Rio Grande Basin Water Plan

Prepared for:

THE RIO GRANDE BASIN ROUNDTABLE

For submittal to:

THE COLORADO WATER CONSERVATION BOARD

Draft – July 31, 2014

DiNatale WATER CONSULTANTS

Above: Alamosa and the Rio Grande. Photo: Adriel Heisey

Front cover photo: Erich Schlegel

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Photo: Rio de la Vista

Important Definitions

Constraint: Hurdle or concern foreseen in completing a goal. Examples may include Rio Grande Compact (the Compact) delivery requirements, watershed health, future hydrology impacts due to climate change, and legislation requiring maintenance of aquifers at a certain level or funding. Constraints are discussed in Section 5.

Goal: Targets needed to support the values of the Basin stakeholders. Goals are identified in Section 3.

Implementation strategy: This includes the project sponsors, partnerships, funding sources, logistics, permitting and additional research needed to implement a project and method. Implementation strategies are identified in Section 8.

Measurable outcome: How this Basin Water Plan will meet the goal in a quantifiable manner. Measurable outcomes are identified in Section 3.

Need: Specific action (research, policy, organization, etc.) or improvement needed to reduce and/or remove vulnerability and meet the goal and measurable outcome. Needs for agriculture, municipal, industrial, environment and recreation are identified in Section 4.

Opportunity: The opposite of a constraint and something that contributes to achieving a goal. Examples may include improving watershed health, public education, retiming of Compact delivery flows, creation of groundwater management subdistricts, new collaborative efforts or multi-use projects. Opportunities are discussed in Section 5.

Project and method: A structural or non-structural project, policy or process identified to meet a goal. Projects and methods are identified in Section 6.

Resiliency: The capacity of social-ecological systems to absorb new or recurrent disturbances, such as drought, fires, pine bark beetle infestation or climate change, while still retaining the essential structures, processes and feedbacks to sustain the systems and recover appropriately. A key part of the Rio Grande Basin's definition of resiliency is the ability of systems to retain as much water as possible and as needed to sustain high-functioning systems.

Water Quality Standards: The Water Quality Control Commission of the Colorado Department of Public Health and Environment (CDPHE) has adopted regulations that establish classifications and numeric standards for the Rio Grande Basin, including all tributaries and standing bodies of water. These standards protect water quality but also result in wastewater discharge limits for municipal and industrial users. In addition, CDPHE and the U.S. Environmental Protection Agency have water quality standards for treated municipal water that impact the cost of treatment.

Watershed Health: Watershed health in the Rio Grande Basin is the ability of the watershed to provide ecosystem services which incorporates and addresses forest health, forest insects, fire risk, soil health, riparian health, and the competence of watercourses to handle sediment loads throughout the Basin, from uplands to bottom lands to wetlands. The benefits and services provided by healthy watersheds are numerous and include increased resiliency and reduced vulnerability to invasive species, climate change, and future land use changes.

Wetlands: Wetlands of the United States are defined by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Wetlands generally include swamps, marshes, bogs, and similar areas." The wetlands in the Rio Grande Basin exist from the highest mountain meadows and forests, along watercourses and to the San Luis Valley floor. They range from riparian wetlands to wet meadows (which also grow pasture and hay for livestock), playas and fen. Comprising only 3% of Colorado's land base, these areas are vital to over 75% of the state's wildlife species. In the Rio Grande Basin, they support a wide range of bird and other wildlife species, including threatened and endangered species, and play a key role in agricultural productivity as well as recreational activities, such as fishing, hunting and birding.

Rio Grande headwaters in the San Juan mountains. Photo: Rio de la Vista

Acronyms, Abbreviations and Words with Multiple Spellings

AF: Acre-feet

AFY: Acre-Feet/Year

Ag: Agriculture (subcommittee abbreviation)

ARWRF: Alamosa River Watershed Restoration Foundation

ATM: Alternative Transfer Methods

AWDI: American Water Development Inc.

BIP: Basin Implementation Plan

BLM: Bureau of Land Management

BOR: Bureau of Reclamation

BWP: Basin Water Plan

CDPHE: Colorado Department of Public Health and Environment

CFS: Cubic Feet per Second

CNHP: Colorado Natural Heritage Program

CPW: Colorado Division of Parks and Wildlife

CRGRF: Colorado Rio Grande Restoration Foundation

CSFS: Colorado State Forest Service

CSU: Colorado State University

CU: Consumptive Use

CWCB: Colorado Water Conservation Board

CWCD: Conejos Water Conservancy District

CWT: Per hundred pounds of weight

DNR: Department of Natural Resources

DWR: Division of Water Resources

Env & Rec: Environmental and Recreational (subcommittee abbreviation); used in this Plan in the place of nonconsumptive, as we recognize that water is consumed by some of these attributes

EPA: Environmental Protection Agency

ESA: Endangered Species Act

G&MOs: Goals and Measurable Outcomes

GOCO: Great Outdoors Colorado

GPCD: Gallons per Capita per Day

HB: House Bill

IBCC: Interbasin Compact Committee

ISF: Instream Flow

IWJV: Intermountain West Joint Venture

IWR: Irrigation Water Requirement

Los Sauces: Also spelled La Sauses, Lasauses, and La Sauces

McIntire: Also spelled McIntyre and MacIntire

M&I: Municipal and Industrial (subcommittee abbreviation)

NAWCA: North American Wetlands Conservation Act

NCNA: Nonconsumptive Needs Assessment

NRCS: Natural Resource Conservation Service

PFW: Partners for Fish and Wildlife

RG: Rio Grande

RGBIP: Rio Grande Basin Implementation Plan

RGBRT: Rio Grande Basin Roundtable

RGB: Rio Grande Basin

RGCT: Rio Grande Cutthroat Trout

RGDSS: Rio Grande Decision Support System

RGHRP: Rio Grande Headwaters Restoration Project

RGNA: Rio Grande Natural Area

RGR: Rio Grande Reservoir

RGWACD: Rio Grande Watershed Association of Conservation Districts

RGWCD: Rio Grande Water Conservation District

RGWCEI: Rio Grande Watershed Conservation and Education Initiative

RiGHT: Rio Grande Headwaters Land Trust

RWEACT: Rio Grande Watershed Emergency Action Coordination Team

SB: Senate Bill

SLV: San Luis Valley

SLVEC: San Luis Valley Ecosystem Council

SLVID: San Luis Valley Irrigation District

SLVWCD: San Luis Valley Water Conservancy District

SSI: Self-supplied Industrial

SWE: Snow Water Equivalent

SWSI: Statewide Water Supply Initiative

TMD: Transmountain diversion

TNC: The Nature Conservancy

TU: Trout Unlimited

USFS: U.S. Forest Service

USFWS: U.S. Fish and Wildlife Service

USGS: U.S. Geological Survey

WAdm: Water Administration (subcommittee abbreviation)

WCRC: Willow Creek Reclamation Committee

WSRA: Water Supply Reserve Account

Rio Grande below Ute Ridge. Photo: Adriel Heisey

SECTION 1

Introduction

The introduction describes the State Plan Process, the Rio Grande Basin Roundtable process including members of the BRT and the steering committee and Basin Water Plan subcommittees. This section includes the organization of the Plan, describing the contents and relevant sections.

1.1 : State Water Plan Process

The State of Colorado initiated in 2003, through the Colorado Water Conservation Board (CWCB), the Statewide Water Supply Initiative (SWSI). SWSI, completed in 2004, investigated the state's 2030 water needs by basin, including estimating the amount and location of predicted shortfalls (termed "gaps") and identifying projects and methods that can address these gaps. Phase II of SWSI focused on four topics: conservation and efficiency; alternative agricultural water transfer methods; delineating and prioritizing the state's environmental and recreational water needs; and addressing the water supply gap. The SWSI report was updated in 2010, and is often referred to as SWSI 2010.

The Colorado Water for the 21st Century Act, passed in 2005, created eight basin roundtables (BRTs), including one for the Denver Metro Area and a 27-member Interbasin Compact Committee (IBCC), to facilitate dialogue that would lead to development of projects and methods to address the water supply gap. The Rio Grande BRT includes 31 appointees, who represent municipalities, counties and local water agencies in the Basin. Nine liaisons from state and federal agencies also sit on the Roundtable.

Where to find more information:

State of Colorado Water Plan
coloradowaterplan.com

Rio Grande Basin Water Plan
www.riograndewaterplan.com

This Water Plan is designed to meet the requirements of the Colorado Water Conservation Board per the Basin Implementation Plan Guidance (December 10, 2013). According to the Guidance:

> "The purpose of the Basin Implementation Plans is for each basin [roundtable] to identify projects and methods to meet basin-specific municipal, industrial, agricultural, environmental, and recreational needs. The Basin Implementation Plans will inform and help drive Colorado's Water Plan."

The Rio Grande BRT is pleased to submit this Rio Grande Basin Water Plan (Water Plan) for inclusion into the Colorado Water Plan process. The projects and methods identified in this Water Plan meet a variety of important needs in the Basin. Every effort was made to recognize the most appropriate goals, projects, and strategies to address the Basin's priorities. Preparation of the Water Plan was overseen by the Rio Grande BRT and its Basin Water Plan Steering Committee. Despite the best efforts to comprehensively address water needs in the Basin, given the accelerated deadline, resource constraints and limited information for key areas of concern, this Water Plan cannot adequately evaluate all of the issues, constraints and opportunities in the Basin or identify all of the projects and methods that can address the future water needs. In addition, the accelerated deadline did not allow for a complete vetting of all issues and the priorities. The projects and methods included in this Water Plan should not be viewed as a prioritization of projects or equally and unanimously supported by all members of the Roundtable.

1.2 : Statement on Future Trans-Mountain Diversions

The IBCC, as part of the Colorado Water Plan Process, has developed the framework of an agreement on how a transmountain diversion (TMD) project could potentially move forward:

1. The East Slope is not looking for firm yield from a TMD project and would accept West Slope hydrologic risk for that project.
2. A TMD project would be used conjunctively with East Slope interruptible supply agreements, Denver Basin aquifer resources, carry-over storage, terminal storage, drought restriction savings and other non-West-Slope water sources.
3. In order to manage when a TMD will be able to divert, triggers are needed.
4. An insurance policy is needed for existing uses, "agreed-to" projects, and some reasonable increment of future West Slope development.
5. Future West Slope needs should be accommodated as part of a new TMD project.
6. Colorado will continue its commitment to improve conservation and reuse.
7. Environmental resiliency and recreational needs must be addressed both before and conjunctively with a new TMD.

The Rio Grande BRT has not evaluated a TMD from the West Slope to the Front Range as part of this Water Plan, instead focusing on how the Rio Grande Basin can address its significant water needs without seeking additional interbasin transfers. The Rio Grande Basin recognizes that it may take the development of Colorado's entitlement under the Colorado River Compact to meet Colorado's water needs. The Basin also recognizes that issues across the state are difficult and complex, and is supportive of the seven general areas of agreements under the IBCC, which capture agriculture, environmental and municipal needs. If and when there is a consensus between the Front Range and the West Slope regarding interbasin water transfers the Rio Grande BRT will participate in those discussions and evaluate if additional interbasin transfers are appropriate to meet the significant water needs of the Basin.

The Rio Grande Basin has experienced several proposals to export water from the Basin to Front Range interests. These proposals were extensively vetted in Division 3 Water Court. The Water Court confirmed that the Basin is over-appropriated, and there are no available water resources for export. This Rio Grande Basin Water Plan details the water short nature of both the surface water and groundwater systems and confirms there are no additional supplies for export and the basin is at currently unsustainable levels of water use. This Plan also details the extensive

scientific studies that indicate that the Basin's current water supplies will decrease more than 30% by the end of this century. The export of existing consumptive use water rights would have a significant negative socio-economic and ecological impact on the Basin, further impacting the Basin's agricultural economy, which is already facing critical issues related to sustainability of water supplies. See Sections 2 and 3 for more detail.

1.3 : Basin Roundtable

The BRT serves as a forum to discuss water-related issues and a place where local water users can seek funding for projects. To date, projects approved by the BRT have secured approximately $9.4 million from the statewide account and $2 million from the Basin account. The funding has gone toward 45 projects in the Basin, ranging from studies to infrastructure improvement and restoration, among others (State of Colorado, Department of Natural Resources, Water Conservation Board 2013). The funding provided by CWCB has been integral in assisting the Basin in addressing key water needs.

As part of the Colorado Water Plan process, which Gov. John Hickenlooper initiated with an executive order in May 2013, the roundtables were assigned a key role in writing the Colorado Water Plan. The governor's executive order called for a water plan that would create:

> "A productive economy that supports vibrant and sustainable cities, viable and productive agriculture, and a robust skiing, recreation and tourism industry; efficient and effective water infrastructure promoting smart land use; and a strong environment that includes healthy watersheds, rivers and streams, and wildlife."

The Rio Grande BRT appointed a steering committee and five subcommittees to give shape to the Water Plan for the Rio Grande Basin. The subcommittees included members of the BRT as well as key stakeholders in the Basin. BRT members called for a plan that will provide a concise history of the development of the Basin, existing and future water needs, future priorities and an initial identification of projects and methods to address these priorities and needs. The Plan addresses agricultural, municipal, industrial, environmental and recreational needs and identifies the opportunities for multi-use projects that can benefit many water users and the Basin.

The steering committee members are shown on the following table.

1.4 : Basin Water Plan Process

1.4.1 : Basin Plan Steering Committee

Basin Plan Steering Committee	
Name	**Organization**
Mike Gibson	Chairperson, San Luis Valley Water Conservancy District
Rick Basagoitia	Colorado Parks and Wildlife
Ron Brink	Rancher
Heather Dutton	Rio Grande Headwaters Restoration Project
Christine Gallegos	Sangre de Cristo National Heritage Foundation
Joe Gallegos	Sangre de Cristo Acequia Association
Eugene Jacquez	Costilla County Water User
Nicole Langley	Transforma Research & Design
Judy Lopez	Rio Grande Watershed Conservation and Education Initiative
Cindy Medina	Alamosa Riverkeepers
Emma Regier	Rio Grande Headwaters Restoration Project
Rio de la Vista	RiGHT
Travis Smith	San Luis Valley Irrigation District, CWCB Board member, Interbasin Compact Committee Member
Charlie Spielman	Industrial Users representative on Basin Roundtable
Kevin Terry	Trout Unlimited
Steve Vandiver	Rio Grande Water Conservation District

The Basin water plan subcommittees were assigned to work with DiNatale Water Consultants. These subcommittees were water administration, agricultural, municipal and industrial (M&I) and environmental and recreational (Env & Rec). These subcommittees were actively involved with the development of the Basin Water Plan related to their specific areas. Much of their work is reflected throughout the Basin Water Plan. In addition, a public outreach subcommittee was organized to coordinate the extensive public outreach effort. The subcommittee members are shown on the following tables.

Steering committee meeting to go over the Rio Grande Basin Plan. Photo: Heather Dutton

1.4.2 : Basin Plan SubCommittees

Water Administration Subcommittee	
Name	**Organization**
Steve Vandiver*	Chairperson, Rio Grande Water Conservation District
Tony Aloia	Colorado Parks and Wildlife
Nathan Coombs*	Rio Grande Water Conservation District
Craig Cotten	Colorado Division of Water Resources, Division 3
Greg Higel*	Senior Water Users
Travis Smith*	San Luis Valley Irrigation District, CWCB Board member, Interbasin Compact Committee member

* Member of the Rio Grande Basin Roundtable

Water Division 3 meeting in the Rio Grande Basin.
Photo: Erich Schlegel

Agricultural Subcommittee	
Name	**Organization**
Ron Brink*	Chairperson, rancher
Peter Clark*	Rancher, Rio Grande County Well Users
Nathan Coombs*	Conejos Water Conservancy District
Ralph Curtis	Retired Rio Grande Water Conservation District Manager
Mario Curto*	Well User
Jim Ehrlich*	Colorado Potato Administrative Committee
Lawrence Gallegos*	Conejos County Clerk
Greg Higel*	Rio Grande Water Users
Keith Holland*	Santa Maria Reservoir Company
Eugene Jacquez*	Rio Culebra Watershed & RC Agricultural Coop
Judy Lopez*	Rio Grande Watershed Conservation and Education Initiative
Ed Nielsen*	Rancher / Real Estate
Karla Shriver*	Rio Grande County Commissioner, San Luis Valley Great Outdoors

* Member of the Rio Grande Basin Roundtable

Municipal and Industrial Subcommittee	
Name	**Organization**
Charlie Spielman*	Chairperson, Industrial representative on Basin Roundtable, Retired geologist
Marty Asplin	Del Norte Trails Association
Nathan Coombs*	Conejos Water Conservancy District
Allen Davey	Davis Engineering
Gene Farish*	Farish Law
Bob Kirkham	GeoLogical Solutions
Nicole Langley	Transforma Research & Design
Jason Lorenz	Agro Engineering
Forrest Neuerburge	Town of Monte Vista
Dale Wiescamp*	Wiescamp Realty LLC

* Member of the Rio Grande Basin Roundtable

Environmental & Recreation Subcommittee	
Name	**Organization**
Rio de la Vista*	Chairperson, RiGHT
Cary Aloia	Wetland Dynamics LLC
Rick Basagoitia	Colorado Parks and Wildlife

Christine Canaly	San Luis Valley Ecosystem Council
Pete Clark*	Rancher, Rio Grande County well users
Heather Dutton*	Rio Grande Headwaters Restoration Project
Ben Doon	Costilla County
Christina Gallagos	Sangre de Cristo National Heritage Foundation
Courtney Hurst	RiGHT
Ruth Lewis	Wetlands Focus Group Chair / NRCS
Jill Lucero	Bureau of Land Management
Members	Sangre de Cristo Acequia Association
Sue Swift Miller	BLM
Jenny Nehring	Wetland Dynamics LLC
Joseph Old Elk	Forest Service
Karla Shriver*	Rio Grande County Commissioner, San Luis Valley Great Outdoors Coalition Chair
Kevin Terry	Trout Unlimited
Paul Tigan	BLM

* Member of the Rio Grande Basin Roundtable

Public Outreach Subcommittee

Name	Organization
Judy Lopez*	Chairperson, Rio Grande Watershed Conservation and Education Initiative
Ron Brink*	Rancher
Rick Basagoitia	Colorado Parks and Wildlife
Heather Dutton*	Rio Grande Headwaters Restoration Project
Christine Gallagos	Sangre de Cristo National Heritage Foundation
Joe Gallegos	Sangre de Cristo Acequia Association
Ruth Heide	Valley Courier
Eugene Jacquez*	Rio Culebra Watershed & RC Agricultural Coop
Cindy Medina*	Alamosa Riverkeeper
Emma Regier	Rio Grande Headwater Restoration Project
Travis Smith*	San Luis Valley Irrigation District, CWCB Board member, Interbasin Compact Committee Member
Kevin Terry	Trout Unlimited

* Member of the Rio Grande Basin Roundtable

1.5 : Organization of Basin Water Plan

This Water Plan is organized in the following manner:

Section 1 – Introduction. The introduction describes the State Plan Process, the Rio Grande Basin Roundtable process including members of the BRT and the steering committee and Basin Water Plan subcommittees. This section includes the organization of the Plan, describing the contents and relevant sections.

Section 2 – Basin Overview. This section contains a general description of the Basin including geography, land ownership, climate, history of the San Luis Valley, culture, demographics and economy. This section is intended as a detailed reference guide of background and supporting information to the Plan and Sections 4 through 5.3 will reference the background information contained in Section 2. There are detailed descriptions of the

- surface and groundwater resources of the Basin water resources,
- history of water development including the reservoirs and canals and well development,
- timeline of the history of water development,
- water rights administration in the Basin including the Rio Grande Compact and surface and groundwater administration, and
- existing Env & Rec attributes in the Basin.

Section 3 is the Goals and Measurable Outcomes. The meat of the plan starts with this section and now follows CWCB suggested organization.

Section 3 – Goals and Measurable Outcomes. This section provides the guidelines for the Rio Grande Basin Water Plan as reflected in the Rio Grande Basin Roundtable's goals and measurable outcomes (G&MOs). The goals identify the priorities of the Roundtable for the entire Basin, while the measureable outcomes provide the specific mechanisms and targets for achieving these goals.

Section 4 – Basin Water Needs. Once the Basin's goals and measurable outcomes were established, the next step in strategically implementing water projects and other methods in the Rio Grande Basin is to identify the water needs within each sector. This section describes the agricultural, M&I and environmental and recreational water needs of the Basin.

Section 5 – Constraints and Opportunities. This section identifies the constraints that limit the ability of the Basin to meet the needs identified in Section 4. This section also identifies opportunities to address the constraints through improved watershed health and water management.

Section 6 – Projects and Methods. This section identifies numerous projects and methods that meet the goals and measurable outcomes listed in Section 3.

Section 7 – Public Outreach. This section details the extensive public outreach effort that was conducted in the preparation of this Plan.

Section 8 – Implementation Strategies. This section provides a framework for meeting the challenges to successful implementation of the projects and methods.

Rio Grande at La Jara Creek confluence. Photo: Adriel Heisey

Basin Overview

This section contains a general description of the Basin including geography, land ownership, climate, history of the San Luis Valley, culture, demographics and economy. This section is intended as a detailed reference guide of background and supporting information to the Plan.

2.1 : Introduction

The Basin Overview is intended as a detailed reference guide of background and supporting information. It provides the general characteristics of the Basin, a background of the Basin's water resources, the history of water development, water administration and environmental and recreational resources.

2.2 : Basin Background

2.2.1 : Geography

The Rio Grande Basin sits in south-central Colorado, occupying approximately 7,500 square miles and containing just under 10% of the state's land area. Two mountain ranges flank the Basin with the San Juan Mountains to the west and the Sangre de Cristo Mountains to the east. Elevations range up to 14,000 feet in the highest peaks of the San Juans; the Sangre de Cristos range up to 7,500 feet at the state line as the Rio Grande flows into New Mexico. At an average elevation of 7,600 feet, the San Luis Valley sits between these two majestic ranges spanning roughly 50 miles east to west and 100 miles from its cramped northern end at Poncha Pass to the New Mexico state line.

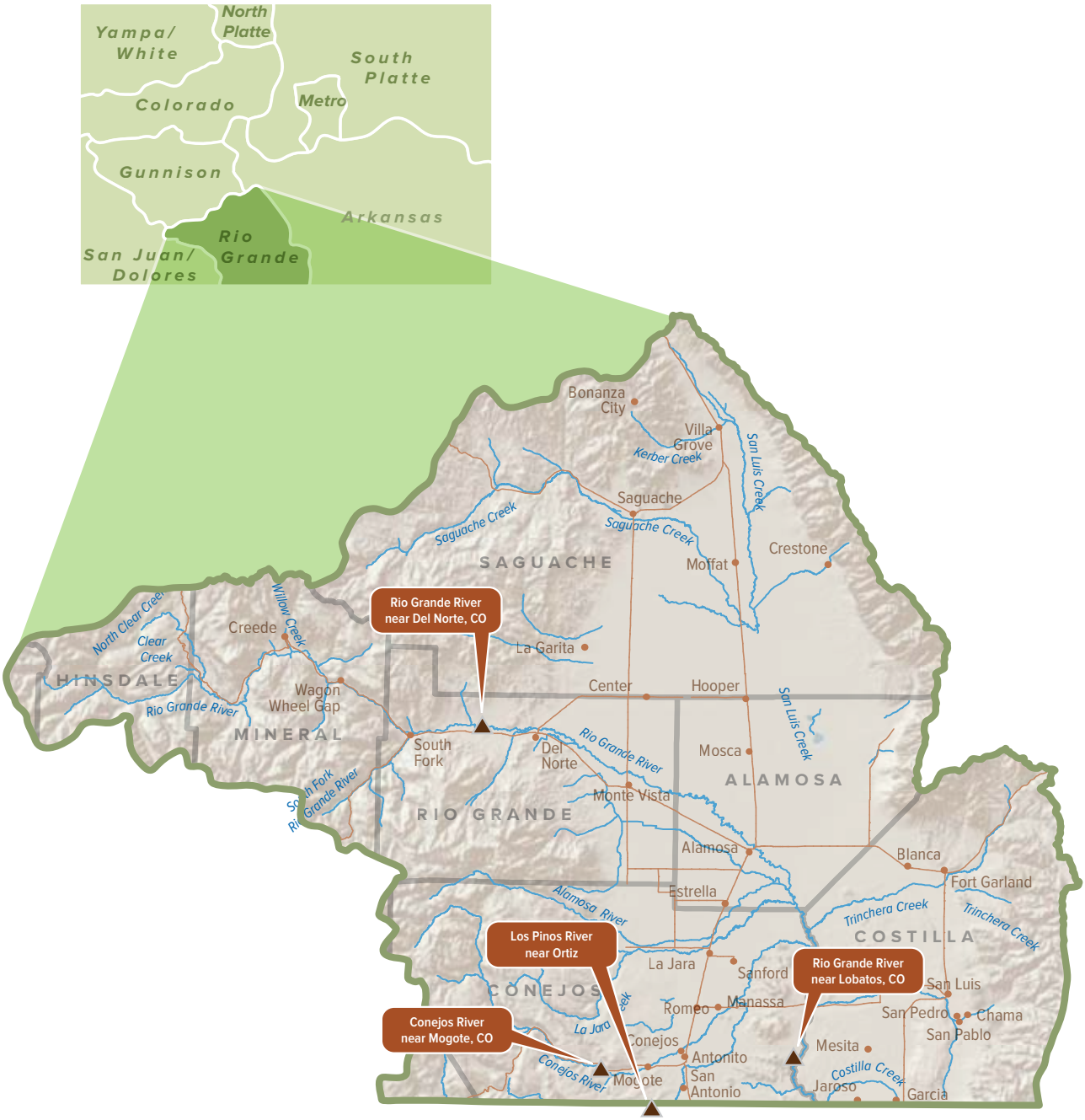
The Basin's namesake and largest river, the Rio Grande, springs from headwaters in the San Juans and touches six of the Basin's seven counties before turning south for its 1,896-mile trip to the Gulf of Mexico. Its biggest tributary — the Conejos River — also begins in the San Juans from the southwestern corner of the Basin before joining the Rio Grande near Los Sauces. One unique feature of the San Luis Valley is the Closed Basin. This large area in the northern part of the Valley drains about 2,900 square miles and is separated from the rest of the Valley by a low alluvial fan. There is no surface water drainage from the Closed Basin to the Rio Grande and much of the water that flows into it is lost through evapotranspiration. Water that is not lost flows into San Luis Lakes or surrounding wetland complexes on the southeastern end of the Closed Basin (Simonds n.d.).

Groundwater, like surface water, does not flow out of the Closed Basin. There appears to be an underground barrier, known as the hydraulic divide, north of the Rio Grande, which separates groundwater in the Closed Basin from the rest of the Basin and prohibits recharge to the river.

Another unique feature of the San Luis Valley is the Great Sand Dunes National Park. The Park contains the tallest sand dunes in North America,

FIGURE 1.

Map of Rio Grande Basin geography.



rising about 750 feet from the Valley floor. The dunes contain endemic species, diverse ecosystems and unique hydrology, which are dependent on the maintenance of groundwater levels.

The seven Basin counties, the major rivers and topography are shown in Figure 1.

2.2.2 : Land Ownership

Agriculture makes up a large portion of the Rio Grande Basin economy, but the majority of land in the Rio Grande Basin — 57% — is publicly owned. Many state and federal organizations own public lands in the Basin, with the USDA Forest Service and the BLM encompassing 67% and 19% of public lands, respectively. Table 1 shows the public lands ownership by entity, total acres and percentage of land in the Rio Grande Basin. The San Luis Valley floor is primarily privately owned and comprises the majority of irrigated land.

TABLE 1.

Public Lands by Ownership Entity, Acres and Percentage in the Rio Grande Basin

Entity	Total Area (acres)	Percent of Public Lands	Percent of Total Basin land
Private	1,282,558	-	43%
Bureau of Land Management	514,741	19%	11%
Colorado Parks and Wildlife	9,707	0.4%	0.2%
Rio Grande National Forest	1,837,817	67%	38%
National Park Service	150,324	5%	3%
State of Colorado	131,597	5%	3%
US Fish and Wildlife Service	119,330	4%	2%
Total Public Lands	**2,763,515**	**-**	**57%**

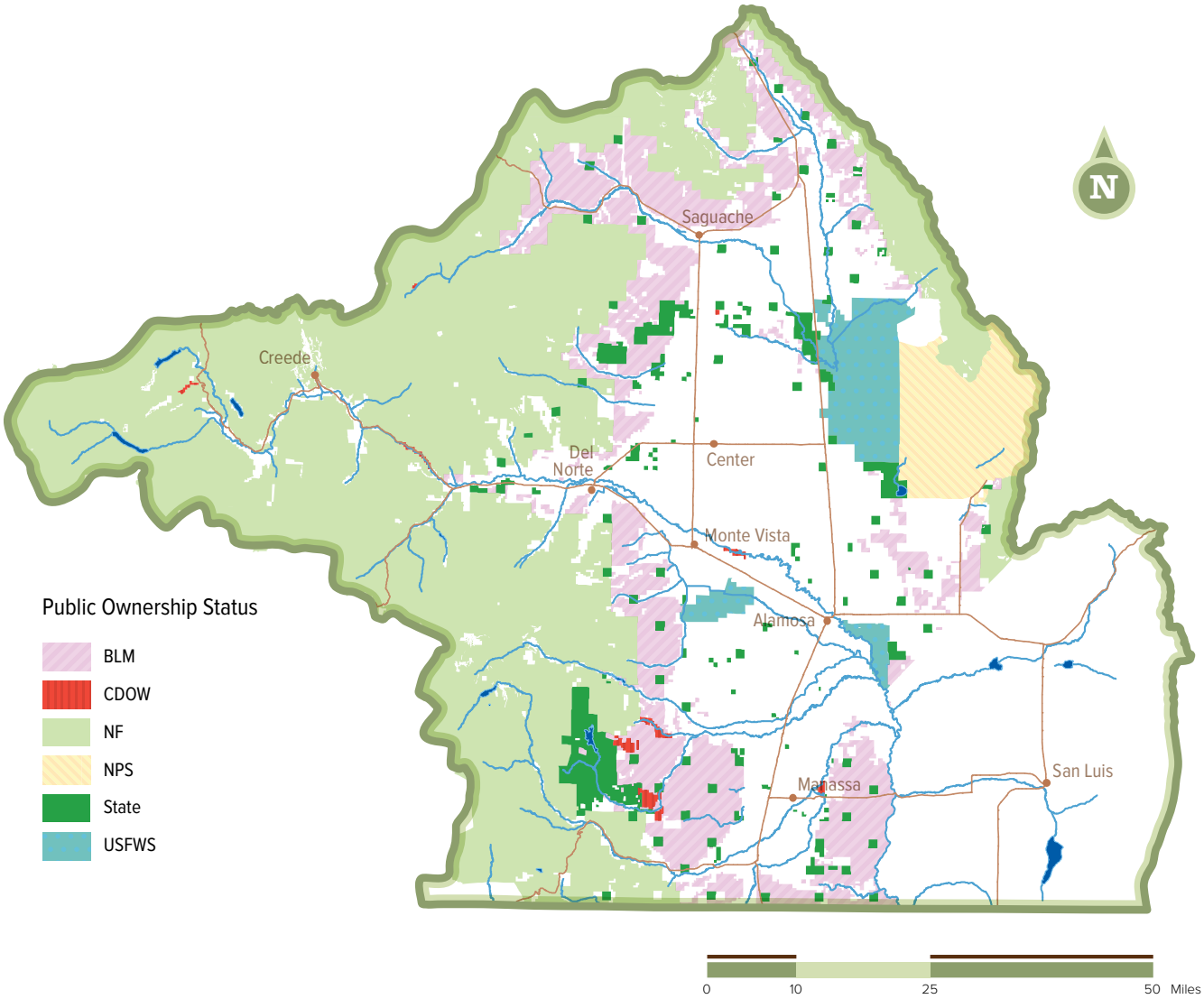
The public land ownership by entity in the Rio Grande Basin is shown in Figure 2. The majority of the western half of the Basin is made up of Rio Grande National Forest land. Information on wetlands, riparian habitats, fisheries and water-based recreation are found in Section 2.6. Information on the impacts of fires and beetle kill on the public lands can be found in Section 5.1.2.

2.2.3 : Climate

The Basin's climate varies dramatically, which is especially true for precipitation. On the San Luis Valley floor, rain and snowfall combine to average between seven and eight inches annually. Wolf Creek Pass on the Continental Divide averages 45.3 inches of precipitation per year (Western Regional Climate Center n.d.). The San Luis Valley floor's elevation of

FIGURE 2.

Public land ownership in the Rio Grande Basin.



approximately 7,600 feet — and its position between two mountain ranges make it a catchment for cold air, which leads to extreme low temperatures in winter. Moreover, the high arid environment contributes to a short, cool growing season of just 90 to 130 days (San Luis Valley Development Resources Group 2013, pp. A-3, A-4). The average date of the latest spring freeze is June 8 (National Weather Service, Pueblo Office).

Winter snowpack, which drives streamflows, can be highly variable year to year in the surrounding Sangre de Cristo and San Juan mountains; it is largely controlled by sea surface temperatures of the Pacific Ocean. The El Niño Southern Oscillation (ENSO) is a well-observed Pacific Ocean temperature pattern that can greatly affect winter precipitation in the Rio Grande Basin. There are three main patterns that are observed: ENSO-neutral, El Niño and La Niña. During El Niño years, warm water pools in the Eastern Pacific Ocean, and moisture is typically increased over the Southern Rocky Mountains. During La Niña years, warm water pools in the Western Pacific near Indonesia and Australia, and cool water prevails in the Eastern Pacific. This reduces moisture and thermal energy in the Southwest United States and often produces below-average winter snowpacks (Llewellyn and Vaddey 2013).

El Niño and La Niña events typically occur for one winter season and are separated by several years of ENSO-neutral conditions. Since 1970, the frequency of El Niño and La Niña events has increased. Also El Niño events now outnumber La Niña events by 2:1 whereas prior to 1970 they occurred at roughly equal frequencies. However, the pool of warm water in the Eastern Pacific Ocean associated with an El Niño event has shifted West, reducing the precipitation potential over the Southern Rocky Mountains. The effects and persistence of a shift in the ENSO pattern are not clear as they pertain to flows in the Rio Grande Basin.

2.2.4 : History of the San Luis Valley

The marshes and ponds in the Closed Basin were formed due to the poor drainage to the Rio Grande and seemed particularly attractive to early Native American hunter/gatherers. These wet, marshy areas supported a large variety of food resources, including fish, waterfowl and edible plants. The surrounding grassland contained small herds of deer, elk and antelope, as well as rabbits and birds. Given the crops available, the Valley's high elevation, long cold winters, and short growing season the possibility of aboriginal agriculture was eliminated. A 1979 archeological survey of the Closed Basin revealed artifacts dating to the Early Archaic period, about 6500 to 3500 years B.C. The most abundantly represented specimens date from 1000 B.C. to 500 A.D. The lack of permanent structures, the scattering of finds and the small size of the discoveries indicate numerous short visits to the area rather than an extended period of occupation (Simonds n.d.).

FIGURE 3.

1873-1876 Wheeler Expedition survey of land use in the San Luis Valley.

Source: First Lieutenant George M Wheeler, U.S. Army Corps of Engineers, Expeditions of 1873-1876, land use map in San Luis Valley

The existence of the San Luis Valley has been known to European settlers since the Spanish settled New Mexico in the 1590s, but it was largely ignored due to its isolation and inhospitable environment. It was a land frequented by various nomadic Indian groups and of little obvious benefit to European settlers. Among the first explorers into the Valley was Diego de Vargas, who entered the region as a show of force following his defeat of the Pueblo Indians at Santa Fe in 1692. But the Indians, mostly Comanche, were not impressed, and the Valley became a major staging area for raids. Several Spanish military expeditions into the area sought to subdue the Indians, but no Spaniards stayed. The Comanche invasions ended when, in 1783, Juan Bautista de Anza, Governor of New Mexico, defeated the Comanche, under Chief Cuerno Verde, in a battle near present day Pueblo, Colorado. Following the defeat of the Comanche, the Valley was once again forgotten.

In the early 1800s, fur trappers began passing through the Valley on the way west to the San Juan Mountains. Since nearby Taos was a major trading center in the region, the Valley was not used as a rendezvous point and no trading posts were built there. Its isolated location, the difficulty in reaching it from the East, and the threat of Indians discouraged permanent settlement by Europeans in the Valley.

In 1803, the Louisiana Purchase gave the United States control over vast areas of the West including parts of Colorado. In 1806, under order of

President Thomas Jefferson, Lieutenant Zebulon Pike left Fort Belle Fontaine, near St. Louis, to explore the Rocky Mountains near Spanish territory. In late 1806, Pike and his men entered the Valley, where they set up camp for the winter. In February of 1807, Pike and his men were arrested by the Spaniards for trespassing and were taken to Mexico. They were released in 1810 and returned to the United States.

Where to find more information

History of the San Luis Valley Project
http://www.usbr.gov/history/sanluisv.html

Pike was the last recorded explorer in the Valley until 1848, when John C. Fremont entered it in search of a rail route through the Rockies. Fremont was followed in 1853 by John Gunnison, also in search of a rail route. In the 1870s, explorer and surveyor, Ferdinand V. Hayden, came to Colorado to map the unexplored regions of the territory. His journey took him into the San Luis Valley, but like the others before him, he passed through without stopping (Simonds n.d.).

By the 1850s Hispanic settlers from New Mexico had migrated into the San Luis Valley to establish small plazas within land grants issued by the New Mexican governor in Santa Fe. These pioneers gave birth to the permanent settling of Colorado, the state's oldest town, San Luis, which is located in the Basin.

2.2.5 : Culture

Nearly 160 years after founding the first permanent settlements in the Basin, today's Basin Hispanic residents retain many of the cultural traits of their forbearers. In three Basin counties, one in three households speak a language other than English, while that figure is as high as half in Costilla County. The acequias, or community irrigation ditches founded

San Luis People's Ditch.
Photo: Jack Dykinga.

by Hispanic settlers, remain in operation throughout the southern end of the Basin. Settlers and immigrants from around the country came to the Basin following the Homestead Act of 1862 and the coming of the railroad. Many put down roots on ranches and farms, setting the stage for the Basin's way of life today. Mormon settlers found a home in the Basin at the end of the 1870s. Their initial settlements at Manassa and Sanford near the Conejos River were and remain agriculture-based communities. Japanese-Americans from California were also drawn to the Basin in the 1920s to grow lettuce, spinach, cauliflower and carrots, mainly in Conejos and Costilla counties.

The Sangre de Cristo National Heritage Area was designated by the federal Omnibus Public Land Management Act of 2009. The National Heritage Area encompasses more than 3,000 square miles spanning across Conejos, Costilla, and Alamosa counties. The area rests in a trove of impressive historic, cultural and natural treasures. Sangre de Cristo's heritage resources represent a profound convergence of the area's cultural past, one in which the stories of American Indians, Hispanics, Mormons, Japanese-Americans, and Amish, Dutch and Anglo people all continue to be represented.

Visitors to this heritage area have the opportunity to experience history in San Luis, the oldest town in Colorado (established 1851), impressive natural splendor at the Great Sand Dunes National Park and Preserve and a diverse built environment that includes over 20 cultural properties listed in the National Register of Historic Places (U.S. Department of the Interior, National Park Service n.d.).

2.2.6 : Demographics

The Rio Grande Basin population in 2010 was approximately 50,200. The Basin is 1% of the total state population of 5,228,000. Demographically, the Basin is a decidedly rural area, with a population density of roughly 15 people per square mile. In some areas there are fewer than three people per square mile. Only two of the seven counties number more than 10,000 people. In Conejos and Costilla counties, the percentage of Hispanic residents exceeds 50% while roughly 4 in 10 people are Hispanic in Alamosa, Rio Grande and Saguache counties. The Basin is also among the most impoverished in the state, as five of its counties exceed the state average for the percentage of the population living in poverty (U.S. Census Bureau 2014).

2.2.7 : Economy

2.2.7.1 AGRICULTURE

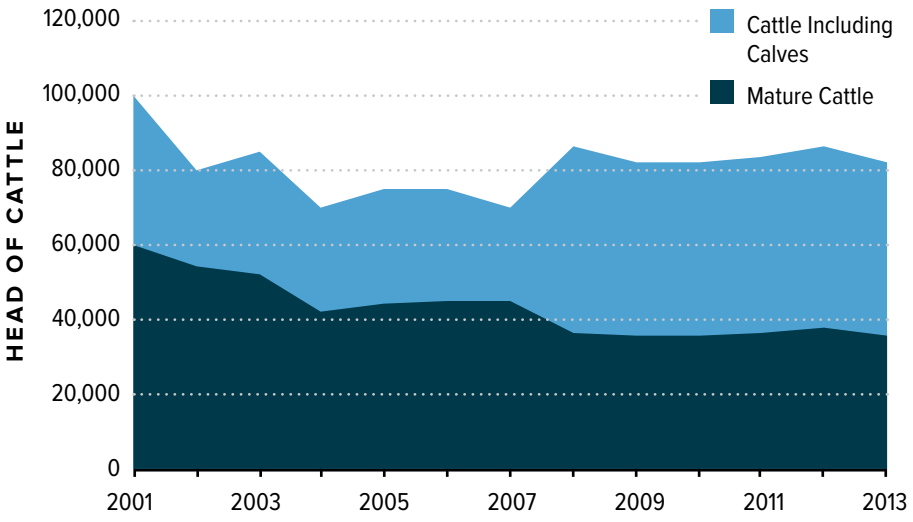
Agriculture ranks as the primary economic driver in the Basin with the value of its products sold amounting to approximately $325 million per year. Without the roughly 600,000 acres under irrigation, such a total would not be possible. Crops account for approximately $285 million of that total, with the largest being alfalfa, barley, potatoes, other hay and spring wheat. Livestock contributes approximately $40 million to that total (San Luis Valley Development Resource Group 2013), though the numbers of mature cattle have been declining since 2001 (Figure 4). Agriculture is also the largest source of base jobs in the San Luis Valley, accounting for 4,000 jobs or 18% of the Valley total (State of Colorado, Department of Local Affairs, Planning and Management 2012). In Rio Grande and Saguache counties, agriculture is a much higher percentage of the economy, approaching 50% of the total income base (San Luis Valley Development Resource Group 2013).

As the Basin's largest economic driver, agriculture has broad economic impacts. The San Luis Valley Development Resource Group evaluated economic impact multipliers for various agricultural products, ranging from approximately 1.5 to 2.0. For agriculture, this indicates that an additional 50 cents to one dollar is spent in the Basin for every dollar that is spent to purchase the agricultural goods. A study of the indirect effects of the 2011 drought on the Basin local economy found that for every dollar of lost revenue by agricultural producers there was a loss of approximately 25 cents to the rest of the economy due to reduction in agricultural inputs (e.g. fertilizers, fuel, etc.) (Bauman et al. 2013). This resulted in a total loss to the Basin economy of between $83 million and $100 million.

FIGURE 4.

Cattle population in the San Luis Valley from 2001 to 2013.

The numbers of mature cattle have declined since 2001 as a result of the extended drought experienced in the Valley.



2.2.7.1.1 HAY PRODUCTION

Hay (largely alfalfa), potatoes and barley are the major crops grown in the Basin. Hay is grown in all of the counties that support agriculture (Alamosa, Conejos, Costilla, Rio Grande and Saguache), with Conejos County being the largest producer. According to the USDA, in 2010 the average price of hay in Colorado was $116 per ton while, in 2012 it was $206 per ton (U.S. Department of Agriculture, National Agricultural Statistics Service n.d.). The large increase in price was due to drought conditions in the Southwest, the demand for hay by dairies in New Mexico and demand for hay in other western states including Texas. Hay prices are not expected to remain at the 2012 level in future average-to-wet years. Production of hay increased in 2012, as compared to 2010, in Conejos and Rio Grande counties, and, as a result, gross income from alfalfa more than doubled in these two counties from $26 million to $60 million in Conejos County and from $15 million to $41 million in Rio Grande County as shown in Table 2. Although hay production decreased from 2010 to 2012, in the other three counties, gross income still increased as a result of the almost doubling in price. In the entire San Luis Valley, production of hay increased from 719,000 tons to 781,000 tons between 2010 and 2012, and gross income nearly doubled from $83 million to $161 million.

TABLE 2.

Gross Income and production of hay in the San Luis Valley.

Based on 2010 and 2012 price and acreage.

County	Tons of Production (tons)		Value of Crop	
	2010	2012	2010	2012
Alamosa	107,900	104,000	$ 12,590,640	$ 21,413,700
Conejos	227,700	288,900	$ 26,453,800	$ 59,626,700
Costilla	111,200	97,800	$ 12,936,900	$ 20,048,950
Rio Grande	130,200	198,300	$ 15,077,100	$ 40,880,700
Saguache	141,600	92,000	$ 16,399,500	$ 18,982,900
Total	**718,600**	**781,000**	**$ 83,457,940**	**$ 160,952,950**

Source: U.S. Department of Agriculture, National Agricultural Statistics Service

2.2.7.1.2 POTATO PRODUCTION

Prices and production of potatoes in the San Luis Valley showed much less variability between 2010 and 2012 than those for hay. Alamosa County is the largest producer of potatoes within the San Luis Valley, but Rio Grande and Saguache counties produced nearly as much in 2012. In Colorado, potatoes sold for an average of $8.25 per hundred pounds (CWT) in 2010 and $9.50 in 2012. Prices for potatoes vary monthly and dropped from $11/CWT in January of 2012 to $6.50/CWT by December of 2012. Timing of sales within 2012 would have a large effect on gross income for producers. While production of potatoes decreased from 2010 to 2012 in Alamosa and Rio Grande counties, the gross income only

decreased by $1.4 million in Alamosa County and increased by $1.9 million in Rio Grande County as a result of the higher prices as shown in Table 3. In the San Luis Valley as a whole, production of potatoes decreased from 21,500,000 CWT to 20,000,000 CWT between 2010 and 2012, but gross income increased from $178 million to $190 million.

TABLE 3.

Gross income and production of potatoes in the San Luis Valley.

Based on 2010 and 2012 price and acreage.

County	CWT of Production		Value of Crop	
	2010	2012	2010	2012
Alamosa	7,505,000	6,365,000	$ 61,927,000	$ 60,537,800
Other Counties	1,823,000	1,945,000	$ 15,045,000	$ 18,496,500
Rio Grande	6,640,000	5,970,000	$ 54,794,000	$ 56,677,000
Saguache	5,560,000	5,700,000	$ 45,816,000	$ 54,150,000
Total	**21,528,000**	**19,980,000**	**$ 177,582,000**	**$ 189,861,300**

Source: U.S. Department of Agriculture, National Agricultural Statistics Service

2.2.7.1.3 CONSUMPTIVE USE OF MAJOR CROPS

The potential consumptive use of irrigation water for various crops grown in the SLV is estimated by the State of Colorado's consumptive use model, StateCU using the Center, Colorado weather station. The average potential consumptive use from 1950 to 2009 is 29.4 inches per year for alfalfa 26.2 inches per year for grass pasture, 17.4 inches for barley and 14.4 inches for potatoes (RGDSS 2011). Potatoes and barley consume significantly less water than hay. These values represent the consumptive portion of water use only, and the amount of water applied to the crops is higher to account for inefficiencies and deep percolation of irrigation water.

Potato Harvest in the San Luis Valley.
Photo: Colorado Potato Administrative Committee

Application of irrigation water using sprinklers is normally assumed to be 80 percent efficient, and application through flood irrigation is normally assumed to be 60 percent efficient. The average annual consumptive use (CU) for the four major crops is shown in Figure 5 along with the consumptive use per quarter-section (assuming 125 irrigated acres per quarter-section as is typical in a circular field). Alfalfa water consumption per quarter is estimated at 306 AFY while grass hay consumption is estimated at 273 AFY. In comparison, barley and potatoes consume less per quarter at 181 and 150 AFY, respectively.

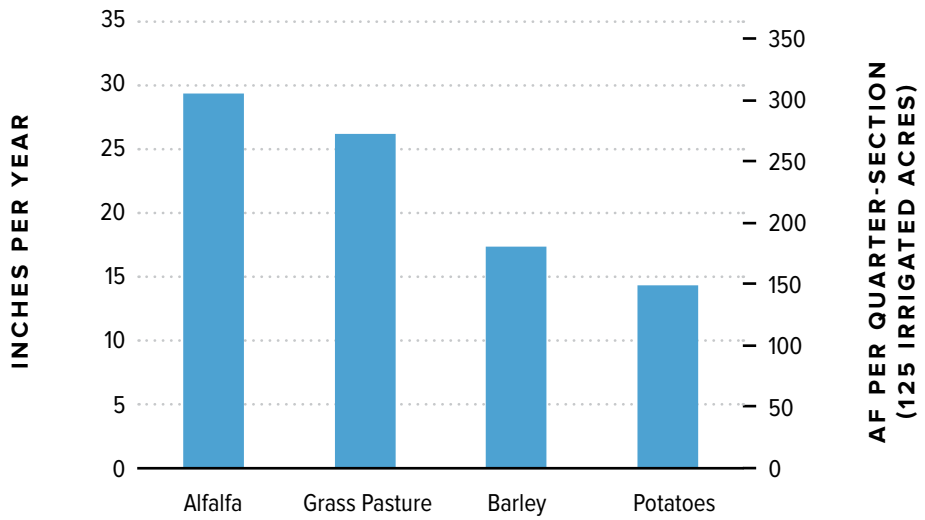


FIGURE 5.

Annual potential consumptive use in the San Luis Valley by crop type.

(Center, CO weather station)

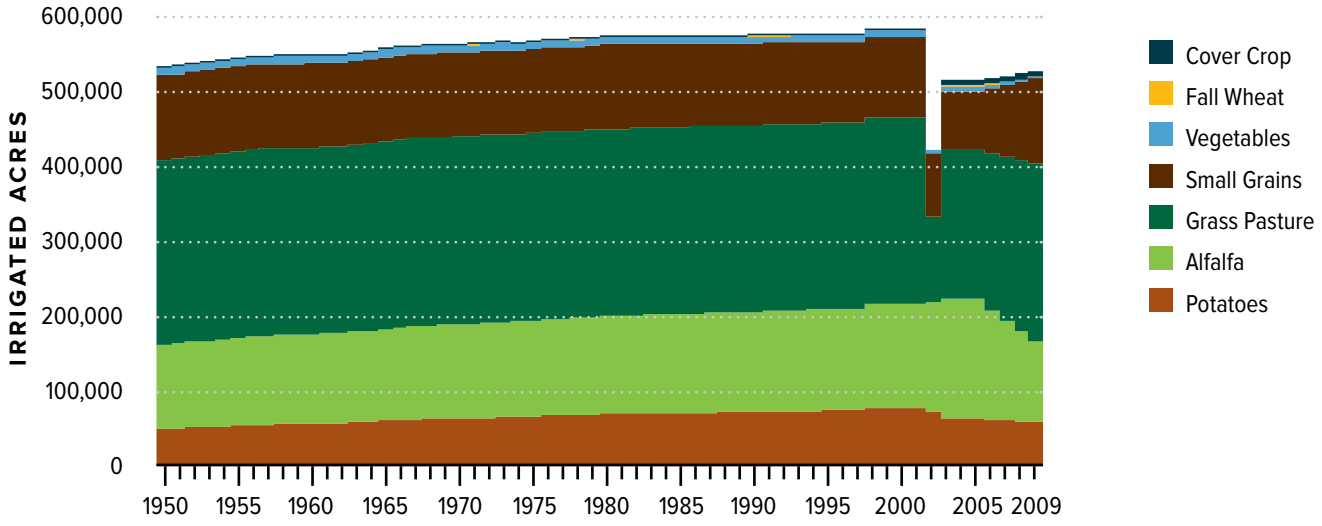
A comparison summary of the total tons produced, acres harvested, total revenue, gross revenue per ton and acre is shown in Table 4. Of note is the gross revenue per AF of water consumed. The gross revenues for alfalfa hay in 2010 were $428 per acre and $175 per AF of water consumption. In contrast, potatoes had gross revenue of $3,217 per acre and the gross revenue per AF of water consumption was $2,681. Even with the unusually high hay prices in 2012, as a result of the western U.S. drought, gross revenue for alfalfa per AF of water consumption was $359 compared to $2,932 per AF of water consumed for potatoes. Potatoes generate five to ten times the gross revenue per AF of water consumed compared to alfalfa.

TABLE 4. Production, revenue and water use by major crop grown in the San Luis Valley.

	Alfalfa Hay		Grass Hay		Potatoes		Barley	
	2010	2012	2010	2012	2010	2012	2010	2012
Total Tons Produced	553,000	619,000	167,000	202,000	1,076,400	999,000	214,380	178,230
Acres Harvested	150,000	145,000	115,000	105,000	55,200	54,000	49,100	43,100
Total Revenue	$64,220,000	$127,530,000	$19,400,000	$41,870,000	$177,580,000	$190,000,000	$27,080,000	$39,920,000
Gross Revenue/Ton	$116	$206	$116	$207	$165	$190	$126	$224
Gross Revenue/Acre	$428	$880	$169	$399	$3,217	$3,519	$552	$926
Consumptive Use (CU) of Water (AF)	367,500	355,250	251,083	229,250	66,240	64,800	71,195	62,495
Gross Revenue/ AF of CU	$175	$359	$77	$183	$2,681	$2,932	$380	$639

The Colorado Water Conservation Board and Division of Water Resources have been developing the Rio Grande Decision Support System (RGDSS), which includes an analysis of irrigated acres by crop type in the Rio Grande Basin. According to RGDSS data, total irrigated acres within the San Luis Valley increased from 1950 to 2001. Beginning with the 2002 irrigated acreage dataset, RGDSS stopped including opportunistic wild-flood-irrigated meadow acreage in the total (Heath 2014). In 1998–2001, the acreage reached its maximum of 584,000 irrigated acres. The steady increase was largely due to increased production of potatoes and alfalfa hay. From the 1950s to the 1990s, irrigated acreage of alfalfa increased from 116,000 to 136,000 acres, and irrigated acreage of potatoes increased from 54,000 to 75,000. In the 2000s, production of alfalfa continued to rise to 141,000 acres, while production of potatoes fell to 1970s levels of 67,000 acres. The other major irrigated acres in the San Luis Valley, including vegetables, grass pasture for livestock and small grains (largely barley), remained steady from the 1950s to the 1990s but declined in the 2000s. The annual irrigated acres by crop type estimated as part of the RGDSS effort from 1950 to 2009 is shown in Figure 6. The average irrigated acres by crop type by decade are shown in Figure 7 and Table 5.

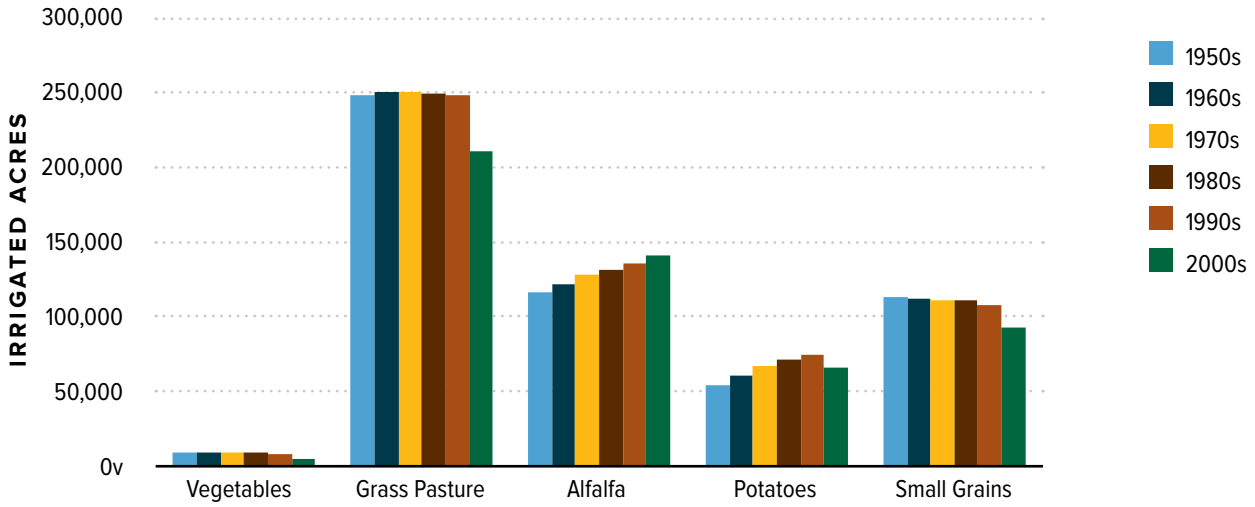
FIGURE 6. Irrigated acres by crop type in the San Luis Valley from 1950 to 2009.



