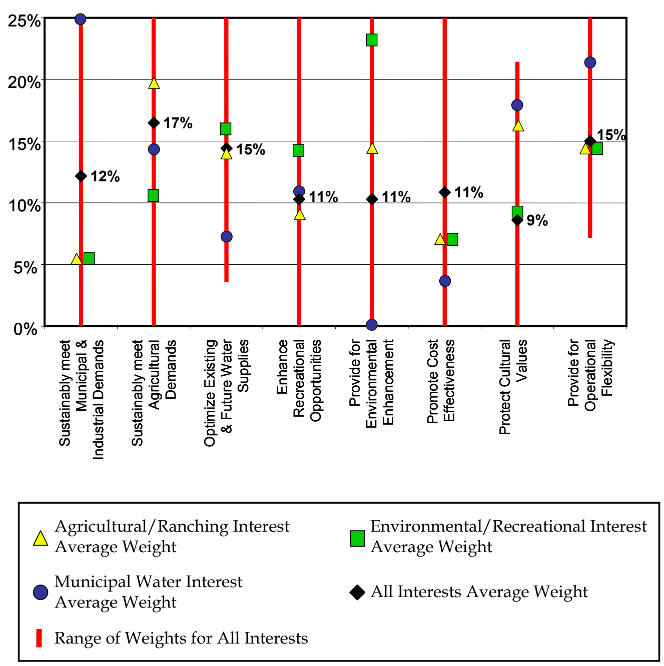


Figure 9-8
Gunnison Basin Objective Weights

The following observations can be made for the Gunnison Basin:

1. For the group as a whole, the highest weighted objectives are Meet Agricultural Demands, Optimize Existing Water Supplies, and Provide Operational Flexibility, which vary between 15 and 17 percent. The lowest weighted objective is Protect Cultural Values at 9 percent.

2. The agricultural interest average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Agricultural Demands, Provide for Environmental Enhancement, and Protect Cultural Values; while they are *lowest* for Meet Municipal & Industrial Demands and Promote Cost Effectiveness; and about *average* for Optimize Existing & Future Supplies, Enhance Recreational Opportunities, and Provide for Operational Flexibility.

3. The municipal interest group average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Municipal & Industrial Demands, Protect Cultural Values, and Provide for Operational Flexibility; while they are *lowest* for Optimize Existing & Future Water Supplies, Provide for Environmental Enhancement, and Promote Cost Effectiveness; and they are about *average* for Meet Agricultural Demands and Enhance Recreational Opportunities.

4. Environmental and recreational interest average weights (when compared against the overall group averages) are *highest* for objectives such as Enhance Recreational Opportunities and Provide for Environmental Enhancement; while they are *lowest* for Meet Municipal & Industrial Demands, Meet Agricultural Demands and Promote Cost Effectiveness; and about *average* for Optimize Existing & Future Supplies, Protect Cultural Values, and Provide for Operational Flexibility.

North Platte and Rio Grande Basins

The results for the North Platte and Rio Grande Basins are shown in Figures 9-9 and 9-10, respectively.

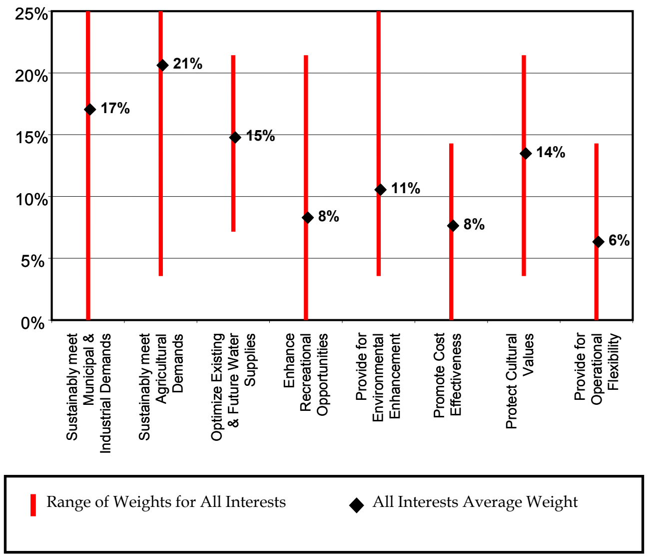


Figure 9-9
North Platte River Basin Objective Weights

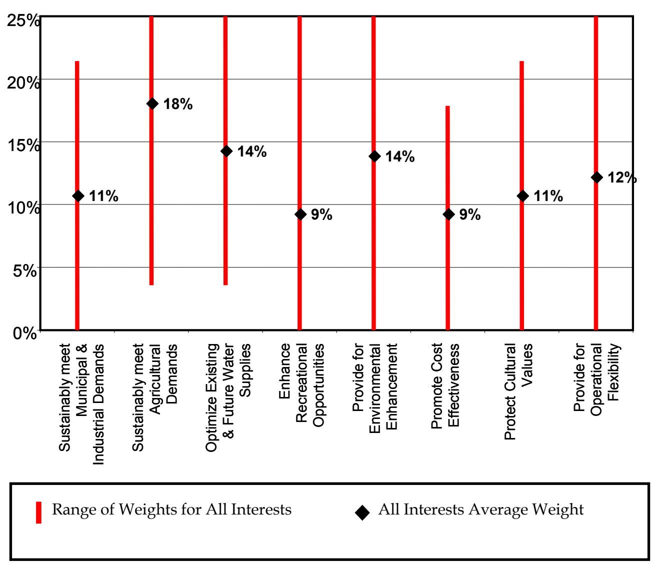


Figure 9-10
Rio Grande Basin Objective Weights

For these two basins, there were not enough participants to group them in the different interests. Therefore, the results are presented for the overall group.

The following observations can be made for the North Platte and Rio Grande Basins:

1. For the group as a whole for the North Platte basin, the highest weighted objectives are Meet Agricultural Demands, Meet Municipal & Industrial Demands, and Optimize Existing Water Supplies, which vary between 15 and 21 percent. The lowest weighted objective is Provide for Operational Flexibility at 6 percent.

2. For the group as a whole for the Rio Grande basin, the highest weighted objectives are Meet Agricultural Demands, Optimize Existing Water Supplies, and Provide for Operational Flexibility, which vary between 12 and 18 percent. The lowest weighted objectives are Enhance Recreational Opportunities and Promote Cost Effectiveness both at 8 percent.

South Platte Basin

The results for the South Platte Basin are shown in Figure 9-11.

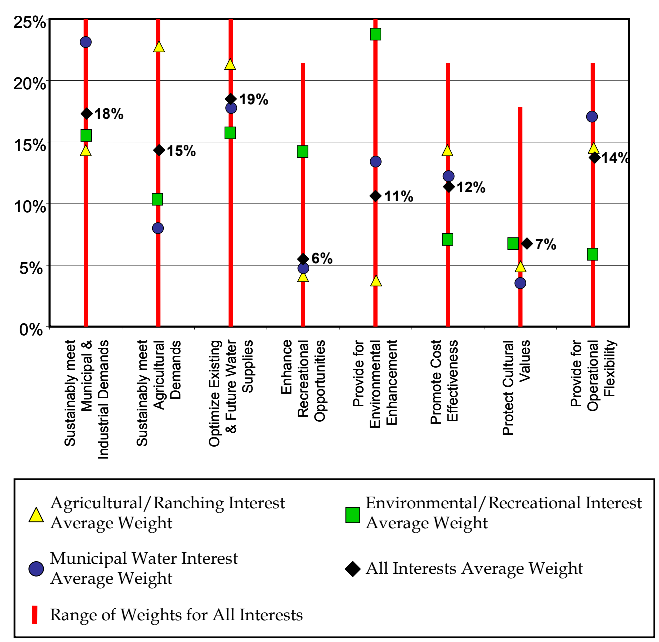


Figure 9-11
South Platte Basin Objective Weights

The following observations can be made for the South Platte Basin:

1. For the group as a whole, the highest weighted objectives are Meet Municipal & Industrial Demands, Optimize Existing Water Supplies, and Meet Agricultural Demands, which vary between 15 and 19 percent. The lowest weighted objectives are Enhance Recreational Opportunities at 6 percent and Protect Cultural Values at 7 percent.

2. The agricultural interest average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Agricultural Demands, Optimize Existing & Future Supplies, and Promote Cost Effectiveness; while they are *lowest* for Provide for Environmental Enhancement; and about *average* for Meet Municipal & Industrial Demands, Enhance Recreational Opportunities, Protect Cultural Values, and Provide for Operational Flexibility.

3. The municipal interest group average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Municipal & Industrial Demands and Provide for Operational Flexibility; while they are *lowest* for Meet Agricultural Demands and Provide for Cultural Values; and they are about *average* for Optimize Existing & Future Supplies, Enhance Recreational Opportunities, and Promote Cost Effectiveness.

4. Environmental and recreational interest average weights (when compared against the overall group averages) are *highest* for objectives such as Enhance Recreational Opportunities and Provide for Environmental Enhancement; while they are *lowest* for Meet Agricultural Demands, Promote Cost Effectiveness, and Provide for Operational Flexibility; and about *average* for Meet Municipal & Industrial Demands, Optimize Existing & Future Supplies, and Protect Cultural Values.

Yampa/White/Green Basin

The results for the Yampa/White/Green Basin are shown in Figure 9-12.

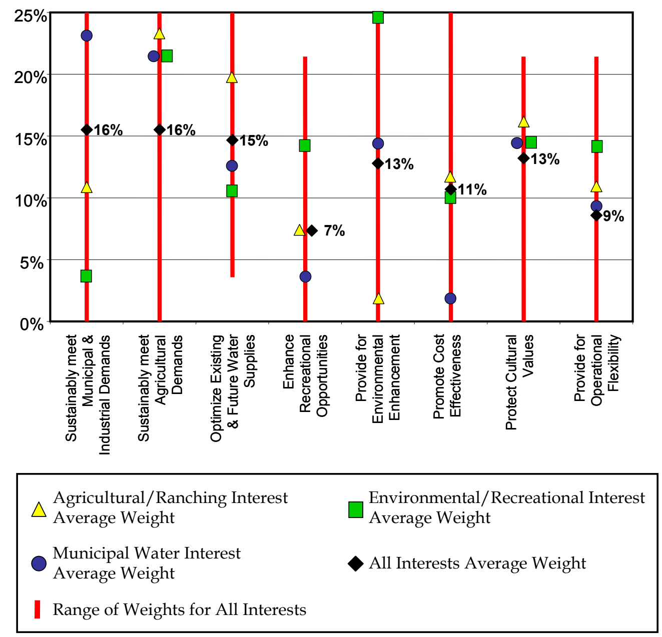


Figure 9-12
Yampa/White/Green Basin Objective Weights

The following observations can be made for the Yampa/White/Green Basin:

1. For the group as a whole, the highest weighted objectives are Meet Municipal & Industrial Demands, Meet Agricultural Demands, and Optimize Existing Water Supplies, which vary between 15 and 16 percent. The lowest weighted objective is Enhance Recreational Opportunities at 7 percent.

2. The agricultural interest average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Agricultural Demands and Optimize for Existing & Future Supplies; while they are *lowest* for Meet Municipal & Industrial Demands and Provide for Environmental Enhancement; and about *average* for Enhance Recreational Opportunities, Promote Cost Effectiveness, Protect Cultural Values, and Provide for Operational Flexibility.

3. The municipal interest group average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Municipal & Industrial Demands and Meet Agricultural Demands; while they are *lowest* for Enhance Recreational Opportunities and Promote Cost Effectiveness; and they are about *average* for Optimize Existing & Future Supplies, Provide for Environmental Enhancement, Protect Cultural Values, and Provide for Operational Flexibility.

4. Environmental and recreational interest average weights (when compared against the overall group averages) are *highest* for objectives such as Meet Agricultural Demands, Enhance Recreational Opportunities, Provide for Environmental Enhancement, and Provide for Operational Flexibility; while they are *lowest* for Meet Municipal & Industrial Demands and Optimize Existing & Future Supplies; and about *average* for Promote Cost Effectiveness and Protect Cultural Values.

9.4.2 Summary of Objective Weighting

Several overall observations can be made from the basin-by-basin assessment of stakeholder preferences for the SWSI objectives. These observations are summarized as follows:

- **Sustainably Meet 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.

9.4.3 Sub-objective Weighting

In addition to the Pair-Wise Comparison of major objectives, Basin Roundtable members were also asked to provide their individual preferences – the relative weights – of sub-objectives within each major objective. As indicated in Table 9-1, performance measures for each objective were generally aligned with that objective's sub-objectives.

For each major objective, Basin Roundtable members were asked to distribute 100 points among that objective's sub-objectives to indicate the relative importance that individual placed on the sub-objectives. For objectives with only one sub-objective, the sub-objective was automatically given all 100 points.

As an example, one Basin Roundtable member may have given the "Protect Cultural Values" objective a relative weight of 20 percent through the Pair-Wise Comparison process. That individual was then asked to distribute 100 points between the "maintain quality of life unique to each basin" and the "maintain open space" sub-objectives. The 100 points could be distributed in any way, e.g., 0 for one of the two objectives, 50 for each, 35 and 65, etc., such that the total for the sub-objectives within that objective added up to 100. For the "Provide the Operational Flexibility" major objective, the Basin Roundtable may have given it a 5 percent major objective weighting through the Pair-Wise Comparison method but would have automatically given its single sub-objective, "Provide for short-term transfer of water to different users/uses while protecting water rights" the full 100 point sub-objective weighting since there were no other sub-objectives.

The sub-objective weighting for each individual in each Basin Roundtable was then used, in combination with the associated performance measures indicated in Table 9-1, to assess the performance of each family of options for that person's preferences, as outlined in Section 8.

9.5 Evaluation of Options

The approach to developing alternatives for each basin in future phases of SWSI can be based on the use of options – individual projects or solutions – as "building blocks" for alternatives. Alternatives can be developed using options that have the likelihood of being preferred by the stakeholders in each basin, as described more specifically below. The approach consists of the following steps:

- Develop options based on Basin Roundtable Technical Meeting discussions and feedback
- Evaluate options and combine option evaluation with stakeholder preferences
- Identify preferred options and use them to construct alternatives to meet the demand gaps for each basin in subsequent phases of SWSI

9.5.1 Develop Options

Using the lists of options developed by each Basin Roundtable, a family of options was developed. The categorization of each option into one of the family of options is appropriate since all of the potential projects discussed by the Basin Roundtables can be categorized into a few types of projects. These types of projects could potentially be implemented in every basin, even if their likelihood of accomplishing the planning objectives may vary.

The family of options (from Section 8) evaluated for each basin were:

- Conservation
  - Current Conservation
  - Moderate Conservation
  - Aggressive Conservation
  - Moderate Conservation with Storage for Reliability
  - Aggressive Conservation with Storage for Reliability
  - Agriculture Conservation
- Agricultural Transfer
  - Interruptible Agricultural Transfer
  - Rotating Agricultural Transfer with Firm Yield for Agriculture
  - Permanent Agricultural Transfer with Reservoir
- Reservoir
  - New Reservoir with New Water Rights
  - New Reservoir Firming Existing Water Rights
  - Reservoir Enlargement
- Non-Tributary Groundwater
- Municipal and Industrial (M&I) Reuse
  - M&I Reuse for Irrigation
  - M&I Reuse by Exchange
- Control of Non-Native Phreatophytes

9.5.2 Evaluate Options and Combine Option Evaluation with Stakeholder Preferences

Figure 9-13 illustrates how the options were evaluated using a multi-criteria score card approach. This approach is widely used by industry and government to rank projects based on multiple, and often conflicting, criteria.

The options that best satisfied the objectives – i.e., those scoring the highest – can be combined to form complete alternatives that would eliminate the water supply gap within each of the basins. This process may be employed in subsequent phases of SWSI.

9.5.3 Identify Likely Preferred Options to be Used to Construct Alternatives

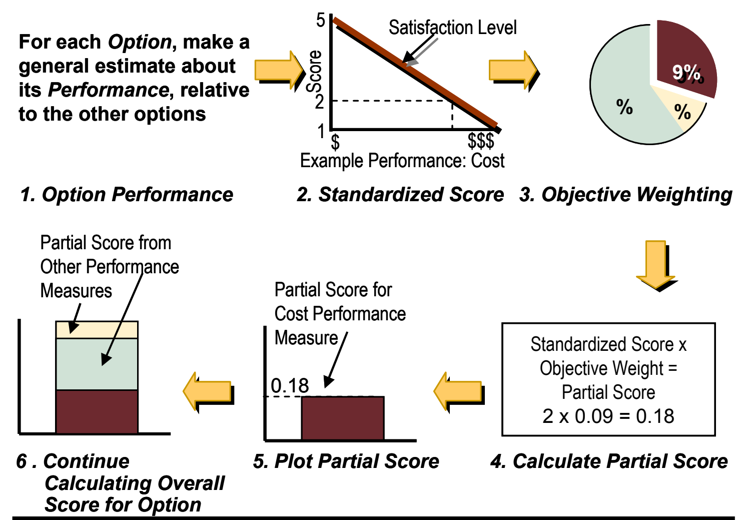
After ranking the family of options for each stakeholder based on raw scores and individual preferences, the results were compared among stakeholders in the basin. The number of times an option was within the top six options for any stakeholder in the basin was compiled and the options that were consistently highly ranked by the stakeholders in each basin are identified with an "x" in Table 9-2.

Due to the multi-objective nature of the process, tradeoffs exist and difficult choices may need to be made. The SWSI process identified general options that seem to best meet the sometimes-conflicting water management objectives. "Diverse" options, or options that address more than one objective and offer benefits in more than one aspect and to more than one user, will have a greater likelihood of being supported and implemented, based on the preferences showed in each basin.

Examples of those multi-objective options are presented in Table 9-3.

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

The options that have the ability to address stakeholders' preferences, as identified through the process described above, could be used to craft alternatives to meet the projected demand gaps for each basin. More specific options for each basin that could be employed in this process are described in Section 10, some of which are multi-objective and some of which are not.



Step 1 of the score card approach is to estimate how each option performs against the objectives. Since SWSI is a reconnaissance-level process, performance was assessed qualitatively based on engineering judgment, using the best available information.
Step 2 of the approach uses the performance measures to convert the qualitative performance for the given option into a score between 1 and 5; where 1 represents poor performance and 5 represents superior performance. In the case of the example shown here, this particular option was fairly expensive in terms of cost, and therefore scores a 2 (relatively poor).
Step 3 of the approach determines the weight that a particular stakeholder places on the sub-objective being evaluated – in this example, cost. This stakeholder gives the cost sub-objective a weight of 9 percent, relative to all other sub-objectives. The weighting approach used was described in Section 9.4.
Step 4 of the approach applies the weight for the sub-objective to the performance score for the option in order to get a partial score. In this example, the partial score is 2 multiplied by 0.09, which yields 0.18.
Step 5 of the approach plots the partial score for the option and sub-objective.
Step 6 of the approach repeats this method for all of the other sub-objectives in order to get a total score for the option. Options were then ranked from highest to lowest in terms of their overall score for each individual Basin Roundtable member.

Figure 9-13
Multi-Criteria Score Card Approach for Ranking Options

Table 9-2 Top-Ranked Options by Basin

Options	Arkansas	Colorado	Gunnison	North Platte	Rio Grande	San Juan/Dolores/San Miguel	South Platte	Yampa/White/Green
Current Conservation								
Moderate Conservation	x		x			x	x	
Aggressive Conservation								
Moderate Conservation w/ storage for reliability	x	x					x	
Aggressive Conservation w/ storage for reliability								
Agricultural Conservation	x		x	x	x	x	x	x
Interruptible Agricultural Transfer	x	x						
Rotating Agricultural Transfer w/ Firm Yield for Agriculture	x	x	x	x	x	x	x	x
Permanent Agricultural Transfer w/ Reservoir								
New Reservoir with New Water Rights								
New Reservoir Firming Existing Water Rights	x	x	x	x	x	x	x	x
Reservoir Enlargement	x	x	x	x	x	x	x	x
Non-Tributary Groundwater								
M&I Reuse for Irrigation	x	x		x	x			x
M&I Reuse by Exchange								
Control of Non-Native Phreatophytes			x	x	x	x		x

"x" indicates that option ranked among the highest-rated options for that basin; basins with ties in the top six options have more than six x marks.

Table 9-3 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 Agricultural 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

Section 10
Basin-Specific Options

Section 6 of this report presented the future water supply options that water providers are pursuing to meet their needs. SWSI has termed these options "Identified Projects and Processes" and it is estimated, under a best case scenario, that approximately 80 percent of Colorado's future needs can be met by implementation of these options. However, that leaves a remaining gap of 20 percent (118,200 AF). In addition, if some portion of the Identified Projects and Processes are not successfully implemented, it may be prudent to have some conceptual solutions that could be pursued. The types of options available were described in Section 8.

This section outlines some of the basin-specific options, which when combined are termed Alternatives, that could help address unmet future water supply needs.

10.1 Overview of Basin-Specific Issues

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

10.1.1 Conditional Storage Rights

Consistent with SWSI's objective of identifying various water management possibilities, the concepts of enhancing water supplies throughout Colorado by perfecting conditional storage rights and rehabilitating existing reservoirs were explored. As was described in Section 4.1.1, a conditional water right is not an absolute water right, and therefore has not been put to beneficial use. A conditional storage right must have two elements in order to exist. First, there must be an intent, and secondly, an act. An intent is a plan that includes diligently proceeding with actions until eventually the full beneficial use of the water is realized. An act could be as simple as staking the location of the structure. Cities are given more flexibility in this process, having only to show expected requirements based on validated growth projections. However, because some conditional storage rights holders have priority dates senior to existing absolute junior rights, if they fully exercise their rights, junior water rights holders would be affected. Conditional storage rights can therefore play an important role in the development of the state's water resources if they were to be fully implemented. Conditional storage rights are discussed in more detail under each basin.

10.1.2 Restricted Reservoirs and Potential New Storage Sites

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

The following sections will describe in further detail the restricted reservoirs for each basin.

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

There has been some confusion regarding the CWCB damsite inventory. It is emphasized that the locations and sites are very conceptual and may prove infeasible due to a number of factors including unsuitable geology, lack of available water, infeasible filling or conveyance canals, property ownership issues, location of storage not conducive to delivering to demand location, not cost effective, etc. In other words, any data from the inventory should be viewed cautiously. During the Basin Roundtable Technical Meetings, very little feedback was provided, and no positive endorsements of any site were obtained.

Nevertheless, the potential damsites can be used in conjunction with demand projections, the location of the demand, water availability, and conditional water rights to explore future water supply opportunities.

It should also be noted that many conditional decrees are seeking to develop the same water source or damsite. This competition far exceeds available supplies.

10.1.3 Arkansas Basin

10.1.3.1 Arkansas Basin Gap Analysis Issues

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

- Most of the major surface water providers believe they will be able to meet 2030 needs through existing supplies, projects underway, and future plans and projects.
- Growth in the Upper Arkansas headwaters region will present challenges in obtaining and storing augmentation water for M&I well pumping.
- Reuse is being pursued by most providers that have reusable supplies through implementation of the following:
  - Water rights exchanges.
  - Non-potable use for irrigation of parks and golf courses.
  - Groundwater recharge.
  - Gravel lake storage for storing reusable return flows for later use for exchange or non-potable irrigation.
- Water conservation is a part of most water providers' plans to meet future water supply needs.
- Most providers do not foresee or propose to implement extreme (Level 5) conservation due to concerns over:
  - Water demand hardening and the related impact on reliability of supply during droughts (explained in Section 8).
  - Quality of life impacts as a result of financial impacts and/or reduced landscaping.
  - Customer acceptance of very high water rates or the inability to landscape as they desire.
  - Lawn watering is a source of water supply and can be used during periods of drought by restricting water use.
- Most providers indicated they would acquire additional agricultural rights to meet future demands rather than implement extreme levels of conservation that would have adverse impacts on their customers.
- Concern over potable water quality and the challenges with providing acceptable quality are key concerns in the basin downstream of Pueblo Reservoir.

Agricultural issues noted throughout SWSI in the Arkansas Basin include:

- There are concerns over agricultural transfers and its impact on rural economies in the basin downstream of Pueblo Reservoir.
- Agricultural water shortages are common and widely distributed throughout the basin but lack of water availability or financial constraints impede throughout additional water development.
- There is a desire to ensure that water right holders retain their ability to sell or transfer their water to the best markets. This issue is controversial in the Arkansas Basin. The challenge is to find options that can protect the social, cultural, and economic integrity of rural and agricultural communities while at the same time protecting the property rights of water rights holders and allowing them to seek water markets that provide the best compensation should they choose to market their water rights/personal property right.

- Water quality concerns in the lower basin also impact agricultural uses.

10.1.3.2 Arkansas Basin Supply Availability Issues

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

- The Arkansas River Compact and existing uses and water rights result in little to no opportunities to develop new, reliable water supplies (see Sections 4 and 7).
- RICDs and CWCB instream flow water rights may impact the ability to manage water supplies upstream of these water rights.
- There will be full utilization of existing rights and transbasin diversions (imports and exports) to meet 2030 demands and these are included in the identified projects and processes.
- Coordinated reservoir operations can assist in providing for recreational and environmental needs through flow management strategies as is currently done between Turquoise, Twin Lakes, and Pueblo Reservoirs.

10.1.3.3 Arkansas Basin Summary of Conditional Storage Rights

To portray the conditional storage rights present in the Arkansas Basin, the area was described using water districts as shown in Figure 10-1.

The 14 water districts in the Arkansas Basin can also be described using the main stream systems, which are shown in Table 10-1.

Table 10-1 Arkansas Basin Water Districts and Associated Stream Names

Water District	Stream Name
10	Fountain/Chico Creeks
11	Arkansas River above Salida
12	Arkansas River between Salida and Cañon City
13	Grape Creek
14	Huerfano River/Chico Creek
15	Saint Charles River
16	Cucharas River
17	Horse Creek/Apishapa River/Purgatoire River
18	Apishapa River
19	Purgatoire River
66	Sand Arroyo/West Fork Carrizo Creek
67	Two Butte/Big Sandy Creeks
79	Huerfano River
103	Arkansas River

Various water districts in the Arkansas Basin contain conditional storage rights that date back to the early 1900s and extend to present day. As shown in Table 10-2, there is 914,000 AF of existing conditional storage rights in the basin, which far exceeds available supplies. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation. The number, rather than volume, of conditional rights is presented in Appendix H.

Water Districts 11 and 14 in the Arkansas Basin have the largest volume of conditional storage rights. This is depicted in Table 10-2 and also presented graphically in Appendix H. A total of nearly 730,000 AF, both with priority dates of between 1940 and 1960, are present in these two water districts. Figure 10-2 focuses on the priority date of the conditional storage rights. The largest portion of storage rights have priority dates of between 1940 and 1960, followed by the 1960 to 1980 time period.

A map of the locations of the conditional storage rights in the Arkansas Basin is shown in Figure 10-3. Different colored circles are used to represent the total volume of conditional rights that each location holds. Most of the rights are held in the western portion of the basin. This figure also shows the locations of potential damsites in the Arkansas Basin, as discussed in Section 10.1.3.4 below.

As described in Section 7, as a result of compact limitations, over-appropriation, and lack of water availability, it is unlikely that significant amounts of conditional rights can be developed in the Arkansas Basin as a primary source of water supply. These conditional rights, however, can store water during very wet periods if cost-effective storage can be developed.

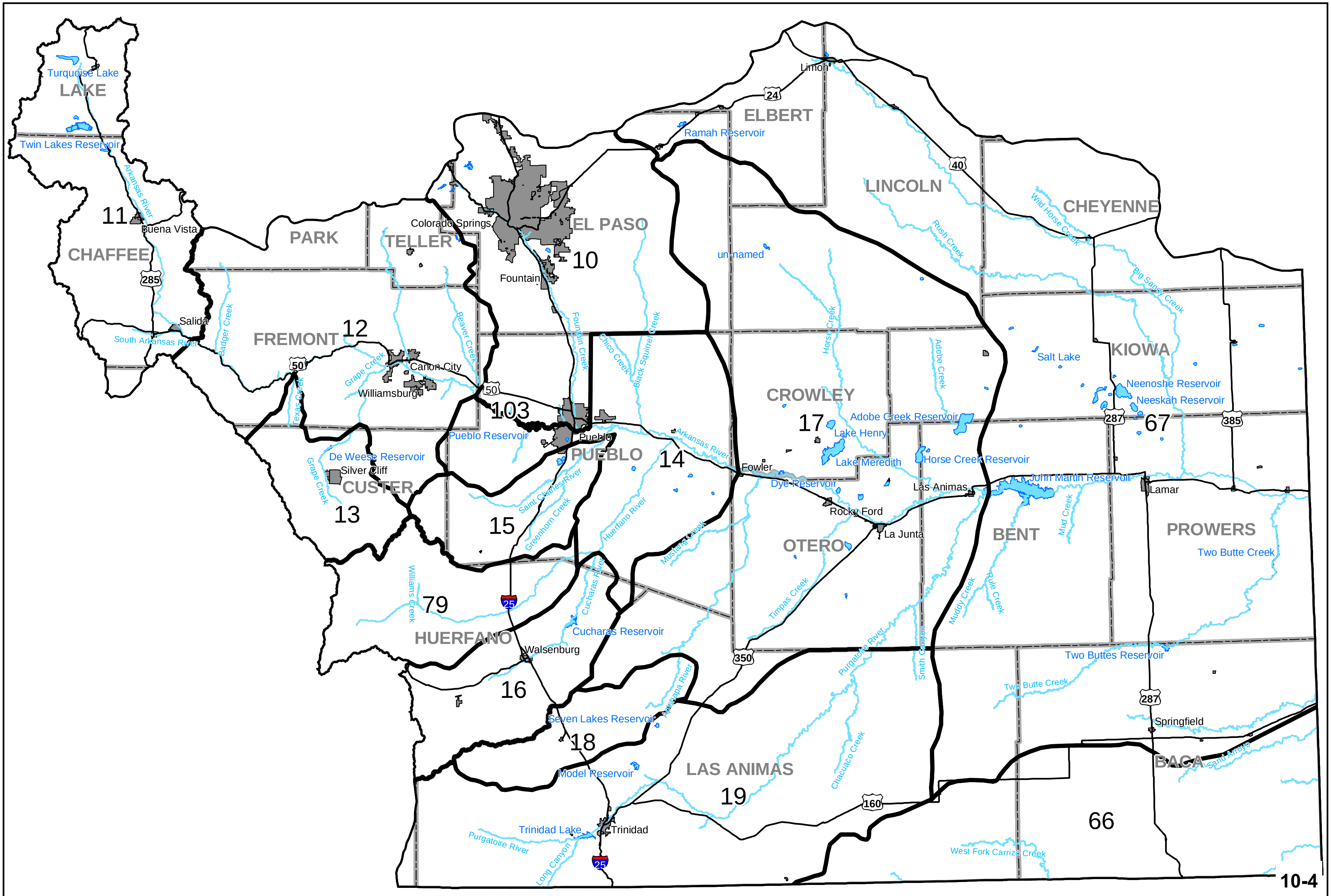


Figure 10-1
Arkansas Basin
Water Districts

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Water District

10 5 0 10 Miles
1:1,500,000

N
Coordinate System
NAD 1927 UTM Zone 13N

Table 10-2 Volume of Conditional Storage Rights by Priority (AF) in the Arkansas Basin

Water District	Stream Name	1900-1920	1920-1940	1940-1960	1960-1980	1980-2002	Total
10	Fountain/Chico Creeks	76	0	0	1,418	3,576	5,070
11	Arkansas River	0	0	297,523	7,678	1,332	306,533
12	Arkansas River	0	0	0	1,621	2,304	3,925
13	Grape Creek	j0	0	0	15	9	24
14	Huerfano River/Chico Creek	8,241	0	432,149	0	871	441,261
15	Saint Charles River	0	0	0	3	26,700	26,703
16	Cucharas River	35,404	0	0	7,848	180	43,432
17	Horse Creek/Apishapa River/ Purgatoire River	2,268	0	0	0	20,005	22,273
19	Purgatoire River	0	1,532	0	63,423	0	64,955
79	Huerfano River	0	0	0	0	6	6
Total		**45,989**	**1,532**	**729,672**	**82,006**	**54,983**	**914,182**

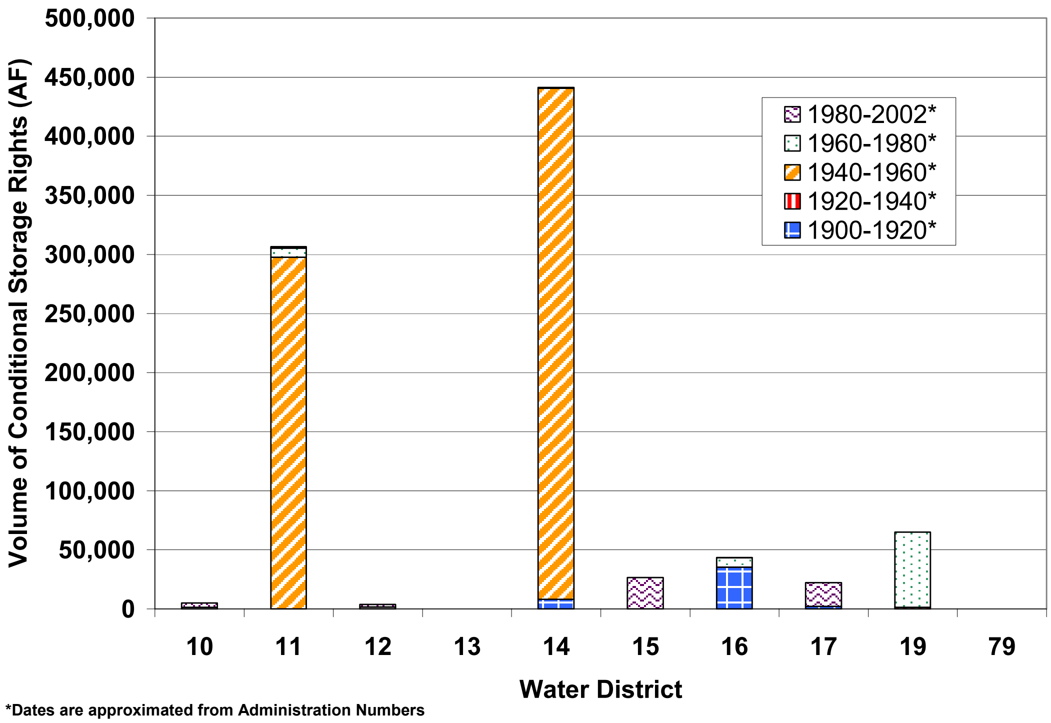


Figure 10-2
Volume of Conditional Storage Rights by Priority (AF) in the Arkansas Basin

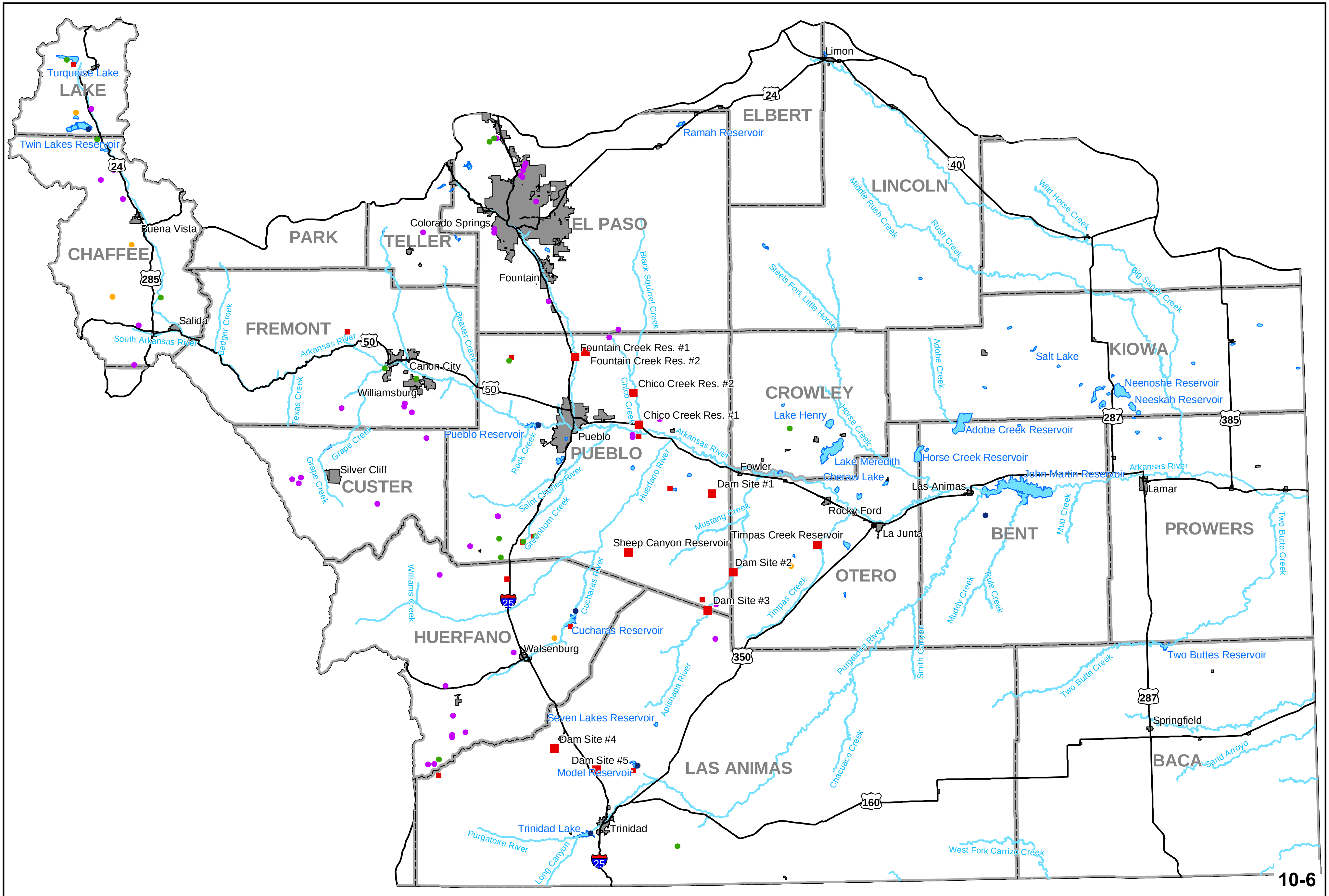


Figure 10-3
Arkansas Basin Conditional Storage Rights and Potential Damsite Locations

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

CWCB Damsite Inventory (AF)
- 5,000 - 100,000
- 100,001 - 400,000
- 400,001 - 1,000,000
- 1,000,001 - 2,550,000
- 2,550,001 - 6,500,000

Conditional Storage Rights (AF)
- <250
- 250 - 1,000
- 1,000 - 10,000
- 10,000 - 1,006,768

10 5 0 10 Miles
1:1,500,000

N

Coordinate System
NAD 1927 UTM Zone 13N

10.1.3.4 Arkansas Basin Summary of Restricted Reservoirs and Potential Storage Sites

Several restricted reservoirs exist in the Arkansas Basin and are listed in Table 10-3. The total volume of restricted storage in the basin is 71,261 AF. However, two reservoirs comprise the majority of this total, one in Water District 16 and one in Water District 67. In District 16, Cucharas #5 is in poor overall condition and has a history of embankment movement resulting in a loss of 33,000 AF of storage. The Two Buttes Dam in Water District 67 could store 31,465 AF if the hydraulically inadequate spillway were repaired. These reservoirs have limited availability of physical supply and the owners do not have the ability, or in some cases desire, to pay for the needed improvements given the limited supply. It is unlikely that these reservoirs will be rehabilitated and the storage restrictions lifted unless a third party provides funding.

Figure 10-4 also shows these data graphically. While the other water districts in the Arkansas Basin have restricted reservoirs, Figure 10-4 shows that each of these districts has less than 5,000 AF of potential storage if all restrictions were addressed and full capacity restored.

Figure 10-3 shows the locations of potential damsites as identified by the CWCB in the Arkansas Basin, along with the conditional storage rights locations. Different colored circles are used to represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage.

Table 10-3 Restricted Damsite Inventory in the Arkansas Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
100123	10	A. McCray	5.0 foot spillway	Instability		4/13/1998	10
100131	10	Garden of the Gods Golf Course	3.0 crest	No spillway	0	5/31/1988	0
100205	10	Keeton Lake	10.0 foot spillway	Erosion of spillway, leakage, piping	0	8/8/1997	10
100215	10	Modern Woodmen of Amer. #2	No storage	Inadequate spillway, poor repair	0	8/12/1983	85
100235	10	Prospect Lake	3.5 crest	No spillway, outlet operability questionable	0	5/31/1988	0
100309	10	Valley No. 1	15.0 crest	Inoperable outlet and blocked spillway	0	12/27/1984	50
100402	10	Valley No. 2	No storage	Inoperable outlet, obstructed spillway	0	9/21/2000	185
110106	11	Evans Gulch	3.0 crest	Insufficient freeboard	0	2/2/1985	2
120136	12	Park Center L&W #2	8.8 crest	Slide on downstream slope	0	1/4/1989	11
150116	15	Occhiato #1	10 foot crest	Slide		9/16/1999	3
160135	16	Clark #1	8.0 crest	Eroded upstream slope	0	2/16/1994	80
160108	16	Cucharas #5	GH 100 feet	Poor overall condition embankment history movement	100	7/21/1988	33,000
170118	17	Cudahy #1	5.0 feet below dam crest	Inadequate freeboard and inoperable outlet		7/15/1985	900
170217	17	Swink #1	5.0 crest	In disrepair, abandoned	0	4/24/1986	500
170218	17	Swink #2	5.0 crest	In disrepair, abandoned	0	4/24/1986	600
170219	17	Swink #5	5.0 crest	In disrepair, abandoned	0	4/24/1986	750
170220	17	Swink #6	5.0 crest	In disrepair, abandoned	0	4/24/1986	650
170222	17	Timpas #3	10.0 crest	In disrepair, abandoned	0	4/21/1986	500
180206	18	Apishapa	22.0 crest	Spillway, outlet silted in	0	2/18/1994	260
180207	18	Seven Lakes	7.0 crest	Dilapidated condition of dam	0	5/6/1987	1,200
190114	19	Model	3.0 foot spillway	Poor condition		6/28/2000	1,000
670236	67	Two Buttes	GH 20 feet	Hydraulically inadequate spillway	20	1/24/1983	31,465

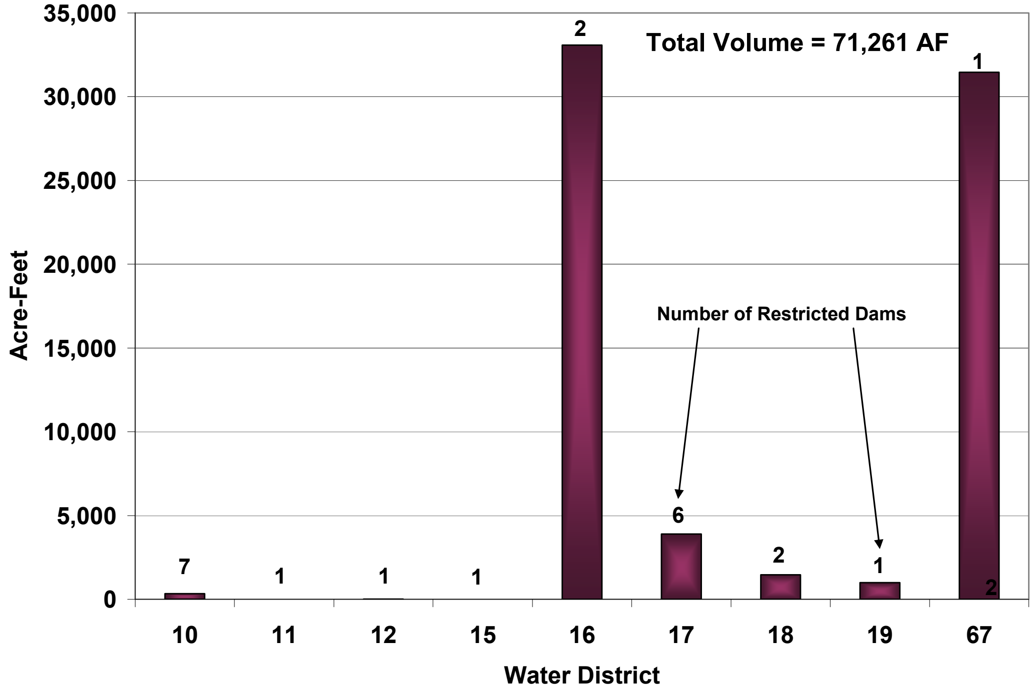


Figure 10-4
Total Volume of Restricted Storage (AF) in the Arkansas Basin

10.1.4 Colorado Basin

10.1.4.1 Colorado Basin Gap Analysis Issues

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

- Rapid growth in the headwaters areas and lack of available supplies as a result of existing in-basin uses, and existing and future transbasin diversions are significant challenges.
- The UPCO and Eagle River processes are critical to meeting future demands in Eagle, Grand, and Summit Counties.
- Water contracts are available out of Ruedi, Green Mountain, and Wolford Reservoirs and can provide direct water supply or for use in augmentation plans.
- Agricultural transfers to M&I use will continue from purchases, developer donations of water rights through annexation requirements, and development on irrigated lands.

Agricultural issues noted throughout SWSI in the Colorado Basin include:

- Agriculture is a key component in the lower basin (Grand Valley).
- There are some agricultural shortages in Water Districts 45, 53, and 70 that are primarily due to the lack of physical supply on tributaries.
- Contract water is available out of Ruedi, Green Mountain, and Wolford Reservoirs for agricultural use but cannot alleviate much of the shortage due to lack of physical supplies on tributaries. Agricultural uses also have difficulty affording the costs of the contracts.

10.1.4.2 Colorado Basin Supply Availability Issues

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

- Colorado Compact
  - Concern over a potential compact call during severe and sustained drought.
- Endangered Species
  - The success of the Endangered Species program is critical to help protect current and future water uses.
- RICDs and CWCB instream flow water rights may impact the ability to manage water supplies upstream of these water rights.
- CWCB instream flows can impact the ability to divert water under junior rights, such as winter diversions for snowmaking.
- Recreation and the environment are key drivers for industries and economic health as well as important components to quality of life.
- Denver and NCWCD Firming Projects will further reduce available flows in Grand and Summit Counties and will impact future growth opportunities in these counties.
- Potential future transmountain diversions such as Homestake II must be considered to ensure that in-basin needs are met.
- Agricultural and hydroelectric power calls and reservoir operations significantly impact water operations and supply availability in the upper portions of the basin.
- Development of conditional water rights, especially for transbasin diversions, may further reduce supply availability for future in-basin needs.

10.1.4.3 Colorado Basin Summary of Conditional Storage Rights

To portray the conditional storage rights present in the Colorado Basin, the area was described using water districts as shown in Figure 10-5.

The 12 water districts in the Colorado Basin can also be described using the main stream systems, which are shown in Table 10-4.

Table 10-4 Colorado Basin Water Districts and Associated Stream Names

Water District	Stream Name
36	Blue River
37	Eagle River
38	Roaring Fork River
39	Elk/Rifle/Parachute Creeks
45	Divide Creek
50	Troublesome/Muddy Creeks
51	Fraser/Colorado Rivers
52	Piney River
53	Rock/Derby/Sweetwater/Deep Creeks
70	Roan Creek
72	Plateau Creek/Colorado River
100	Colorado River

Various water districts in the Colorado Basin contain conditional storage rights that date back to the early 1900s and extend to present day. As shown in Table 10-5, there are nearly 3,000,000 AF of conditional storage rights, which exceeds available supplies. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation. The number, rather than volume, of conditional rights is presented in Appendix H.

Water Districts 37 and 70 in the Colorado Basin have the largest volume of conditional storage rights. This is depicted in Table 10-5 and also presented graphically in Appendix H. A total of nearly 800,000 AF, both with priority dates of between 1960 and 1980, are present in these two water districts.

Figure 10-6 focuses on the priority date of the conditional storage rights. The largest portion of storage rights have priority dates of between 1960 and 1980, followed by the 1980 to 2002 time period.

A map of the locations of the conditional storage rights in the Colorado Basin is shown in Figure 10-7. Different colored circles are used to represent the total volume of conditional rights that each location holds. These rights are held throughout the Colorado Basin. This figure also shows the locations of potential damsites in the Colorado Basin, as discussed in Section 10.1.4.4 below.

As noted in Section 7, water supply availability in the Colorado Basin increases downstream, with the headwater areas limited by physical water availability, environmental and recreational needs, and transbasin firming projects. Overall, there is water available for development and existing conditional rights can produce reliable yields with adequate storage, but the firm yield is variable depending on location.

10.1.4.4 Colorado Basin Summary of Restricted Reservoirs and Potential Storage Sites

Several restricted damsites exist in the Colorado Basin and are listed in Table 10-6. However, the total volume of restricted storage in the basin only equates to 1,881 AF and rehabilitation of all of these reservoirs will not significantly improve the availability of supply.

Figure 10-8 also shows these data graphically. While the other water districts in the Colorado Basin have restricted damsites (except Water District 100), Figure 10-8 shows that each district has less than 100 AF of potential storage if repairs were made.

Figure 10-7 shows the locations of potential damsites as identified by the CWCB in the Colorado Basin, along with the conditional storage rights locations. Different colored circles are used to represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage.

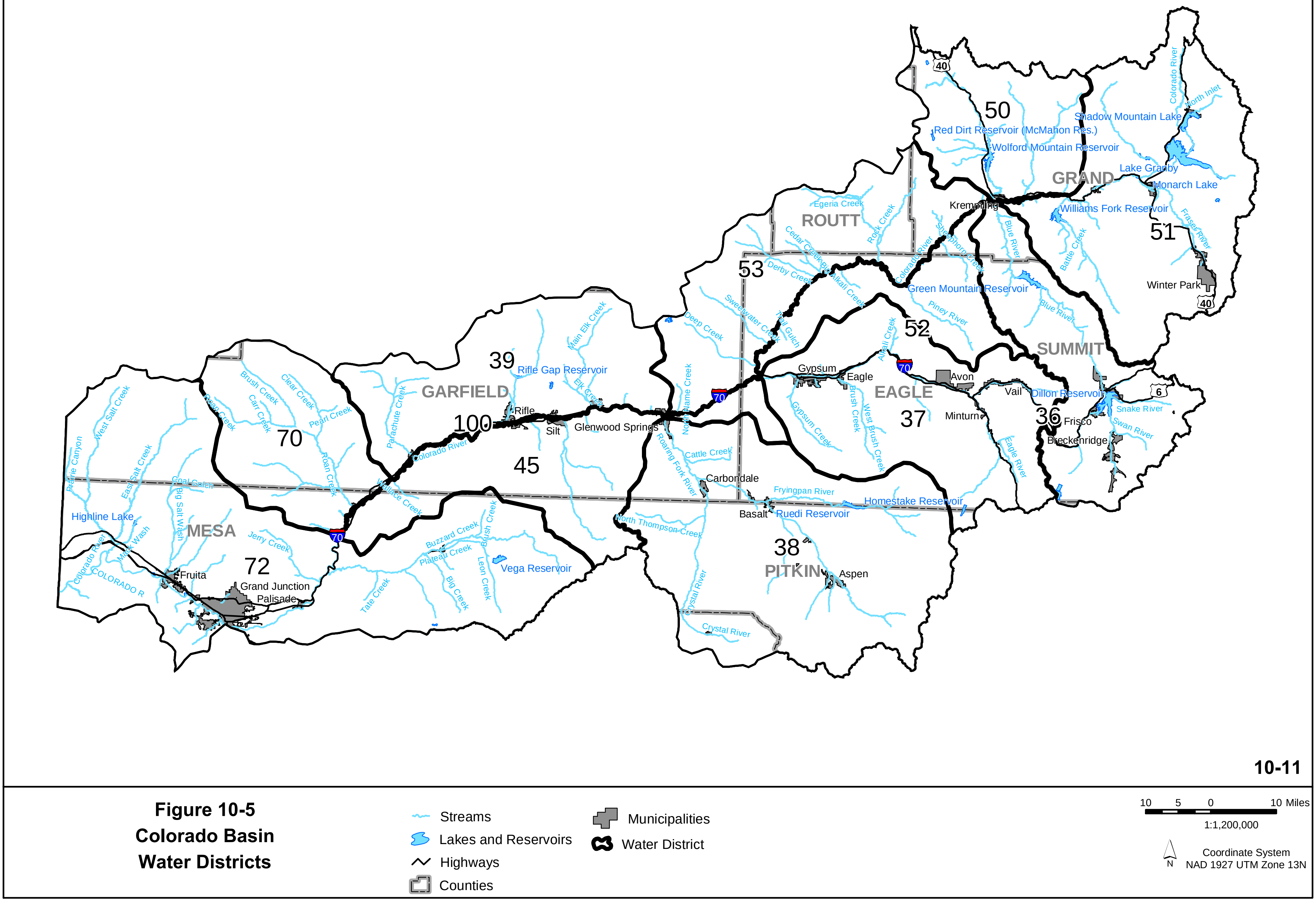


Figure 10-5
Colorado Basin
Water Districts

Table 10-5 Volume of Conditional Storage Rights by Priority (AF) in the Colorado Basin

Water District	Stream Name	1900-1920	1920-1940	1940-1960	1960-1980	1980-2002	Total
36	Blue River	0	0	3,828	28,548	255,165	287,541
37	Eagle River	0	0	151,643	419,349	76,563	647,555
38	Roaring Fork River	10	0	190,765	73,872	71,289	335,936
39	Elk/Rifle/Parachute Creeks	0	0	49,303	98,675	55,582	203,560
45	Divide Creek	0	0	21,950	49,383	2,550	73,883
50	Troublesome/ Muddy Creeks	18	0	3,470	152,094	218,671	374,253
51	Fraser/Colorado Rivers	2,600	1,465	10,651	26,072	21,405	62,193
52	Piney River	0	0	0	129,408	285	129,693
53	Rock/Derby/ Sweetwater/Deep Creeks	46	0	11	106,929	70,315	177,301
70	Roan Creek	0	0	10,000	376,127	174,624	560,751
72	Plateau Creek/ Colorado River	0	13	632	75,529	8,600	84,774
Total		**2,674**	**1,478**	**442,253**	**1,535,986**	**955,049**	**2,937,440**

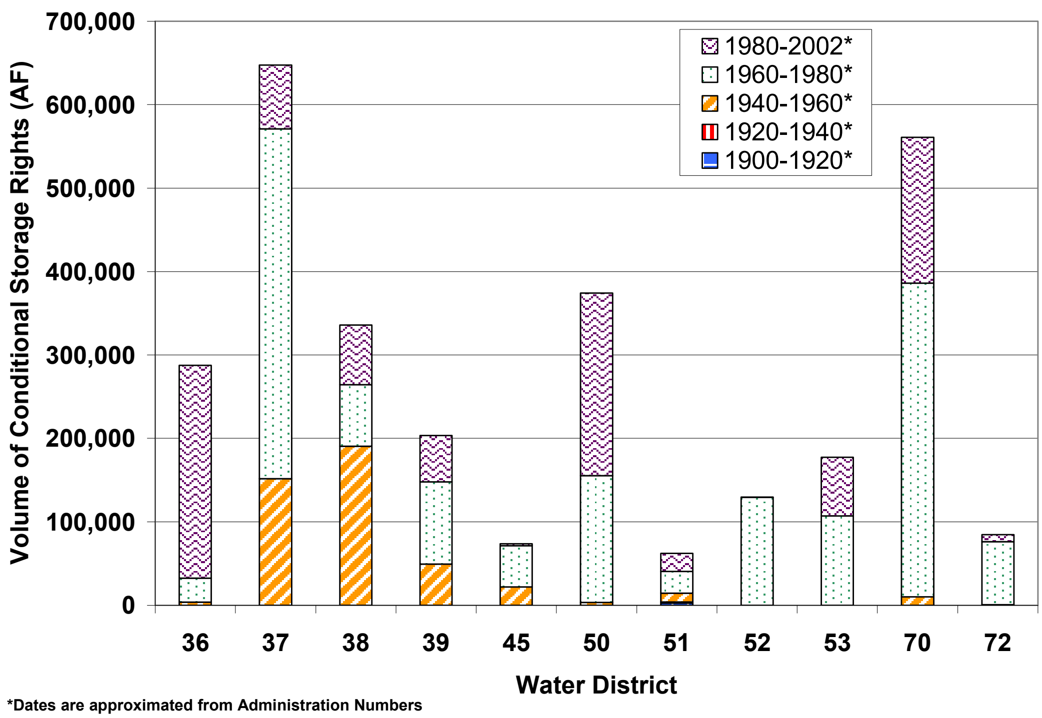


Figure 10-6
Volume of Conditional Storage Rights by Priority (AF) in the Colorado Basin

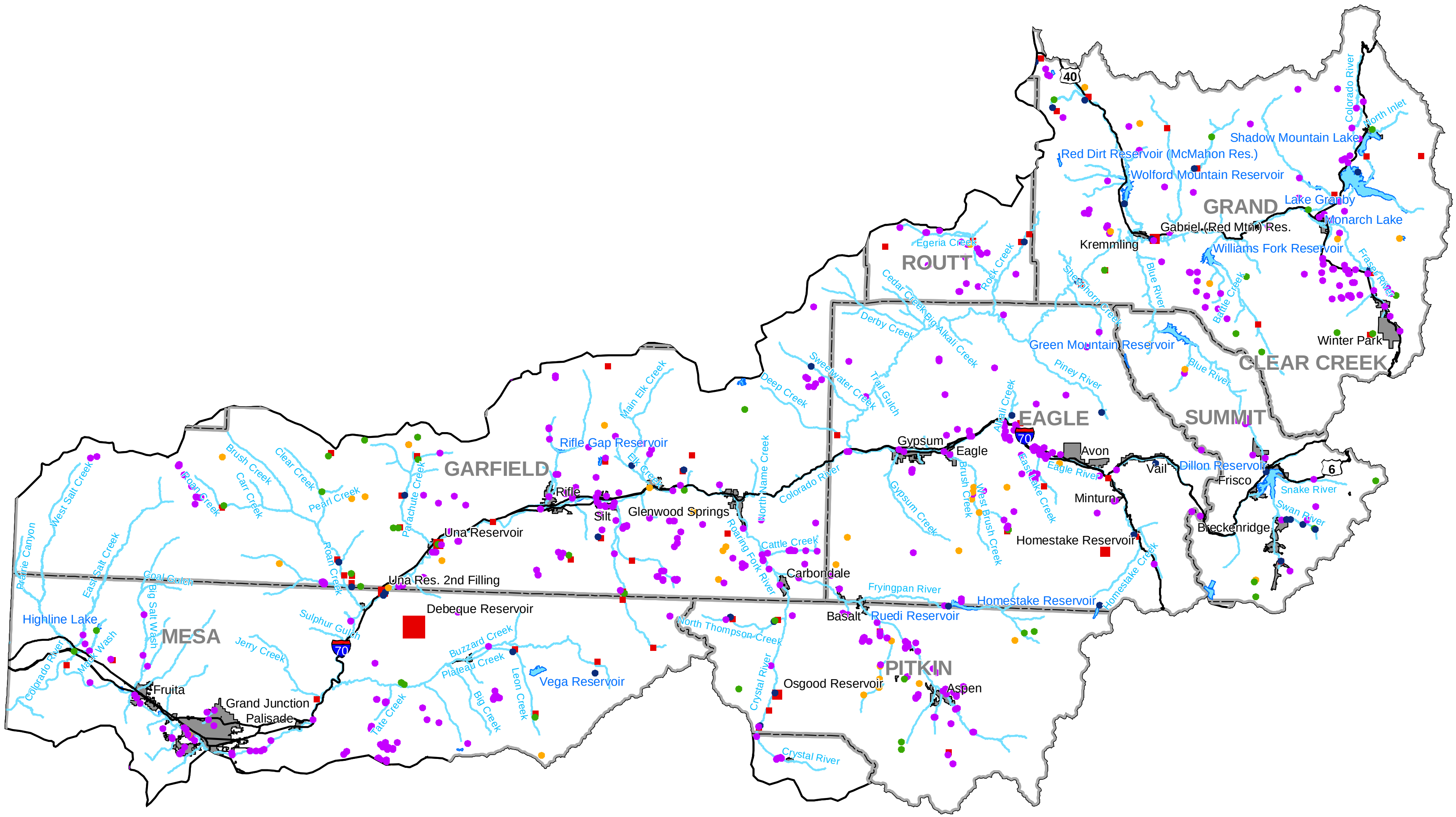


Figure 10-7
Colorado Basin Conditional Storage Rights and Potential Damsite Locations

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities

CWCB Damsite Inventory (AF)

- 5,000 - 100,000
- 100,001 - 400,000
- 400,001 - 1,000,000
- 1,000,001 - 2,550,000
- 2,550,001 - 6,500,000

Conditional Storage Rights (AF)

- <250
- 250 - 1,000
- 1,000 - 10,000
- 10,000 - 1,006,768

10 5 0 10 Miles
1:1,200,000
N
Coordinate System
NAD 1927 UTM Zone 13N

Table 10-6 Restricted Damsite Inventory in the Colorado Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
370205	37	Forier #3	No storage	Illegal dam/ inadequate spillway	0	11/9/1995	3
370116	37	G G Lower	4.0 crest	Inadeq frbd., stability of downstream slope	0	12/14/1992	7
380217	38	Christine Lake	3.5 ft crest	No spillway		5/4/2001	10
380212	38	Flannery	1.0 ft spillway	Spillway erosion		9/17/2001	20
500113	50	Matheson	Full stor in spring. Drain to GH 30 by 9/1	Monitoring device installed	30	10/30/2002	0
500126	50	Milk Creek	15.0 crest (Aug. 1 thru May 1)	Excessive leakage	0	5/10/1991	56
510114	51	Little King Ranch	10.0 spillway	Excessive seepage	41	3/7/1978	439
510129	51	Rock Creek	No storage	Dam breached by owner but wants to repair	0	5/28/1989	66
510124	51	Scholl	Seasonal GH 18 in spring GH 10 by July 1			3/30/2004	212
530119	53	Kelly	5.0 crest	Spillway erosion	0	9/20/1985	54
530125	53	Newton Gulch	20.0 crest, gage 17	Excessive seepage through abutments	17	7/3/1975	465
530129	53	Sterner	Relax 5/1-8/15, 3.0 spillway	Uncontrolled leakage		8/2/1995	71
720117	72	Carpenter	No storage	Piping hole		8/23/1994	39
720126	72	Currier #2	5.0 spillway	Slide on hill above spillway, backcutting		5/24/1995	79
720136	72	Hawxhurst	9 feet below crest/6 feet below spillway	Hole in dam		9/9/2003	120
720304	72	Long Slough	Zero storage	Piping along outlet works conduit		9/9/2003	219
720237	72	Y T Ranch	6 feet below dam crest low point	Sloughing of upstream slope and seepage		5/28/2003	21

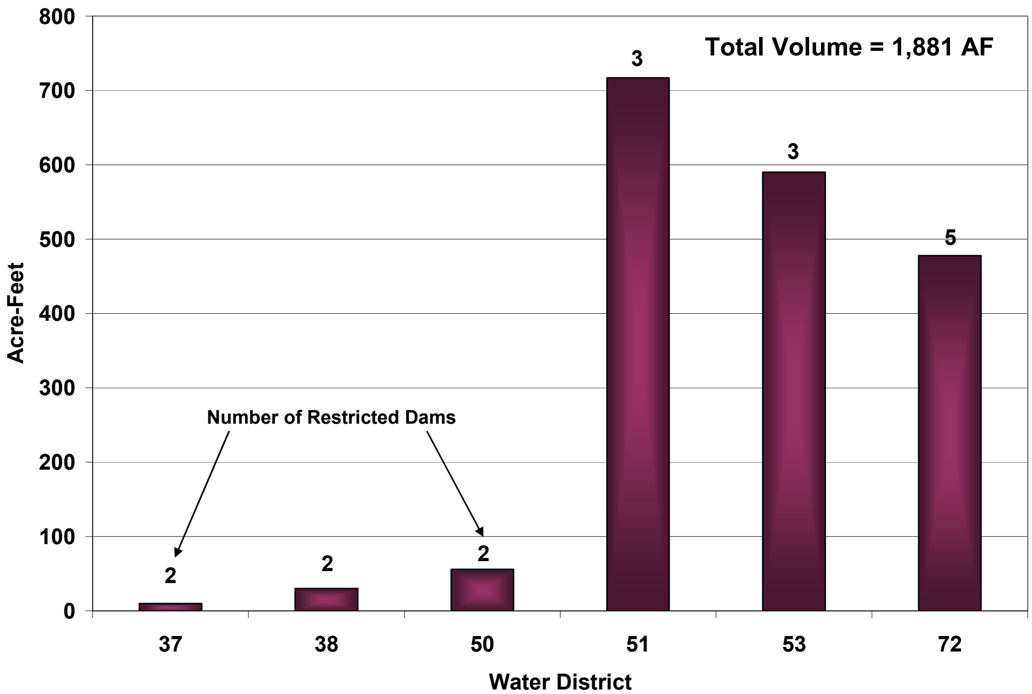


Figure 10-8
Total Volume of Restricted Storage (AF) in the Colorado Basin

10.1.5 Dolores/San Juan/ San Miguel Basin

10.1.5.1 Dolores/San Juan/San Miguel Gap Analysis Issues

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

- This multi-basin area of the state is extremely diverse with changing demographics in the Pagosa Springs-Bayfield-Durango corridor. This rapidly growing area has areas of localized water shortage and is transitioning from mining/agricultural to tourism, recreation, and a retirement/second home area. It will likely not be financially feasible to serve some unincorporated areas not served by water districts due to the high costs of transmission and delivery infrastructure.
- The Cortez area remains strongly agricultural but is also seeing rapid growth with retirees moving to the area. The San Miguel area is a mix of recreation and tourism along with a strong desire to maintain agriculture.
- The San Miguel subbasin will need the development of additional supplies to meet projected M&I demand
- The Dolores subbasin has a gap in providing for augmentation of well pumping and surface water diversions upstream of CWCB instream flow rights. A finding of de minimus impacts on CWCB instream flow rights can also address these gaps where depletions are minor.

Agricultural issues noted throughout SWSI in the Dolores/San Juan/San Miguel Basin include:

- Agricultural shortages greater than 10 percent were identified in many water districts as shown in Section 5.
- A potential project was identified for supplemental irrigation water supply in San Miguel Basin.
- Long Hollow Reservoir can regulate La Plata River flows required under the La Plata Compact and maximize supplies for use in Colorado.
- Supplies have been identified to irrigate an additional 4,000 acres in the Dolores Water Conservancy District.

10.1.5.2 Dolores/San Juan/San Miguel Supply Availability Issues

In the Dolores/San Juan/San Miguel Basin, the following issues were identified regarding supply availability:

- Overall water supply availability in the San Juan subbasin is good. The M&I allocations in the Dolores and Animas-La Plata Projects can provide the supplies to meet these future M&I needs. The challenge will be to develop the infrastructure to deliver project water to the areas of need. In addition, Colorado River Compact allocations to New Mexico have not been an issue to date, but may affect supply availability in the future.
- State Engineer probable maximum precipitation and spillway sizing requirements render some new reservoir projects financially infeasible due to high spillway construction costs.
  - Additional storage could be realized in existing reservoirs if spillway requirements were less stringent.
- Colorado River Compact
  - The Colorado River Compact places pressure on uses of the San Juan River because New Mexico's primary source of the upper basin supplies is the San Juan River.
  - Concern over a potential compact call during severe and sustained drought.
  - Allocation of water within the State of Colorado if there is a compact call due to severe and sustained drought.
- Endangered Species
  - The success of the Endangered Species program is critical to help protect current and future water uses.
- The potential Durango RICD may reduce free river conditions and require that new upstream diversions develop supplies to augment depletions.

10.1.5.3 Dolores/San Juan/San Miguel Summary of Conditional Storage Rights

To portray the conditional storage rights present in the Dolores/San Juan/San Miguel Basin, the area was described using water districts as shown in Figure 10-9.

The 15 water districts in the Dolores/San Juan/San Miguel Basin can also be described using the main stream systems, which are shown in Table 10-7.

Table 10-7 Dolores/San Juan/San Miguel Basin Water Districts, Subbasins and Associated Stream Names

Water District	Subbasin	Stream Name
29	San Juan	San Juan River
30	Animas	Animas River
31	Pine	Los Pinos River
32	McElmo	McElmo Creek
33	La Plata	La Plata River
34	Mancos	Mancos River
46	Pine/San Juan	Navajo Reservoir/San Juan River
60	San Miguel	San Miguel River
61	Dolores	Dolores River
63	Dolores	Dolores River
69	Dolores	Disappointment Creek
71	Dolores	Dolores River
73	Dolores	Little Dolores River
77	San Juan	Navajo River
78	San Juan	Piedra River

Various water districts in the Dolores/San Juan/San Miguel Basin contain conditional storage rights, with one conditional right in Water District 33 dating back to the early 1900s. As shown in Table 10-8, there are 1,600,000 AF of conditional storage rights in the basin. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation. The number, rather than volume, of conditional rights is presented in Appendix H.

Water District 30 in the Dolores/San Juan/San Miguel Basin has the largest volume of conditional storage rights. This is depicted in Table 10-8 and also presented graphically in Appendix H. This water district includes the Animas-La Plata Project conditional water rights, and a modified and much reduced size of the project is under construction.

Figure 10-10 focuses on the priority date of the conditional storage rights. The largest portion of storage rights have priority dates of between 1960 and 1980, followed by the 1940 to 1960 time period.

A map of the locations of the conditional storage rights in the Dolores/San Juan/San Miguel Basin is shown in Figure 10-11. Different colored circles are used to represent the total volume of conditional rights that each location holds. This figure also shows the locations of potential damsites in the Dolores/San Juan/San Miguel Basin, as discussed in Section 10.1.5.4 below.