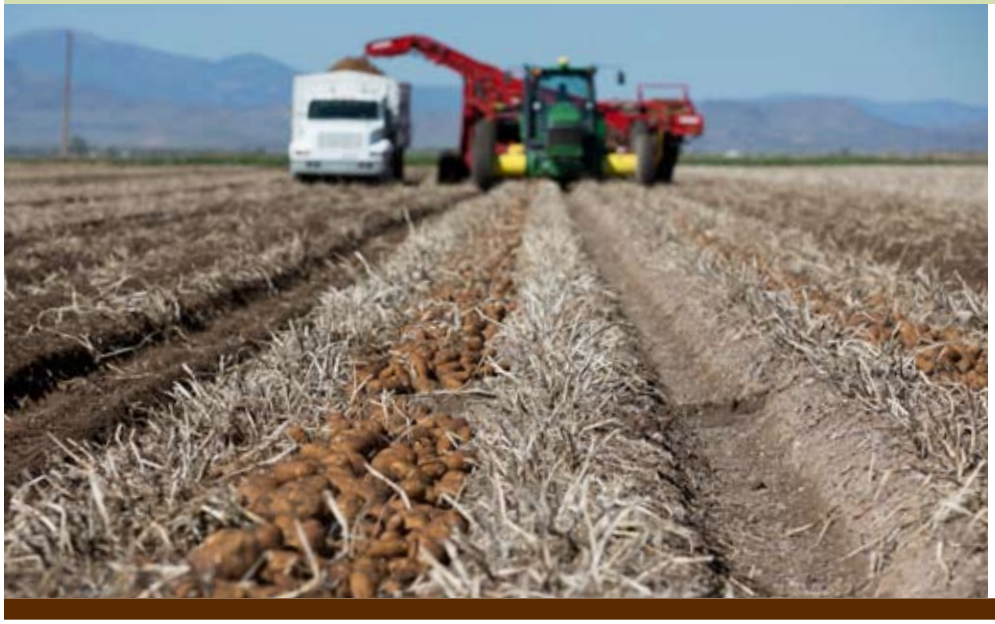
Source: RGDSS 2011

FIGURE 7.

Decadal irrigated acreage of major crops produced in the San Luis Valley from 1950s to 2000s.



Source: RGDSS 2011



Potato harvest in the San Luis Valley.
Photo: Julie Messick

TABLE 5.

Decadal irrigated acreage of major crops produced in the San Luis Valley from 1950s to 2000s.

	Vegetables	Grass Pasture	Alfalfa	Potatoes	Small Grains	Total
1950s	9,900	248,700	116,100	54,400	112,900	**542,000**
1960s	9,800	250,000	122,200	60,800	112,200	**555,000**
1970s	9,600	250,400	127,900	67,000	111,700	**566,600**
1980s	9,300	249,400	132,000	71,800	111,300	**573,800**
1990s	8,500	248,400	135,700	75,200	108,300	**576,100**
2000s	5,100	210,600	140,900	66,700	93,500	**516,800**

Source: RGDSS 2011

Photo: Rio de la Vista

Photo: Erich Schlegel

2.2.7.2 TOURISM AND RECREATION

With the Great Sand Dunes National Park and over two million acres of public land in the Basin, tourism is also important to the local economy. The Great Sand Dunes National Park alone receives approximately 300,000 visitors annually. The tourism industry accounts for 1,865 basic jobs or 10.7% of basic jobs in the Basin (San Luis Valley Development Resources Group 2013). Outdoor recreation is also a vital part of the economy and a significant pastime for its residents and visitors. Wolf Creek Ski Area, the Basin's lone developed ski area, draws an average of 190,000 skiers per year. Between roughly 15,000 and 18,000 hunters visit the Basin every year for elk, deer and pronghorn seasons (State of Colorado, Department of Natural Resources, Division of Parks and Wildlife n.d.). Hunting-related economic benefits to the SLV equate to $14.4 million annually (BBC Research & Consulting 2008). Fishing is also an important activity tied to the Basin's streams and reservoirs. There are approximately 121,000 angling recreation days in the Basin annually. A 2008 economic impact study determined that one angler recreation day provides an average of $100 per day to the local economy from resident and nonresident anglers. Angling-related economic benefits to the SLV approach $30.2 million annually (BBC Research & Consulting 2008). The migration of nearly 20,000 greater sandhill cranes and a few thousand lesser sandhill cranes provides wildlife viewing opportunities for crowds of visitors annually and is the drawing card for the Monte Vista Crane Festival.

2.3 : Water Resources

2.3.1 : Surface Water Hydrology

The Rio Grande Basin experiences highly variable seasonal and year-to-year hydrologic fluctuation. Snowmelt runoff and, to a lesser extent, summer monsoons are the main sources of water to the Rio Grande headwaters and tributary systems. Snowmelt generally produces a runoff pattern that is characterized by a long buildup and decline in flow from March to August, with a peak in late May or June most years. Summer thunderstorms typically last hours and can cause dramatic spikes in flow rates, but account for a much lower volume of the Rio Grande system as their durations are short.

2.3.1.1 RUNOFF VOLUME

Annual flows of the Rio Grande at Del Norte have historically varied from a high of 1.1 million acre-feet (AF) in 1988 to a low of 160,000 AF in 2002 as shown in Figure 8. The difference between the minimum and maximum annual flow varies by more than a factor of six. The sum of the annual flow at the three Conejos index gages used for determining Rio Grande Compact deliveries (Conejos near Mogote, Los Pinos and San Antonio) is shown in Figure 9. Between 1926 and 2012, the largest flow in

FIGURE 8. Annual streamflow at the Rio Grande near Del Norte gage.

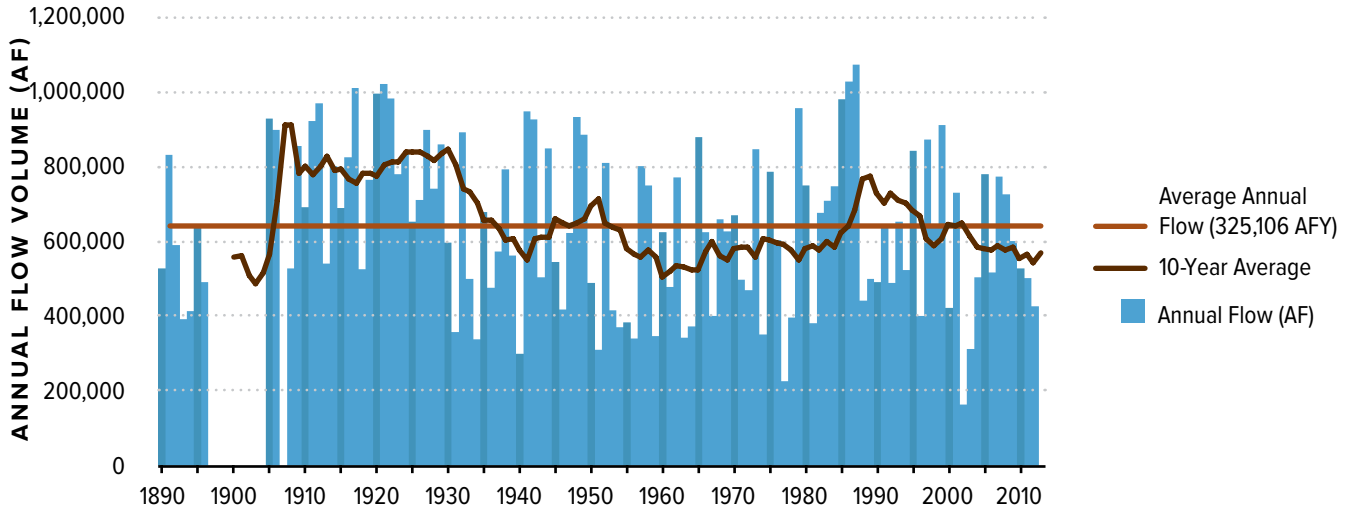
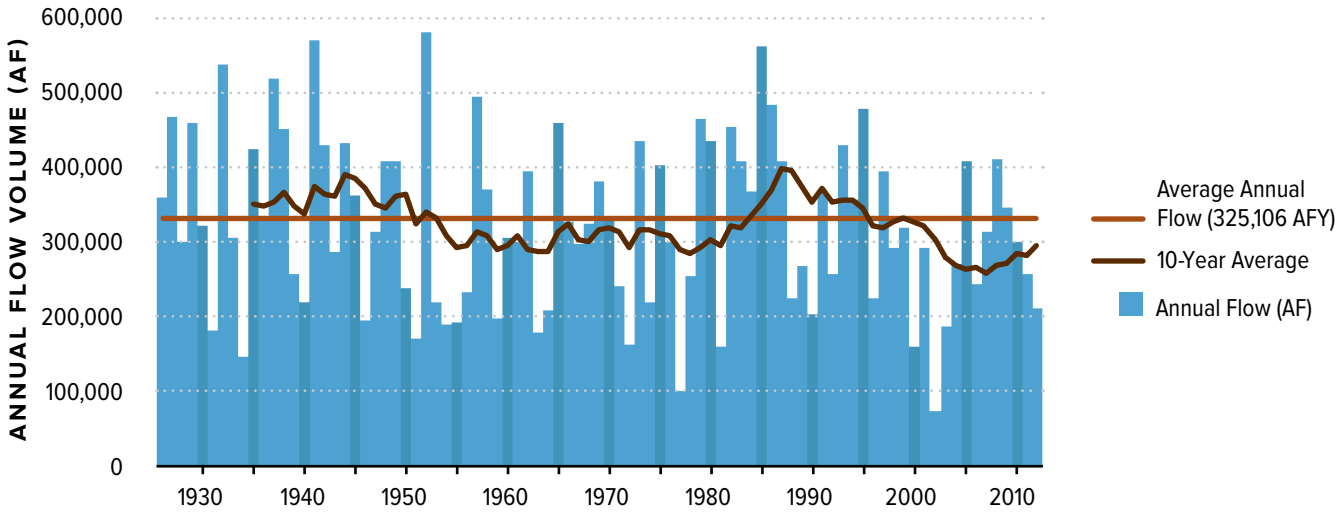


FIGURE 9.

Annual streamflow at the Conejos River index gages.

From 1926–2012 (Conejos River near Mogote, Los Pinos River near Ortiz, and San Antonio River at Ortiz)



the Conejos was 578,000 AF in 1952 and the smallest flow was 68,500 AF, more than an eight-fold difference. The 10-year running average peaks in 1987 for both sets of river gages, then show a steady 25-year decline that has continued until present day.

Minimum, average and maximum monthly flow for the Rio Grande near Del Norte from 1950–2012 is shown in Figure 10. In wet and average years, the hydrograph peaks in June as snowmelt from the surrounding San Juan Mountains runs into the Rio Grande. Runoff from the Sangre de Cristo Mountains reach the Rio Grande only in very high flow years in Trinchera, Culebra and Costilla Creeks. Runoff from the Sangre de Cristo Mountains also contributes flow to the Closed Basin, generally by recharging the aquifer. In dry years, the hydrograph peaks earlier in May, indicating a smaller snowpack and earlier runoff. A similar analysis for the monthly flow past the sum of the Conejos index gages from 1950–2012 is shown in Figure 11. For all three Conejos index gages, the hydrograph peaks in May, indicating that the Conejos system experiences earlier snowmelt runoff than the Rio Grande system.

Daily flows past the Rio Grande near Del Norte from 1890–2012 and the Conejos River near Mogote from 1926–2012 during the driest and wettest years are shown in Figure 12 and Figure 13, respectively. These figures illustrate the dramatic differences in daily flow between the driest and wettest years (2002 and 1987, respectively, for the Rio Grande near Del Norte gage; 2002 and 1952, respectively, for the Conejos near Mogote gage). The maximum daily flow at the Rio Grande near Del Norte in 1987 was 7,150 cfs while the maximum daily flow in 2002 was only 671 cfs. At the Conejos near Mogote, the maximum daily flow in 1952 was 2,400 cfs

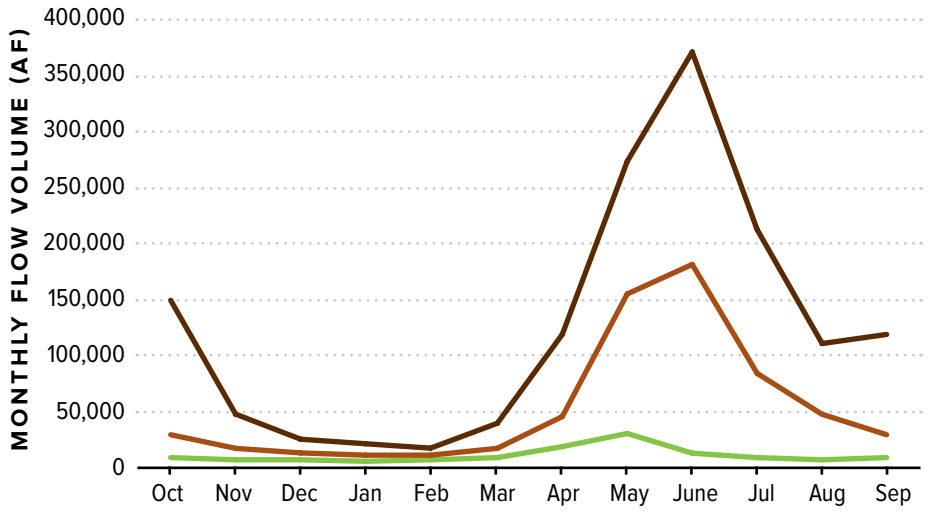


FIGURE 10.

Monthly flow volume at the Rio Grande near Del Norte gage.

Max
Avg
Min

while the maximum flow in 2002 was only 409 cfs. For both rivers, we also see an earlier peak flow in the driest year by roughly a month compared to the wettest years.

The average annual flow at the Rio Grande near Del Norte gage shows significant decadal variation from the 1930s to the present, with extended droughts and wet periods causing substantial differences between the decades (Figure 14). The average annual flow in the 1950s was 502,000 AF, which is 78% of the annual average from 1890 to present. In the 1950s, the years 1952, 1957, and 1958 were above average streamflows, but the decade as a whole experienced an extended drought. The 1980s was the wettest decade on record for the Rio Grande near Del Norte gage and experienced an average annual flow of 728,000 AF, which is 113% of the annual average from 1890 to present. The years 1985, 1986 and 1987 were

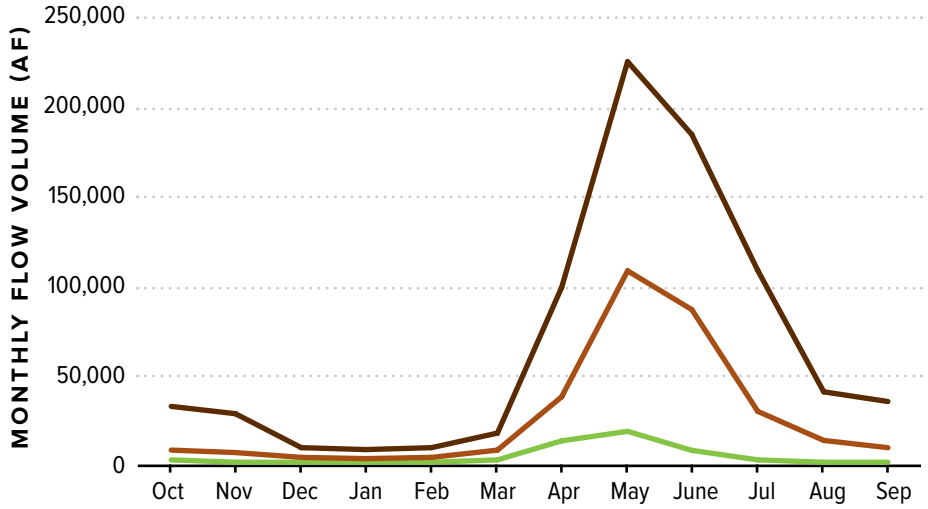


FIGURE 11.

Monthly flow volume at the Conejos River index gages.

Max
Avg
Min

three of the wettest on record and significantly increased the decadal average.

At the three Conejos index gages, the driest decade in recorded history was the 2000s, when the average annual streamflow was 271,000 AF, 83% of the annual average from 1926 to the present (Figure 15). Only three years in that decade had above-average streamflow (2005, 2008 and 2009)

FIGURE 12. Daily flow of Rio Grande near Del Norte for the driest and wettest years, 1890–2012.

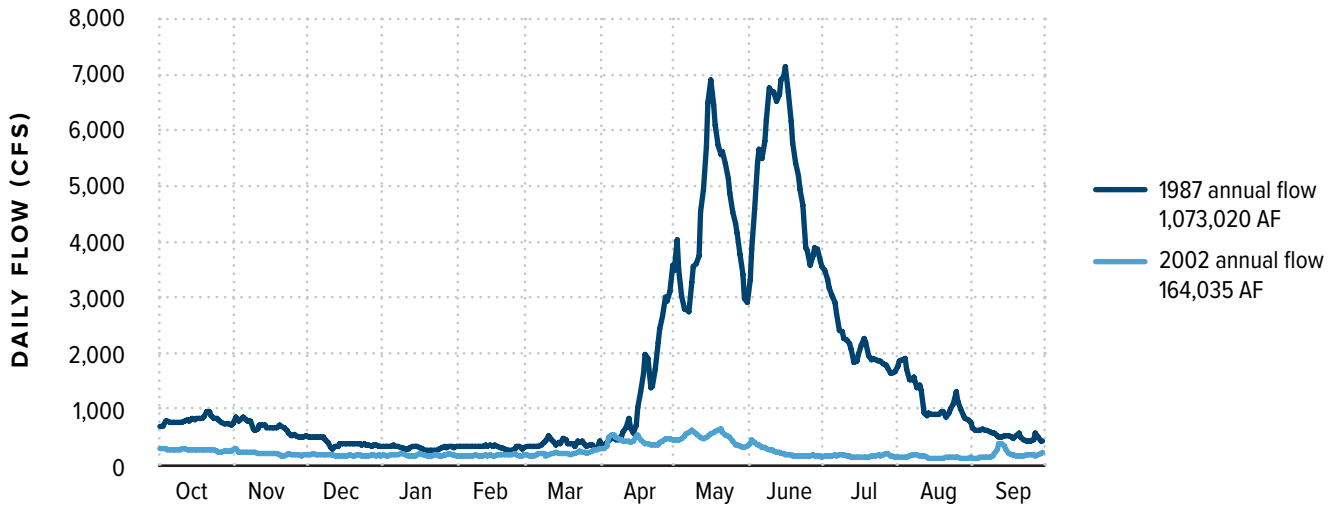
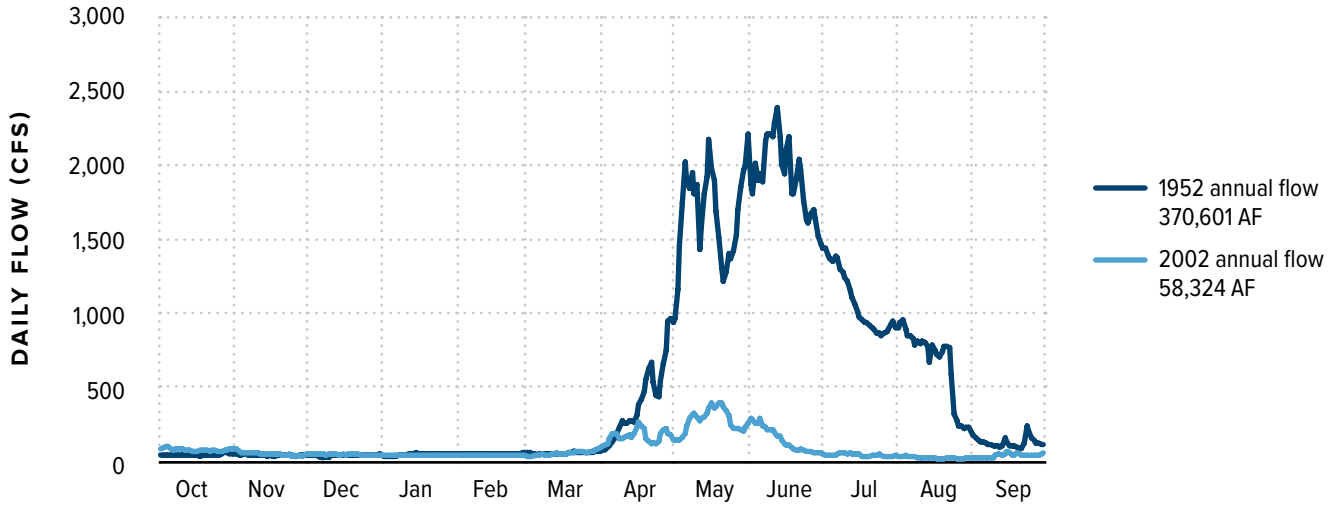


FIGURE 13. Daily flow of Conejos River near Mogote for the driest and wettest years, 1926–2012.



while the other seven years were below average, with 2002 as the driest year on record. As at the Rio Grande near Del Norte gage, the 1980s were the wettest decade with an average annual streamflow of 378,000 AF, which is 116% of the annual average. The years 1982–1987 were all wetter than average years.

FIGURE 14. Average annual flow by decade at the Rio Grande near Del Norte gage, 1930s to 2000s.

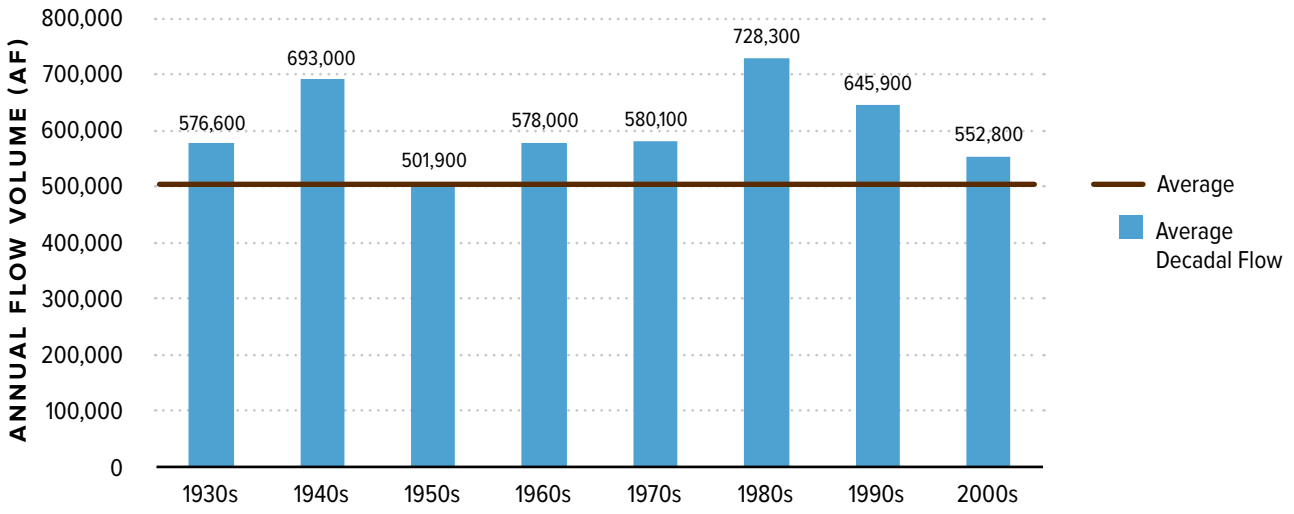
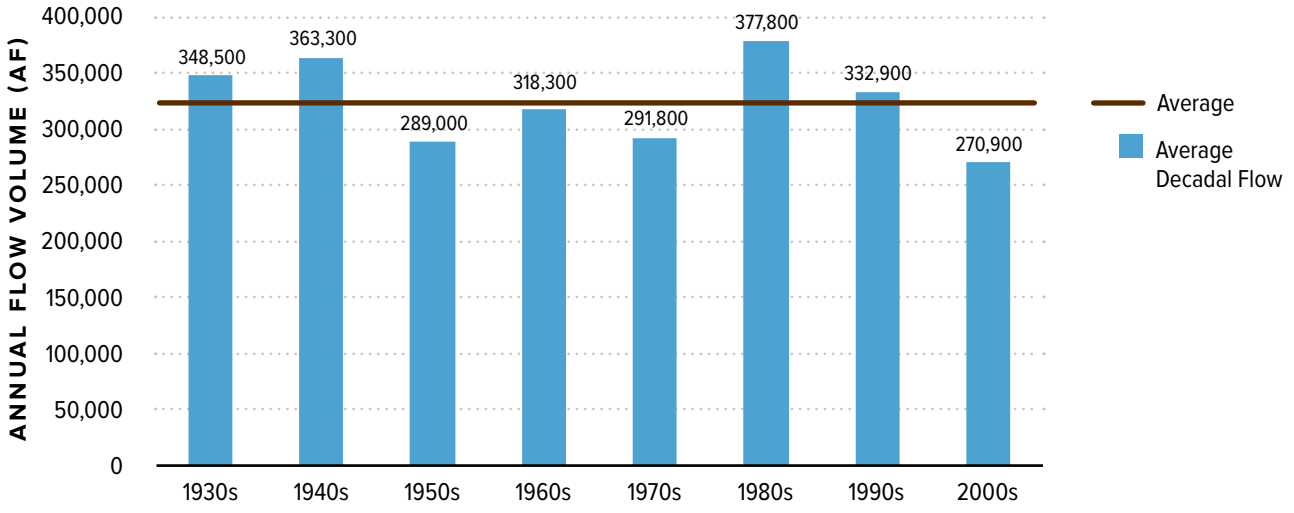


FIGURE 15. Average annual flow by decade at the Conejos index gages, 1930s to 2000s.



2.3.1.2 RUNOFF TIMING AND PATTERNS

The date of peak flow each year from 1890–2012 for the Rio Grande near Del Norte gage and 1904–2012 for the Conejos near Mogote gage, respectively, are charted in Figure 16 and Figure 17. The Rio Grande near Del Norte gage is at 8,000-feet elevation and the Conejos near Mogote gage is at 8,280-feet elevation. The date of peak snowfall runoff was not necessarily the date of highest flow at each gage due to summer thunderstorms that can produce exceptionally high flows for a very short period. The data were manually inspected when peak flow occurred after June 20 to determine whether the hydrograph peaked due to snowmelt or a thunderstorm. When the high flow was due to a thunderstorm, those data were excluded to determine the date of highest flow due to snowmelt.

The historical peak snowmelt runoff occurred between May 3 and June 28 at the Rio Grande near Del Norte gage between 1890 and 2012 (Figure 16). The average date of peak snowmelt runoff was May 31. Similar to data shown in the chart of annual flow, the 10-year running average of the date of peak snowmelt runoff is highest in 1987 at June 8, suggesting a correlation between annual flow and date of peak snowmelt runoff. After 1987, the 10-year running average declines until 2012, when it reaches May 23, 16 days earlier than its peak in 1987.

Between 1904 and 2012 at the Conejos near Mogote gage, the earliest date of peak runoff was May 4 and the latest date was June 23. The average date of peak runoff was May 30. In the 10-year running average, the latest date of peak runoff of June 9 occurred in 1923, followed by a trend of earlier runoff until 1943, when the 10-year running average of peak runoff shifted 22 days earlier to May 18. In the following 60 years, there is an oscillating pattern in the 10-year running average of date of peak runoff with trends for later dates of peak runoff in the 1960s and 1980s. However, since the late 1980s, there has been a generally steady trend to an earlier peak runoff, with the 10-year running average now at May 23. This average date of May peak runoff is not unprecedented in the historical record; however, there is now a 25-year continuing trend to earlier runoff in the 10-year running average.

Rio Grande north channel upstream of the Farmer's Union canal headgate. Photo: Arista Hickman

There are several variables that affect the rate and timing of snowmelt runoff and peak spring flow. Some of these climatic variables include peak snowpack, spring snow and rain accumulation, temperature, soil moisture and humidity. There are other environmental and anthropogenic considerations, including dust on snow, wildfire, beetle kill and flood control that also affect the rate and timing of peak runoff. These issues are examined in Section 5.1.2.

FIGURE 16.

Date of peak snowmelt runoff at Rio Grande near Del Norte gage, 1890–2012.

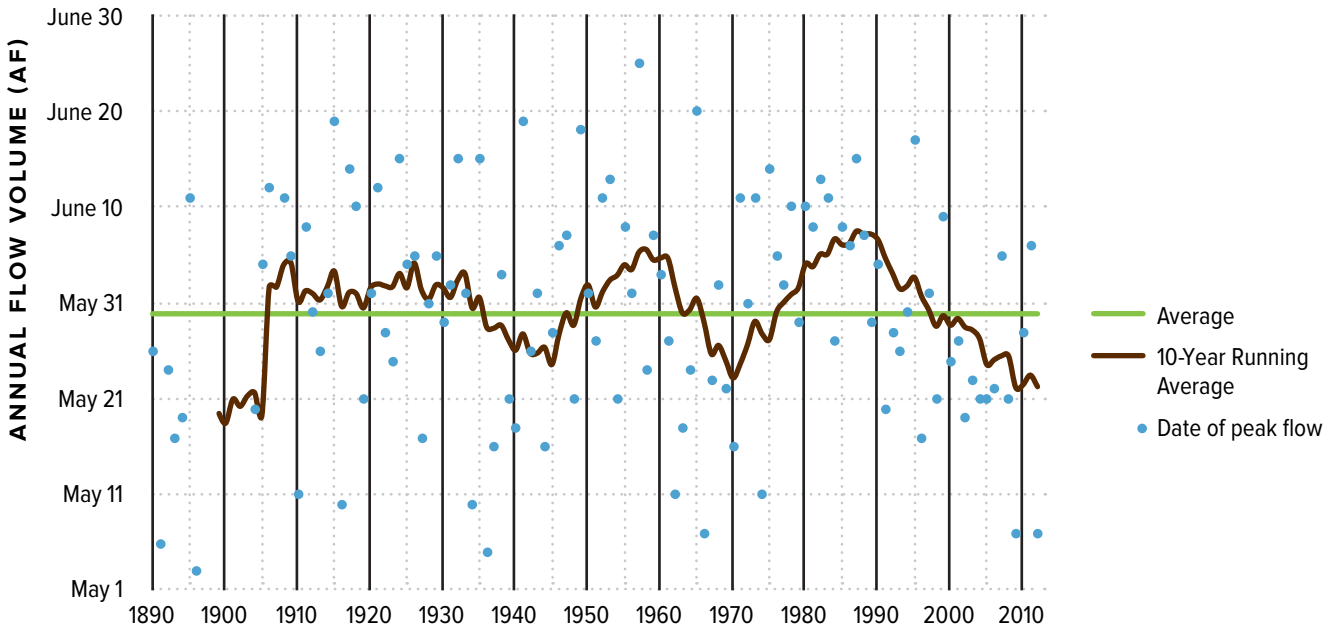
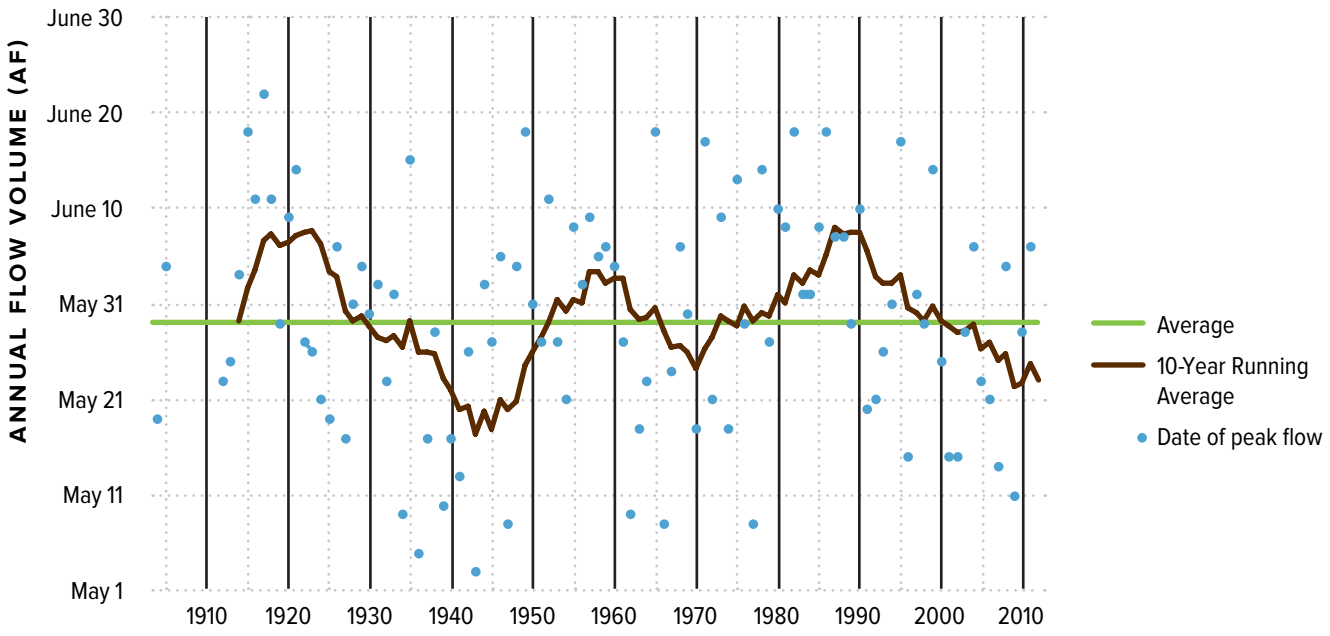


FIGURE 17.

Date of peak snowmelt runoff at Conejos River near Mogote gage, 1904–2012.



2.3.2 : Groundwater

The total amount of reservoir storage in the Basin is small compared to most other basins in the state. Agricultural producers rely heavily on a pair of aquifers that sit beneath the Valley floor. The uppermost aquifer is comprised of sandy and gravelly soils that sit on top of a confining clay unit. The aquifer varies in thickness throughout the Valley, but is usually between 30 and 50 feet thick, and up to 100 feet thick in the Closed Basin. This upper aquifer is known as the *unconfined aquifer*, which simply means that the water in the aquifer is not under pressure from an overlying confining unit. The unconfined aquifer is recharged from a number of sources, including the many streams that enter the Valley from the surrounding mountains.

In addition to the natural recharge coming from mountain stream runoff surrounding the Valley, the unconfined aquifer is recharged through canal leakage and return flows from irrigation. Several large canals divert water from the Rio Grande and Conejos and deliver to lands adjacent to the streams and in the Closed Basin. Water diverted for irrigation into the Closed Basin area recharges the aquifer through canal leakage, return flows from irrigation and delivery into recharge pits, often located in the corner of center-pivot fields. The unconfined aquifer acts as a large reservoir that helps retime water supply to parallel the crop water needs. Irrigators can fill the aquifer when their surface water right is in priority and pump the water out of the aquifer later in the year when surface water flows have receded.

In the Closed Basin (Figure 19), surface water has no natural outlet to the Rio Grande, and early reports from explorers indicate large swampy areas in the Closed Basin where the water table rose to the surface and simply evaporated through swamps and lakes. The Closed Basin Project, which pumps water from this sump area (located on the eastern edge of the

FIGURE 18.

Timing of water availability versus timing of agricultural need in the San Luis Valley.

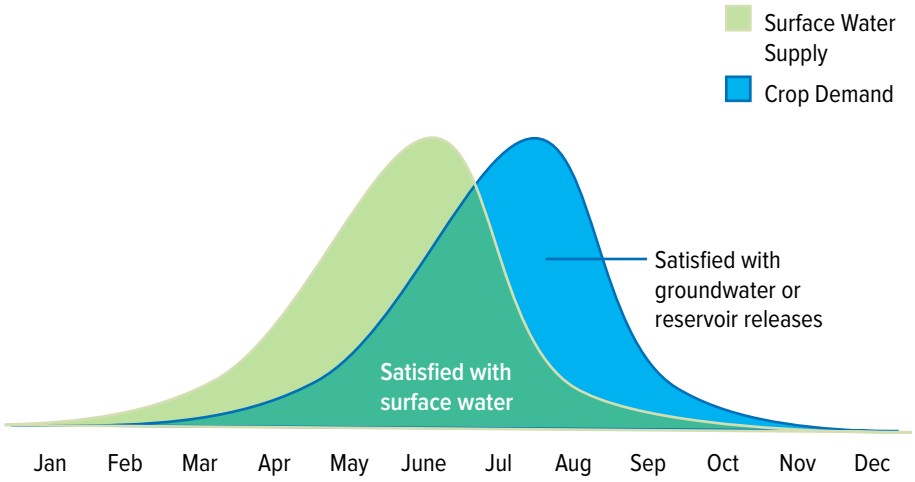
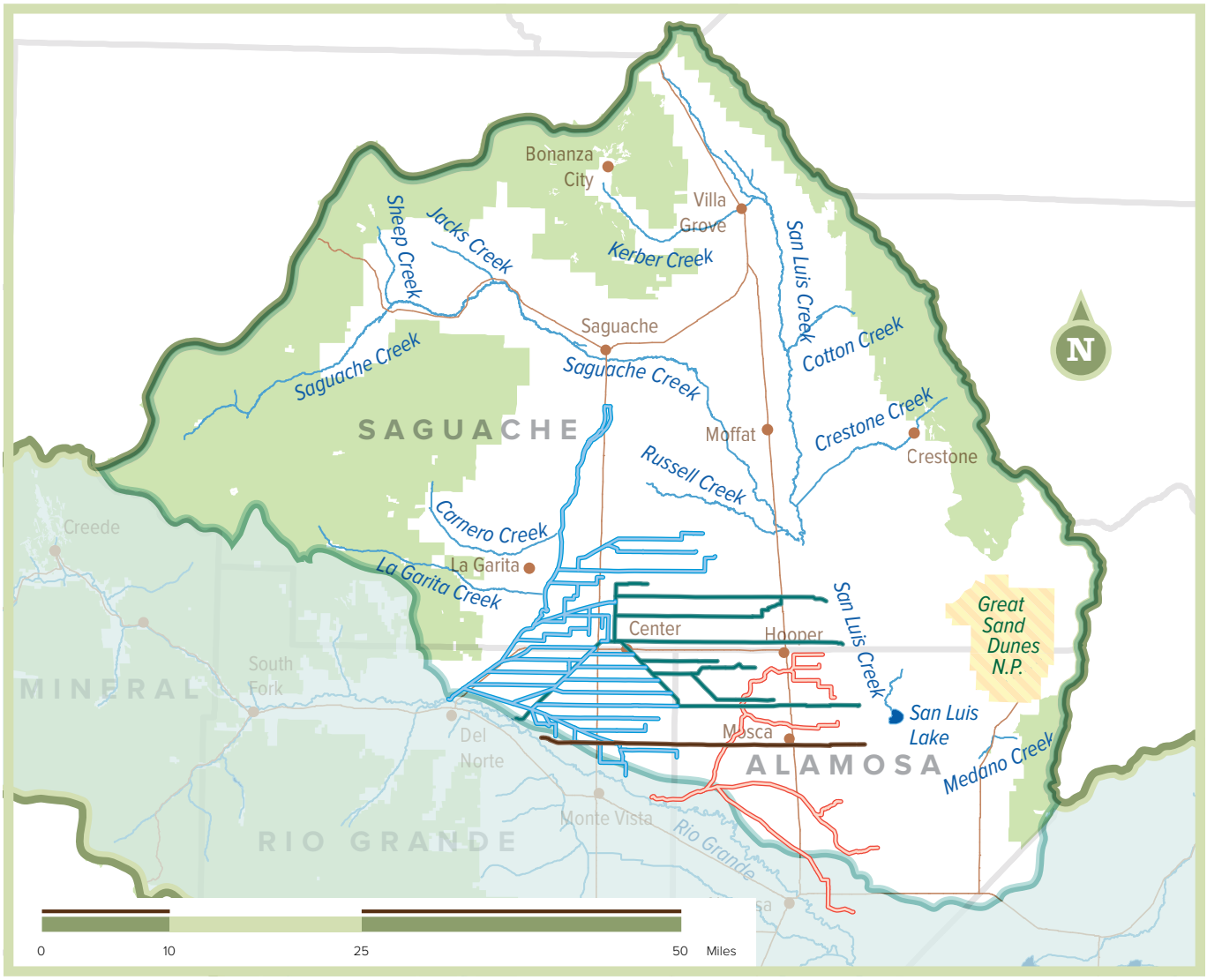
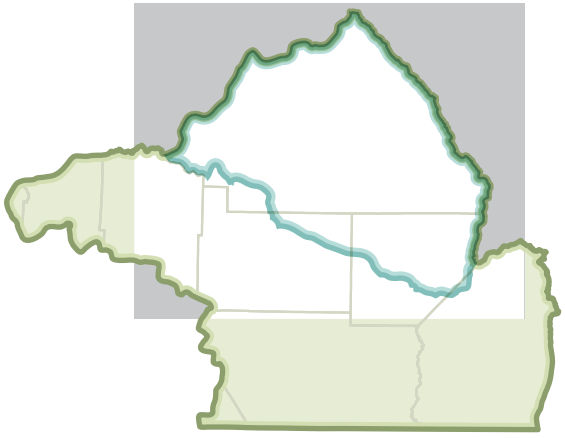


FIGURE 19. Map of Closed Basin area.



Farmers Union Canal
Rio Grande Canal
Prairie Ditch
San Luis Valley Canal
Closed Basin Boundary



Where to find more information:

Section 3.2.4 (Administration of Groundwater) [ESTABLISH HYPERLINK]

Section 3.6.3 (Groundwater Sustainability) and Section 3.7.2 (Subdistricts)

Historical reports (1910–1939) on water resources in the San Luis Valley (WEBLINK TO BE ESTABLISHED)

Groundwater Atlas of Colorado weblink

Water Court ruling on Confined Aquifer rules (WEBLINK TO BE ESTABLISHED)

Subdistrict No. 1 Plan for Water Management and Annual Replacement Plan (weblink to be established)

Valley north of the Rio Grande), was conceived in the early 1900s as a way to use this water rather than lose it to evaporation, although the Project was not built until the 1980s. A groundwater divide that approximately parallels the Rio Grande from Del Norte to Alamosa one to three miles north of the river provides a buffer between groundwater that is tributary to the Rio Grande and groundwater in the Closed Basin. The extent of the hydraulic divide is the subject of much study and current importance with respect to administration of groundwater.

The confined aquifer is separated from the unconfined by blue clay deposits and basalt, although there is upward leakage into the unconfined aquifer in some locations. The confined aquifer is recharged by streamflow at the rim of the San Luis Valley, where neither of the barrier deposits are found. To varying degrees, the two aquifers and surface streams are hydraulically connected (Case No. 2004CW24, District Court, Water Division No. 3 (Nov. 9, 2006) at 87). The confined aquifer is much thicker than the unconfined aquifer, extending in some locations to several thousand feet below the surface. The confined aquifer is under hydraulic pressure, as the recharge areas near the edge of the Valley are higher than the Valley floor. Flowing wells, also known as *artesian wells*, result by tapping into the pressurized confined aquifer. McIntire Springs, located near the confluence of the Conejos and the Rio Grandes, is fed by the confined aquifer. Flow at the McIntire Springs has decreased over time, indicating a declining aquifer pressure most likely a result of groundwater withdrawals from the confined aquifer. The general location of the unconfined and confined aquifers is shown in Figure 20. A schematic showing the dynamics of the unconfined and confined aquifers is shown in Figure 21. This figure depicts the general water balance of gains and losses to the aquifers. One additional source of recharge to the unconfined aquifer that is not shown in Figure 21 is return flows from irrigation.

High commodity prices coupled with long-term drought have helped to drive high groundwater withdrawals in recent years, as irrigators, seeking to maximize crop yields and revenues, have withdrawn significantly more water from the aquifer than was recharged. Senate Bill 04-222, described in more detail in Section 2.5.4, was enacted by the Colorado legislature in 2004 and requires restoration of aquifer levels and pressure in the confined aquifer as well as long-term sustainable use of the aquifers. Irrigators are in the process of developing methods to reduce groundwater withdrawals while maintaining viable agricultural production. The Rio Grande Water Conservation District is spearheading the formation of groundwater management subdistricts, with the goals of managing the aquifer in a sustainable manner, and avoiding the strict regulation by the State Engineer's Office intended to force compliance with the 2004 law.

Discharge from a confined aquifer artesian well. Photo: Kelly DiNatale.

With the exception of the Bureau of Reclamation's Closed Basin Project, the Basin's water supply and delivery infrastructure has changed little through the latter half of the twentieth century. Intra-basin conflicts emerged in the 1970s, pitting surface-water users against groundwater irrigators in legal battles, and again following the 2002 drought. The Basin's water users have also defended against efforts to export groundwater by speculators proposing to sell water to Front Range interests. The defeat in local water court of the American Water Development Inc. (AWDI), and defeat of the state ballot initiative by Stockman's water, both of which were efforts to export groundwater from the confined aquifer, ended up paving the way for the creation of Great Sand Dunes National Park as a means of preserving the confined aquifer.

FIGURE 20.

Hydrologic aquifer map of Rio Grande Basin.

Source: *Headwaters*, Summer 2013, Colorado Foundation for Water Education

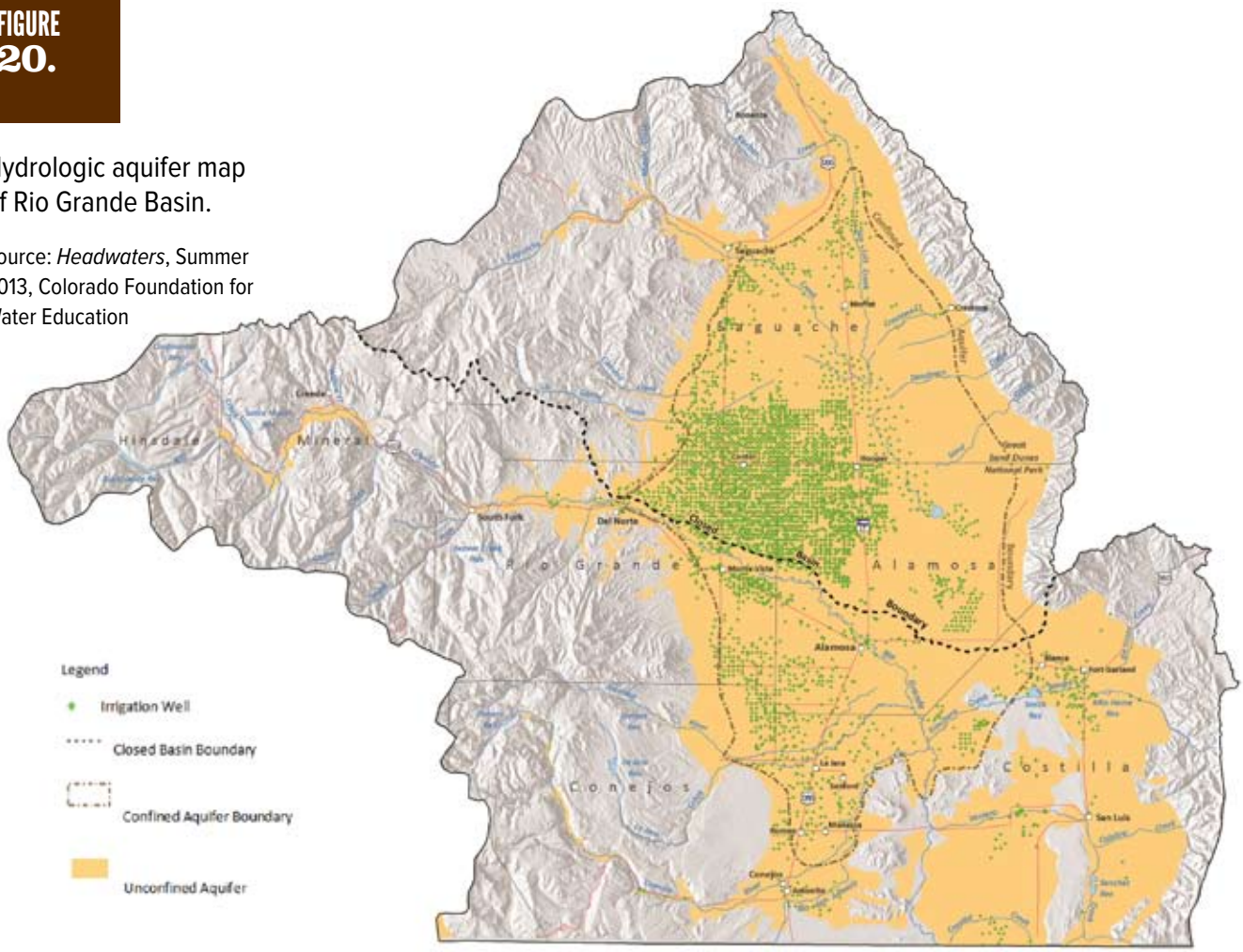
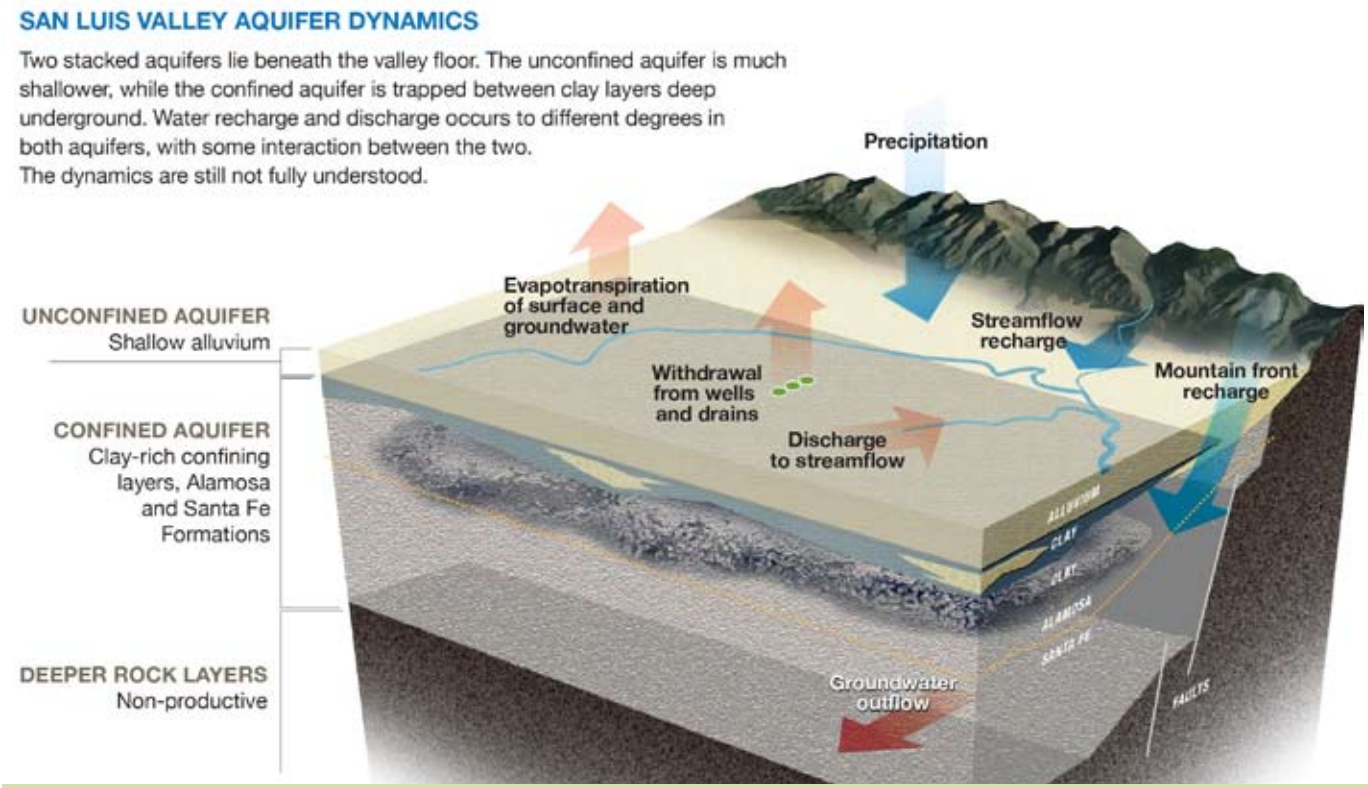


FIGURE 21. Aquifer recharge of the confined and unconfined aquifers along a mountain front of the San Luis Valley.



Source: *Headwaters*, Summer 2013, Colorado Foundation for Water Education. Illustrations by Charles Chamberlin.

2.4 : History of Water Development

The Rio Grande Basin has one of the oldest traditions of water development in the state. In the Rio Grande Basin, the greatest use of water is for irrigation. This section describes the history of water development in the Basin from the surface water development via canals, ditches and reservoirs and groundwater development of the unconfined and confined aquifers.

2.4.1 : Canals and Ditches

Hispanic settlers from New Mexico settled along the Conejos and Culebra rivers in the 1850s and almost immediately began digging community irrigation ditches, known as *acequias*. Colorado's first surface water right was appropriated in the Rio Grande Basin in 1852 — the People's Ditch near San Luis diverts water from Culebra Creek. In 1855 the first diversion from the Conejos River occurred via the Guadalupe Ditch. The first diversion from the Rio Grande main stem occurred in 1866 at the Silva Ditch.

Beginning in the mid-1800s, an extensive system of irrigation canals and ditches was built throughout the Basin. By 1870, nearly 50,000 acres in the Basin were irrigated by canals and ditches. The arrival of the Denver and Rio Grande Railroad in 1879 ushered in a new wave of settlement and water development. Over the next 15 years, the number of acres under irrigation rose to nearly 400,000, thanks to a canal building boom and the construction of nearly 2,000 artesian wells (San Luis Valley Advisory Committee n.d.). By 1900, the flow in the Basin's streams were over-appropriated, meaning there were more claims to use the water than available to satisfy these claims at all times. This over-appropriation of the water in the streams led to a recognition of the need to construct storage to capture winter flows and the high flows during runoff when all of the canals were diverting at capacity. Intensive irrigation development continued until there were nearly 700,000 irrigated acres by the 1930s. Today these canals and ditches provide water for farms and ranches, along with wetlands, wildlife areas, and municipal and industrial uses. The areas that can be served by the canals and ditches are shown in Figure 22. A more detailed description of the water rights administration of the ditches and canals is found in Section 2.5.3.

Sunset on a canal. Photo: Erich Schlegel

2.4.2 : Reservoirs

Basin water users suffered a major setback in the development of water supplies for irrigation in 1895, when the U.S. Secretary of the Interior imposed an embargo on the use of federal rights of way for development of water diversion and conveyance facilities and storage diverting from the Rio Grande in Colorado and New Mexico. The embargo, which was prompted by efforts to negotiate a water-use treaty with Mexico, saw certain terms relaxed in 1907 and fully lifted in 1925. The relaxing of the embargo in 1907 allowed the completion of several reservoirs in the Basin in Colorado; several other reservoirs were completed after the embargo was lifted in 1925. These reservoirs include Sanchez, Rio Grande, Santa Maria, Continental, Mountain Home, Terrace, La Jara and other smaller structures. There is a limited ability to store and retime the erratic flow of the Basin's rivers through storage in these and other private reservoirs.

In the headwaters of the Rio Grande, the largest reservoirs are Rio Grande Reservoir, Santa Maria Reservoir and Continental Reservoir. Rio Grande Reservoir is an on-channel reservoir constructed from 1910–1912 during a relaxation of the federal storage embargo. It has a capacity of more than 50,000 AF and provides supplemental irrigation supply to the Farmer's Union Canal. The reservoir also stores water for other entities, including the San Luis Valley Water Conservancy District and Colorado Parks and Wildlife. Rehabilitation work was performed at Rio Grande Reservoir during the summer of 2013 to reduce seepage through its left abutment. There are plans to improve the outlet works and spillway. Currently, there

Rio Grande Reservoir as viewed from Papoose Creek. Photo courtesy of San Luis Valley Irrigation District

is not a storage restriction hold order on Rio Grande Reservoir.

Continental Reservoir is located on North Clear Creek, a tributary to the Rio Grande, and has a capacity of 27,000 AF. Continental Reservoir delivers supplemental irrigation water to users under the Rio Grande Canal and Monte Vista Canal. For the past 20 years, storage has been limited to 15,000 AF by a State hold order due to leakage at the dam and the deteriorating outlet works. Funding from a CWCB loan and a Water Supply Reserve Account (WSRA) grant was used in 2014 for repairs.

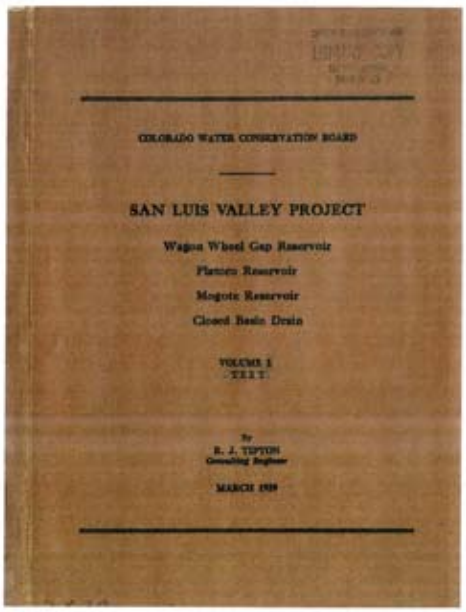
Town of Del Norte, CO. Source: http://www.wagonwheel-gap.freehomepage.com

Santa Maria Reservoir is an off-channel reservoir that receives water from North Clear Creek, a tributary to the Rio Grande, and provides supplemental irrigation water to users under the Rio Grande Canal and Monte Vista Canal. Santa Maria has a capacity of 43,500 AF. There is not a hold order on Santa Maria Reservoir. A pipeline diverts water from North Clear Creek into an open ditch that flows into Santa Maria Reservoir. The pipeline and ditch are aging and prohibit maximum diversion during the reservoir's priority water diversion. As such, Santa Maria Reservoir Company is using funds from a CWCB loan and a WSRA grant to repair the system in 2014.

IN THE NEXT DRAFT THERE WILL BE A DISCUSSION OF THE EFFORTS FROM THE 1920s TO THE 1940s TO CONSTRUCT WAGON WHEEL GAP AND CONEJOS RESERVOIRS . THERE WILL ALSO BE ADDITIONAL INFORMATION ABOUT TERRACE AND SANCHEZ RESERVOIRS.

Wagon Wheel Gap, Platoro, and Mogote reservoirs and Clsed Basin Drain projects.

Platoro Reservoir was constructed on the headwaters of the Conejos River in 1951 by the U.S. Bureau of Reclamation (BOR). Unlike the high proportion of federally operated reservoirs on the Rio Grande downstream of Colorado, Platoro is the only federally built reservoir in the Basin in Colorado. Platoro is a post-compact reservoir subject to storage limitations under Article VII of the Rio Grande Compact. Platoro is operated and managed by the Conejos Water Conservancy District, which has a long-term agreement with the BOR.


COLORADO WATER CONSERVATION BOARD

SAN LUIS VALLEY PROJECT

Wagon Wheel Gap Reservoir

Platoro Reservoir

Mogote Reservoir

Closed Basin Drain

VOLUME I
TEXT

By
R. J. TIPTON
Consulting Engineer

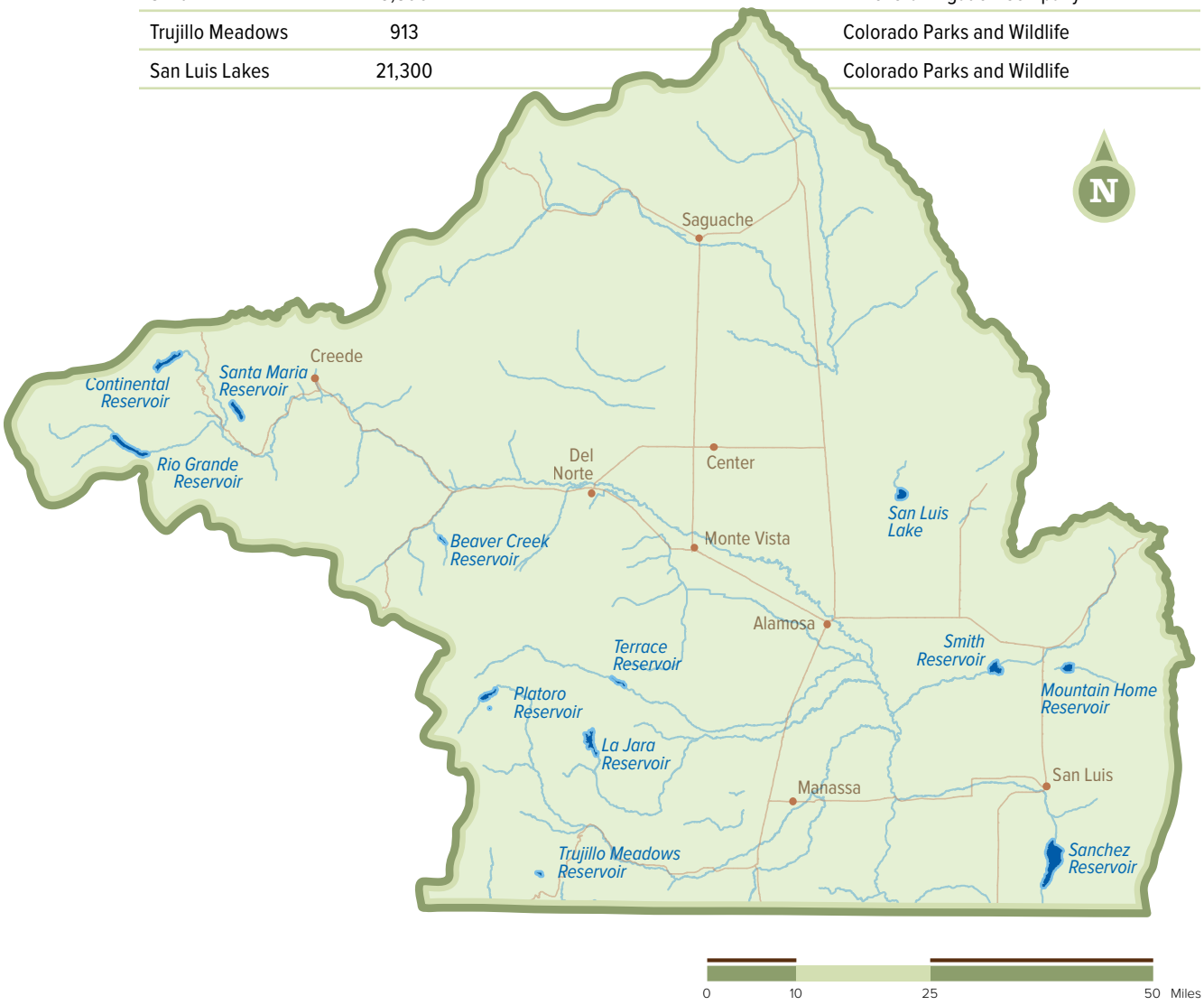
MARCH 1959

The major reservoirs in the Basin, including the owner/operator, storage volume and pre- or post-compact status are shown in Figure 23. The pre-compact reservoirs hold special importance as described in Section 2.5.2.

FIGURE 23.

Major Rio Grande Reservoirs

Reservoir Name	Capacity (AF)	Pre–Compact Reservoir	Ownership
Continental	22,680	X	Santa Maria Reservoir Company
Santa Maria	43,800	X	Santa Maria Reservoir Company
Rio Grande	52,000	X	San Luis Valley Irrigation District
Beaver Park	4,758	X	Colorado Parks and Wildlife
La Jara	14,060	X	Colorado Parks and Wildlife
Mountain Home	17,370	X	Trinchera Irrigation Company
Platoro	59,570		Bureau of Reclamation/CWCD
Sanchez	103,100	X	Sanchez Ditch and Reservoir Company
Terrace	15,180	X	Terrace Reservoir Company
Smith	5,800		Trinchera Irrigation Company
Trujillo Meadows	913		Colorado Parks and Wildlife
San Luis Lakes	21,300		Colorado Parks and Wildlife



2.4.3 : Groundwater

Prior to the construction of storage, irrigators practiced surface irrigation where water was diverted from the stream and crops were flood irrigated. These high spring diversions and settling of water into the Closed Basin gave way to a method of irrigation known as *subirrigation*. Subirrigation involved the use of flood irrigation to build up the water table to within one to three feet of the surface. Although subirrigation offered irrigators flexibility and extended late-season use, losses due to evaporation and transpiration increased. Furthermore, the water table became so high that ditches were dug to drain water out of saturated soils.

Groundwater development in the Valley began with the discovery of the confined aquifer in 1887. By 1891 there were estimated to be 2,000 flowing artesian wells in the Valley; by 1904 the estimate was 3,234 flowing wells; and by 1916 the estimate was 5,000 flowing wells. The number of flowing wells increased to 6,074 by 1936 and grew to an estimated 7,500 flowing wells by 1958 (Case No. 2004CW24, District Court, Water Division No. 3 (Nov. 9, 2006) at 86). The majority of confined well usage is outside of the Closed Basin.

Faced with a shortage of surface-water storage and water-logging of soils from subirrigation, by the 1950s, the Basin's irrigators began to make extensive use of the unconfined aquifer — the shallower of the two groundwater bodies that sit beneath the San Luis Valley — through well pumping. While the first irrigation well in the unconfined aquifer was constructed in 1903, there was little or no further development of the unconfined aquifer for irrigation purposes for the next 25 years. The number of wells withdrawing water from the unconfined aquifer increased from 176 in 1936 to approximately 1,300 wells in 1952 (Case No. 2004CW24, District Court, Water Division No. 3 (Nov. 9, 2006) at 87). Extensive use of the unconfined aquifer continued through the twentieth century, and irrigators turned to the use of center-pivot sprinklers rather than subirrigation as the preferred method to irrigate crops.

Artesian well on Dutton Ranch, near Alamosa.
Source: Heather Dutton

The Water Rights Adjudication and Administration Act of 1969 integrated groundwater into the surface water prior appropriation system. In 1972, the State Engineer determined that new groundwater appropriations from the confined aquifer and alluvial aquifers in the Basin would cause injury to vested water rights. The State Engineer imposed a moratorium on new groundwater

appropriations in the confined aquifer that year, and extended the moratorium to the unconfined aquifer of the Closed Basin in 1981 for the same reason. The moratorium affected all new non-exempt groundwater appropriations. In 1975, the State Engineer issued Rules and Regulations meant to force well users to either obtain an augmentation plan for their well or prove their pumping did not cause injury to senior water rights. These rules resulted in a decade-long legal battle that ultimately was not resolved through rules and regulations by the Division Engineer. Instead, the Closed Basin Project was developed and it was thought that the yield from the project would allay concerns about stream depletions and help meet the Compact obligations. As part of the Closed Basin Project, water users in other parts of the Basin "waived all claims against all existing wells located within the boundaries of the Rio Grande Water Conservation District for alleged effects on [streamflow in the Basin]" (Case No. 2004CW24, District Court, Water Division No. 3 (Nov. 9, 2006) at 109). The Closed Basin Project was intended to provide replacement water for the then-existing groundwater use. However, the Closed Basin Project has not yielded the amount of water originally projected, and concerns over well depletions by other water users resurfaced during the drought of the early 2000s. During this time, water users sought other means of relief from well depletions.

In 1998, the legislature instructed the Division 3 Engineer to promulgate Rules and Regulations that addressed the water use in the confined aquifer. The effect of these rules is the recognition that new groundwater withdrawals will require a plan for augmentation. The rules were to be promulgated by July 1, 2004 and were subsequently approved by court decree in 2007. This legislation provided for extensive study of the San Luis Valley's aquifers and their interaction with surface water through the RGDSS.

A monthly survey of water levels in the unconfined aquifer by Davis Engineering is used to estimate the change in storage in the unconfined aquifer since 1978, as shown in Figure 24. The figure shows the rapid decline in aquifer storage levels beginning with the 2002 drought and continuing through the present. As of early 2014, there is approximately 1,200,000 AF less water in the unconfined aquifer than in 1976. The water level declines led to reduced well yields for some well owners, but have not affected others. Some of the most significant water level declines have been reported near the edge of the unconfined aquifer. Hydrographs of various confined aquifer wells are shown over time in Figure 25. McIntire Springs is located near and discharges into the Conejos River west of Manassa, Colorado. The discharge from McIntire Springs has declined over time, as seen in Figure 26, and the reduction in discharge appears to be attributable, in large part, to the reduction in artesian head in the confined aquifer. Additional discussion related to the current state of administration of groundwater is presented in Section 2.5.4.

Where to find more information on history of water development:

Bill Paddock Legal Review paper on Compact (WEBLINK TO BE ESTABLISHED)

04CW24 Water Court ruling on Confined Aquifer rules (WEBLINK TO BE ESTABLISHED)

Joint Investigations (WEBLINK TO BE ESTABLISHED)

FIGURE 24.

Change in storage in unconfined aquifer since 1976.

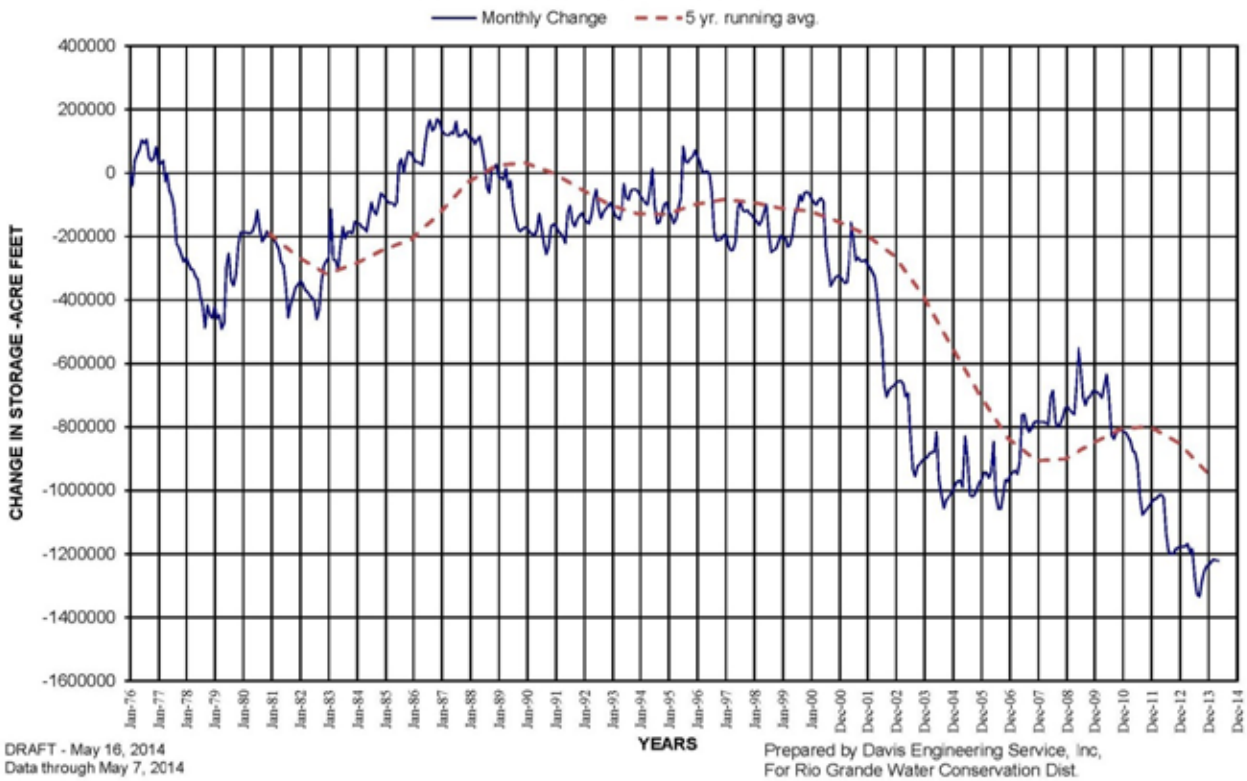


FIGURE 25.

Hydrographs of various confined aquifer wells.

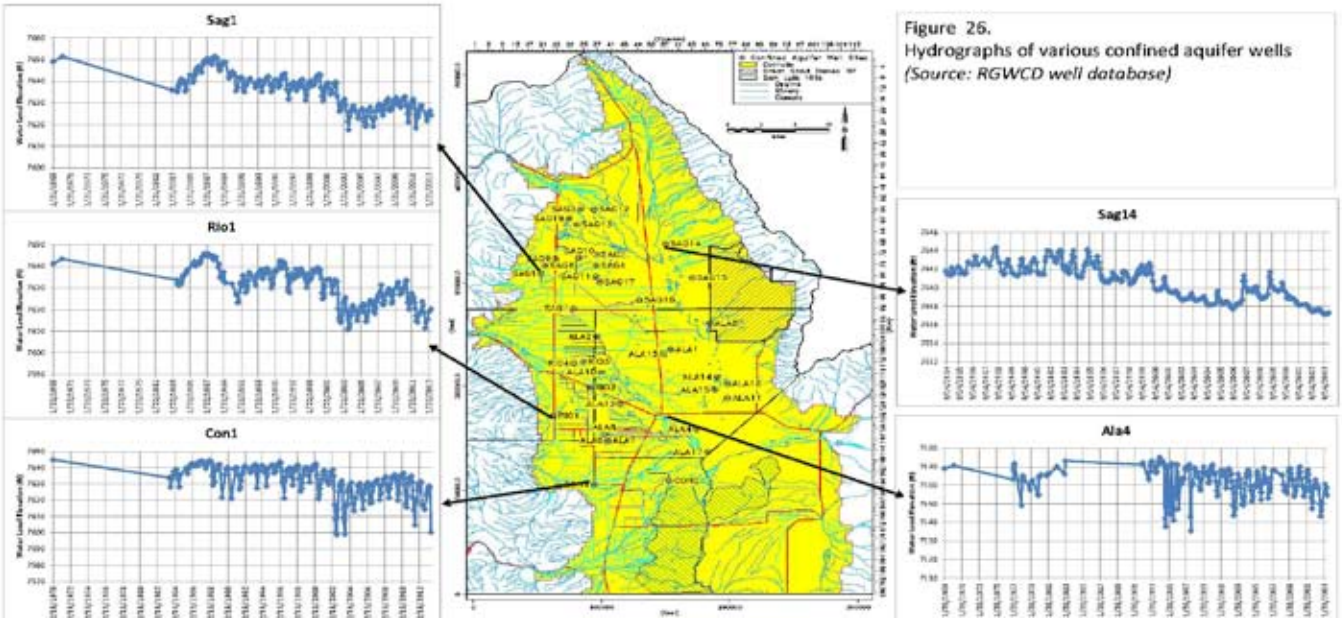
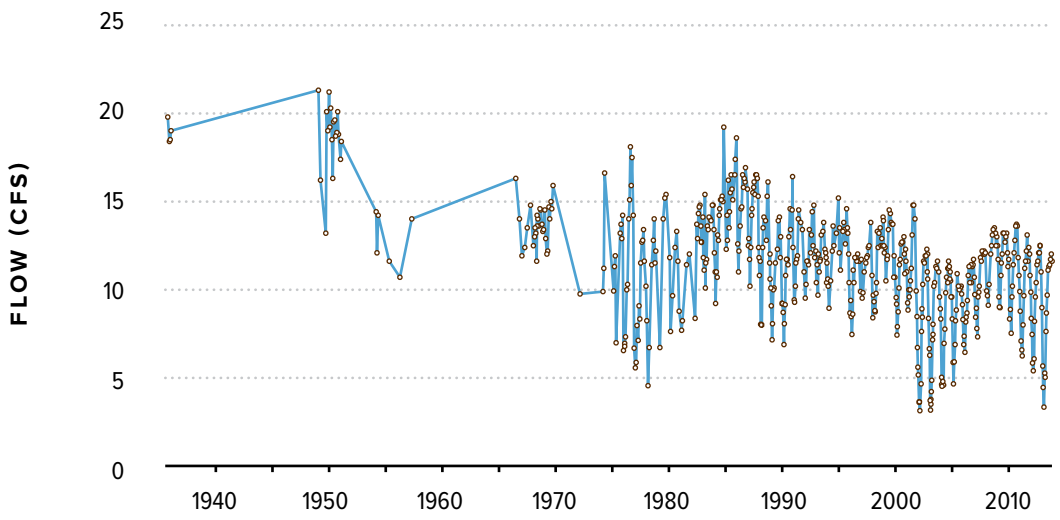


FIGURE 26.

McIntire Springs flow, 1936–2014.



2.4.4 : Timeline of Water Development

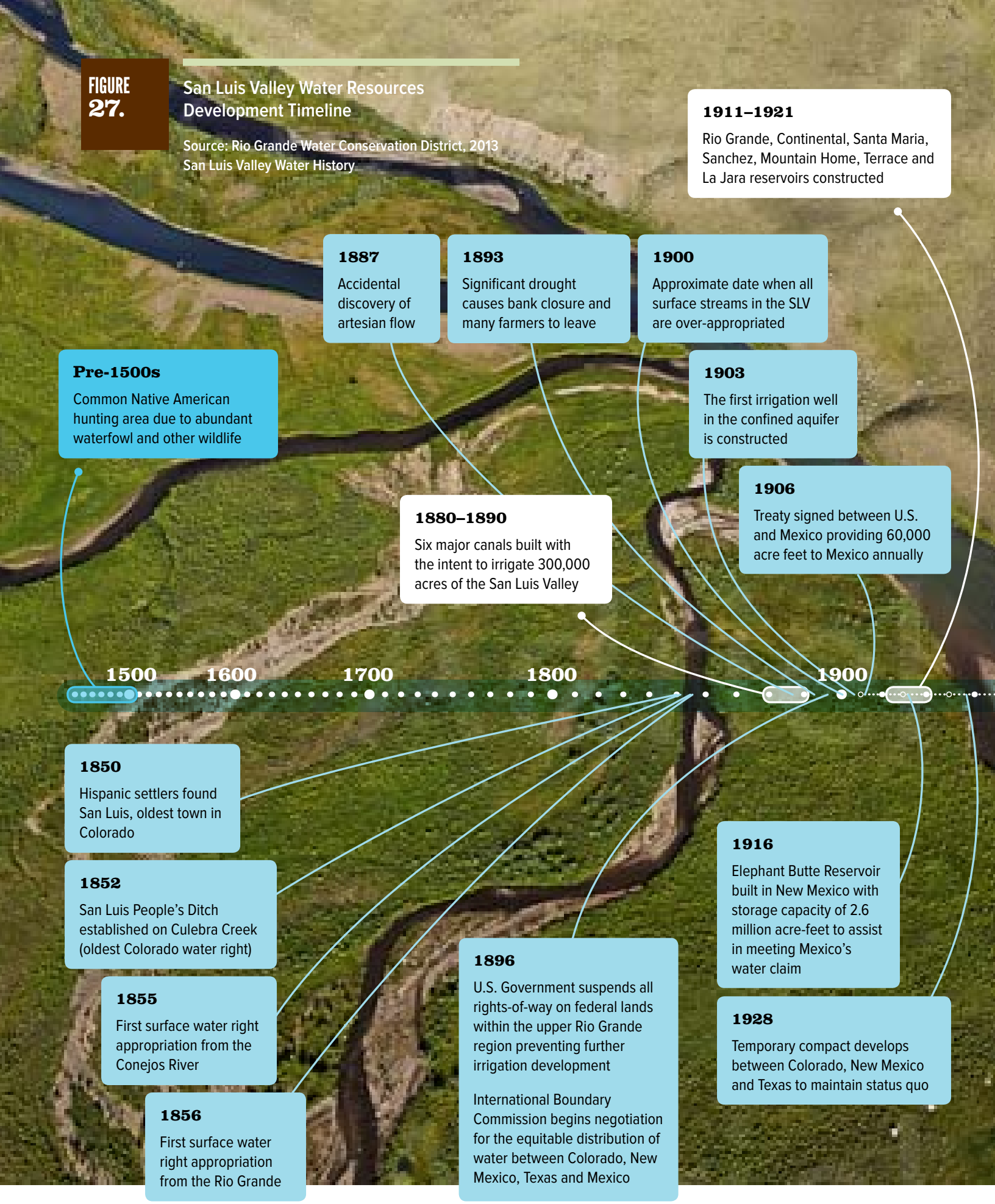
Two timelines of water development in the Rio Grande Basin have been previously prepared by the Rio Grande Water Conservation District in 1991 and 2013. The following timeline shown in Figure 27 represents a merging of major events from the two timelines and some recent updates.

Ranches and hayfields along
Rio Grande above Del Norte.
Photo: Adriel Heisey

FIGURE 27.

San Luis Valley Water Resources Development Timeline

Source: Rio Grande Water Conservation District, 2013 San Luis Valley Water History



Rio Grande at confluence with Trout and Mountain Creeks in Antelope Park. Photo: Adriel Heisey

1938

Rio Grande Compact formally charted, defining water delivery amounts to New Mexico, Texas and Mexico with deliveries varying annually based on precipitation

1952–1956

Long drought causes water users to supplement surface water with groundwater

1962

Construction of Platoro reservoir completed

1967

Rio Grande Water Conservation District established

1972

State imposes a moratorium on the construction of new high capacity wells in the confined aquifer and aquifers tributary to the Rio Grande

1973

Extensive center pivot sprinkler development begins, increasing irrigation efficiencies

1981

Construction begins on Closed Basin Project

State imposes a moratorium on the construction of new high capacity wells to the unconfined aquifer

1985

Elephant Butte Reservoir spills, erasing the alleged Rio Grande Compact debt owed by Colorado to the downstream states

1986

American Water Development Inc. (AWDI) files application to withdraw 200,000 acre feet of water annually with intent to sell outside the San Luis Valley

2000

1966

New Mexico and Texas sue Colorado over Rio Grande Compact alleged indebtedness

1968

First year Colorado administered the Compact pursuant to the U.S. Supreme Court stipulation with Texas and New Mexico

1991

Water court dismisses the AWDI water claim

1992

Closed Basin Project completed

1998

Two State ballot initiatives posing significant changes in San Luis Valley water management defeated by electorate

2004

Senate Bill 222 passes, requiring sustainable use of the aquifers

2004–Present

Implementation of Groundwater Measurement Rules, Confined Aquifer Rules, and encouraging the use of subdistricts

2.5 : Water Administration

2.5.1 : Introduction

Water users in the Rio Grande Basin, as in the rest of the arid West, operate under the doctrine of prior appropriation. The doctrine allows the first water users on a stream to fill their decreed amount before junior appropriators, commonly known through the shorthand description of "first in time, first in right." A water user must also put their water to beneficial use; in Colorado this includes a slew of purposes, but in the Rio Grande Basin the most common is irrigation.

By 1900 the Basin's streams were over-appropriated, meaning there were more rights to use water than available water to fill them. Over time, water levels in the unconfined aquifer and pressures in the confined aquifer have declined as pumping has increased and led to a determination that the groundwater system is also over-appropriated. This determination, in conjunction with the over-appropriated nature of the surface streams, means that there is no water available for new appropriations or for transfer out of the Basin.

Center pivots in the San Luis Valley. Photograph by Dan Downing

Groundwater users in the Basin will also soon face regulation from the Colorado Division of Water Resources. In 2009, State Engineer Dick Wolfe

convened an advisory council to help formulate rules and regulations for all groundwater withdrawals in the Basin. The development of draft rules has also included computer modeling to determine the impact of groundwater use on surface water availability. A final version of the rules and their court approval remain pending. Draft rules indicate groundwater users will be required to have an augmentation plan or join a groundwater management subdistrict if they wish to continue pumping. The proposed groundwater management subdistricts constitute a voluntary effort by water users to limit groundwater pumping and comply with the sustainability requirements of Senate Bill 04-222. Failure to meet these requirements would likely result in the State Engineer ordering the direct curtailment of well pumping. The experience in the South Platte Basin with mandatory State Engineer well regulations indicate that the lack of flexibility in enforcement of mandatory rules and regulations can result in a significant loss of irrigated acres.

2.5.2 : Rio Grande Compact

The waters of the Rio Grande Basin are divided between Colorado, New Mexico and Texas through the Rio Grande Compact of 1938. The Division 3 Engineer is responsible for the administration of the Rio Grande and the Conejos rivers in order to meet Colorado's delivery obligations under the Compact. Administration of the Compact affects administration of Colorado water rights in the Rio Grande Basin on a daily basis. Former Division Engineer and current Rio Grande Water Conservation District General Manager, Steve Vandiver, and attorney Bill Paddock have both written comprehensive documents that describe the history, development and administration of the Compact (Vandiver 1999; Paddock 2001; U.S. National Resources Committee 1938). In addition, the Decree in Division 3 Water Court Case No. 2004CW24 provides an extensive discussion on the history, geology, legal background and technical aspects of water use and administration in the Rio Grande Basin. (Case No. 2004CW24 was the result of a lawsuit filed against the State based on the implementation of rules and regulations for the confined aquifer.)

The need for a Compact between the states was born out of water shortages in El Paso, Texas and Juarez, Mexico in the 1880s and 1890s, the time frame when irrigated agriculture in the San Luis Valley in Colorado increased from just over 100,000 irrigated acres to approximately 400,000 irrigated acres (Case No. 2004CW24, District Court, Water Division No. 3 (Nov. 9, 2006) at 71). As noted in the reservoirs subsection 2.4.2, a federal embargo on the construction of storage in the Rio Grande Basin was imposed in 1895 and not lifted until 1925. Shortly after in 1929, the three states entered into a temporary Compact in which all states agreed to not increase depletions until a final Compact could be negotiated. Paddock (2001) provides an excellent description of the process used by the states to forge the terms of the Compact, including the states' opening positions at the Compact negotiations, description of the State Engineers' reports to the Commission, Colorado's response and, ultimately, the terms of the final Compact. The Compact was ratified in 1938.

2.5.2.1 HISTORICAL ADMINISTRATION OF THE COMPACT

Vandiver (1999) describes Compact administration in three distinct time periods. The initial period was from 1938 to 1967 where "Colorado officials made the decision to continue with the administration of water rights as they had during the [Compact] study period of 1927 to 1936." During this period, Colorado water rights were not curtailed, and Colorado under-delivered by 154,000 AF in 1952 and continued increasing its cumulative debits to approximately 940,000 AF in 1967. In 1966, New Mexico and Texas filed suit with the U.S. Supreme Court to require Colorado to meet its Compact obligations.

This action at the U.S. Supreme Court ushered in the second Compact administration period from 1968 to 1985. During this time, Colorado curtailed water users to meet the Compact obligations through various methods and, in 1975, promulgated rules for administration. These rules were contested by water users and lengthy litigation ensued. Ultimately, the Colorado Supreme Court determined that the Compact would be administered to the Rio Grande and Conejos systems independently and that curtailment of water to meet the Compact obligations would come from the junior water rights that would have otherwise been in priority. Through this second period, Colorado met or exceeded the delivery obligations and reduced its accrued debits to approximately 430,000 AF.

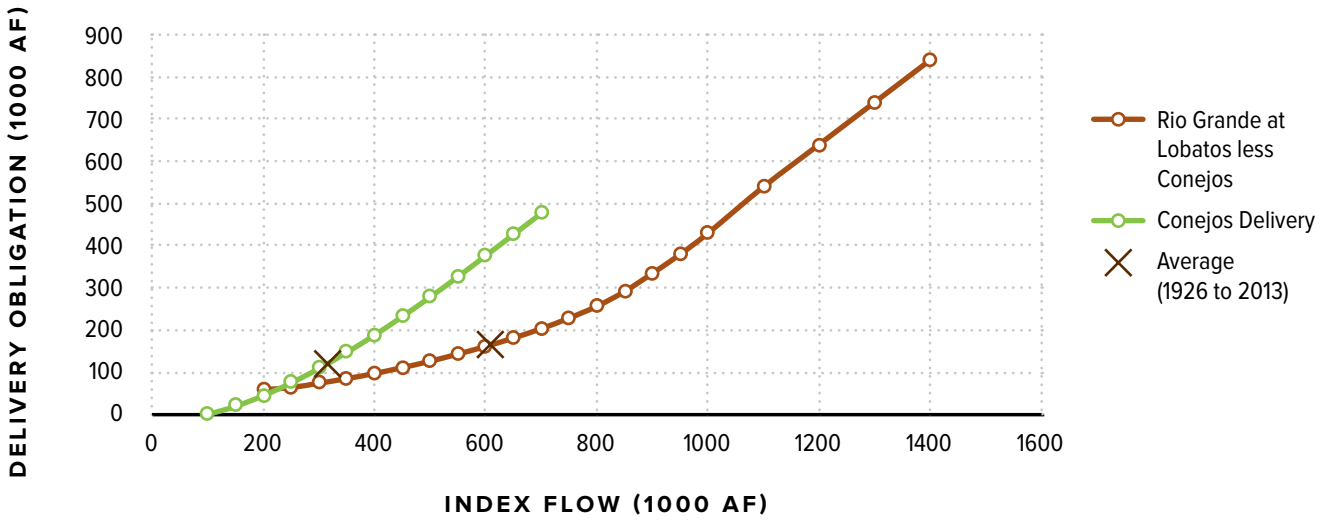
In 1985, Elephant Butte Reservoir in New Mexico spilled and, under the terms of the Compact, eliminated Colorado's remaining debt balance. Since 1985, Colorado has administered water rights to meet its Compact obligations annually. In order to meet the delivery obligations, the Division Engineer curtails a portion of the flow available to water users throughout most of the year. The process to determine the amount of flow to curtail or make unavailable to water users is described in further detail below. This third period of Compact administration began in 1985 and has continued to present. The Basin has been in full compliance with all provisions of the Compact since 1985.

2.5.2.2 COMPACT REQUIREMENTS

Colorado is required to deliver a certain amount of water each calendar year to the Rio Grande near Lobatos stream gage, located near the Colorado-New Mexico state line. Deliveries are required from both the Rio Grande and Conejos River. The delivery requirement is determined as a portion of the flow measured at stream gages in the upper parts of the Basin, above the majority of the water use in Colorado. Flows at these gages are referred to as the *index flows*. For the Rio Grande, the index is the flow at the Del Norte gage, where the Rio Grande enters the San Luis Valley from the headwaters to the west. For the Conejos, the index is the sum of the flows at three gages: Conejos River near Mogote, and the April through October flows at Los Pinos River near Ortiz and the San Antonio River at Ortiz. Adjustments are made to these gages to account

FIGURE 28.

Rio Grande and Conejos index flow and delivery obligation volume.



for transbasin inflows and any post-Compact reservoir operations. The delivery schedules were developed based on the relationship of the index flows and the flows at the state line during the 1928 to 1937 Compact Study Period (Paddock 2001). The difference between the index and the delivery obligation is the amount of consumptive use from the stream systems that was contemplated during Compact negotiations and helped to determine the delivery schedules.

As the index flows increase, the Compact delivery requirement becomes a larger percentage of the index flow as illustrated in Figure 28 and Figure 29. The allowed consumptive use in Colorado in relation to index flows is shown in Figure 30, indicating that the maximum annual amount of allowed consumptive use levels off at approximately 560,000 AF for the Rio Grande and 224,000 AF for the Conejos. Each of the figures also includes the 1926 to 2013 average index flow and delivery obligation (not including the "paper credit" or Closed Basin Project described below). An analysis of Figure 30 shows that the long-term average flows of the Rio Grande provide for Colorado to use 78% of the maximum allowed consumptive use amount contemplated under the Compact. In the Conejos, the long-term average flows provide for 87% of the maximum allowed consumptive use contemplated under the Compact.

The Compact provides Colorado with a 10,000 AF credit annually against the delivery obligation, generally known as the *"paper credit."* According to Paddock (2001), the basis for this credit during Compact negotiations is not entirely clear, but it was added to the later drafts of the Compact, potentially due to a dispute between Rio Grande and Conejos interests, to provide a buffer due to one Colorado engineer's opinion that the Conejos

delivery schedule might be difficult to meet, or as part of a compromise surrounding deliveries to Mexico and releases from Elephant Butte Reservoir. The paper credit is allocated 60% to the Rio Grande obligation and 40% to the Conejos obligation.

The Compact obligations are partially offset through water deliveries from the Closed Basin Project. The Closed Basin has no natural surface water outlet to the Rio Grande. Groundwater and surface water in the Closed Basin flow towards the sump area located in the southeastern portion of the Closed Basin and are consumed through evapotranspiration of the vegetation in the area or evaporated from ponded surface water in the sump area. The Closed Basin Project was envisioned in the early 1900s as a way to salvage water from the Closed Basin sump area. The Project, constructed in the 1980s, pumps water from wells located in the sump area and delivers the pumped water into a canal that discharges into the Rio Grande. Water from the Closed Basin Project enters the Rio Grande below the index gages and above the New Mexico state line; thus, it does not increase the index flow, but can be used to meet Compact obligations. The curtailment on water users, therefore, can be reduced by the amount of water delivered to the Rio Grande from the Closed Basin Project. Annual deliveries from the Closed Basin Project were initially projected to average 60,000 AF per year. However, the actual performance of the project has been far less, averaging approximately 12,000 AF per year due to water quality concerns and iron-bacterial clogging of the project wells. Deliveries of Closed Basin Project water are credited 60% to the Rio Grande Compact obligation and 40% to the Conejos Compact obligation under the 60/40 Agreement.

FIGURE 29. Rio Grande and Conejos index flow and delivery obligation percentage.

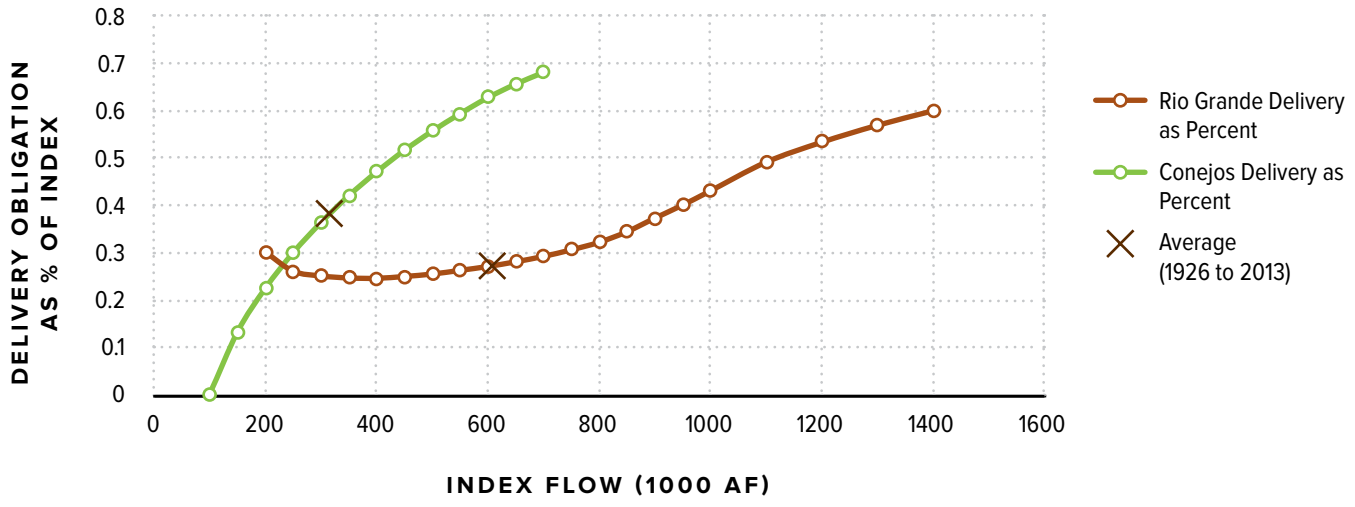
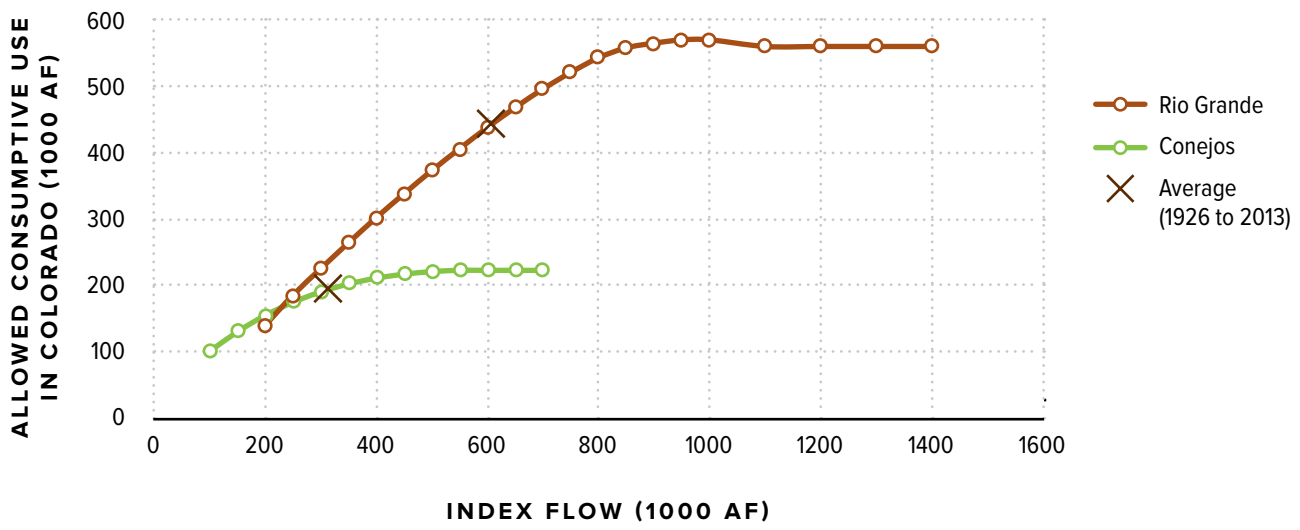


FIGURE 30.

Rio Grande and Conejos allowed consumptive use in Colorado under Compact.

(index supply minus delivery obligation)



2.5.2.3 ADMINISTRATION OF THE COMPACT

It is the responsibility of the Division 3 Engineer to deliver water to Colorado water users and determine how Colorado will meet its Compact delivery obligations. Vandiver (1999) provides a thorough discussion of the various challenges associated with meeting this obligation. One of the most significant challenges is that the target delivery changes on a daily basis as more flow is added to the index every day. This requires daily administration of the Compact and staff that are available to analyze the historical, current and projected stream conditions in order to balance the responsibility of meeting the Compact and delivering water to Colorado water users. Vandiver (1999) describes three categories of tools available to the Division Engineer to perform this administration: 1) legal tools, such as the prior appropriation doctrine and the rules and regulations governing Compact administration; 2) physical tools, such as multiple stream gages, snowpack and runoff forecasting, and 10-day reporting; and 3) political tools of active water users associations and strong relationships between Division 3 staff and the water user community.

Rio Grande near Del Norte gage.
Photo credit: Heather Dutton

In order to meet the Compact delivery requirement, Colorado water users are required to allow water to flow downstream past their headgates at different rates throughout the year. The amount of water

bypassed is known as the *curtailment*. The Division Engineer determines the curtailment amount in order to meet the Compact obligation, generally expressed as a percentage of the index flow.

Administration of the Compact varies throughout the year. In January, February and March, and again in November and December, the curtailment of irrigation rights is normally set to 100%, meaning that no diversions are allowed other than at pre-Compact reservoirs. There are exceptions to the 100% curtailment under more rare circumstances, such as a projected over-delivery of Compact water that year, a projected spill at Elephant Butte Reservoir or a large amount of Colorado credit stored in Elephant Butte Reservoir. Under these circumstances, the Division Engineer may allow winter recharge decrees to operate, reducing the potential of over-delivery or a spill at Elephant Butte. The 100% curtailment during the winter months maximizes the deliveries to New Mexico and reduces the curtailment required during the irrigation season.

Compact administration is actively managed during the irrigation season of April through October. In order to determine the curtailment during the irrigation season, the Division Engineer staff relies on snowpack and streamflow forecasts from the National Resource Conservation Service (NRCS), which projects April through September flows and updates these projections throughout the summer. Observed January through March index flows and average October through December index flows are added to the runoff projection to estimate the annual index flow and the associated Compact delivery obligation. This obligation

Closed Basin Project in the Rio Grande Basin.
Photo: Erich Schlegel

is further refined by subtracting the 10,000 AF "paper credit" and the projected Closed Basin Project deliveries. The observed January to March deliveries and average October through December deliveries are subtracted from the estimated annual delivery obligation to arrive at an estimate of the amount of water that must be delivered to New Mexico during the irrigation season. This amount is divided by the estimated index flow during the irrigation season to arrive at a percentage of the flow that must be bypassed by Colorado users and delivered to the New Mexico state line. This percentage is reduced by Division Engineer staff based on engineering judgment and experience to account for irrigation return flows, groundwater accretions and other gains or losses below the index gage(s). The curtailment is recomputed every 10 days during the irrigation season using updated observed flows and runoff forecasting. This information is published and distributed to the water user community in the form of the "10-Day Report."

The curtailment effectively removes a portion of the streamflow at the index gage from the amount of water that can be allocated to in-priority water rights. For example, if the curtailment is set to 20% and the flow at the index gage is 1,000 cfs, then 200 cfs is not available for diversion by any water user and is delivered to the state line. The remaining 800 cfs is delivered to in-priority water users. Rainfall, return flows, groundwater accretions and other gains may increase the 200 cfs curtailment at the index gage to a larger amount by the time it arrives at the state line. Different hydrologic conditions can result in higher than anticipated stream losses due to evaporation, consumption by phreatophytes, infiltration into the alluvium or river bank storage.

Like most Western rivers, the majority of the total annual flow of the Rio Grande and the Conejos occurs within a two-to-three month window during the spring and early summer as the headwaters snowpack melts. Because the bulk of the flow occurs during these peak months, the winter flows are not normally sufficient to meet the delivery obligation and curtailment through the irrigation season — particularly the early part of the irrigation season when flows are highest — is

TABLE 6. Monthly index flows and irrigation season delivery obligation.

Average from 1926 to 2013.

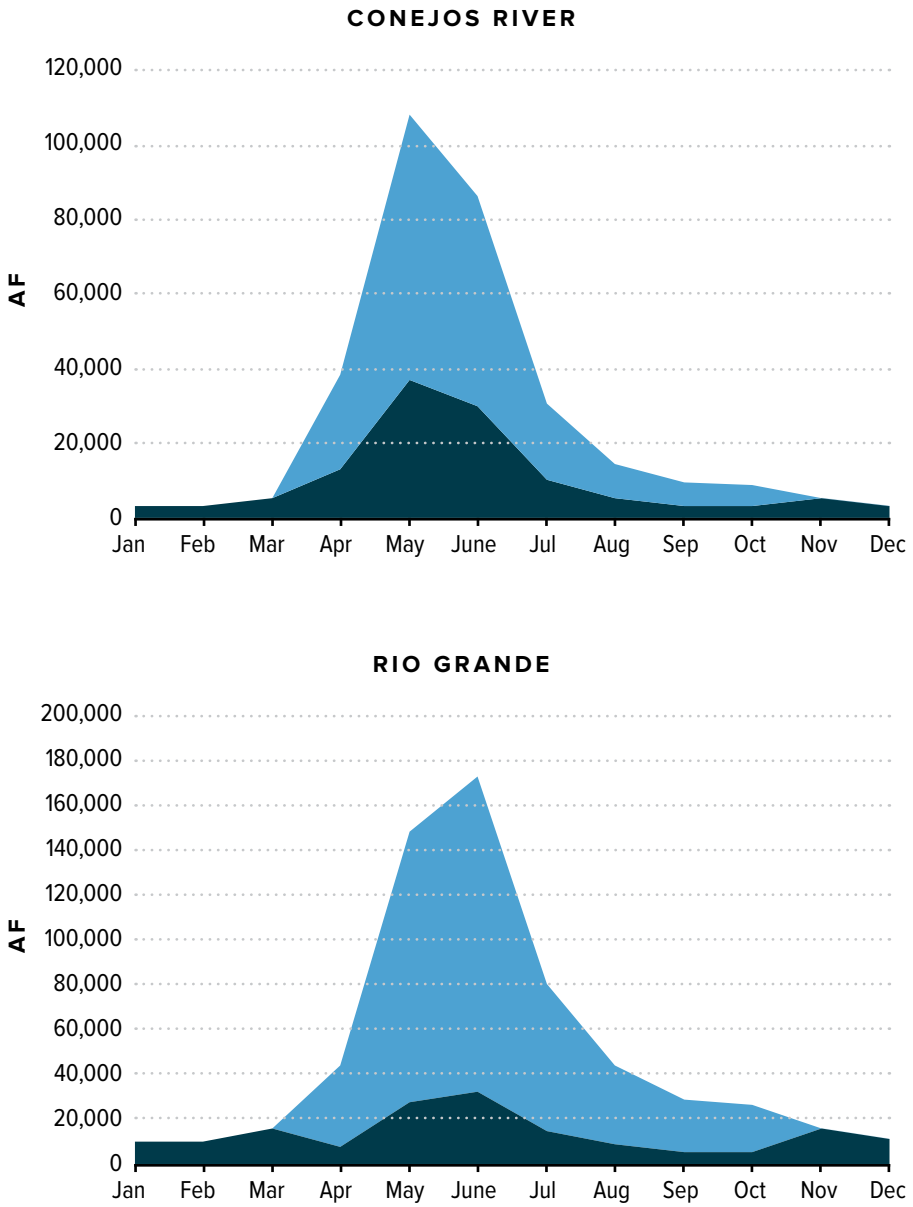
Index Flows	Rio Grande Index	Conejos Index
Jan	10,500	2,900
Feb	10,200	2,900
Mar	15,700	5,000
Apr	43,600	38,100
May	148,800	107,900
Jun	173,000	86,400
Jul	80,400	30,700
Aug	44,600	14,500
Sep	29,100	9,600
Oct	27,000	9,100
Nov	15,400	5,600
Dec	11,500	3,100
Winter (Nov through Mar)	63,300	19,500
Irrigation Season (Apr through Oct)	546,500	296,300
Total	**609,800**	**315,800**
Delivery Obligations	Rio Grande Delivery Obligation	Conejos Delivery Obligation
Delivery Obligation	165,900	121,000
Delivery Obligation as Percent of Annual Index Flow	27%	38%
Delivery Obligation during Irrigation Season (assuming 100% curtailment Nov through Mar)	102,600	101,500
Irrigation Season Curtailment (irrigation delivery obligation divided by irrigation season index)	19%	34%

the reality for Basin water users. The average monthly index flows for 1926 to 2013, the winter flows and irrigation season flows; it also shows the curtailment based on long-term averages, prior to considering return flows and other gains below the index gage are shown in Table 6. An illustration of the average monthly amount of curtailed water and water available for Colorado users based on a constant curtailment throughout the irrigation season and accurate runoff forecasting is shown in Figure 31. Actual curtailment varies based on the hydrologic conditions of each year and generally changes throughout the irrigation season due to errors in the projected index flow compared to the actual index flow.

FIGURE 31.

Monthly average index flows, Colorado use, and curtailment for Conejos River and Rio Grande.

1926-2013. Assumes constant curtailment during irrigation season and 100% curtailment November through March.

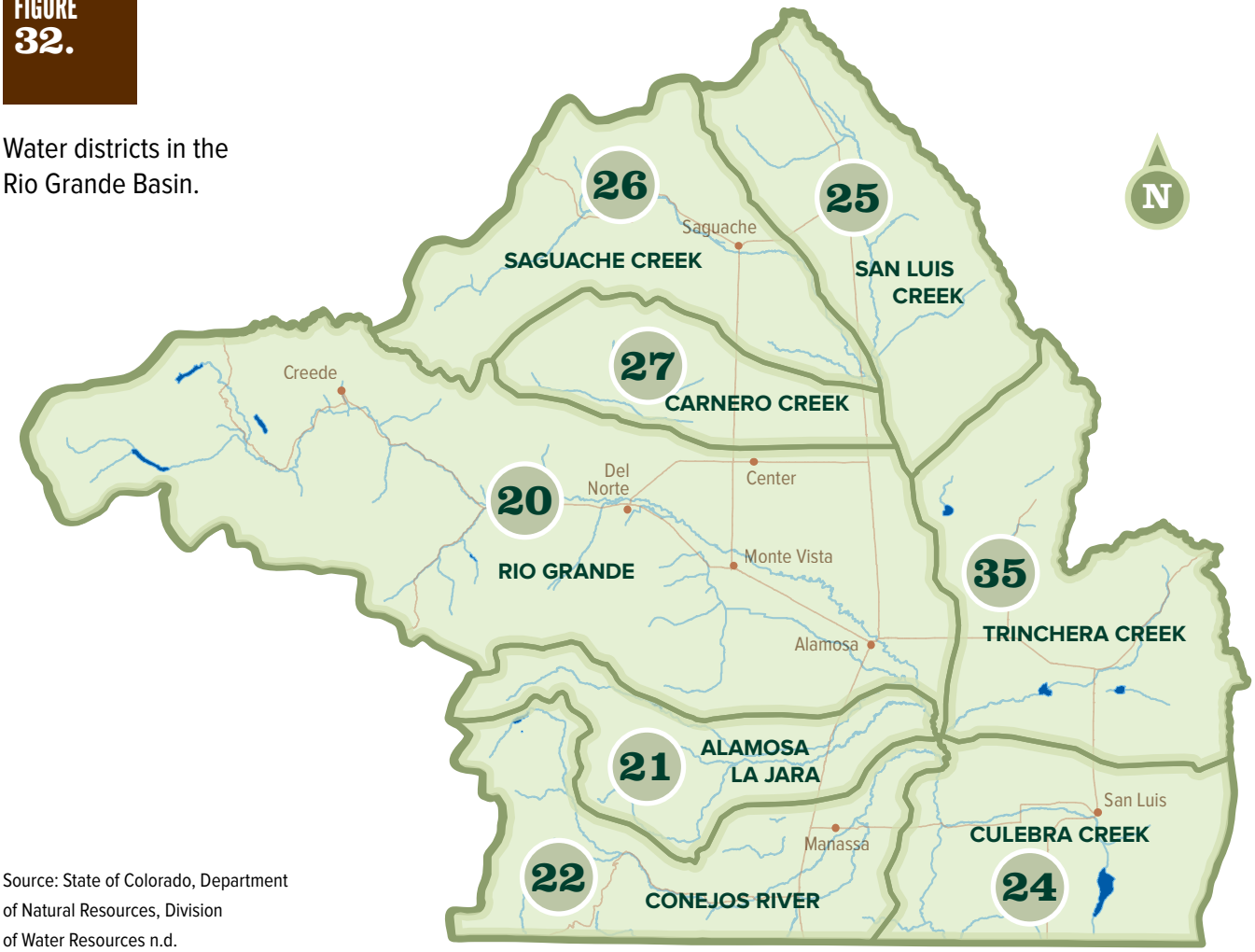


The method used to compute the curtailment has been effective in making the Compact deliveries to New Mexico for nearly 30 years. Although effective, it is not without its challenges. For example, Vandiver (1999) explains that thunderstorms and rainfall in the later part of the summer can make meeting the Compact obligation quite difficult. These late-season flows, often unpredictable and lasting for a matter of days, increase the index flow and the associated delivery obligation, but in the late summer, the peak runoff has already occurred and there may not be other large-flow events to meet the delivery obligation. As is shown in the Compact delivery in Figure 28, Figure 29 and Figure 30, once the index flow exceeds 900,000 AF on the Rio Grande and 550,000 AF on the Conejos, 100% of any additional flow must be bypassed. Therefore, late-season increases to the index can result in very high curtailment amounts approaching 90%.

Confluence of the Rio Grande and Conejos River on the Cross Arrow Ranch. Photo: John Fielder

FIGURE 32.

Water districts in the Rio Grande Basin.



Source: State of Colorado, Department of Natural Resources, Division of Water Resources n.d.

2.5.3 : Surface Water Administration

The Rio Grande Basin is subdivided into eight water districts that generally correspond to major watersheds within the Basin. Figure 32 shows the water district boundaries and names.

Each water district has a water commissioner that is responsible for the day-to-day administration of water rights, although a single water commissioner is currently assigned to Districts 25, 26 and 27. In addition to administering water rights, water commissioners for District 20 (Rio Grande main stem) and District 22 (Conejos River) must also administer the Compact curtailment as computed for each day by the Division 3 Engineer staff.

Water districts 25, 26 and 27 drain into the Closed Basin and have no natural surface water outlet to the Rio Grande. Therefore, water rights within these districts are independent of water rights on the Rio Grande. Most of the creeks within these water districts are ephemeral streams that

bring snowmelt from the mountains surrounding the San Luis Valley to the Valley floor. At the edges of the Valley, much of the water from these streams infiltrates into the ground, recharging both the confined and unconfined aquifers. Many of these creeks will carry flow beyond the edges of the Valley towards the interior during the runoff, but are dry in the later part of the year or are fed only by return flows from nearby irrigation.

The method of water administration does not change year to year. During wet years, more junior water rights receive water, whereas in dry years, many junior water rights receive water for only a short period of time or no water at all. The Rio Grande and Conejos stream systems are over-appropriated, meaning that there are more water rights filed than there is water to fill the rights. Vandiver (1999) illustrates this point by tabulating the amount of new water rights adjudicated by decade in the Rio Grande and Conejos, reproduced here as Table 7. The peak flow of the Rio Grande at Del Norte averages about 5,400 cfs, and the peak flow on the Conejos averages about 2,000 cfs. The adjudication year shown in Table 7 is that year where the priority of water rights was confirmed through court decrees. This table shows that by 1890, adjudicated water rights exceeded the average peak flow in the Conejos, and by the late 1890s and early 1900s, the adjudicated water rights exceeded the average peak flow on the Rio Grande. In essence, water rights with priority dates junior to the early 1900s would not expect to receive water except in above-average flow years.

TABLE 7.

Adjudicated water rights by year.

Rio Grande			Conejos and Tributaries		
Adjudication Year	Adjudicated Rights (cfs)	Cumulative Adjudicated Rights (cfs)	Adjudication Year	Adjudicated Rights (cfs)	Cumulative Adjudicated Rights (cfs)
1896	3,209	3,209	1883	1,459	1,459
1903	2,501	5,710	1890	1,312	2,771
1916	678	6,388	1914	502	3,273
1934	353	6,741	1915 to 1999	375	3,648
1959	765	7,506	Cumulative including instream flow rights: 4,104 cfs		
1960 to 1999	140	7,646			
Cumulative including instream flow rights: 9,139 cfs					

Source: Vandiver 1999

Water Districts 20 (Rio Grande) and 22 (Conejos) have the largest water users because these are the two largest streams in the Basin. There are several hundred water rights in each basin, with a single ditch often holding multiple water rights that were obtained as the ditch was enlarged. In the Rio Grande Basin, there are six large canals, referred to as the Big 6, with combined water rights of over 4,300 cfs: Rio Grande Canal (1,699 cfs), Farmer's Union Canal (841 cfs), Prairie Ditch (367 cfs), San Luis

Valley Canal (575 cfs), Monte Vista Canal (340 cfs) and Empire Canal (512 cfs). Together, these ditches divert approximately 385,000 AFY.