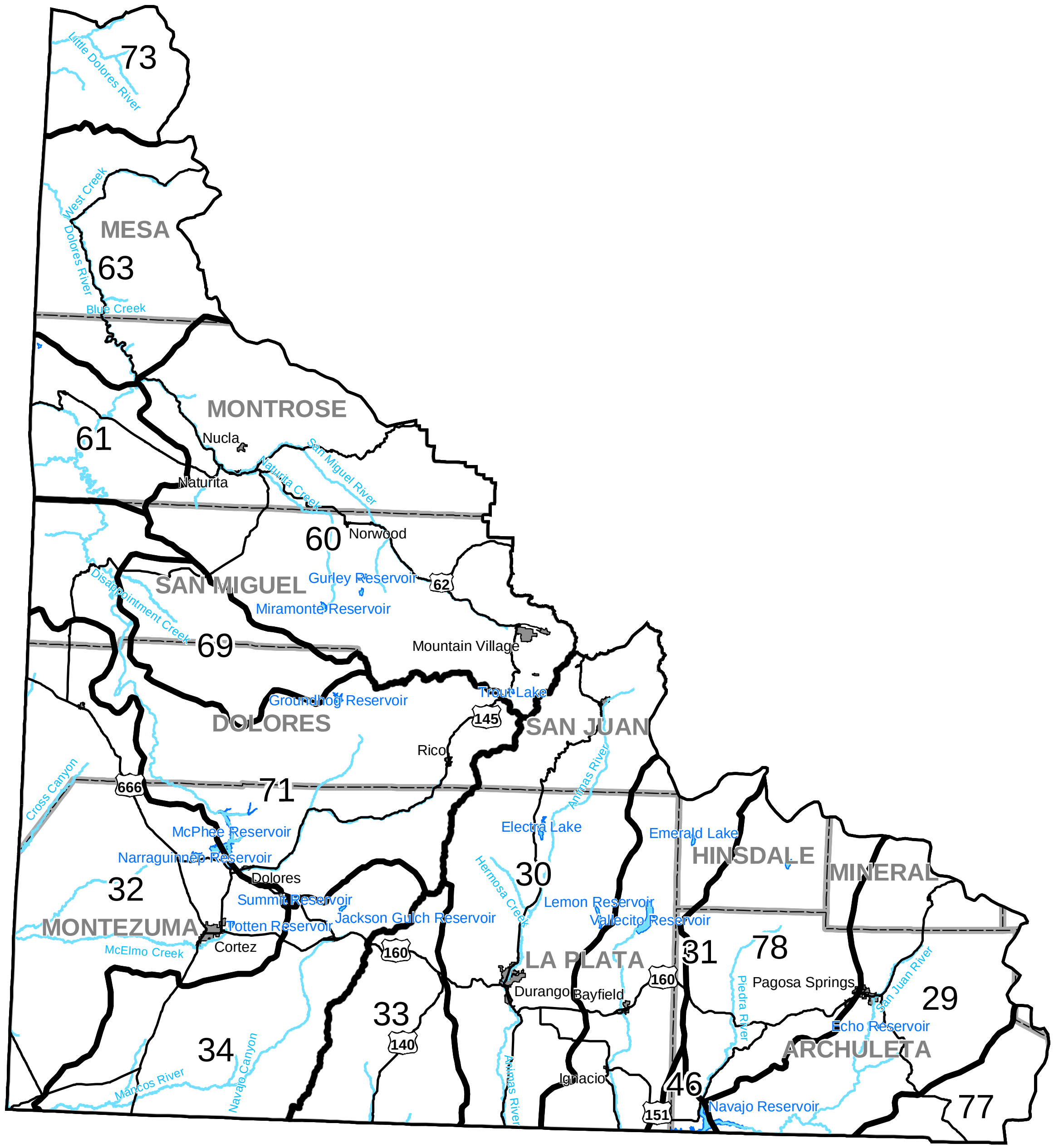
As described in Section 7, the development of existing conditional water rights, including the Animas-La Plata Project, would result in less available water for the rest of the basin.

10.1.5.4 Dolores/San Juan/San Miguel Summary of Restricted Reservoirs and Potential Storage Sites

Several restricted reservoirs exist in the Dolores/San Juan/San Miguel Basin and are listed in Table 10-9. The total volume of restricted storage in the basin is 1,301 AF and rehabilitation of all of these reservoirs will not significantly improve the availability of supply.

Figure 10-12 also shows these data graphically. Besides Water District 34, few other water districts in the Dolores/San Juan/San Miguel Basin have restricted reservoirs. Figure 10-12 shows that Districts 60, 63, and 68 each have less than 300 AF of potential storage if repairs were made.

Figure 10-11 shows the locations of potential damsites as identified by the CWCB in the Dolores/San Juan/San Miguel Basin, along with the conditional storage rights locations. Different colored circles are used to represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage.



10-18

Figure 10-9
Dolores/San Juan/San Miguel Basin
Water Districts

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Water District

10 5 0 10 Miles
1:1,435,694

N
Coordinate System
NAD 1927 UTM Zone 13N

Table 10-8 Volume of Conditional Storage Rights by Priority (AF) in the Dolores/San Juan/San Miguel Basin

Water District	Stream Name	1900-1920	1920-1940	1940-1960	1960-1980	1980-2002	Total
29	San Juan River	0	0	0	103,492	4,822	108,314
30	Animas River	0	9	111,340	665,148	35,417	811,914
31	Los Pinos River	0	0	0	32	15	47
32	McElmo Creek	0	0	0	216	364	580
33	La Plata River	2,898	0	172,670	60	6,411	182,039
34	Mancos River	0	0	0	0	2,006	2,006
46	Navajo Reservoir/ San Juan River	0	0	0	0	83	83
60	San Miguel River	0	0	81,831	216,112	8,431	306,374
61	Dolores River	0	0	0	3,600	500	4,100
63	Dolores River	0	0	0	1,000	65	1,065
69	Disappointment Creek	0	0	0	1,967	0	1,967
71	Dolores River	0	59,107	51,600	0	23,930	134,637
73	Little Dolores River	0	0	0	0	6	6
77	Navajo River	0	0	0	90	1,386	1,476
78	Piedra River	0	0	0	44,900	142	45,042
Total		**2,898**	**59,116**	**417,441**	**1,036,617**	**83,578**	**1,599,650**

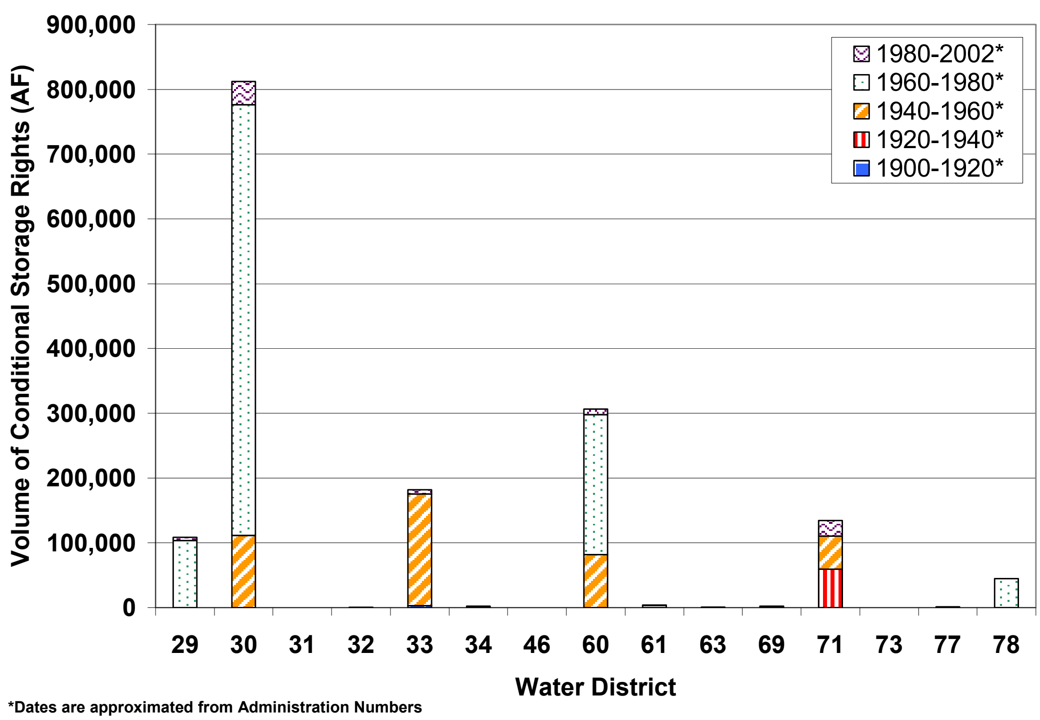


Figure 10-10
Volume of Conditional Storage Rights by Priority (AF) in the Dolores/San Juan/San Miguel Basin

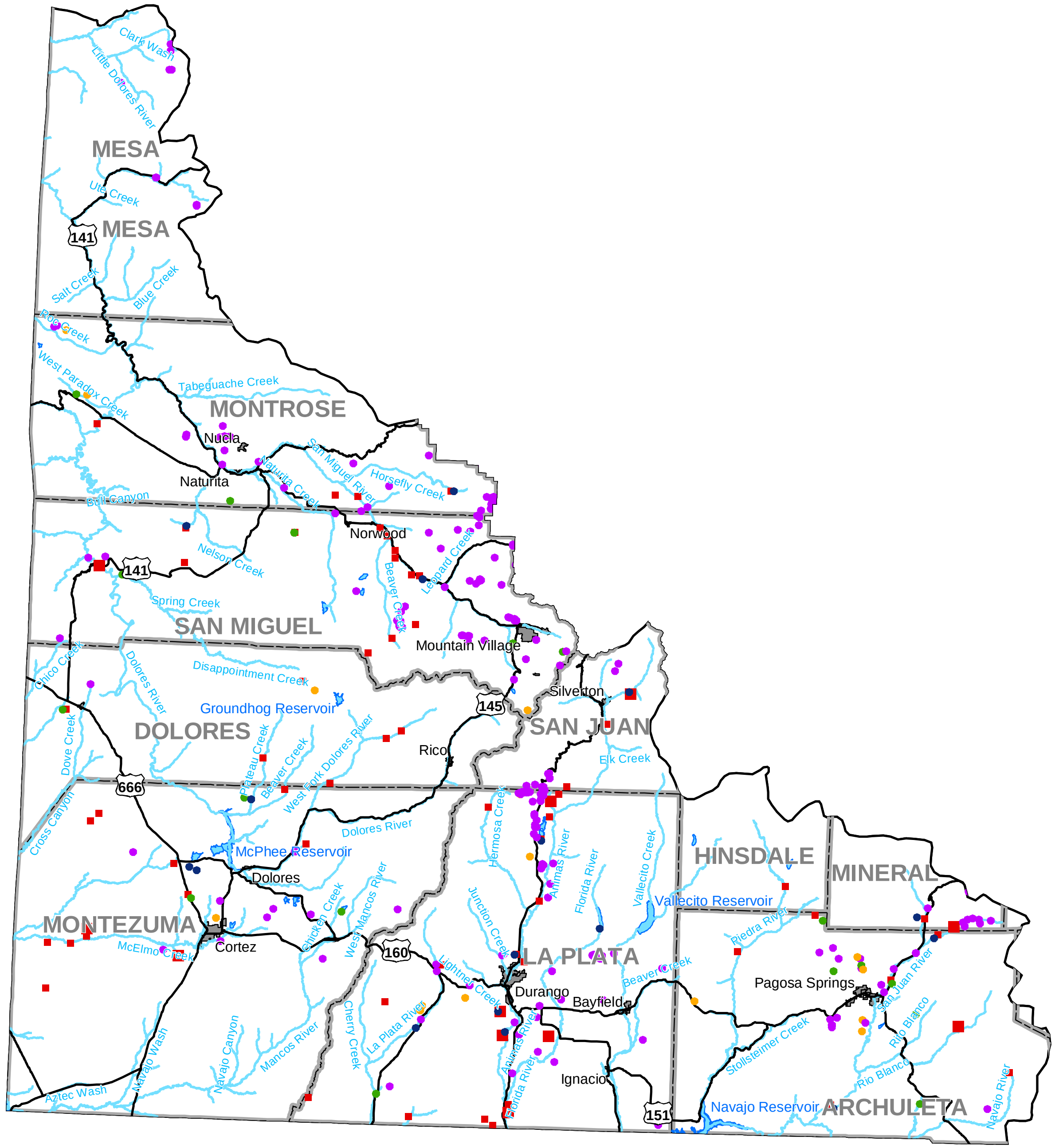


Figure 10-11
Dolores/San Juan/San Miguel Basin Conditional Storage Rights and Potential Damsite Locations

Streams
Lakes and Reservoirs
Highways
Counties

Municipalities

CWCB Damsite Inventory (AF)
5,000 - 100,000
100,001 - 400,000
400,001 - 1,000,000
1,000,001 - 2,550,000
2,550,001 - 6,500,000

Conditional Storage Rights (AF)
<250
250 - 1,000
1,000 - 10,000
10,000 - 1,006,768

10 5 0 10 Miles
1:1,400,000

N
Coordinate System
NAD 1927 UTM Zone 13N

Table 10-9 Restricted Damsite Inventory in the Dolores/San Juan/San Miguel Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
340106	34	Hurst	No Storage	Outlet Failure	0	3/29/1999	35
340119	34	J. O. Spencer	No Storage	Inoperable Outlet	0	5/8/2000	16
340117	34	Sellers and McClane	4 feet Below Dam Crest	Seepage, Muskrat Damage		5/29/2003	12
340203	34	Summit – Main Dam	Not to Exceed 1.1' below spill for > 3 weeks	Excessive Seepage	23.6	6/3/1998	400
340205	34	Summit – South Dam	Not to Exceed 1.1' below spill for > 3 weeks	Excessive Seepage	23.6	6/3/1998	400
600105	60	Blue Lake #1	5.0 Feet Spillway	Poor Condition		11/21/2001	100
600126	60	Cushman	6.0 Crest	Outlet Inoperable, Spillway Inadequate, Emb. Seeps	0	7/29/1975	36
600118	60	Paxton	2.5 Spillway	Seepage	0	8/8/1988	100
600127	60	Priest	3.0 Crest	Insufficient Freeboard	0	9/16/1985	25
630103	63	Burg	Zero Storage	Damaged Outlet Controls		9/30/2003	91
780111	78	Pinon Lake	3 Feet Spillway	Poor Condition of Outlet		7/27/2001	86

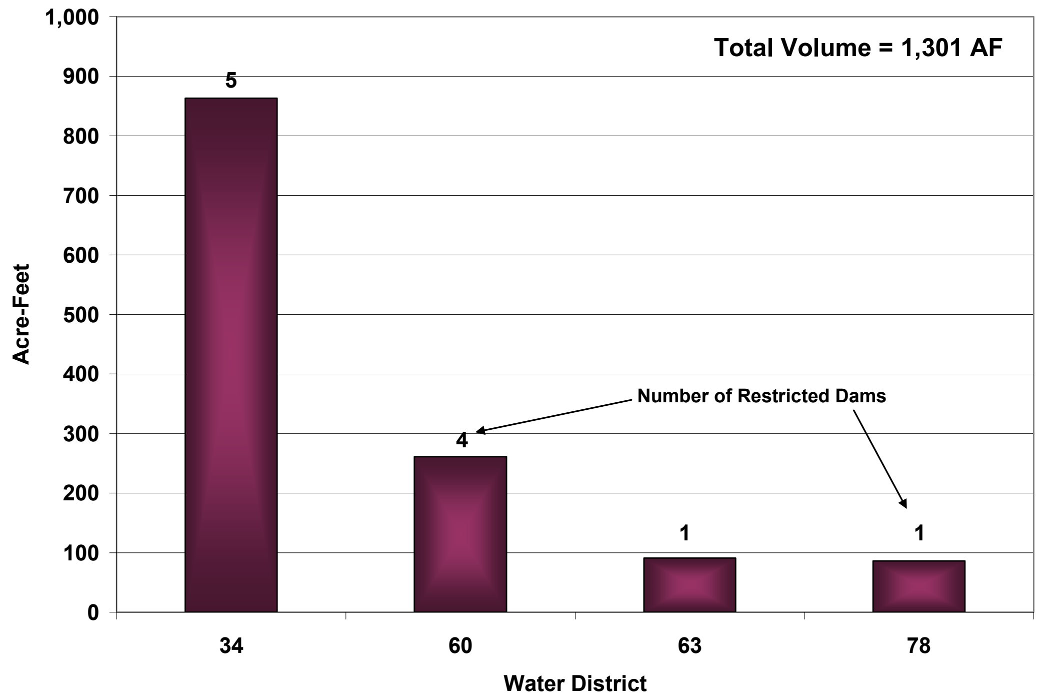


Figure 10-12
Total Volume of Restricted Storage (AF) in the Dolores/San Juan/San Miguel Basin

10.1.6 Gunnison Basin

10.1.6.1 Gunnison Basin Gap Analysis Issues

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

- Growth in the headwaters regions of Ouray and Gunnison Counties will require additional water management strategies.
- Augmentation supplies are needed for existing and future M&I growth in Ouray County and UGRWCD.
- Potential growth and snowmaking demands at Crested Butte Mountain Resort will require additional storage.
- The Uncompahgre Valley has experienced and will continue to experience significant growth.
  - Tourism is important in the headwater area of Ouray County.
  - Agriculture remains the dominant water use in the Uncompahgre Valley.
  - A rapid influx of retirees and growth in the Uncompahgre Valley may dramatically change the agricultural uses and land use in the area.
- Most water providers in the North Fork of the Gunnison have identified plans to meet future M&I needs.
- Possible future transbasin diversions are an ongoing concern.

Agricultural issues noted throughout SWSI in the Gunnison Basin include:

- There are average annual shortages exceeding 10 percent in most of the basin except for the Uncompahgre Valley. However, in some years there are water deliveries less than a full project allocation.
- Addressing agricultural water shortages in the upper portion of the basin is an important goal of the community; however, a lack of financial resources is an impediment.

10.1.6.2 Gunnison Basin Supply Availability Issues

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

- Resolving federal issues is a priority, which include:
  - Resolving the National Park Service claims for flows in the Black Canyon.
  - Completion of the Blue Mesa/Aspinall Re-operations Environmental Impact Statement to provide flows for endangered fish.
  - Future Aspinall Unit operations will affect supply availability.
  - Addressing Endangered Species issues in the Gunnison River near the confluence with the Colorado River main stem.
- The Upper Gunnison Water Conservancy District has a 60,000 AF subordination agreement with the United States that allows for upstream depletions against the Aspinall Unit storage priorities.
- Water contracts are available out of Blue Mesa and Ridgway Reservoir for augmentation of upstream depletions.
  - Augmentation is required for agricultural, instream flow, and potential/pending RICD water rights above these reservoirs that cannot be met from Blue Mesa or Ridgway.
- Colorado Compact
  - Concern over a potential compact call due to severe and sustained drought.
- Endangered Species
  - The success of the Endangered Species program is critical to help protect current and future water uses.
- CWCB instream flows can impact the ability to divert water. Growth and water use above CWCB instream flows will need storage and augmentation plans to ensure that these instream flows are satisfied.
- RICDs and CWCB instream flow water rights may impact the ability to manage water supplies upstream of such water rights.
- Recreation and the environment are key drivers for their industries and economic health as well as important components to quality of life. Gunnison has

a pending RICD right that will limit future water availability upstream of the right.

- Agricultural and hydroelectric power calls and reservoir operations significantly impact water operations and supply availability in the upper portions of the basin.

10.1.6.3 Gunnison Basin Summary of Conditional Storage Rights

To portray the conditional storage rights present in the Gunnison Basin, the area was described using water districts as shown in Figure 10-13.

The seven water districts in the Gunnison Basin can also be described using the main stream systems, which are shown in Table 10-10.

Table 10-10 Gunnison Basin Water Districts and Associated Stream Names

Water District	Stream Name
28	Tomichi Creek
40	North Fork Gunnison/Gunnison Rivers
41	Uncompahgre River
42	Gunnison River
59	Taylor/East/Gunnison Rivers
62	Cebolla Creek/Lake Fork Gunnison River/ Gunnison River
68	Uncompahgre River

Various water districts in the Gunnison Basin contain conditional storage rights that date back to the early 1900s and extend to present day. As shown in Table 10-11 there are over 2,000,000 AF of conditional storage rights in the basin, which likely exceed available supply. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation. The number, rather than volume, of conditional rights is presented in Appendix H.

Water District 59 in the Gunnison Basin has the largest volume of conditional storage rights, comprising over 1,600,000 AF of the 2,170,000 AF in the basin. This is depicted in Table 10-11 and also presented graphically in Appendix H.

Figure 10-14 focuses on the priority date of the conditional storage rights. Over one-half of the conditional storage rights in the Gunnison Basin have priority dates between 1960 and 1980.

A map of the locations of the conditional storage rights in the Gunnison Basin is shown in Figure 10-15. Different colored circles are used to represent the total volume of conditional rights that each location holds. These rights are in locations scattered throughout the basin. This figure also shows the locations of potential damsites in the Gunnison Basin, as discussed in Section 10.1.6.4 below.

Conditional water rights could eventually be developed in the Gunnison Basin as described in Section 7, resulting in less available water for the rest of the basin.

10.1.6.4 Gunnison Basin Summary of Restricted Reservoirs and Potential Storage Sites

Several restricted reservoirs exist in the Gunnison Basin and are listed in Table 10-12. The total volume of restricted storage in the basin is 3,604 AF and rehabilitation of all of these reservoirs will not significantly improve the availability of supply. Eighteen reservoirs in Water District 40 and five in Water District 42 comprise the majority of this total. In Water District 40, Barren, Big Battlement, and Hotel Lake Dams have the largest volumes lost, approximately 2,000 AF. Due to outlet works failure, Grand Mesa #1 Dam in Water District 42 has 300 AF of lost storage.

Figure 10-16 shows the total storage lost to storage restrictions in each water district.

Figure 10-15 shows the locations of potential damsites as identified by the CWCB in the Gunnison Basin, along with the conditional storage rights locations. Different colored circles are used to represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage.

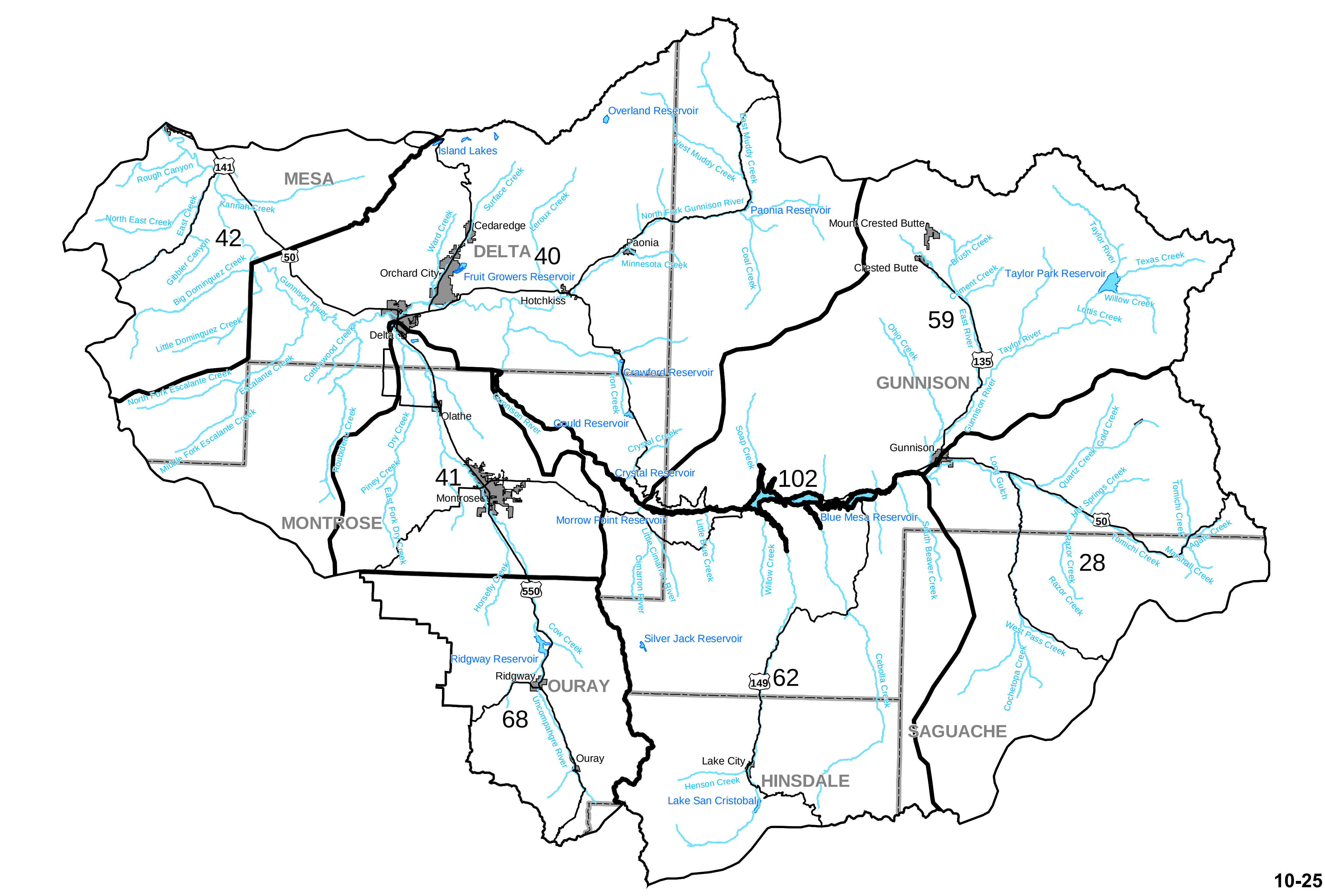


Figure 10-13
Gunnison Basin
Water Districts

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Water District

10 5 0 10 Miles
1:900,866

N
Coordinate System
NAD 1927 UTM Zone 13N

Table 10-11 Volume of Conditional Storage Rights by Priority (AF) in the Gunnison Basin

Water District	Stream Name	1900-1920	1920-1940	1940-1960	1960-1980	1980-2002	Total
28	Tomichi Creek	0	0	0	80,049	150	80,199
40	North Fork Gunnison/ Gunnison Rivers	971	220	72,729	212,330	2,341	288,591
41	Uncompahgre River	0	0	64	0	112	176
42	Gunnison River	176	0	0	1,794	6,042	8,012
59	Taylor/East/ Gunnison Rivers	0	0	38	1,199,754	470,555	1,670,347
62	Cebolla Creek/Lake Fork Gunnison River/ Gunnison River	0	0	97	42	519	658
68	Uncompahgre River	0	0	39,438	4,313	84,774	128,525
Total		**1,147**	**220**	**112,366**	**1,498,282**	**564,493**	**2,176,508**

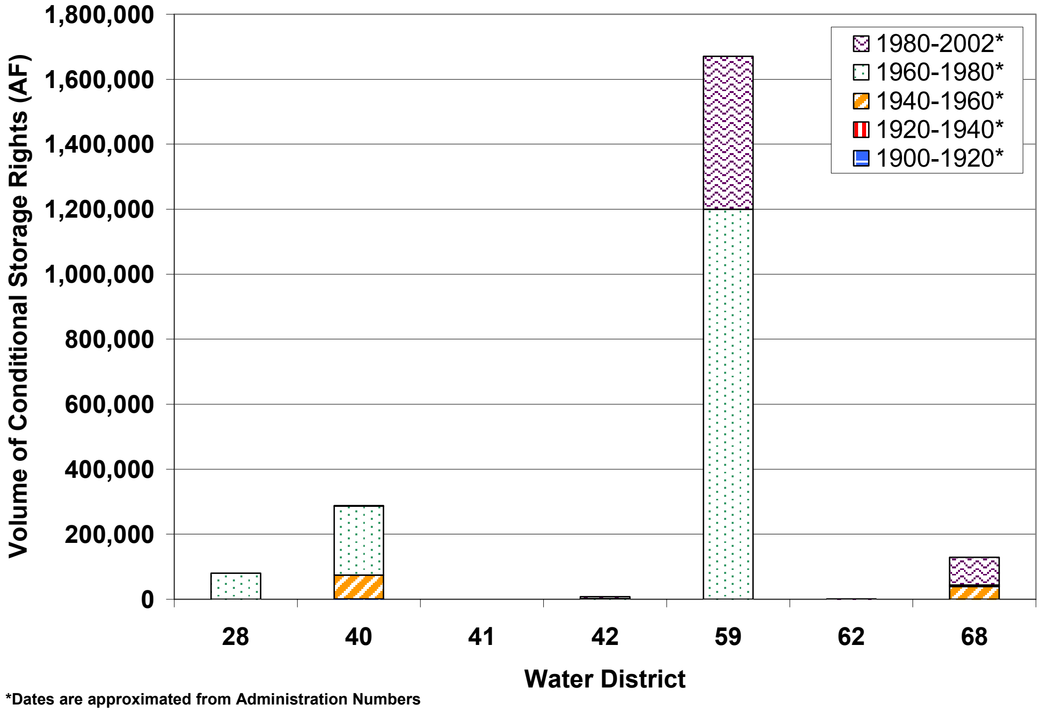


Figure 10-14
Volume of Conditional Storage Rights by Priority (AF) in the Gunnison Basin

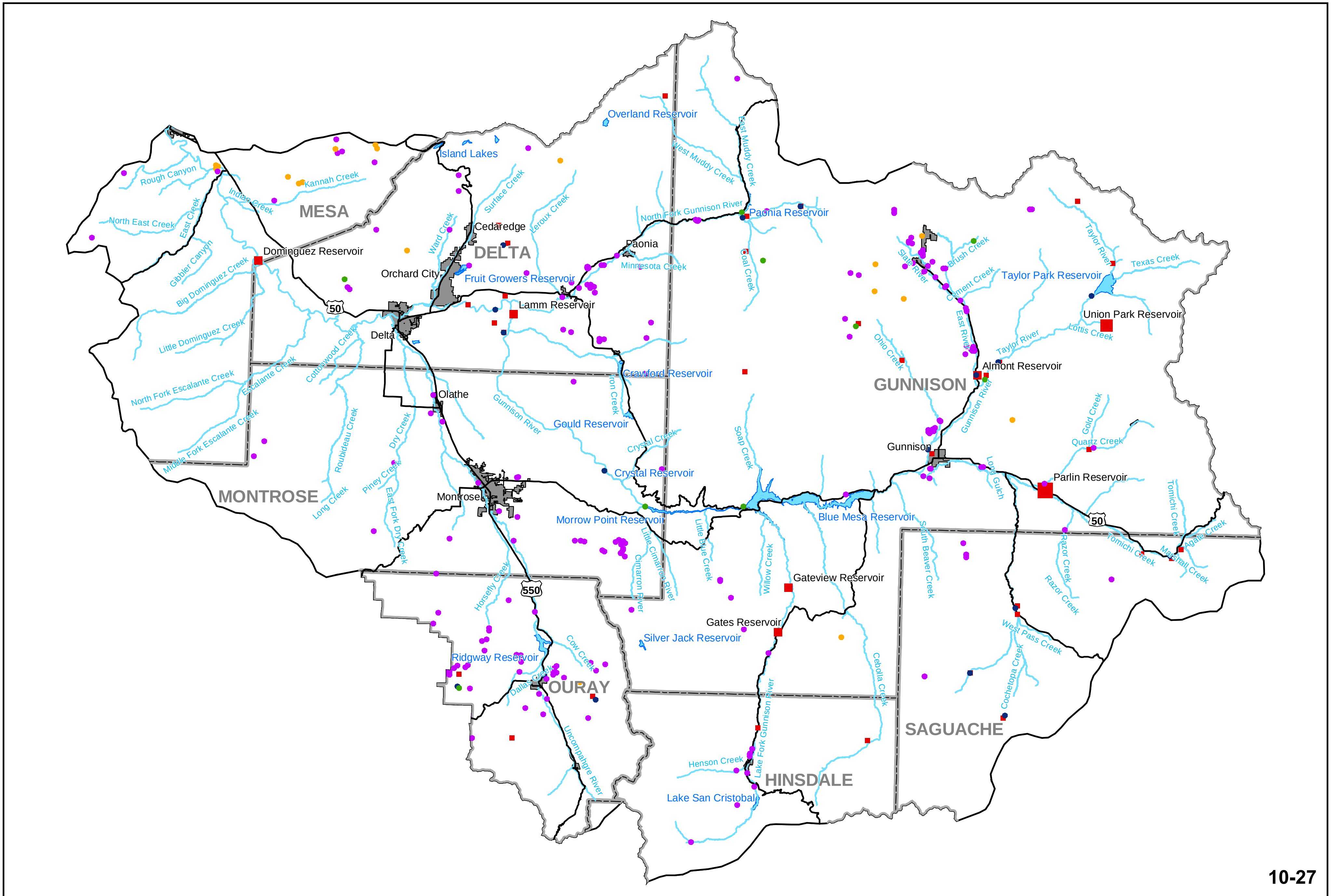


Figure 10-15
Gunnison Basin Conditional Storage Rights and Potential Damsite Locations

Streams
Lakes and Reservoirs
Highways
Counties

Municipalities

CWCB Damsite Inventory (AF)
5,000 - 100,000
100,001 - 400,000
400,001 - 1,000,000
1,000,001 - 2,550,000
2,550,001 - 6,500,000

Conditional Storage Rights (AF)
<250
250 - 1,000
1,000 - 10,000
10,000 - 1,006,768

10 5 0 10 Miles
1:900,000

N

Coordinate System
NAD 1927 UTM Zone 13N

Table 10-12 Restricted Damsite Inventory in the Gunnison Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
400103	40	Arch Slough	Dam was abandoned, but can still hold water	Poor condition	0	12/12/1985	66
400108	40	Barren	Zero Storage	Outlet deficiencies	0	12/11/2003	759
400112	40	Big Battlement	GH 8 ft.	Sinkholes on embankment	8	9/24/1991	750
400212	40	Cypher #1	4.0 below emergency spillway crest	Repairs not completed		1/14/2003	8
400306	40	Granby #12	GH 17 ft.	D/S face slide due to seepage	17	10/15/1987	0
400601	40	Harry White #2	5.0 crest	Poor outlet valve, lack of freeboard, maintenance	0	8/9/1991	30
400318	40	Hotel Lake	No storage	Weakened conditions!	0	1/14/2002	549
400330	40	Knox	Full storage from 4/1 to 8/15 if monitored	Excessive seepage at toe and on embankment	17	1/8/1988	0
400405	40	Lone Star #1	30.0 crest	Cracks on crest, unapproved plans, poor construction	0	7/31/1996	0
400619	40	Lone Star #2	10.0 crest	Construction without approved plans & specs	0	6/2/1988	0
400411	40	Military Park		Piping	10	9/7/2000	150
400413	40	Monument	10.0 spillway, fill/ monitoring plan in place	Cracks on dam and left abutment slide	33.5	4/29/1993	175
400419	40	Oasis	3 feet below normal water surface	Uncontrolled seepage		9/30/2003	40
400434	40	Pitcairne #1	5.5 ft. spillway	Beaver dens on US face		8/2/2000	50
400522	40	Todd	10.0 crest	6 ft. elevation diff. along crest with no spillway	0	10/19/1984	112
400524	40	Trio	8.0 spillway	Slide on downstream slope	14	1/11/1989	75
400705	40	Webster #1	No storage	Poorly constructed	0	5/6/1987	15
400707	40	Webster #3	No storage	Poorly constructed	0	5/6/1987	15
410201	41	Coffey Reservoir	No storage	General poor condition, const. without app plans	0	7/21/1988	90
410202	41	Mock #1	9.0 crest (after 60 days full)	Built without approved plans and seepage	0	4/26/1989	0
420116	42	Fruita #1	20 ft. crest	Slide on downstream slope		8/12/1998	100
420119	42	G.H. and S. #2	No storage	Narrow crest, steep slopes, poor outlet	0	8/26/1992	29
420120	42	Grand Mesa #1	8 ft. spillway	Outlet works failure	12	12/21/2000	300
420123	42	Grand Mesa #9	3.4 ft. spillway	Outlet works problems	8	12/21/2000	100
420135	42	Reeder	8.0 crest	Seep. on d/s surface, numerous large trees	0	8/26/1985	96
590113	59	Meridian Lake Park #1	2.0 spillway (prin spwy lowered)	Severe erosion of the emergency spillway	0	6/4/1987	10
620122	62	Fish Creek #1	Zero storage	Stability, seepage, outlet control	0	9/11/2003	85

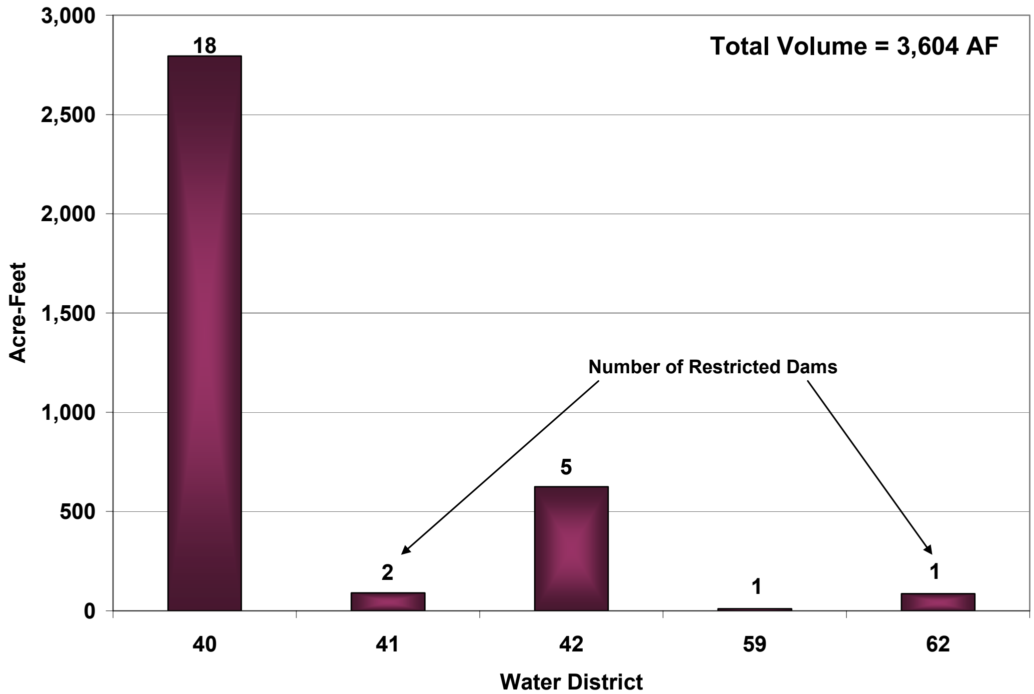


Figure 10-16
Total Volume of Restricted Storage (AF) in the Gunnison Basin

10.1.7 North Platte Basin

The North Platte Basin includes the North Platte and Laramie Rivers. The North Platte Basin is one of Colorado's only basins with concern over the lack of growth and economic development. Other issues include a desire to ensure protection of existing water supplies, and a concern over the impact of the lack of forest management. It is important to ensure that Endangered Species issues on the Platte River in central Nebraska do not put pressure on North Platte water users to reduce existing uses.