During the irrigation season, water is delivered to ditches as they are in priority and water is bypassed when there is a curtailment. If sufficient water has been delivered to the State Line, the Division Engineer may set the curtailment to zero. When the curtailment is zero, ditches are able to divert the entire flow of the river, resulting in dry-up points along the river. Historically, these dry-up points have occurred on the Rio Grande below the Chicago Ditch, the Excelsior Ditch. On the Conejos, dry-ups occur below Highway 285. Downstream of the dry-up points, return flows, tributary inflows or other groundwater gains discharge to the river, and this flow either passes through to the state line or is diverted by another ditch downstream.

Rio Grande, Continental, Santa Maria, Beaver Park, Lake Humphreys and Road Canyon #1 reservoirs are pre-compact reservoirs located upstream of the Del Norte index gage. As pre-compact reservoirs, they are able to store water regardless of whether Article VII of the Compact is in effect. Article VII of the Compact restricts the ability to store water when storage levels in Elephant Butte and Caballo reservoirs in New Mexico are below 400,000 AF. This restriction is detailed in Article VII of the Compact. Additionally, any water carried over in these reservoirs is not counted in the index flow. However, these reservoirs all have relatively junior priorities compared with the direct flow water rights in the San Luis Valley. Because of this, these reservoirs are rarely in priority to store water during the irrigation season except in high flow years. The reservoirs store water primarily in the winter months, with storage normally beginning on November 1 and continuing until the onset of the irrigation season the following spring. Several ditch systems have direct flow decrees that allow these ditches to store direct flow water in Rio Grande, Continental and Santa Maria under certain conditions. This allows water users to store water that would be available to them in priority at their headgate at times when the supply exceeds the demand, which allows for more efficient use of the water at later times during the year, by better aligning crop demands with water supply.

In the Conejos Basin, the most significant reservoir is Platoro Reservoir, located on the Conejos main stem. The reservoir has a capacity of 59,570 AF. Unlike the Rio Grande headwaters reservoirs, Platoro is a post-compact reservoir and cannot carry over water when Article VII of the Compact is in effect. Although Platoro was constructed by the U.S. Bureau of Reclamation, the Conejos Water Conservancy District (CWCD) is the operator. Water users within the CWCD have the right to receive allocations of Platoro water when available. The CWCD obtained a water court decree to store, under certain conditions, direct flow water rights in Platoro Reservoir for the benefit of those water rights holders.

Platoro Reservoir in the Conejos Basin. Photo: Richard Stenzel

2.5.4 : Groundwater Administration

Groundwater use and administration is a long-standing issue and currently provides some of the most significant challenges for the Rio Grande Basin. The primary use of groundwater in the Basin is for irrigation. In 1998, an estimated 628,000 AF was pumped for irrigation, while less than 10,000 AF was pumped for domestic and municipal use. Metered pumping in Groundwater Management Subdistrict No. 1 (about half the irrigated acreage of the Basin) has averaged 286,000 AF since it was first measured in 2010. Modeling under the Rio Grande Decision Support System (RGDSS) suggests that groundwater withdrawals result in minor depletions to certain surface streams that are hydraulically connected to the aquifer. The hydraulic connections between the surface streams and the unconfined and confined aquifers in the Rio Grande Basin are a matter of some dispute and uncertainty. A long history of groundwater use, changes in water administration and water law, and use of computer models to simulate the aquifer have all combined to bring groundwater administration to its current state. Additional discussion of the history of groundwater use and administration is presented in Section 2.4.3

Due in part to concerns over streamflow depletions from pumping and the less than projected performance of the Closed Basin Project, Senate Bill 04-222 was passed in 2004, requiring that well depletions be replaced and that the aquifers remain at a sustainable level of use. Sustainability was described in the 2004 Senate Bill 222 (SB-04-222):

> "Use of the confined and unconfined aquifers shall be regulated so as to maintain a sustainable water supply in each aquifer system, with due regard for the daily, seasonal, and long-term demand for underground water."

The sustainability of the aquifer was defined for the confined aquifer as pressures observed in the aquifer between 1978 and 2000. For the unconfined aquifer, sustainable was defined as maintaining aquifer storage in the range that was seen between 1978 and 2000. Figure 24, Figure 25 and Figure 26 in Section 2.4.3 illustrate the challenges of achieving sustainability, given that the unconfined aquifer has approximately 1,200,000 AF less than in 1976 and that artesian pressure in the confining aquifer has been falling throughout the basin.

Many water users and managers believe that meeting stream depletions caused by pumping will be relatively simple compared to maintaining the sustainability of aquifer levels. Aquifer levels will increase only when inflows to the aquifer exceed withdrawals. The sources of inflow to the aquifers are limited to the natural recharge that occurs on the perimeter of the San Luis Valley near the mountain fronts (including infiltration of ephemeral streams) and water that seeps into the aquifer from irrigation return flows and canal leakage.

On June 30, 2004, the State Engineer adopted Rules and Regulations developed in accordance with SB 98-1011 and SB 04-222. The ruling in Case No. 04CW24 confirmed these rules and put them into effect as of November 9, 2006. These rules remain in effect as of the date of this Water Plan. The moratorium on new groundwater appropriations (see Section 2.4.3) is still in place for the unconfined aquifer and alluvial wells while the State Engineer develops new groundwater use rules for the rest of the Basin. The moratorium was not applied to exempt uses, such as defined domestic use wells, and allowed for replacement of existing wells. Currently, supplemental and alternate points of diversion of existing groundwater rights can only be granted with court approval.

Currently, draft rules and regulations pertaining to the unconfined aquifer have been circulated to water users that provide that all wells must replace injurious depletions and maintain aquifer sustainability. The confined aquifer rules and the most recent draft rules for the unconfined aquifer state:

> "In adopting these rules, the State Engineer has been guided by the recognition that the Rio Grande Basin is a separate entity, that aquifers are geologic entities and that different aquifers possess different hydraulic characteristics even though such aquifers underlie the same river in the same water division, that there exists a shallow unconfined aquifer and a Confined Aquifer System underlying portions of Water Division 3, that rules applicable to one type of aquifer need not apply to another type, and that the hydrology and geology of the shallow

> unconfined aquifer and the Confined Aquifer System and their relationship to surface streams in Water Division 3 are unique and among the most complex in the state.
>
> In adopting these rules, the State Engineer has considered the particular qualities and conditions of the unconfined aquifer and the Confined Aquifer System and has considered the relative priorities and quantities of all water rights and the anticipated times of year when demands will be made by the owners of such rights for waters to supply the same. The State Engineer has also considered Colorado's obligations under the Rio Grande Compact and the manner of administration of water rights necessary for Colorado to comply with its obligations under the Rio Grande Compact." (San Luis Valley Advisory Committee 2014)

SB 04-222 also provided that wells that were included in a groundwater management subdistrict with an approved plan would not be curtailed. Provisions of SB 04-222 were integrated into Rules and Regulations under SB 98-1011. In response, water users have formed several groundwater management subdistricts (subdistricts) in the Basin. The largest subdistrict is Subdistrict No. 1, which encompasses the majority of irrigated lands in Closed Basin, except for lands in the Saguache Creek and San Luis Creek drainages in the northern area of the Closed Basin. Subdistrict No. 1 has used the RGDSS groundwater model to compute stream depletions due to pumping in the Closed Basin. Based on these results, the Subdistrict contracts for replacement water from a number of water sources and delivers this replacement water to the Rio Grande daily, making it available to in-priority senior water users and for Compact deliveries.

Subdistrict No. 1 has a court-approved Plan for Water Management and has developed an annual replacement plan that outlines how the Subdistrict will make replacement water available to the stream in location, time and amount and reduce groundwater withdrawals to bring the aquifer into a sustainable state. Subdistrict No. 1 is able to acquire replacement water through assessments levied on its users. The assessments are based on each individual's amount of pumping and amount of surface water brought into the Closed Basin through a number of canals. Four canals that divert from the Rio Grande and deliver water into the Closed Basin have recharge decrees that allow its shareholders to claim an amount of recharge water based on a the number of shares owned in each ditch (Rio Grande Canal, Farmer's Union Canal, San Luis Canal and Prairie Ditch). Well users are not assessed for water they have rights to under the recharge decrees. However, pumping in excess of recharge credits is assessed at a variable rate that is set each year in anticipation of the amount of replacement water needed and the cost to obtain such replacement water. In addition to generating revenue to pay for replacement water, another intent of this "pay to pump" concept is to

use market forces to reduce groundwater pumping in the Closed Basin and thereby help the aquifer recover to sustainable levels.

As of the date of this Water Plan, no other proposed subdistricts have an approved plan for water management or an annual replacement plan. The Division of Water Resources is still in the process of calibrating the RGDSS groundwater model for other regions covered by the other subdistricts, known as *response areas*. Preliminary results released by the State Engineer indicate that the replacement requirements to streams in the Basin are generally higher for regions in the Basin outside of the Closed Basin.

A recent letter from the State Engineer dated May 2, 2014 indicates that replacement water required for the various response areas is between near zero to more than 13,000 AFY, depending on response area. The different response areas are shown in Figure 33. The replacement amounts are an accumulation of lagged impacts to the surface water system from past ground water withdrawals. Basin-wide, the stream impacts are less than ground water withdrawal volumes, but will be variable, based on future hydrology and intensity of groundwater use. The allocation of this replacement requirement will likely fall heavier on those groundwater users without offsetting surface water recharge credits, but, as of the date of this Water Plan, the allocation is unknown and the subject of debate. The average annual groundwater withdrawals associated with the stream impacts presented in the May 2, 2014 letter indicate that impacts are highly variable from year-to-year and depend on the hydrology at the time of groundwater withdrawals, hydrology after groundwater withdrawals, the aquifer conditions at the time of groundwater withdrawals and changing conditions after groundwater withdrawals. The impacts presented by the State Engineer present a wide range over a 10-year time frame and show groundwater withdrawal impacts can be near zero percent, and upwards of 35% of net ground water consumptive use for a particular year depending on the previous years' groundwater withdrawals and hydrologic and aquifer conditions. Due to the relatively shallow water table especially in riparian areas, additional groundwater withdrawals do not necessarily induce an equal increase in stream impacts because the water would have been intercepted by native vegetation instead of discharging to the stream.

It is also important to note from the May 2, 2014 letter that groundwater withdrawals in many of the response areas impact multiple surface water streams. Groundwater withdrawals from the confined aquifer, including municipal wells, will generate impacts on stream reaches quite distant from the groundwater withdrawal locations, and may prove challenging to deliver replacement water to these locations from an operational and financial standpoint. This concern is discussed in more detail in Section 4.3.1.3.

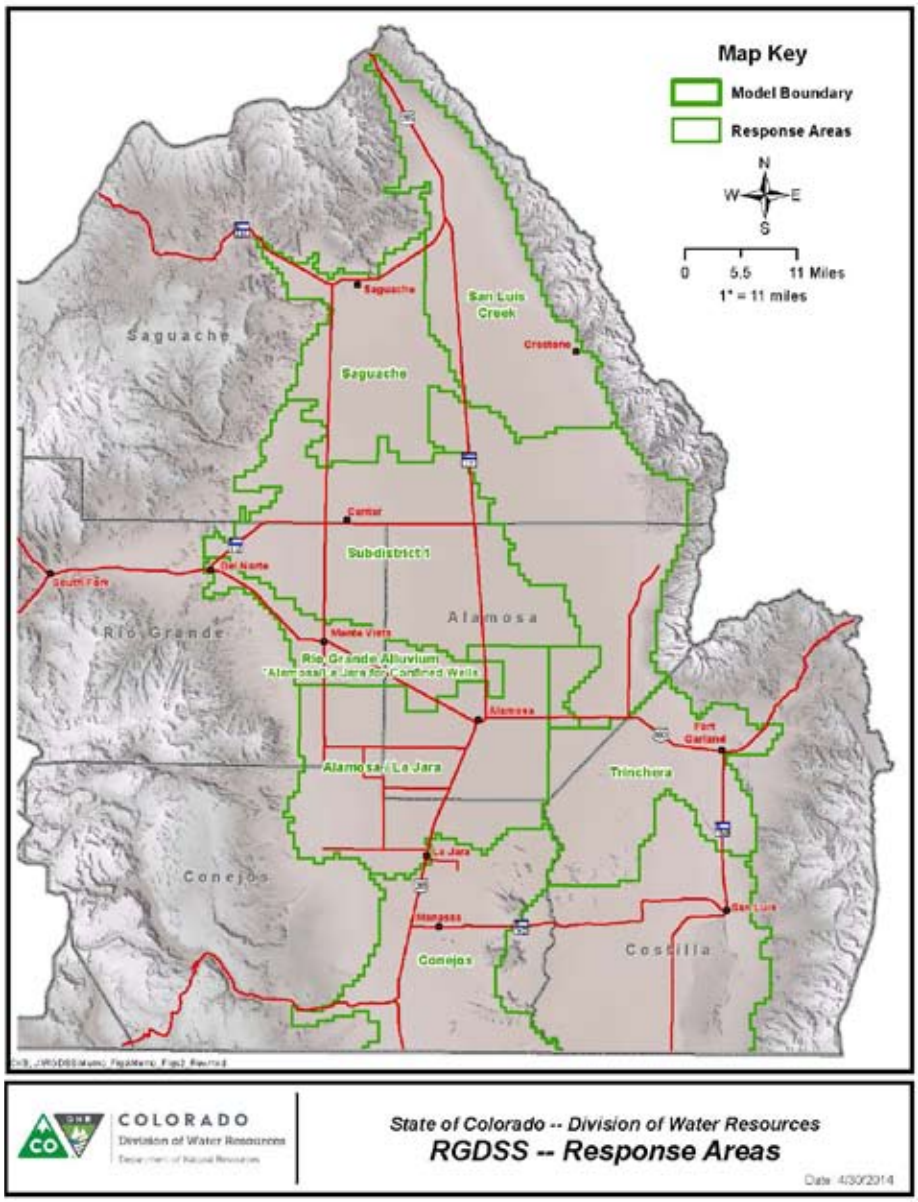


FIGURE 33.

RGDSS response areas.

2.5.5 : Administration in Other Areas in the Basin

The smaller tributaries in the Rio Grande Basin, including Trinchera Creek, Costilla Creek, Alamosa River and La Jara Creek, do not reliably reach the Rio Grande and are not subject to the Compact restrictions. During times when there is sufficient water to satisfy all water rights on a tributary, excess water must be delivered to the Rio Grande to help meet Compact obligations and cannot be appropriated as in a "free river" condition that other parts of the State experience.

San Luis Creek and Saguache Creeks drain into the Closed Basin and have no natural surface water outlet to the Rio Grande; they are therefore not subject to the Compact limitations. These creeks are administered by the

prior appropriation system, and water from these creeks recharges the unconfined and confined aquifers in the Closed Basin.

Trinchera Basin:

The Trinchera Basin includes Trinchera Creek and two primary tributaries, Sangre de Cristo Creek and Ute Creek. There are two primary reservoirs in the basin: Mountain Home Reservoir and Smith Reservoir, both of which are operated by the Trinchera Irrigation Company. Trinchera Creek rises above Mountain Home Reservoir and effectively ends at the reservoir. The historical Trinchera stream channel below Mountain Home Reservoir has since been farmed over and no longer exists between Mountain Home and Smith reservoirs. Trinchera Creek begins again below Smith Reservoir and flows towards the Rio Grande. Flows into the Rio Grande from Trinchera Creek are unreliable and during the recent drought years has not contributed to the Rio Grande flows.

The two major water users in the Trinchera basin are the Trinchera Ranch and the Trinchera Irrigation Company. The Trinchera Ranch has water rights on Ute Creek and Trinchera Creek above Mountain Home Reservoir. Once on the Valley floor, Trinchera Irrigation Company delivers water from Mountain Home Reservoir to irrigated lands near Fort Garland. The Trinchera Irrigation Company also releases water from Smith Reservoir to water rights holders below the reservoir and exchanges water to Mountain Home Reservoir. Irrigators in the Trinchera Irrigation Company use surface water supplies first, then supplement

Trinchera Ranch and Blanca Massif. Photo: John Fielder

with groundwater. Groundwater can be delivered to approximately 50% of the Trinchera Irrigation Company lands. Lower in the Basin, there are approximately 36 quarter-sections irrigated with sprinklers that use groundwater only as a supply.

The Trinchera Basin includes the Sand Creek Drainage which flows through the Great Sand Dunes National Park. This drainage is self-regulating, with a small number of water rights on the Medano Ranch. The National Park Service is in the process of acquiring Medano Ranch and its associated water rights. The National Park Service is evaluating the use of the water rights and may convert them to minimum streamflow right or simply abandon the water rights.

One of the challenges facing the Trinchera Basin is the recent development of greenhouses in the region, perhaps growing marijuana under Colorado's recent Amendment 64. Many of the parcels where greenhouses are located either do not have a well permit or have one for in-house use only, which explicitly prohibits greenhouses. Local water officials will require guidance on how to regulate and enforce water laws with these new water users.

Costilla Basin:

Similarly to other tributaries, Costilla Creek is not under the Rio Grande Compact limitations because water does not reliably reach the Rio Grande. However, Costilla Creek flows into New Mexico and back into Colorado. New Mexico and Colorado entered into the Costilla Creek Compact in 1944, but the Compact was amended in 1964. The Compact is overseen by a commission, composed of Colorado's and New Mexico's state engineers. This Compact requires that Colorado receive 36.5% of the water from Costilla Creek and New Mexico receive 63.5%. A natural flow diversion of 1,000 AF may be stored in Eastdale Reservoir No. 1 in Colorado. In order to assure the most efficient utilization of the available water supply, Eastdale Reservoir No. 1 shall be filled from Costilla Creek as early in the spring as possible. Operation of the Eastdale Reservoir and use of water in wet years have both been controversial.

2.6 : Environmental and Recreational Resources

2.6.1 : Introduction

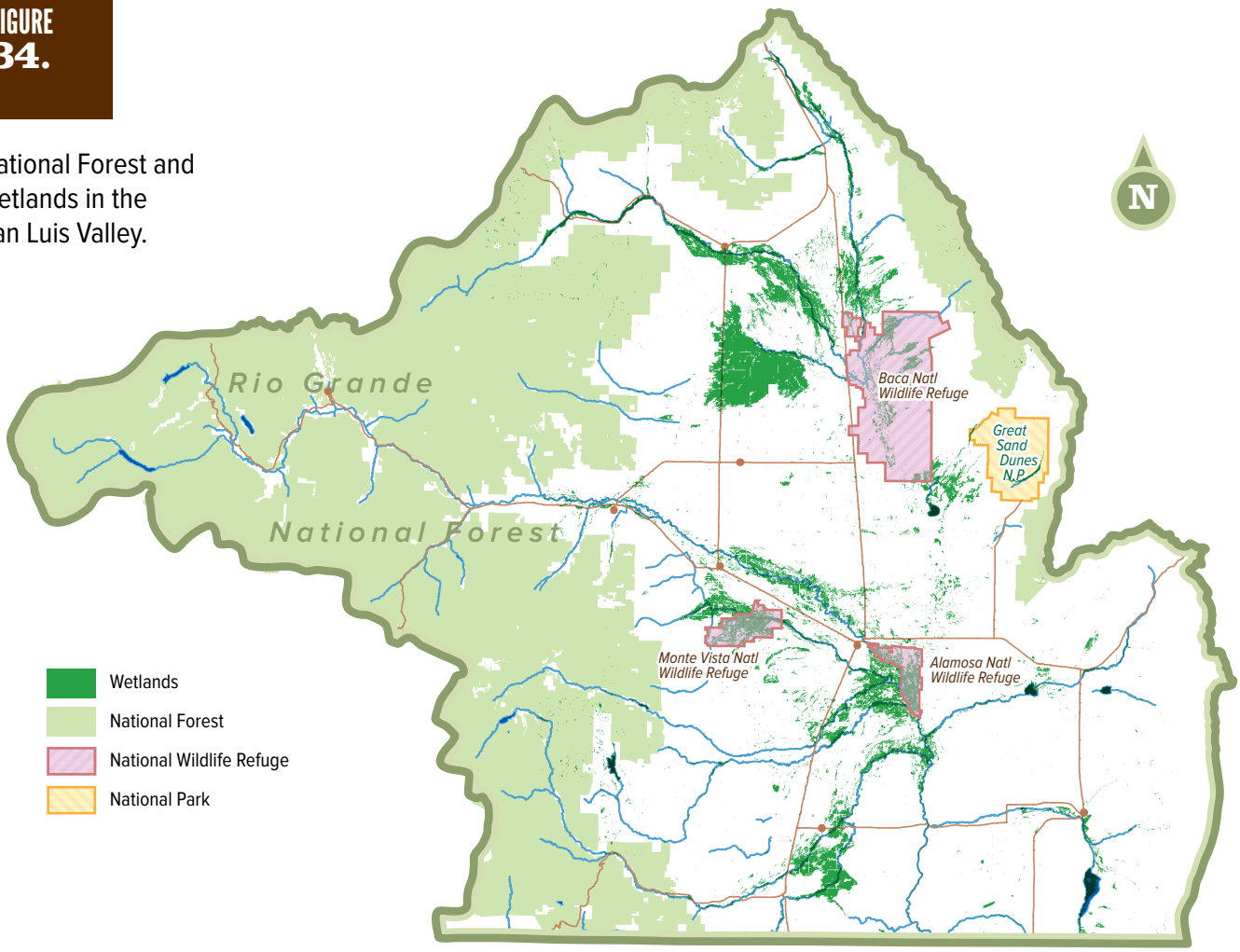
Flanked by the jagged 14,000-foot summits of the Sangre de Cristo Mountains to the east and the San Juan mountains to the west, the SLV and Rio Grande Basin encompass the headwaters of the Rio Grande and its largest tributary in Colorado, the Conejos River. In addition, many smaller tributary streams and a vast underground aquifer system support working farms and ranches, critical wildlife habitat and a wide array of unique recreational opportunities. The Basin presents a remarkable opportunity for continued and expanded partnerships among private, local, state and federal interests to conserve the unique ecological and cultural components of this working landscape.

2.6.2 : Key Environmental Attributes

The SLV includes extensive wetlands and riparian habitats that support at least 13 threatened and endangered species and over 160 species of birds, including greater sandhill cranes and the endangered southwestern willow flycatcher. Working farms and ranches support a rural lifestyle and provide food, livestock and habitat. The Basin is home to a national park, three national wildlife refuges, three wilderness areas and a ski area in the Rio Grande National Forest and other extensive state and federal public land holdings that likewise provide important wildlife habitat and recreational opportunities. A healthy watershed and the Valley's critical underground aquifers are all crucial to sustaining biodiversity, wetland and riparian ecosystems, and a diversity of recreational opportunities that are inherently important to sustaining a vibrant and resilient local economy.

FIGURE 34.

National Forest and wetlands in the San Luis Valley.



Great Sand Dunes National Park. Photo: Rio de la Vista

2.6.3 : Watershed Health

The Rio Grande National Forest (RGNF), located in south central Colorado, is named after the Rio Grande whose headwaters arise in the San Juan mountains west of Creede. Portions of the Sangre de Cristo and the San Juan mountain ranges are located within the RGNF, which surrounds the San Luis Valley.

The RGNF was officially created on July 1, 1908 by President Theodore Roosevelt in Executive Order Number 887. It was formed by combining 1,102,798 acres from the existing San Juan National Forest and 159,360 acres from the existing Cochetopa National Forest, for a total of 1,262,158 acres (U.S. Department of Agriculture, Forest Service, Rio Grande National Forest n.d.). In 1944, the west side of the Sangre de Cristo range and the Saguache Creek area were added, while the Mount Blanca area was added in 1954 (U.S. Department of Agriculture, Forest Service, Rio Grande National Forest n.d.).. The RGNF now totals 1.84 million acres, which makes up 38% of the total Rio Grande Basin land area.

West Fork Complex Fire with the Rio Grande in the background. Photo: Erich Schlegel

Because the RGNF comprises the headwaters of the Basin, impacts to the forest directly affect downstream users. Currently, the condition of the RGNF is being adversely affected by a variety of factors including spruce bark beetles, fire, and climate change.

The RGNF is undergoing a major transformation in the high elevation forests as millions of trees are succumbing to the spruce bark beetle. The native spruce bark beetle primarily attacks mature Engelmann spruce, although infestations in blue spruce also occur. Spruce bark beetles have infested more than 480,000 acres and 85% of spruce-fir forests in the RGNF since 2005 and the beetles are continuing to spread. These large stands of dead forests have lower rates of interception and infiltration than living forests, which leads to faster snowmelt and earlier runoff, directly impacting downstream water users and the aquatic ecosystem. Additional concerns include threats to infrastructure and human safety from falling beetle-killed trees and the loss of usable biomass from the forest due to insect infestation and subsequent rotten trees.

Tent Caterpillar infestations are also spreading throughout the RGNF. These insects feed on the leaves of aspen trees and other broad-leafed plants. When populations are large enough, entire stands of aspen trees may be defoliated. As long as the aspen have sugar reserves in their root systems, the trees will sprout new leaves following defoliation. Individual and clones of aspen trees may begin to die after several years of repeated defoliation as sugar reserves are depleted or from other insects and diseases attacking the weakened trees. In most cases of large caterpillar outbreaks, a virus eventually infests the caterpillar and the populations collapse. Timing of when that will occur is difficult to predict. There is local concern by Basin stakeholders that infestations of tent caterpillars in the Million and West Fork Complex Fire burned areas may harm and possibly reduce already fragile populations of regenerating aspen.

Wildfires in the West are increasing in size and frequency. With historical fire suppression, reduced timber harvesting, and a chronic insect outbreak killing trees and producing an unprecedented amount of standing dead fuels, fires are burning more intensely and causing more severe impacts than historically experienced. Larger and more severe fires have a greater impact on public health and fish and wildlife; the trend is expected to continue and worsen.

In June 2013, several lightning strikes on San Juan National Forest and RGNF lands ignited three wildfire events identified as the "West Fork Complex Fire." By the time the West Fork Complex Fire was contained, it was estimated to have claimed approximately 109,500 total acres with roughly 88,000 acres occurring on the RGNF. The fire was fueled primarily by the vast acreages of beetle-killed spruce trees, and its intensity was influenced by hot and dry winds, low humidity, a lack of precipitation, steep drainages and minimal road access due to both roadless areas as well as the Weminuche Wilderness Area. These extreme fire conditions ultimately resulted in severe wildfire behavior with as much as 60% to

70% of the watersheds within the West Fork Complex Fire perimeter "moderately" to "severely" burned.

This level of burn severity resulted in subsequent impacts on downstream and downslope environments through episodes of flooding and debris flow. In addition, the Rio Grande watershed, including those tributaries affected by the fire, may sustain high volumes of ash, debris and sediment moving into the streams and rivers causing a significant degradation in water quality that could affect river health and wildlife at all levels. As has been documented in other post-wildlife landscapes, wildfires have several direct and immediate impacts upon hydrology and water quality. Wildfire disturbance affects patterns of snow accumulation and ablation by reducing canopy interception, and modifying the surface reflective properties and sunlight radiation balance, which leads to increased snow accumulation, but earlier and more rapid melt. Wildfires also impact physical and chemical processes, including acute loss of vegetation and soil organic matter, decreased soil cohesion, and enhanced soil water repellency. Post-fire watersheds experience diminished water quality from increased erosion and sediment loading. Elevated stream discharge and turbidity downstream from burned areas have the potential to have profoundly negative impacts on downstream aquatic ecosystems and quality of water supplies.

Forests significantly contribute to quality of life in the watershed, but climate change is also adversely affecting this natural resource. A wide range of changes to climate and hydrology at local, regional and global scale are projected in numerous published reports and scientific studies. The Rio Grande Basin is expected to experience warmer temperatures and receive decreased precipitation. Variability in weather is another important factor in climate and water resources management that is projected to increase due to climate change. More frequent extreme weather events such as drought, flood and early runoff are expected.

The effects of climate change, drought, wildfire, and insect and disease epidemics on forest and watershed health are a cause of serious concern. In the aftermath of the West Fork Complex fire and the growing spruce bark beetle epidemic, efforts to address these concerns and improve forest heath and resiliency are of increasing importance to the health of the Rio Grande watershed. The USFS, Colorado State Forest Service (CSFS), Rio Grande Watershed Emergency Action Coordination Team (RWEACT), Colorado Rio Grande Restoration Foundation (CRGRF) and others are working with stakeholders to implement projects in the RGNF to improve watershed health.

In July 2013, in the midst and as a result of the West Fork Complex Fire, RWEACT was formed with the cooperation of over 40 entities to address general concerns regarding public safety and environmental health concerns. RWEACT and the RGNF have partnered to identify priorities and complete post-wildfire hazard mitigation, short-term projects and

long-term forest restoration. For a complete list of projects initiated by RWEACT, see Section 6: Projects and Methods.

The CRGRF has recognized the need to play a significant role in regional efforts to safeguard the Upper Rio Grande watershed as a source of water, habitat and extraordinary natural and cultural resources. As such, the CRGRF is working with stakeholders and partners through RWEACT to complete wildfire restoration and hazard mitigation projects and will initiate future projects to improve watershed health through efforts to reduce the threat of catastrophic wildfire, protect natural resources and infrastructure and improve forest function.

2.6.4 : Riparian Areas

Riparian areas are interfaces between uplands and a river or stream. They are transition areas between aquatic and terrestrial ecosystems that are inherently dynamic over time, frequently flooded for short times, and connected hydrologically to the surrounding areas. Because of this, biological diversity and productivity are high in riparian areas (Naiman et al. 2005; Hubert 2004; Mitsch and Gosselink 1993). Naturally functioning riparian areas significantly affect and improve the health of surrounding lands and the entire ecosystem of the Rio Grande Basin by performing integral hydrologic and chemical functions that act as filters for pollutants, erosion control, flood control and recharge aquifers (Mitsch and Gosselink 1993; Niemuth et al 2004).

Riparian area along the Rio Grande on the conserved Gilmore Ranch west of Alamosa. Photo: Rio de la Vista

Many of the riparian areas in the San Luis Valley are degraded and no longer perform these important ecosystem services. As such, restoring impaired riparian areas would greatly benefit the entire Rio Grande Basin as restoration results in improved water quality, enhanced fish and wildlife habitat, improved groundwater recharge, flood control and sediment transport, protection of private property and socioeconomic values associated with agriculture, tourism and recreation. The health of the Rio Grande watershed, its water quality and its associated riparian areas is not only critical to the reach in Colorado, but also to the downstream stakeholders in New Mexico, Texas and Mexico. If the condition of the Rio Grande and its tributaries is not maintained and enhanced in Colorado, then the efforts of the downstream stakeholders to improve the Rio Grande's condition will have limited success. It is for these reasons the restoration of the Rio Grande and conservation of its riparian areas in Colorado is so important.

2.6.4.1 KEY RIPARIAN AREAS

The Basin contains thousands of miles of rivers, from major tributaries to small streams. This section will detail the condition and current efforts to improve key riparian areas in the basin. This section is by no means a summary of all riparian areas; rather it discusses the largest systems or those that have been the focus of a great amount of reclamation, conservation or riparian improvement projects.

2.6.4.1.1 RIO GRANDE

The headwaters of the main stem of the Rio Grande originate above timberline in the RGNF and Weminuche Wilderness Area. Numerous small tributaries join together from Hinsdale, San Juan and Mineral counties to make up the Rio Grande headwaters, which flow through

Rio Grande near South Fork, CO. Photo: Richard Stenzel.

steep, rocky canyons. The area is home to elk, mule deer, black bear, bighorn sheep, moose, beaver and many other wildlife species. Golden eagles, other raptors and songbirds are prevalent. The river offers premium trout fishing, and the area provides recreational fishing, hunting, hiking, camping and opportunities for solitude. Throughout this reach, the watershed and river corridor of the headwaters occur on public lands, managed for multiple uses by the RGNF. As discussed in Section 2.6.3, the health of the forest impacts the health of the Rio Grande in the Upper Reaches.

As the Rio Grande enters the San Luis Valley at South Fork, the land ownership becomes largely private. The 91-mile stretch of the Rio Grande from South Fork to the Alamosa-Conejos county line was documented in the Rio Grande Headwaters Restoration Project 2001 Study (2001 Study). River conditions including diversion structures, bank conditions, fluvial geomorphology, channel capacity and structures on the banks or in the floodplain were described in detail. This reach also encompasses the Coller State Wildlife Area, Rio Grande State Wildlife Area, Home Lake State Wildlife Area, Higel State Wildlife Area and the Alamosa National Wildlife Refuge.

Land use within the San Luis Valley and the Rio Grande corridor is primarily agricultural on private land, but increasing development is occurring. Ranch lands are under increasing pressure from residential developers. Some of these ranches have obtained conservation easements to protect their land and lifestyle from the encroaching development. Organizations such as The Nature Conservancy and the Rio Grande Headwaters Land Trust have partnered with state and federal agencies to protect important private land habitats through conservation easements. Because of changing land use patterns and outdated floodplain maps, there may be increased potential for flood damage in Alamosa, Monte Vista and other parts of the San Luis Valley. Flows in the reach of the river from South Fork to Alamosa are highly affected by agricultural uses of water. In some cases, diversion structures and/or fences have been installed across the river.

Beginning in South Fork, cottonwoods are the predominant tree along the Rio Grande and provide wildlife habitat as well as aesthetics. Land and livestock management, roads and driveways, houses, and other structures have interrupted the regenerative growth of the cottonwood stands that remain along the river corridor from South Fork to Alamosa. Much of the narrow leaf cottonwood forest is currently of a mature age class. This could be due to declining groundwater levels and grazing of the younger trees. Some regeneration is occurring but, as a whole, the forest is not made up of a diverse range of age classes. Willow stand regeneration throughout the 2001 Study reach are impacted by wildlife and livestock grazing, land clearing and alterations in flow regimes.

Many organizations, including the NRCS, CPW, USFWS Partners for Fish and Wildlife and Rio Grande Headwaters Restoration Project

(RGHRP) have partnered to focus a great amount of resources on riparian restoration and improvement projects in the 2001 Study reach.

The RGHRP was formed to implement the recommendations of a riparian study completed in 2001. In 2004, the Colorado Rio Grande Restoration Foundation was established to serve as the governing body and fiscal agent for the RGHRP. In 2007 the RGHRP completed a Watershed Restoration Strategic Plan for the entire Rio Grande Basin in Colorado. The Strategic Plan highlighted additional restoration priorities and the need for continued efforts to implement the recommendations from the 2001 Study. The RGHRP is working to improve the function of the Rio Grande in Colorado. This means the river will:

- Provide high quality water throughout the Rio Grande in Colorado
- Sustain sufficient flow for sediment transport, native riparian vegetation, aquatic and wildlife habitats and to meet the Rio Grande Compact obligations
- Support the existing agricultural lifestyle
- Contribute to groundwater recharge
- Enhance and sustain aesthetic and recreational values for the residents and visitors to the watershed
- Be connected to the floodplain, oxbows and upland habitat.

Together, the above-mentioned organizations have partnered with landowners to complete riparian restoration, streambank stabilization and irrigation infrastructure improvement projects along the Rio Grande and its tributaries.

The main environmental goals of the riparian stabilization projects are to improve stabilization of the streambanks, improve riparian and fish habitat, enhance the function of floodplains and increase capacity of the river to transport sediment. Benefits of the projects include reduced sediment loading, improved water quality, enhanced and increased fish and wildlife habitat and reduced damage during flood conditions. A typical riparian stabilization project includes bank shaping and installation of streambank stabilization structures. Structures include willow bundles and clump plantings, rock structures, including "J" hooks, weirs, and rock barbs and log structures. These structures move the flows away from the bank, thereby halting lateral movement of the stream channel and reducing sediment loading; this allows for vegetation to become reestablished in the riparian zones. Grazing management and bioengineering enhance the riparian habitat and further stabilize the streambank.

One of the priorities highlighted by the 2001 Study was the need to address aging and poorly functioning diversion dams and headgates. Many of the existing structures are inefficient, hazardous, and impassible by boats, fish and wildlife. The RGHRP and NRCS are working with ditch companies and irrigators to improve and replace poorly functioning

diversion dams and headgates. New structures improve diversion efficiency, include state of the art automated headgates, provide fish passage or barriers (as the location indicates), boat passage (where possible and in collaboration with willing landowners) and enhanced wildlife habitat.

Directly, these projects benefit the participating landowners, local water users and downstream water users. Indirectly, local, state and regional communities benefit from the enhanced water quality, river function, riparian condition, wetlands and habitat. These benefits stem from increased land value, water availability and quality, tourism opportunities and habitat potential.

The lower portion of the 2001 Study area was the reach of the Rio Grande through the Alamosa Nation Wildlife Refuge (ANWR). The ANWR is downstream of Alamosa and is managed by the USFWS. The ANWR extends for about 12 miles along the east side of the river. Several large cattle ranches are located south and west of the ANWR. Along some stretches of the river through the ANWR willow stands are separated from the river by high cut banks. The ANWR is taking steps to improve riparian health and has consulted with USFWS's National Riparian Service Team, members of the RGHRP and other interested parties to determine measures to address these issues.

South of the ANWR, is the Rio Grande Natural Area (RGNA), which was established by the U.S. Congress on October 12, 2006, to conserve, restore and protect the outstanding natural, historical, cultural, wildlife and recreational resources of the area. The RGNA includes the 33-mile stretch of the Rio Grande, one-quarter mile on either side of the river, from the ANWR to the Colorado–New Mexico state border, shown in Figure 35. It encompasses both private and BLM-managed lands along the western banks of the Rio Grande, as well as private lands along the Rio Grande's eastern banks. The RGNA provides habitat for many species of upland,

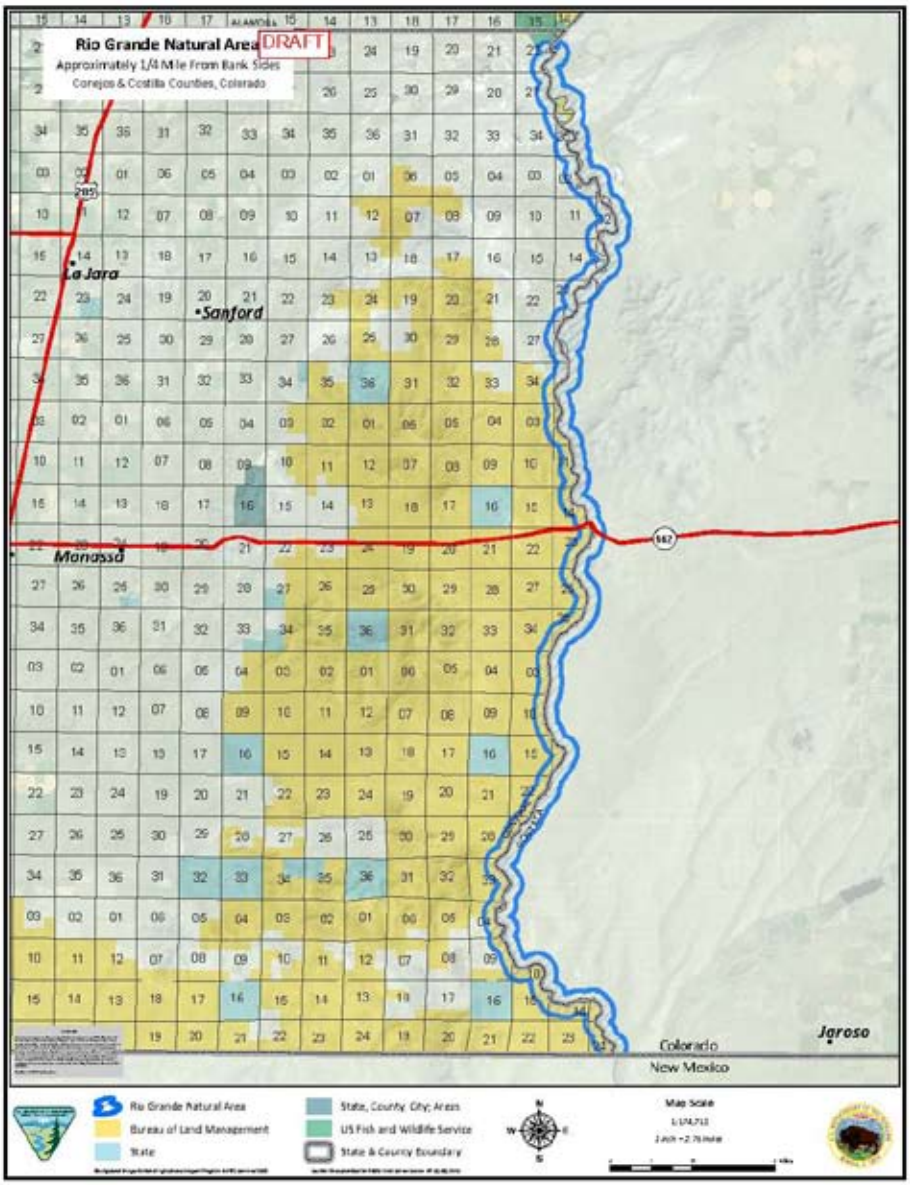
Feral horses in the Rio Grande Natural Area. Photo: Emma Regier

riparian and aquatic species. The area also offers recreation, including wildlife viewing, hiking and floating when river levels are adequate in May and June, fishing opportunities and pull-outs on the BLM-managed land, with beautiful views of the river as it winds through the Dry Fairy and Brownie Hills.

The Rio Grande Natural Area Act established a nine-member Commission to advise the Secretary of the Interior with respect to the Natural Area and to develop a management plan for the non-Federal land within the Natural Area. The RGNA Commission is a BLM Resource Advisory Council (RAC). The Commission has a plan in progress for this area and has identified key issues, which include the need to reduce and manage trespass grazing by feral horses and cattle, enhance riparian health and habitat, protect cultural resources and enhance public recreation

FIGURE 35.

Draft map of the Rio Grande Natural Area.



Source: Simon 2011.

opportunities in the reach. For more information see: http://www.blm.gov/co/st/en/fo/slvfo/rio_grande_natural.html

2.6.4.1.2 WILLOW CREEK

Willow Creek originates near the Continental Divide on the north side of the basin. It flows through Creede and then enters the Rio Grande at an elevation of 8,600-feet. Surface water quality in Willow Creek and a short reach of the Rio Grande downstream of Willow Creek is affected by mine drainage north of Creede. Most of the current heavy metal loading in surface waters originates in water from the historical mining tunnel system rather than from dump material.

Below Creede, Willow Creek was highly braided and unstable due to disturbance and heavy sediment loading from mining operations. The Willow Creek Reclamation Committee (WCRC) and Lower Willow Creek Restoration Company recently completed a restoration project that created a new channel for Willow Creek through the floodplain, navigating around tailings piles. These actions greatly improved riparian function and water quality in the reach. In 2014, re-vegetation and topsoil spreading efforts were ongoing.

The WCRC has a firm commitment to find innovative, practical and non-regulatory approaches to improve the water quality in Willow Creek and to protect the Gold Medal fishery in the Rio Grande downstream.

Willow Creek restoration project.
Photo: Heather Dutton

WCRC has developed a Willow Creek Watershed Plan to identify and subsequently implement projects to improve water quality conditions on Willow Creek and protect the Rio Grande from future water quality impairments. WCRC is actively seeking funding to implement priority projects.

2.6.4.1.3 CONEJOS RIVER

The Conejos River, which originates in the South San Juan Wilderness of the San Juan mountains, is a major tributary to the Rio Grande, with its confluence approximately 20 miles south of Alamosa, at an elevation of 7,500-feet. The Conejos River is subject to many of the same pressures that the Rio Grande is experiencing. It is over-appropriated, with agricultural diversions routinely being curtailed to meet Compact obligations. The lower reaches of the Conejos River flow through private land, which is under development pressure. Land use changes could potentially affect water quality, riparian and aquatic habits.

The Conejos has been the focus of significant riparian restoration, irrigation infrastructure, diversion measurement and habitat improvement projects in recent years. Ditch companies and the Conejos Water Conservancy District (CWCD) have updated aging and poorly functioning diversion dams and headgates. The CWCD has also taken great strides toward automating gates and measuring devices in the Conejos system to improve river and irrigation accounting. The local chapter and Colorado Water Project from Trout Unlimited have partnered with CPW to invest time and funds toward restoring and protecting fisheries on the Conejos through projects to improve vegetation cover and grazing management. The CWCD also has plans to complete riparian restoration projects in the near future.

2.6.4.1.4 ALAMOSA RIVER

The Alamosa River, under normal conditions, is not tributary to the Rio Grande because the water is typically stored and diverted for agricultural purposes. The Alamosa River has areas of significant water quality impairments from both naturally occurring geologic sources and historic mining in the watershed.

Gold and silver mining began at Summitville, situated south of Wightman Fork, a tributary of the Alamosa River about two miles east of the Continental Divide, around 1870. Large-scale, open-pit mining began at the site in 1984. The mine operator, Summitville Consolidated Mining Corp., Inc. (SCMCI), used cyanide heap leaching to extract precious metals from the ore. In this process, ore excavated from the mountain was crushed and placed onto the clay and synthetic-lined heap leach pad (HLP). A sodium cyanide solution was then applied to leach out gold and silver. Almost immediately after its construction in

1986, a leak was detected in the HLP. The leak caused many chemicals of concern, including heavy metals (copper, cadmium, manganese, zinc, lead, nickel, aluminum and iron) on site and in the acid mine drainage to be discharged and contaminate the Alamosa River system below the site. Surface water quality downstream of the mine has been degraded by low pH (acidic) water and by elevated levels of dissolved solids and heavy metals, especially copper.

SCMCI abandoned the site and announced it was filing for bankruptcy in December 1992. The U.S. EPA immediately assumed responsibility of the site as an emergency response. On May 31, 1994, Summitville was placed on the National Priorities List (NPL) of Superfund sites. The U.S. EPA cleanup of the site has involved capping and re-vegetating large piles of mine waste, building large impoundment facilities to catch and reroute runoff and acid drainage into water treatment facilities, and building a new, state of the art water treatment plant that was completed in 2013 (U.S. EPA 2014).

Downstream of Summitville, local citizens' groups have worked to clean up the Alamosa River. The Alamosa Riverkeepers recently partnered with the Terrace Irrigation Company to rebuild the Terrace Reservoir spillway. The spillway was not an adequate size, which resulted in a storage restriction on the reservoir. By building a new spillway, the Terrace Irrigation Company can store more water, some of which will be made available to the Alamosa Riverkeepers for instream flows. This project improved irrigators' storage ability and flexibility, fish and wildlife habitat, water quality and late season flows.

Another group, the Alamosa River Watershed Restoration Foundation (ARWRF) is a non-profit group made up of landowners and area stakeholders, which was established in 2000 for the purpose of restoring the Alamosa River downstream from Terrace Reservoir to a more natural functioning stream. The ARWRF is currently sponsoring restoration work on the remaining 2.8-mile segment of a total of 5 miles of the Alamosa River under restoration since 2004. Project funding comes from an NPS 319 Grant with local in-kind match from landowners and from Natural Resources Damages funds from the Summitville Mine settlement. The ARWRF completed a restoration master plan for the Alamosa River watershed, which guides efforts to improve riparian function in that watershed.

2.6.4.1.5 SAGUACHE CREEK

Saguache Creek is another key waterway that is non-tributary to the Rio Grande. Saguache Creek begins in the La Garita Mountains west of Saguache. It flows through important public grazing allotments on the RGNF and BLM lands before meandering through historic ranchlands nestled in a productive ranching valley. The cottonwood-lined creek and lush meadows are visible to travelers along scenic Highway 114 between

Saguache and Gunnison, which is the longest undeveloped pass in Colorado. The creek supports a wide array of wildlife including wintering bald eagles and provides important habitat for the area's elk, bighorn sheep, pronghorn and mule deer. Saguache Creek flows into the Closed Basin, disappearing underground during low flows.

There are approximately 20,000 acres of private land in the 20-mile long Saguache Creek Valley, surrounded by more than 300,000 acres of public lands. Ranchers in the area work cooperatively to bring livestock to and from high country pasture in the RGNF, a system that has been in place for more than a century. Because of its high conservation value, the Colorado Cattleman's Agricultural Land Trust, NRCS and several partner organizations have partnered with ranchers along Saguache Creek to secure 15 ranchland conservation easements that have protected more than 11,000 acres along Saguache Creek and its tributaries.

2.6.4.1.6 KERBER CREEK

The Kerber Creek watershed is located in northeastern Saguache County, west of Villa Grove. The watershed includes Bonanza, the smallest town in Colorado, which once hosted the Bonanza Mining District, operational from the 1880s to the early 1970s. The legacy of mining in the watershed resulted in contaminated soils, degraded water quality and eroding streambanks. Since 2007, a partnership between the Bonanza Stakeholders Group, NRCS, USFS, BLM, USFWS, Trout Unlimited (TU) and many

Alamosa River. Source: Alamosa River Foundation

other partnering organizations has resulted in 60 acres of contaminated soils reclamation, installation of 250 rock structures, and restoration of 4,000-feet of streambank. This work has been accomplished with over 14,000 hours of volunteer labor and over $2 million in grant funding.

2.6.4.1.7 RIO CULEBRA

The Rio Culebra Watershed is located entirely in Costilla County, which was originally settled as part of Mexico in a large Mexican land grant and later became part of the U.S. in the Treaty of Guadalupe Hidalgo. The watershed is bounded to the east by the peaks of the Southern Sangre de Cristo Mountain Range and to the west by the Rio Grande. Historically, the Rio Culebra was a tributary of the Rio Grande; however, water development by early settlers stopped flows to the Rio Grande in the early 1900s.

The Rio Culebra watershed encompasses approximately 23,000 acres, all of which are privately owned. The majority of the landowners are fifth and sixth generation farmers, descendants of Spanish conquistadors who intermarried with indigenous tribes and citizens of Mexico. These settlers brought with them the acequia irrigation system. Acequias are primarily un-lined, gravity-fed ditches that flood-irrigate each farmers' fields. Acequias are culturally and historically unique and significantly contribute to the identity of the watershed.

Historical land uses in the Culebra watershed, including significant logging in the upper watershed by a large landowner, an extensive network of subdivision roads in sensitive portions of the watershed and a gold mine, have exacerbated issues of sediment load in what is a naturally steep and unstable system and have created concerns about water quality and quantity within the community. The community is working to develop a plan, which will prioritize culturally appropriate solutions to improve natural resource values of the Rio Culebra Watershed.

2.6.5 : Instream Flow Protections

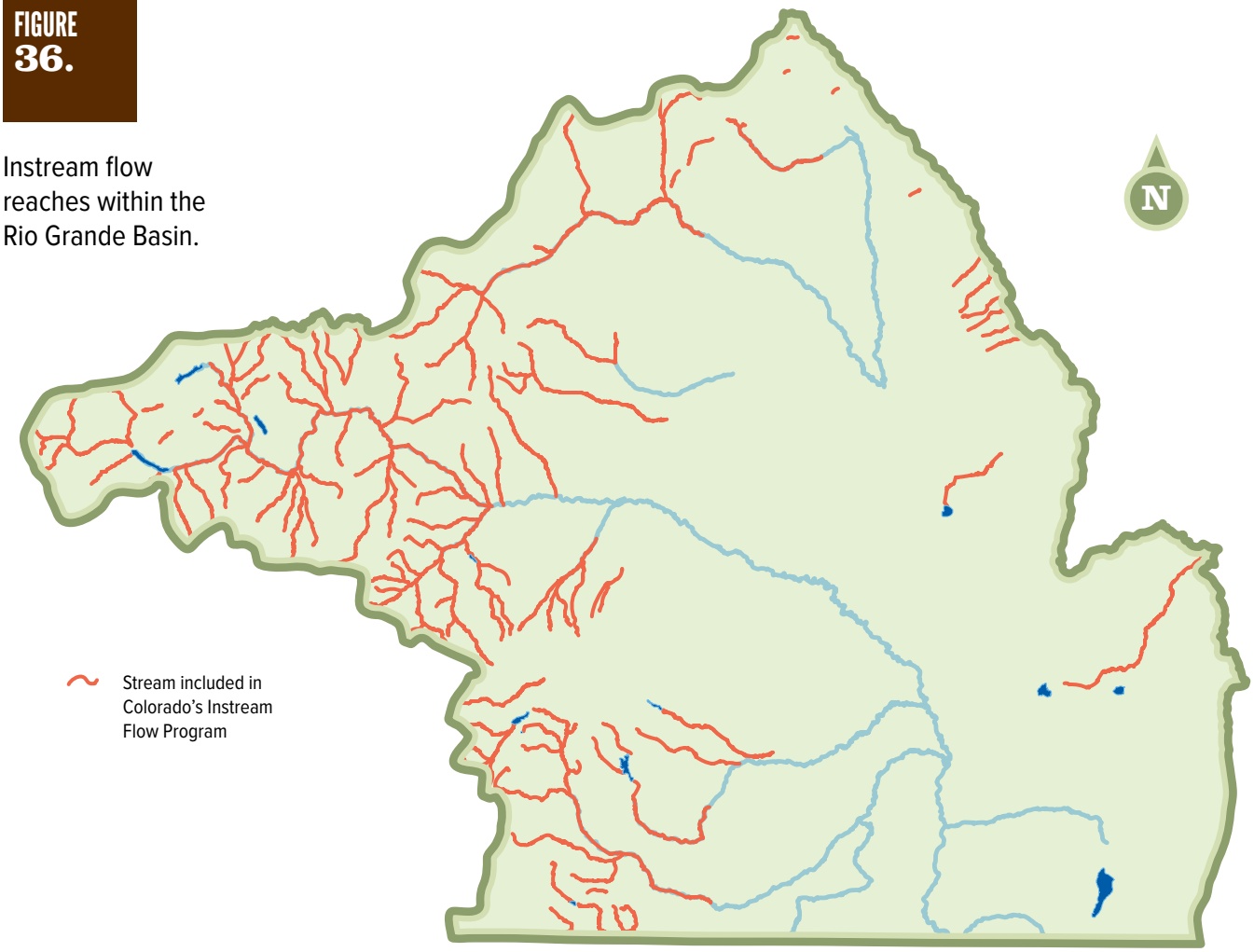
Recognizing the value of environmental habitats and recreational activities as well as the importance of maintaining natural flows for agriculture, the Rio Grande Basin views instream flows as multi-purpose attributes. According to CWCB, instream flows are water rights that are nonconsumptive, in-channel or in-lake uses of water made exclusively by the CWCB for minimum flows between specific points through a reach of stream or levels in natural lakes. Instream flow rights are administered within the State's water right priority system to protect against injury at any point within the instream flow reach and to legally preserve, protect or improve the natural environment to a reasonable degree.

Currently, there are almost 1,000 miles of instream flow protections in the Rio Grande Basin. These occur mainly in the headwaters of the Basin's streams and rivers, including the Rio Grande, Conejos and Alamosa rivers. This is largely due to the successful negotiation of a settlement in 2000 recognizing instream flow rights for the U.S. Forest Service on every major stream in the Rio Grande Basin. Additionally, in 2008, the Colorado water courts recognized a unique groundwater right based on federal law for the Great Sand Dunes National Park (U.S. Department of Justice 2013). The groundwater right requires sustained aquifer levels around the park in order to protect its unique hydrology. The map below details all of the instream flow designations in the Basin.

See Appendix B: Environmental and Recreational Needs for a list of all of the instream protections in the Rio Grande Basin.

FIGURE 36.

Instream flow reaches within the Rio Grande Basin.



2.6.6 : Wetlands

Wetlands are lands that are permanently or seasonally saturated with water such that it takes on the characteristics of a distinct ecosystem. Wetland vegetation has adapted to grow in saturated or hydric soil conditions. Like riparian areas, wetlands are highly productive and support a diversity of plants and animals. Naturally functioning wetlands also provide many ecosystem services, which significantly affect and improve the health of surrounding lands and the entire ecosystem of the Rio Grande Basin. They perform integral hydrologic and chemical functions that act as filters for pollutants, erosion control, flood control and recharge aquifers (Mitsch and Gosselink 1993; Niemuth et al. 2004).

Wetlands in the Rio Grande Basin face many serious challenges. Currently, prolonged drought, changes in agricultural practices and groundwater pumping have caused the general lowering of the water table, decreased water flow in rivers and creeks that historically fed the Rio Grande, promoted a discontinuous river system during multiple times of the year and negatively affected regional hydrology and ecology of wetlands (Cooper and Severn 1992). For example, current groundwater levels have been described as below normal at a monitoring well located on the Alamosa National Wildlife Refuge (USGS groundwater watch website, Site Number: 372550105455001 – NA03701122CC1 ALA 4). As a result, floodplain soils adapted to maintaining high water tables (Hubert 2004) have become dry and no longer act as a buffer to dry climatic conditions. Thus, riparian forest species like cottonwood have become old, even-aged

Frozen wetlands along the Rio Grande, on the conserved Gilmore Ranch, west of Alamosa. Photo: Rio de la Vista

classes with little regeneration, as root systems established during the first couple years of growth can no longer reach lowered water tables or react to large or quick changes in water resources (Shafroth et al. 2000; Andersen 2005).

As water tables have diminished, the ability to move water through the soil decreases and becomes slower due to a lack of capillary action (Millar and Turk 1943). Therefore, re-wetting of the soil takes longer each year, given that soils are dry and must slowly regain their ability to maintain soil moisture throughout the profile. Continued low flows in rivers and creeks, along with declining groundwater resources, prevent water tables from responding quickly to spring snowmelt and precipitation events.

Livestock grazing has occurred throughout the SLV since the late 1800s and primarily includes sheep, cattle and horses. Herbivory within these habitats is natural. However, when improperly managed, livestock tend to spend a majority of time in riparian areas, impacting these areas through grazing and disturbance (Niemuth et al. 2004). Consistent, improper grazing, especially in newly established cottonwood and willow communities, also impacts the diversity and complexity of riparian woodland stands, along with the wildlife communities that depend on them (Shafroth et al. 2000). Poorly managed grazing of grasslands has been shown to increase the distribution and cover of shrub species, such as greasewood (Pannell 1980).

In the past, wetland management strategies did not take into account natural processes or location within the landscape and focused on single-species management, such as waterfowl (Laubhan et al. 2012). Past wetland management tended to stabilize hydrologic regimes, thus removing the dynamic nature of natural wetland functions (Heitmeyer and Aloia 2013). Over a century of alterations and use along the Rio Grande and its tributaries has highly altered the system such that many areas no longer function naturally and may not function at all.

2.6.6.1 WETLAND TYPES

The Rio Grande Basin has several types of wetlands. The most abundant type is freshwater emergent wetlands, comprising 90% of the total wetland acreage. The other five types of wetland make up the remaining 10% as seen in Table 8.

2.6.6.2 MAJOR RIO GRANDE BASIN WETLAND COMPLEXES

As Table 8 details, there are significant wetlands in the Rio Grande Basin. While many of these wetlands are seasonal and connected to agriculture, there are large complexes of perennial wetlands on the Valley floor that are largely owned by CPW, USFWS and BLM. These wetlands provide outstanding habitat value for migrating birds, wetland vegetation

and other dependent species. These wetlands also face pressures as many are tied to aquifers and impacted by lowered groundwater levels. Furthermore, many of these wetlands are actively managed and water is supplied through irrigation wells. As such, these areas will be subject to groundwater rules and regulations and the managing agencies will have to comply with subdistrict rules or obtain augmentation plans. The major, agency-owned wetland complexes in the Rio Grande Basin with their management objectives and other important details are discussed below.

2.6.6.3 COLORADO PARKS AND WILDLIFE MAJOR WETLAND COMPLEXES

Over 300 State Wildlife Areas (SWAs) are owned and managed by CPW across Colorado. In the Rio Grande Basin, there are 27 SWAs (see listings of these in Appendix B: Environmental and Recreational Needs) with nearly all of them dependent on water in some manner to provide either wildlife habitat or wildlife-related recreation. SWAs are held by CPW as fee-title properties, long-term easements or leased properties. They are acquired using funds derived from the sales of hunting and fishing licenses, habitat stamps or from federal excise taxes collected on the sales of sporting arms and ammunition or fishing equipment through the Pittman-Robertson Act and Wallop-Breaux Act, respectively.

TABLE 8.

Wetlands in the Rio Grande Basin by type and acreage.

Wetland Type	Area (acres)	Percentage of Total Wetland Area
Freshwater Emergent Wetland	206,330	90%
Freshwater Forested/Shrub Wetland	6,933	3%
Freshwater Pond	3,700	2%
Lake	6,582	3%
Riverine	3,907	2%
Other	1,314	1%
Total	**228,766**	**100%**

CPW owns a portfolio of surface and ground water rights that are used for "beneficial" decreed use to meet the goals and Colorado Parks and Wildlife Commission policy and statutory mandates for managing wildlife and their habitats and to provide for public recreation on SWAs and/or for complementary habitat needs through cooperative agreements. The Division of Water Resources requires that CPW maintain reliable water sources to augment state wildlife areas, parks and recreation areas in a sustainable manner.

The SWAs that have notable wetland complexes and wetland management programs are detailed below:

- Russell Lakes SWA is a mitigation property for the Closed Basin Project; the BOR owns a majority of the property and wells although CPW owns 500 acres of the most intensively managed area and two of the large capacity wells. Through an operating agreement, CPW with a wetland contractor manages the area providing migration, breeding, and brood-rearing habitat for waterfowl and waterbirds in addition to habitat for a variety of other wildlife species. This area contains a series of large natural playa lakes that were historically maintained through springs and annual spring runoff from the surrounding creeks and are now maintained through artesian wells located on the property. Russell Lakes SWA provides recreational activities including quality waterfowl hunting in the mornings on portions of the area. This SWA is a National Natural Landmark and provides habitat for one of the largest white-faced ibis nesting colonies in the state.

- Rio Grande SWA contains 2.1 miles of the Rio Grande and associated floodplain wetlands providing habitat for a variety of waterbirds and waterfowl along with a variety of other wildlife. The area is managed through a wetland contract with CPW to provide habitat for various wildlife, recreation, and outreach activities for local and statewide school groups. Water rights associated with this area provide year round habitat for many different species including openwater areas from a warm water well in the winter, spring migration forage and shelter habitat, breeding and brood-rearing habitat, and fall migration habitat. This area is one of the main nesting areas for the endangered southwestern willow flycatcher and provides habitat for a variety of other species of concern and priority species including the greater sandhill crane, white-faced ibis, and northern leopard frog.

- Higel SWA contains portions of the Rio Grande and associated floodplain wetlands providing habitat for a variety of wildlife. This SWA has a 25 year cooperative use agreement with the Higel Family who graze and hay the property. CPW staff and a wetland contractor help guide management actions to promote wildlife habitat and use while maintaining the agricultural context of the area. Water rights associated with this area are strictly surface water driven and dependent upon the irrigation season and climatic conditions. Waterfowl and waterbird use predominantly occur from April through November. Higel SWA provides quality waterfowl hunting through a reservation system and limited number days of use. This area provides some habitat for the endangered southwestern willow flycatcher along with other species of concern and priority species including the greater sandhill crane and northern leopard frog.

- San Luis Lakes state recreation and wildlife area is located near the Great Sand Dunes National Park. Management of San Luis Lakes is tied to the Closed Basin Project, and San Luis Lakes were originally looked at as a potential mitigation property for the Project. San Luis Lakes provides habitat and recreation when water is available. Unfortunately the Lakes have dried up in recent years. When water levels are low, state managers utilize the wetlands between San Luis Lakes and Head Lake, a catchment for water and wildlife habitat.

Higel State Wildlife Area. Photo: Cary Aloia

- Coller SWA is located on the Rio Grande west of South Fork. Coller is primarily used for fishing and big game winter range. CPW is trying to improve bear habitat by encouraging berries and shrubs as a means to reduce bear pressure in and around South Fork.

- Pre Compact Reservoirs: CPW owns two major pre-compact reservoirs, Beaver Park and Road Canyon. These reservoirs are utilized to exchange and move water through the Rio Grande system to meet management needs. Beaver Park is the primary tool for CPW's water management activities. Road Canyon is a much smaller reservoir and is part of a more complex system, so utilization is more limited. However, Road Canyon is still important for water management and exchanges.

2.6.6.4 U.S. FISH AND WILDLIFE SERVICE MAJOR WETLAND COMPLEXES

The USFWS manages many large refuges with significant wetland components in the Rio Grande Basin. These refuges provide important habitat to migrating and nesting birds, and big game species.

Wildlife refuge in Rio Grande Basin. Photo: Heather Dutton.

- Monte Vista National Wildlife Refuge (MVNWR) includes over 14,000 acres of intensely managed artificial wetlands that provide crucial feeding, resting, and breeding habitat for over 200 bird species and other wildlife. Water from irrigation ditches and wells maintain this wetland habitat. The main challenge facing MVNWR is loss of surface water and the lowering of the unconfined aquifer, which has led to a loss in wetland habitat. With

decreasing water supplies, managers are working to salvage as much remaining habitat as possible.

- Alamosa National Wildlife Refuge includes over 12,000 acres of wetland areas, riparian corridors, wet meadows and river oxbows that provide critical habitat for migratory birds, waterfowl and other wildlife. In addition to habitat loss from decreased surface water and declining unconfined aquifer levels, the river corridor through ANWR is degraded from reduced river flows. Riparian restoration and irrigation infrastructure improvement projects are needed to restore and conserve this critical habitat.

- Baca National Wildlife Refuge includes 92,500 acres of shrublands, grasslands, wet meadows, playa wetlands and riparian areas. In addition to protecting diverse habitat for migratory birds and resident wildlife, BNWF was set aside to protect water resources on the north and eastern parts of the San Luis Valley. With loss of surface water and declining unconfined aquifer levels, managers are working to salvage as much remaining habitat as possible.

2.6.6.5 BUREAU OF LAND MANAGEMENT MAJOR WETLAND COMPLEXES

The BLM's San Luis Valley Field Office (SLVFO) manages over 500,000 acres of public land in accordance with BLM's multiple-use mission to sustain the health, diversity, and productivity of America's public lands for the use and enjoyment of present and future generations. In addition to managing rangelands, shrublands and forested lands, the BLM manages critical wetland complexes in the Rio Grande Basin.

Where to find more information on Blanca wetlands:

BLM's website on Blanca wetlands
http://www.blm.gov/co/st/en/fo/slvfo/blanca_wetlands.html

BLM's website on Blanca Wetlands Recreation Area
http://www.blm.gov/co/st/en/BLM_Programs/recreation/recreation_areas0/san_luis_valley_field/blanca_wetlands_recreation.html

- The Blanca Wetlands, a BLM Area of Critical Environmental Concern and Special Recreation Management Area, lie ten miles northeast of Alamosa and consist of approximately 9,700 acres and over 200 basins. The Blanca Wetlands include productive playa and marsh habitats containing high densities of water birds and waterfowl, amphibians, macroinvertebrates, and 13 threatened, endangered, and sensitive wildlife and plant species. The area is a popular recreation destination for bird watching, waterfowl hunting, and fishing. The BLM utilizes a variety of water sources to create this remarkable habitat, including pumping approximately 40 confined aquifer wells (pursuant to a plan of augmentation) and an annual 800 AF mitigation water allocation from the Closed Basin Project. For over a decade, CPW has partnered with the BLM in providing water to help meet its mission to provide quality habitat for waterfowl. Blanca Wetlands is also a great environmental education classroom used by teachers across the San Luis Valley and the region.

BLM Blanca Wetlands.
Source: Paul Tigan, BLM

The Blanca Wetlands have experienced stark declines in bird populations over the last few years as persistent drought has greatly impeded the BLM's ability to maintain sufficient habitat. A national review of the Blanca Wetlands operation indicated that varying the wetting and drying cycles of the basins across a larger landscape would improve the productivity of the area. In recent years, the BLM has partnered with Ducks Unlimited and The Nature Conservancy to wet neighboring basins that had not seen water in many decades. The BLM plans to build on the success of this project in coming years, but water availability and cost, as well as the cost to build and maintain permanent infrastructure improvements remain a barrier.

- The Rio Grande Natural Area (RGNA) was designated by Congress in 2006 to conserve, restore, and protect the natural, historic, cultural, scientific, scenic, wildlife and recreational resources of the Rio Grande below the Alamosa National Wildlife Refuge. This area, which is 33-miles long and half a mile wide, consists mostly of private land (about 65%). The remaining third is managed by the Bureau of Land Management. This portion of the Rio Grande is an Area of Critical Environmental Concern for its threatened and endangered species habitat, such as the southwestern willow flycatcher, and also a Special Recreation Management Area for recreation activities such as boating, fishing and hunting. The area has a rich heritage that spans thousands of years and many cultural affiliations. The Rio Grande Natural Area has a number of management challenges,

Rio Grande Natural Area. Source: Paul Tigan, BLM

ranging from trespass livestock to persistent drought. The BLM will be amending its Resource Management Plan (RMP) in the coming years to develop a plan of action for addressing the myriad challenges in the RGNA. This plan will coordinate, where practicable, with the ongoing work of the Rio Grande Natural Area Commission, an advisory group that is writing a non-binding plan for the private lands within the RGNA. As part of the RMP Amendment, the BLM is partnering with the RGHRP through the Lower Rio Grande Study to analyze the RGNA corridor for great restoration opportunities. Major projects for the BLM in the Rio Grande Natural Area will focus on mitigating the impacts of livestock trespass, by either constructing fences parallel to the river or enclosures, which fence off small sections of habitat from larger animals.

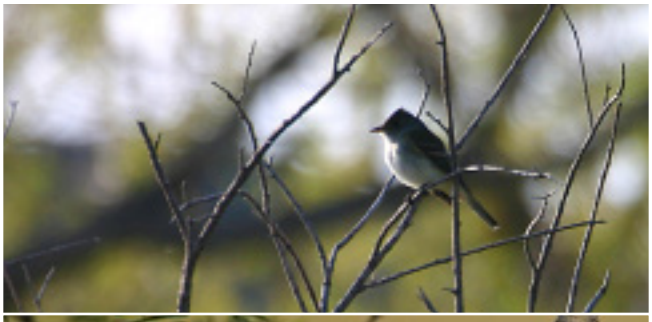
- The McIntire-Simpson property, which lies five miles west of the confluence of the Conejos River and the Rio Grande, is a 1,600-acre tract that is managed primarily for habitat for threatened and endangered species such as the southwestern willow flycatcher (SWFL). The BLM acquired the properties in the 1990s and early 2000s through the Land and Water Conservation Fund. The Simpson property surrounds the State of Colorado's historic Pike's Stockade site, and visitors frequent that portion of the property. The McIntire property, which is not currently accessible to the public without crossing the Conejos River, has the productive McIntire Spring and the historic home of Governor Albert McIntire, Colorado's ninth governor. The BLM utilizes a combination of surface and groundwater resources to maintain critical habitats on this property. Willow stands and mature cottonwood galleries provide necessary habitats for as many as 25 breeding pairs of the southwestern willow flycatcher, as well as the yellow-

billed cuckoo, bald eagles, waterfowl and big game species such as mule deer. A human-caused wildfire in 2013 demonstrated a vulnerability of the landscape to rapid change, and the BLM is currently looking at projects to mitigate potential for further wildfire damage. Persistent drought, as well as damage from the 2013 fire, has coincided with a marked decline in the number of southwestern willow flycatchers establishing breeding territories on the McIntire-Simpson property. The BLM will continue to explore projects, such as willow planting, increased water distribution, and fire mitigation efforts, to encourage SWFL habitat maintenance and growth.

From top: southwestern willow flycatcher training at McIntire-Simpson BLM property, photo: Paul Tigan, BLM; yellow-billed cuckoo, photo credit coming; Rio Grande cutthroat trout, photo credit coming; Boreal toad, photo credit coming.

2.6.7 : Key Species

The diversity and abundance of wetlands and riparian areas located throughout the SLV makes it the most important area for wetland-dependent birds in Colorado. This, along with a variety of wildlife, including fish and amphibians also depend upon these resources annually. In addition, the wetlands and riparian zones along the Rio Grande, the Conejos River, and their smaller tributaries are important to over 75% of the area's wildlife species, including many mammals, such as river otter and big game species. Numerous river reaches and tributary stream corridors are also included in designated areas of important seasonal habitat and/or winter range habitat for elk, deer and moose. The specific species discussed in this Plan represent the key species that serve as indicators of healthy habitats and populations of other species, given their similarities in relation to resource needs; however, this list is not intended to be an exhaustive list of all species of concern.



Colorado is a relatively arid state with wetland and riparian areas dispersed throughout. The San Luis Valley, the North Platte River Valley and the Arkansas River Valley are the three largest wetland strongholds in the state and are incredibly important to hydrologic systems and innumerable resident and migratory wildlife species. The Basin's wetlands provide important habitat for a wide range of migrating, nesting and wintering bird species. Many of these birds have been

listed as priority species for the Intermountain West Joint Venture (IWJV), including waterfowl, such as mallards and northern pintails; a variety of raptors, such as Swainson's hawks and peregrine falcons; shorebirds, such as the snowy plover, (National Watch List species); waterbirds, such as the Rocky Mountain greater sandhill cranes; and many neotropical migrants that migrate and/or nest in the SLV, such as the endangered southwestern willow flycatcher. Specific objectives have been developed to meet the needs of a variety of species through habitat conservation, enhancement and management.

A significant conservation effort is the SLV Regional Habitat Conservation Plan (HCP) that outlines specific needs for two bird species: the southwestern willow flycatcher and the yellow-billed cuckoo. These species require specific riparian and wetland habitat areas in the SLV. The HCP ensures there is adequate habitat for the species through a voluntary habitat banking program and allows landowners to continue historic management activities in riparian areas and wetlands (ERO Resources Corporation 2012; see http://www.slvhcp.com/ for a copy of that plan).

Three fish species are at risk in the Rio Grande Basin of Colorado: the Rio Grande cutthroat trout (RGCT), Rio Grande chub (RGC) and Rio Grande sucker (RGS). The common denominator for the reduction in population abundance and distribution for the RGCT, RGC and RGS is the predation by and competition with non-native fish species. In addition, the decline of these species indicates a number of stream issues that need to be addressed in order to sustain these species and local fisheries. Fish

Pond on the conserved Rio Oxbow Ranch, on the Rio Grande above Creede. View of Bristol Head. Photo: Rio de la Vista

habitat is threatened by river and stream modification from management activities, including public land use, recreation, improper grazing, road construction, dewatering, logging, historic mining impacts and more. While much remains to be done throughout the Basin, improvements in habitat are occurring on private and public land as a result of protection efforts, improved management practices and active restoration projects.

Boreal toads are under great pressure in the Rio Grande Basin. Amphibians are sensitive to changes in their environments and can serve as an ecological indicator of healthy wetland systems. Amphibians also are a key part of the food chain, both as prey and as predators; amphibians are preyed upon by several species of mammals, birds, fish and reptiles. Additional discussions of key species needs can be found in Section 4.4.2.4. See Appendix B: Environmental and Recreational Needs for more in depth information about these species and their recovery plans.

2.6.8 : Conservation Easements

With Colorado's growing population, which is a key impetus for this Water Plan, there continues to be intense pressure for land development and, with that, pressure to convert more water from agriculture to other uses. In response to this, the interest in and support for land and water conservation has also grown steadily across Colorado for many years. Voluntary, incentive-based conservation of private land is one solution-oriented tool that the community and the state have available to work with willing landowners to secure key lands from development and to tie the water rights to the land, especially on sites where agriculture and important wildlife habitat converge. In addition, conservation of private lands is a key tool for the Rio Grande Water Conservation District's Habitat Conservation Plan (HCP) for the federally endangered southwestern willow flycatcher.

Protecting critical water sources on private land is a key objective in the SLV. Wetland habitat in the SLV is often on private lands where ranchers irrigate and use habitat for native hay meadows and pastureland for livestock. Protection of wetland habitat types will ensure proper drying and flooding cycles while maintaining historic water use patterns in wetland basins that are beneficial to wildlife.

Land protection is a relatively new practice in the San Luis Valley, as most conservation easements have been completed since 2000. However, during this short time frame, close to 300,000 acres of land have been protected, which suggests that public support for land protection in the SLV is strong. Citizens of the San Luis Valley understand that the rural lifestyle and wildlife habitat make the area unique and have voiced their concern over the loss of these values. They recognize that conservation easements are a tool to keep working farms and ranches and water rights intact, along with protecting critical wildlife habitat.

The severe drought of 2002 brought the Valley's local concerns about water to a crisis point. During this time, protecting the Rio Grande corridor and its water resources emerged as a clear priority. Research found that, in contrast to many of Colorado's highly fragmented mountainous river corridors, there is still a substantial amount of relatively intact land along the Rio Grande corridor, much of which has senior water rights associated with it. The local Rio Grande Headwaters Land Trust (RiGHT), along with core partners, The Nature Conservancy and Ducks Unlimited, and the commitment of many willing landowners, launched the Rio Grande Initiative in 2007 to focus efforts on private land conservation along the river corridor. CPW, the Colorado Cattlemen's Agricultural Land Trust, the Natural Resources Conservation Service (NRCS) and numerous other partners have likewise been involved in the effort.

Overall, these conservation organizations have tripled the pace of conservation along the Rio Grande. They are also working with landowners along on the Conejos and other key tributaries, which are likewise vital areas to keep land and water intact. As of the end of 2013, over 23,000 acres and 39 river miles of private land were protected

Ducks on Rio Grande wetland.
Photo: Rio de la Vista

through the Rio Grande Initiative. Approximately $40 million in conservation has been achieved through these efforts, about half of that amount came into the community as direct payments to landowners. A recent Trust for Public Land study indicated that every dollar invested in conservation generates six dollars of economic return in communities, meaning conservation funds serve as a substantial economic driver in the San Luis Valley (The Trust for Public Land 2009).

Among the major supporters of the Rio Grande Initiative, in addition to Great Outdoors Colorado (GOCO), are the local Rio Grande Basin Roundtable and the statewide Colorado Water Conservation Board, which have contributed approximately $2 million in WSRA funds to this effort. The USFWS's North American Wetlands Conservation Act has awarded $8 million to Ducks Unlimited and RiGHT, funding SLV conservation efforts for both easements and restoration projects. Other major funders include CPW, the NRCS's Farm and Ranchland Protection Program and several private foundations. Nearly all conservation transactions include a substantial donation from the landowners.

As part of the RGBRT's work to create a Water Plan that balances the Rio Grande's water supplies and needs, voluntary conservation is one of many tools that can continue to contribute and be part of the solution.

2.6.9 : Recreation in the Rio Grande Basin

Significant water based recreation opportunities exist in the Rio Grande Basin. Residents and visitors enjoy abundant hunting, fishing, boating, wildlife viewing and other exciting activities.

2.6.9.1 WATERFOWL HUNTING

The floor of the SLV is well known for early-season waterfowl hunting opportunities that are enjoyed by residents from all over the state. It is well-known that good public land waterfowl hunting is extremely limited in Colorado. Monte Vista Refuge and Russell Lakes SWA provide the bulk of public land waterfowl hunting in the Basin. Higel SWA, Playa Blanca SWA and Rio Grande SWA and most other SWAs provide smaller, quality waterfowl hunting opportunities as well. Due to its unique hunting access, Higel SWA is the only public waterfowl hunting area in the SLV on a reservation system, allowing up to 25 waterfowl hunters a day. BLM's McIntire-Simpson Wildlife Management Area is another parcel of public land that provides waterfowl hunting. With landowner permission, extensive wetlands on private lands also provide hunting opportunities.

2.6.9.2 CONSERVATION POOLS AND STORAGE AGREEMENTS

In general, operating reservoirs are typically used to meet seasonal demands, such as late-summer irrigation needs. Thus, they are subject to dramatic fluctuations in water level and may be periodically drained in the course of normal operations. When reservoirs are operated in this way, it results in a sterile environment, with little to no significant benefit to fish and wildlife. Furthermore, the downstream environment may also be impacted by wide flow fluctuations. In order to address these issues to the greatest extent possible, CPW has utilized conservation pools.

There are two kinds of conservation pools in use in the Rio Grande Basin: 1) privately owned water rights held in high-altitude reservoirs that function as small fisheries, for which CPW exchanges irrigation water to reservoir owners and in return owners leave water in the reservoir to maintain a fishery; and 2) CPW-owned water rights that are stored in larger reservoirs and used to replace water from the smaller conservation pools when called for by the water user, as well as to maintain fisheries and boating recreation in the larger bodies of water and to maintain stream flows through timely releases. CPW has conservation pools in numerous reservoirs that function as a means to protect fisheries. There is a limit to how much water can be drawn down for irrigation or repair purposes under the CPW conservation pool agreements to protect fisheries. If complete drainage is necessary, CPW has a mechanism in place to work with reservoir owners to manage fisheries as needed. Examples of this type of conservation pool are located at Mountain Home, Smith, Terrace and Continental reservoirs.

2.6.9.2.1 PRIVATELY OWNED WATER RIGHTS

In these conservation pool agreements, the reservoirs are operated to allow substitution of CPW-owned water for water held in a reservoir. This enables privately held reservoirs within public lands to maintain adequate water in each vessel to support a productive aquatic system that is capable of sustaining populations of game fish, and providing boating and fishing opportunities. CPW annually agrees with the reservoir owners to provide water to the Rio Grande upon their request. The reservoir owners (usually farmers and ranchers) call the CPW water manager and request the amount of their water right to be released to the river, leaving their water in the reservoir to maintain a fishery. CPW, upon consultation with DWR, releases water from a reservoir, such as Beaver Park Reservoir, pays the levied transportation and evaporation cost and provides "wet water" in the Rio Grande, which the owners then divert for use on their property. Benefits are significant for all parties; owners no longer have to travel to remote locations to release their water rights, owners do not lose water in transportation, the public gains a viable fishery, wildlife habitat is enhanced through the increased availability of water resources over different time periods, instream flows are enhanced (the reservoirs typically operate as a "flow-through" facility) and a variety of riparian and

wetland areas receive water. According to the CPW's Southwest Region Aquatic Biologist, these conservation pool reservoirs provide an estimated 8,247 days of angler recreation annually. The following lakes in the Rio Grande Basin have such conservation pool agreements:

- Pogue Lake
- Spruce Lakes
- Shaw Lake
- Goose Lake
- Regan Lake
- Hunter Lake
- Trout Lake
- Mountain Home Reservoir
- Smith Reservoir
- Terrace Reservoir
- Continental Reservoir

World class fishing on the upper Conejos River. Photo: Rio de la Vista

2.6.9.2.2 CPW-OWNED WATER RIGHTS

Many larger reservoirs in the Basin have storage agreements for conservation pools with CPW for CPW-owned water. These reservoirs can be managed for delivery of replacement water for privately owned water rights needed for irrigation, as discussed above. In addition, the conservation pool agreements in these reservoirs help to maintain the fisheries and boating opportunities that the larger reservoirs provide by maintaining a certain minimum level of water. A temporary storage agreement is in place for Rio Grande Reservoir, with a permanent storage agreement being negotiated as part of the Rio Grande Cooperative Project. Other storage agreements are pending for Santa Maria Reservoir and Continental Reservoir.

2.6.9.3 ANGLING

The Rio Grande Basin has excellent fishing opportunities, from many high-altitude streams and lakes to the Gold Medal waters of the Rio Grande and superb fishing on the upper Conejos River. CPW offers extensive information about fishing opportunities, including an interactive fishing atlas map, at http://ndismaps.nrel.colostate.edu/fishingatlas/.

A CPW report documents the number of Rio Grande Basin angler days at approximately 120,800 annually (see table in Appendix B: Environmental and Recreational Needs). The economic benefit from fishing recreation to the local economy can be summarized by the average expenditure for each recreation day. Resident anglers spend an average of $67 per recreation day, while non-resident anglers spend an average of $118 per recreation day in Colorado (BBC Research & Consulting 2008). Therefore, about

Where to find more information on lake and reservoir boating and fishing opportunities in the Rio Grande Basin:

Rio Grande National Forest fishing **weblink**

Rio Grande National Forest boating **weblink**

State wildlife areas, state parks and state trust lands boating and fishing **weblink**

$10.5 million dollars are expended annually by anglers during fishing trips to waters supported by CPW water rights in the Rio Grande Basin.

2.6.9.4 BOATING

2.6.9.4.1 RAFTING ON THE RIO GRANDE

Rafting largely occurs on the Rio Grande in the upper reaches beginning in the Rio Grande National Forest, from below Rio Grande Reservoir and extending to South Fork. Above South Fork, the river flows through public and private lands, with several boating access points. When river levels allow, floating can be possible below South Fork to above Del Norte, where large irrigation diversions make access difficult between Del Norte and Alamosa. Increasing boat access and passage through diversion structures is an ongoing process in the community. The Rio Grande Headwaters Restoration Project includes these components in

FIGURE 37.

Flatwater boating in the Rio Grande Basin.

its restoration projects and rehabilitation of diversion structures when possible and with willing landowners. Below the Alamosa National Wildlife Refuge, there are no additional diversion structures. There are periods during the irrigation season and late-season when adequate river flows for boating are not available. There is public access to the river at several points in the lower reach of the Rio Grande.

2.6.9.4.2 FLAT WATER BOATING

Flat Water Boating occurs at many of the small conservation pools and throughout larger reservoirs in the Basin. Rio Grande, Continental, Beaver Park, Big Meadows and Road Canyon reservoirs provide high mountain public access boating opportunities in the San Juan Mountains. Most boaters fish for trout while enjoying these settings. Additional boating and fishing for warm water species occurs on the east side of the Basin at Mountain Home, Terrace, and Smith reservoirs. When conditions allow, San Luis Lakes State Park has been a site for water sports since the 1920s. Water skiing, motor boating, personal watercraft, fishing, sailing and windsurfing are popular there when water levels are adequate. San Luis Lakes is currently dry, due to low winter snowpack and, consequently, low spring runoff. Figure 37 below identifies flat water boating areas in the Rio Grande Basin. The water needs of these areas are important for a variety of recreational opportunities and economic benefits.

2.6.9.5 BIRDING TRAILS AND WATCHABLE WILDLIFE

The term "watchable wildlife" simply refers to the opportunity to view and enjoy wildlife in a nonconsumptive manner. Watching wildlife often takes place while hiking, boating, on horseback or any of the many ways in which residents and visitors to Colorado choose to recreate. The recreational, watchable wildlife opportunities in the Rio Grande Basin are limitless and almost impossible to track in terms of recreational user-days and occur throughout the Rio Grande Basin on all land ownerships, public and private.

CPW has established a Watchable Wildlife Trail at the Shriver-Wright State Wildlife Area on the east side of Monte Vista, along the Rio Grande. This includes educational signage and an easy, well-marked trail where visitors can enjoy the wildlife in the neighboring wetlands and river corridor. There is potential for additional trails and access in the area that is being explored by CPW and partners.

The Rio Grande.

SECTION 3

Rio Grande Basin Goals and Measurable Outcomes

This section provides the guidelines for the Rio Grande Basin Water Plan as reflected in the Rio Grande Basin Roundtable's goals and measurable outcomes (G&MOs). The goals identify the priorities of the roundtable for the entire Basin, while the implementation techniques and measureable outcomes provide the specific mechanisms and targets for achieving these goals.

3.1 : Goal Identification Process

The goals identified in the 2010 Statewide Water Supply Initiative (SWSI 2010) report (State of Colorado, Department of Natural Resources, Water Conservation Board 2011) were used to inform the discussion of the Basin's priorities for the Rio Grande Basin Water Plan (the Plan). An initial set of goals was provided to the Basin Plan Steering Committee and subcommittees (Agriculture, Municipal and Industrial, Environmental and Recreational, and Water Administration) for discussion and revisions. Over the course of two months and a dozen meetings, the subcommittees, with the assistance of DiNatale Water Consultants (DWC), revised the goals and measurable outcomes and submitted final drafts to DWC. Through review of the individual subcommittees' goals and measurable outcomes, commonalities were identified. G&MOs from each committee were combined and condensed into a complete Basin list and returned to each committee for final approval, before submittal to the Steering Committee.

At the end of February 2014, the Steering Committee refined the goals and measureable outcomes over two working sessions. The final G&MOs were presented to the Rio Grande Basin Roundtable (RGBRT) at the March 11, 2014 meeting.

3.2 : Description of Goals and Measurable Outcomes

The Rio Grande Basin Plan Steering Committee and subcommittees identified 14 Basin goals. These goals focus on the most important aspects of the Rio Grande Basin: a resilient agricultural economy, watershed and ecosystem health, sustainable groundwater resources, the encouragement of projects with multiple benefits, and the preservation of recreational activities. The Basin goals ultimately strive for a resilient and healthy watershed and economy for generations to come.

Intrinsic to the Basin goals are the important aspects of resiliency and risk management. To effectively address future uncertainties, including changes in climate and the resulting drought and fire, the RGBRT supports the use of an operation and planning model developed for Basin-wide water supply planning as part of this Plan. The analyses in this report include various potential future hydrologic and water demand scenarios. In addition to scenario planning, the goals below call for a resilient watershed and water supply system that will prevent harm to existing water rights while maximizing Colorado's entitlement under the Rio Grande and Costilla Creek compacts.

To provide a roadmap to measure the success in meeting existing and future water needs, each goal is paired with measurable outcomes. Each goal includes a brief description, implementation techniques for achieving the goals and measurable outcomes. Implementation techniques include tasks, studies, projects and methods to be included in the Plan, other steps needed to help achieve the goal and, finally, measurable outcomes.

The RGBRT sought to create specific goals and implementation techniques, avoiding arbitrary or uninformed measurable outcomes that would not be meaningful to the Basin. Measurable outcomes are more qualitative due to the lack of quantitative analyses performed in the Basin to date and time restrictions in completing the analysis before the draft of the Basin Plan is requested to be delivered to the Colorado Water Conservation Board (CWCB). However, the Plan has included implementation techniques to include the necessary additional analyses. This Plan is a dynamic document that will be revisited and revised as additional analyses are completed.

3.2.1 : Rio Grande Basin Goals

The following are the Rio Grande Basin goals, each accompanied by a list of the subcommittees that identified the goal. The list also corresponds to the needs that are met by the goal.

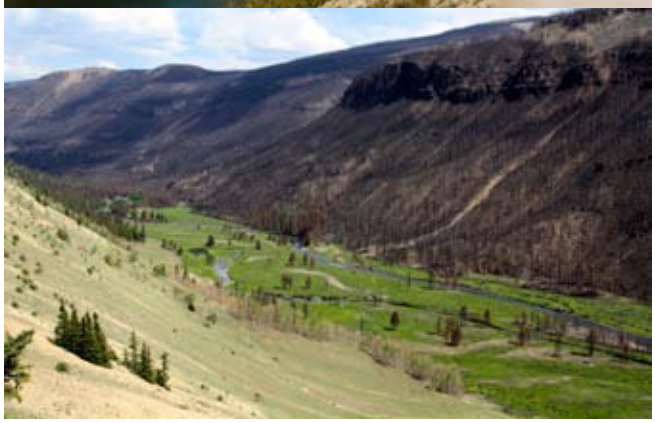
Ag = Agriculture
M&I = Municipal and Industrial
Env&Rec = Environmental and Recreational
WAdm = Water Administration

	Goal	Needs Met			
1.	Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.	Ag	M&I	Env&Rec	WAdm
2.	Protect and preserve the doctrine of prior appropriation and vested water rights and fully utilize Colorado's compact entitlements as specified under the Rio Grande and Costilla Creek compacts.	Ag	M&I		WAdm
3.	Sustain the confined and unconfined aquifer in accordance with Senate Bill 04-222 and operate within the State Engineer's new Rules and Regulations for the San Luis Valley.	Ag	M&I	Env&Rec	WAdm
4.	Operate, maintain, rehabilitate and create necessary infrastructure to meet the Basin's long-term water needs, including storage.	Ag	M&I	Env&Rec	WAdm
5.	Manage water use to sustain optimal agricultural economy throughout the Basin's communities.	Ag	M&I	Env&Rec	WAdm
6.	Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.	Ag	M&I	Env&Rec	WAdm
7.	Meet new demands for water, to the extent practicable, without impacting existing water rights and compact obligations.	Ag	M&I	Env&Rec	WAdm
8.	Establish a long-term education and outreach effort for water use and needs in San Luis Valley/Rio Grande Basin.	Ag	M&I	Env&Rec	WAdm
9.	Make progress toward meeting applicable water quality standards throughout the Basin.	Ag	M&I	Env&Rec	
10.	Promote water management and administration practices that are adaptive, flexible and responsive to optimize multiple benefits.	Ag	M&I	Env&Rec	WAdm
11.	Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.			Env&Rec	
12.	Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.	Ag	M&I	Env&Rec	
13.	Work to establish active river flows throughout the year in cooperation with water users and administrators to restore and sustain ecological function of the rivers and floodplain habitats within the context of existing water rights and compact obligations.			Env&Rec	
14.	Maintain and enhance water-dependent recreational activities.			Env&Rec	

3.2.2 : Detailed Goals and Measurable Outcomes

Goal	Needs Met			
1. Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.	Ag	M&I	Env&Rec	WAdm

The resiliency of the Rio Grande Basin depends on protecting, preserving and/or restoring the Basin's watersheds. Watershed health and ecosystem function are essential to ensuring the sustainability of the Rio Grande and Conejos rivers and their tributaries, especially in the wake of a changing climate that may include increased drought, earlier spring runoff, reduced runoff volume, late-season monsoons and additional forest fires. To maintain existing water resources and to protect against future natural disasters and unpredictable climate changes, it is critical to ensure that the watersheds of the Rio Grande are healthy and resilient. Healthy Basin watersheds provide the basis for continued water supplies to meet the Basin's economic, agricultural, environmental, recreational, and municipal and industrial needs.



Above: Rio Grande Reservoir.
Below: River Hill fire downstream of Rio Grande Reservoir. Photos: Heather Dutton

MEASURABLE OUTCOMES:

- Watershed resiliency is improved through science-based adaptive management.
- Inventory and assessment of existing watershed plans is completed.
- Report on Basin-wide Values at Risk Assessment is developed.
- Mapping and response plans are developed to assess pre- and post-natural disaster conditions.

Goal	Needs Met		
2. Protect and preserve the doctrine of prior appropriation and vested water rights and fully utilize Colorado's compact entitlements as specified under the Rio Grande and Costilla Creek compacts.	Ag	M&I	WAdm

The doctrine of prior appropriation is the legal framework in Colorado that regulates the use of surface water in rivers and tributary groundwater connected to the river basin. The Plan will work within the framework of the prior appropriation system to prevent injury to any vested water rights. Both the prior appropriation system and the Colorado's compact obligations are regulated by the Colorado Division of Water Resources (DWR). The Rio Grande Basin Water Administration Subcommittee will be working with the DWR to identify current and future projects and re-operations that may better meet compact deliveries while fully utilizing Colorado's compact entitlements. Public and private entities working in partnership to re-operate reservoir releases and better meet Basin water needs will be key in the compact delivery process.

In addition all current, new and proposed water supply projects will continue to comply with Colorado water law and the prior appropriation system. These regulations will be used as criteria for approval of future projects.

MEASURABLE OUTCOMES:

- Meet compact deliveries annually with minimal over- and under-deliveries.
- Continue to comply with Colorado water law and the prior appropriation system for all water administration and water supply projects.

Frosty Rio Grande. Photo: Heather Dutton

Goal	Needs Met			
3. Sustain the confined and unconfined aquifer in accordance with Senate Bill 04-222 and operate within the State Engineer's new Rules and Regulations for the San Luis Valley.	Ag	M&I	Env&Rec	WAdm

Irrigated circles in the Closed Basin. Photograph by Dan Downing

While surface water use in the San Luis Valley continues to be limited by the Rio Grande Compact, groundwater has long been a source of irrigation water for agriculture. Especially during drought, groundwater has been relied upon by many San Luis Valley farmers, which has resulted in substantial over-draft of the confined and unconfined aquifers in recent years. Due to the unsustainable aquifer use, Senate Bill 222 was passed in 2004 requiring the State Engineer to manage the confined aquifer's artesian pressure. As a result of this legislation, the State Engineer, with assistance of an appointed advisory committee, promulgates groundwater rules for Water Division 3 (Rio Grande) to allow withdrawals of groundwater within the Rio Grande Basin, by calculation and replacement of injurious depletions to surface water and the restoration and maintenance of sustainable aquifer water supplies, while not unreasonably interfering with the state's ability to fulfill its obligations under the Rio Grande Compact. To assist with replacement of injurious depletions and restoration of sustainable aquifer supplies, groundwater subdistricts will be formed and augmentation plans will be developed and operated.

MEASURABLE OUTCOMES:

- Groundwater subdistricts and augmentation plans for replacement are successfully formed and operated.
- All of the annual plans for replacement meet Division of Water Resources requirements and subdistrict augmentation requirements.
- An RGDSS groundwater model that is continuously updated as new information is generated.
- Division 3 groundwater use rules are adopted and complied with.

Goal	Needs Met			
4. Operate, maintain, rehabilitate and create necessary infrastructure to meet the Basin's long-term water needs, including storage.	Ag	M&I	Env&Rec	WAdm

Fully operable infrastructure within the Rio Grande Basin, including reservoirs, dams, canals, headgates and municipal water systems, is essential for meeting the Basin's long-term water needs. Currently, several reservoirs within the Basin are under storage restrictions and require rehabilitation in order to operate at full design capacity. It is particularly important to rehabilitate infrastructure that enables the use of water rights that predate the Rio Grande River Compact. Surface irrigation is not operating as efficiently as it could due to suboptimal function of diversion structures and conveyance systems. Furthermore, in many cases restoration or modernization efforts serve to address multiple purposes, such as improved diversion reliability and accuracy, reduced system conveyance losses both in agriculture and in municipal and industrial uses, and improved measurement of surface and groundwater depletions. To have up-to-date knowledge of rehabilitation needs, a database of existing infrastructure will be created, maintained and utilized in the projects and methods portion of the Plan.

Terrace Reservoir spillway repair.
Photo: Heather Dutton

MEASURABLE OUTCOMES:

- A database of existing water infrastructure including documentation of infrastructure condition and mapping of all storage reservoirs and major ditch diversions, is created.
- Reservoirs operate at full design capacity without restrictions.
- Diversion structures and conveyance systems function optimally.
- Municipal potable water supplies are adequate to meet needs.
- Water supplies and wastewater treatment systems are fully functional and meet all necessary standards.

Goal	Needs Met			
5. Manage water use to sustain optimal agricultural economy throughout the Basin's communities.	Ag	M&I	Env&Rec	WAdm

In the Rio Grande Basin, agriculture makes up over 30% of the economy and plays a large part in the cultural heritage of the San Luis Valley. Over 40,000 acres of agricultural land may be dried up to comply with the groundwater rules and regulations. The RGBRT and Agricultural Subcommittee strongly support, at a minimum, the maintenance of current levels of agricultural income in the Basin. Water shortages in agricultural areas represent a significant need and an opportunity for improvement. This Plan refines the agricultural water supply gap in the Rio Grande Basin. To reduce the agricultural water supply gap, the RGBRT and Agricultural Subcommittee will seek to inform irrigators about and encourage them to consider alternative agricultural techniques and practices to improve soil health, farm and rangeland, and provide for continued levels of production while reducing consumptive use to the extent practicable.

San Luis Peoples Ditch, the oldest surface water right in Colorado. Photo: Coyote Gulch website

MEASURABLE OUTCOMES:

- The cultural heritage of agricultural water use in the San Luis Valley is recognized.
- Agriculturally supported jobs are sustained.
- Rangeland is maintained and improved.
- Soil health is enhanced and soil loss is minimized on both farmland and rangeland.
- Alternative agriculture practices that improve soil health and/or reduce consumptive use without impacting crop yields are supported and implemented to the extent practicable.

Goal	Needs Met			
6. Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.	Ag	M&I	Env&Rec	WAdm

There exists a wide range of opportunity for multiple-benefit projects in the San Luis Valley, from restoring habitat and stabilizing stream banks, thereby reducing erosion and land loss, to replacing dilapidated headgates and implementing new irrigation technologies, to evaluating reservoir operations scenarios. In a water-short Basin that has experienced a prolonged drought, the RGBRT strives to incorporate opportunities for multiple-use benefits wherever possible. An emphasis on multi-purpose projects will be carried through the analysis of needs and projects and methods for all sectors.

MEASURABLE OUTCOMES:

- Opportunities for multiple use benefits have been explored and implemented where possible.
- Multiple-purpose projects will have preference in the funding process.

Pole Mountain. Photo: Heather Dutton

Goal	Needs Met			
7. Meet new demands for water, to the extent practicable, without impacting existing water rights and compact obligations.	Ag	M&I	Env&Rec	WAdm

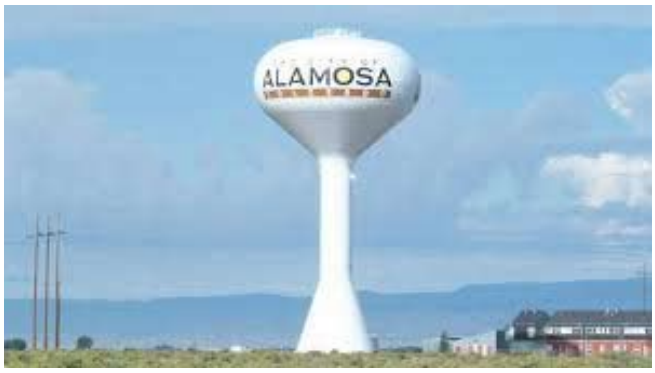
The SWSI 2010 report revealed that the Rio Grande Basin's municipal and industrial (M&I) water usage was the highest in gallons per capita per day (GPCD) of all basins in the state (State of Colorado, Department of Natural Resources, Water Conservation Board 2011). This Plan has identified that the per capita use in the Basin, while elevated, is much lower than reported in SWSI 2010. The population in the Rio Grande Basin, although small and representing a very minor fraction of total Basin water use, is projected to grow by an average annual rate of 1.2% until 2050, resulting in a 50–75% increase to the current population (CDM 2011).

This Plan documents the water rights and infrastructure of the municipal water providers in the Basin necessary to meet needs projected through the year 2050. An emphasis on multiple-purpose projects is carried throughout the analysis, where applicable. Projected population and water use data were initially pulled from SWSI 2010, with updated information from water providers provided in this Plan. The M&I water supply gap, primarily for augmentation of well-pumping depletions in the Basin, will eventually need to be recalculated once the groundwater rules and regulations for all subdistricts are finalized and plans for augmentation are developed.

MEASURABLE OUTCOMES:

- Minimize per capita per day use to a reasonable level.
- Inventory existing and anticipated future M&I and environmental and recreational water needs.
- Add hydropower electrical generating capacity where possible.
- Develop a M&I plan that addresses water needs, availability and a strategy for meeting the needs for M&I while sustaining agricultural water use and minimizing impacts to other uses.

Alamosa municipal water tower.



Goal	Needs Met			
8. Establish a long-term education and outreach effort for water use and needs in San Luis Valley/Rio Grande Basin.	Ag	M&I	Env&Rec	WAdm

The Rio Grande Basin Roundtable and the Education and Outreach Subcommittee would like to increase public understanding and involvement in water issues throughout the Basin. Modeled after the Gunnison Basin's River Handbook, the Education and Outreach Subcommittee is developing a Rio Grande Water Education 101 pamphlet geared towards Basin-specific water issues. Current and future educational efforts will include public outreach programs developed through several avenues within counties and communities. Multiple forms of media, including newspaper articles, radio announcements, public meetings and a website, will be used to help educate the public. These efforts will help promote increasing public understanding and participation in essential water issues in the Rio Grande Basin.

MEASURABLE OUTCOMES:

- Continued enhancement of the public information process via
  - Announcements through the RGBRT.
  - RGBRT meetings, as appropriate, hosted at various locations around the Basin.

- Implementation of annual water education plan.
  - Education plan has watershed management components that include drought, flooding and fire restoration.
  - Quarterly water education and information newsletter.
  - Radio spots.

- Public education and outreach via
  - Communication through consistent messaging with county commissioners, elected officials, State and Federal agencies, agricultural and M&I users, environmental and recreational users.
  - Educational outreach regarding land and water management that benefits agricultural and environment/wildlife habitat.

Boy Scout volunteers for a river restoration project. Photo: Heather Dutton

Goal	Needs Met		
9. Make progress toward meeting applicable water quality standards throughout the Basin.	Ag	M&I	Env&Rec

Water quality is equally as important as water quantity in terms of watershed health and resiliency. Following the guidelines of the CDPHE Classification and Numeric Standards for the Rio Grande Basin, including all tributaries and standing bodies of water, identification of water quality impairments should occur. The Basin Water Plan will support projects that mitigate point and nonpoint source water quality contamination and enhance water quality in streams, rivers and lakes. Projects that identify existing current improvements and recommended future development will be carried throughout the analysis.

MEASURABLE OUTCOMES:

- Mitigation of point and nonpoint source water quality impairments.
- Creation of capital improvements plan that will monitor current improvements and recommend future development that will enhance M&I water quality parameters.
- Implementation of measures to prevent future impairments.

Rio Grande headwaters near Montezuma Peak. Photo: Heather Dutton

Goal	Needs Met			
10. Promote water management and administration practices that are adaptive, flexible and responsive to optimize multiple benefits.	Ag	M&I	Env&Rec	WAdm

Water management is an issue that touches every resident in the San Luis Valley, with aquifer sustainability an increasing concern. The Plan will allow for wise and thoughtful water supply planning and administration that addresses critical issues, such as compact compliance and streamflow forecasting, along with opportunities to enhance streamflows through re-operations that do not negatively impact water rights. The Plan considers all solutions and addresses the varied water needs of all sectors and citizens.

The Basin's water supply is under near-continuous curtailment of water rights in order to remain compact-compliant. Hence, water users in the Basin keep water inventory current and are taking steps to ensure reservoirs can store to the original designed and constructed storage volumes. The Plan will provide a variety of tools that water administrators can use to preserve the social, cultural and economic resilience of the Rio Grande Basin and that are adaptive, flexible and responsive to optimize multiple benefits.

Rio Grande. Photo: Heather Dutton

MEASURABLE OUTCOMES:

- Compliance with the Rio Grande and Costilla Creek compacts.
- Reliable streamflow forecasting.
- Voluntary water management that may enhance instream flows to promote sustainable aquatic and wildlife habitats and recreation in accordance with Colorado water law and protection of existing water rights.
- Protection of instream flow water rights.

Goal	Needs Met
11. Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.	Env&Rec

Rio Grande Cutthroat Trout.
Photo: National Park Service

The Rio Grande Basin includes important habitat for the endangered southwestern willow flycatcher, the threatened bald eagle, the candidate species Rio Grande cutthroat trout and yellow-billed cuckoo, and the rare slender spider flower, among others. Protecting, preserving and enhancing terrestrial and aquatic wildlife habitats is beneficial not only for threatened, endangered and/or candidate species, but also for environmental and recreational purposes. This Plan is intended to refine the analysis of the habitat water gap in the Rio Grande Basin by incorporating data on recreational flows, economic impacts of environmental and recreational benefits, and wildlife habitat project recommendations. An emphasis on multi-purpose projects that address the water needs of terrestrial and aquatic wildlife habitats, in addition to those of agricultural and M&I users, will be provided a high priority and carried through the analysis.

MEASURABLE OUTCOMES:

- Species that are listed by either the federal or state government as threatened, endangered or candidate species are recovered or de-listed.
- Additional species are prevented from being listed by the federal or state government.
- Economic impact studies for environmental and recreational benefits are considered in the decision-making process for new water supply projects.
- Wildlife habitat needs are considered in the decision-making process.
- Natural resource agencies in the SLV coordinate and cooperate with each other to comply with the groundwater rules and regulations and augmentation plans to benefit wildlife and recreation to the largest extent possible.
- Water needs for wildlife habitat are addressed in plans, databases and SLV-wide surveys of appropriate wildlife populations.

Southwestern willow flycatcher.
Photo: Arizona Game & Fish
file photo/Associated Press

Goal	Needs Met		
12. Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.	Ag	M&I	Env&Rec

The Rio Grande Basin has approximately 200,000 acres of exceptional wetlands. There is a strong recognition that the vitality of wetlands and riparian areas is dependent upon and contributes to sustainable aquifers and healthy, functioning rivers. This Plan seeks to further refine the analysis of wetlands and riparian areas in the Rio Grande Basin, with the goal of restoring the ecological function of these areas. An emphasis will be placed on multi-purpose projects that conserve, restore and maintain wetlands and riparian areas.

MEASURABLE OUTCOMES:

- Needs for properly functioning wetlands and riparian areas are identified.
- Ecological function of wetlands and riparian areas are restored.
- Projects are developed and implemented to restore, conserve and sustain functioning wetlands, riparian areas and associated habitats with a focus on incorporating connectivity for species.

Sand Creek, Great Sand Dunes National Park. Photo: Heather Dutton

Goal	Needs Met
13. Work to establish active river flows throughout the year in cooperation with water users and administrators to restore and sustain ecological function of the rivers and floodplain habitats within the context of existing water rights and compact obligations.	Env&Rec

In the Rio Grande Basin, water administrators maintain a balancing act of delivering the necessary water to existing water rights and meeting compact obligations. The goal of compact compliance is neither to over- or under-deliver water to New Mexico while still meeting the needs of water users. Due to this complicated process, there are times during the year, specifically in the late summer and early fall, when the compact obligation has been met and water users "sweep" or dry up the river by diverting all of their water rights entitlement. Ecological functions of the river and floodplain habitats suffer when there is no flow in the river. Through multi-purpose projects and river and reservoir re-operations, this report strives to identify opportunities to establish active river flows throughout the year within the context of existing water rights and compact obligations.

Rio Grande Canal headgate.
Photo: Arista Hickman

MEASURABLE OUTCOMES:

- Active plans and cooperative agreements are negotiated that enhance streamflows through re-operations while ensuring full compliance with Colorado water law.

Goal	Needs Met
14. Maintain and enhance water-dependent recreational activities.	Env&Rec

Recreational opportunities are rich in the Rio Grande Basin. Fishing, rafting and canoeing activities are found at various locations along the Rio Grande River, from below the Rio Grande Reservoir to the Colorado/New Mexico state line and similarly on the Conejos River. The stretch of the Rio Grande from Coller State Wildlife Area to just west of Del Norte has been designated as a "Gold Medal" fishery. The 130,000 acres of public and numerous private wetland areas have created a plethora of birding and wildlife opportunities for watchers and hunters alike. Due to the importance of recreation in the Rio Grande Basin, the RGBRT and the Environmental and Recreation Subcommittee seek to find creative solutions that maximize water for the benefit of the environment and recreation while simultaneously protecting water rights, agriculture, municipalities and other water users.

MEASURABLE OUTCOMES:

- Floatable flow levels are identified by reach.
- Cooperative water management provides flows to extend recreational opportunities.
- Recreational facilities are improved and/or added to.
- Quality and quantity of fishing opportunities are improved.
- Fish and boat passages are installed where appropriate.
- Conservation pools are rehabilitated, secured and/or conserved as possible.
- Quality and quantity of hunting (waterfowl, small game and big game) opportunities are improved.
- Fish hatcheries have sustainable, secure and adequate physical and legal water supplies.
- Economic benefits of recreation are recognized in decision-making processes.

Rafting on the Rio Grande. Photo: Bureau of Land Management.

The Rio Grande. Photo: Adriel Heisey

SECTION 4

Basin Water Needs

Once the Basin's goals and measurable outcomes were established, the next step in strategically implementing water projects and other methods in the Rio Grande Basin is to identify the water needs within each sector. This section describes the agricultural, M&I and environmental and recreational water needs of the Basin.

Irrigating fields at sunset.
Photo: Julie Messick

4.1 : Background

Once the Basin's goals and measurable outcomes were established, the next step in strategically developing and implementing water projects and other methods in the Rio Grande Basin is to identify the water needs within each sector. In order to focus on project implementation, this Water Plan relied, to the extent practicable, on previous data of water needs from SWSI 2010 and other relevant sources. However, as noted in this section, there were significant data gaps in quantifying environmental and recreational needs. At the request of the RGBRT, agricultural and Municipal and Industrial (M&I) needs were also independently analyzed by the consultant team and the Basin M&I subcommittee and results are reported in this section.

While the Basin Water Plan process does not include a systematic update of agricultural, M&I and environmental/ recreational water needs, pertinent new information is included as noted to build on and improve upon existing reports and databases. The Colorado Water Conservation Board (CWCB) plans to provide a comprehensive update of water needs to maintain its technical foundation for statewide water planning in the SWSI 2016 report. New information compiled in this report will be further updated by the CWCB as part of the SWSI 2016 process.

Numerous subcommittee meetings and workshops were held to review the existing data and studies and to determine where additional information was needed. In addition to the workshops, targeted phone, personal, and email communication helped to update information throughout the Basin.

4.2 : Agricultural Water Needs

4.2.1 : Summary of Process

In Colorado, over 80% of all water use is used for agriculture. In the Rio Grande Basin, the proportion of agricultural water use to all other water uses is even larger, approximately 99% of total Basin water use. The economy of the Rio Grande Basin is driven in large part by agriculture, and, therefore, meeting the agricultural water needs is critical not only for individual farm operators, but for the entire Basin.

There are several components of agricultural water needs in the Rio Grande Basin that must be addressed to understand the complexity and immediacy of the need. There are physical shortages, where an insufficient amount of water is available to meet the needs of the crops. There are legal shortages, where water may physically be available at the point of use, but cannot be used because the water is legally obligated for other uses. Layered over both physical and legal shortages is the reliance on groundwater resources. Aquifer sustainability requirements are applying pressure to agricultural water users to change historical practices and have the potential to significantly alter agricultural water use and production in the coming decades.