10.1.7.1 North Platte Basin Gap Analysis Issues

Because no M&I gap is anticipated, no issues arose in the North Platte Basin Roundtable process for this use.

10.1.7.2 North Platte Basin Supply Availability Issues

- The North Platte Decree, as described in Section 4 and 7, limits the total irrigated acres, agricultural reservoir storage, and transmountain diversions.
- RICDs and CWCB instream flow water rights may impact the ability to manage water supplies upstream of such water rights.

10.1.7.3 North Platte Basin Summary of Conditional Storage Rights

To portray the conditional storage rights present in the North Platte Basin, the area was described using water districts as shown in Figure 10-17.

The two water districts in the North Platte Basin can also be described using the main stream systems, which are shown in Table 10-13.

Table 10-13 North Platte Basin Water Districts and Associated Stream Names

Water District	Stream Name
47	North Platte River
48	Laramie River

The two water districts in the North Platte Basin have conditional storage rights of approximately 45,000 AF with a priority of between 1900 and 1920, and 25,000 AF with a priority between 1980 and 2002. As shown in Table 10-14, there is a total of approximately 70,000 AF of conditional storage rights in the basin, which far exceeds the amount allowed under the North Platte Decree. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation.

Water District 48 in the North Platte Basin has the largest volume of conditional storage rights, comprising almost 45,000 AF. Water District 47 comprises the remaining 25,000 AF. This is depicted in Table 10-14 and also presented graphically in Appendix H.

Figure 10-18 focuses on the priority date of the conditional storage rights. All of the conditional storage rights in Water District 48 in the North Platte Basin have priority dates between 1900 and 1920. Water District 47 has conditional rights with priority dates between 1940 and 2002.

A map of the locations of the conditional storage rights in the North Platte Basin is shown in Figure 10-19. Different colored circles are used to represent the total volume of conditional rights that each location holds. This figure also shows the locations of potential damsites in the North Platte Basin, as discussed in Section 10.1.7.4 below.

The development of conditional water rights in the North Platte Basin is limited by interstate decree as described in Section 7.

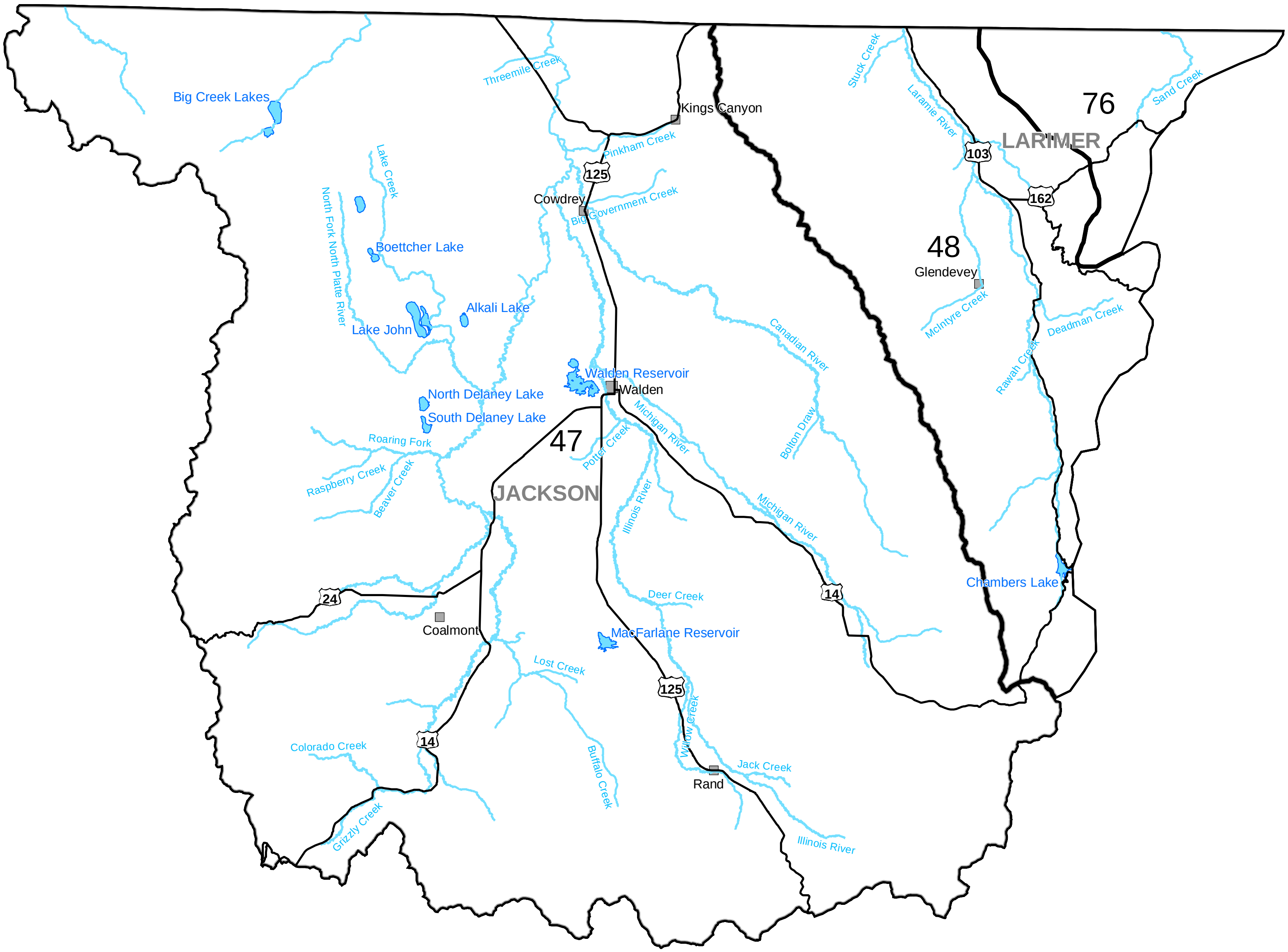


Figure 10-17
North Platte Basin
Water Districts

Table 10-14 Volume of Conditional Storage Rights by Priority (AF) in the North Platte Basin

Water District	Stream Name	1900-1920	1920-1940	1940-1960	1960-1980	1980-2002	Total
47	North Platte River	0	0	68	402	24,804	25,274
48	Laramie River	44,536	0	0	0	0	44,536
Total		**44,536**	**0**	**68**	**402**	**24,804**	**69,810**

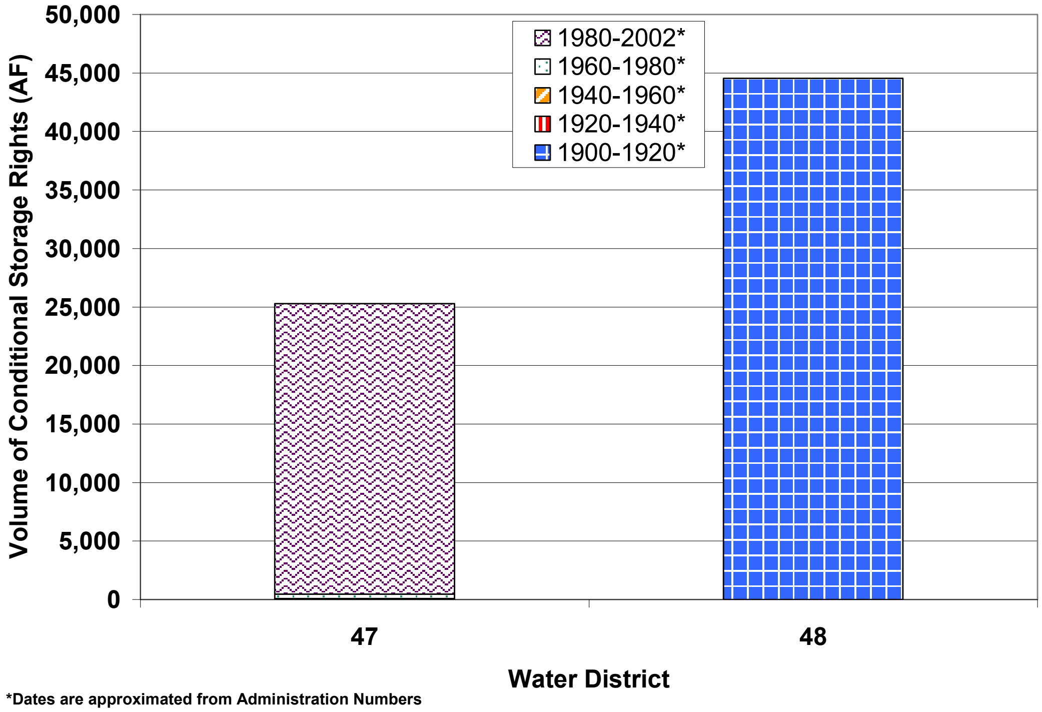


Figure 10-18
Volume of Conditional Storage Rights by Priority (AF) in the North Platte Basin

10.1.7.4 North Platte Basin Summary of Restricted Reservoirs and Potential Storage Sites

One restricted reservoir exists in the North Platte Basin and is listed in Table 10-15. The reservoir, located in Water District 48, is the Johnson Dam, which has an improper freeboard and erosion and seepage problems. This site loses 68 AF of storage due to these problems.

Figure 10-19 shows the locations of potential damsites identified by the CWCB in the North Platte Basin, along with the conditional storage rights locations. Different colored circles are used to represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage. Coalmont is a viable future site, but the conditional water right for this reservoir was cancelled by the Water Court in 2001. Hyannis Reservoir was discussed at the Basin Roundtable Technical Meeting as a possible project as there were two conditional decrees for this reservoir site. The original was for 2,123 AF with a conditional enlargement for 737 AF. Both of these conditional rights were cancelled by the Water Court in 2001, when the applicant indicated they no longer wished to pursue diligence (Plaska 2004).

Table 10-15 Restricted Damsite Inventory in the North Platte Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
480101	48	Johnson	4.0 Crest (3.0 Crest Irr. Season)	Eros on U/S face, Improper FB., Seep/D/S Toe	0	7/18/1994	68

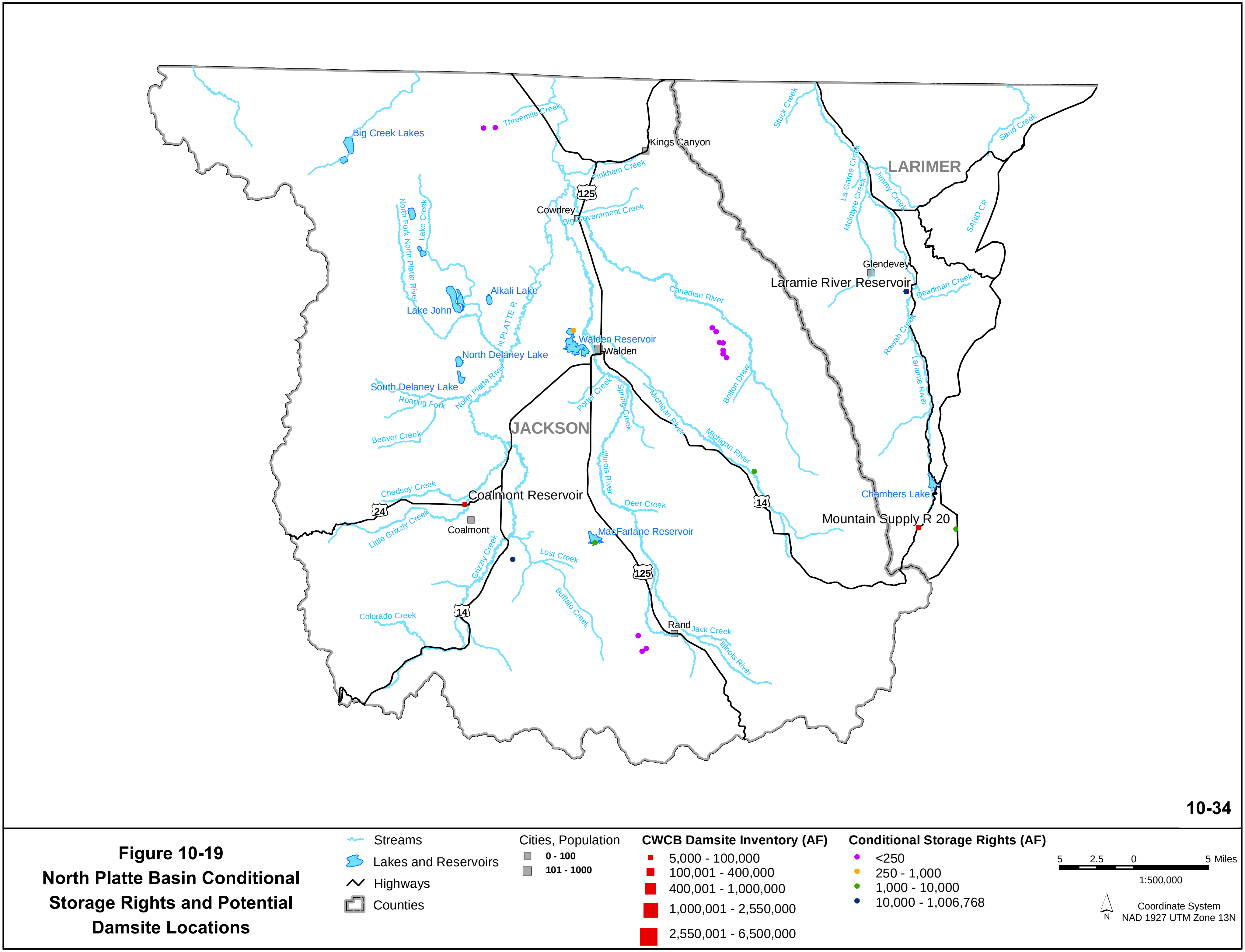


Figure 10-19
North Platte Basin Conditional Storage Rights and Potential Damsite Locations

10.1.8 Rio Grande Basin

10.1.8.1 Rio Grande Basin Gap Analysis Issues

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

- There are not any existing or projected SSI uses.
- There is potential for additional M&I conservation and some providers are starting to install water meters.
- Groundwater is physically available for most anticipated M&I growth.
- Augmentation of all new wells is required.

Agricultural issues noted throughout SWSI in the Rio Grande Basin include:

- Agricultural use is at unsustainable levels of pumping in the closed basin and water levels have dropped in the unconfined aquifer and in parts of the confined aquifer.
- Up to 100,000 acres of agricultural land may need to no longer be irrigated in order to return and maintain groundwater at historical levels.
- It will be a challenge to achieve voluntary reduction of irrigated acres and offset the economic impacts of reducing irrigated acreage.
- There will be some minor potential loss of irrigated acres as a result of dry-up and transfer of the consumptive use for M&I augmentation.

10.1.8.2 Rio Grande Basin Supply Availability Issues

In the Rio Grande Basin, the following issues were identified regarding supply availability:

- There is very limited availability of water for development under the Rio Grande Compact. Sections 4 and 7 describe the compact and supply availability.
- RICDs and CWCB instream flow water rights may impact the ability to manage water supplies upstream of these water rights.

10.1.8.3 Rio Grande Basin Summary of Conditional Storage Rights

To portray the conditional storage rights present in the Rio Grande Basin, the area was described using water districts as shown in Figure 10-20.

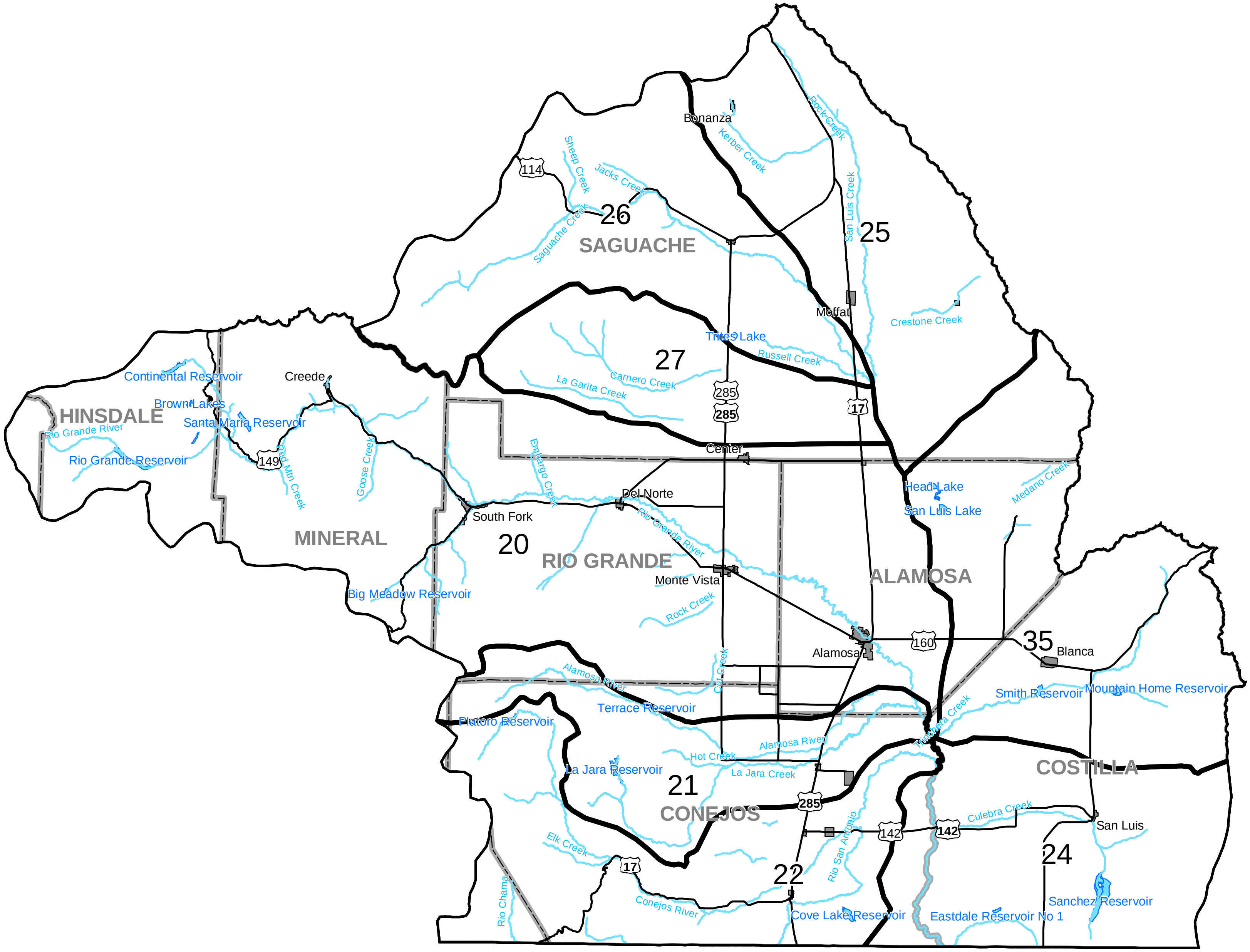
The eight water districts in the Rio Grande Basin can also be described using the main stream systems, which are shown in Table 10-16.

Table 10-16 Rio Grande Basin Water Districts and Associated Stream Names

Water District	Stream Name
20	Rio Grande River
21	Alamosa River
22	Conejos River
24	Culebra Creek
25	San Luis Creek
26	Saguache Creek
27	Camero/ La Grita Creek
35	Trinchera Creek

As shown in Table 10-17, four water districts in the Rio Grande Basin contain a total of 134,105 AF of conditional storage rights, which exceeds the amount that can be developed given compact limitations. Approximately 8,600 AF of these rights have priority dates of 1900 to 1920. The remaining have priority dates that begin in 1960 and that extend to present day. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation. The number, rather than volume, of conditional rights is presented in Appendix H.

Water District 20 in the Rio Grande Basin has the largest volume of conditional storage rights. This is depicted in Table 10-17 and also presented graphically in Appendix H. There is approximately 120,000 AF of conditional storage rights in this water district with priority dates beginning in 1900. Figure 10-21 focuses on the priority date of the conditional storage rights. The largest portion of storage rights have priority dates of between 1960 and 1980, followed by the 1980 to 2002 time period.



10-36

Figure 10-20
Rio Grande Basin
Water Districts

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Water District

10 5 0 10 Miles
1:1,000,000

N
Coordinate System
NAD 1927 UTM Zone 13N

Table 10-17 Volume of Conditional Storage Rights by Priority (AF) in the Rio Grande Basin

Water District	Stream Name	1900-1920	1920-1940	1940-1960	1960-1980	1980-2002	Total
20	Rio Grande River	8,606	0	0	79,660	34,548	122,814
26	Saguache Creek	0	0	0	0	4	4
27	Camero/ La Grita Creek	0	0	0	0	2,750	2,750
35	Trinchera Creek	0	0	0	0	8,537	8,537
Total		**8,606**	**0**	**0**	**79,660**	**45,839**	**134,105**

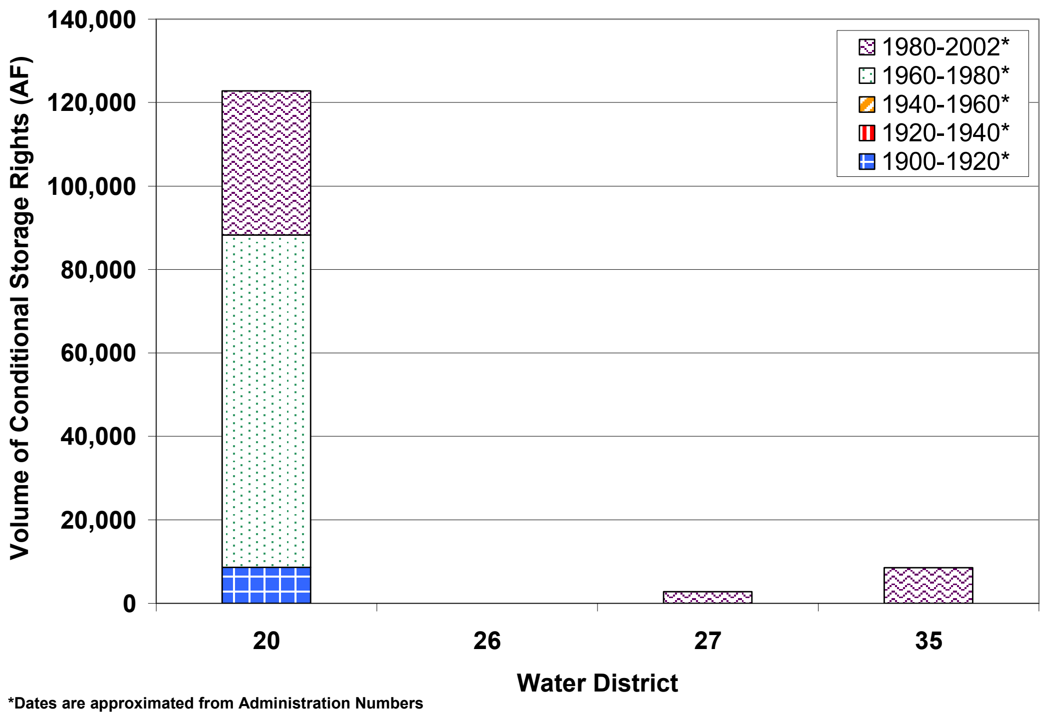


Figure 10-21
Volume of Conditional Storage Rights by Priority (AF) in the Rio Grande Basin

A map of the locations of the conditional storage rights in the Rio Grande Basin is shown in Figure 10-22. Different colored circles are used to represent the total volume of conditional rights that each location holds. Most of the rights are held in the western portion of the basin. This figure also shows the locations of potential damsites in the Rio Grande Basin, as discussed in Section 10.1.8.4 below.

Due to the limited availability of water in the Rio Grande and compact limitations on post-compact reservoir storage as described in Section 7, development of conditional rights is not anticipated.

10.1.8.4 Rio Grande Basin Summary of Restricted Reservoirs and Potential Storage Sites

A few restricted reservoirs exist in the Rio Grande Basin and are listed in Table 10-18. The total volume of restricted storage in the basin is equal to 9,800 AF. Two reservoirs are located in Water District 20 – the Bristol Head #1 and the Continental Reservoirs. Reasons for restrictions include inoperable outlet/poor general condition, causing a loss of 121 AF, and leakage that causes a loss of 7,679 AF, respectively. Continental is a pre-compact reservoir, which makes storage very valuable; however, extensive work has been done on the reservoir to reduce leakage, but with limited success. The other restricted reservoir is located in Water District 21. The Terrace Dam has 2,000 AF of restricted storage due to a deteriorated spillway. These reservoirs have limited availability of physical supply and the owners do not have the ability to pay for the needed improvements. It is unlikely that these reservoirs will be rehabilitated and the storage restrictions lifted unless a third party provides funding.

Figure 10-23 also shows these data graphically. No other water districts in the Rio Grande Basin have restricted damsites.

Figure 10-22 shows the locations of potential damsites identified by the CWCB in the Rio Grande Basin, along with the conditional storage rights locations. Different colored circles are used to represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage.

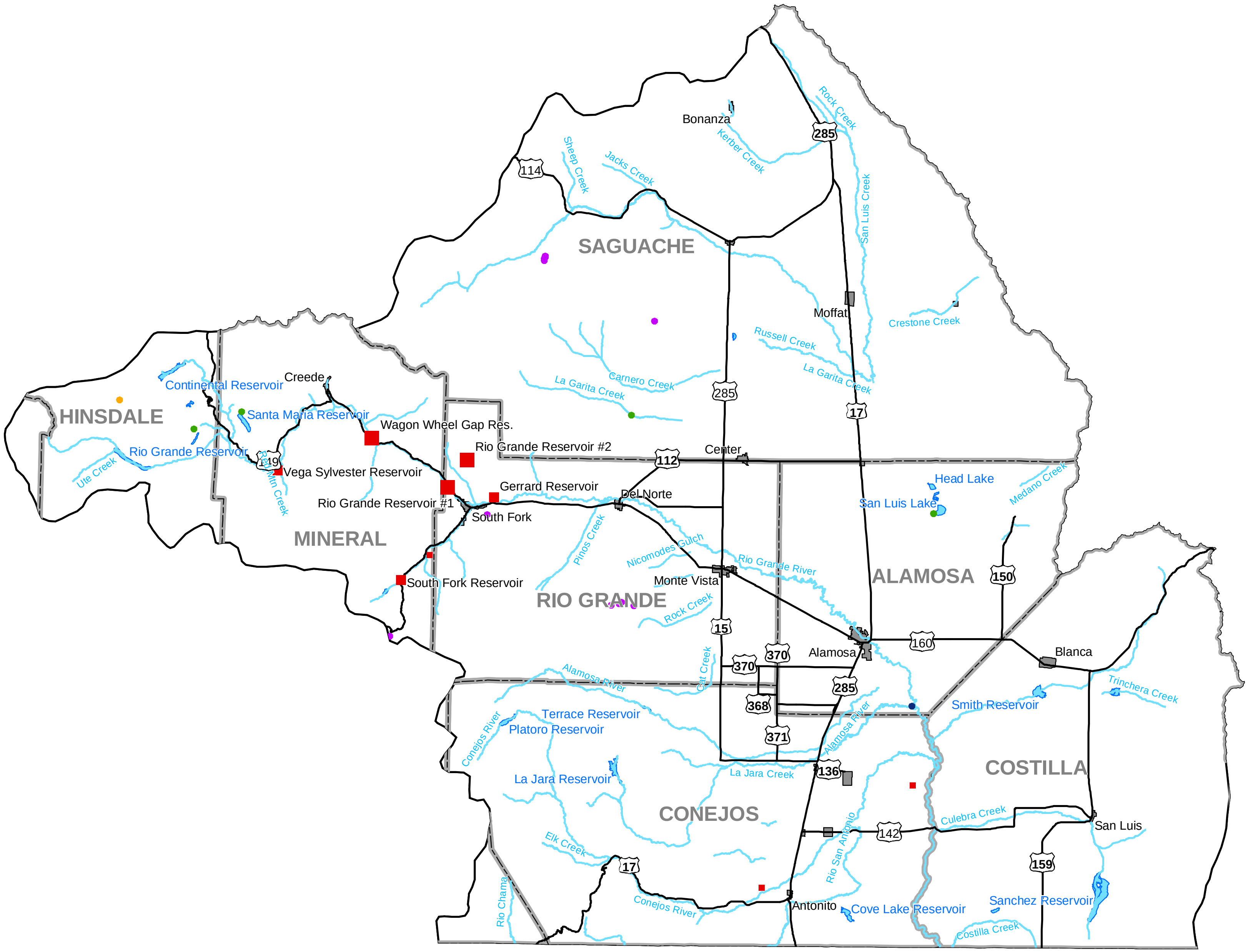


Figure 10-22
Rio Grande Basin Conditional Storage Rights and Potential Damsite Locations

Streams
Lakes and Reservoirs
Highways
Counties

Municipalities

CWCB Damsite Inventory (AF)
- 5,000 - 100,000
- 100,001 - 400,000
- 400,001 - 1,000,000
- 1,000,001 - 2,550,000
- 2,550,001 - 6,500,000

Conditional Storage Rights (AF)
- <250
- 250 - 1,000
- 1,000 - 10,000
- 10,000 - 1,006,768

10 5 0 10 Miles
1:1,000,000

N

Coordinate System
NAD 1927 UTM Zone 13N

Table 10-18 Restricted Damsite Inventory in the Rio Grande Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
200105	20	Bristol Head #1	Zero Storage	Inoperable Outlet/Poor General Condition	0	8/6/2002	121
200110	20	Continental	GH 64.5	Leakage	64.5	8/1/1995	7,679
210102	21	Terrace	7.0 Spillway	Deteriorated Spillway	117	7/18/1984	2,000

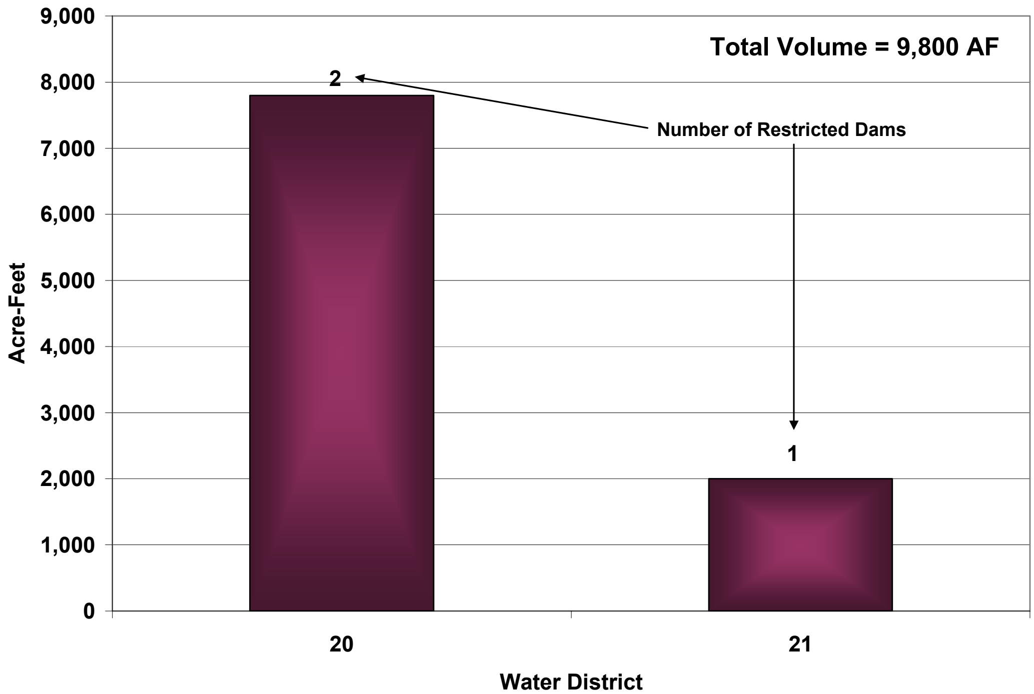


Figure 10-23
Total Volume of Restricted Storage (AF) in the Rio Grande Basin

10.1.9 South Platte Basin

10.1.9.1 South Platte Basin Gap Analysis Issues

As presented in Section 6, the gap analysis process presented at the Basin Roundtable Technical Meetings provided information on the Identified Projects and Processes that M&I water providers are reasonably confident of implementing to meet 2030 water demands. As noted in earlier sections of this report, the Republican River subbasin was not analyzed for this report. Key activities related to water supply planning and basin specific issues raised throughout the meetings and SWSI process with respect to M&I and SSI demands in the South Platte Basin include the following:

- The South Platte is a diverse and heavily urbanized basin. Agriculture is still the dominant water use but rapid changes are occurring and the impacts to rural communities are a key concern.
- Turf based recreation (soccer, baseball, golf, football), parks, and urban landscape is very important to the economy and an important component to quality of life.
- Many of the major surface water providers believe they will be able to meet 2030 needs through existing supplies, projects underway, and future plans and projects.
- New storage and enlargement of existing reservoirs will be major components in meeting 2030 demands.
- Approximately 2 to 3 AF of storage is needed to carry over agricultural water rights transferred for use by M&I users in the non-irrigation season and for below-average runoff years.
- Reuse is being pursued by most providers that have reusable supplies through implementation of the following:
  - Water rights exchanges.
  - Non-potable use for irrigation of parks and golf courses.
  - Groundwater recharge.
  - Gravel lake storage for storing reusable return flows for later use for exchange or non potable irrigation.
- Water conservation is a part of most water providers' plans to meet future water supply needs.
- Most providers do not foresee or propose to implement extreme (Level 5) conservation due to concerns over:
  - Water demand hardening and the related impact on reliability of supply during droughts (explained in Section 8).
  - Quality of life impacts as a result of financial impacts and/or reduced landscaping.
  - Customer acceptance of very high water rates or the inability to landscape as they desire.
  - Lawn watering is a source of water supply and can be used during periods of drought by restricting water use.
- Most providers indicated they would acquire additional agricultural rights to meet future demands rather than implement extreme levels of conservation that would have adverse impacts on their customers.
- Water reuse and conservation will put added pressure on agriculture as return flows diminish.
- Return flows from M&I lawn watering are used to maintain historical agricultural return flow requirements from transferred agricultural rights. Reducing these return lawns through water conservation may result in the need for the M&I provider to acquire other sources of water to maintain the required return flows.
- Competition for water is fierce and it is unclear how much competition there is for the same water supplies.
- The lack of any new major water storage in the last 20 years has led to the use of non-renewable groundwater in Douglas, Arapahoe, and northern El Paso Counties (El Paso County is in the Arkansas Basin). Explosive growth in these counties coupled with the lack of surface water supplies led to the creation of multiple small water districts and makes coordinated water development a challenge and less efficient, especially in light of limited renewable surface water supplies.