4.2.1.1 PHYSICAL SHORTAGES

The Rio Grande Basin is a water-short system, meaning that demand for water exceeds the available supply. Sections 2.3 through 2.5 detail the surface and groundwater resources, history of water development, and the administration and over-appropriated nature of the surface water rights and groundwater resources. Throughout the Basin, water users rely on groundwater to supplement surface water supplies. Only the most senior surface water rights holders consistently receive a full water supply sufficient to meet the potential consumptive use. The majority of irrigators utilize surface water when available, but rely on groundwater or subirrigation later in the summer, when surface water supplies have decreased after the spring runoff. In general, lands with a supplemental supply of groundwater have a reasonable water supply. Many of the water users on the smaller tributary streams in the Basin do not have a supplemental groundwater supply and irrigators must rely on a relatively short period of time when water is available during the spring runoff. Many meadows and pastures without a groundwater supply are irrigated opportunistically when surface water is available, but are left without irrigation water once surface water flows recede and may not receive any water in dry years. The combination of the relatively short runoff period, Compact restriction and water rights system may provide some water

Harvesting hay in the San Luis Valley. Photo: Rio de la Vista

users with only a few days of surface water supply. The importance of a supplemental groundwater supply is further evidenced by the fact that during times of drought, the irrigated acreage of surface water only lands decreases much more sharply than lands that have access to groundwater.

Physical water shortages occur when there is less irrigation water applied to a crop than the crop could potentially consume through evaporation and evapotranspiration, the amount of water taken up by the roots and used for plant growth. This amount of water is referred to as *potential evapotranspiration*, and is met in part by natural precipitation. The amount of potential evapotranspiration not met by precipitation is called the irrigation water requirement (IWR) and represents the maximum potential consumptive use of any irrigation water applied. Deficit irrigation, which involves irrigating less than the potential consumptive use, results in some level of reduced crop yield, but is often practiced for a variety of reasons. For example, water users may wait for the beginning of an electrical billing cycle prior to using irrigation pumps in order to minimize flat-fee charges from the electrical utility for any usage within a billing cycle. Another example of deficit irrigation occurs on several ditch systems that utilize a rotating system of water delivery, where water is available to only certain portions of the ditch on a given day, and then is shifted to a different section of the ditch at other times.

Nearly half of the irrigated acreage in the Rio Grande Basin is located in the Closed Basin, an area north of the Rio Grande that has no natural stream that drains to the Rio Grande. The aquifer characteristics of the Closed Basin are described in Sections 2.3.2 and 2.5.4. Several of the large ditches that deliver water into the Closed Basin have filed for recharge decrees, which allows for appropriation of ditch losses and irrigation return flows within the Closed Basin. These recharge decrees allow irrigators under these ditches to deliver water into the aquifer via

the canal losses and on-farm recharge facilities and withdraw the water from the aquifer through wells connected to the center-pivot sprinklers. Over the past several years, the withdrawal of groundwater has exceeded the amount of water recharged into the aquifer from both manmade and natural sources. While this has allowed irrigators in the Closed Basin to provide a full water supply to their crops, it has resulted in a reduction of more than 1,200,000 AF of water stored in the unconfined aquifer since 1976 (see Figure 24) . It is important to note that only a very small fraction of the surface water available in much of the Closed Basin area is used for direct application by flooding or through a sprinkler. The vast majority is recharged and added to the aquifer storage and then pumped from wells through center-pivot sprinklers.

The State of Colorado has developed a computer model called StateCU (State Consumptive Use) to simulate the amount of potential consumptive use and the estimated actual consumptive use of crops through the Rio Grande Decision Support System (RGDSS). The RGDSS model evaluates the water needs of specific crops, considering multiple factors, including irrigated acreage, irrigation method and efficiency, soil moisture capacity, local climate, crop type and available water supply (State of Colorado, Department of Natural Resources, Water Conservation Board, and Division of Water Resources 2011). The StateCU model for the Rio Grande Basin was updated by the State in 2011 for use in the Subdistrict No. 1 Annual Replacement Plan (see Section 2.5.4). The State's model summarizes results by Water District, which do not align geographically with ditch systems, irrigation districts or the proposed groundwater management subdistricts, making comparisons to other published data challenging in some areas. The following information represents a portion of the results presented in the report associated with the 2011 StateCU model for the Rio Grande.

Table 9 tabulates results of the most recent StateCU model run through the recent drought conditions of 2000 to 2009. The table shows the potential consumptive use and actual consumptive use for the different Water Districts in the Basin. The difference between the full water supply and actual water supply is the amount of water that would have been needed to provide a full water supply. Drought conditions have prevailed through much of the 2000 to 2009 time period, including the driest year on record in 2002. Due to the drought conditions, differences between potential and actual consumptive use are larger than would occur under normal hydrologic conditions. In addition, in some areas of the Basin, subirrigation still occurs where the unconfined aquifer is shallower, such as in the Conejos River basin, and parts of the Alamosa, La Jara, Saguache and San Luis basins. The increased consumption from subirrigation is not shown in Table 8 because it is accounted for in the State's groundwater model of the Basin, not in StateCU. The amount of water consumed through subirrigation is approximately 200,000 AF. The difference between ground water withdrawals predicted by StateCU and metered ground water withdrawals can be attributed to either subirrigation or farming practices where water is not applied even if

FIGURE 38. Irrigated Acreage in Rio Grande Basin Water Districts.

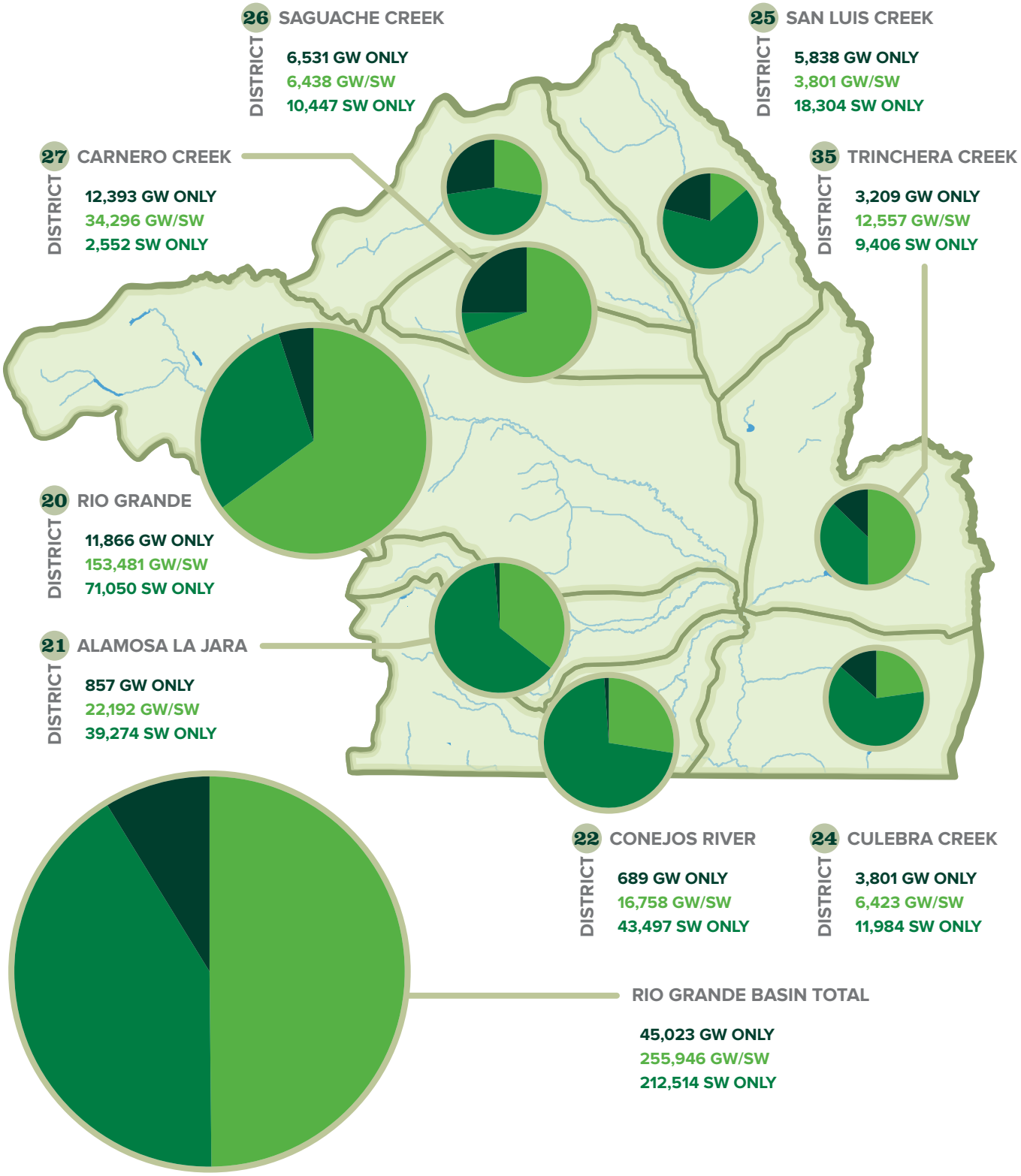
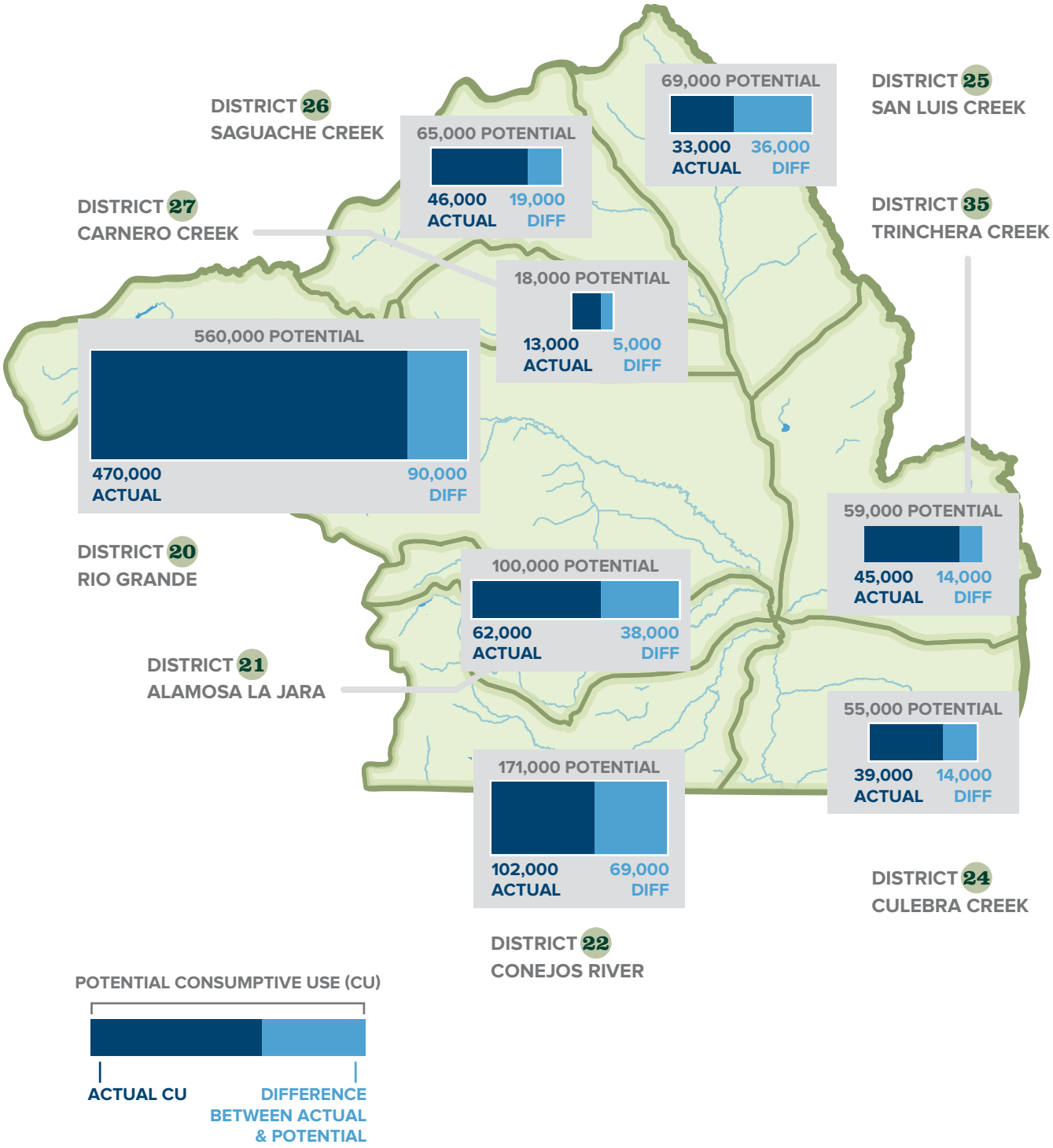


FIGURE 39.

Map of Crop Potential CU, Actual CU, and Difference for each water district.

(2000–2009 average)



there is a crop demand (e.g. drying a field out for cutting, or waiting to pump until the beginning of an electrical billing cycle). In the Conejos River basin, the 2011 StateCU model predicts an average annual ground water withdrawal of approximately 46,000 AF, but metered groundwater withdrawals in from 2009 and 2010 indicate that actual groundwater use was approximately 25,000 AF on average (Heath 2014). This indicates that up to 21,000 AF of consumptive demand from irrigated crops in the Conejos basin may be met by subirrigation.

Table 9 in the first row labeled "Closed Basin Ditches and Subdistrict 1 GW only" includes irrigated acreage located in the Closed Basin that are served by the four large Closed Basin ditch systems and Closed Basin lands irrigated with groundwater only. For the drought period of 2000 to 2009, the lands in the Closed Basin experience, on average, approximately half the water shortages compared to those in the rest of the Basin. The use of groundwater is a vitally important component in vibrant agricultural production from farms in the Closed Basin, providing a buffer against low surface water supplies, but is also in danger of being over-utilized.

TABLE 9. Average StateCU output for the Rio Grande Basin.

Showing irrigated acreage, irrigation water requirement (IWR), consumptive use (CU), and water shortage for drought conditions experienced in 2000–2009.

Region	Irrigated Acreage**	Potential Consumptive Use (AFY)	Actual Consumptive Use (AFY)	Difference (AFY)	Difference as Percentage of Potential
Closed Basin Ditches and Subdistrict 1 GW Only*	169,000	285,000	242,000	43,000	15%
Rest of District 20 (Rio Grande)	1g6,000	275,000	228,000	47,000	17%
District 21 (Alamosa/La Jara Rivers)	43,000	100,000	62,000	38,000***	38%***
District 22 (Conejos River)	70,000	171,000	102,000	69,000***	40%***
District 24 (Culebra Creek)	22,000	53,000	39,000	14,000	26%
District 25 (San Luis Creek)	29,000	69,000	33,000	36,000***	52%***
District 26 (Saguache Creek)	27,000	65,000	46,000	19,000***	29%***
District 27 (Carnero Creek)	8,000	18,000	13,000	5,000	28%
District 35 (Trinchera Creek)	29,000	59,000	45,000	14,000	24%
Total Basin	**523,000**	**1,095,000**	**810,000**	**285,000**	**26%**

* Acres grouped with the Rio Grande Canal, Farmer's Union Canal, San Luis Valley Canal, Prairie Ditch, and Subdistrict No. 1 groundwater only parcels in the most recent StateCU model.

** Irrigated acreage based on RGDSS model inputs. Excludes some wild-flood meadows and irrigated pasture because irrigation there is provided sporadically when surface supply is available

*** Subirrigation supplies a portion of the difference between potential consumptive use and actual consumptive use.

In addition to the consumptive use shown in Table 9, additional consumption of water can occur from operational losses, such as evaporation of wind-blown sprinkler irrigation water that does not reach crops, and the practice of pre-irrigating, whereby a water user will apply water to a field when there is no crop demand to aid in seed germination or increasing the soil moisture for better over-wintering of fields and pastures (Vandiver 2014).

To a large degree, the hydrology of the Basin drives the physical availability of water. In drier years, there is less water available to meet the crop requirements, and water users supplement the surface water supply with groundwater. Figure 40 shows the variability in water supply and the variability in water shortages. The figure reveals that the variability in water shortages is less than the variability in water supply, showing the importance of the aquifer system in smoothing out the water supply from year to year, providing a more reliable water supply to the crops. Water users have relied heavily on the aquifers through the current drought period, as indicated by the declining unconfined aquifer storage and confined aquifer artesian pressure shown in Figure 24 and Figure 25 (see Section 2.4.3). Water levels in and artesian pressures in the aquifers will not increase until the amount of water recharging the aquifer exceeds the withdrawals from the aquifer. Continued reduction in water stored in the aquifer may lead to further diminished well yields and/or curtailment by the State (see Section 2.5.4).

Hay bales in the San Luis Valley.
Photo: Rio de la Vista

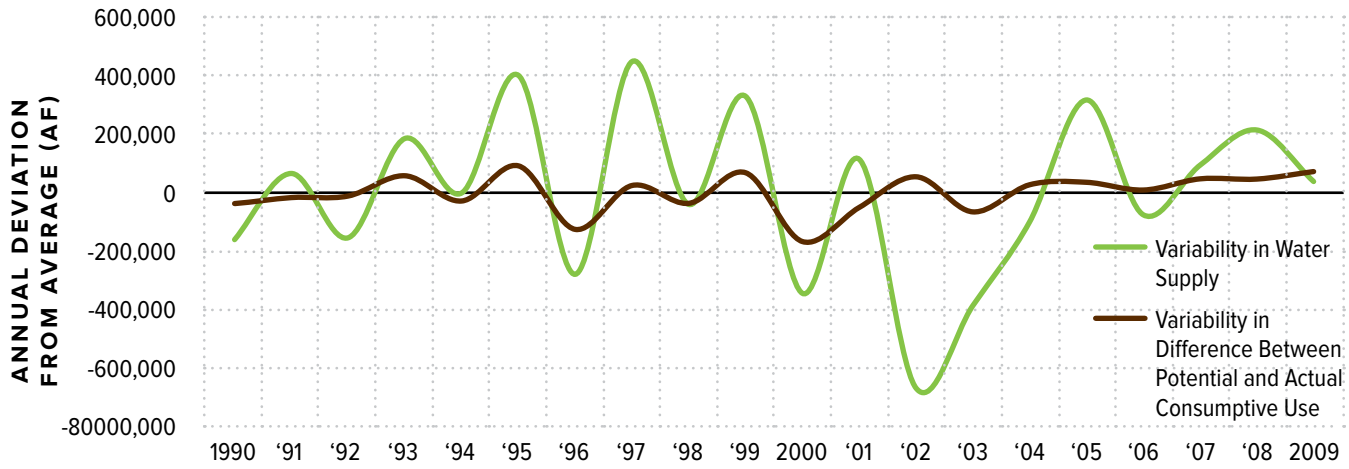
4.2.1.2 LEGAL SHORTAGES

A legal shortage of water occurs when water is physically available for use, either at a river headgate or at a well, but cannot be used because it is not legally available at that particular location and time. The most common reason for a legal shortage is the administration of the prior appropriation system of Basin water rights and obligations under the Rio Grande Compact. Water rights are satisfied in order of seniority, regardless of the location along the river. Therefore, upstream headgates may have to allow water to flow past to a downstream senior water right. This is a common scenario throughout Colorado and one not unique to the Rio Grande Basin. Since the late 1800s and early 1900s, both the Rio Grande and Conejos River have been over-appropriated streams, meaning that there are more decreed water rights than there is water in most years (see Table 7). This means that the more junior water rights can divert water only at very high flows, and may not be in priority to divert for several years. Well users are legally limited to a maximum pumping rate (e.g. 1,000 gallons per minute) and often an annual diversion amount (e.g. 500 AF), and must reduce or stop pumping if either limit is met, even if there is water physically available to be pumped at the well. The sustainability requirements of Senate Bill 04-222 may produce additional legal shortages for well users in the future (see Sections 2.4.3 and 2.5.4). Section 2.5.3 provides additional discussion on the over-appropriated nature of the Rio Grande and Conejos River and groundwater systems.

Crop circles in the San Luis Valley.
Photo: Senator Gail Schwartz

The Rio Grande Compact is unique to the Rio Grande Basin and further limits the amount of water that is legally available to water users. A more detailed discussion on the administration of the Compact is provided in Section 2.5.2. Current administration of the Compact in Colorado generally involves a complete curtailment of irrigation diversions throughout the winter for delivery to the state line. Reservoirs are allowed to store if in compliance with the provisions of the Compact. Once the spring runoff begins, a percentage of the flow is deemed unavailable for any Colorado water user so it can be delivered to the state line. This amount that must be bypassed by all water users is called the *Compact curtailment* and is determined by the Division Engineer's Office. During the irrigation season (April to October), the curtailment effectively acts as the most senior water right on the stream and causes a legal shortage of water for the calling water rights on each day.

FIGURE 40. Comparison of variability from the average index flow and Basin agricultural shortage.



Note the large variability in water supply (shown in green), and the less variability in the difference between the potential and actual consumptive use due to reliance on groundwater (shown in brown).

4.2.2 : Summary of Agricultural Needs

Based on the amount and timing of the physical water supply and legal constraints associated with the Rio Grande Compact and the legislative requirements for aquifer sustainability, the full agricultural water needs of the Basin cannot be fully satisfied with the current surface and groundwater supplies available to the Basin. Section 5 describes projected changes in hydrology that will further decrease the future available surface and groundwater supplies.

4.3 : Municipal and Industrial Needs

In 2004, the Colorado Water Conservation Board completed the Statewide Water Supply Initiative (SWSI) Phase 1 Study, which included a reconnaissance level water use forecast that evaluated water needs through 2030. Two water needs evaluated in SWSI Phase 1 included Municipal and Industrial (M&I) demand (i.e., all of the water use of a typical municipal system, including residential, commercial, industrial, irrigation and firefighting) and Self-Supplied Industrial (SSI) demand (i.e., large industrial water users that have their own water supplies or lease raw water from others).

Since the initial SWSI effort, CWCB has conducted a series of water demand updates throughout the State. In 2011, it completed the Statewide Water Supply Initiative 2010, which includes an update of SWSI M&I water use projections using an extended forecast horizon of 2050.

M&I water demands were forecast with county and statewide population projections as predictors of future growth, along with estimated rate of use in gallons per capita per day. Low, medium and high scenario population projections were developed using a forecasting process and models used by the Colorado State Demographer's Office. The SWSI 2010 Report (State of Colorado, Department of Natural Resources, Water Conservation Board 2011) indicates:

> "The Rio Grande Basin is projected to increase from approximately 50,000 people in the year 2008 to 80,000 people by the year 2050; an increase of about 60%. Agriculture was the largest basic employment sector in the Rio Grande Basin in 2007 but is expected to be slightly behind household basic sectors

San Luis Valley Brewery in the City of Alamosa. Photo: Emma Regier

by 2050. Also by 2050, the portions of mining, regional and national service, and tourism jobs compared to total jobs in the Basin are expected to increase."

The population projections by county for the Rio Grande Basin, as depicted in SWSI 2010, are shown in Table 10. Alamosa County is projected to have the highest population growth and total population in 2050, with a medium population estimate of 34,045. Mineral County is projected to remain the least populated county, with a medium growth projection for 2050 and a total population of 1,955.

TABLE 10. Rio Grande Basin population projections from SWSI 2010 report.

	2010	2020	2030	2035	2050			Average Annual Change		
County					Low	Middle	High	Low	Middle	High
Alamosa	16,776	20,374	24,112	26,128	28,390	30,727	34,045	1.28%	1.46%	1.69%
Conejos	8,615	9,446	10,039	10,265	11,076	11,744	12,470	0.55%	0.68%	0.82%
Costilla	3,552	3,847	4,083	4,184	4,575	4,868	5,158	0.49%	0.63%	0.76%
Mineral	1,026	1,153	1,213	1,228	1,369	1,621	1,955	0.80%	1.17%	1.60%
Rio Grande	12,800	14,492	15,948	16,462	17,614	19,088	20,920	0.63%	0.81%	1.01%
Saguache	7,394	8,730	9,704	10,098	11,038	11,545	12,137	1.03%	1.13%	1.24%
Total	**50,162**	**58,043**	**65,099**	**68,366**	**74,062**	**79,593**	**86,684**	**0.9%**	**1.1%**	**1.25%**

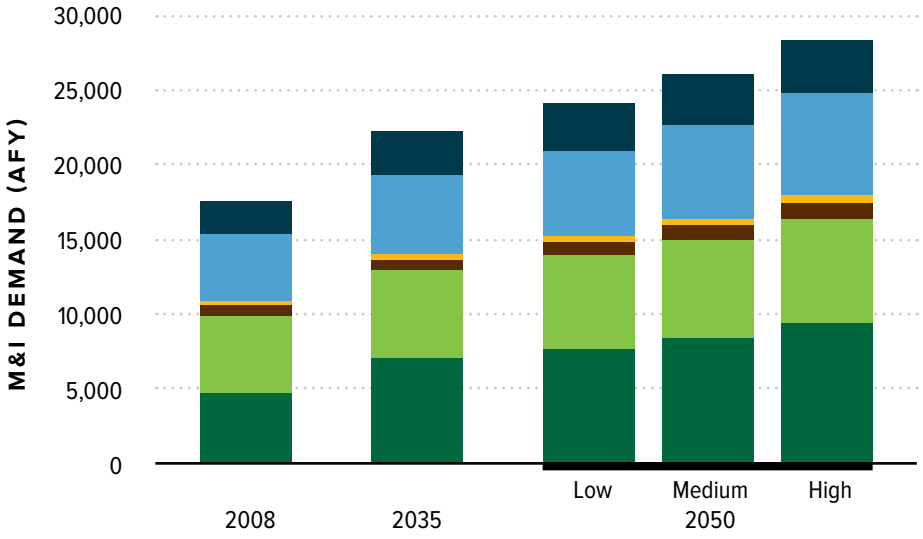
Estimated baseline per-capita water-use rates for each county were multiplied by the projected population of each county to estimate current and future municipal water demand. Figure 41 illustrates the M&I water demand projections (with passive conservation savings) for each of the counties in the Rio Grande Basin.

The Rio Grande Basin's Self-Supplied Industrial water demands, as projected in SWSI 2010, were estimated based on the potential water use related to solar power generation. At the time of the SWSI 2010 Report, some of the solar power generation technologies proposed were water-intensive, and a potential range of 1,200- to 2,000-AFY demand for solar energy development by 2050 in Alamosa County was estimated.

The total SWSI 2010 Municipal and Industrial and Self-Supplied Industrial water demands projections are shown in Figure 42. This figure shows the projected water demands (including reductions as a result of passive conservation measures) for 2035 and the 2050 low, medium and high scenarios. M&I and SSI demands in the Rio Grande Basin are expected to increase from 18,000 AFY in 2008 to up to 30,000 AFY in 2050 under the high demand scenario. This is an increase of 12,000 AFY from 2008 to 2050.

FIGURE 41.

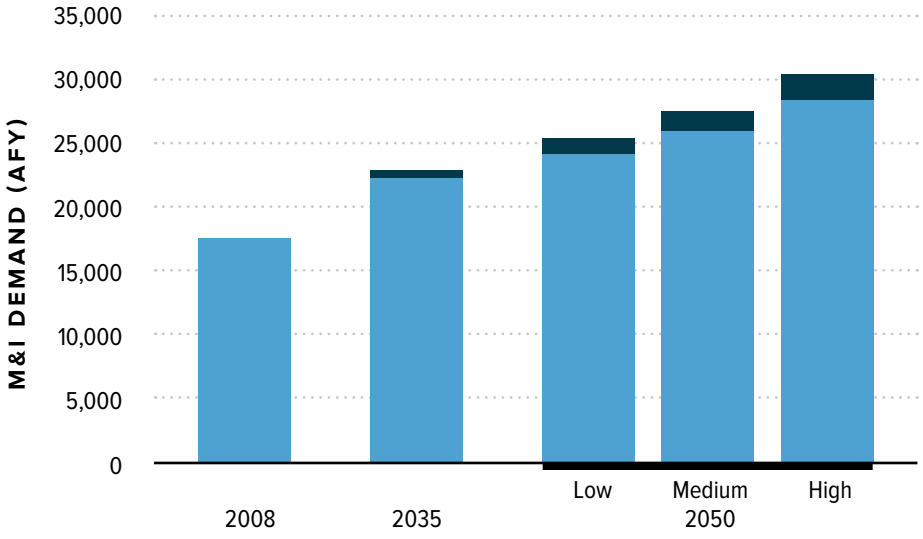
Municipal and Industrial water demands by county in the Rio Grande Basin.



Source: SWSI 2010 report, Figure 5-19

FIGURE 42.

Projected Municipal and Industrial and Self-Supplied Industrial demands in the Rio Grande Basin.



Source: SWSI 2010 report, Figure 5-21

4.3.1 : Recent Updates

The various SWSI M&I water demand projections, needs assessment and gap analysis were conducted at a statewide planning level. The SWSI effort depended upon the provision of information on water demands, supplies and future needs by individual water providers. In the Rio Grande Basin, many of the M&I water providers have a service area population of less than 1,000. Most of the Basin water providers do not have dedicated staff with the time to compile the information necessary for refined water

demand projections. The M&I Subcommittee was formed of volunteers within the Basin to assist in data collection and analysis and to provide an update to the SWSI 2010 M&I projections. The M&I Subcommittee collected updated data related to M&I and SSI water use in the Basin. The data were collected through research of existing local, state and federal data sources; a review of professional studies conducted by local consulting and engineering firms; and personal interviews with municipal clerks, council members and public works employees of the local municipalities.

This M&I update is intended to provide useful M&I data that is the first step in updating water demand projections and the M&I needs assessment. The updated data will assist the RGBRT in determining future water needs and evaluating funding priorities. The work of the M&I Subcommittee identified some of the continuing, difficult data collection challenges faced in the SWSI effort related to M&I water needs in the Rio Grande Basin.

4.3.1.1 BACKGROUND ON M&I WATER PROVIDERS

Nearly half of the residents of the Rio Grande Basin live outside of municipalities and are not served by municipal water systems. Their water use, while not part of a municipal system is important and has been included as a part of residential water use as shown in Table 11. Table 11 was developed by the M&I Subcommittee based on the 2010 census of towns and portions of counties falling within the boundaries of the Rio Grande Basin. Projections from 2010 to 2013 are based on information provided by the Colorado State Demographer's office. Although the M&I Subcommittee had different projected rates of growth through 2050, for consistency with the Colorado Water Plan, the 2050 population projections listed in SWSI 2010 have been used in this table.

As shown in Table 11, the populations of many Basin towns and of three counties had minor decreases between 2010 and 2013. There are two potential developments in Mineral County — the Wolf Creek Ski Area expansion and the commencement of a commercial silver mining/milling operation at the Bulldog Mine near Creede — that may have a dramatic effect on Mineral County population within the next 10 years. These potential effects should be considered and accounted for in projecting future residential water use.

Monte Vista Fire Department. Source: http://www.wagon-wheel-gap.freehomepage.com

4.3.1.2 ANALYSIS OF GALLONS PER CAPITA PER DAY

Detailed municipal water use in the Rio Grande Basin was updated for three of the Basin's four largest towns: Alamosa, Monte

TABLE 11. Actual and projected populations for Rio Grande Basin towns.

		2010	2013	SWSI 2050		Basin M&I Subcommittee	
County	**Municipal and Rural Residential**	**Population**	**Population**	**Pop.**	**Annual Percentage Growth Rate**	**Pop.**	**Annual Percentage Growth Rate**
Alamosa	Alamosa	8,780	9,018				
	Hooper	103	103				
	Rural Residential	6,562	6,684				
Total		**15,445**	**15,805**	**30,727**	**1.49%**	**22,800**	**1.00%**
Rio Grande	Monte Vista	4,444	4,355				
	Del Norte	1,686	1,652				
	South Fork	386	375				
	Rural Residential	5,466	5,142				
Total		**11,982**	**11,524**	**19,088**	**0.92%**	**12,200**	**0.25%**
Conejos	Manassa	991	978				
	Sanford	879	868				
	La Jara	818	808				
	Antonito	781	771				
	Romeo	404	399				
	Rural Residential	4,383	4,404				
Total		**8,256**	**8,228**	**11,744**	**0.74%**	**8,800**	**0.25%**
Saguache	Center	2,230	2,267				
	Saguache	485	496				
	Crestone	127	152				
	Moffat	116	118				
	Bonanza	16	16				
	Rural Residential	3,134	3,559				
Total		**6,108**	**6,608**	**11,545**	**1.12%**	**16,500**	**2.50%**
Costilla	San Luis	629	614				
	Blanca	385	372				
	Rural Residential	2,510	2,520				
Total		**3,524**	**3,506**	**4,868**	**0.72%**	**3,700**	**0.25%**
Mineral	Creede	290	292				
	Rural Residential	422	429				
Total		**712**	**721**	**1,621**	**1.16%**	**800**	**0.25%**
Hinsdale	Rural Residential	12	15	0		--	
Total		12	15	0		--	
Total		**46,039**	**46,407**	**79,593**	**1.12%**	**64,800**	**0.91%**
Percentage of rural residential Basin population		48.8%	48.9%				

Vista and Del Norte. Figure 43 shows the calculated gallons per capita per day for these three towns using several methods. For Del Norte, the GPCD is shown as calculated using total pumping and also based on metered use. The difference between the total water pumped and the metered water use represents unaccounted for water of 12%, which may consist of system leakage, meter inaccuracies and unmetered water use. The GPCD for the Del Norte total water use was 282, after deducting for the unaccounted for water, the total was 247. The GPCD for the Town of Monte Vista, based on total pumping was 206; after deducting the water use for the golf course, the total was 191 GPCD. The Alamosa total GPCD for 2013 was 238 GPCD. The unweighted average GPCD for these three towns, calculated on total pumping, was 242 GPCD. This is significantly less than the Basin-wide GPCD of 332 reported in SWSI Phase 1 and the GPCD of 314 reported in the SWSI 2010 update. Updated GPCD numbers were not available for the remaining towns, but are proposed to be collected as part of the next phase of the Basin Water Plan.

Due to the relative minor water use represented by municipal users, there is little pressure for water conservation as a new water supply strategy. However, as municipal water rates increase to fund needed capital improvements and provide for augmentation supplies, the response to higher rates will tend to reduce water use.

4.3.1.3 EVALUATION OF MUNICIPAL WATER AND WASTEWATER SYSTEMS AND NEEDS

The municipal water systems of 16 communities in the Basin were evaluated and municipal officials interviewed, where possible. In general,

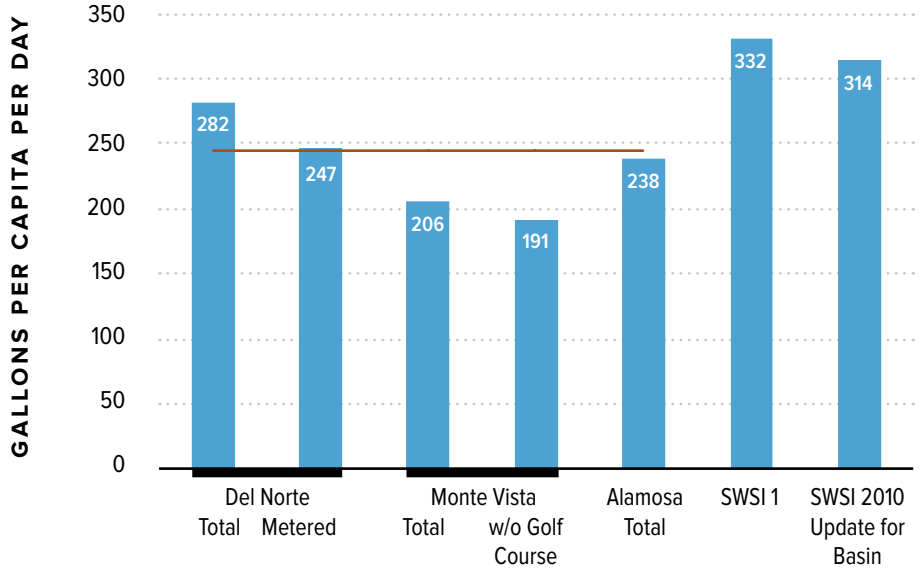


FIGURE 43.

Comparison of calculated 2013 GPCD for select San Luis Valley towns vs. values reported in the SWSI 2010 report for the Rio Grande Basin.

the municipal water systems of many of the communities are antiquated and in need of major and costly repair, replacement and/or upgrades within the next 10 years. The water quality of the wastewater discharges nominally meet current CDPHE discharge permit standards.
If new and more stringent requirements are imposed, however, few of the towns have the ability or are prepared to fund the capital improvements required to upgrade the water and wastewater systems. With the exception of the Town of Sanford, the treated water infrastructure is believed to have adequate capacity to meet the treated water demands for the foreseeable future. A few of the towns may require the development of a new well in the future.

Many of the cities and towns are either unaware of the new well augmentation requirements or struggle to comprehend and understand the impacts of the well augmentation rules. They will be required to replace their well pumping depletions to senior surface water rights that divert from surface streams. Most of the towns will face the challenge of having to acquire additional augmentation water rights and the storage and/or recharge facilities necessary to replace well pumping depletions in location, time and amount. A viable alternative for the towns will be to join the groundwater management subdistrict that has either been formed or will be formed to provide for augmentation of well pumping within the subdistrict boundaries. The requirements to provide augmentation water to multiple water subbasins as well as potentially providing physical recharge to the confined aquifer will require the towns, if acting independently, to acquire and transfer water rights, to acquire or purchase storage or recharge facilities, to replace well pumping depletions to multiple streams, including in different subbasins, and to manage the operations and reporting requirements for a well augmentation plan.

It will be important that, once well regulations or subdistrict requirements are implemented, municipalities that are currently pumping from the confined aquifer be allowed to claim return flow credit for the wastewater discharges and lawn irrigation return flows that return to the stream system. The wastewater returns are approximately 50% of the total water pumped and the lawn irrigation return flows could be as much as an additional 10%. Use of the wastewater discharges and lawn irrigation return flows as credit in a plan for augmentation would significantly reduce the water rights required to replace well pumping depletions.
The towns that were part of the survey of water needs by the M&I Subcommittee are shown in Figure 44.

FIGURE 44.

Map of water provider locations in the Rio Grande Basin.

Information, to the extent provided in the individual interviews, on the current population, current water sources, water treatment and wastewater treatment infrastructure, future infrastructure needs, water rights and ability to meet the physical and legal water needs in the future was collected for each town. Information on each town from the interviews is shown in the following summary. The information is condensed in tabular form and presented in Table 12.

Alamosa: Population 9,018: Alamosa is the largest city in the Rio Grande Basin. Water is supplied by confined aquifer wells approximately 800 to 1,200 feet depth. Infrastructure and system finances are generally in good condition. Water rights and physical supply is considered to be adequate. No additional wells are planned. Alamosa recently constructed a new water treatment facility to reduce arsenic in its groundwater supply to 10 micrograms per liter (ug/l). A major concern is if drinking water standards reduce the mandatory arsenic limit to 2 ug/l. The cost of meeting the potential reduction in the allowable arsenic limit, which is under evaluation by government regulators would have a significant impact on the ability of the city to operate and maintain its water and wastewater systems.

Monte Vista: Population 4,355: Water is supplied primarily by confined aquifer wells approximately 500 to 600 feet depth. Monte Vista also has some shallower unconfined aquifer wells. The City's municipal system experiences problems due to antiquated water transmission and distribution and sewer lines. The physical ability to meet water demand is currently adequate and no additional wells are planned in the near term. The City currently has adequate water rights for its well pumping, but will likely need to acquire additional augmentation rights under the new well augmentation rules. The City has a long-term storage lease in Rio Grande Reservoir that will help provide for meeting future augmentation requirements. There are not any identified drinking supply water quality problems, but new state nutrient regulations for streams will probably require upgrades to the wastewater treatment facility.

Center: Population 2,267: Water is supplied by confined aquifer wells approximately 500 to 600 feet depth. The Town's treated water and sewer lines are antiquated. The Town's, treated water storage tank is badly in need of replacement. The physical ability to meet water demand is currently adequate, with the exception of the treated water storage tank. The Town's water rights are likely not adequate to meet the well augmentation requirements and it will need to join Groundwater Management Subdistrict No. 1 or develop and decree its own plan for augmentation plan.

Del Norte: Population 1,652: Water is supplied by two alluvial aquifer wells approximately 120 to 140 feet depth. No issues concerning drinking water quality compliance, such as a designation of the infiltration gallery as groundwater under the direct influence of surface water have been identified. New chlorinators have been installed in the water supply

system, and the town is now engaged in a program to improve the sewer discharge lines. Del Norte has adequate physical supply for current and forecasted future needs. The Town is working on ensuring it has the necessary water rights to augment its alluvial well pumping.

Wastewater is treated in a sewage lagoon. Currently, the wastewater effluent is discharged and spread across a meadow. The Town will be able to discharge the treated effluent into the Rio Grande in the near future. There are no reported water quality problems with either the water supply or wastewater effluent.

Manassa: Population 978: Since 2000, the Town's population has declined by 5.4%. Water is supplied by two confined aquifer wells approximately 500 to 600 feet depth. Chlorine disinfection equipment is available at both wells where water is disinfected before delivery to the distribution system. The Town's physical water supply is sufficient for the foreseeable future, particularly considering the declining population trend. No water quality constituents in the treated water have been identified that exceed State regulatory requirements.

Wastewater treatment is provided by an aerated lagoon system. The treatment capacity of the system is overloaded during summer months when nearby irrigation water raises groundwater levels resulting in groundwater infiltrating into the sewage collection system pipes. The overloading condition often causes the treatment system to violate discharge standards.

Compliance with proposed State well augmentation rules will likely require an augmentation plan or joining the proposed groundwater management subdistrict for the geographic area, which is being investigated. The town owns irrigation surface water rights that have historically been used for lawn and garden irrigation. These rights may be useful in partially addressing the augmentation requirements.

Sanford: Population 868: Water supplied by two confined aquifer wells approximately 800 to 1,000 feet depth. Infrastructure is operationally sound, but about 25% of the town is not served by the treated water and wastewater system and these home owners must provide their own well for water supply and individual sewage disposal system, e.g.; septic tank. Any potential growth of the Town is on hold until adequate water infrastructure is in place. The town has identified the physical water supply for the existing and future customers that are not currently on the Town's system, and has conducted engineering studies to expand the system. The Town, however, lacks the funds to do the water and wastewater infrastructure expansion. Household water meters have not been installed, in spite of legal requirement to do so. Sewage is treated in an aerated lagoon. Water supply and effluent quality is ok, but more stringent nutrient standards will pose a problem for effluent. The Town is beginning to assess the need for acquiring and developing augmentation

water rights or joining the local groundwater management subdistrict to comply with the proposed well augmentation rules.

La Jara: Population 808: Since 2000, the Town's population has declined by 7.1%. Water is supplied by two confined aquifer wells approximately 600 to 800 feet depth. The physical water supply is adequate for the foreseeable future, particularly considering the declining population trend. No water quality constituents have been identified that exceed State regulatory requirements. Chlorine disinfection equipment is available at both wells where water treatment occurs before delivery to the distribution system.

Wastewater treatment is provided by a two-cell facultative lagoon system. Upgrade to a treatment system that would provide consistent high quality effluent is likely to be needed.

The Town is beginning to assess the need for acquiring and developing augmentation water rights or joining the local groundwater management subdistrict to comply with the proposed well augmentation rules.

Antonito: Population 771: For the last ±10 years there has been a decline in population. It is anticipated that town growth will eventually reach the County growth rate of approximately 0.25% per year.

Municipal water is supplied by one well approximately 200 feet depth and an infiltration gallery that diverts surface water from the Conejos River. The Town of Antonito water right is a surface water diversion decreed for a continuous diversion of 0.6 cfs is located approximately 2.5 miles west of the Town. The average annual withdrawal from the well during the period 2009 to 2012 is 225 acre-feet. During the same period the annual surface water diversions averaged 430 acre-feet. Provided the water sources continue production at present levels, there is not a projected need for additional supplies.

Water is disinfected with a chlorine injection system before water is delivered to the storage tank. No issues concerning water quality compliance, such as a designation of the infiltration gallery as groundwater under the direct influence of surface water with state regulatory limits have been identified. Wastewater treatment is accomplished by an aerated lagoon system.

The very senior Town of Antonito decree may be useful in developing an augmentation plan to replace depletions resulting from well withdrawals. The Town has not assessed the need for acquiring and developing augmentation water rights or joining the local groundwater management subdistrict to comply with the proposed well augmentation rules.

San Luis: Population 614: Water is supplied by two wells, 90 and 300 feet deep. The water supply and treatment system is adequate for current demand. There is not an anticipated need to expand the physical supply, but the raw and treated water lines are old and in need of repair and

improvement. The Town is currently seeking a way to upgrade its infrastructure. A previous fecal coliform problem in its treated water system was solved by installing chlorination facilities. The Town is not aware of the pending need for developing a plan for augmentation or joining a groundwater management subdistrict to replace any well pumping depletions.

Saguache: Population 496: For the last ±10 years there has been a decline in population. It is anticipated that the Town's projected growth rate will eventually conform to the County growth rate of approximately 2.5% per year.

Town of Saguache. Source: http://www.city-data.com/picfilesc/picc72095.php

The Town obtains its water supply from two confined aquifer wells approximately 500 to 600 feet depth, one located on the west side of town and the other on the east side. Average total annual diversions were 287 acre-feet.

No water quality state compliance issues concerning compliance with state regulatory limits have been identified. Recent planned improvements at the wells will include equipment to provide adequate disinfection.

Wastewater from the town is delivered to a facultative lagoon treatment system where treatment occurs with the effluent discharged to the North Branch of Saguache Creek where it is diverted by downstream surface water right owners.

The Town owns four of the seven cubic feet per second decreed to the Gotthelf Ditch No. 1 that historically delivers water to town residents for irrigation of lawns and gardens. The ditch has a priority No. 7 from Saguache Creek which is a relatively senior right that diverts its full priority in most years. It is possible that the town could change the use of this water right from irrigation to augmentation and use the transferred water to replace its depletions to the creek resulting from well withdrawals. If this change of water right is accomplished, it may partially satisfy the requirements of the anticipated State well augmentation rules.

Romeo: Population 400: Since 2000, the Town's population has increased by 6.7%. Water is supplied by one confined aquifer well approximately 400 to 500 feet depth. Chlorine disinfection equipment is available at the well where disinfection occurs before delivery to the water storage tank and distribution system. The physical water supply is marginally sufficient for the foreseeable future, but an additional well will be needed if the population growth continues. No water quality constituents have been identified that exceed State regulatory requirements.

Wastewater treatment is provided by an aerated lagoon system. There are no compliance issues reported by the Town.

The Town is beginning to assess the need for acquiring and developing augmentation water rights or joining the local groundwater management subdistrict to comply with the proposed well augmentation rules. The Town does own irrigation surface water rights that have historically been used for lawn and garden irrigation. These rights may be useful in helping to address the requirement for well augmentation.

South Fork: Population 375: Population has declined during the past ±5 years largely due to economic reasons that are unlikely to continue over the long term. There has been a significant decline in home values as a result of the 2008 economic crash and recent nearby forest fires have discouraged tourist visits. The 2007 census reported a population of 1,263 and a 2.56% per year growth rate. Future plans should recognize the likely return to the previous population growth rate.

The town does not presently provide municipal water to its residents. Existing residents are on individual wells or small privately owned water systems. The Town is actively seeking funding in the range of $3,000,000 for construction of the first stage of a municipal water supply and distribution system. A recently prepared water system preliminary feasibility study estimated there are approximately 35 privately owned water systems providing water to ±2074 subdivision lots within the town. There are also numerous individual wells. Of the 35 water systems, data collected indicated that approximately 1,014 lots are served by system wells that are included in augmentation plans. Continued supply of water to the balance of the lots not covered by a plan for augmentation will require replacement of depletions to senior surface water rights resulting from well withdrawals.

The South Fork Water and Sanitation District owns and operates a wastewater collection and treatment system that serves town residents.

Blanca: Population 372: Water is supplied by one confined well 400 feet deep. The Town has available well pumping capacity of 300 gpm and is currently only pumping 200 gpm. The water distribution system is relatively new, but distribution lines will need some upgrading to be adequate for the future. The town evaluated options for independently acquiring water rights for its own plan for augmentation and voted it was more cost effective to join the groundwater management subdistrict. The Town limits lawn watering. There are not any reported problems or concerns re water quality. Wastewater is treated in an evaporative lagoon.

Creede: Population 292: Creede obtains its municipal water from two alluvial aquifer wells. The Town has adequate water rights and water supply to provide water to the forecasted population. The Town's infrastructure is in relatively good condition, thanks to a bond-funded replacement of water supply lines that was completed in 2012. It employs

a sewage lagoon to treat sewage effluent before discharging it into the Rio Grande. There are currently no water quality problems for either supply or discharge; and none is anticipated.

At present Creede utilizes decreed non-tributary mine water discharge as augmentation for its well pumping. Mine development work at the Bulldog Mine might reduce that discharge up to 90%, in which case Creede may need to seek additional water sources for its augmentation water.

Town of Creed. Source: Will Blanchard, http://www.gottrout.com/info/creede_colorado.htm

Crestone: Population 152: Population growth has been significant since about 2000 at an annual rate of about 2%. The water supply for the municipal system is from three wells approximately 150 feet depth with two providing most of the water. 35 water services taps are connected to the Town water supply and distribution system that was constructed in 2010. The water taps serve primarily homes; however, water is provided to a school with approximately 85 students and a downtown commercial area. Approximately 35% of the Town's residents chose not to connect to the municipal system and continue to rely on old exempt wells for their water supply.

The water supply from the wells was designed to meet municipal needs for full build out within town limits with single family homes on all remaining vacant lots. Adjacent to the town lying primarily south is the Baca Grande Development that includes several subdivisions providing residential home sites and small commercial areas.

Analysis of the quality of water from the wells indicates compliance with all regulatory limits. Well water is disinfected by chlorine before water is delivered to a storage tank and then for distribution. Through an intergovernmental agreement wastewater from the town wastewater collection system is delivered to and treated by the Baca Grande wastewater treatment facility.

The ability to replace depletions to senior surface water rights resulting from operation of town wells in accordance with anticipated State well rules is a major concern of the town administration. As with many cities and towns, the well augmentation requirements have not been finalized. The Town has been actively searching for water rights that could be purchased for this purpose, but has been unsuccessful to date. A solution to this issue is very likely to be needed within one to three years when the well augmentation rules are finalized. The Town could join the local groundwater management subdistrict once it is formed.

Baca Grande Development: Baca Grande is located south of and adjacent to the Town of Crestone. Baca Grande currently provides drinking water to approximately 670 individual connections to its water distribution

TABLE 12. Summary of Water Supply, Infrastructure and Water Rights for Basin Towns

Town	Current Population (Estimate)	Sources of Physical Supply			Supply Availability		Infrastructure Assessment		Comments
		Confined Wells	Unconfined Wells	Alluvial wells/ surface water rights	Adequate Physical Supply	Adequate Legal supply	Water Treatment Infrastructure	Wastewater Treatment Infrastructure	
Alamosa	9,018	X			Yes	Yes	Good	Good	Potential arsenic rules will be costly to meet.
Monte Vista	4,355	X	X		Yes	In process	Upgrades needed	Upgrades needed	Acquired storage lease in Rio Grande to assist with augmentation. Acquiring water rights.
Center	2,267	X			Yes	In process	Upgrades needed	Upgrades needed	Evaluating individual augmentation or joining groundwater management subdistrict.
Del Norte	1,652			X	Yes	In process	Good	In process	Depletions are likely owed only to the Rio Grande.
Manassa	9,78	X			Yes	Will need plan to augment pumping depletions	Acceptable	Upgrades needed	Replacement of well pumping depletions may be required to multiple streams. Town has irrigation water rights.
Sanford	868	X			Uncertain	Assessing need to augment pumping depletions	Upgrades needed	Upgrades may be needed in the future	Replacement of well pumping depletions may be required to multiple streams. 25% of town is not served by the Town's water and wastewater system.
La Jara	808	X			Yes	Will need plan to augment pumping depletions	Acceptable	Upgrades may be needed in the future	Replacement of well pumping depletions may be required to multiple streams.
Antonito	771	X		X	Yes	Will need plan to augment pumping depletions	Acceptable	Acceptable	Replacement of well pumping depletions may be required to multiple streams. Town has senior surface rights that may be useful in replacing depletions.
San Luis	614	X				Will need plan to augment pumping depletions	Upgrades needed	Upgrades needed	
Saguache	496	X			Yes	Will need plan to augment pumping depletions	Acceptable	Acceptable	Town owns surface water rights that are used for irrigation in Town that may be useful for replacing depletions.

TABLE 12. Summary of Water Supply, Infrastructure and Water Rights for Basin Towns

Town	Current Population (Estimate)	Sources of Physical Supply: Confined Wells	Sources of Physical Supply: Unconfined Wells	Sources of Physical Supply: Alluvial wells/ surface water rights	Supply Availability: Adequate Physical Supply	Supply Availability: Adequate Legal supply	Infrastructure Assessment: Water Treatment Infrastructure	Infrastructure Assessment: Wastewater Treatment Infrastructure	Comments
Romeo	400	X			Marginal; may need additional well if growth continues	Assessing need to augment pumping depletions	Acceptable	Acceptable	Town owns surface water rights that are used for irrigation in Town that may be useful for replacing depletions.
South Fork	375			X		Some existing small system wells are augmented	Does not exist	Does not exist	Town does not have a water or sewer system, but is seeking funding to develop a system.
Blanca	372	X				Joining the groundwater management subdistrict	Recent upgrades, but additional upgrades may be needed in the future		Town limits lawn watering.
Creede	292			X	X	May need to acquire additional augmentation sources	Good	Good	Town may need to acquire additional augmentation sources if mining reduces the available nontributary supply used by the Town for augmentation.
Crestone	152	X			X	Actively seeking augmentation supplies. May join the groundwater management sub district when formed.	Good	Served by Baca Grande	Replacing depletions in the required locations is a concern. A portion of the Town decided to remain on individual wells.
Baca Grande	900	X			May need an additional well if growth continues		Distribution system needs additional repairs to address excessive leakage	Good	USFWS provides augmentation per agreement.

system. Nearly all of the connections are to residences. During the summer months there are approximately 1,200 residents and the population declines during winter months to nearly one-half of the summer population. The development has experienced a population growth rate in the range of one percent annually for the last several years.

The Development has two water supply wells approximately 150 feet depth with the Grant 18 well providing nearly the entire current supply until 2013 when revocation of the well was initiated. Well 17 has been used during this period. If past growth rates continue into the future, an additional well or wells will be needed. Average annual pumped water from well 18 for the period 2009 to 2012 was 232 acre-feet.

No water quality state compliance issues concerning compliance with state regulatory limits have been identified. Recent improvements at the well and storage tank facility include chlorination equipment to provide adequate disinfection. This recent improvement project has also focused on replacing significant portions of the water distribution system that was original constructed in approximately 1970. The Development has experienced in the recent past leakage from the distribution pipe network equal to nearly 63% of supplied water. There is an urgent need for repair of the distribution system to reduce the leakage.

Wastewater treatment is achieved with a sequential batch reactor system with little open liquid surface where evaporation could occur. The Town of Crestone is connected to the Baca Grande wastewater treatment system.

The Development has an agreement with the US Fish and Wildlife Service that owns senior surface water rights on the nearby Baca National Wildlife Refuge to provide augmentation for Development wells.

4.3.1.4 SELF-SUPPLIED INDUSTRIAL

The strength of a community's industrial sector is often the determinant of its economic success. Economic development efforts persist, striving to attract business and industry, yet the San Luis Valley lacks a significant base of industrial enterprises.

The types of industrial water use in the Basin are electric power generation, aquaculture & fisheries, oil and gas exploration and production, manufacturing of equipment or goods for sale and processing of agricultural products. Industrial water use is not anticipated to change significantly in the near term future. Water use attributable to solar electric power generation will tend to increase in the long term and water use for oil and gas is likely also to increase.

As indicated in Table 13, industrial water use in the Rio Grande Basin is a very small part of Basin water use, compared to agricultural water use. Water use associated with industrial uses is not anticipated to change significantly in the near term future.

Statistics on well pumping for commercial/industrial uses have not been kept as accurately as they have been for municipal uses. The compilation of industrial water use, combined with and modified by data from DWR records of commercial pumping, allows for a fairly accurate estimate of current industrial water demand and consumptive use. Consumptive use for self-supplied industrial uses is estimated to average 15% of the total water delivered to the industrial user.

TABLE 13.

Self-supplied industrial water use in Rio Grande Basin.

(AF)

	Total Water Use from DWR Records				Estimated Water Use	
	2009	2010	2011	2012	2013–2014 Average	2050
Fisheries and Aquaculture	7,697	7,294	6,650	6,623	6,600	7,500
Agricultural Product Processing	678	537	777	751	750	750
Solar Power Generation					200	800
Oil and Gas Development*					1.4	200
Biofuel Production					0	0
Manufacturing and Miscellaneous	0	669	488	0	300	600
Total estimated SSI Demand	8,376	8,500	7,915	7,375	7,851	9,850
Estimated Consumptive Use at 15%					1,178	1,478

* At maximum development level, this could be around 1,000 acre-feet/year

4.3.1.5 SUMMARY OF M&I AND SSI NEEDS

The combined municipal, rural residential, industrial and commercial water use, which is primarily met with confined aquifer pumping, represents a very small part of water use in the Rio Grande Basin compared to agricultural use.

The current population of the Rio Grande Basin as estimated by the M&I Subcommittee is estimated to be 46,400 and the SWSI 2010 projection is for an increase to about 79,600 in 2050, reflecting an average growth rate of approximately 1.1%. Saguache County is presently the fastest growing county and Crestone is the fastest growing town.

The towns generally report having adequate raw water delivery infrastructure to deliver the physical supply of water to meet their needs. The municipal wells in the confined aquifer generally provide good quality water, but there are water quality concerns for M&I use in certain geographic areas. As an example, the concentration of arsenic in its confined aquifer wells has been a concern for the City of Alamosa in meeting applicable state and federal drinking water regulations. The likelihood of more stringent water quality standards in the future represents a serious challenge to providers of municipal water supply and wastewater systems. Higher standards, if adopted, will place a severe financial burden on an already economically stressed region.

Municipal water use, based on figures from three of the largest towns in the San Luis Valley, is approximately 242 GPCD. This is significantly less than the Basin-wide GPCD of 332 reported in SWSI Phase 1 and the GPCD of 314 reported in the SWSI 2010 update. Updated GPCD numbers were not available for the remaining towns, but are proposed to be collected as part of the next phase of the Basin Water Plan.

The principal industrial water uses are for fisheries, aquaculture and agricultural product processing. Water for solar power generation is minimal, but it is anticipated to increase dramatically by 2050 due to increased economic interest in and anticipated rapid expansion of alternative energy production. Water use for oil and gas production is expected to remain relatively small over the next 10 years due to the combined effect of diminished oil company interest in the Basin, public concern in the San Luis Valley to protect its water resources and opposition to oil and gas development.

M&I and SSI water demand projections have not yet been recalculated from the SWSI projection of a total demand of 25,200 to 30,000 AFY. M&I water use is projected to increase with population growth, while agricultural water use is under pressure to decrease in order to reduce drawdown of the subsurface water table. As a result, M&I water use is projected to increase to about 3.0% of agricultural use by 2050.

4.4 : Environmental and Recreational Needs

4.4.1 : Summary of Process

A statewide effort to address environmental and recreational needs was initially conducted in 2007 as part of the Statewide Water Supply Initiative, Phase 2. The State effort used the term "nonconsumptive" as a term inclusive of all recreational and environmental attributes and needs. The RGBRT recognizes that many environmental attributes, such as wetlands, have a significant consumptive water use component. For example, many wetlands are integral elements of agricultural operations, such as wet meadows that are also hay fields and pastures, which are irrigated by water rights and have an associated consumptive use. In addition, a number of government agencies and conservation entities own consumptive water rights that are dedicated to environmental and recreation-based attributes in the Rio Grande Basin. As a result, the term "environmental and recreational" has been used in this Basin Water Plan when the work of the RGBRT and the Environmental and Recreational (Env & Rec) Subcommittee is referenced.

The SWSI Phase 2 effort summarized initial environmental and recreational data and programs to serve as the technical platform for the Roundtable-specific work of the Phase 1 Nonconsumptive Needs Assessment. The Phase 1 Assessment was rolled out to fulfill the legislative requirement to identify nonconsumptive needs in each basin. This process was intended to assist the RGBRT by providing mapping of environmental and recreational attributes to identify environmental and recreational focus areas where future studies and projects can be targeted. The process is described in more detail in SWSI 2010 and its appendices. Over half of the projects identified in the Phase 2 process have been completed. A table identifying all of the projects can be found in Appendix B: Environmental and Recreational Needs.

The Env & Rec Subcommittee chose to expand beyond the attributes previously identified in SWSI Phases 1 and 2 and undertake a more comprehensive approach that utilizes updated geographic information system (GIS) layers to determine where key environmental and recreation components exist, where measures are in place to protect or restore those components and where action needs to be taken. Using these methods, the subcommittee identified high priority environmental and recreational attributes that are in need of additional protection, restoration or management.

For longer-term projects and methods, the Environmental and Recreational Subcommittee will inventory, update and quantify

environmental attributes in relation to water needs. Through this process, the group will define and update maps of environmental focus areas in the Rio Grande Basin and develop strategies to address needs and sustain their attributes.

4.4.2 : Summary of Environmental and Recreational Needs

The Rio Grande Basin is water-short, which makes sustaining healthy wildlife and aquatic populations, habitats, ecosystems and associated recreation difficult. The Environmental and Recreational Subcommittee identified the needs of several ecosystems, species, recreational areas and habitats of concern in the Rio Grande Basin that will be the focus of projects and methods.

Major environmental and recreational goals and objectives are:

- Protect, preserve, and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on watershed health and ecosystem function.
- Conserve, restore, and maintain wetlands and riparian areas for the benefit of a healthy watershed.
- Protect, preserve, and enhance terrestrial and aquatic wildlife habitats.
- Work to establish active river flows throughout the year, in cooperation with water users and administrators to restore and sustain ecological function of the rivers and floodplain habitats within the existing context of water rights and compact obligations.
- Maintain and enhance water dependent recreational activities.

4.4.2.1 WATERSHED HEALTH AND ECOSYTEM FUNCTIONS

The Upper Rio Grande Basin is a critical water supply basin for downstream water users, outstanding habitat and great recreation. As such, the need exists to improve the resistance to and resiliency from disturbances to ecosystem functions. This includes improving resiliency of forest ecosystems in the RGNF following fires and current beetle and disease outbreaks. Resistance can be added into the system by: improving the amount of varied stand classes in forests, which leads to a patchwork of life stages across the landscape and provides a buffer against total stand impacts; identifying areas where risks to critical values, such as reservoirs and infrastructure, cultural resources and key natural resources, can be reduced or mitigated; restoring ecosystem functions, such as nutrient cycling and providing habitat, through forest and riparian restoration projects. Additional discussion about factors impacting watershed health and opportunities to address those factors are discussed in the Constraints and Opportunities Section.

4.4.2.2 RIPARIAN NEEDS

Section 2.6.4 described the value of riparian areas and a brief overview of the work being done to protect and restore key drainages in the Basin. Many riparian areas in the Basin are in need of additional efforts to improve and safeguard the critical ecosystem functions they provide. The Rio Grande Headwaters Restoration Project 2001 Study, 2007 Strategic Watershed Restoration Plan, Alamosa River Watershed Plan and Willow Creek Restoration Plan highlighted needed projects in key riparian systems in the Valley.

One of the greatest causes of degradation to riparian areas in the Rio Grande Basin is heightened streambank erosion due to loss of anchoring vegetation, land management and changes in hydrology. While erosion and deposition are natural, necessary riparian processes, higher than normal rates of erosion result in loss of upland habitat and riparian shading, degraded water quality and aquatic habitat, reduced water transport capacity, risk to irrigation and domestic structures and loss of floodplain connectivity.

As such, riparian stabilization projects are needed to maintain and improve riparian habitat, conveyance, stability and floodplain function. Riparian stabilization often involves improvements to aquatic habitat through improved pools, riffles and runs. Terrestrial habitat is also improved through increased quantity and quality of streambank cottonwood and willow forests. Reconnecting the floodplain allows for

Erosion along streambanks in the Rio Grande Basin. Photo: Heather Dutton

overbank events to support riparian wetlands and build in flood resiliency. Finally, improved stability in river reaches reduces maintenance of agriculture diversions and protects structures during flood events.

Other significant needs are improvements to water quality that is impaired from historic mining. Willow Creek, Kerber Creek and the Alamosa River continue to experience impacts from mining runoff, which impacts habitat, recreation and agriculture users. It is important that the groups' efforts to address these impacts are supported.

Finally, the need exists to improve aging and poorly functioning agriculture diversions and headgates. Many structures have outlived their engineered life, or were never engineered. A significant amount of diversion dams are push up dams, meaning the ditch companies incur high maintenance costs and have to use heavy equipment annually to maintain their dams. These actions impact the fisheries, riparian areas, recreation, Compact administration and diversion efficiency. As such, projects to improve agriculture infrastructure can have significant benefits to multiple users and need to be actively pursued.

4.4.2.3 WETLAND NEEDS

As discussed in Section 2.6.6, the wetlands of the Rio Grande Basin provide extraordinary resources for many species, habitats and water users. As such, there is a great need to improve wetland conditions. Wetland and riparian hydrologic regimes are closely tied to climatic conditions, geomorphic features, soil types and vegetation distribution. Wetland systems require flood and drought in order to maintain the health, quality and diversity of the wetland. Historically, flood events associated with high river flows would deposit and scour sediment from various locations within the active river channel and adjacent wetlands. Monsoonal rains in the late summer provided water to temporary wetlands and helped maintain typically groundwater driven playa lakes. Mimicking wet and dry cycles is a significant factor in the sustainability of all wetland types. Therefore, wetlands can be improved through irrigation that incorporates periods of flooding and drought to mimic natural processes that no longer occur due to extensive alterations to the ecosystem.

Wetland and riparian conservation efforts have occurred throughout the Valley for decades. Given drought conditions and declines in the aquifers, further conservation is necessary to maintain available resources and sustain wildlife populations that depend upon these habitats for some or all of their life cycles. Future efforts must be multi-faceted to protect a variety of wetland types on private and public lands. In order to develop comprehensive conservation efforts, there is a wide range of information that is needed to accurately assess limiting factors to providing healthy habitats that are available at appropriate times of the year for various species. Specific needs to address how these systems function and methods for restoration include:

- How water tables function within wetland complexes
- Subsurface and surface connectivity between historic and current drainage pathways of creeks and rivers along with adjacent floodplain wetlands
- How water table fluctuations in cottonwood galleries may affect regeneration
- How past and present management practices influence current vegetation communities and restoration efforts
- Use of wetland complexes by migratory species throughout the SLV in drought or wet conditions.

Additionally, Environmental and Recreation Subcommittee members suggested the need to complete a recharge study within publicly owned wetland complexes documenting water table fluctuations over the long-term in regard to surface and groundwater irrigation practices; complete the Rio Grande Functional Wetland project Annual wetland water management plan among natural resource agencies for the SLV; monitor wetland and riparian conservation projects to document changes over time in relation to habitat and wildlife population use.

4.4.2.4 HABITAT NEEDS FOR INDICATOR SPECIES

Because over 75% of species in Colorado depend on riparian areas or wetlands, this Plan recognizes that addressing the water and habitat needs of some specific species will inherently address the needs of many others. As such, projects that benefit threatened, endangered, candidate or indicator species will have high value toward improving environmental attributes. While many of the needs discussed above in Riparian Needs and Wetland Needs will improve habitat for indicator species, the Environmental and Recreation Subcommittee felt it was important to discuss specific species' needs.

Early morning greater sandhill cranes on the Monte Vista National Wildlife Refuge. Photo: Rio de la Vista

4.4.2.4.1 THREATENED, ENDANGERED, CANDIDATE AND INDICATOR SPECIES

Bird Species at Risk

The San Luis Valley lies in the Southern Rockies/Colorado Plateau Bird Conservation Region #16 and contains numerous wetland complexes that support a variety of bird species throughout their annual cycle. Past estimates indicate approximately 200,000 acres of nationally and internationally important wetlands in the area, much of which is sustained by the Valley's underlying aquifers and/or irrigation for agricultural and/or wildlife purposes. An updated analysis of the extent, condition and trend of the SLV's wetlands is an identified need, which will assist in evaluating water needs for the long-term sustainability of key habitat areas.

The Intermountain West Joint Venture (IWJV) is a significant partner in conservation and science efforts for bird species throughout its 11 state regions, including Western Colorado and the SLV. The IWJV considers the SLV to be one of its 20 important landscapes (Intermountain West Joint Venture n.d.) and has documented 30 of 40 listed priority species within the SLV, most of which are wetland-dependent during some or all of their life cycle events. For example, the SLV is considered the most significant waterbird production area in Colorado with more than 200 nesting pairs of white-faced ibis (an IWJV priority species). Wetland complexes coupled with the SLV's extensive agricultural grain production support the entire Rocky Mountain population of greater sandhill cranes (another IWJV priority species) during spring and fall migration, a total of approximately 20,000 birds at goal levels as defined in the Pacific and Central Flyway's Sandhill Crane RMP Management Plan (Intermountain West Joint Venture n.d.). The Blanca Wetland Management Area is one of the most important shorebird migration areas in the Intermountain West and has been designated as one of the IWJV's 18 Shorebird Key Sites. Specifically, this area supports the largest breeding population of western snowy plover (a State Species of Concern) in the state of Colorado annually nesting in the saline playa wetlands, plus up to 27,000 Wilson's phalarope utilizing the area for breeding as well as spring and fall migration.

The following bird species are currently listed as endangered or threatened by state or federal agencies, or are "proposed" for listing as "candidate species" or as "species of concern": the southwestern willow flycatcher, yellow-billed cuckoo, sage thrasher, snowy plover and Gunnison sage grouse. The SLV provides important habitat for these species for which significant associated water needs exist in order to sustain thriving populations. See Appendix B: Environmental and Recreational Needs for more in-depth information about these species and their recovery plans.

Southwestern willow flycatcher: These neo-tropical migrants occur in the SLV at the northern portion of their breeding range, along riparian areas, predominantly on the Rio Grande and Conejos River. The San Luis Valley Regional Habitat Conservation Plan has been developed for the SLV and critical habitat designated in the lower portion of the Rio Grande in Colorado, and on the Conejos River on BLM's McIntire-Simpson property. Current water table declines and conversion of riparian areas for other uses have limited quality habitat as willows associated with some cottonwood and standing water through late July are required for successful nesting.

Yellow-billed cuckoo: These neo-tropical migrants are fairly secretive and occur in the SLV along riparian areas on the Rio Grande and Conejos River. The Habitat Conservation Plan also incorporates habitat needs for this species. Typically, this species requires a cottonwood over story, with some understory and available water. The yellow-billed cuckoo has been proposed for federal listing with a listing decision by the USFWS due in September 2014. Only a few surveys have been conducted on BLM lands; future surveys are needed to fully understand the extent of this population in the SLV and to clearly define habitat needs.

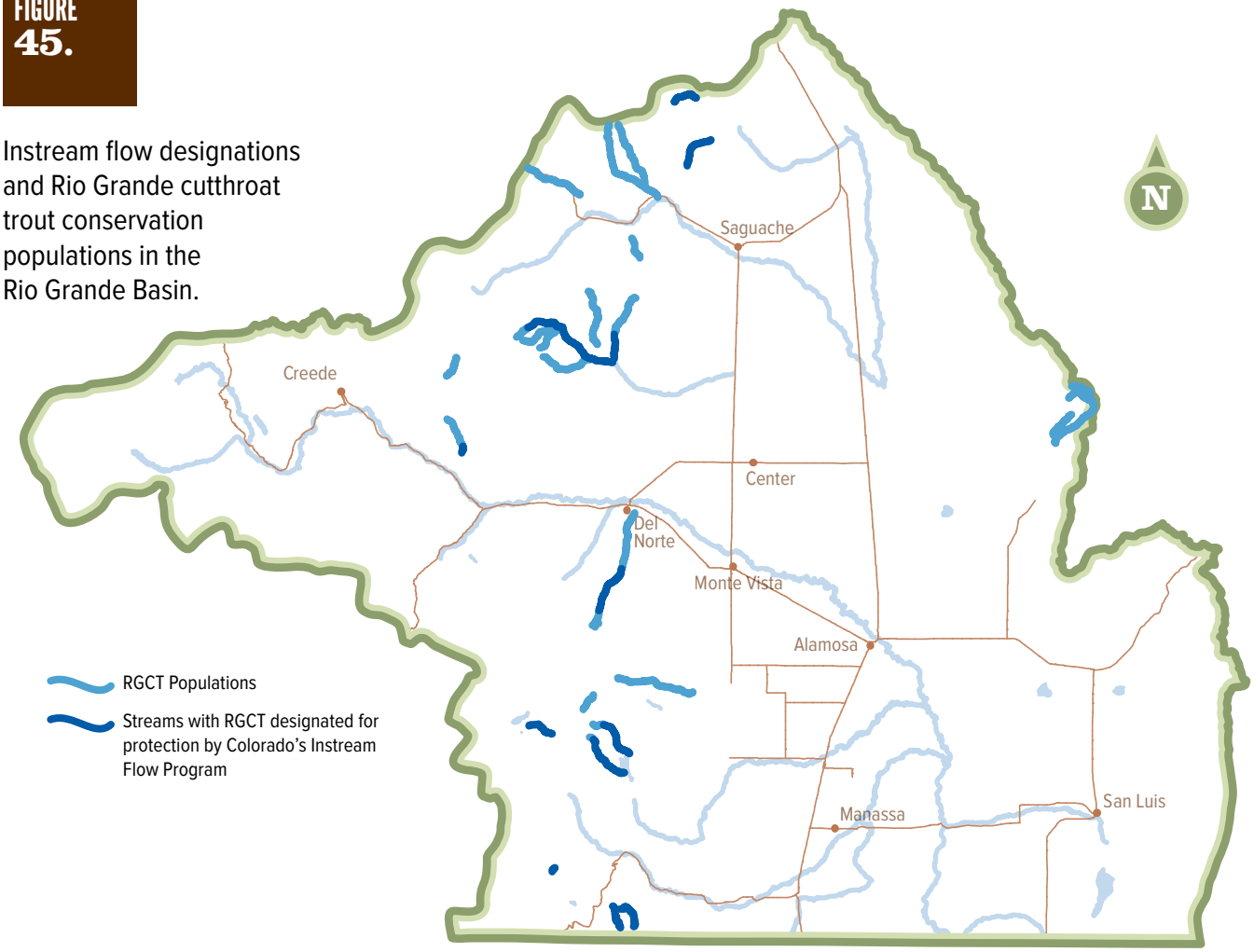
Sage thrasher: The sage thrasher relies on large expanses of sagebrush steppe for successful breeding; it is recognized by Canada and several U.S. state agencies as a sensitive species and is a Colorado State Species of Concern. The sage thrasher and the Brewer's sparrow are IWJV Priority Species that can be found throughout the SLV in healthy greasewood and sagebrush habitat. To maintain populations of sage thrasher, it is important to protect and maintain extensive, intact shrub-steppe habitats and to rehabilitate sagebrush habitats that have been lost, fragmented or degraded. Loss of wet meadow habitat is of particular concern as it affects sage thrasher populations. In addition, it is essential to understand the impacts of habitat alteration on local and range-wide sage thrasher populations.

Fish Species at Risk

Rio Grande cutthroat trout: The primary causes for the decline of RGCT are habitat loss, competition with non-native species of fish, persistent drought, wildfire, climate change and disease. While the historic distribution of RGCT existed in the main stem of the Rio Grande and its tributaries in higher elevations, RGCT "conservation populations" occur in limited, high-elevation tributary waters only within the Rio Grande Basin (RGCT Conservation Team 2013). The RGCT has been a candidate for listing under the federal Endangered Species Act since 2008. The RGCT is classified as a "species of special concern" in Colorado and a "candidate species" by the USFWS. RGCT habitat protection and fish restoration projects have occurred on both public and private lands throughout its current range in the Rio Grande Basin. In addition, the only existing wild-run, spawn-take for RGCT that is available occurs at Haypress Lake on private land in the Basin. For nearly 20 years, the private landowners of Haypress Lake have been instrumental in allowing for RGCT spawn-taking operations by CPW that has served RGCT

FIGURE 45.

Instream flow designations and Rio Grande cutthroat trout conservation populations in the Rio Grande Basin.

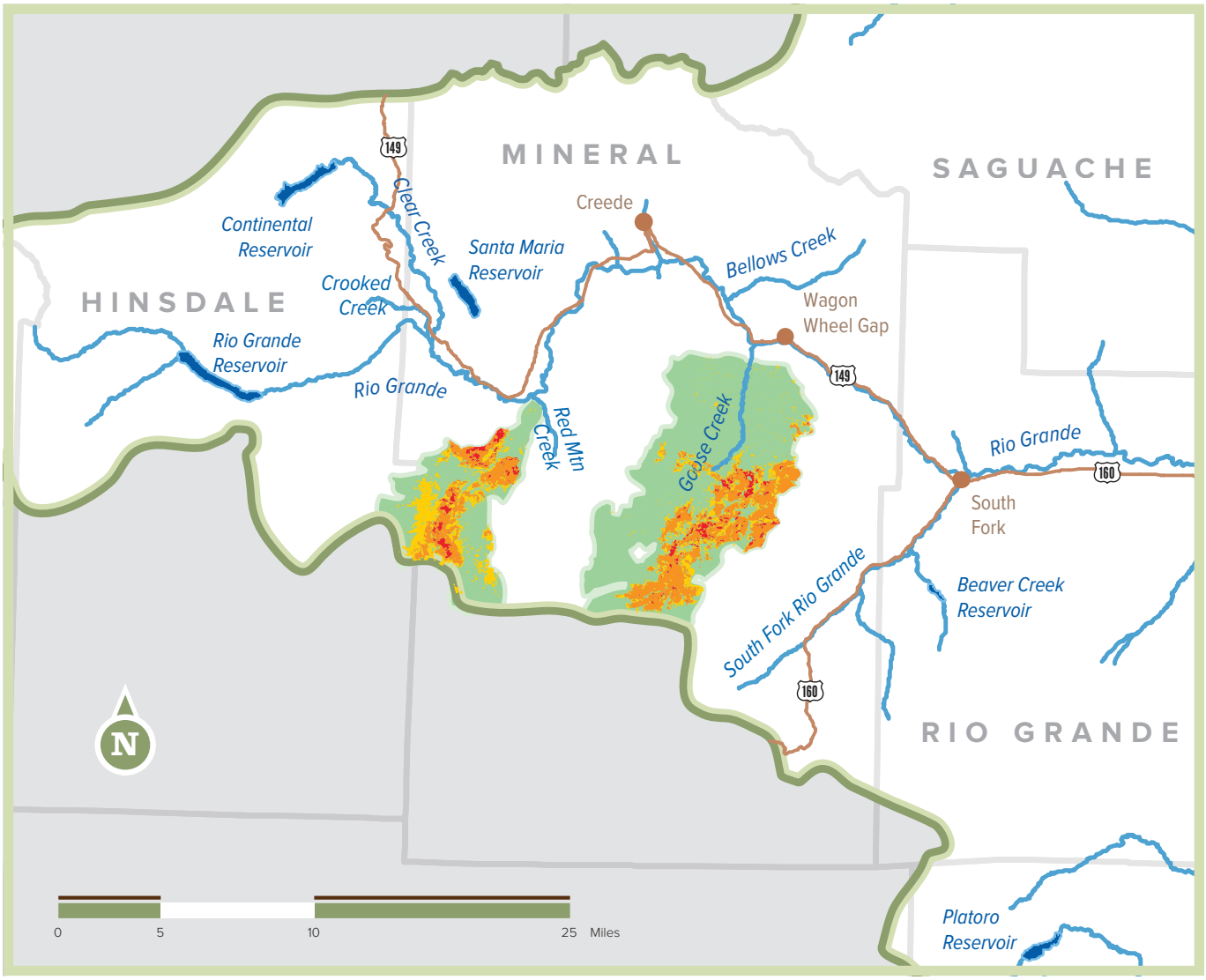


Spawning Rio Grande cutthroat trout at Haypress Lake on Humphreys Ranch, high in the Goose Creek corridor. Photo: Rio de la Vista

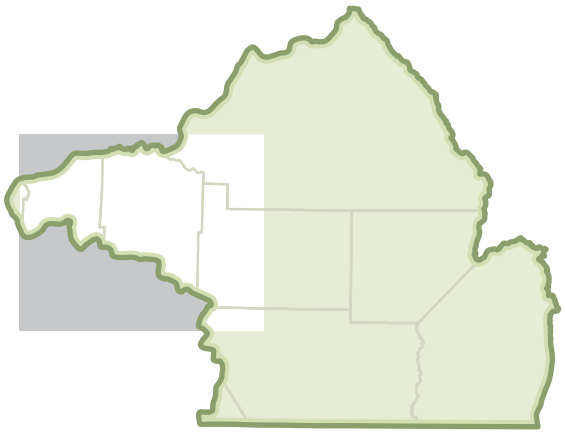
stocking efforts throughout its native range. Currently, Haypress Lake is in need of dam repair that is essential for this operation to continue into the future. Instream flows and other protections are important for RGCT habitat. Below, Figure 45 shows a map of the Rio Grande conservation populations and the CWCB-decreed instream flow protections. As can be seen, additional protected stream miles could be beneficial to the RGCT.

Rio Grande chub: The Rio Grande chub is considered a sensitive species within the U.S. Forest Service (USFS), Rocky Mountain Region (Region 2). Native populations of this species in Region 2 occur on the Rio Grande National Forest within the Rio Grande Basin of Colorado. Rio Grande chub populations in Colorado have been reduced from historic levels. The species has likely been extirpated from the main stem Rio Grande and is now found only in tributary streams. The primary threats to the Rio Grande chub generally result from anthropogenic (human-caused) events. Water diversion projects have resulted in flow regime changes in both tributary and main stem rivers and streams. Construction of diversion dams and reservoirs have degraded and fragmented habitats and caused passage barriers. The introduction of non-native species has increased predation of and competition with the Rio Grande chub. Other threats to this species include land use changes and local development and excessive grazing in riparian zones, which reduce the natural stream ecosystem function (Rees et al. 2005).

FIGURE 46. Boreal toad habitat impacted by the West Fork Complex Fire.



Burned Areas (low)
Burned Areas (moderate)
Burned Areas (high)
Boreal Toad Habitat



Rio Grande sucker: In November 1993, the Colorado Wildlife Commission passed a regulation that designated the Rio Grande sucker as an endangered fish in Colorado. This regulation was based in part on the rarity of the species in the state. Rio Grande sucker are not listed as federally threatened or endangered by the USFWS. The Commission directed the Division of Wildlife to identify actions needed to ensure the long-term survival of this fish in Colorado. Additional studies of the life history and ecology of the Rio Grande sucker have provided important information for understanding the reason for its decline to endangered status. One of the primary contributors is that interaction with non-native fishes in degraded habitats has lowered population viability (Langlois et al. 1994).

Amphibian Species at Risk

Boreal toad: Once common in montane habitats between 7,000–12,000 feet in the Southern Rocky Mountains, the boreal toad has experienced dramatic population declines over the past two decades. The boreal toad has been listed as an endangered species by Colorado since 1933. Pursuant to this listing, Colorado Division of Wildlife (CPW) developed a recovery plan for the boreal toad in 1994, and an interagency recovery team was formed that same year. In 1998, the existing recovery plan was updated and combined with an existing draft conservation strategy to create a comprehensive Boreal Toad Conservation Plan for the Southern Rocky Mountains. As part of the conservation planning process, conservation agreements have been signed by eight state and federal agencies, and by the Colorado Natural Heritage Program, outlining and confirming respective roles in implementing the Conservation Plan. A revised and updated version of the Boreal Toad Conservation Plan was completed in 2001 (Boreal Toad Recovery Team and Technical Advisory Group 2001).

Due to the 2013 West Fork Complex Fire in the upper Rio Grande Basin, boreal toad habitat may have been impacted, as seen in Figure 46 below. Recovery and regeneration of the boreal toad habitat is inextricably tied with forest recovery and will require overall and brood-rearing habitat protection on public lands as well private lands where boreal toads occur.

4.4.2.4.2 OTHER RARE, KEY OR REPRESENTATIVE SPECIES

Other wildlife species that occur in the Rio Grande Basin that are considered key or indicator species relying upon wetland and riparian habitat for some or all of their life cycle events are discussed in the section

below. See Appendix B: Environmental and Recreational Needs for more in-depth information about these species.

Bird Species

Greater sandhill crane: The greater sandhill crane utilizes a variety of wetland and riparian habitat types, along with agricultural crops, during their spring and fall migration. In addition to this species' importance as an indicator for wetland extent and health as well as availability of water to agricultural areas throughout the SLV, the crane is an important socio-economic attraction for tourists and birders, with an annual Crane Festival held in Monte Vista that attracts people from across Colorado and beyond. Early spring water resources (prior to the irrigation season) are essential to providing the appropriate conditions for these birds and other species during spring migration as they begin to arrive in February, utilizing open water areas as they slowly melt or as water is applied through wells in wetland areas. Climate variability and prolonged drought may threaten the early spring water resources that sandhill crane depend on.

White-faced ibis: The white-faced ibis is a North American Wetlands Conservation Act (NAWCA) and IWJV priority species. Ibis colonies declined throughout the 1960s and 1970s potentially due to exposure to the pesticide DDT in Mexico while wintering there. Large colonies occur at the Russell Lakes State Wildlife Area and at the Alamosa and Monte Vista national wildlife refuges, with other smaller colonies located on other public wetland complexes, making the SLV the most significant breeding area in Colorado (State of Colorado, Department of Natural Resources, Division of Parks and Wildlife, n.d. "Natural Diversity Information Source: White-Faced Ibis"). Habitats comprise freshwater marshes, including tall emergent and open water areas, short emergent and seasonal wetlands, and wet meadows. Protecting the wetland complexes, wildlife refuges and wet meadows that the ibis depends on is an important factor in helping ibis populations rebound in the SLV.

Western snowy plover: The western snowy plover is on the National Watch List, indicating a high conservation need both locally and throughout its range. Fewer than 100 pairs of snowy plovers nest in Colorado. Snowy plovers' nest sites and breeding success are sensitive to water levels, which are subject to management for irrigation and other uses. Due to its small numbers and limited range, this species is not monitored by the CPW; however, it has been monitored at BLM's Blanca Wetland for over 10 years. Blanca Wetlands has supported the highest breeding numbers in the state, with up to 140 individuals reported. Breeding numbers have declined substantially at Blanca Wetlands over the past 5 years.

Bald eagle and golden eagle: Bald eagles are of special state concern according to CPW. Within the Rio Grande Basin, bald eagles have a large range of habitat, but only two permanent nesting sites, located near North Clear Creek in the headwaters of the Rio Grande. Bald and golden eagles winter throughout the SLV from December through March. Mid-winter

eagle surveys have been conducted for decades and are used as an indicator of population stability. Mid-winter waterfowl surveys also provide a coincidental opportunity to document locations of eagles throughout the SLV annually. Typically, bald eagles select areas near and adjacent to open water where waterfowl congregate or fish populations are accessible. Availability of open water areas varies annually, dependent upon climatic conditions and wetland management on public lands. Throughout the SLV, some areas remain open within the active channels of the Rio Grande and Conejos River, as well as San Antonio, Trinchera and Culebra creeks. In addition, adjudicated state and federal wells provide some open water areas on the Monte Vista National Wildlife Refuge, Alamosa National Wildlife Refuge, Russell Lakes Sate Wildlife Area and Rio Grande State Wildlife Area. However, changes in well administration and depletions in artesian groundwater wells have decreased the number and location of available open areas during the winter.

Wintering bald eagle in a cottonwood, along the Rio Grande south of Alamosa. Photo: Rio de la Vista

Amphibian Species

Northern leopard frog: The northern leopard frog is a Colorado state species of special concern**.** Typical habitats for northern leopard frogs in Colorado (below 8,000 feet) include wet meadows, marshes, shallow wetlands, beaver ponds, depressional wetlands, deep-water wetlands, reservoirs, irrigation ditches and along the banks of streams and rivers. Usually leopard frogs are found at the water's edge or in the shallows. Some vegetation along shorelines is necessary to use as cover to protect them from predation. Leopard frogs hibernate in the mud, gravel, sand or similar substrate under a body of water, such as a pond or stream. Reasons for their decline include the introduction of predators, such as the bullfrog and several fish species, along with a reduction in semipermanent wetlands, including fluctuations in water regimes in managed wetland complexes, water table declines, conversion of wetlands to agricultural lands and drought conditions (Hammerson 1999).

Rare Plants

Slender spiderflower: The slender spiderflower is an annual herb that occurs in saline and alkaline soils, commonly associated with wet meadow species, such as inland saltgrass. This species has been classified by the Colorado Natural Heritage Program (CNHP) as globally imperiled and is listed as state-imperiled in Colorado. The spiderflower may be found in wetlands that are shallowly flooded early in the spring but are commonly saturated and not flooded throughout most of the growing season. Typical wetland locations throughout the SLV include meadows, shorelines of ponds and playas, and old lakebeds. The plant also occurs in transition areas from shorelines or wet meadows into greasewood areas. The Baca National Wildlife Refuge, Monte Vista National Wildlife Refuge, Blanca Wetland Management Area and Russell Lakes State Wildlife Area represent several public wetland complexes where this species exists in the SLV. The density of these plants and the amount of ground they cover may shift annually due to climate and wetland management regimes. Available habitat has decreased over time as a result of development in wetland areas that shifts hydrologic regimes, causing the conversion of vegetation communities, or habitat has been altered for agricultural production or expansion of municipalities.

Rare Mammals

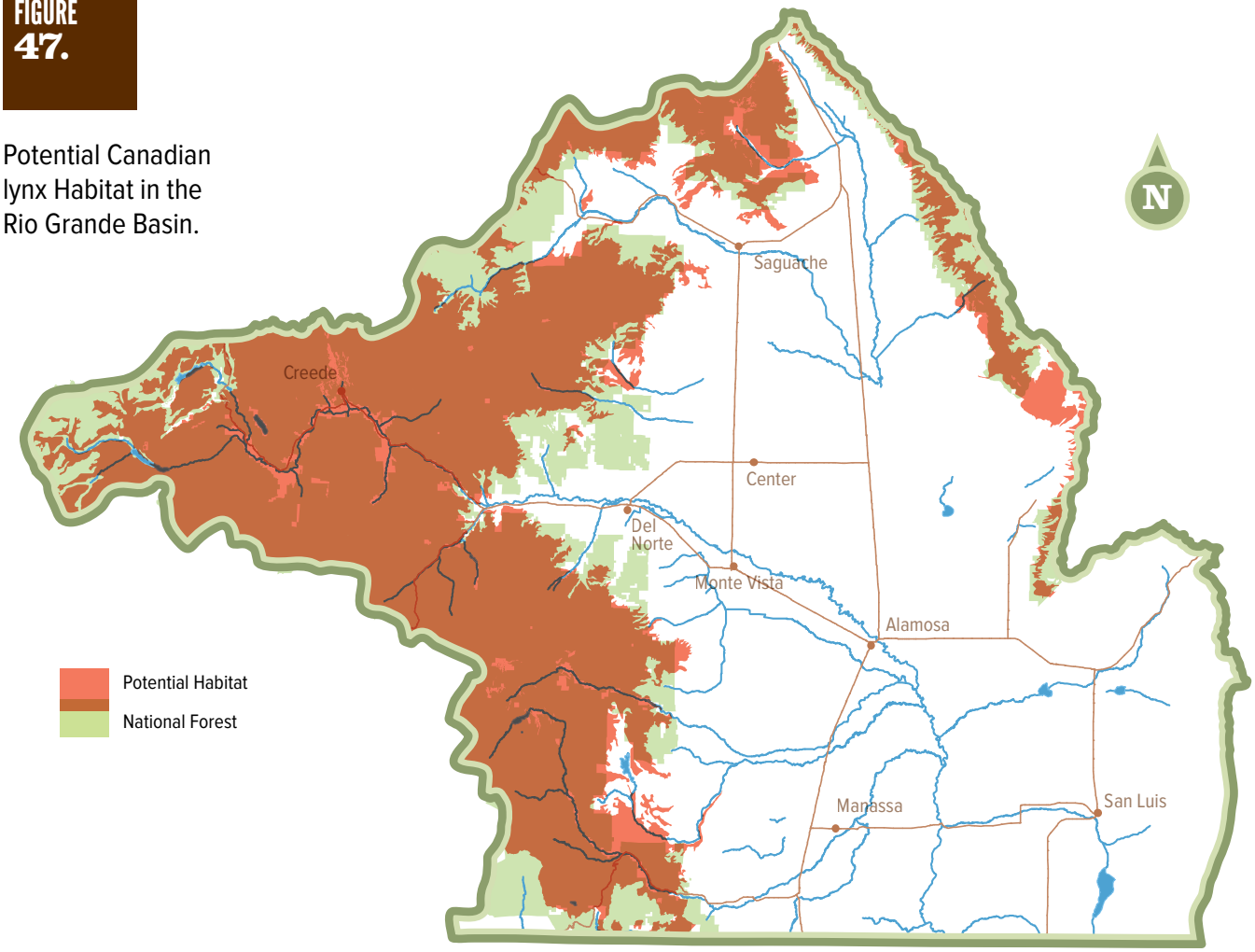
Canada lynx: Canada lynx were reintroduced into the Rio Grande Basin beginning in the early 1990s by CPW. The potential habitat for this species, which is federally threatened and Colorado state endangered, covers much of the Rio Grande National Forest, as seen in Figure 47 below. The Rio Grande Basin lies in the center of the Core Conservation Area (defined by Wildlife Commission Regulation and in the Recovery Plan) for Canada lynx. Healthy forests and watersheds are an important element for quality lynx habitat. The ongoing beetle infestation, as well as the West Fork Complex fire of 2013, has impacted important forest and watershed habitats for lynx. Lynx rely on the forests for hiding, and for thermal and foraging cover. Additionally, the primary food source for lynx is the snowshoe hare, with squirrels and other small woodland mammals as a secondary food source — all of which are closely associated with healthy forests. The extent of these impacts to lynx habitat and its primary food sources is unknown. Therefore, the Rio Grande National

Forest, in conjunction with CPW and possibly the Rio Grande Watershed Emergency Action Coordination Team (RWEACT), plan to conduct a post-wildfire, lynx habitat condition study to begin within the next year to assess the level of impact that has occurred from these stochastic environmental events. In addition, the Rio Grande National Forest Plan is slated for revision in the coming months. Lynx conservation, habitat restoration and protection strategies will be further discussed during the revision that will consider forest and watershed health.

River otter: River otters were quite common in the 1800s, and probably occurred in major streams statewide in Colorado, although they apparently have never been abundant. With settlement, subsequent water pollution and control of streamflows, otters disappeared from the state by the early part of the 1900s. In the 1970s, however, the Colorado

FIGURE 47.

Potential Canadian lynx Habitat in the Rio Grande Basin.



Parks and Wildlife began to release otters and restore populations to several drainages, including the Upper Colorado, the Dolores, Piedra and the upper South Platte rivers. According to Area Wildlife Manager Rick Basagoitia, otters have been seen recently along the Rio Grande: "We do have otters on the valley floor and all along the river up to and likely above Creede. We are in a unique location in that otters were released years ago in the Piedra drainage on the Durango side, as well as in New Mexico just a few years ago. We are seeing otters here that likely came from one or both of those areas, and they seem to be staying and making a living here."

4.4.2.4.3 OPPORTUNITIES FOR SPECIES RECOVERY SUPPORT

Aquatic Species Restoration

The Colorado Parks and Wildlife's John W. Mumma Native Aquatic Species Restoration Facility (NASRF), located near Alamosa, is the only state-run facility in the nation specifically designed and built to raise threatened and endangered fish, amphibians and mollusk species. Dedicated in June 2000, the NASRF has had a great deal of success with threatened and endangered fish species, as well as various species that are of special concern to Colorado. The NASRF has boreal toads and 12 species of fish, including three Colorado River species federally listed as endangered. As many of these species have never been raised in aquaculture and bring unique challenges to typical aquaculture procedures, it is vital that the water supplies for this unique facility be maintained. Similar to all wells in the SLV, the high capacity wells that supply this facility are in need of augmentation plans or participation in a groundwater management subdistrict.

4.4.2.5 RECREATIONAL NEEDS — ENSURE PROTECTIONS, RESTORATION, WATER AND ENHANCEMENT OF FACILITIES

As discussed in Section 2.6.9, a wide variety of recreational activities exist in the Rio Grande Basin. The Environmental and Recreational Subcommittee identified needs to improve the amount and quality of recreation opportunities. Studies on the Rio Grande and Conejos River are needed to gather information about optimal recreational flows, timing of different types of recreation (i.e., white-water boating, float fishing and wading fishing) during different flows and late-season recreation developments.

As noted in the Riparian Needs Section, projects that improve irrigation infrastructure can also improve recreation opportunities, through the addition of boat and fish passages. Boat passages should be supported by the surrounding community and be part of a larger recreation plan. Fish passage should be added with consultation from CPW as fish barriers are needed in some locations. These multi-faceted projects are greatly needed in the Rio Grande Basin.

Finally, projects that improve riparian and aquatic habitat are a great asset to the angling community and provide a boost in recreation. As such, riparian and habitat restoration efforts are needed.

Boating the Rio Grande past the conserved Rocky River Ranch, west of Del Norte. Photo: Rio de la Vista

Alamosa in the evening. Photo: Adriel Heisey

SECTION 5

Constraints and Opportunities

This section identifies the constraints that limit the ability of the Basin to meet the needs identified in Section 4. This section also identifies opportunities to address the constraints through improved watershed health and water management.

5.1 : Identified Constraints

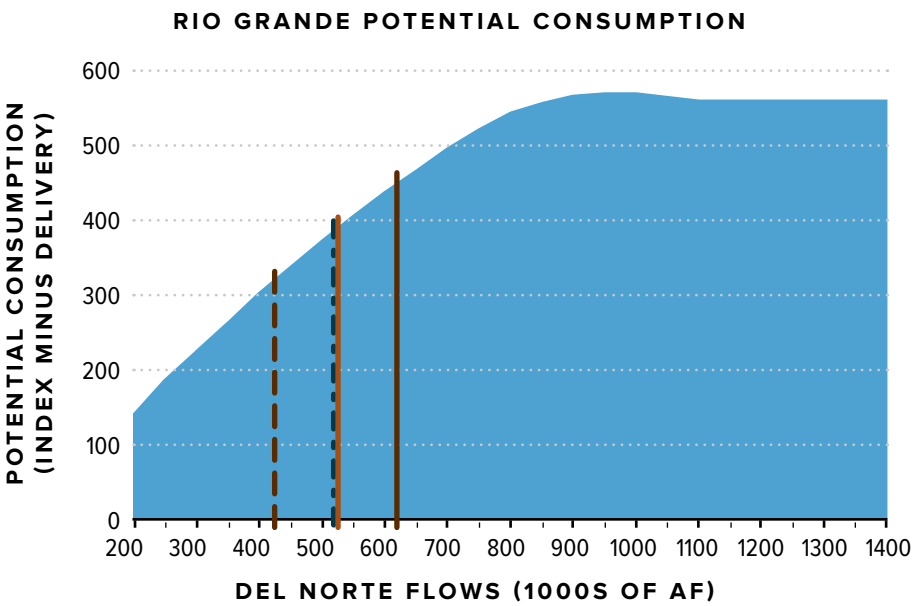
The constraints identified in this section of the Plan are meant to tell the story of the challenges the Basin is currently facing. These are not meant to restrict the Basin from addressing future, unforeseen constraints that may influence projects and methods. They are only intended to give an overview of current challenges and how they may be addressed.

5.1.1 : Rio Grande Compact

The Rio Grande Compact plays a very important role in the administration of water in the Basin. A brief history and description of the administration of the Compact is provided in further detail in Section 3.2, above. The Rio Grande Compact requires that a portion of the flow in the Rio Grande and Conejos River be delivered to New Mexico. The amount of water that must be delivered is a sliding scale (see Figure 28, Figure 29, and Figure 30) with increasing delivery requirements as the total flow increases.

The Compact was negotiated based on a relationship between the observed flows at key stream gage locations in the Basin (the index gages) and the flows at the New Mexico state line. This relationship contemplates a certain amount of water consumption by Colorado water users. Figure 48 illustrates the relationship of flows to water consumption that is contemplated by the Compact and shows the long-term average, the average since 2000, and 15% and 30% reductions from the long-term average flow. The average since 2000 represents approximately a 15% decrease over the historical average. Some climate change scenarios indicate that flows could decrease by 30% from the long-term average (see Section 5.1.2.4 for additional detail on climate change). According to consumptive use models developed by the state, the total water consumption by Colorado water users in the Rio Grande Basin exceeds 800,000 AF per year (State of Colorado 2014). The difference between the depletions contemplated under the Compact at 800,000 AF is made up by inflows into the Closed Basin and declines in the amount of water stored in the aquifers. If the flows in the Rio Grande and Conejos Rivers continue at their 2000 to 2013 average or lower, the Compact will still require deliveries to New Mexico, but will not allow for as much water consumption in Colorado. See Sections 2.4.3 and 5.1.3 for additional information about the impacts of lower flows and Compact deliveries on the groundwater resources in the Basin.

Colorado and the Rio Grande Basin have been in full compliance with the Rio Grande Compact since the 1968. However, there are endangered species, such as the silvery minnow in New Mexico, which represent potential concerns that must be monitored to ensure that the downstream states properly manage their supplies and not endanger these species through mismanagement or overuse of Colorado's legal and fully Compact-compliant deliveries.



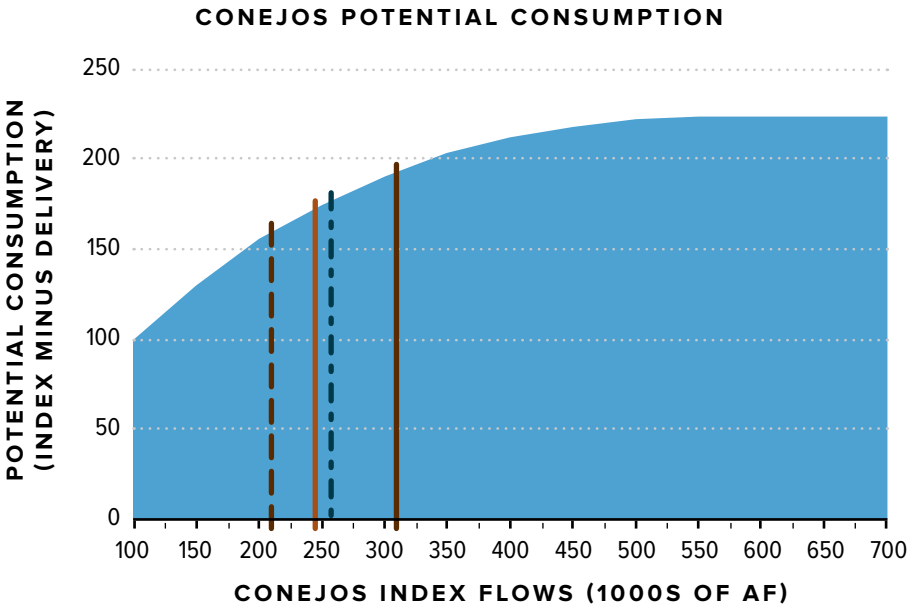


FIGURE 48.

Consumption for Compact streams under various hydrology scenarios.

- Long Term Average
- 2000–2013 Average
- 15% Decrease
- 30% Decrease

5.1.2 : Factors Affecting Hydrology

5.1.2.1 DUST ON SNOW

5.1.2.1.1 GENERAL SCIENCE OF DUST ON SNOW IMPACTS ON HYDROLOGY

Dust on snow is a recent phenomenon occurring throughout Colorado. Initiated by strong winds, desert dust blows into the Colorado high country and settles in thick, dark layers on the snowpack in the headwaters of many river basins. Snow covered with dark particles absorbs more of the sun's rays and melts faster than clean white snow. New snowfall will delay the effect of dust to some extent, depending on the thickness and water content of the new snow layer. Once the new snow layer thins to a few inches, dust layers beneath it will again begin absorbing direct solar energy, enhancing snowmelt and runoff starting with the lowest elevation snow cover in a given watershed. To exacerbate the problem, dust doesn't melt. It only grows darker and more concentrated as the snow beneath it melts, increasing the runoff rate as the sun's intensity grows with the approach of summer. A recent study (Deems et al. 2013) details the extent to which dust on snow has impacted runoff, evapotranspiration and snow cover in the Upper Colorado River Basin. The results of the study are summarized below:

Wolf Creek Pass CODOS site concentrated sample all merged dust layers. Source: Center for Snow and Avalanche Studies, Colorado Dust on Snow program

- More absorption of solar radiation from dust on snow shortens snow cover by several weeks
- Shortened snow cover causes peak runoff to occur an average of three weeks earlier.
- A longer snow-free season results in earlier plant germination and increases evapotranspiration losses.
- Evapotranspiration losses are estimated to decrease annual runoff by 5% of the annual average flow.
- The highest snow accumulation areas show the greatest sensitivity in date of snowpack disappearance

For more information about this study please refer to Appendix D: Current Factors Affecting Hydrology or the full Deems et al. report, located at http://www.hydrol-earth-syst-sci.net/17/4401/2013/hess-17-4401-2013.pdf

This and other studies couldn't model physical snow surface processes that might result in increased sublimation and evaporation.

Therefore, no specific publications are available on sublimation as a source of water loss. However, sublimation should not be discounted as a potential loss resulting from dust on snow.

5.1.2.1.2 SOURCES OF DUST ON SNOW IN THE RIO GRANDE BASIN

The general source for dust in the Colorado Dust on Snow (CODOS) study sites comes from the greater Colorado Plateau located in northwest New Mexico, northern Arizona, southwestern Colorado and central to southeastern Utah, as shown in the map below. The Colorado Plateau is centered in the Four Corners area, where the states of Colorado, New Mexico, Arizona and Utah come together (see Figure 49 below). Its boundaries are:

- East – The Rocky Mountains of Colorado and New Mexico
- South – The Mogollon Rim in Arizona
- West – The Wasatch Range in Utah
- North – The Uinta Mountains on the border between Utah and Wyoming

(http://pubs.usgs.gov/ha/ha730/ch_c/C-text1.html)

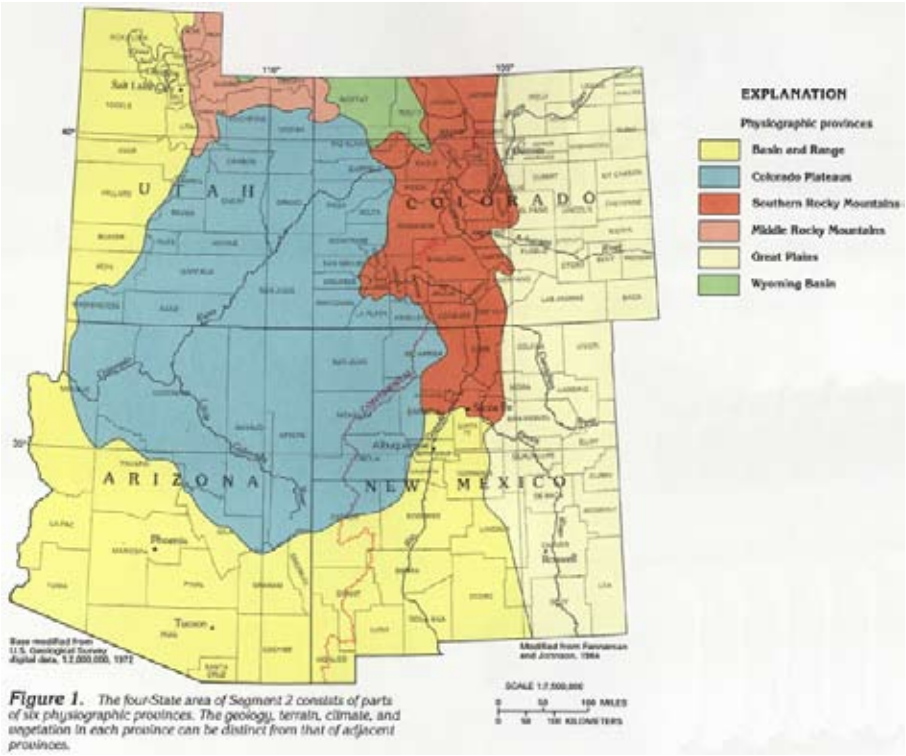


FIGURE 49.

The greater Colorado Plateau.

The source of dust that deposits on snow in the Rio Grande headwaters comes from a very complex mixing of multiple source areas before it lands on snow. However, the northwest area of New Mexico could be an important source of dust that travels to the Rio Grande headwaters. No data have been published at this time, but the CODOS program collects dust from snow sites and performs chemical analysis to tie the dust back to samples collected by USGS in the Colorado Plateau source area. In the same regard, the San Luis Valley could be a source of dust for other parts of Colorado. While dust coming from the San Luis Valley does not impact the Rio Grande headwaters due to wind patterns blowing from southwest to northeast, it could be a source for dust blown on the western part of the Sangre de Cristo mountain range.

5.1.2.1.3 ANALYSIS OF POTENTIAL IMPACTS ON FUTURE HYDROLOGY

Dust on snow is a current problem within the Rio Grande Basin. However, as will be addressed later on in the Water Plan, studies show that the future climate will also impact snowmelt and runoff in the Basin. To evaluate combined dust and future climate impacts, Deems et al. (2013) compared combinations of dust and climate scenarios to the medium dust historical scenario that represents current conditions. The study found that while faster and increased snowmelt due to dust has a greater impact on the deeper snow packs at higher elevations (caused by a longer snowmelt season), climate warming influences the duration of snow cover at all elevations due to decreases in snow accumulation (caused by increased rainfall and accumulation season melt [Nov-March]) and enhanced melt (earlier melt onset, faster melt rates).

Dust on snow at the top of Red Mountain Pass. Photo: Steve Vandiver

To make matters worse, grass and shrub coverage in regional dust source areas is likely to decline in response to increased aridity, leaving soil surfaces more frequently exposed to wind-blown erosion and dust emission. Dust-emission modeling suggests that plant coverage decline will lead to exponential increases in dust emission under climate warming (Munson et al. 2011). The combination of faster and increased snowmelt due to dust and direct climate warming impacts on snow accumulation and melt represents an amplified, dual impact on upper Colorado River Basin snow packs from regional warming. Dust on snow has the potential to result in earlier runoff in the near term than does climate change alone (Deems et al. 2013; Skiles et al. 2012).

The Deems et al. (2013) model results show that a future warmer climate has a substantial impact on snow cover duration relative to the current climate and dust environment, with mid-century snow cover duration decreasing by 45–50 days and end-of-century snow cover by up to 60 days. The study further suggests that earlier runoff as a result of dust on snow will continue under future climate scenarios, but the effects of climate change and dust on snow are not completely additive. Both result in earlier runoff, but the combined effect is not the sum of the two effects. For example if dust on snow results in a two-week-earlier runoff and climate change results in a three-week-earlier runoff, the combined effect will be significant, but likely less than the inferred five-week sum (two weeks for dust on snow and three weeks for climate change).

Snow melting on sand dunes.
Photo: Julie Messick

5.1.2.1.4 SOLUTIONS FOR DUST ON SNOW MITIGATION

Three factors are required for dust production: winds sufficient to suspend soil particles, exposed soils (often through the reduction of vegetation) and soils having characteristics making them vulnerable to wind erosion. In general, the research suggests that, by adopting dust- and wind-reducing land management strategies and practices there are ways to keep snow on mountains longer. Constructing physical windbreaks or planting vegetation can reduce winds speeds at ground level. Vegetative cover reduces soil exposure; thus, sites currently dominated by annual plants (e.g., abandoned croplands, heavily disturbed sites) can be rehabilitated by establishment of perennial grasses and shrubs that provide protection even in drought years (Deems et al. 2013). Most dry land soils are stable until disturbed (Deems et al. 2013); thus, reducing surface disturbance (e.g., livestock over-grazing, off-road vehicles, agricultural activities, fire) in lower-elevation regions, especially during drought years, can be highly effective in reducing dust production.

The Center for Snow and Avalanche Studies and the CODOS program do not work directly with mitigating dust emissions from source areas, but researchers have learned a lot about emissions from working with the USGS. The challenge of mitigating dust emissions from the Colorado Plateau is, in part, climatic. The arid landscape that has been in a prolonged drought proves a challenging environment to develop and implement solutions to reduce dust emissions due to this lack of water. Complicated land use patterns and the fact that the Colorado Plateau is comprised of land ownership spanning four different states, several national parks, a few sovereign nations and a mix of state, private and

federal lands provides a challenge to perform landscape-scale mitigation of dust on snow. From a soil conservation standpoint, the amount of dust and soil being moved massive distances from the Colorado Plateau is staggering, an inconceivable amount of mass. This amount of soil erosion is non-trivial, even from the standpoint of a small 35-acre parcel of farmland. There are opportunities for dust mitigation on private lands, including farm land, that may be worth implementing, as the San Luis Valley is a dust emitter. These strategies may have an effect on dust only on the margins, but reducing every little speck helps.

5.1.2.2 BEETLE KILL

5.1.2.2.1 GENERAL SCIENCE ON BEETLE KILL IMPACTS ON HYDROLOGY

Hydrology and other watershed effects that result from beetle infestations are complex, and cannot be thought of simply as reductions in water uptake and increases in the amount of surface runoff due to tree death. Earlier peak runoff from snowmelt has several causes, one of which is widespread tree death due to bark beetle infestations.

The term *bark beetles* refers to a family of insect species, all of which eat through bark and the living tissue of trees. There are many species of bark beetles, including, mountain pine beetles, ips beetles, and spruce beetles, that are currently active in Colorado and the Western U.S. They typically kill relatively few trees each year, but, under certain conditions, such as drought and relatively warm winters, are able to multiply rapidly and spread across entire landscapes. Scientists believe the current beetle outbreak in the Western United States, which began in the mid-1990s, was spurred by the drought that has affected much of the west since the early 2000s. Estimates indicate that, since the mid-1990s, nearly 400,000 square miles or 256 million acres of total forest in western North America have been affected by bark beetles. Although the current infestation may be larger than ever observed before, beetle epidemics have occurred historically in coniferous forests.