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

- There are average annual shortages throughout the basin.
- The continued pressure on the transfer of Colorado Big Thompson units from agriculture to M&I will

further increase shortages as CBT water is a supplemental agricultural supply.

- The Lower South Platte groundwater users need alternatives for developing augmentation supplies for irrigation wells. Over 60,000 acres of currently irrigated lands may no longer be irrigated due to recent well augmentation requirements.

10.1.9.2 South Platte Basin Supply Availability Issues

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

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

10.1.9.3 South Platte Basin Summary of Conditional Storage Rights

To portray the conditional storage rights present in the South Platte Basin, the area was described using water districts as shown in Figure 10-24.

The 15 water districts in the South Platte Basin can also be described using the main stream systems, which are shown in Table 10-19.

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

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

Various water districts in the South Platte Basin contain conditional storage rights that date back to the early 1900s and extend to present day. As shown in Table 10-20 there are 3.6 million AF of conditional storage rights in the basin. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation. The number, rather than volume, of conditional rights is presented in Appendix H.

Water District 1, followed by District 8 in the South Platte Basin, has the largest volume of conditional storage rights. This is depicted in Table 10-20 and also presented graphically in Appendix H. Water District 1 has almost 1.4 million AF of conditional storage rights and Water District 8 has nearly 638,000 AF.

Figure 10-25 focuses on the priority date of the conditional storage rights. The most recent priority time period of between 1980 and 2002 has the largest amount of conditional storage rights in the South Platte, about 1.8 million AF, which far exceeds available supplies. The 1960 to 1980 period follows with a total of approximately 892,000 AF.

A map of the locations of the conditional storage rights in the South Platte Basin is shown in Figure 10-26. Different colored circles are used to represent the total volume of conditional rights that each location holds. Most of the rights are held in the western portion of the basin and along Interstate 76. This figure also shows the locations of potential damsites in the South Platte Basin, as discussed in Section 10.1.9.4 below.

As described in Section 7, in the South Platte Basin, many M&I providers have reservoir enlargement plans that will help them grow into existing rights and allow development of some existing conditional water rights.

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

Nearly 100 restricted reservoirs exist in the South Platte Basin and are listed in Table 10-21. The total volume of restricted storage in the basin is 48,929 AF. Eighteen restricted reservoirs are located within Water District 1, totaling about 25,000 AF of lost storage, and two reservoirs are located in Water District 64 with slightly less than 10,000 AF of lost storage. More than 7,000 AF of storage is lost in the seven restricted reservoirs in Water District 23. Given the limited water supply availability in the South Platte Basin, recovery of storage lost to restrictions should be explored in more detail.

Figure 10-27 also shows these data graphically. While the other water districts in the South Platte Basin have restricted damsites, except Districts 49, 80, and 101, Figure 10-27 shows that each district has less than 5,000 AF of potential storage if repairs were made.

Figure 10-26 shows the locations of potential damsites identified by the CWCB in the South Platte Basin, along with the conditional storage rights locations. Different colored circles are used to represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage.

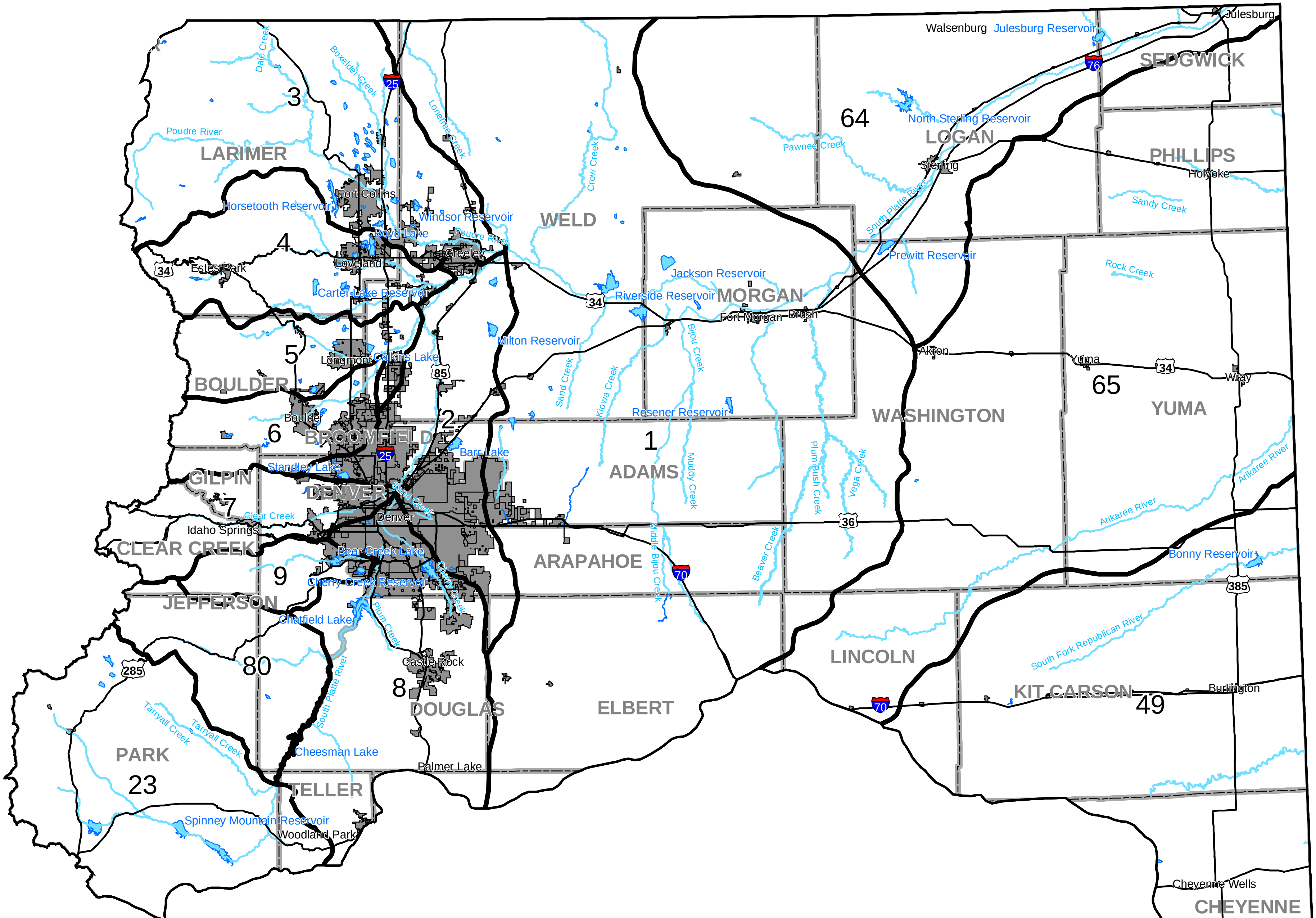


Figure 10-24
South Platte Basin
Water Districts

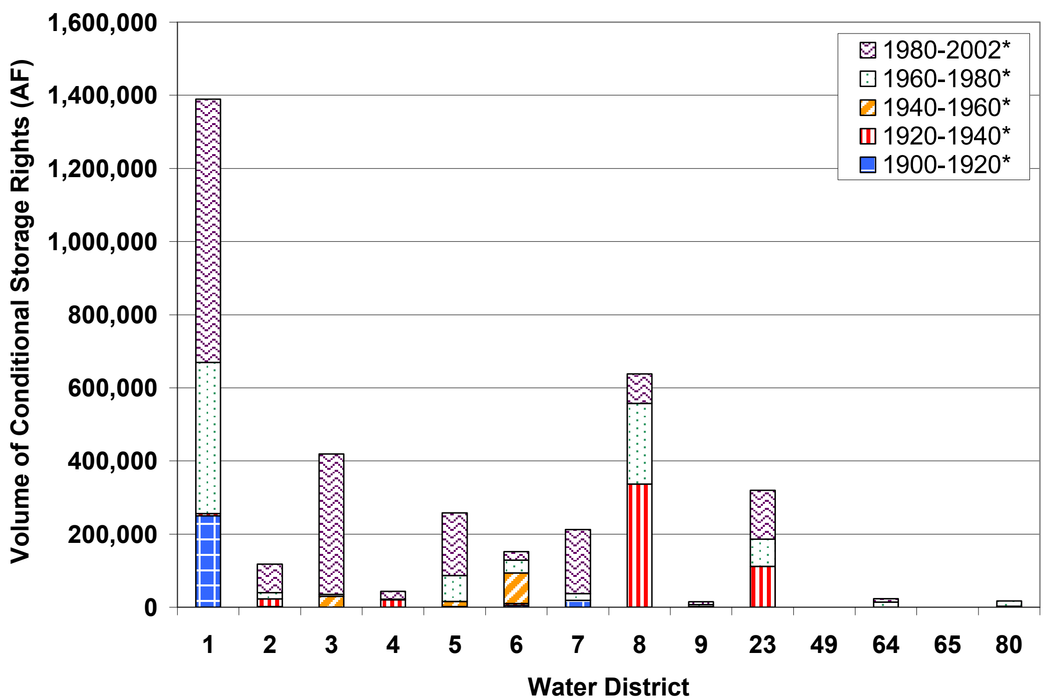
Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Water District

10 5 0 10 Miles
1:1,500,000

N
Coordinate System
NAD 1927 UTM Zone 13N

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

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



*Dates are approximated from Administration Numbers

Figure 10-25
Volume of Conditional Storage Rights by Priority (AF) in the South Platte Basin

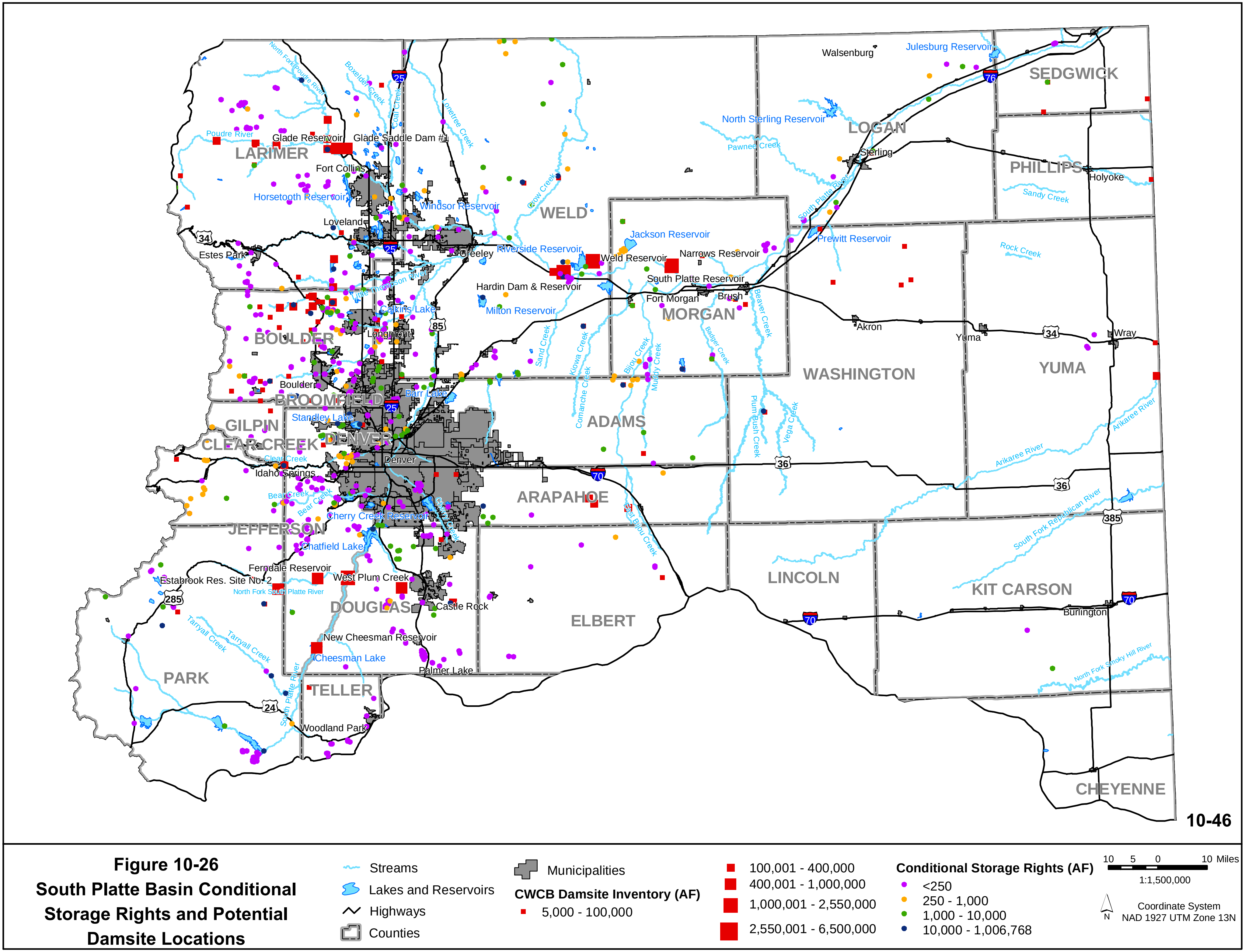


Figure 10-26
South Platte Basin Conditional Storage Rights and Potential Damsite Locations

Table 10-21 Restricted Damsite Inventory in the South Platte Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
010104	01	Adams & Bunker #3	6.0 crest	Inadequate freeboard, seepage	0	5/22/1975	150
010115	01	Bijou #2 Dam #1	GH 16 but not > GH 15 for > 30 days	Scarping, seepage, no spillway	16	6/1/1993	2,400
010723	01	Bijou #2 Dam #2	GH 16 but not > GH 15 for > 30 days	Scarping, seepage, no spillway	16	6/1/1993	2,400
010724	01	Bijou #2 Dam #3	GH 16 but not > GH 15 for > 30 days	Scarping, seepage, no spillway	16	6/1/1993	2,400
010725	01	Bijou #2 Dam #4	GH 16 but not > GH 15 for > 30 days	Scarping, seepage, no spillway	16	6/1/1993	2,400
010419	01	D.A. Lord #4	2.0 spillway	Inadequate spillway	0	9/19/1980	400
010138	01	Dover	10.0 ft. crest	Poor condition		6/27/1996	60
010728	01	Empire (east embankment	GH 29.0	Lack of emergency spillway	29	3/7/1985	2,779
010729	01	Empire (freeboard dike)	GH 29.0	Lack of emergency spillway	29	3/7/1985	2,779
010727	01	Empire (McIntyre Dike)	GH 29.0	Lack of emergency spillway	29	3/7/1985	2,779
010726	01	Empire (NW embankment)	GH 29.0	Lack of emergency spillway	29	3/7/1985	2,779
010210	01	Empire (outlet embankment)	GH 29.0	Lack of emergency spillway	29	3/7/1985	2,779
010716	01	Howards Lake	3.0 ft. spillway	Erosion of dam and crest		6/3/1998	50
010132	01	J.B. Cooke	3 ft. below top of headwall	Provide minimum freeboard		5/6/1998	0
010709	01	Jolly John	No storage	Scour hole from outlet	0	10/27/2000	297
010612	01	No Name 1-1 #1	10 ft. crest	Scour of d/s slope due to failure of outlet		11/2/2000	100
010806	01	Prospect	GH 35.5	Maintenance & monitoring issues	35.5	4/15/1981	588
010506	01	Riverside	GH 33.55 ft.	No spillway; 33.55 is max decree	33.5	5/9/1984	0
020109	02	Bright View #1	7.0 crest	Inop. Outlet, inadequate freeboard	0	9/30/1985	17
020113	02	Carlin	5.0 crest	No spillway	0	7/29/1986	0
020119	02	Cole	No storage	Poor condition	0	6/30/1994	95
02023	02	East Lake #1	No storage	Inadequate spillway, poor condition	0	3/19/1992	125
020615	02	Havana Street Dam	No storage	No spillway	0	6/17/1987	0
020615	02	Havana Street Dam	No Storage	No Spillway	0	6/17/1987	0
020115	02	Lower Church Lake	3.0 feet Crest	Inadequate Spillway		6/22/1999	0
020237	02	Marshall	5 ft. below dam crest	Obstructed spillway, etc.		10/21/2002	10
020606	02	Mower	3 Feet below Lowest Point of Dam Crest	Inadequate Spillway and Freeboard		5/22/2002	8
020411	02	Nissen #2	1.75 Spillway	Lack of Freeboard		9/11/1995	50
020314	02	North Start	5.0 Below Dam Crest	Sinkhole on Downstream Slop		2/11/2003	
020327	02	Rankin Reservoir	No Storage	Poor Condition	0	7/12/1995	44
020322	02	Signal #1	5.0 Crest	Concentrated Spg. Areas & Questionable Condition of Outlet	0	6/21/1993	60
020333	02	Thompson	5.0 Crest	Inadequate Freeboard, Generally Poor Condition	0	10/7/1987	30
030107	03	Black Hollow	4.2 feet Spillway	Inadequate Spillway	31	10/22/1997	999

Table 10-21 Restricted Damsite Inventory in the South Platte Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
030108	03	Box Elder #2	3.0 feet Spillway	Excessive Seepage	6.5	8/8/1989	49
030122	03	Curtis Lake	GH 10 feet	Crest, Slope, Ext. Seep. Area Below D/S Toe	10	7/2/1985	397
030128	03	Dry Creek	GH 11.5 feet	Outlet Deterioration, See Page, Inad. SW	11.5	1/17/1996	150
030138	03	Gray #3	No Storage	Sinkhole Over Outlet	0	5/27/1997	100
030214	03	Law, John	3.0 Crest	Inadequate Spillway and Freeboard	11	6/22/1987	45
030220	03	Mattingly	2.0 feet Spillway	Erosion/3-5 Feet Scarp on U/S Face		10/23/1997	99
030225	03	Mountain Supply # 1	10 feet Crest	Poor Condition	5	11/5/1997	500
030226	03	Mountain Supply # 2	10 feet Crest	Poor Condition	5	11/5/1997	300
030227	03	Mountain Supply # 6	3.0 Crest	No Freeboard		10/19/2000	120
030229	03	Mountain Supply # 8	No Storage	Poor Condition	0	10/3/1978	643
030236	03	North Poudre # 1	7.0 Crest	Seep @ Higher Stge. Levels/Cond. Of upslope	9	10/17/1988	365
030301	03	North Poudre # 4	GH 17 feet	Poor U/S Face, General Condition	17	4/17/1984	562
030512	03	Rist Canyon	3.0 Crest	Seepage, Inadequate Spillway	0	4/19/1983	33
040101	04	Arrowhead	zero storage	Sinkhole; inoperable outlet	0	1/14/2003	230
040123	04	Fairport	6.0 Spillway	Poor Condition	6	6/22/1987	363
045234	04	Ide and Starbird #1	3.0 Crest	Poor Mn, Eroded U/S Face, Quest. Spillway	0	7/3/1985	0
040211	04	Ryan Gulch	GH 27.6	Inadequate Spillway, Leakage	27.6	2/12/1997	40
040213	04	South Side	8.0 Crest	Dam Unsafe for Orig. Stor. Amount	8	7/7/1978	105
040237	04	Westerd OIl Lake	8.5 Crest	Poor Condition		3/30/1992	9
050101	05	Akers & Tarr	7.0 Crest Oct. 1 – April 1	Slide on D/S Slope, Spge. In Area of Aband. Otl.	0	3/23/1989	34
050132	05	Highland	3.0 Below top of concrete wall at outlet	No Spillway	0	11/26/1990	0
050206	05	Knoth	No Storage	Never Completed Dam	0	12/24/1985	204
050212	05	Little Gem	10.0 Crest	Erosion on U/S Slope & Crst, Trees on U/S Slope	0	10/11/1985	60
050301	05	Steele Brothers #1	4.0 Spillway	Sat Embkmt.; Inop. O's.; Inad. Fbd.; Spwy. Repair	0	12/1/1987	34
050302	05	Steele Brothers #2	3.0 Spillway	Total Rehabilitation Required	0	11/23/1987	14
050304	05	Swede	5.0 Crest	Embankment Seepage & Inadequate Freeboard	0	11/14/1986	75
050308	05	Union	GH 28.0	Spillway design based on GH=28.0	28	12/6/1977	0
060122	06	Green Lake No. 1	3.0 Crest	Seepage, No Spillway	0	10/12/1984	30
060124	06	Green Lake No. 3	3.0 Crest	Leaks, Inadequate Spillway Freeboard	0	10/8/1984	60

Table 10-21 Restricted Damsite Inventory in the South Platte Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
060314	06	Hogdson-Harris	6.0 Crest	Poor Condition		11/14/1995	60
060202	06	McKay Lake – East Dam	GH 11 feet	Inadequate Freeboard, Seepage	11	9/11/1995	90
060204	06	Mesa	No Storage	Poor Condition		6/28/2000	100
060212	06	Section 19	4.0 Crest	No Spillway	0	7/24/1984	10
060306	06	Varsity Pond	1 feet Spillway	Seepage/Spillway		8/31/1999	1
070126	07	Dewey No. 1	3.0 Crest (NW)	Poor Condition	0	11/19/1990	15
070111	07	Idaho Springs	8.0 Crest	Seepage, Settlement & Repairs Reqd. on Spwy.	22	2/27/2002	19
070201	07	Kalcevic	11.0 Crest	Eroded Upstream Slope	0	2/10/1983	43
070202	07	Kelly	3.0 Crest	No Spillway	0	12/5/1986	0
075311	07	Smith	1.0 Spillway	Seepage	0	1/26/2000	100
080101	08	Allis	15.0 Crest	Sloughing, Seepage	0	8/25/1992	50
080105	08	Baird #1	7.0 Crest	Severe Beaver Activity, Plugged Outlet	0	1/8/1990	25
080110	08	Cantrill	No Storage	No Spillway, Inoperable Outlet	0	10/22/1987	37
080424	08	Gerlits	No Storage	Dam Partially Breached Due to Overtopping.	0	11/13/1984	10
080321	08	Quick	No Storage	No Spillway, Inoperable Outlet	0	10/22/1987	64
080422	08	Rainbow Falls #5	9.0 Crest	Inadequate Spillway	0	9/11/1985	25
080327	08	Skeel	2.0 feet Spillway	Poor Condition		4/2/1997	10
080306	08	Wakeman	No Storage	Spillway Erosion		10/17/1994	110
090102	09	Beers Sisters Lake	5' Below Dam Crest	Inadequate Spillway		1/8/1999	15
090115	09	Harriman	GH 19 feet	Excessive Seepage	19	11/12/1992	300
090138	09	Haystack #1	No Storage	Spillway Undermined	0	5/8/1987	3
090204	09	Willow Springs #1	1.0 Spillway	Erosion of U/S Face	13.5	9/14/2000	10
230102	23	Antero	GH 18 feet	Stab. Berm Const. & new Instr. Monitoring	18	2/4/1986	5,100
230104	23	Bayou Salado	One-Foot Below Spillway Crest	Unsatisfactory & Unsafe Condition of Spillway		8/29/2002	26
230308	23	Mountain	4.0 Crest	Insufficient Freeboard, Seepage at Toe	0	11/6/1985	3
230310	23	Stocking Pond	No Storage	Inadequate Spillway	0	6/13/1988	10
230311	23	Sun	5.0 Crest	Seepage-Restrict O 8' Below Crest	0	12/31/1984	6
230208	23	Tarryall	No Storage	Unstable During Overtopping		8/21/2002	1,963
230312	23	Wind	5.5 Crest	Saturated D/S Slope	0	9/20/1985	3
640104	64	Julesburg #4	GH 24 Feet for 90 days, then GH 23 feet	Condition of Outlet, Excessive Seepage	24	5/2/1995	6,964
640108	64	Prewitt	GH 26.5 feet	No Spwy & Excessive Seepage	26.5	8/23/1990	2,531
650121	65	Duck	4.0 Spillway	Narrow Crest, Steep Slopes	0	3/23/1987	15
650123	65	Hanshaw	5.0 Crest	Seepage, slide, overall poor	0	7/7/1987	12

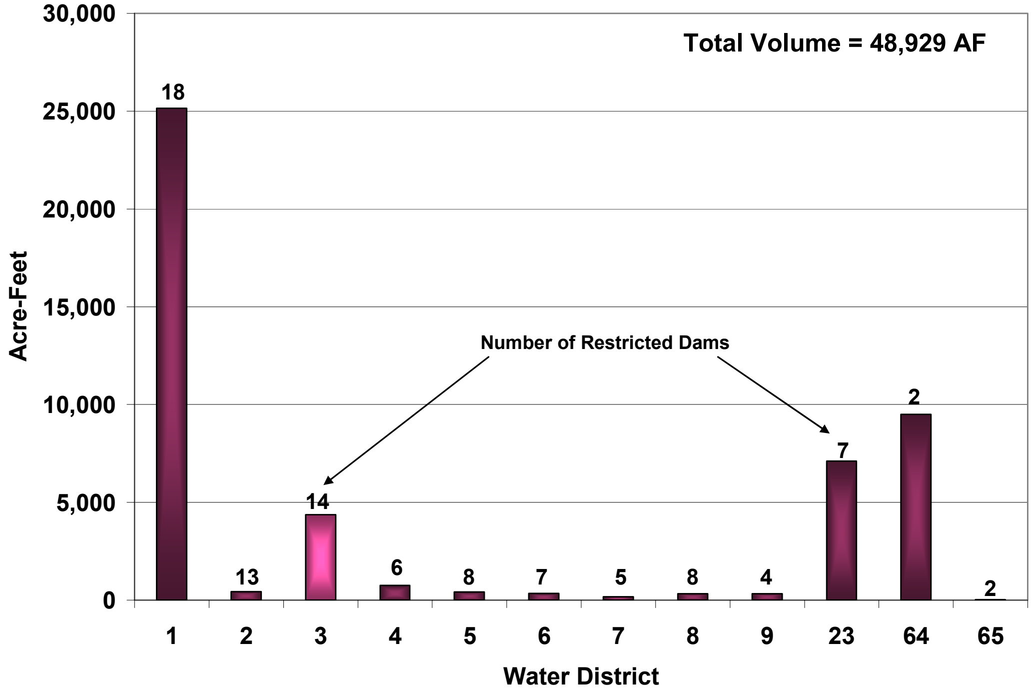


Figure 10-27
Total Volume of Restricted Storage (AF) in the South Platte Basin

10.1.10 Yampa/White/Green Basin

10.1.10.1 Yampa/White/Green Basin Gap Analysis Issues

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

- Agriculture, tourism, and recreation are vital components to this basins economy.
- Industrial uses, especially thermal electric power generation, is a major water use.
- Projects have been identified to meet 2030 M&I and SSI demands.
- Excessively high transit losses have been experienced during dry years delivering stored water downstream to water users.
- Elkhead and Stagecoach Reservoir enlargements are critical to meeting future needs.
- The timing and magnitude of oil shale development are an unknown, but could be significant if oil shale development were to occur.

Agricultural issues noted throughout SWSI in the Yampa/White/Green Basin include:

- Agricultural shortages greater than 10 percent were identified in Water Districts 44 and 54.
- 20,000 to 40,000 acres of potentially irrigable lands and available supply were identified, but funding would be needed as agricultural users do not have the ability to pay for the projects.
- Water shortages occur on many tributaries, but developing storage is a challenge without financial assistance.

10.1.10.2 Yampa/White/Green Basin Supply Availability Issues

In the Yampa/White/Green Basin, the following issues were identified regarding supply availability:

- Colorado River Compact
  - While rapidly growing in some areas (Yampa River/Steamboat area), the basin is not developing as rapidly as other portions of the state. This has led to concern that the basin will not get a "fair share" of the water use afforded to Colorado under the Colorado River Compact.
  - Concern over a potential compact call due to severe and sustained drought.
- Endangered Species
  - The success of the Endangered Species program is critical to help protect current and future water uses.
- RICDs and CWCB instream flow water rights may impact the ability to manage water supplies upstream of these water rights.

10.1.10.3 Yampa/White/Green Basin Summary of Conditional Storage Rights

To portray the conditional storage rights present in the Yampa/White/Green Basin, the area was described using water districts as shown in Figure 10-28.

The seven water districts in the Yampa/White/Green Basin can also be described using the main stream systems, which are shown in Table 10-22.

Table 10-22 Yampa/White/Green Basin Water Districts and Associated Stream Names

Water District	Stream Name
43	White River
44	Williams Fork/Yampa River
54	Slater Creek/Little Snake River
55	Little Snake River
56	Green River
57	Yampa River
58	Elk/Yampa Rivers

All the water districts in the Yampa/White/Green Basin contain conditional storage rights, with a total of 204 AF in Water District 43 that has a priority date of 1900 to 1920. The other conditional storage rights were adjudicated beginning in 1940. As shown in Table 10-23, there are approximately 5,000,000 AF of conditional storage rights in the basin, which far exceeds available supplies. The numbers presented in this table describe the total volume of conditional rights by priority time period and not the number of individually decreed conditional rights. These priority time periods are based on adjudication dates and used solely for the purpose of aggregating the numerous conditional rights into a table for presentation. The number, rather than volume, of conditional rights is presented in Appendix H.

Water Districts 44 and 43 in the Yampa/White/Green Basin have the largest volume of conditional storage rights. This is shown in Table 10-23 and also presented graphically in Appendix H. Almost 4,000,000 AF are present in these two water districts.

Figure 10-29 focuses on the priority date of the conditional storage rights. The largest portion of storage rights have priority dates of between 1960 and 1980, followed by the 1980 to 2002 time period.

A map of the locations of the conditional storage rights in the Yampa/White/Green Basin is shown in Figure 10-30. Different colored circles are used to represent the total volume of conditional rights that each location holds. This figure also shows the locations of potential damsites in the Yampa/White/Green Basin, as discussed in Section 10.1.10.4 below.

10.1.10.4 Yampa/White/Green Basin Summary of Restricted Reservoirs and Potential Storage Sites

A few restricted reservoirs exist in the Yampa/White/Green basin and are listed in Table 10-24. The total volume of restricted storage in the basin is 667 AF and rehabilitation of all of these reservoirs will not significantly improve the availability of supply.

Figure 10-31 also shows these data graphically. Figure 10-31 shows that Water Districts 43 and 56 in the Yampa/White/Green Basin also have restricted reservoirs, totaling 73 AF in lost storage.

Figure 10-30 shows potential damsite locations as identified by the CWCB in the Yampa/White/Green Basin, along with the conditional storage rights locations. Different colored circles are used to represent the total volume of conditional rights that each location holds. Potential damsites are classified by total potential storage.

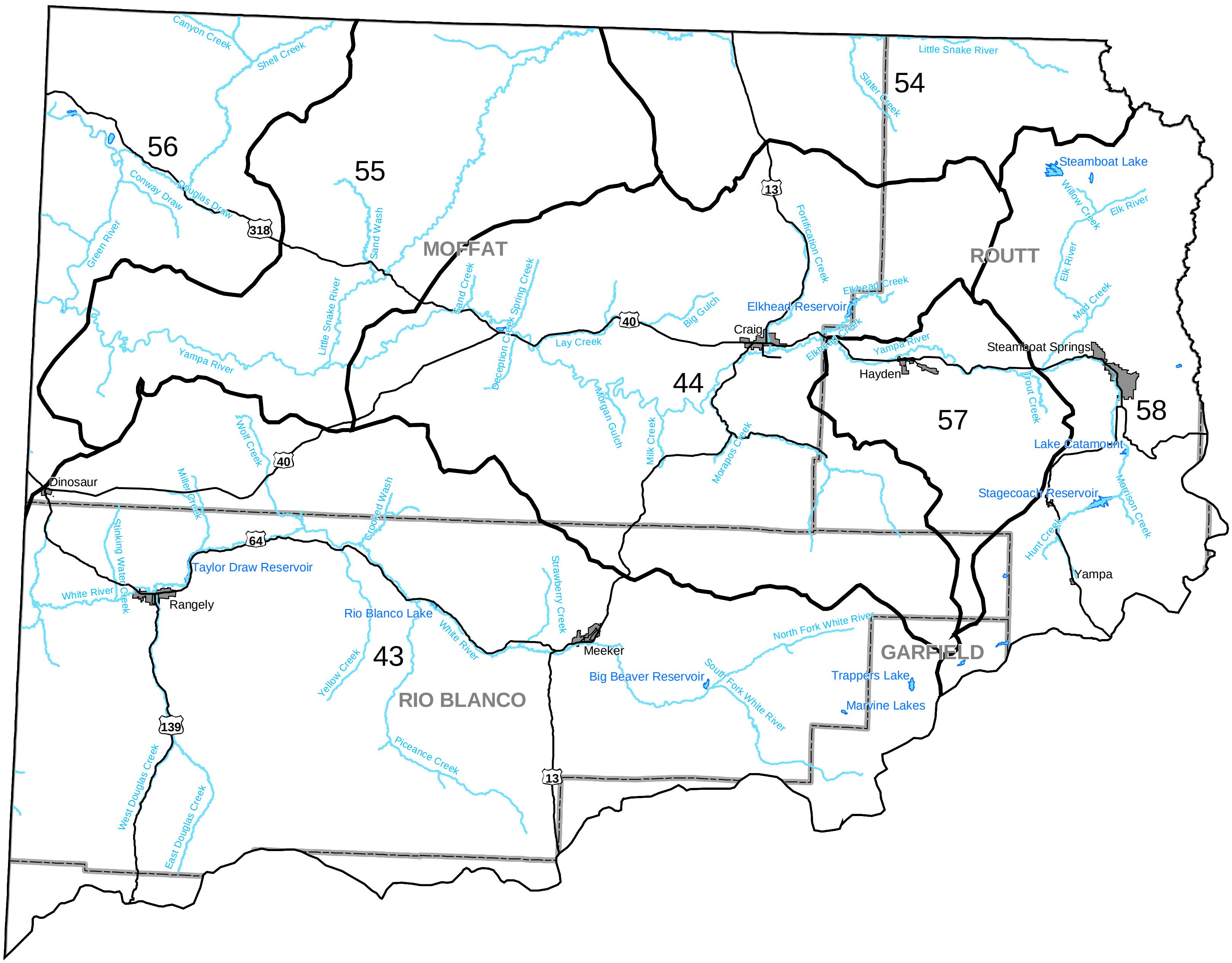


Figure 10-28
Yampa/White/Green Basin
Water Districts

Streams
Lakes and Reservoirs
Highways
Counties
Municipalities
Water District

10 5 0 10 Miles
1:1,000,000

N
Coordinate System
NAD 1927 UTM Zone 13N

Table 10-23 Volume of Conditional Storage Rights by Priority (AF) in the Yampa/White/Green Basin

Water District	Stream Name	1900-1920	1920-1940	1940-1960	1960-1980	1980-2002	Total
43	White River	204	0	12,548	1,018,918	266,128	1,297,798
44	Williams Fork/Yampa River	0	0	844,294	638,662	1,179,449	2,662,405
54	Slater Creek/Little Snake River	0	0	0	323,580	166,898	490,478
55	Little Snake River	0	0	0	0	46,426	46,426
56	Green River	0	0	0	1,200	500	1,700
57	Yampa River	0	0	0	111,010	52,616	163,626
58	Elk/Yampa Rivers	0	0	34	201,579	97,449	299,062
Total		**204**	**0**	**856,876**	**2,294,949**	**1,809,466**	**4,961,495**

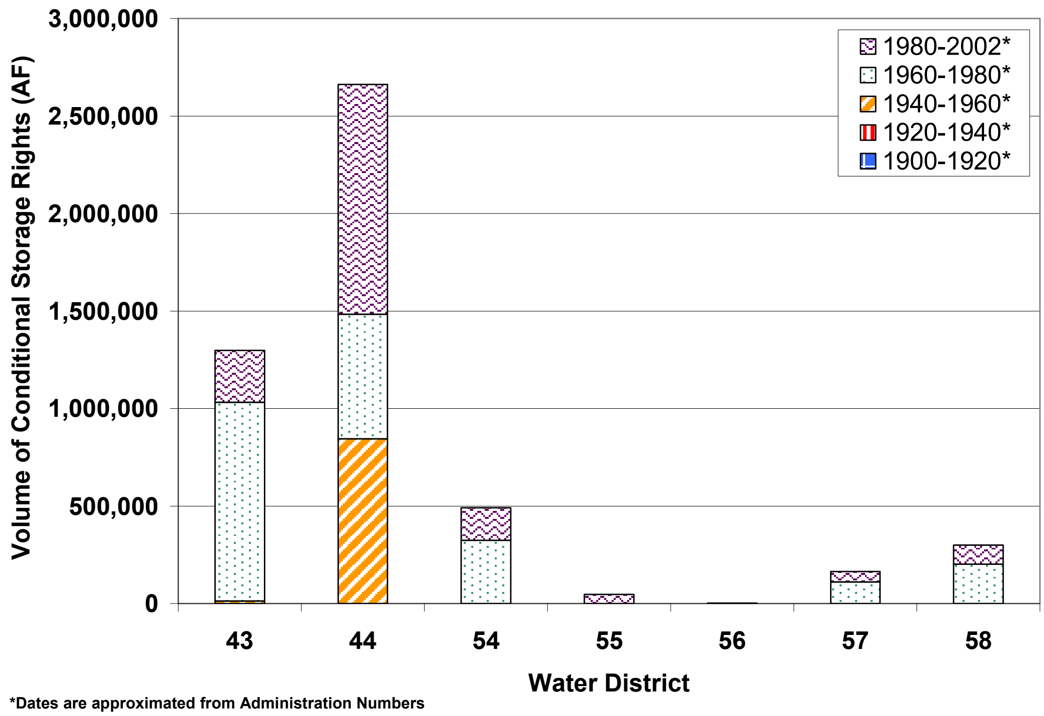


Figure 10-29
Volume of Conditional Storage Rights by Priority (AF) in the Yampa/White/Green Basin

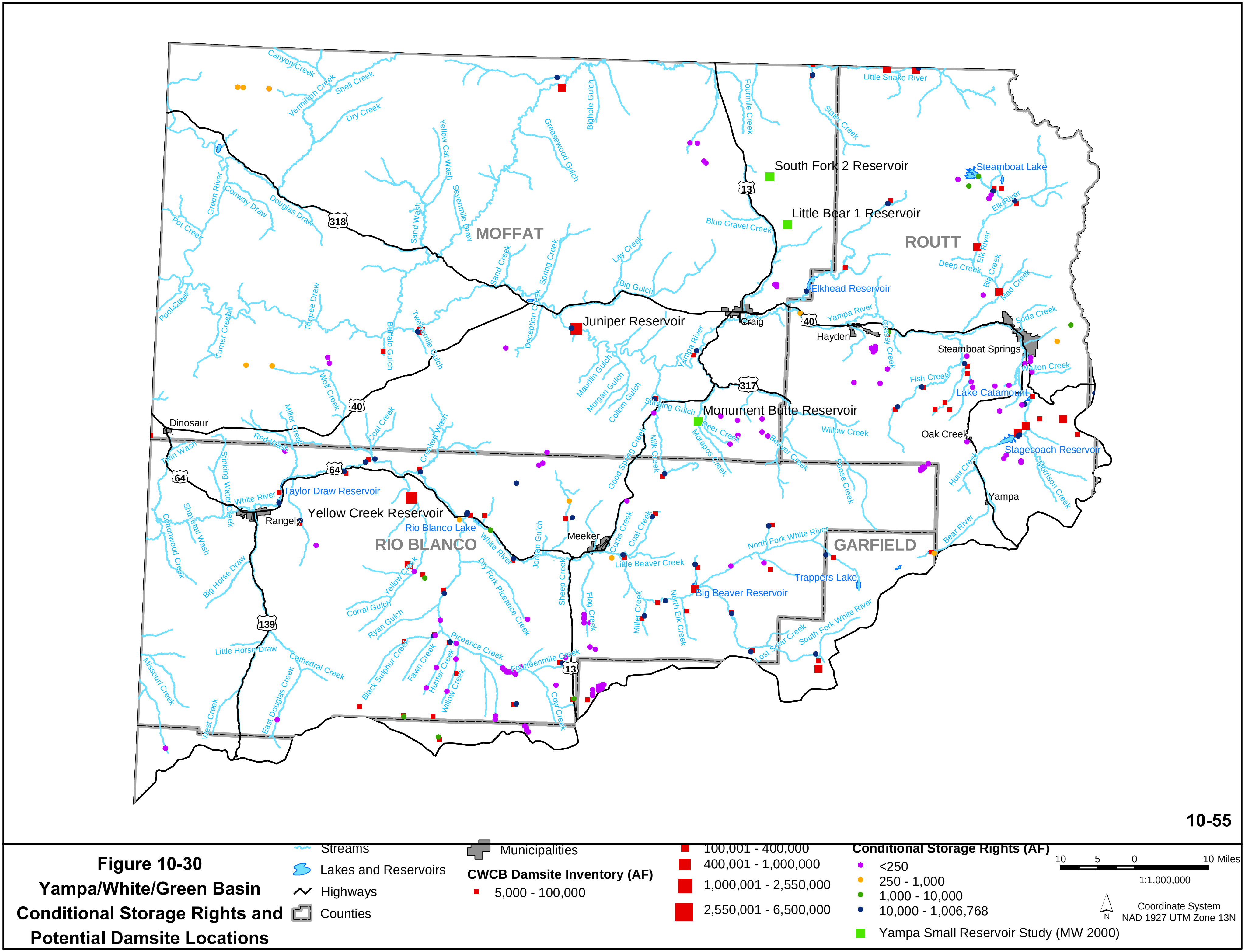


Figure 10-30
Yampa/White/Green Basin
Conditional Storage Rights and
Potential Damsite Locations

Table 10-24 Restricted Damsite Inventory in the Yampa/White/Green Basin

DAMID	Water District	Dam Name	Restricted Reservoir Level	Reason for Restriction	Gage Height	Action Date	Volume Lost
430205	43	Baxter	5.0 feet Spillway	Seepage, Erosion of U/S Face		11/13/1997	30
430212	43	Wilson #3	3.0 Spillway	Inoperable Outlet, Inad. Spillway	3	9/30/1989	10
440106	44	Biskup	5.0 Spillway	Dilapidated Condition	0	8/19/1987	55
440120	44	Drescher	8.0 Spillway	Seepage & Instability	8	8/1/1988	159
440124	44	Ellgen #2	Full Storage	New outlet pipe. Recommend restriction lifted.		2/16/1999	
440213	44	Flattop	5.0 feet Crest Main Dam	Breached, Beaver Dams, Freeboard		8/2/1999	50
560107	56	Basset #2	5-feet Below Spillway Crest	Illegal Dam, Poor Condition		10/21/2002	25
560105	56	Haunted Spring	Zero Storage	Uncontrolled seepage/piping		9/9/2003	8
570114	57	Lake Emrich	15.0 Crest	Slides on Downstream Slope	0	8/30/1988	330

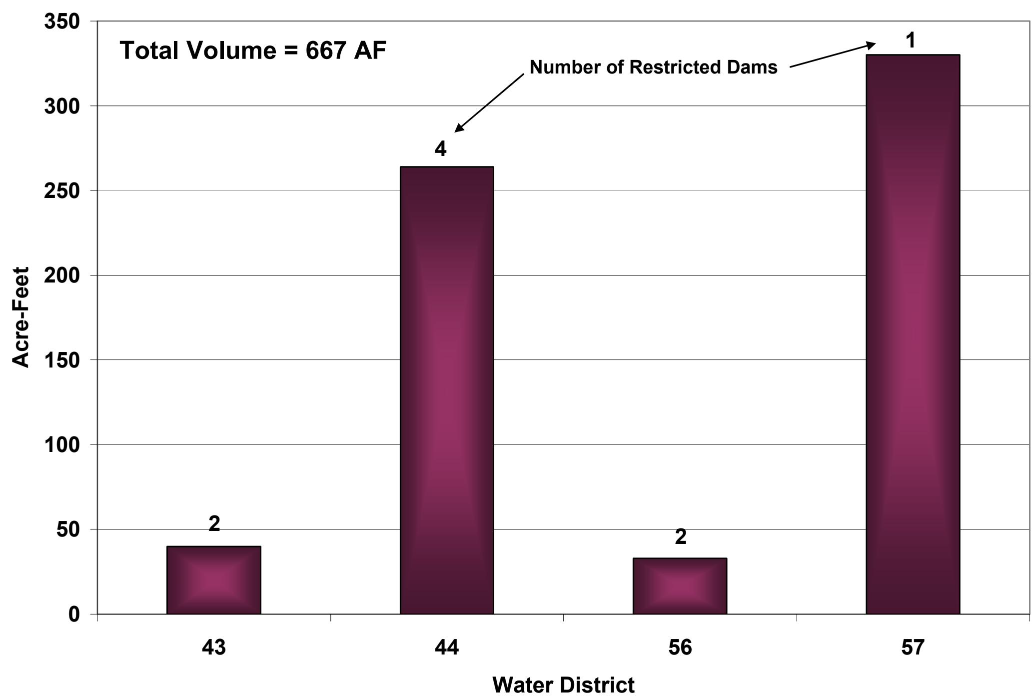


Figure 10-31
Total Volume of Restricted Storage (AF) in the Yampa/White/Green Basin

10.2 Environmental and Recreational Options

Colorado's current and future environmental and recreational water needs bring a unique set of issues to water management. As highlighted in Section 6.1.3, a number of new and innovative approaches to meeting environmental and recreational needs and moving from mitigation to enhancement were discussed through the course of SWSI and the Basin Roundtable Technical Meetings. However, to date, there is no single agreed upon approach or set of criteria, other than the CWCB instream flow program, for prioritizing stream reaches for environmental and recreational enhancement or setting associated flow goals.

Section 6 also provided background on existing flow goals and key programs geared toward meeting environmental and recreational flows on major rivers and tributaries in each basin. Many of the identified flow goals do not have an associated Identified Project or Process to meet the goals, though some Identified Projects and Processes meet multiple goals that can include environmental and recreational benefits.

Looking ahead, SWSI sought to further identify approaches and possible new projects or management strategies – many of which are stand-alone, many of which could potentially be integrated into multi-beneficiary projects – that could be used to address environmental and recreational water needs. In this section, the key concepts guiding the development of future environmental and recreational "options" are discussed along with some potential statewide approaches to environmental and recreational flow enhancement. Section 10.3 presents a basin-by-basin discussion of specific M&I, agricultural, and environmental and recreational options that could be used to meet future needs.

10.2.1 Overview of Environmental and Recreational Options

The primary objectives of the environmental and recreational options compiled and discussed in SWSI are to provide flow and/or habitat enhancement of surface water features – both streams and lakes. Specifically, environmental and recreational options may provide for enhancement of:

- Fish habitat
- Endangered species habitat
- Aquatic recreation
- Water quality
- Wetlands
- Riparian corridors

Some key characteristics and features of these types of options are:

1. Environmental and recreational options are not intended to merely provide mitigation of the impacts of other water supply projects. Mitigation of environmental impacts of new projects is required by law and is already a critical component of project planning. Mitigation is performed to offset potentially deleterious impacts of these projects. Environmental and recreational options, on the other hand, are meant to provide enhancement of resources. As an example, replacing wetlands impacted by a new water supply pipeline is considered environmental mitigation rather than an environmental and recreational option.

2. Environmental and recreational options may be stand-alone projects or may be integrated into other water supply projects (e.g., M&I or agricultural).

3. Environmental and recreational options are to be implemented consistent with state water law and interstate compacts.

4. Environmental and recreational options are subject to NEPA, CWA, ESA, and other applicable laws with respect to mitigating unintended adverse impacts of the options.

10.2.2 Existing Statewide Environmental and Recreational Options

As noted in Section 6, the CWCB has an existing program for appropriating, acquiring, and protecting instream flow water rights and natural lake levels. This stream and lake protection program is designed to "preserve and improve the natural environment to a reasonable degree." The CWCB appropriates minimum stream flows or natural surface water levels or volumes for natural lakes to preserve the natural environment to a reasonable degree. The CWCB is also authorized "to acquire, by grant, purchase, donation, bequest, devise, lease, exchange, or other contractual agreement, from or with any person, including any governmental entity, such water, water rights or interests in water in such amount as the Board determines is appropriate for stream flows or natural surface water levels or volumes for natural lakes to preserve or improve the natural environment to a reasonable degree." The CWCB protects these instream flow water rights both by obtaining terms and conditions in water rights decrees filed by other water users and by monitoring stream flows and assisting the State and Division Engineers in administering the prior appropriation system so that the CWCB's instream flow water rights are not injured.

Additionally, the passage of Senate Bill 216 in 2001, which recognizes a new type of water right – RICDs – has provided a legal avenue for establishing recreational options.

The presence of endangered fish in basins across the state, as described in Sections 3 and 6, influences current stream management in accordance with the ESA. Critical habitat designations have been applied to many reaches in the state with corresponding flow recommendations. While these recommendations are not legally binding, water users are making good faith efforts to meet the recommendations. In this way, the ESA has provided for the establishment of environmental options, albeit non- legally binding options.

In addition, interstate compacts and decrees and senior water rights serve to ensure that river flows are maintained. For example, approximately 75 percent of the water in the Colorado River and its tributaries must flow out of the state pursuant to the compact.

10.2.3 Possible Future Statewide Environmental and Recreational Options

Statewide environmental and recreational options are those that are not specific to a stream reach or locality, and that could potentially be applicable in more than one part of the state. Possible statewide environmental options discussed in the Basin Roundtable Technical Meetings include:

- Sizing of new storage projects to include a dedicated "pool" for environmental instream flow management
- Acquiring by purchase or lease existing water rights to maintain higher instream flows
- Voluntary re-operation of existing projects to enhance environmental benefits without impacting yield
- Releasing reservoir water in a pattern that generally follows "natural" flow conditions; e.g., The Nature Conservancy paper (Richter 1997):
  - Releasing periodic high flows
  - Maintaining average monthly stream flows within ±1 standard deviation of historical average monthly flows

Possible statewide recreational options discussed in the Basin Roundtable Technical Meetings include:

- New reservoir pool sizing to allow for recreational opportunities
- Developing minimum reservoir pool levels to maintain flatwater recreational appeal
- Voluntary flow management agreements
- Voluntary re-operation of existing projects to enhance recreational benefits without impacting yield
- Establishing new RICDs

The acquisition by purchase and transfer of existing water rights may be necessary for many of the options above. Leases and/or interruptible water supply agreements may also play a role. Water leases provide temporary water rights to users while interruptible water supply agreements refer to agreements whereby water supplies may be interrupted during water short years. Specific environmental and recreational options identified through the Basin Roundtable process are presented by basin in Section 10.3.

CDOW has identified several "statewide" approaches that could be implemented to address environmental needs, as indicated in Table 10-25. This table also shows a conceptual strategy (the "Three-Species Conservation Strategy") that could be applied to Colorado's Western Slope basins.

Table 10-25 CDOW Statewide and Western Slope Water Management Options

Project	Description	CDOW Priority	State of Implementation
Three-Species Conservation Strategy	Five-State Conservation Agreement and Strategy document(s) for long-term conservation and protection of three native fish populations (bluehead sucker, roundtail chub, flannelmouth sucker)	High	Conservation Agreement between AZ, WY, UT, NM, and CO to be signed in spring 2004. Strategy document draft due Dec. 2004. La Plata and Mancos River roundtail chub broodstocks at Mumma Native Aquatic facility.
Water Quality	Continue to work through State's water quality rule-making procedures to improve standards and classifications for streams and water bodies. ▪ Continue/ improve monitoring data collection, standardization, analyses, and posting; ▪ Continue advising watershed assemblies on water quality and wildlife issues.	High	Ongoing Division of Wildlife participation in WQCC hearings and other local processes to ensure non-degradation and cooperation on wildlife issues.
Dynamic flows	Improve coordination and communication w/ water suppliers so that within operational, institutional, and hydrologic constraints, dynamic releases can be made to simulate natural flow conditions.	Medium	No substantive discussions have occurred to date. Successful implementation in other western river systems and Canada.
Return Flow Mitigation Project	Recognition of connectivity between irrigated agriculture and late-season baseflow and water temperatures. Ensure that changes to agricultural practices (e.g., sprinklers, or type-conversions) do not significantly impair or reduce these benefits.	Low to Medium	No discussions. Inventory of affected areas not compiled and anecdotal to date.
Western Slope: Three-Species Conservation Strategy	Five-State Conservation Agreement and Strategy document(s) for long-term conservation and protection of three native fish populations (bluehead sucker, roundtail chub, flannelmouth sucker) in Arizona, Wyoming, Utah, New Mexico, and Colorado.	High	Strategy document draft due Dec. 2004. La Plata and Mancos River roundtail chub broodstocks at Mumma Native Aquatic facility.

Numerical analyses were performed with the WatSIT model, described in Section 7 and Appendix F, to illustrate how an environmental option might be quantitatively incorporated into the planning of a new water supply project.

As an illustrative example, Figure 10-31 shows storage to yield curves for a hypothetical reservoir located on Leroux Creek in the Gunnison River Basin. Predicted yield versus storage values are a function of legally available flows for the site (as simulated by the Gunnison River Basin DSS, described in Section 7) and assumed monthly evaporation. Two curves are shown in this figure corresponding to:

Alternative A – A management alternative in which the reservoir is allowed to completely empty.

Alternative B – A management alternative in which a minimum pool volume of 30 percent of capacity is maintained as a recreational option.

The model simulations show that to achieve a firm yield of 4,000 AFY, for example, without minimum reservoir capacity considerations (Alternative A), approximately 8,000 AF of storage is required. Alternatively, for the same system but with a minimum permanent pool requirement of 30 percent (Alternative B), approximately 12,000 AF of storage is required. The additional storage requirement (4,000 AF) for Alternative B would allow for the capture and storage of a greater percentage of the legally available flows, which can then provide the minimum pool. The acquisition of additional water rights may be required for the implementation of Alternative B. Costing of the two reservoir options could then be performed and assessed relative to the recreational benefits gained from maintaining the minimum pool.

As a second example, Figure 10-32 shows model simulations for a hypothetical reservoir located on Little Bear Creek in the Yampa River basin. Predicted yield curves are again a function of legally available flows for the location, as predicted by the Yampa River basin CDSS. For this analysis, the two curves shown on the figure correspond to:

Alternative A – A management alternative in which no minimum release requirements are maintained.

Alternative B – A management alternative that follows the approach outlined by The Nature Conservancy in the paper "How much water does a river need?" This approach maintains average historical monthly flows, minus 1 standard deviation, downstream of the reservoir.

Minimum release flow values for Alternative B were calculated using legally available flows captured by the reservoir. Model simulations show that, for the environmental Alternative B, significantly larger reservoirs are needed to provide the same firm yield when compared to the alternative without environmental considerations (A). For example, to provide 2,000 AF per year of firm yield, Alternative A requires approximately 2,000 AF of storage, while Alternative B requires approximately 17,000 to 18,000 AF of storage. It is possible for releases from the reservoir for downstream uses can serve a dual purpose and provide for the target environmental flows. This is a site specific issue and is determined by the location of the diversion from the reservoir for the water use.

Both sets of simulations show that these types of environmental and recreational alternatives are technically feasible with the proper planning. The simulations also show that the potential costs associated with environmental and recreational options may be significant. These costs might be monetary, such as those associated with larger storage requirements, or they might be in the form of yield reductions. While the benefits realized from environmental and recreational options are clear, to date, there is no clearly-accepted or widely implemented mechanism for investing in these types of flow enhancement projects.

10.3 Potential Options for Addressing Remaining Water Needs and Enhancements

Throughout the course of SWSI, using Basin Roundtable Technical Meetings and Public Information Meetings as forums for discussion, many potential approaches to meeting Colorado's future water needs were identified. Specific options moving forward toward implementation for addressing water needs were categorized as Identified Projects and Processes, as described in Section 6. Generalized water supply options for meeting future needs were outlined in Section 8. Additional basin specific water management solutions discussed and developed through SWSI are presented for each basin in the sections below. These solutions are less certain in their implementation, in many cases due to one or more of the following:

- More significant implementation concerns or barriers
- Lack of an identified project sponsor
- Status of development, e.g., conceptual level versus a more defined solution that may be among the Identified Projects and Processes

In the sections that follow, specific options are presented that were discussed in SWSI but not categorized as Identified Projects and Processes for each basin. The options include those brought forth and discussed in SWSI for M&I, agricultural, environmental, and recreational uses beyond the Identified Projects and Processes. These options could be used toward meeting the remaining gap in supply for basins and/or uses where the Identified Projects and Processes do not fully address the projected future water needs. Moreover if a percentage of the Identified Projects and Processes are not fully implemented, the options discussed in this section could be used toward addressing the resulting increase in gaps. It is also emphasized that there is not unanimity regarding these options. More dialogue and consensus building would be needed to move these options forward.

10.3.1 Arkansas Basin

Water needs in the Arkansas Basin were identified and characterized in Section 6.2. While over 80 percent of the basin's increased M&I needs could be met by the Identified Projects and Processes described in that section (if all of the Identified Projects and Process are fully successful), the remaining gap for M&I and agricultural, environmental, and recreational needs will need to be addressed by additional water management options. As discussed in Section 6, the size of the gap will depend on the degree of uncertainty and successful implementation of the Identified Projects and Processes.

Table 10-26 contains a list of projects or water management options for further consideration in meeting the basin's future water needs. This list was developed and refined through the series of four Basin Roundtable Technical meetings held in the Arkansas Basin, augmented by additional input from the Basin Advisors, Basin Roundtable members, and individual entities throughout the basin. This list represents a broad range of options, both in terms of the types of options and their degree of development. In many cases, the options are at a conceptual stage of development and therefore have relatively little information available about their storage size, yield, or other characteristics. In most cases, additional studies or information is needed to advance these water management options toward implementation.

Urban areas within the Arkansas Basin are expected to grow significantly in the next 30 years and water development will be needed to meet these M&I demands. Specifically, the need to develop additional water management solutions in the Arkansas Basin is based on the following:

- Potential competition for the same supplies of water in the Identified Projects and Processes, especially Fry-Ark Project water
- Reliance on non-tributary groundwater in northern El Paso County that is expected to be unsustainable in the long term
- Potential for greater than projected growth in the basin
- The reduction in basin supply available after full reuse of consumable return flows
- Potential impacts of climate change
- Concern over water quality of existing supplies

Based on discussion with the Arkansas Basin Roundtable members and the evaluation of options presented in Section 9, the following types of options have the potential to meet the Arkansas gap. Some of these options, such as construction of new storage and enlargement of existing reservoirs have been identified by potential project sponsors.

- Construction of new storage in Upper Arkansas River subbasin to regulate sources for augmentation.
- Shared storage in existing reservoirs in the Upper, Southwestern, Urban, and Lower subbasins.
- Re-operations of existing reservoirs to provide multiple benefits.
- Enlargement of existing reservoirs.
- Conjunctive use of surface water and non-tributary groundwater.
- Transfer agricultural water rights for M&I use and develop storage to firm yield for M&I use.
- Additional M&I conservation with an evaluation of impacts on reliability.
- Interruptible agricultural transfers.
- Rotating agricultural following with increased firm yield to agricultural users.

The largest M&I gap in the basin is in unincorporated northern El Paso County. Concepts for meeting the northern El Paso County M&I gap include:

- Development of satellite well field.
- Construction of 20,000 or more AF of surface water storage.
- Pumping non-renewable groundwater at low pumping rate and storage in surface water reservoirs to meet peak demands and provide drought yields.

These concepts address 50 percent of unincorporated El Paso County's needs with a reduced impact on non-renewable groundwater supplies. In addition to the above concept, El Paso County will need to develop a source of renewable supply to meet the other 50 percent of its demand.

Meeting the Arkansas Basin's future agricultural water needs will require a focus on firming existing supplies, and in particular could address the following concerns:

- Existing agricultural shortages identified in the basin.
- Concern over water quality of existing supplies.
- Potential impacts of climate change.

Table 10-26 Potential Future Arkansas Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
Arkansas Valley Pipeline	La Junta	Infrastructure	None	None	Would improve water quality and reduce transit losses for M&I users downstream of Pueblo Reservoir
El Paso County Water Authority	El Paso County Water Authority	Development of surface water storage and conjunctive use of non-renewable groundwater and development of renewable water supplies	Not Applicable	Variable	Long-term supply for unincorporated Northern El Paso County
Pueblo RICD	City of Pueblo	Recreation	Not Applicable	Not Available	Flows for City of Pueblo kayak course
UAWCD Augmentation Plan North Fork Reservoir	UAWCD	Additional Storage	2,000	500	Storage for augmentation of domestic wells. Yield number is consumptive.
UAWCD Augmentation Plan Boss Lake	UAWCD	Additional Storage	2,000	500	Storage for augmentation of domestic wells. Yield number is consumptive.
Oak Creek Reservoir Project	Florence; Joint Project w/USACE	Additional Storage	Up to 7,000	Not Available	Storage for the Town of Florence for M&I needs.
Cache Creek Reservoir	East Twin Lakes Ditches & Waterworks Economic Development	Additional Storage	7,620	3,000	—
Las Animas County Augmentation Plan	Las Animas County	Additional Storage	Not Available	Not Available	Acquisition of water rights and storage upstream of Trinidad Lake to augment domestic wells

Irrigated agricultural acreage in the Arkansas Basin is expected to decline over the course of the next 30 years, as described in Section 5. In light of that, meeting the Arkansas Basin's future agricultural needs will need to focus primarily on meeting existing needs and firming supplies available to existing agricultural users rather than expanding irrigated acres. General water management solutions that could be used to support these goals include:

- Construct new storage
- Reservoir enlargements or dredging
- Removal of storage restrictions
- Additional groundwater recharge
- Agricultural efficiency improvements

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, restore") highlighted in Section 6.1.3. Specific management solutions introduced through the Basin Roundtable process toward achieving environmental and recreational goals are presented below.

- **Rehabilitate Skaguay Reservoir** – This project would increase the current storage capacity of 2,056 AF to the historical maximum capacity of 3,079 AF. In addition, it would revisit the potential for hydroelectric power generation to use existing CDOW decreed water rights for beneficial use. This is a high priority project for CDOW and there is a high level of interest by local water users including Beaver Park Water Inc., Penrose Water District, City of Victor, City of Cripple Creek, and Colorado Springs.
- **Acquire additional pond and lake resources for habitat and fisheries** – Plans for this project include using CDOW water rights to augment unlined gravel pit evaporation and stream flows for Threatened and Endangered fish species. This is a medium priority project for the CDOW and the Water for Waterlife acquisition of the Center Farms water rights will provide substantial water supply for future needs.

- **Re-operate CDOW storage rights in DeWeese Reservoir** – For this project, CDOW plans to investigate the potential to maximize the 500 acre-foot storage right currently being used as a minimum pool for other beneficial uses such as exchanges with main stem Arkansas River or supplemental flows for habitat and fisheries in Grape Creek below DeWeese Reservoir. CDOW considers this project a low priority but has established relationships with BLM and DeWeese Dye Ditch Company that would aid in putting this storage space to additional uses.
- **Lower Arkansas River Water Conservation Strategy** – This project is a regional water change case, which offers a choice between selling or leasing water through conservation and fallowing in the Lower Arkansas Valley. It is anticipated that the process would improve regional economic performance. There may be significant legal impediments to implementation of this strategy as discussed in Sections 4 and 8.

In addition to these environmental enhancements, the Voluntary Flow Management Agreement between Turquoise Reservoir and Pueblo Reservoir is a continuing recreational enhancement for the Arkansas Basin.

10.3.2 Colorado Basin

Water needs in the Colorado Basin were identified and characterized in Section 6.2. While nearly all of the basin's increased M&I needs could be met by the Identified Projects and Processes described in that section (if all of the Identified Projects and Process are fully successful), the remaining gap for M&I, agricultural, environmental, and recreational needs will need to be addressed by additional water management options. As discussed in Section 6, the size of the gap will depend on the degree of uncertainty and successful implementation of the Identified Projects and Processes.

Table 10-27 contains a list of projects or water management options for further consideration in meeting the basin's future water needs. This list was developed and refined through the series of four Basin Roundtable Technical meetings held in the Colorado Basin, augmented by additional input from the Basin Advisors, Basin Roundtable members, and individual entities throughout the basin. This list represents a broad range of options, both in terms of the types of options and their degree of development. In many cases, the solutions are at a conceptual stage of development and therefore have relatively little information available about their storage size, yield, or other characteristics. In most cases, additional studies or information is needed to advance these water management options toward implementation.

M&I demands in the Colorado Basin are expected to grow significantly in the next 30 years as more people seek residence in headwater counties or in the lower basin that is attracting increasing numbers of retirees. Specifically, the need to develop additional water management solutions in the Colorado Basin is based on the following:

- The relative success of UPCO and Eagle River Processes to address in-basin needs, including M&I, recreational and environmental
- Long-term issues with Green Mountain Reservoir slope stability
- Potential Colorado River Compact calls from downstream states
- Potential for greater than projected growth
- Should current Endangered Species Recovery programs not provide desired results

Based on discussion with the Colorado Basin Roundtable members and the evaluation of options presented in Section 9, the following types of options have the potential to meet the Colorado gap. Some of these options, such as the construction of new storage in the Upper Fraser Basin have been identified by potential project sponsors.

- Construct new storage in the Upper Fraser River basin
- Transfer agricultural water rights for M&I use and develop storage to firm yield for M&I use

Table 10-27 Potential Future Colorado Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
Sulphur Gulch Reservoir	NCWCD, Denver Water	Additional Storage	Not Available	Not Available	Multi-purpose
Irrigation Canal Lining	None	Water Conservation	Not Applicable	Not Available	Reduce salinity in return flows.
Colorado River Return Project	CWCB	Additional storage, pipeline, pumpback	Not Available	250,000 to 750,000	250,000 to 750,000 AFY total project size. Project could provide for multiple needs in several basins.
Grand Valley Lake	None	Additional Storage	200,000	Not Available	Multi-purpose.
Tamarisk Removal	None	Control of non-native phreatophytes	Not Applicable	Not Available	Would benefit junior water rights.
Green Mountain Pumpback	Denver Water	Additional storage, pumpback	Not Available	Not Available	Could benefit Denver Water and Grand and Summit Counties.
West Slope storage in East Slope reservoirs to leave water on West Slope in dry years	None	Additional Storage	Not Available	Not Available	Could ensure additional flows on West Slope.
Dominguez Project	None	Storage	Not Available	Not Available	Project could benefit multiple users.

- Use of reservoir contract water to replace depletions to downstream calls
- Additional M&I conservation
- Agricultural efficiency improvements
- Re-operations of hydropower call and transmountain diversions to maximize in-basin supplies without impacting transmountain yields

In the Colorado Basin there are limited agricultural shortages on some tributaries. To address agricultural shortages in the basin, the following options may be applicable:

- Construct new storage to provide for late season water on tributaries
- Agricultural efficiency improvements
- Use of reservoir contract water to replace depletions to the downstream call

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, restore") highlighted in Section 6.1.3. Specific management solutions introduced through the Basin Roundtable process toward achieving environmental and recreational goals are presented below.

- **Shoshone Sediment Release** – This project would improve timing and coordination of sediment releases from the Shoshone diversion in order to maintain water quality during spring and fall spawns. CDOW considers this project a high priority and has developed an agreement with Xcel Energy to revise release timing. A permit revision may be required for this project.
- **Windy Gap Bypass Channel** – The Northern Colorado Water Conservation District (NCWCD) bypass channel would improve access upstream and aquatic conditions downstream of Windy Gap Reservoir. The project would also mitigate reservoir effects on the Upper Colorado River Fishery. This high priority project is being pursued with NCWCD and other interests.
- **Cutthroat Habitat Restoration** – A series of water exchanges could expand the Colorado River cutthroat habitat in Abrams Creek. CDOW is conducting analyses of water rights and discussion with other interests for this high priority project.
- **Gypsum State Wildlife Area Instream Habitat Improvement** – For this project, CDOW suggested improving instream habitat conditions in the Eagle River on the west end of the Gypsum Ponds State Wildlife Area. For this medium to high priority project, CDOW is in the initial planning and data collection

stage. There is not a final plan for the project to date but bank stabilization in the area is ongoing.

- **Eagle Mine Superfund Project** – This high priority CDOW project involves mitigation of the Eagle mine impacts.
- **Summer Baseflow Project** – Because of low baseflows, high water temperatures, increasing stress, and disease on aquatic resources in the Avon-Dotsero reach of the Eagle River, CDOW has proposed a summer base-flow project. The problem has clearly been identified for this high priority project but no substantive discussion or clear mechanism for solving the problems has been identified to date.
- **Aquatic Wildlife Management Plan** – This plan provides management guidance and strategies in order to conserve and protect aquatic resources in the basin. It is a collaborative and iterative process with various intra-basin task force partners. This high priority plan is in the draft stage and expected approval and completion is expected in late 2004.
- **Fryingpan Valley Economic Study and Fryingpan/ Roaring Fork Rivers Fishery Study** – These studies have been done in order to characterize both water-based recreation activities and the condition of the aquatic ecosystem. An important goal of these studies is to provide information on water levels and flow rates that maximize economic and ecologic values. This work is being used to inform decisions about how Ruedi Reservoir is operated and to specify flow targets.

10.3.3 Dolores/San Juan /San Miguel Basin

Water needs in the Dolores/San Juan /San Miguel Basin were identified and characterized in Section 6.2. While the majority of the basin's increased M&I needs could be met by the Identified Projects and Processes described in that section (if all of the Identified Projects and Process are fully successful), the remaining gap for M&I, agricultural, environmental, and recreational needs will need to be addressed by additional water management options. As discussed in Section 6, the size of the gap will depend on the degree of uncertainty and successful implementation of the Identified Projects and Processes.

Table 10-28 contains a list of projects or water management options for further consideration in meeting the basin's future water needs. This list was developed and refined through the series of four Basin Roundtable Technical Meetings held in the Dolores/San Juan/San Miguel Basin, augmented by additional input from the Basin Advisors, Basin Roundtable members, and individual entities throughout the basin. This list represents a broad range of options, both in terms of the types of solutions and their degree of development. In many cases, the options are at a conceptual stage of development and therefore have relatively little information available about their storage size, yield, or other characteristics. In most cases, additional studies or information is needed to advance these water management options toward implementation.

Specifically, the need to develop additional water management solutions in the Dolores/San Juan/San Miguel Basin is based on the following:

- Construct infrastructure to deliver existing supplies from Dolores and Animas-La Plata Projects.
- Develop additional storage and supplies in San Miguel Basin.
- Augmentation to CWCB instream flows will be needed in Upper Dolores Basin. Storage will be needed or CWCB finding of de minimus impacts to instream flow rights.

In addition to M&I needs, agricultural water supply alternatives could address the following concerns:

- Develop additional storage to meet supply shortages in all basins.
- Agricultural efficiency improvements.

Based on discussion with the Dolores/San Juan/San Miguel Basin Roundtable members and the evaluation of options presented in Section 9, the following types of options have the potential to meet the Dolores/San Juan/San Miguel gap. Some of these options, such as the construction of new storage, have been identified by potential project sponsors.

Table 10-28 Potential Future Dolores/San Juan/San Miguel Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
WETPACK – New Irrigated Lands - Use of Totten Reservoir	Dolores Water Conservancy District	Additional Storage	2,800	1,840	Totten Reservoir has not been operated since 1992. Project would provide supply to irrigate additional lands in the Dolores Water Conservancy District.
WETPACK - New Irrigated Lands - Class B shares	Dolores Water Conservancy District	Water Rights Acquisition	Not Applicable	6,000	Purchase of 1,500 Class B Montezuma Valley Irrigation Co. shares. Project would provide supply to irrigate additional lands in the Dolores Water Conservancy District.
WETPACK New Reservoir Construction - Plateau Reservoir	Dolores Water Conservancy District, Colorado Department of Natural Resources and potential for environmental interests	Additional Storage	20,000	3,300 to 3,700	Construct Plateau Reservoir; Yield is limited as McPhee Reservoir spills 50 percent of the time. Project would provide for environmental flows.
WETPACK Groundhog Reservoir Storage Increase	Dolores Water Conservancy District	Additional Storage	1,000	Not Available	Storage would be increased by raising spillway elevation without raising dam
WETPACK - Construction of Storage Upstream of McPhee Reservoir	Dolores Water Conservancy District	Additional Storage	Not Available	Not Available	This project is needed if the Rico alluvium project is not viable
WETPACK Lawn and Garden M&I Water	Dolores Water Conservancy District	M&I Reuse	Not Applicable	4,500	If specific service areas are determined. This could provide non-potable irrigation water for M&I uses.
Long Hollow Reservoir	La Plata Water Conservancy District	Additional Storage	up to 5,400	Not Available	Would maximize yield in Colorado by providing storage for compact compliance.
Red Mesa Ward Reservoir Enlargement	La Plata Water Conservancy District and Red Mesa Ward Reservoir and Ditch Company	Additional Storage	up to 2,898	Not Available	Additional storage for agricultural users.
Durango West Raw Water Pump and Pipeline	Durango West Metro Districts No. 1 & 2 and Lake Durango Water Company	Pipeline	Not Applicable	Not Available	Additional water source for M&I use.
Reconstruct Emerald Lake Dam	Pine River Irrigation District/Southern Ute Indian Tribe	Additional Storage	Not Available	Not Available	Located in the Weminuche Wilderness Area. Project would reconstruct dam and provide water for agricultural uses.
Pine River Donation of Instream Flow Rights	Pine River Irrigation District, CWCB and Southern Ute Indian Tribe	Environmental	Not Applicable	Not Available	Currently awaiting draft donation agreement from CWCB and draft water rights application to implement donation of instream flow right.
Animas River instream flows	Potentially CWCB	Environmental	Not Applicable	Not Available	Need for instream flow right.
Agricultural Drought Insurance Program	None	Drought Insurance	Not Applicable	Not Available	This would be an alternative to developing storage projects to increase reliability for agriculture
La Plata River Instream flows	CWCB	Environmental	Not Applicable	Not Available	Need for instream flow right.

Table 10-28 Potential Future Dolores/San Juan/San Miguel Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
Mancos Water Conservancy District Borrow Pit Storage	Mancos Water Conservancy District	Additional Storage	Not Available	Not Available	Storage to firm the yield for district uses.
Reservoir Re-operation	Federally - owned reservoirs	Additional Storage	Not Available	Not Available	Change in USACE flood criteria could allow increased storage.
Habitat Restoration	None	Environmental	Not Applicable	Not Available	Restore riparian and aquatic habitat.
Southern Ute Indian Tribe - Bison Lake	Southern Ute Indian Tribe	Additional Storage	620	Not Available	Multi-purpose project for Southern Ute tribe needs.
Southern Ute Indian Tribe - Ute Creek Reservoir	Southern Ute Indian Tribe	Additional Storage	2,390	Not Available	Multi-purpose project for Southern Ute tribe needs.
Southern Ute Indian Tribe - Cat Creek Reservoir	Southern Ute Indian Tribe	Additional Storage	1,170	Not Available	Multi-purpose project for Southern Ute tribe needs.
Town of Rico Pipeline	Town of Rico	Pipeline	Not Applicable	Not Available	Project will replace existing surface water source on Silver Creek and improve water quality.
Straw Dam	San Miguel Water Conservancy District.	Additional Storage	Not Available	Not Available	Multi-purpose project.
New Marie Scott Reservoir	San Miguel Water Conservancy District	Additional Storage	Not Available	Not Available	Feasibility Study funded by CWCB. Multi-purpose project.
Increase in Pre-construction Funding for Water Projects	CWCB and Colorado Water Resources and Power Development Authority	Various	Not Applicable	Not Available	Provide for grants to study water supply development options.
Revise Probable Maximum Precipitation Events	None	Additional Storage	Not Available	Not Available	Would decrease cost of new reservoirs and allow raising spillway in existing reservoirs.
WETPACK San Juan County, Utah M&I Project	Dolores Water Conservancy District	Additional Storage	Not Available	Not Available	Requires resolution of interstate issues. Would benefit Utah water users.
Forest Management	None	Management Practice	Not Applicable	Not Available	Increase runoff from national forests.
City of Durango Recreational In Channel Diversion	City of Durango	Recreation	Not Applicable	Not Available	Provide for flows for Durango kayak course.
Irrigation System Efficiency Improvements	NRCS for Salinity Control, other potential sponsors to reduce losses	Water Conservation	Not Applicable	Not Available	Line canals to increase deliveries to users.
Operational or reallocation option	None	Additional Storage	Not Available	Not Available	Use portion of agricultural storage for M&I use.
Alternate storage approach - alluvial and tributary groundwater storage	None	Additional Storage	Not Available	Not Available	Recharge surface water into groundwater storage ands lag returns to stream.

- Moderate Conservation
- Agricultural Conservation (efficiency)
- Increased storage (all uses)
  - Reservoir enlargements
  - New storage
- Agricultural transfers to meet M&I and SSI
  - Rotating agricultural transfer with firming of existing agricultural yield
  - Permanent agricultural transfer with storage for reliability
- Control of Non-native Phreatophytes (all uses)
  - Identify if control will produce additional yield

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, restore") highlighted in Section 6.1.3. Specific management solutions discussed through the Basin Roundtable process toward achieving environmental and recreational goals are presented below.

- **Dolores River below McPhee Reservoir** – This project includes a combination of improved flow management, channel reconstruction, and channel rehabilitation to enhance the downstream fishery. In addition, there are ancillary benefits to downstream native roundtail chub populations. The project may also consider increasing the available fish pool water contemplated by Dolores Project Definite Plan Completion Report. The BOR, DWCD, and DWR are in ongoing discussions regarding administration, opportunities, and constraints with re-operation of the fish pool for this high priority project.
- **Long Hollow /La Plata River Mitigation Flow** – The purpose of this project is to ensure winter and late-season base flows in the Long Hollow/La Plata River to support roundtail chub. CDOW is conducting discussions with project proponents for this high priority project including CWCB regarding instream flow needs for native fish.
- **Woods Lake Cutthroat Refugia** – CDOW has an engineering design in place to isolate Woods Lake and Fall River above the lake as Colorado River Cutthroat Trout refugia. This medium to high priority project's design includes addressing spillway and outlet isolation. In addition, there is a design underway for instream improvements above Woods Lake to ensure isolation.
- **Aquatic Wildlife Management Plan** – Both the Dolores/San Juan and the San Miguel River basin have plans for implement Aquatic Wildlife Management Plans. These high priority plans provide management guidance and strategies to conserve and protect aquatic resources. The Dolores/San Juan plan is in its early phases and completion is anticipated in 2006. The San Miguel plan is draft form and should be complete by the end of 2004.

Also noted in the Basin Roundtable Technical meetings was that the BLM has developed a Dolores management plan and instream flow assessment that could be used toward environmental enhancement. Also noted from the meetings was that Long Hollow Reservoir may need a 1,600 acre-foot pool for environmental purposes, but like many enhancement projects, an outstanding issue is allocation and payment for the cost of such an environmental pool.

10.3.4 Gunnison Basin

Water needs in the Gunnison Basin were identified and characterized in Section 6.2. While the majority of the basin's increased M&I needs could be met by the Identified Projects and Processes described in that section (if all of the Identified Projects and Process are fully successful), the remaining gap for M&I, agricultural, environmental, and recreational needs will need to be addressed by additional water management options. As discussed in Section 6, the size of the gap will depend on the degree of uncertainty and successful implementation of the Identified Projects and Processes.

Table 10-29 contains a list of projects or water management options for further consideration in meeting the basin's future water needs. This list was developed and refined through the series of four Basin Roundtable Technical meetings held in the Gunnison Basin, augmented by additional input from the Basin Advisors, Basin Roundtable members, and individual entities throughout the basin. This list represents a broad range of options, both in terms of the types of options and their degree of development. In many cases, the options are at a conceptual stage of development and therefore have relatively little information available about their storage size, yield, or other characteristics. In most cases, additional studies or information are needed to advance these water management options toward implementation.

Table 10-29 Potential Future Gunnison Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
Aspinall Unit EIS	Bureau of Reclamation	Environmental	Not Available	Not Available	Provide flows for endangered species flow recommendations and National Park Service reserved right.
Lake San Cristobal water development	Upper Gunnison River Water Conservancy District and Hinsdale County Commissioners	Additional Storage	Not Available	450 - M&I; 500 – Environ-mental	Augmentation water for internal calls on the Lake Fork; Requires CWCB to modify natural lake level decree.
Grand Mesa Dams Rehabilitation	Grand Mesa Water Conservancy District, Colorado River Water Conservation District and CWCB	Additional Storage	Not Available	Not Available	Restoring existing dams, building new dams and interconnecting these with feeder canals for agricultural users.
Cactus Park Reservoir	Change Sponsor (per BRT3) Grand Mesa Conservancy	Additional Storage	Not Available	Not Available	This is an alternate to enlarging reservoirs on Grand Mesa; Would use existing decrees.
Paonia Reservoir Dredging	North Fork Water Conservancy District	Additional Storage	2,000	1,000	Restore storage capacity due to siltation; Costs would include purchase of a used dredge and yearly dredging practices.
Electric Mountain Reservoir	North Fork Water Conservancy District	Additional Storage	Not Available	1,000	This is an alternate to dredging Paonia Reservoir.
Leroux Creek - Overland Reservoir	Change Sponsor (per BRT3)	Additional Storage	Increase Overland Storage by 8%	450	Overland Dam and Canal owners have 900 AF of conditional decreed storage for Overland Reservoir; New storage down the canal or in Leroux Creek for agricultural users.
Cunningham Gulch Reservoir - Ohio Creek	Upper Gunnison River Water Conservancy District	Additional Storage	2900	Not Available	Construction of storage for agricultural and M&I use.
Taylor River Canal	Upper Gunnison River Water Conservancy District	Infrastructure	Not Applicable	100 cfs direct flow	Direct flow diversion for M&I and agricultural use.
Long Branch Reservoir - Tomichi Creek	Upper Gunnison River Water Conservancy District	Additional Storage	1,500 AF	1,500 AF	Construct storage for existing agricultural users to reduce shortages.
Reservoirs on Cochetopa Creek	Upper Gunnison River Water Conservancy District	Additional Storage	up to 500 AF via enlargements	up to 500 AF	Construct storage for existing agricultural users to reduce shortages.
Augmentation Storage for Mt. Crested Butte	Primarily Mt. Crested Butte and the Upper Gunnison River Water Conservancy District	Additional Storage	400	400	Construct storage for augmentation water to allow snowmaking and M&I depletions in the Mt. Crested Butte area; Consumptive use credits will also be required.
Uncompahgre Valley Water Users canal lining	Uncompahgre Valley Water Users Association and others	Infrastructure	Not Applicable	10,000	Line sections of main canals and laterals to reduce seepage losses and reduce salinity; 537 miles total canal miles.
Uncompahgre Valley Water Users in-system reregulating reservoirs and supply enhancements	Uncompahgre Valley Water Users Association	Additional Storage	Not Available	2,000	Store Gunnison Tunnel Diversions in the Uncompahgre Valley to better manage water deliveries.

Table 10-29 Potential Future Gunnison Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
Project 7 Water Supply Enhancements - South Canal	Project 7 Water Authority and Uncompahgre Valley Water Users Association	Additional Storage	500 to 2,500	0 (increases reliability)	Managing water in Uncompahgre system for firming up water supply and increasing reliability if Gunnison tunnel cannot divert; three storage sites along South Canal.
Project 7 Water Supply Enhancements - Fairview Reservoir	Project 7 Water Authority and Uncompahgre Valley Water Users Association	Additional Storage	Not Available	0 (increases reliability)	Managing water in Uncompahgre system for firming up water supply; Enlargement or dredging of Fairview reservoir.
Project 7 Water Supply Enhancements - Cerro Reservoir	Project 7 Water Authority and Uncompahgre Valley Water Users Association	Additional Storage	About 300	0 (increases reliability)	Managing water in Uncompahgre system for firming up water supply and increasing reliability if Gunnison tunnel cannot divert; Enlargement of Cerro Reservoir.
Ramshorn Reservoir - Dallas Creek Project	Tri-County Water Conservancy District	Additional Storage	Not Available	Not Available	Part of the original Dallas Creek Project. Storage could be used for long-term M&I needs.
Dallas Divide Reservoir - Dallas Creek Project	Tri-County Water Conservancy District	Additional Storage	Not Available	Not Available	Part of the original Dallas Creek Project. Storage could be used for long-term M&I needs.
Redlands Power Call	None	Re-operation	Not Applicable	Not Available	Re-operations can increase available supply for upstream junior water rights.
Paonia – Lone Cabin Reservoir Enlargement	Town of Paonia	Additional Storage	Not Available	Not Available	Provide firm supply for Town of Paonia's future needs. May be enlarged in two phases.

The need to develop additional water management options in the Gunnison Basin is based on the following:

- Potential uncertainty in the implementation of the North Fork providers' identified plans
- Need for augmentation in Ouray County and Upper Gunnison River Water Conservancy District
- Potential growth and snowmaking demands at Crested Butte Mountain Resort

Based on discussion with the Gunnison Basin Roundtable members and the evaluation of options presented in Section 9, the following types of options generally meet the objectives of the Gunnison Basin Roundtable members and could be further evaluated for their role in addressing the remaining M&I gap in the Gunnison Basin:

- Construct new storage in Upper Gunnison and Ouray County to replace depletions
- Enlarge Lone Cabin Reservoir (Paonia)
- Interruptible or rotating agricultural consumptive use credits
- Continue to acquire ditch and reservoir company shares
- Use of Blue Mesa and Ridgway Reservoirs to replace depletions to downstream calls
- Resolve impact to CWCB instream flow rights and finding of deminimus impacts, where appropriate
- Additional conservation
- Agricultural efficiency improvements
- Re-operations of the Redlands power call

There is projected to be some loss of irrigated agricultural acreage in the Gunnison Basin over the course of the next 30 years, as a result of development of irrigated lands as described in Section 5. The Gunnison Basin's future agricultural needs have focused primarily on meeting existing needs and firming supplies available to existing agricultural users. Water management options that could be used to support these goals include:

- Construct new storage in Upper Gunnison to reduce shortages for agricultural uses.
- Construct new storage or enlarge or dredge reservoirs in the North Fork and Grand Mesa.
- Agricultural efficiency improvements.
- The use of Aspinall contract water to replace depletions to downstream calls.
- Re-operations of the Redlands power call.

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, restore") highlighted in Section 6.1.3. Specific management options discussed through the Basin Roundtable process toward achieving environmental and recreational goals are presented below.

- **Cochetopa Creek and Archuleta Creek Easement** – The water right holder and CDOW Regional and Area managers have discussed relieving the perennial dry-up on Cochetopa Creek. This project would address habitat degradation and improve flow conditions on Cochetopa, Archuleta, Los Pinos, and Pauline Creeks. There is no resolution to date for this high priority project.
- **Aspinall Unit EIS** – This ongoing high priority process includes CDOW and CWCB participation in operations discussion for the Aspinall Unit Re-operations EIS process to meet flow recommendations for Upper Colorado Recovery Implementation Plan.
- **Aquatic Life Management Plan** – This plan provides management guidance and strategies in the order to conserve and protect aquatic resources in the basin. It is a collaborative and iterative process with various intra-basin task force partners. This high priority plan is in the draft stage and expected approval and completion is expected in late 2004.
- Taylor Reservoir Operations
  - Sets flow releases for given year based on stakeholder input (ongoing process) to benefit instream uses
  - Goodwin-Knox and Kelmel-Owens diversion point fish and recreation passage to improve aquatic habitat
  - Tomichi and Cochetopa Creeks rehabilitation and improvements to improve aquatic habitat

10.3.5 North Platte Basin

As discussed in Section 6.2, the North Platte Basin is not expected to see significant increases in M&I water needs between now and 2030. As noted in Section 5, the North Platte Basin's irrigated agricultural acreage is expected to remain within the amount allowed under the decree. The basin's future demands will primarily be met using existing supplies and water rights, and as such, specific Identified Projects and Processes were not cataloged for the North Platte Basin. As in each basin, opportunities to manage water to enhance the environment and recreational opportunities may exist in the North Platte Basin.

A list of projects or water management options for further consideration in meeting the basin's future water needs is presented in Table 10-30. This list was developed and refined through the series of three Basin Roundtable Technical meetings held in the North Platte Basin, augmented by additional input from the Basin Advisor, Basin Roundtable members, and individual entities throughout the basin.

As noted in the table, each of the water management options brought forth through SWSI for the North Platte Basin revolves around additional storage to firm up water supplies for M&I and agricultural users. In many cases, the options are at a conceptual stage of development and therefore have relatively little information available about their yield or other characteristics. In most cases, additional studies or information would be needed to advance these water management options toward implementation.

Depending on the nature of each of the storage projects, it may be possible to broaden their purpose to include storage and releases for environmental and recreational needs. However, as noted throughout SWSI and in each basin, cost allocation and funding/financing for such modifications and beneficiaries would need to be addressed before these enhancements could be incorporated. In addition, storage limitations under the decree may limit future options.

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, and restore") highlighted in Section 6.1.3. No specific recreational projects were brought forth through the Basin Roundtable process for the North Platte Basin. However, CDOW has proposed an environmental enhancement option for the North Platte Basin. CDOW suggests that expanding Lake John could be accomplished by raising existing dams by 4 feet. This could in turn provide additional augmentation water for the North Platte River and address evapotranspiration losses from the reservoir. CDOW anticipates that this option could then eliminate the problems associated with winter kills of the trophy sport fishery in North Park. Listed as a medium priority by CDOW, this project is conceptual at present, and no project authorization or expansion filing is in place to date.

Table 10-30 Potential Future North Platte Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
Forest Management	None	Management Practice	Not Available	Not Available	Increase runoff from national forest.
Coalmont Reservoir	None	Additional Storage	30,000	Not Available	Would improve ag reliability on Little Grizzly Creek for existing agricultural users. Conditional water right abandoned in 2001. Would need financial assistance.
Damifiano/Richland Reservoir	None	Additional Storage	12,000	Not Available	Big Grizzly Creek; Conditional rights abandoned. Could provide supplies for existing agricultural users.
Unnamed Reservoir	None	Additional Storage	50,000	Not Available	Colorado Creek; No existing conditional water rights. Could provide supplies for existing agricultural users.
Case Flats Reservoir	None	Additional Storage	100,000	Not Available	Illinois River; Located on a refuge; Limited supply due to existing reservoirs on Illinois River. Could provide supplies for existing agricultural users.
Willow Creek Reservoir	None	Additional Storage	20,000	Not Available	Willow Creek; No water right; source would be other creeks. Could provide supplies for existing agricultural users.
Unnamed Reservoir	None	Additional Storage	300,000	Not Available	Michigan River; Has been evaluated in past study. Could potentially provide for endangered species flows.
Unnamed Reservoir	None	Additional Storage	550,000	Not Available	North Platte River; May be workable under Compact; Could drop water into Laramie and increase supply to South Platte for M&I use.

10.3.6 Rio Grande Basin

As presented in Section 6, the gap analysis process presented at the Basin Roundtable Technical Meetings provided information on the needs of the Rio Grande Basin. The basin's increased M&I needs can be met by the augmentation of groundwater pumping. Agricultural shortages were discussed in Section 5, and limitations to addressing these shortages were discussed in Section 7.

A list of projects or water management options for further consideration in meeting the basin's future water needs is presented in Table 10-31. This list was developed and refined through the series of three Basin Roundtable Technical Meetings held in the Rio Grande Basin, augmented by additional input from the Basin Advisors, Basin Roundtable members, and individual entities throughout the basin. In many cases, the options are at a conceptual stage of development and therefore have relatively little information available about their storage size, yield, or other characteristics. However, each option listed was brought forth in SWSI as a potential means toward meeting future water needs in the basin. In most cases, additional studies or information would be needed to advance these water management options toward implementation.

Because the Identified Projects and Processes described in Section 6 could address nearly 100 percent of the basin's projected M&I needs, the need to consider additional water management solutions for this basin's M&I demands lies largely in the potential uncertainties associated with implementation of the Identified Projects and Processes.

The need to develop additional water management solutions in the Rio Grande Basin for M&I demands is also based on the following:

- Alternative sources for augmentation
- Uncertainty analysis - reliability of groundwater for M&I
- Arsenic in drinking water supplies

Based on discussion with the Rio Grande Basin Roundtable members and the evaluation of options presented in Section 9, the following types of options generally meet the objectives of the Rio Grande Basin Roundtable members and could be further evaluated for their role in addressing the remaining gap in the Rio Grande Basin keeping in perspective the limited water available for development:

- Agricultural conservation (efficiency), recognizing the potential for unintended effects on downstream users' supplies from reduced return flows
- Increased storage (all uses) through enlarging or rehabilitating existing reservoirs (limited by compact).
- Rotating agricultural transfer (fallowing) with firming of existing agricultural yield
- Control of Non-Native Phreatophytes (all uses), recognizing the need to identify whether such control would actually produce additional yield

In addition to M&I needs, agricultural water supply alternatives could address the significant concerns expressed by Rio Grande Basin Roundtable members related to the current unsustainable levels of groundwater pumping, particularly in the San Luis Valley. Agricultural water supply options for the Rio Grande Basin are largely focused on reducing or enhancing the management of agricultural demands in the basin. Irrigated acreage in the Rio Grande Basin is expected to decrease significantly by 2030 in order to restore and maintain groundwater levels, as discussed in Section 5.

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, and restore") highlighted in Section 6.1.3. Specific water management solutions discussed through the Basin Roundtable process toward achieving environmental and recreational goals are presented in Table 10-31 above and in the bullets below.

- **Fully Utilize Transmountain Return Flows** – One of CDOW's suggested options, this option seeks to establish criteria and procedures that will prioritize any annual surplus of transmountain return flows to allow full consumptive use. Considered a high priority by CDOW, CDOW has developed the accounting tool necessary for the determination of available transmountain return flows and is now using the preliminary data.

Table 10-31 Potential Future Rio Grande Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
National Forest Timber Management	None	Flow augmentation	Not Applicable	Not Available	Increase runoff from national forests.
Rio Grande Headwaters Restoration Project	San Luis Valley Conservancy District Water Task Force - consisting of various interests	River restoration including bank stabilization, J-hooks to redirect flows, riparian fencing, planting of willows and improvement and/or relocation of ditch and canal diversion structures.		Not Available	Purpose is to restore river to historical functions including maintenance of channel capacity, flood protection, riparian habitat, Rio Grande Compact deliveries and access for water diversion.
Ground Water Recharge and Management Project	Rio Grande WCD, San Luis Valley WCD, various ditch and reservoir companies, conservancy districts and Fish and Wildlife Service	Groundwater recharge	Not Applicable	Will increase groundwater storage in underground reservoirs - No estimate at this time.	Oversize the capacity of existing irrigation canals and ditches and dedicate large recharge areas to take advantage of flood flows and flows available under Rio Grande Compact. Enhance recharge of closed basin aquifer to allow better utilization of surface water supplies.
Creation of Groundwater Management Districts	Rio Grande WCD or San Luis Valley WCD Water Management Subdistrict and various ditch and reservoir companies	Groundwater	Not Applicable	Not Available	Establish groundwater management subdistricts to manage consumption while maximizing aquifer sustainable yield.
Upper Rio Grande Basin Water Operations Review	Bureau of Reclamation and Army Corps of Engineers	Re-operations	Not Applicable	Not Available	Improved management of federal water facilities in Colorado and New Mexico; Enhanced administration of this water by the BOR to ensure no expansion of irrigated acreage in New Mexico.
Expanding Outreach and Education	Rio Grande WCD and San Luis Valley WCD	Public Education	Not Applicable	Not Available	Education Programs and Speakers Bureaus to raise the awareness of the importance of a healthy river and a sustainable water supply and prudent management of entire basin.
Ground and surface water conservation program	None	Conservation	Not Available	Not Available	Maximize beneficial use of surface water and groundwater resources.

- **Continental Reservoir Storage Agreement** – A second CDOW option is to acquire storage and a water agreement in Continental Reservoir to protect fisheries resources and provide adequate access for fishing from shore and boats. CDOW is investigating ways to re-establish the pool that previously existed, and considers this to be a medium priority option.
- **Rio Grande Reservoir Operations** – Winter flows below Rio Grande Reservoir are low after irrigation season, resulting in stresses to fish associated with warm temperatures and crowding. CDOW has a recent storage agreement that may offer potential for future exchange opportunities to meet wildlife goals, and considers this to be a medium priority for implementation.
- **Platoro Reservoir Minimum Flow Modification** – CDOW suggested this option to increase winter minimum flows below Platoro Reservoir in the Conejos basin. This could include consideration of dam operation changes to prevent extreme daily fluctuations in flow. Considered a medium priority by CDOW, CDOW has transmountain waters sources that may be suitable for exchange to cover evaporative losses. Potential also exists for leasing Joint Use Pool Water sources.
- **Dredging of Conservation Pools** – CDOW has several permanent pools that have lost capacity due to siltation throughout the basin. A program for extended dredging could prolong the life of these reservoirs and preserve the CDOW conservation pool interests. CDOW considers this to be a high priority option, and has identified silt problems in Big Meadows, Beaver, Road Canyon, Upper and Lower Brown Reservoirs.
- **Alamosa River Watershed Project** – the Alamosa River was severely impacted by channel straightening, channel excavation, and levee construction undertaken in the early 1970s. In response to these river and land impacts, the community established the Alamosa River Watershed Project. It is a community-wide effort involving local landowners, water users, and concerned citizens to stabilize riverbanks and improve riparian habitat along the river.

It was also noted through the Basin Roundtable process that Terrace Reservoir could be modified to improve yields and enhance environmental flows, though there are currently no firm plans or funding in place at this time. Participants were also reminded that agricultural water provides secondary benefits (i.e., ecosystem enhancement, wildlife habitat). Finally, the Alamosa River Restoration project was cited as a key example of another environmental enhancement option that should be supported throughout its implementation.

10.3.7 South Platte Basin

Water needs in the South Platte Basin were identified and characterized in Section 6.2. While about 78 percent of the basin's increased M&I needs could be met by the Identified Projects and Processes described in that section (if all of the Identified Projects and Processes are fully successful), the remaining gap for M&I, agricultural, environmental, and recreational needs will need to be addressed by additional water management solutions. As discussed in Section 6, the size of the gap will depend on the degree of uncertainty and successful implementation of the Identified Projects and Processes.

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

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

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

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

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

- Potential for failure of the Identified Projects and Processes to address in-basin needs
- Some future growth areas do not have identified water planning processes
- Limitations in the reliability and sustainability of non-tributary groundwater
- Limitations in the ability to reliably store water under junior water right appropriations
- Competition for the same supplies
- Potential for greater than projected growth
- The success of the proposed Endangered Species Program.
- The potential "domino effect" of increased M&I reuse of consumable supplies, resulting in reduced downstream flows and more senior calls
- Potential impacts of climate change

Based on discussion with the South Platte Basin Roundtable members and the evaluation of options presented in Section 9, the following types of options generally meet the objectives of the South Platte Basin Roundtable members and could be further evaluated for their role in addressing the remaining M&I gap in the South Platte Basin:

- Construct new storage to maximize existing water rights and conditional storage rights
- Reservoir enlargements to maximize existing water rights and conditional storage rights
- Additional conservation, possibly coupled with additional storage to enhance reliability
- Rotating Agricultural Transfers
- Agricultural conservation (efficiency improvements) while recognizing the potential negative effects on return flows

Specific options identified through the Basin Roundtable process were cataloged in Table 10-32 above.

Agricultural water solutions could address the following concerns:

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

Irrigated agricultural acreage in the South Platte Basin is expected to decline significantly over the course of the next 30 years, as described in Section 5. Development of irrigated lands, transfer to M&I use, and the inability to augment well pumping will all contribute to this decline. Meeting the South Platte Basin's future agricultural needs will focus primarily on meeting existing needs and firming supplies available to existing agricultural users rather than expanding irrigated acreage. Water management solutions that could be used to support these goals include:

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

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, and restore") highlighted in Section 6.1.3. Specific water management solutions discussed through the Basin Roundtable process toward achieving environmental and recreational goals are presented below.

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

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

10.3.8 Yampa/White/Green Basin

Water needs in the Yampa/White/Green Basin were identified and characterized in Section 6.2. While essentially 100 percent of the basin's increased M&I needs could be met by the Identified Projects and Processes described in that section, this will heavily depend on the degree of uncertainty and successful implementation of the Identified Projects and Processes.

A list of projects or water management options for further consideration in meeting the basin's future water needs is presented in Table 10-33. This list was developed and refined through the series of four Basin Roundtable Technical meetings held in the Yampa/ White/Green basin, augmented by additional input from the Basin Advisor, Basin Roundtable members, and individual entities throughout the basin. In many cases, the options are at a conceptual stage of development and therefore have relatively little information available about their storage size, yield, or other characteristics. However, each option listed was brought forth in SWSI as a potential means toward meeting future water needs in the basin. In most cases, additional studies or information would be needed to advance these water management options toward implementation.

Because the Identified Projects and Processes described in Section 6 could address 100 percent of the basin's projected M&I needs, the need to consider additional water management options for this basin's M&I demands lies largely in the potential uncertainties associated with implementation of the Identified Projects and Processes. In addition, the potential for transit losses from storage during drought was identified as another area that may drive the need for additional water management options.

Based on discussion with the Yampa/White/Green Basin Roundtable members and the evaluation of options presented in Section 9, the following types of options generally meet the objectives preferred by Yampa/White/Green Basin Roundtable members and could be further evaluated for their role in addressing water needs in the Yampa/White/Green Basin.

- Increased storage to benefit all uses
  - There is available supply for development
  - New reservoirs have been identified (Montgomery Watson 2000; Morrison-Knudsen Engineers 1986)
  - New reservoirs and infrastructure would be needed to irrigate additional lands
  - Reservoir enlargements are planned for Stagecoach and Elkhead
- Reservoir re-operations or exchanges to minimize transit losses
- Control of Non-native Phreatophytes (all uses), recognizing the need to identify whether such control would actually produce additional yield
- Agricultural Conservation (all uses)
  - Reduce calls from downstream agricultural diverters during low flow periods
  - Improve delivery efficiency to agricultural users during water short periods
  - Can impact other water rights and volume and pattern of return flows

Specific options identified through the Basin Roundtable process were cataloged in Table 10-33.

Agricultural water solutions could address the following concerns:

- Existing shortages in Water Districts 44 and 54
- Additional potentially irrigable land, which would require new delivery infrastructure and additional storage for reliability

Irrigated agricultural acreage in the Yampa/White/Green Basin could change significantly over the course of the next 30 years, as described in Section 5, ranging from a potential increase of 39,000 acres to a decrease of 2,600 acres. In light of that, meeting the Yampa/ White/Green Basin's future agricultural needs will need to focus on meeting existing needs and firming supplies available to existing agricultural users, but would require more aggressive measures to meet the demands if irrigated acreage increases. These projects could be multi-purpose and provide for recreational and environmental needs.

Environmental and recreational water management solutions were discussed conceptually in SWSI, with many of the concepts aligning with the approaches (such as "conserve, protect, and restore") highlighted in Section 6.1.3. Specific water management solutions discussed through the Basin Roundtable process toward achieving environmental and recreational goals are presented in Table 10-33 and the bullets below, each of which was identified and described by CDOW participants.

- **Programmatic Biological Opinion** – CDOW is working with the USFWS and other partners to complete the Programmatic Biological Opinion for threatened and endangered fish and critical habitat in the Yampa River. Considered a high priority by CDOW, this project is nearing completion.
- **White River/Lake Avery** – Also known as Big Beaver Reservoir, this medium-priority CDOW option would maintain or improve administrative flexibility below Lake Avery to ensure that water released for instream flow purposes will be used for such purposes between the reservoir and Meeker. Successful verbal agreements to maintain instream flow releases were reached in 2002.
- **Chuck Lewis State Wildlife Area Instream Habitat Improvement** – CDOW is participating in a cooperative project to improve instream habitat conditions in the Yampa River at this State Wildlife Area. Considered a medium to high priority project for CDOW, its implementation is underway and anticipated by fall 2005.
- **Yampa River Flow Enhancement** – CDOW has identified this medium-priority project to maintain operational flexibility between the major users and suppliers of water to mitigate drought impacts to the fishery in the Yampa River (i.e., Stage Coach to Elk River). Successful re-operation/exchanges in 2002 allowed flow increases through the upper reach that minimized the effects of high water temperatures.
- **Aquatic Wildlife Management Plan** – CDOW has completed its plan that provides management guidance and strategies geared toward conserving and protecting aquatic resources in the basin. This 5-year process is a high priority for CDOW.

Table 10-33 Potential Future Yampa/White/Green Basin Water Management Options

Project	Sponsor	Type of Project	Additional Storage (AF)	Additional Yield (AFY)	Project Purpose and Notes
Small Reservoir Study	CRWCD	Additional Storage	1,900	2,800	Would provide for storage on tributaries for agricultural uses.
Management Plan for Endangered Fishes in Yampa River Basin	None	Environmental	Not Applicable	Not Available	Manage flows for protection of endangered fishes.
Little Snake	None	Additional Storage	Not Available	Not Available	Storage for agricultural uses. Could be multi-purpose.
Morrison Creek Reservoir	None	Additional Storage	Up to 5,000	Up to 4,000	---
Yellow Jacket WCD Reservoirs	None	Additional Storage	Not Available	Up to 87,500	Storage in the White Basin for energy development and associated water needs.
Stillwater Reservoir	None	Additional Storage	Not Available	Not Available	Could be multi-purpose.
Yamcolo Reservoir	None	Additional Storage	Not Available	Not Available	Could be multi-purpose.
Agricultural Storage Delivery Structures	None	Additional Storage	Not Available	Not Available	Provide storage and delivery structures to irrigate an additional 20,000 to 40,000 acres. Could be multi-purpose project.

Section 11
Implementation

11.1 Introduction

This section outlines CWCB's implementation plan for SWSI. In particular, it reflects on the findings of SWSI and how we as a state can use SWSI to help meet Colorado's future water needs, including a discussion of:

- Major findings of SWSI on both a statewide and a basin-specific level
- Key recommendations
- Implementation issues
- The path forward for meeting our future water needs
- The implementation process, and specific CWCB tasks toward implementation
- Next phases of SWSI

The reader is encouraged to reflect on the information and provide feedback to the Board as we evaluate how to best meet our current and 2030 water needs.

11.2 Major Findings of SWSI

11.2.1 Major Statewide Findings

SWSI explored all aspects of Colorado's water use and development on both a statewide and an individual basin basis. 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 and are discussed in the Executive Summary.

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, under the most optimistic scenario.**
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, non-tributary 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.**

These Findings and the Recommendations found in Section 11.3 were drawn from all aspects of the SWSI process. However, they should not be viewed as consensus products of the Basin Roundtables.

11.2.2 River Basin Issues at a Glance

Section 10 of this report presents a comprehensive view of our state and its water uses and needs. A brief overview of some of the individual basin issues is provided here to assist the reader in linking the basin issues to SWSI implementation.

11.2.2.1 Arkansas Basin

- Arkansas River Compact requirements and existing uses and water rights result in little to no water availability for new uses.
- Growth in the headwaters region will present challenges in obtaining augmentation water for new demands.
- Concerns over agricultural transfers and its impact on rural economies are significant in the lower portion of the basin downstream of Pueblo Reservoir.
- Concern over water quality and suitable drinking water are key concerns in the lower basin.
- The success of two major projects are key to meeting future water needs.
- The urban landscape is very important to the economy and an important component to quality of life.

11.2.2.2 Colorado Basin

- Rapid growth in the headwaters areas and lack of available supplies or storage are significant challenges to meeting future water needs.
- Recreation and the environment are key drivers in the basin and are important for economic health and quality of life.
- Agriculture is important in the basin, especially in the lower basin (Grand Valley).
- The success of the Endangered Species program is critical to help protect current and future water use.
- There is concern over a potential compact shortage during severe and sustained drought and potential impacts to in-basin supplies.
- The development of water rights associated with transbasin projects are a concern and their effect on in-basin supplies must be considered.

11.2.2.3 Dolores/San Juan/San Miguel Basin

- This multiple basin area of the state is extremely diverse with changing demographics
  - The Pagosa Springs-Bayfield-Durango corridor is rapidly growing, has areas of localized water shortages, and is transitioning from mining/agricultural to tourism, recreation, and a retirement/second home area.
  - The Cortez area remains strongly agricultural but is also seeing rapid growth with retirees moving to the area.
  - The San Miguel area is a mix of recreation and tourism along with a strong desire to maintain agriculture.
- Overall water supply is available but getting sufficient infrastructure and water distribution will be a key challenge.
- The Colorado River Compact places pressure on uses of the San Juan River because New Mexico's primary source of the upper Colorado River Basin supplies is the San Juan River.

11.2.2.4 Gunnison Basin

- Growth in the headwaters will require additional water management strategies.
- Addressing agricultural water shortages in the upper portion of the basin is an important goal of the community; lack of financial resources is an impediment.
- There is concern over possible future transbasin diversions and the effect this might have on the basin's future.
- Resolving federal issues is a priority. Federal issues include: resolving the National Park Service claims for flows in the Black Canyon, completion of the Blue Mesa/Aspinall reoperations EIS, and addressing Endangered Species issues in the Gunnison River near the confluence with the Colorado River main stem.
- The area between Ouray and Montrose is rapidly growing. Tourism is important in the headwater but agriculture is dominant in the Uncompahgre Valley. A rapid influx of retirees and growth in the Uncompahgre Valley may dramatically change the agricultural uses and land use in the area.

11.2.2.5 North Platte Basin

- One of Colorado's only basins with concern over lack of growth and economic development.
- There is a desire to ensure protection of existing water supplies, and a concern over the impact of the lack of forest management. It is important that Endangered Species issues on the Platte River in Central Nebraska are successfully resolved and in a manner that does not put pressure on North Platte water users to reduce existing uses.
- The equitable apportionment decree quantifies the amount of available water and lands that can be irrigated.

11.2.2.6 Rio Grande Basin

- The Rio Grande Compact and the effects of sustained drought make new water development very difficult.
- In the Rio Grande Valley, agricultural water use is at unsustainable levels and economic impacts of reducing irrigation use of groundwater supplies will be difficult to address.
- Groundwater is a key component of water use in the basin.

11.2.2.7 South Platte Basin

- Colorado's most diverse and industrialized basin. Agriculture is still a dominant water use but rapid changes are occurring and the impacts to rural communities are a key concern.
- Competition for water is fierce and it is unclear how much competition there is for the same water supplies.
- The lack of any new major water storage in the last 20 years has led to reliance on non-renewable groundwater in Douglas, Arapahoe, and northern El Paso (El Paso County is in the Arkansas Basin) Counties. Explosive growth in these counties coupled with the lack of surface water supplies led to the creation of multiple small water districts and makes coordinated water development a challenge and less efficient especially in light of limited renewable surface water supplies.
- Water reuse and conservation are major components to meeting future water needs but this will put added pressure on agriculture as return flows diminish.
- The urban landscape is very important to the economy and an important component to quality of life.
- Transfers of agricultural water rights to M&I use will continue to be a significant option for meeting future needs.

11.2.2.8 Yampa/White/Green Basin

- Agriculture, tourism, and recreation are vital components to this basin's economy.
- Industrial uses, especially power production, are a major water use. Future energy development is less certain.
- While rapidly growing in some areas (Yampa River/Steamboat area) the basin is not developing as rapidly as other portions of the state. This has led to concern that the basin will not get a "fair share" of water use afforded to Colorado under the Colorado River Compact.
- Implementation of a successful Endangered Species Program is vital to ensuring protection of existing and future water uses.

11.3 Key Recommendations

Following from SWSI's major findings, and based primarily on feedback obtained from the CWCB Board, Basin Roundtables, and public input, the recommendations outlined below provide guidance on how Colorado should proceed in addressing its future water needs. The reader is encouraged to look at the Key Recommendations section of the Executive Summary, which expands on these key recommendations.

1. **Ongoing Dialogue Among all Water Interests is Needed**
2. **Track and Support the Identified Projects and Processes**
3. **Develop a Program to Evaluate, Quantify, and Prioritize Environmental and Recreational Water Enhancement Goals**
4. **Work Toward Consensus Recommendations on Funding Mechanisms for Environmental and Recreational Enhancements**
5. **Create a Common Understanding of Future Water Supplies**
6. **Develop Implementation Plans Toward Meeting Future Needs**
7. **Assess Potential New State Roles in Implementing Solutions**
8. **Develop Requirements for Standardized Annual M&I Water Use Data Reporting**

The precise timing and method in which these recommendations can be implemented is flexible, and more discussion of ideas and suggestions is welcome. The remainder of this section outlines some of the implementation issues, and a framework for moving forward to address Colorado's water needs.

11.4 Implementation Issues

Implementation of solutions that will help meet Colorado's future water needs is not easy. Many of the issues faced by water users in meeting their needs were highlighted throughout the SWSI Basin Roundtable and public input processes. Perhaps the most prominent issue raised in SWSI was funding to implement the desired solutions. Funding opportunities, along with other implementation issues, are discussed in the sections below.

11.4.1 Project Hurdles

The key findings and recommendations abbreviated in this section and expanded on in the Executive Summary outline a plan for moving forward to ensure Colorado's water future. Colorado has enjoyed a rich and colorful history. Throughout time Coloradans have been characterized as courageous, innovative, industrious, and ruggedly individualist. Many of these characteristics were apparent in the personalities of the Basin Roundtable members. It is therefore not surprising that as SWSI was launched, it was met with support and the expressed need to work together in defining our water future from some interests, but also with significant skepticism that local needs and interests would not be respected. Many water providers did not support state involvement in water supply planning, believing that planning is best conducted by individual water providers. Smaller communities and less populated portions of the state were concerned that their economic, social, and cultural future would be "sacrificed" for the needs of urban areas. Environmental and recreational interests expressed concern that the process was intended to push for the development of new water supply storage projects at the expense of the environment or recreation. The West Slope was fearful that there was a pre-ordained outcome of SWSI to justify new large transbasin diversions.

The SWSI Basin Roundtable process was the first step in developing open communication across a wide range of interests in each basin. It was intended to facilitate communication and dialogue and the first step towards identifying a common understanding of future water needs and potential options and the trade-offs of each option to meet future water needs. The time constraints and direction from the Legislature limited the ability to completely explore the issues, but the SWSI process was an important first step in having a basinwide and statewide dialogue on how to best provide for future water needs. It is helpful to address some of the fears and myths of SWSI.

The SWSI process is **NOT**:

- Designed to supersede local water supply planning.
- A process designed to facilitate transbasin projects.
- An attempt to relieve water providers from the financial responsibility to provide for mitigation as required by law.

The SWSI process, however, **IS** intended to:

- Develop a common understanding of future water needs and the options available to meet those needs.
- Facilitate discussion among various interest groups of the tradeoffs associated with all water supply options.
- Identify options for meeting environmental and recreational needs.
- Identify options to address agricultural shortages.

Against this backdrop, the SWSI process faced challenges in evaluating how to meet Colorado's future water needs. These obstacles were technical, social, and political in nature. There are some people that are simply seeking answers to legitimate questions while others would raise issues to maintain the status quo, or to advance specific agendas. The following comments are an acknowledgment that obstacles and issues were encountered that made the SWSI process more difficult. Yet it is essential that we not only recognize our differences but also what we have in common and continue to work together help ensure Colorado's water future.

The following observations have been made of the SWSI process:

- The mandated timeline for completion of the report did not allow adequate time for feedback and discussion among Basin Roundtable members.
- There was difficulty in communicating project goals, objectives, and findings to Basin Roundtable participants and interest groups in an understandable manner. There continues to be misconceptions and suspicion over the project goals, findings, and recommendations.
- Some Basin Roundtable participants had a difficult time in representing a broader interest group, instead representing the interests of their individual agency or group.
- Some Basin Roundtable participants were willing to critique information presented, but did not provide any information from their agencies that would assist in the analysis and evaluation of data and findings.
- Many of the larger and urban water providers were wary of SWSI and questioned the benefits of active participation in the process.
- Data sources on M&I demands were difficult to access. Interpretation of the data was also difficult because this reporting is not routinely provided, and is not available in a standardized format. Requirements for standardized reporting for this information by all water providers would allow refinement of supply and demand and conservation efforts, and help ensure a better understanding of out future water needs and issues.
- Questions and misunderstandings on data interpretation are an ongoing challenge. SWSI will continue to provide technically sound analyses, but there needs to be the opportunity and willingness of Basin Roundtable participants to not just critique data but to offer other better data sources, if they exist, and solutions.
- Water supply and demand data is complex and dynamic. Use of averages, differing periods of record, and differing methods and assumptions can result in competing conclusions. This in turn can lead people to question the resulting conclusions or have competing "facts."
- Some people are willing to critique and judge the validity of plans of other interest groups but do not want people to judge their own planning and projects. At times it appeared that some interest groups wanted to utilize SWSI to help put pressure on other interests in order to obtain a competitive advantage on an issue or to help them "negotiate" something of importance to them and/or advance their own individual agendas or projects.
- Water providers are sometimes reluctant to disclose information. There is competition for water, especially along the Front Range where many providers are competing for the same water supplies. Water providers are confident that they will be successful in the competition for the limited supplies and they are not seeking nor want assistance from the state. Water suppliers feel that full disclosure of their plans may impede their ability to be successful. This can occur in several ways. For example, disclosing information on projects can create greater competition and increase

cost. In addition, the information can be used to complicate logistics and legal and regulatory processes. Water providers sometimes view state involvement as complicating these issues even further.

- Larger water providers have traditionally dominated water development issues. As growth dynamics change and service areas of major providers are defined and near buildout, these providers are not planning for the future growth areas beyond their service area boundaries. These larger providers are not responsible for providing solutions to entities beyond their immediate customer base. The SWSI process needs to be expanded to ensure inclusion of interests of the future growth areas, even though there may not currently be an agency responsible for planning for future water needs.
- Permitting was identified as one of the primary implementation hurdles for water supply projects, and has the greatest impact on the uncertainty associated with the Identified Projects and Processes. Many water providers and agricultural users believe that one of the most significant hurdles to reliable water delivery in Colorado is environmental permitting. Federal permitting triggered by authorizations, funding, rights-of-way, licenses, or Section 404 of the CWA can entangle projects for years and cost millions in delays, consultants, and attorneys. Where threatened or endangered species or their habitat are present (every major river basin in Colorado), onerous consultations with the USFWS and lengthy, often litigated NEPA procedures, present daunting obstacles towards progress. Local and state permits may also be required for water projects. State water quality regulations and 1041 land use authority have the ability to impact the feasibility of water supply development. Existing water projects and water rights are also subject to permitting issues.
- Environmental and recreational interests and local governmental agencies view the federal, state, and local permit process as vital to protecting the environment, recreational opportunities, and the local economy. These regulatory processes are viewed as the only way that these interest groups can have meaningful input to ensure that the local interests and the environment and recreational opportunities are protected.

11.4.2 Funding

The costs to implement water supply and water resources projects continue to escalate. In light of the significant investments that must often be made to meet the needs of water users, numerous federal and state agencies have developed programs for partnering with project sponsors. Some agencies, such as the BOR, had their genesis in the immense need to support water management solutions in working with local project sponsors. Many of today's water resources programs include the ability to provide funding to support water supply and water resources projects, through grants, loans, or related mechanisms.

Colorado water resources projects are currently funded through a variety of sources, including outlays from cities, businesses, water districts, and local water users.

Some of the key existing funding agencies that are relevant to water resources projects in Colorado are highlighted below. Relevant funding programs of each of these agencies are detailed in Appendix I.

- Federal agencies
  - USACE
  - BOR
  - EPA
  - USDA
- State of Colorado
  - CWCB
  - CWRPDA
  - CDPHE
- Local entities, such as water providers and conservancy districts

In the next phase of SWSI, CWCB will examine CWCB's two principal funding sources (Construction Fund and Mineral Severance Tax Perpetual Base Account). Potential modifications could increase CWCB's ability to address water supply needs for rural and agricultural users, and to help address environmental and recreational enhancements. However, this may only offer a partial solution. Other funding options such as fee based approaches, alternate state fund sources, federal funding, and other revenue generating options will also be considered. In addition, if the state wishes to take a more prominent role in water resource protection and development, the above referenced change will only help in the near-term. Ultimately, in the long-term (2 to 5 years) a significant source of ongoing revenue would be needed to invest in projects with multiple beneficiaries, to assist rural Colorado water providers and agriculture, and to provide funds for additional environmental and recreation enhancements associated with water resource development and protection. CWCB does not have a recommendation at this time to pursue this more comprehensive funding strategy.

11.5 The Path Forward

The action word in Statewide Water Supply Initiative is "initiative."

While the CWCB was directed to complete SWSI and deliver its findings and recommendations to the General Assembly in 18 months, implementing SWSI will take years and decades. The state and its partners must now slow from a sprint and pace themselves for a longer-term effort. Helping ensure Colorado's water future is a complex and difficult challenge. Addressing our water future means that we must ensure the social, economic, and cultural health and integrity of all of our river basins. This is a daunting challenge and it will require creative solutions, dedication, and persistence.

As with its own Strategic Plan, the CWCB should identify its SWSI mission and specific goals that can be accomplished with the help of both the supporters and opponents of the SWSI process and state involvement in water planning.

These goals should be met by developing sound implementable objectives that can be met regularly over a longer term if SWSI's success is to be capitalized on. We now know, based on Basin Roundtable information, **Colorado can potentially meet 80 percent of its M&I water needs by 2030; however, some water suppliers may need help building infrastructure, mitigating and permitting projects, enhancing and improving the environment, and conserving water.** We also now know that the state can reassure the General Assembly and other state decisionmakers to an extent never before possible that we are not facing an immediate water crisis, but long-term challenges. There are certainly some tough decisions to be made and parts of the state need to take action sooner than others, but realistically, none of these tough decisions or actions can be made overnight or in an atmosphere of crisis.

11.5.1 The 80 Percent Solution for M&I

SWSI has catalogued the specific projects, plans, and processes that local water suppliers have identified and are undertaking as components of their own water supply planning efforts to meet the needs they themselves have identified. As a whole, if these projects are implemented, 80 percent of the state's long-term M&I needs will be met. This is the most optimistic scenario. But is there uncertainty, and hurdles to overcome?

Therefore, the mission of the state with respect to meeting 80 percent of our M&I water needs by 2030 should be:

Following the lead of local water suppliers, the state will monitor long-term water needs, provide technical and financial assistance to put the necessary plans, projects and programs in place to meet those needs, and foster cooperation to avoid being forced to make trade-offs that would otherwise harm Colorado's environment, lifestyle, culture, and economy.

The goals of this mission are to:

1. **Follow the lead of local water suppliers.** In order for the CWCB to follow, local water suppliers must not only lead, but also must share information and be inclusive so that state leaders can confidently make decisions and provide the support required to ensure the fourth goal can be met.

2. **Monitor long-term water needs.** One of the major hurdles faced was the difficulty in collecting water use and water planning data. Our information about agricultural water use comes from statistics, water commissioner records, and aerial and satellite imagery that demonstrate that over time growing patterns and crops change over geographic areas. The state has even less information to share that is provided on a regular basis about M&I water use and demand. We must develop a better system that still protects water rights holders.

3. **Provide technical and financial assistance to put the necessary plans, projects, and programs in place to meet those needs.** The Drought Assessment that was conducted by the CWCB highlights that most water suppliers want technical and financial assistance from the state. SWSI provided for some categorization among water users so that we can pinpoint the type of help and assistance needed.

4. **Foster cooperation to avoid being forced to make trade-offs that would otherwise harm Colorado's environment, lifestyle, culture and economy.** SWSI makes it clear that future plans include drying up farmland to provide water for cities, towns, communities, and industries. While there will be the inevitable reductions of irrigated acres as development occurs on these lands, some of the additional projected losses of irrigated lands can be reduced if viable alternatives are available to M&I providers. Options exist that could reduce the need to dry up additional irrigated agricultural lands, but cooperation is essential and the state may be able to help level the field so that "win-win" options can be chosen. This must be done in a way that enhances our environment and protects recreational resources.

There are numerous issues that should be explored in this dialogue:

- Competition among water providers for the same sources of water.
- The trade-offs between in-basin agricultural transfers and new water supply development.
- How to create win-win scenarios where the basin or area of origin and the area of beneficial use both derive sufficient benefits from a proposed water development project.
- How to collaborate on the implementation of the Identified Projects and Processes, and further development of the options for meeting future needs.
- Identify options to allow for more use of non-permanent transfers of water from agriculture.

11.5.2 The 20 Percent M&I Gap, Agricultural Shortages, and Environmental and Recreational Enhancements

Another major achievement of SWSI was the identification of an inevitable gap in water supply that exists between current M&I water supply planning and the projected need for water. In addition, localized agricultural shortages have been identified in all basins and significant environmental and recreational needs were identified. Articulating the CWCB's role in helping to narrow and eventually eliminate this gap is much trickier – both institutionally and politically.

It is this gap that must be filled with "new" water so to speak. If water suppliers had the water to meet the demand represented by this gap, there would be no gap.

The mission for the state in filling this gap should be:

Foster cooperation among water suppliers and citizens in every water basin to examine and implement options to fill the gap between ongoing water planning and future water needs.

The goals of this mission are to:

1. **Foster cooperation among water suppliers and citizens in every water basin.** And, because SWSI is an *initiative*, work must obviously continue. The CWCB should continue the discussions that began at the Basin Roundtable meetings about in-basin projects and needs. The state should also identify and help foster the discussion about when these in-basin plans and projects are likely to impact out-of-basin interests, and what if anything, can be done to mitigate, or better yet *improve* water resource management and the economic, social, and environmental conditions in both basins – keeping in mind that if water development proceeds as planned, these discussions focus on only 20 percent of our

long term M&I needs. These discussions must be conducted in such a manner that our 80 percent solutions aren't jeopardized by institutional, political, or social rancor. Remember, we are planning to meet water needs by 2030.

2. **Examine and implement options to fill the gap between ongoing water planning and future water needs.** SWSI did not produce a list of specific projects to fill the 20 percent M&I gap, or provide for environmental and recreational needs. SWSI did identify the options, both at the conceptual and project specific level that would most likely be pursued to meet the gap between supply and demand. The examination and implementation of these options should be placed in the context of goal number one.

3. **Examine and implement options to fill the gap associated with local agricultural shortages and environmental and recreational enhancements.** As we move forward in addressing statewide needs, we should look to foster multipurpose projects that could also satisfy M&I, environmental, and recreational needs. These multipurpose projects will enhance project feasibility. In addition, opportunities for nonpermanent agricultural transfers warrant further consideration.

Crafting new water supply alternatives to address anticipated supply gaps will be the work of the Basin Roundtables for SWSI's next phase in those basins where a gap exists. These alternatives can serve two purposes – that of a new water supply project, and as an alternative to Identified Projects and Processes that may be unsuccessful. The options to be used as building blocks for these water supply projects have been presented in Section 10.

11.6 Implementation Process

The state can only control and begin to implement those activities for which it has the authority and funding. Therefore, the CWCB's work-plan must have at least two components – today and tomorrow. Fortunately, the Board's own mission is broad enough to allow it to assume the two new missions articulated above to be assumed. The mission of the CWCB is to:

Conserve, Develop, Protect and Manage Colorado's Water for Present and Future Generations.

How the Board achieves its fundamental goals will likely change as SWSI is implemented, but in the meantime, its goals of conserving, developing, protecting, and managing are sound. Its annual process of reviewing and revising its Strategic Plan, Objectives, and Workplans will also accommodate the long-term implementation of the SWSI missions.

Therefore, the principal new work-plan task is to ***integrate the SWSI missions into the Board's strategic planning processes***.

This will take place over time. The Board and the staff should be prepared to adopt specific recommendations by July 2005, when the Board is scheduled to next review its Strategic Plan. Each section of the Board's staff should examine how it will assist in the implementation of SWSI and, if appropriate, develop individual Strategic Plans to aid in implementing SWSI goals, findings, and recommendations. This is an important part of the Board's mission, and we should all be headed in the same direction.

Future work-plan tasks were identified at Basin Roundtable Technical Meetings – some very specific and some general. Some we can do now, others will take time to develop and, in some cases, new authority to implement.

We have attempted to capture those recommendations and shape them into some potential work-plan tasks. These tasks are in line with how water suppliers, state leaders and the public view the Board – not as a single entity, but usually as separate programs administered on their behalf.

CWCB's major programs include:

- Water Supply Planning and Finance
- Water Supply Protection
- Instream Flow and Natural Lake Level Protection
- Conservation and Drought Planning
- Flood Protection
- Water Information

Activities that can be undertaken by the Board and each section toward implementing SWSI are presented below.

11.6.1 CWCB Board Tasks

When discussing Board tasks, one is speaking not just of basin representatives, but also the CWCB Director, the DNR Executive Director and other ex-officio members representing the DOA, the CDOW, the SEO, and the Attorney General's office. When the General Assembly created the Board and gave it such broad representation it meant for these Board members to work together to accomplish the mission it set forth. Members should focus on how they are collectively accomplishing the mission and not just the individual activities they are undertaking that contribute to accomplishment of the mission. This is absolutely essential – not only for the 80 percent M&I supply to be realized, but also if the 20 percent water supply gap is to be filled and agricultural, environmental, and recreational needs satisfied.

With the above in mind, the following are some potential work-plan tasks:

- Using the list of specific projects and options laid out by SWSI, report to other members and staff about the status of local implementation efforts.
- Convey "collective" information about Board activities issues and needs and challenges to their local elected officials to maintain a sense of order and facilitate communication when the need for legislative action arises.
- Help identify and support requests for statutory, regulatory, and financial requests made to Congress and federal agencies.
- Support the designation of staff within the Board to be dedicated to SWSI implementation.
- Identify specific ways to foster cooperation.
- Support the implementation of identified projects and processes.
- Working with water suppliers, make a recommendation about how the staff should collaboratively track local project implementation.
- Examine the need for project permitting and mitigation assistance, recognizing that permit requirements and mitigation have resulted in uncertainty and increased project costs for many users. This has resulted in many M&I providers moving towards agricultural transfers due to greater certainty and flexibility. This might include examining the need for a state/ federal/local project permitting assistance "team."
- Promoting and facilitating coordinated operations of existing facilities and infrastructure.
- Promote and support the development of projects that serve multiple purposes.
- Evaluate alternative methods for determining environmental and recreational needs, and ways to implement potential solutions.

11.6.2 Water Supply Planning and Financing Tasks

The CWCB is now totally self-financed. In fact, it is now paying a significant share of the costs for running the DNR and the SEO. Beyond that, it is also the chief source of financing for water planning done by its customers. It does this with a very small staff, limited appropriated resources, and significant oversight.

The CWCB Construction Fund was created by the Colorado General Assembly in 1971 to provide low interest loans to water users in the development of water resource projects. The CWCB Construction Fund is a partially self-supporting revolving loan fund. Sources of revenue are from the return of principal and interest on outstanding loans, interest earned on the cash balance of the fund through investments by the State Treasurer, mineral lease fund distributions, and occasional cash transfers from the General Assembly. The types of projects that are eligible for funding are specified by state statute.

If the Board is to be successful in meeting the needs identified by SWSI it must have the ability to remain flexible and its funding sources must be protected, for without stable and reliable financing, none of the projects or programs identified can be implemented.

Take for instance, the strong interest on the part of SWSI Basin Roundtable participants to further develop environmental and recreational enhancements. Yet, while there may be an overall willingness of some environmental and recreational beneficiaries to pay for such enhancements, there is no funding mechanism.

Obviously, sponsors of water development projects have a fiduciary responsibility to their ratepayers to develop projects in a fiscally prudent manner. Costs attributed to water acquisition, storage, treatment, transportation, project mitigation, and other factors are rolled into a rate structure that finances these projects. There is currently no mechanism for rolling costs related to recreational or environmental enhancements unrelated to specific project mitigation into that equation.

One ongoing activity that should include the Board and its staff is a dialogue about whether a consensus can be developed regarding potential payment mechanisms to account for environmental and recreational enhancements. These recommendations could be presented to the CWCB and/or the State Legislature for action. In addition, the CWCB should:

- Utilize the list of identified projects and processes to conduct outreach and education regarding the CWCB's loan program and other fiscal services available to water users and interest groups.
- Analyze how the state could help meet the need for rural water supply delivery systems.
- Categorize, target and prioritize financial assistance. "Major" water suppliers don't need or want state involvement, smaller entities can't succeed without it.
- Identify how much financial assistance should be set aside annually to help targeted entities get the technical assistance they need for projects and programs, whether from the state or private entities such as engineering consulting firms.
- Make recommendations to the Board about the need for future project reconnaissance and feasibility studies that can aid the state in meeting needs, without simply relying on water suppliers to request such support.
- Build higher awareness of existing state and federal loan and grant programs, and assessing the need to expand or revise them.
- Identify and exploit federal funding opportunities.

11.6.3 Water Supply Protection Tasks

The Water Supply Protection Program is directed by statutory requirements for the CWCB to protect the authority, interests, and rights of the state and its citizens in matters pertaining to interstate waters of the State of Colorado. Under these statutes, the CWCB is required to cooperate with federal agencies and other states to better utilize the waters of the State of Colorado, develop legislation to secure greater beneficial utilization of these waters, and recommend mitigation to maintain a balance between water development and protection of the state's fish and wildlife resources.

One of the most commonly asked questions during the SWSI process was how much water is available to the state to develop. While on its face this is a seemingly simple question, the answer is far more elusive. Indeed, the inability to answer that question has been a source of frustration for many.

There are two principal reasons why SWSI has not yet produced an agreed upon answer to that question. First, there are many variables related to supply, and no consistency among water interests in how to define each variable. These include:

- Existing water rights.
- Current and future water demands.
- Conditional water rights.
- Hydrologic conditions.
- Compact interpretations.
- Federal laws.
- Operations of existing and future facilities.
- Endangered species.
- Environmental and recreational needs.

We need to develop a common understanding of each of these variables before this question can be answered in a manner where there is more agreement.

The difficulty in developing that common understanding goes to the very root of the values and interests that people hold in regard to their water future. Water providers assume an advocacy role when asked that question, interpreting the answer with their customers' and stakeholders' interests in mind.

Not until we can move beyond these positions to one where a thoughtful dialogue can take place, will we know the answer to this question. Yet, it is a critical question, and too important to not probe further. Basin Roundtables should continue to explore this issue, and determine whether it is possible to move stakeholders beyond an advocacy role and develop a consensus on how much water we have that can be developed. The answer is too important to our collective water future to not make this effort.

In addition, the section should:

- Work to ensure supplies available under compacts remain available to meet future water needs.
- Make recommendations to the Board about the need for future project reconnaissance and feasibility studies that can aid the state in meeting needs, without simply relying on water suppliers to request such support.
- Identify and exploit federal funding opportunities.

11.6.4 Instream Flow and Natural Lake Level Protection Tasks

Preserving the natural environment of streams and lakes, consistent with the doctrine of prior appropriations and the laws of the state, is a priority for Colorado. The CWCB's Instream Flow Program managed by the CWCB has been the primary means by which this objective has been pursued. Since its creation in 1973, the program has resulted in the appropriation of instream flow water rights on more than 8,000 miles of streams and 475 natural lakes in the state.

There was interest among some of the Basin Roundtables to further enhance the flows for environmental and recreational purposes beyond the instream flow program, and in developing new and creative mechanisms to achieve this goal. **The key to doing this lies in involving all key stakeholders in this discussion – environmental interests, recreational advocates, agriculture, municipal, and industrial. In addition, it is imperative that these stakeholders strive for balance in how this goal is achieved.**

In developing new water projects, this Program also was identified as having an important role to play.

- CWCB should identify stream segments or ecological areas for flow prioritization or enhancement. Working through the Basin Roundtable process, the CDOW, 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.
- Prioritize the need for instream flow and natural lake protection to coincide with SWSI related plans.
- Use the program to provide regulatory stability to help water suppliers meet permitting requirements.

- Make recommendations to the Board about the need for future project reconnaissance and feasibility studies that can aid the state in meeting needs, without simply relying on water suppliers to request such support.
- Identify and exploit federal funding opportunities.

11.6.5 Office of Conservation and Drought Planning Tasks

General statutory authority is given to the Board to provide conservation and drought planning support to the state and its citizens. The Conservation and Drought Planning Section develops and approves water efficiency plans, monitors water use, provides technical assistance and public information, inventories and prepares drought plans, and assists with policy development, while networking with water suppliers, legislators, and key constituencies.

Water conservation was identified as a major component of meeting future demands in every basin. Yet, until the passage of HB 04-1365, the CWCB had neither the funding nor authority to help meet this goal. Further discussions and enhancements to the Board's authority and role must be made, especially to help those water suppliers that want to integrate conservation and drought planning into their systems, but are in need of technical assistance.

- Implement HB 04-1365 in such a manner as to give priority for funding to those entities applying for grants that have identified conservation as a component of the 80 percent solution.
- Using the guidelines discussed above, implement the Technical Assistance to Covered Entities Program.
- Annually publish a report about our progress toward having implementable conservation and drought plans.
- Continue to promote the use of landscape BMPs.
- Identify and exploit federal funding opportunities.

11.6.6 Flood Protection Tasks

The Flood Protection Program is directed by statute to prevent flood damages, review and approve floodplain designations prior to adoption by local government entities, and provide local jurisdictions with technical assistance and floodplain information.

The location of new development greatly impacts the level of safety required of water suppliers. The level of safety required for hazard reduction in turn impacts the cost of building, repairing, and enlarging water projects. In addition, our watershed protection and river restoration programs have begun to be utilized to make existing water supplies more useful for a wide variety of purposes. The Flood Section should:

- Monitor and assist the SEO 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 while protecting life and property.
- Develop project floodplain delineations to help local government locate growth.
- Examine the potential for USACE flood control projects to be used to store more water to meet needs. In addition, explore the potential to use non-structural floodway designs, such as wetlands and parks, to help offset the impacts of new water project development, and provide environmental benefits.
- Make it a priority, using river restoration techniques and projects to identify areas of the state that would benefit from such projects when combined with a SWSI identified project.
- Make recommendations to the Board about the need for future project reconnaissance and feasibility studies that can aid the state in meeting needs, without simply relying on water suppliers to request such support.
- Identify and exploit federal funding opportunities.

11.6.7 Water Information Tasks

The Water Information section operates and maintains the Colorado DSS. This system supports informed decisionmaking regarding historic and future use of water.

Data and information gathering and dissemination were a major obstacle SWSI had to address and attempt to overcome. There is no doubt that the material presented in this report will generate much discussion. The SWSI team put forth the best available data and information at this time. But, if there is new information and new data, or if interpretations must change, there is time to make these changes.

In the meantime, the CWCB should:

- Provide specific recommendations to the Board about future information needs and gaps and how those needs and gaps should be met and filled.
- Develop guidelines and proposed requirements for standardized annual M&I water use data reporting.

- Work with the Colorado Foundation for Water Education to determine how to convey the information gathered during SWSI.
- Analyze and, with Board approval, promote specific conjunctive use projects utilizing surface water and groundwater resources.
- Develop water availability and sustainability estimates for non-tributary groundwater areas, particularly the Denver Basin and Northern and Southern High Plains.
- Identify and exploit federal funding opportunities.

11.7 Next Phases of SWSI

Building on the foundation laid by this first phase of SWSI, SWSI will continue with at least two meetings scheduled for most basins between November 2004 and July 2006. The subject of future Basin Roundtable Technical Meetings is expected to be as follows:

- Continue to refine technical data and demands on a statewide level.
- Assess supply availability on a statewide basis.
- Determine risk associated with uncertainty in the implementation of the Identified Projects and Processes.
- Identify key Identified Projects and Processes and develop a monitoring mechanism to track the progress of Identified Projects and Processes.
- Develop basin-specific alternatives using options for 20 percent M&I gap, agricultural, recreational, and environmental needs, and uncertainty associated with the Identified Projects and Processes.
- Assess the ability of existing funding programs to meet Colorado's water needs, begin to develop a framework for new programs if a need is identified, and develop basin-specific implementation and funding plans.
- Develop water supply and water use reporting mechanisms and work with water users to develop consensus; identify levels of conservation and work with the Colorado Municipal League to facilitate this process.
- Facilitate the creation of partnerships between water suppliers and state and federal agencies.

In addition, the next phase of SWSI should include more emphasis on the identification of solutions involving multiple basins. In support of this, CWCB should schedule meetings of multiple basins where solutions for water supply involve more than one basin.

11.8 Opening

A report such as this usually has a conclusion. However, the entire report is the conclusion – we know how much water we need and how much water can be provided if current plans and processes are implemented.

Therefore, what has truly been provided is an ***Opening***.

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