An adult spruce beetle bores into the bark of a spruce. Source: Grand Mesa Uncompahgre and Gunnison National Forests

Spruce bark beetles are native to and the most active disturbing agent on the RGNF. Spruce bark beetles kill the trees by burrowing under the bark and eating tunnels through the layers of cambium and phloem just underneath the bark. These layers transport water, nutrients and sugars throughout the tree. The beetles and their larvae will create tunnels encircling the tree, breaking the continuity of the cambium and phloem, thus stopping flow of water, nutrients and sugars throughout the tree. As a result, the trees essentially starve and die. In addition, the beetles often carry a fungus on their backs, which spreads throughout the tree and clogs the vessels that transport water through the tree. This fungus leaves dark blue-grey streaks throughout the tree, leading to "blue stained wood" (U.S. Department of Agriculture, Forest Service, Rio Grande National Forest n.d.).

The hydrologic impacts of large landscape changes can last for decades, making it important for water resource managers to understand how these infestations affect surface water supplies.

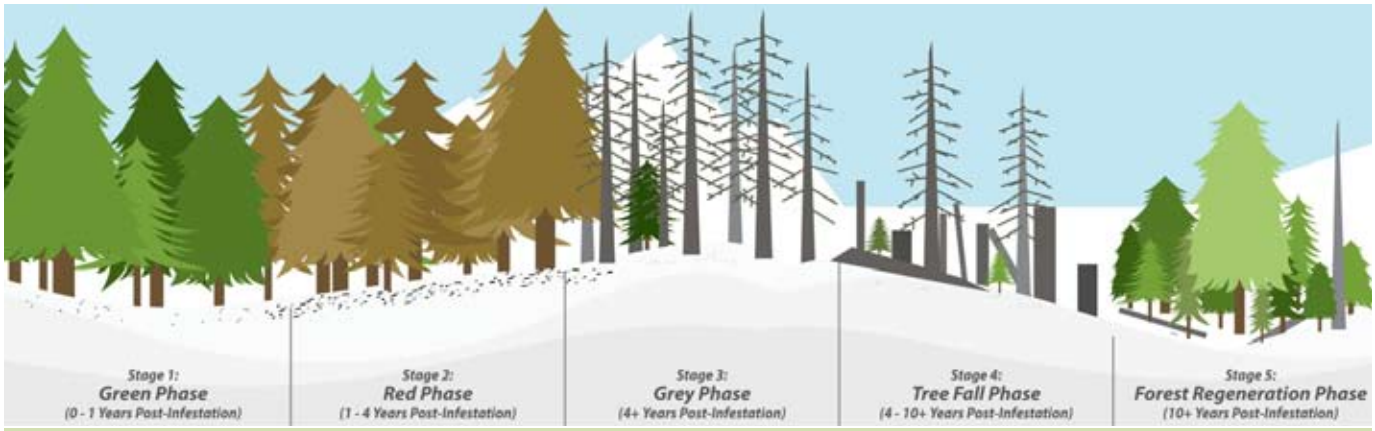
Beetle infestations, like forest fires and clear-cutting, can result in the death of large areas of forest. However, that is where the similarities end. Although the vast majority of a given patch of forest may be killed during a bark beetle infestation, the trees are not naturally removed from the landscape. Also, in contrast to forest fires and clear-cutting, the rate of forest disturbance is much slower with beetles — in the former, whole swaths of forest could be removed in hours, while beetle infestations kill trees slowly over years. Finally, the remaining living trees, which are usually the youngest ones, continue to grow, often at a faster rate because of decreased competition and increased resource availabitly. Thus, due to the mix of slow, widespread tree death and accelerated young tree growth (see Figure 50 below), the impacts on snowpack and streamflow from beetle infestations are not the same as with fires and clear-cutting.

Tree death from beetle kill can affect snowpack in two specific ways: by increasing total snow accumulation and by changing factors that control how the snow disappears through melt and/or sublimation (snow directly evaporating rather than melting into water), collectively known as *ablation*. Changes in total snow accumulation are related to reduced snow interception and retention by leaves and branches, the primary mechanism that controls the amount of precipitation reaching the forest floor. Dead trees in bark-beetle-infested coniferous forests drop their needles and develop drooping branches, reducing their ability to intercept snow and to cause snowflakes to sublimate into gas and return to the atmosphere, and leaving more snow to accumulate on the ground.

FIGURE 50.

Phases of forest after bark beetle infestation.

Source: Gordon et al. 2014



Although this reduction in tree canopy material can lead to greater snowpack accumulation in forests, bark-beetle-related changes in forests also generally result in an overall increase in the rate at which snow melts. Snowmelt is driven by numerous factors, but the primary mechanism is incoming shortwave radiation or visible sunlight. Tree branches and leaves not only shield the ground from greater snow accumulation, but they also reduce the amount of incoming sunlight reaching the snowpack. Thus, as trees killed by beetle infestations lose needles and twigs, more sunlight can reach the ground. This additional sunlight leads to increased melting of snow. Snowmelt is further increased by litter — dead needles, branches and twigs — accumulation on the snowpack that reduces the reflectivity of the snow and causes it to absorb more of the sun's radiation and heat up slightly, thus increasing melt rates. Studies in Colorado have shown up to a one-week advance in the timing of snowmelt from litter fall. Finally, dead trees do less to block the wind, resulting in higher rates of snow sublimation on the ground.

Beetle-infested forests will likely experience more snow on the ground but faster snowmelt. This combination may have mixed effects on water yield. Gordon et al. (2014) used computer models to assess how sensitive streamflow is to beetle impacts at catchment scales, roughly the size of a small Western creek watershed. Results showed that the amount of water coming from the catchment could rise up to 10% as a result of forest canopy loss due to bark beetle kill, as compared with expected flow in the same catchment prior to the infestation. However, a number of other factors that weren't taken into account in the modeling are likely to reduce the increase in water yield. First, growth of the surviving younger understory trees can accelerate dramatically after beetles kill older trees. Young trees can grow up to three times their previous rates in some cases, due to a new abundance of root-zone water, nutrients and sunlight. The modeling of Gordon et al. suggests that young tree growth alone could reduce the increase in water yield sensitivities by half. Second, the patchwork nature of beetle infestations means that it is rare for entire watersheds to be completely killed at the same time, which can moderate impacts. Third, year-to-year variability in snowfall — up to a 300% change is common in Colorado — can essentially disguise most of the contribution of changes in water yield due to beetle infestations.

5.1.2.2.2 EXTENT OF BEETLE KILL IN RIO GRANDE WATERSHED

In the Rocky Mountains, spruce beetles primarily infest Engelmann spruce (*Picea engelmannii)*, which grow in high-elevation forests. Spruce beetles have been found in blue spruce *(Picea pungens)* on the Rio Grande National Forest (RGNF).

From 2002–2005, a total of 480,000 acres of the RGNF have been infected with spruce beetle. This equates to approximately 85% of the total spruce-fir forest, as seen in Figure 51. In 2013 alone, the spruce beetle infestation of the RGNF grew by 98,000 acres, as detected by a forest health aerial

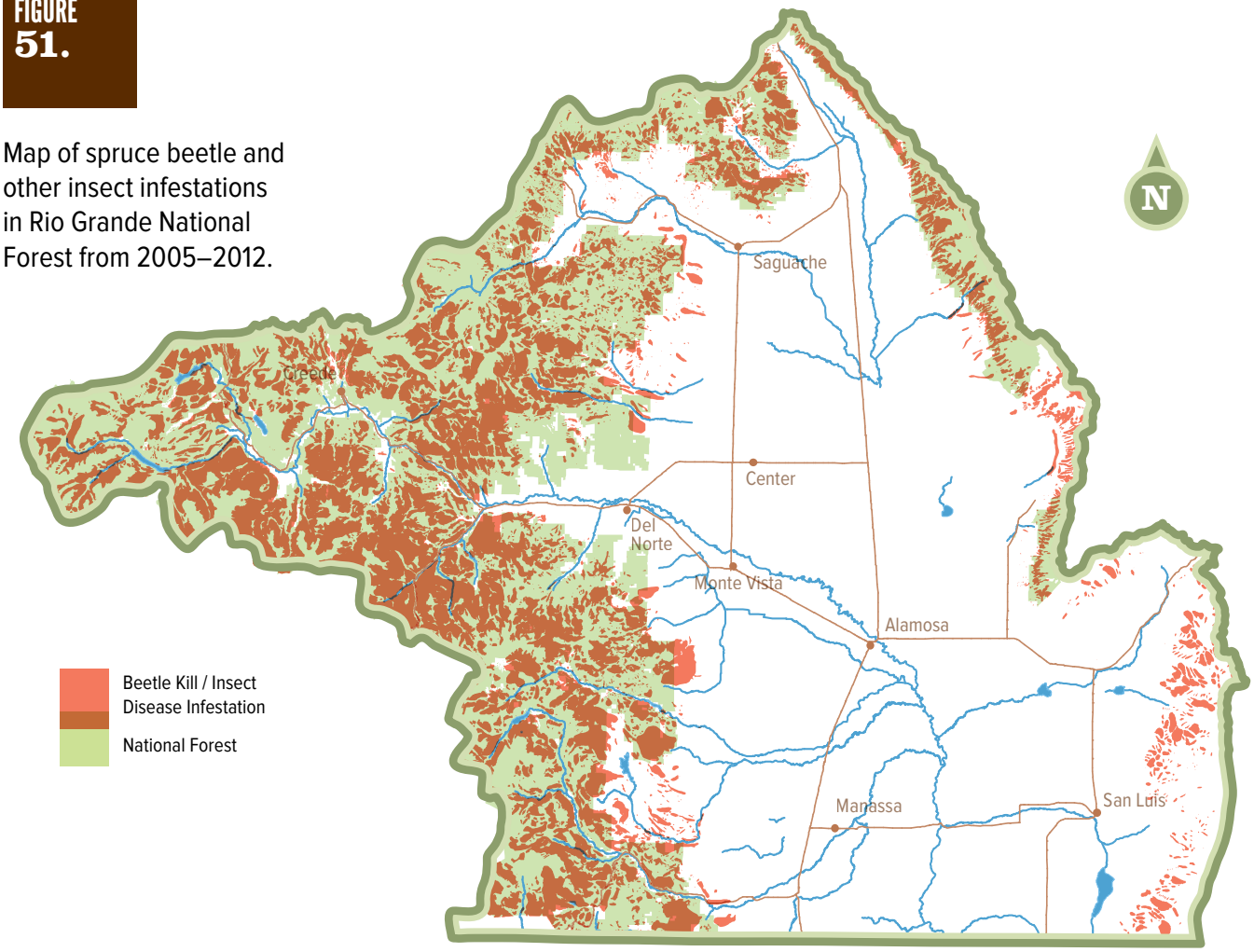
survey. However, aerial survey data is generally at least one year behind the actual spread of the spruce beetle infestation because it takes a year or more from the time of infestation for the needles of the trees to die, thus allowing detection from the air. Thus, the impacts of spruce beetle on RGNF are likely greater than they appear from aerial survey data.

The beetles continued to spread on the east side of the La Garita Mountains and have infested most of the spruce forests on the west side of the Saguache Ranger District. Pockets of spruce beetle infestations are expanding throughout the Sangre de Cristo Mountains. Beetle infestations are also expanding throughout the South San Juan Mountains west of La Jara and Antonito, and in the mountains south of Del Norte and South Fork (U.S. Department of Agriculture, Forest Service, Rio Grande National Forest 2013).

Spruce beetle on the Rio Grande National Forest. Photo: U.S. Department of Agriculture

FIGURE 51.

Map of spruce beetle and other insect infestations in Rio Grande National Forest from 2005–2012.



Beetle kill in Rio Grande National Forest. Photo: U.S. Department of Agriculture

Not all areas are infested equally. In some areas, all the spruce trees larger than five inches in diameter have been killed by spruce beetles. In other areas, there is a mixture of dead and living spruce trees of all sizes.

At this point, nothing can be done by humans to stop a landscape-level spruce beetle epidemic such as the one the RGNF is experiencing. Certain weather conditions, such as a severe cold snap in the late spring or early autumn, could kill large numbers of spruce beetles. However, spruce beetles are well-adapted to the spruce forests in which they live, and the ending of a spruce beetle outbreak by a cold weather event is a rare occurrence. According to Rio Grande National Forest Supervisor Dan Dallas, "the spruce beetle epidemic will begin to wind down on the Rio Grande National Forest over the next few years as the beetles run out of food."

5.1.2.2.3 ANALYSIS OF POTENTIAL IMPACTS ON FUTURE HYDROLOGY FROM BEETLE KILL

Records and studies have demonstrated that bark beetle infestations do increase snow accumulation, speed up snowmelt and lead to minimal additional streamflow, but a variety of mitigating factors may make such changes hard to detect (Gordon et al. 2014). At the watershed and basin scales that are most often of concern to water managers, it may be that the slow progression of tree death and decomposition, along with the patchwork nature of beetle infestations and the effects of rapid growth from young trees, will keep effects from being particularly great, although more significant changes are certainly possible as forests continue to respond to climate change.

Climate change may add compounding effects to areas already infested with bark beetles including even earlier runoff and smaller runoff amounts. In areas with little-to-no beetle infestations, climate change may play a role in new or increased beetle kill. When drought conditions exist, trees become stressed and cannot produce a normal quantity of sap. This weakened state and low sap production provides the perfect opportunity for bark beetles to successfully attack trees without being pushed out by sap. Local beetle populations may explode during dry periods by overwhelming the trees' defenses.

There has been a great amount of interest is the impacts of bark beetles on fire regimes in Colorado forests. The Forest Service Rocky Mountain Research Station and fire experts often state that occurrence of wildfire is not affected by the presence or absence of beetle-killed trees. Regarding wildfire intensity, the USFS has stated that most beetle-infested trees will burn with less intensity than live trees because the trees lose their needles and the majority of their crown, leading to straight boles with lowered amounts of fuels than living trees with full canopies. This scenario is

relevant to pine species impacted by mountain pine beetles, which include Lodgepole and Ponderosa pines.

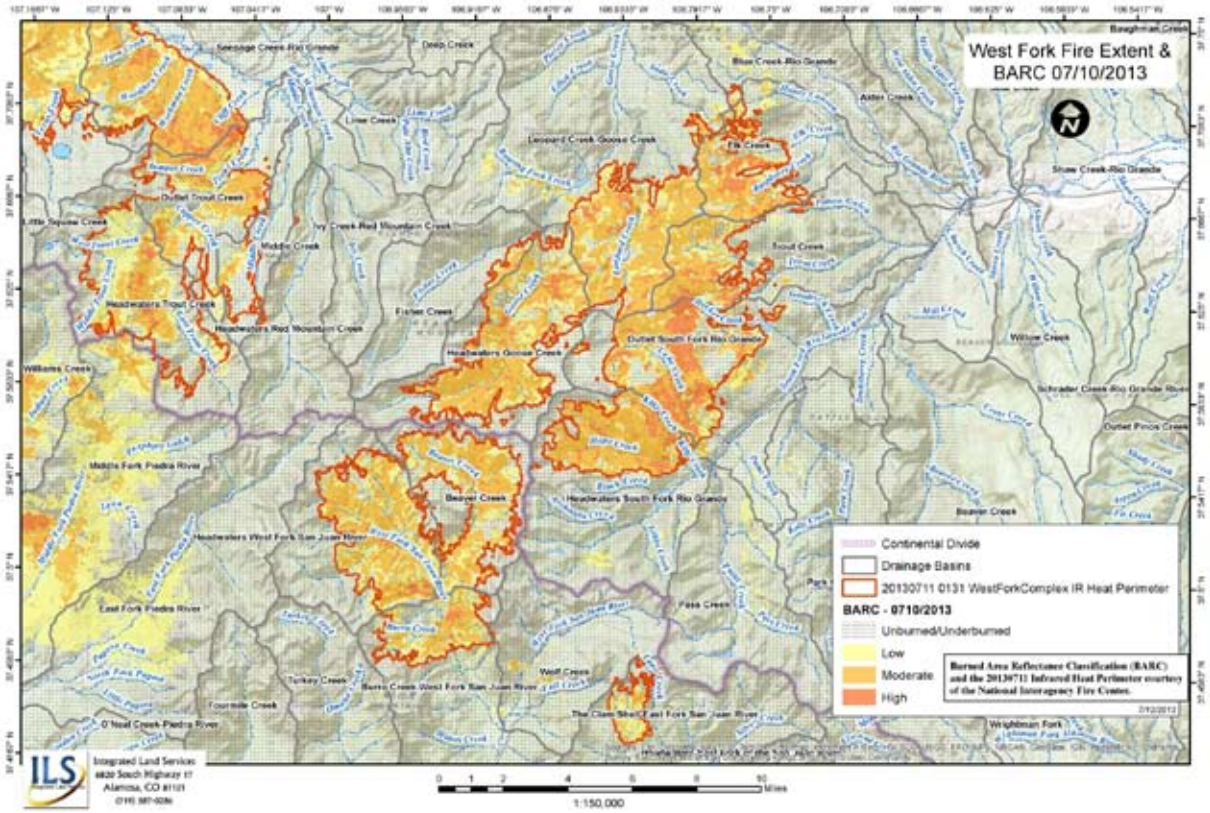
The broad applicability of this theory to all beetle-killed forests has been challenged by members of the public and USFS alike after the 2013 West Fork Complex Fire on the RGNF and SJNF. The West Fork Complex Fire exhibited extreme fire behavior that did not follow existing models used by incident commander teams. As such, the fire behavior specialist pulled pieces from many different models and built his own for the West Fork Complex Fire. It is believed that the severe drought, high temperatures, high wind and stand structure of the dead spruce impacted behavior. Unlike pines, Engelmann spruce maintain a canopy structure of branches and twigs, which provides ladder and canopy fuels.

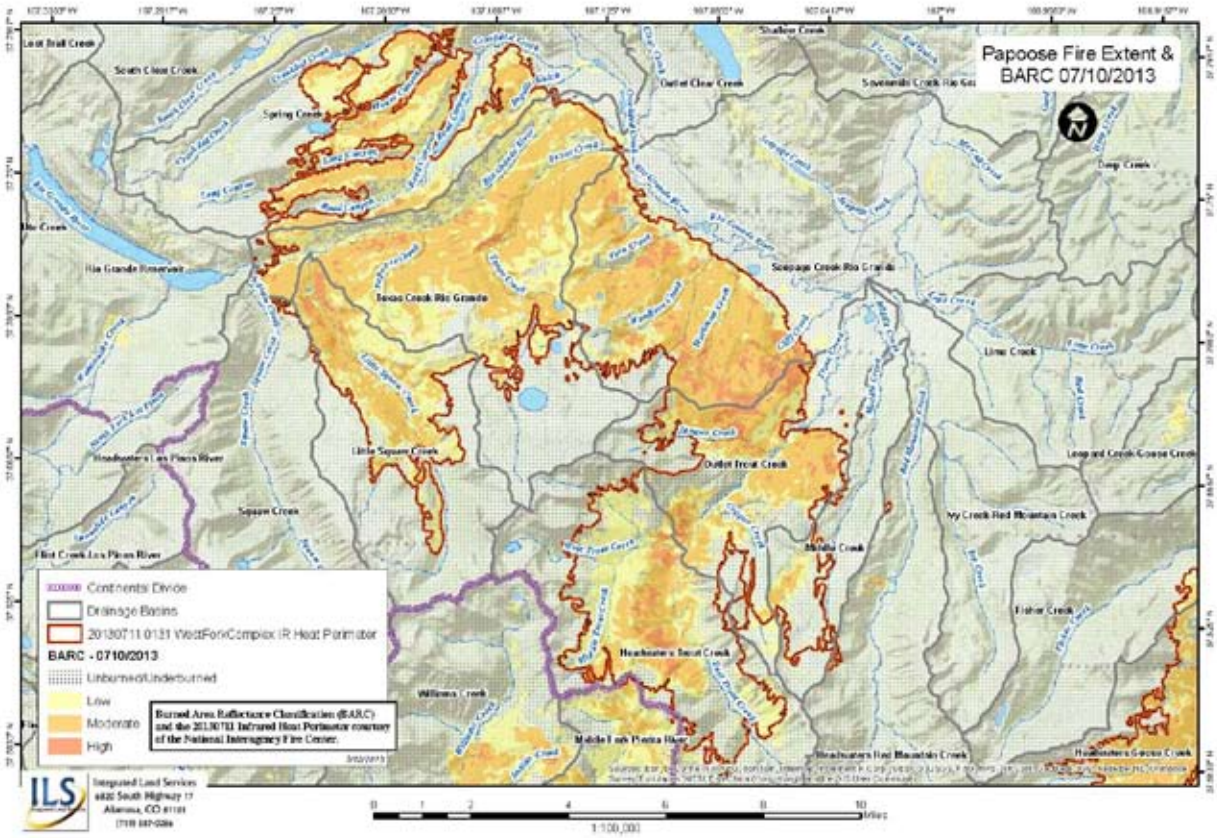
Thus, the spruce beetle-killed forests burned at a much hotter level and fires moved from ground cover to the crown at a much faster rate than observed in healthy forests. As depicted on the BARC maps (Figure 52) that were developed for the West Fork Complex Fire, higher levels (up to 75%) of medium to high-intensity fires occurred in spruce beetle-killed forests as compared to healthy stands (less than 50%). A GIS analysis of that fire completed for this Plan indicated that 67% of the low-intensity burned area had beetle infestation, while 87% of the medium and high-intensity burned areas had beetle infestation (Rio Grande Watershed Emergency Action Coordination Team n.d.).

Due to concerns about wildfire, threats to infrastructure and human safety from falling beetle-killed trees, and the loss of usable biomass from rot of beetle-killed trees, harvesting of beetle-infested forest stands is highly desirable to a large population in the Rio Grande Basin. With 85% of the Rio Grande National Forest affected by spruce bark beetles, timing and ability to permit harvesting infested stands has major implications for logging and the local economy. Salvage logging of beetle-kill trees may also effect new stand development and fire risk. Findings from a study by the USFS suggest that salvage logging beetle-killed trees will dampen the behavior and severity of potential future wildfires through reduced fuel loading and tree densities. Harvesting reduces coarse fuel loads by more than 50% compared with untreated stands. Harvesting fuels also reduces the duration and magnitude of soil heating associated with the combustion of heavy fuels in a post-infestation wildfire. Soil heating is known to damage plant root systems and soil biota, increase erosion and soil losses, and delay post-fire ecosystem recovery (USDA Forest Service, 2014).

FIGURE 52.

Burned Area Reflective Classification map from RWEACT





5.1.2.3 FOREST FIRES

5.1.2.3.1 GENERAL SCIENCE ON FOREST FIRE IMPACTS ON HYDROLOGY

Wildfires are increasing in size and frequency. With historic fire exclusion, inactive forest management, and a chronic insect outbreak killing trees and producing an unprecedented amount of wildfire fuels, wildfires are burning more intensely and causing more severe impacts than historically experienced. Larger and more severe fires have a greater impact on public health and on fish and wildlife, and the trend is expected to continue to worsen. Moreover, the number of large fires (greater than 1,000 acres) in Western states has increased, and wildfire seasons are longer now than in the 1970s. Temperature warming in the Western U.S. is expected to continue producing faster snowmelt and drought stress to plants, drying live fuels, inviting insect and disease damage to plants, and producing more dead fuels. Human population increases, resulting in more forest use, present the potential for more fire starts and amplify the risk to life, property and resources. Research and recent fire history predict more fires, hotter fires, larger fires and longer fire seasons.

Wildfires continue to be fought in the short term with continuous improvements in firefighting strategy and tactics, such as initial attack. However, without active forest management, fuel loads will increase for the longer term, increasing fire risk and impacts and inhibiting our ability to fight wildfire effectively and safely.

5.1.2.3.2 DOCUMENTATION OF FOREST FIRE EVENTS IN THE RIO GRANDE BASIN

On June 5, 2013, a lightning strike on U.S. Forest Service lands northeast of Pagosa Springs, Colorado, ignited the West Fork fire. The fire initiated in the San Juan National Forest and quickly spread over the Continental Divide to the northeast and onto the Rio Grande National Forest. A separate wildfire was also started by lightning but later on in the month near the headwaters of the Rio Grande and became known as the Papoose fire. A spark from the "West Fork fire" created the "Windy Pass fire." The three wildfire events together — due to proximity and ease of management — were identified as the West Fork Complex Fire.

The West Fork Complex Fire was deemed "contained" by the US Forest Service by January 1, 2014. At that time, the West Fork Complex Fire was estimated to have claimed approximately 109,500 acres, with roughly 88,000 acres occurring in the Rio Grande National Forest. The Rio Grande portion of the fire threatened public safety and personal property of residents near the towns of Creede, South Fork and Del Norte, primarily in Hinsdale and Mineral Counties. In addition to the public safety and private property concerns, there were concerns for damage to plant and animal species in the watershed as the fire was situated at the headwaters

and along the watershed of the main stem of the Rio Grande and many of its tributaries.

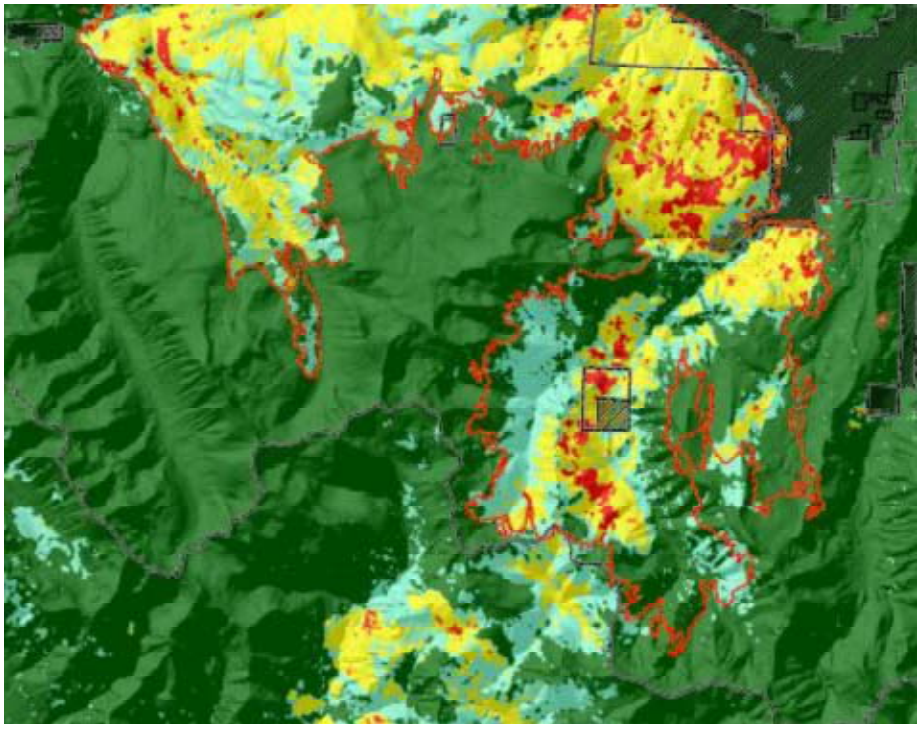
The intensity of the fire was fueled primarily by the vast acreages of beetle-killed spruce trees, hot and dry winds, lack of precipitation, steep drainages, and minimal road access in the inaccessible landscapes of this terrain situated in both roadless areas and the Weminuche Wilderness Area. These extreme fire conditions ultimately resulted in extreme wildfire behavior. The Forest Service released its BARC (Burned Area Reflective Classification) map to RWEACT (Rio Grande Emergency Action Coordination Team) which indicated that as much as 60% to 70% of the watersheds within the current West Fork Complex Fire perimeter were "moderately" to "severely" burned.

The level of burn severity resulted in subsequent and significant impacts on downstream and downslope environments through flooding and debris flow as soils that are burned to this degree become *hydrophobic*. The term hydrophobic relates to the soil's inability to absorb water. Hydrophobic soils repel water like pavement. Massive impacts to the environment and natural resources occurred that greatly increase the need to take emergent and immediate, pro-active measures to prevent loss of human life and property.

Moreover, it is inevitable that the Rio Grande watershed including those tributaries affected by the fire, will sustain high volumes of ash, debris and sediment moving into the streams and rivers causing a significant degradation in water quality that will affect river health and wildlife at

FIGURE 53.

Fire severity map for West Fork Complex Fire.



all levels. As has been documented in other post-wildlife landscapes, snowpack and spring snowmelt levels and timing will be impacted or altered by a lack of overstory vegetation and tree limbs to gather snow and to shade ground level snow pack as well as by the black, charred backdrop that increases solar intensity and temperatures.

After a wildfire larger, than 500 acres on Forest Service land, is determined to be at 50% contained, the Forest Service may deploy a Burned Area Emergency Response (BAER) team. According to Forest Service Policy (U.S. Department of Agriculture, Forest Service, Forest Service Manual National Headquarter 2012), the purpose of the BAER team is "to identify imminent post-wildfire threats to human life, safety, property, and critical natural or cultural resources on National Forest System lands and take immediate actions, as appropriate, to manage unacceptable risks." This is accomplished by the BAER team using a "Values At Risk" analysis, which inventories and evaluates the post-wildfire threats to structures, roads, culverts, dams, etc. that occur on Forest Service lands.

5.1.2.3.3 ANALYSIS OF POTENTIAL IMPACTS ON FUTURE HYDROLOGY

Wildfires have several impacts upon hydrology and water quality. Wildfire disturbance affects patterns of snow accumulation and ablation by reducing canopy interception and modifying the surface reflective properties and sunlight radiation balance. Soot particles and burnt woody debris from charred trees accumulate at the snowpack surface darkening the snowpack and absorbing more radiant energy in the burned forest than in the unburned forest. Recent work done by Gleason et al. (2012) documenting snow-vegetation interactions in burned and unburned forests show that burned forests experience 50% lower snow albedo, increased snow accumulation but also earlier and more rapid melt. Wildfires also have an impact on physical and chemical processes, including acute loss of vegetation and soil organic matter, decreased soil cohesion, and enhanced soil water repellency. Fires can reduce infiltration into the soil by forming a water-repellent soil layer or plugging soil pores with fine ashy material. Percolation through the soil can also be reduced this way. Reduced infiltration and percolation in turn can increase surface runoff and sedimentation. Increases in streamflow may also occur following fire because the removal of vegetation reduces transpiration losses by plants.

Water Quality Effects

Increased erosion has been observed in several post-fire Colorado Front Range watersheds (Vandiver 2014; Writer et al. 2012). Results from Writer et al. suggest that dramatic differences in sediment loading and associated water-quality can be expected between unburned and burned areas during high-intensity storm events, such as summer monsoons and spring snowmelt pulses. Stream discharge and turbidity increased by several orders of magnitude at monitoring locations downstream

from the burned areas, meaning that the increased sediment-associated carbon and nutrient fluxes from burned watersheds have the potential to profoundly influence downstream aquatic ecosystems and watershed water supplies. Erosion and sediment loading generally have negative effects on downstream ecosystems and water supplies, but concurrently increased nutrient loading can be beneficial to aquatic ecosystems. The results also suggest that the primary productivity of the aquatic ecosystem increased as a result of increased sediment loading and associated nutrient supply, including both dissolved nitrogen species and sediment-bound phosphorus. This response has been observed in other wildfire-affected watersheds (Writer et al. 2012).

Little Squaw Canyon after the West Fork Complex Fire. Photo: Heather Dutton

5.1.2.4 CLIMATE CHANGE

5.1.2.4.1 GENERAL DESCRIPTION OF CLIMATE CHANGE AND MODELS

Climate change describes the observed and projected trends and variability associated with long-term weather patterns. The hydrology of the Rio Grande Basin is driven predominately by precipitation and temperature; decision making and policy in this area have been implemented over many decades based on the existing hydrology. With changes already observed and climate change science suggesting even greater change, new decision-making protocols and policy should consider the best available science, forecasts and understanding of uncertainty in order to minimize negative impacts from these changes in hydrology.

A wide range of changes to climate and hydrology at local, regional and global scale are projected in numerous published reports and scientific studies. Most sources agree that temperatures are increasing and will continue to increase globally. Projections of precipitation are generally less consistent, but point to increased precipitation in the arctic and sub-arctic regions and decreasing precipitation in subtropical areas (Karl et al. 2009). The Rio Grande Basin borders the semi-arid and temperate regions of the United States, so qualitatively would be expected to receive decreased precipitation. Variability in weather is another important factor in climate and water resources management that is projected to increase due to climate change. Extreme weather events such as drought, flood and early runoff, put strain on infrastructure and require different policies than with the more consistent climate that Colorado has experienced in the past. For example, higher frequencies of floods and droughts require greater storage (reservoir or subsurface) in order to get the same long-term beneficial use from precipitation that a more consistent climate would offer. Climate change for the Rio Grande Basin means there is a need for better utilization of the storage that we currently have.

Most studies that quantitatively project climate change do so by applying results from Global Climate Models (GCMs) specific to a geographic location. GCMs are large-scale computer models that mathematically depict the physics and properties of the atmosphere, oceans, land, etc. and the interactions between all of these components as they relate to climate. Emission scenarios are predictions of Carbon Dioxide and other greenhouse gas outputs that are likely to occur in the coming decades and act as input to the GCMs. The Coupled Model Intercomparison Project (CMIP) is a standard set of GCMs and emission scenario outputs that have been developed, peer-reviewed by worldwide, federal, and educational institutions, and reflect future climate. Many of the results listed below rely on results from CMIP that are applied to a specific region (e.g., Colorado, the Rio Grande Basin) and present predicted values of temperature, precipitation, and other climate variables from the present until the year 2100. It is up to the scientist to evaluate these results

and determine what effect this future climate will have on hydrology, agriculture, water supply or any other system that depends on climate.

5.1.2.4.2 SUMMARY OF CLIMATE CHANGE STUDIES IN COLORADO

Several scientific publications and studies have been produced by international bodies, federal agencies, the State of Colorado and municipalities within Colorado that document anticipated impacts of climate change within Colorado. Highlights of those findings are listed below. For a more comprehensive review of climate change studies conducted for Colorado, see Appendix E: Climate Change in Colorado.

Where to find more information on Climate Change in Colorado:

Colorado Foundation for Water Education's Citizen's Guide to Colorado Climate Change
weblink

- Temperatures are rising globally and within Colorado and may accelerate in the coming decades .
- Snowpack in Colorado is projected to decline by 10 to 20% by 2050, but projections of average annual precipitation do not significantly suggest drier or wetter conditions.
- The hydrologic cycle will likely change, bringing longer periods of drought alternating with spells of heavy rainfall. This may reduce the reliability of water storage and could increase reliance on groundwater potentially changing the interface between groundwater and surface water.

5.1.2.4.3 THE UPPER RIO GRANDE IMPACT ASSESSMENT

The Upper Rio Grande Impact Assessment was performed by the Bureau of Reclamation in partnership with Sandia National Laboratories and the U.S. Army Corps of Engineers to assess the impact of climate change on the Upper Rio Grande Basin from the headwaters in Colorado to Caballo Reservoir in south-central New Mexico. This report is the most applicable climate change study to the Rio Grande Basin and San Luis Valley of Colorado, as it used GCM data and a runoff model to predict flow at the Rio Grande and Conejos Compact index gages (Rio Grande near Del Norte, Conejos near Mogote, San Antonio at Ortiz, and Los Pinos near Ortiz) from the present to 2100 and analyzed the results to show the impact of these flows on the Rio Grande and Conejos Compact obligations and diversions under the Prior Appropriation system. This report also focused heavily on Rio Grande operations in New Mexico under its obligations to downstream users.

Key results from the report include:

- Flows at the index gages (Rio Grande near Del Norte, Conejos River near Mogote, Los Pinos River near Ortiz, San Antonio River at Ortiz) will decrease by approximately one-third overall by 2100.

Upper Rio Grande near Rio Grande Reservoir. Photo: John Fielder

- The peak flows shift to earlier in the year — from June to May.

- Downstream, flows would decrease by 50% at the Rio Grande near Lobatos gage.
  - This reduction is greater than the reduction at the index gages, suggesting the Rio Grande Compact structure may buffer consumptive use in San Luis Valley at the expense of downstream deliveries to New Mexico.

- Fewer water rights are served on average as a result of the decreased flow.
  - From 1950 to 1999 the average junior-most water right to be served in June on the Rio Grande was a 1910 priority, whereas by 2100 it is anticipated to be an 1890 water right. The junior-most priority in May is predicted to increase from 1895 to 1900 due to earlier runoff.

For a more detailed description of the report, the model used to generate the results, and plots of key results, see Appendix E: Climate Change in Colorado.

5.1.2.5 SUMMARY OF FACTORS AFFECTING HYDROLOGY

The current factors affecting hydrology, combined with the impacts of climate change, can lead to cascading impacts. For example, more intense droughts and higher temperatures lead to a greater moisture deficit in the region's forests. Trees that aren't getting enough water are more susceptible to beetle infestations, and infected weakened and dead trees are more susceptible to catastrophic wildfires. Thunderstorms tend to build over fire scars because heat builds up over the blackened ground, and intense thunderstorms on the fire scars lead to the washing of ash into rivers, and to debris flows (Llewellyn and Vaddey 2013). Climate change may add compounding effects to areas already infested with bark beetles including even earlier runoff and smaller runoff amounts. For dust on snow, the combination of faster and increased snowmelt due to dust and direct climate warming impacts on snow accumulation and melt represents an amplified, dual impact on snowpacks from regional warming.
An overview of the impacts on hydrology from the factors mentioned in previous sections of the Plan — Dust on Snow, Beetle Kill, Forest Fires, and Climate Change — is provided in Figure 54.

In light of these constraints, it's important to understand how hydrology can change under different scenarios, and how to best plan for this modified water availability.

5.1.3 : Aquifer Sustainability

As discussed in Section 4.2, Agricultural Needs, water users are required by law to maintain the aquifer at sustainable levels, which is defined as the levels seen through the 1978 to 2000 time frame. Since 2002, water levels have declined in the aquifers significantly. The general manager of the Rio Grande Water Conservation District and Subdistrict No. 1, Steve Vandiver, has noted that meeting the sustainability requirement will be a very difficult challenge for the Basin and will require significant reductions in pumping unless snowpack and streamflows increase over a prolonged period of time (Vandiver 2014).

By combining some information from the Rio Grande Compact and information from the State's recent consumptive use data, it becomes clear why aquifer levels have been declining. The average surface water supply into the Basin through the Rio Grande and Conejos River can be quantified at the Compact index gages for each stream. Subtracting off the Compact obligations for these streams results in the net consumption from surface water allowed under the Compact. Since 2000, the average consumption from surface water permissible under the Compact on the Rio Grande and Conejos combined is approximately 565,000 AF (see Figure 30). The State's most recent estimate of consumptive use for 2000 to 2009 is 810,000 AF (see Table 9). The difference of 245,000 AF is derived from surface water inflows to the Closed Basin and drafts on aquifer storage. The inflows to the Closed Basin are approximately 160,000 AF per

FIGURE 54. Summary schematic of environmental impacts on hydrology.

FACTOR	Dust on Snow	Beetle Kill — red and grey phases	Forest Fires — immediate impact	Climate Change
IMPACT ON...				
Timing of Runoff Flow and Peak Runoff	EARLIER 3–6 weeks earlier for UCRB	EARLIER Up to 1 week earlier in the red phase due to decreased albedo	EARLIER Increased, up to 2–3 weeks earlier	EARLIER Up to 1 month earlier (from June to May)
Volume of Runoff Flow	DECREASE Reduce by about 5% due to evapotranspiration, does not include sublimation for UCRB	MIX Undetermined. Higher rates of sublimation and increased sunlight penetration, but up to 5% rise in streamflow due to forest canopy loss, offset by increased growth rate of surviving understory trees, patchwork nature of infestations, slow progression of tree death and decomposition	INCREASE Increased, varies by watershed, climaate and fire severity, but up to 100 times those previously recorded	DECREASE Decrease by approximately 1/3 overall at the index gages and by 50% at the Lobatos Gage by 2100
Snow Accumulation	No Impact	INCREASE Grey Phase - 5%–15% more total snow accumulation	INCREASE	DECREASE Projected to decline by 10-20% by 2050 in Colorado
Water Infiltration	No Impact	INCREASE Increased or No change, surviving trees can grow up to 3x faster in beetle kill conditions, up-taking 3x more water	DECREASE Reduced, dead trees do not consume as much water, higher instances of sediment loading	MIX Undetermined, maybe earlier or later due to several factors
Time of Snow Disappearance	EARLIER 50–43 days earlier, shortened duration of snow cover	EARLIER	EARLIER several weeks earlier and more rapid	EARLIER Earlier up to 1 month, similar to peak runoff
Data Source:	Deems et al. 2013 and personal conver. Chris Landry (5/19/2014)	Gordon, Pugh, and Livneh	Gleason et al. 2012, Neary et al. 2011	Llewellyn 2011

year (based on State of Colorado's groundwater modeling) and means the aquifer has declined on average 85,000 AF per year. This average annual decline computed from a mass balance is an agreement with the change in aquifer storage chart produced by the Rio Grande Water Conservation District (see Figure 24) which shows a decrease in storage in the aquifer of approximately 1,115,000 AF from 2000–2014 which is approximately 82,000 AFY.

TABLE 14.

Effect of drought on Rio Grande water supply.

2000–2013 Annual Flow of Rio Grande Compared to Historical Averages			
Year	Flow of Rio Grande Flow at Del Norte Gage	Deviation from 1890-1999 Average of 656,831	Deviation from 1950-1999 Average of 607,158
2000	391,200	-265,631	-215,958
2001	725,400	68,569	118,242
2002	156,400	-500,431	-450,758
2003	319,100	-337,731	-288,058
2004	527,625	-129,206	-79,533
2005	793,063	136,232	185,905
2006	570,400	-86,431	-36,758
2007	709,979	53,148	102,821
2008	710,073	53,242	102,915
2009	593,074	-63,757	-14,084
2010	539,365	-117,466	-67,793
2011	502,710	-154,121	-104,448
2012	406,949	-249,882	-200,209
2013	460,000	-196,831	-147,158
Cumulative Shortage:		**-1,790,295**	**-1,094,873**

Table 14 shows the severity of the drought, beginning in 2000 through 2013 and provides additional insight into the reasons for overuse of the aquifer during these dry years. The prolonged period of below-average surface water flows during a time in which consumptive use has not seen similar declines has led the Basin into an unsustainable aquifer situation. High commodity prices have encouraged the pumping of groundwater in order to maximize yields in the short term. The current Basin experience of overuse of this natural resource asset has numerous historical precedents and is commonly termed "tragedy of the commons." This behavior is defined by Wikipedia *(http://en.wikipedia.org/wiki/Tragedy_of_the_commons)* as:

> "The tragedy of the commons … describes individuals [who], acting independently and rationally according to each one's self-interest, behave contrary to the whole group's long-term

best interests by depleting some common resource. The concept is often cited in connection with sustainable development, meshing economic growth and environmental protection, as well as in the debate over global warming. 'Commons' can include the atmosphere, oceans, rivers, fish stocks, national parks and any other shared resource."

In the example of the Rio Grande groundwater pumping, individual farmers are acting rationally, in accordance with the Tragedy of the Commons principle, to maximize groundwater pumping when required to maximize crop yields. The high commodity prices for alfalfa, potatoes and other crops allow for high cash payments to acquire augmentation supplies to replace depletions. However, these rational actions are contrary to the Basin's long-term best interests in that the groundwater is being depleted at an unsustainable rate. Only one of the subdistricts has been formed, so other groundwater users at this time are not required to replace depletions. The result is continuing drawdown of the unconfined aquifer and reduced pressure in the confined aquifer. The combination of higher surface water flows and reduction in consumptive use (e.g., a reduction in irrigated acres, a change to less water-intensive crops, deficit irrigation etc.) is required to achieve aquifer sustainability. Basin water users are taking active steps to reduce consumptive use through the groundwater management subdistricts (see Section 5.2.3).

Based on the current average over-draft of the unconfined aquifer of 85,000 AF per year, water users are faced with the decision to hope for a series of wet years or reduce consumptive use. Reduction of consumptive use by 85,000 AF per year represents more than a 10% decrease in agricultural production that would likely result in a 10% decrease in the economic output of the Basin's agricultural sector. Considering that the Great Recession saw a decline of 5% of economic output nationally between 2007 and 2009 (Commerce Department statistics), a reduction of 10% in dominant economic sector of the Rio Grande Basin will have significant economic impacts on the entire Basin that could be twice as severe locally than those of the Great Recession nationally.

5.1.3.1 AGRICULTURAL GROUNDWATER SUPPLY AVAILABILITY

The declines in aquifer storage over the past 15 years have not gone unnoticed by groundwater users. Deeper water levels translate into higher pumping costs. The eastern area of the Closed Basin and some parts along the far western edge near the blue clay line have seen significant drops in water levels that have resulted in reduced pumping yields and well surging. If aquifer storage levels continue to drop, the physical supply of water available to well users may continue to decrease and make some lands unusable for irrigated crops.

5.1.3.2 AUGMENTATION REQUIREMENT

Groundwater users in the Basin are now required to develop plans to replace injurious well pumping depletions. A Water court ruling (Case No. 2004CW24, District Court, Water Division No. 3 (Nov. 9, 2006)) found that the aquifers are hydraulically connected to the Rio Grande and Conejos River, but the extent of the connection is not known. As part of the Subdistrict No. 1 initial formation, the State enhanced its groundwater model of the Basin to determine stream depletions caused by pumping wells located within Subdistrict No. 1 and has shown depletions to be approximately 5% of the pumping in excess of surface water imports into the Closed Basin. The State has also performed preliminary modeling for other areas of the Basin, and depletions are higher, reaching as high as 25% of pumping. Pumping impacts are lagged over many years, and changing hydrologic conditions and pumping amounts make this percentage a rough estimate. Well users in the confined aquifer will be required to replace stream impacts on multiple streams, often quite distant from the well location. Agricultural well pumpers are forming subdistricts to jointly develop replacement water supplies.

M&I well pumping will also be subject to the same model results and will need to find replacement water supplies to continue pumping into the future. While M&I pumping makes up only a very small fraction of the overall groundwater pumping in the Basin, a requirement to augment approximately 25% of total pumping is a new and difficult addition to the operation of a municipal system. In particular, municipal wells completed in the confined aquifer will be required to provide replacement supplies on multiple streams throughout the Basin. With M&I pumping anticipated to climb to nearly 20,000 AF by 2035 (Table 7), M&I providers will need to replace approximately 5,000 AF of groundwater pumping to meet this obligation. Approximately half of this replacement might be replaced with wastewater discharges and lawn irrigation return flows from the M&I use if these return flows can be made in the required location, time and amount.

5.1.4 : Funding

5.1.4.1 FUNDING AND SUPPLY AVAILABILITY TO MEET ENVIRONMENTAL AND RECREATIONAL NEEDS

While the San Luis Valley has a long history of collaboration and track record of successful projects, there remain serious constraints to the efforts to achieve the full suite of projects that are identified and needed for long-term water sustainability for environmental and recreational needs.

The RGBRT and its many members and partners have developed innovations for the design and implement multi-use projects that address

many needs. While these will not achieve all that is needed to provide adequate water for environmental and recreational needs, they are useful and important. Riparian restoration and irrigation infrastructure improvement projects have improved the function of riparian areas and the ability of riparian ecosystems to meet multiple needs. Over time, SLV water rights have been acquired by the USFWS National Wildlife Refuges, the Great Sand Dunes National Park, CPW and numerous conservation organizations. In addition, conservation easements have helped to secure water rights in strategic places that help sustain some of the historic use patterns that support riparian zones and wetlands. These do not necessarily replicate the historic flow patterns of the rivers and streams, but they can help prevent the potential permanent dry-up of wetlands that would occur if those water rights were sold and transferred to augment well depletions off the river corridor. Possible adjustments in river administration could provide some additional opportunities to provide water to the river corridor in new time frames and patterns. Improving and rehabilitating the Basin's reservoirs is vital to any future flexibility in that regard. The imperative to restore aquifer levels to a sustainable basis, as is directed by State law and attempting to be implemented by the Groundwater Management Subdistricts, is also vital to the future of the Basin's internationally important wetlands. In these and many, many other ways, the "consumptive" and "nonconsumptive" uses of water are closely tied in the Rio Grande Basin.

Wetlands greening up in the spring, looking east to the Sangre de Cristos, on the conserved Gilmore Ranch, along the Rio Grande west of Alamosa. Photo: Rio de la Vista

Funding is a constant constraint to organizations working to improve environmental and recreational water uses. Combined with the overall scarcity of and multiple demands upon on the Basin's water, sufficient and timely funds are critical to achieve the identified projects in this Plan. Many organizations and agencies have a long track record of success in obtaining funds through the Water Supply Reserve Account (WSRA) process and other avenues. The collaborative activities have been a key element of this, along with the exceptional natural resources that are in the Basin. The ability of stakeholders to sustain collaborations and work together proactively will be critical to the future ability to compete for funds from a number of sources. Organizations also need sound data and continued scientific research to compete for funds and make science-based decisions for future projects. One area of funding that has long been difficult to obtain and sustain is for monitoring of resources. Too often, funds are available for projects and

implementation, but the vital role of monitoring to inform management decisions and future project design is among the most difficult efforts to fund.

A major constraint for the non-profit partners that implement many of the Basin's projects is funding for operating costs. This is especially challenging within the demographics of the SLV, a small, rural and relatively poor population. Other areas of Colorado, with larger urban populations can implement fees, support programs, and undertake larger-scale projects. It is important that State entities recognize this in funding decisions, as rural areas, such as the SLV are home to many of the environmental and recreational attributes that urban dwellers value.

5.1.4.2 ABILITY TO FINANCE M&I IMPROVEMENTS

The municipal treated water supply systems in the majority of Basin towns are antiquated, with many towns facing the need to invest in capital improvements to update their water infrastructure. The cost of these capital improvements will be significant with respect to the ability of the revenues and ability to fund improvements. The water rates for towns in the San Luis Valley, which may be high for the income level of residents, are insufficient to fund the major infrastructure repair, replacement and upgrades that will be required to remain in compliance with water and wastewater regulations and ensure reliable service. In the face of such large capital improvement projects, most Basin towns will have to obtain grants or loans from outside sources, with a resulting increase in water use rates. These increased costs will impose financial hardships for many Basin residents.

5.2 : Opportunities

The opportunities identified in this section of the Plan are meant to tell the story of the potentially favorable circumstances the Basin is currently facing. These are not meant to restrict the Basin from addressing future, unforeseen opportunities that may influence projects and methods. They are only intended to give an overview of current circumstances and how they may be addressed.

5.2.1 : Improving Streamflow Forecasting

Administration of the Compact, including the setting of daily curtailments for the Rio Grande and Conejos River is dependent upon accurate predictions of streamflow. Ideally, these forecasts should be based on accurate estimates of snowfall, careful monitoring of the water content and behavior of snowpack, and a good understanding of snowmelt, run-off, and streamflow. However, the ability to accurately collect all of these

data is limited. If the April through June streamflow forecasts are higher than what actually occurs through the summer and fall, the April through early summer curtailment will be established at a higher percentage than necessary, creating the potential for over-delivery under the Compact. In order to avoid over-delivery, the curtailment will then be lowered in mid to late summer, or even dropped to zero later in the season, once it is realized that the streamflow forecast was too high. An overestimation of streamflow, resulting in a higher-than-required curtailment through peak runoff, may result in reduced opportunities for junior water rights to divert and/or reservoirs to store. In the Rio Grande, this can mean less water diverted into the Closed Basin for groundwater replenishment. On the Conejos, it can result in lost opportunities to implement direct flow storage in the Platoro Reservoir for release to irrigators later in the season. Eliminating the risk of over-delivery through improved streamflow forecasting will also minimize the dry-up of the river by creating a greater potential of a curtailment throughout the irrigation season and a live stream all the way to the state line. Maintaining a live stream and eliminating dry-up locations, in addition to the environmental and recreational benefits, also reduces delivery lags to downstream users in the Basin and the Compact by not having to replenish the stream alluvium that was drained during periods of dry-up.

If the streamflow forecast is low, the curtailment will also have been set low as the delivery as a percentage of the index gages is less at lower streamflows. If it is determined after runoff that there is a chance for under-delivery under the Compact, the curtailment may be increased. Since the flows are lower after runoff, the increased curtailment is more likely to affect senior water rights holders. Streamflow forecasts were compared to the actual streamflow that occurred. The years 2006 through 2012 are shown in Figure 55 and Table 15, revealing large discrepancies between forecasted and actual April through September flow at the Rio Grande near Del Norte gage. Both over-forecasting and under-forecasting were observed, though only one year was over-predicted in this study period. For instance, in 2007 the April 1 forecast was 48% lower than the observed flow. The June forecast was not much improved over the April forecast and was still 41% lower than the observed flow. In 2008 the flow was over-predicted on April 1 by 58% while the June 1 forecast over-predicted by 46% (Table 15).

FIGURE 55.

NRCS-forecasted and actual April–September flow at the Rio Grande near Del Norte gage.

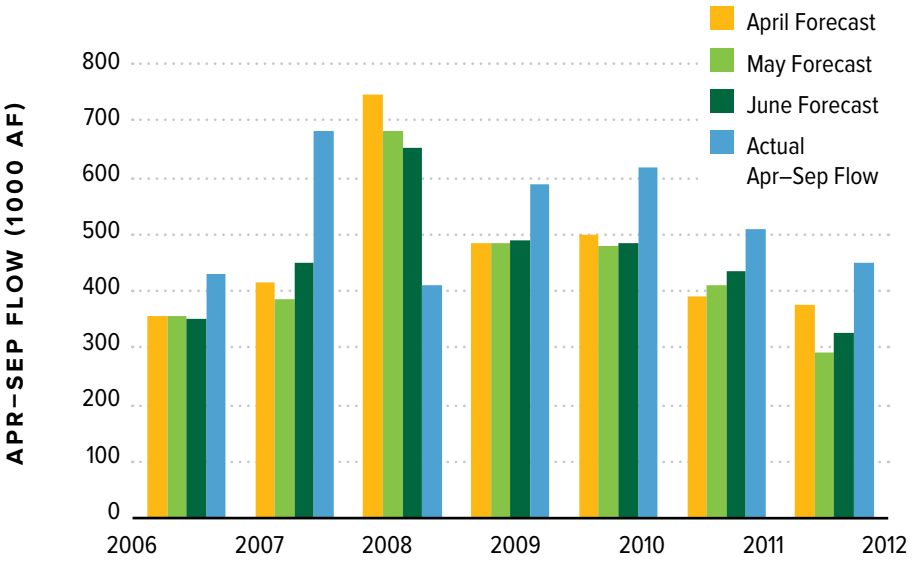


TABLE 15.

NRCS-forecasted and actual April–September flow at the Rio Grande near Del Norte gage.

Note: The percentage difference between the actual April–September flow and April 1 forecast is shown in the last column.

	NRCS Forecasts (Apr-Sep Flow) Rio Grande near Del Norte, 1,000 AF							
	Jan	Feb	Mar	Apr	May	Jun	Actual Apr–Sep Flow	Difference from April 1 Forecast
2006	395	315	280	355	355	350	430	19%
2007	555	555	490	415	385	450	680	48%
2008	690	790	850	745	680	655	410	-58%
2009	600	585	535	485	485	490	590	20%
2010	475	530	530	500	480	485	620	21%
2011	570	485	440	390	410	435	510	27%
2012	495	460	500	375	290	325	450	18%

It would be very beneficial to water users if the streamflow forecasting in the Rio Grande Basin can be improved. Improved streamflow forecasting also aids the Division Engineer's office in its water management decisions and determining curtailment percentages. The Conejos Water Conservancy District is conducting a Radar Project that is intended to generate historical forecasts using the Weather Service hydrologic models to better understand forecast errors and to use snow-covered area data to improve snow modeling and water supply forecasts. In addition, projects such as the USFWS LiDAR forecasting have the potential to greatly improve streamflow predictions with the benefits of protecting both junior and senior water rights holders and maintaining a more vital river for longer periods of time.

5.2.2 : Additional Uses For Basin Reservoirs

There are opportunities to better administer the pre- and post-compact reservoirs in the Rio Grande Basin to improve the management of the Basin's water resources. With coordinated operation, storage in the Basin's reservoirs can be better utilized to achieve multiple benefits. Climate variability will make storage important as the Basin's snowpack may have a reduced ability to store water seasonally. Specific to the Rio Grande Basin, the pre-Compact reservoirs are beneficial for fully developing and re-timing Compact deliveries, groundwater augmentation, and other water deliveries from state agencies.

5.2.2.1 STORAGE IN PRE-COMPACT RESERVOIRS

There are four pre-Compact reservoirs located in the Basin upstream of Del Norte: Rio Grande, Santa Maria, Continental and Beaver Park. These reservoirs, when they store in-basin supplies, do not trigger a delivery obligation until the water is released and passes the Del Norte gage. The storage in these reservoirs can be used to manage Colorado's Compact deliveries to prevent over-delivery and provide for a more consistent and equitable curtailment. Storage can be accomplished by seeing to it that these reservoirs are provided the greatest opportunity to be in-priority to store water and to utilize available space to better manage Compact deliveries.

Benefits of Compact storage include:

- A consistent curtailment percentage amount creates potential equity among all water users.
- Limits the potential for over-delivery by holding over water until the next water year if Compact deliveries will be satisfied.
- Maximizes the beneficial use of water within Colorado within the legal framework of the Compact.
- Consistent curtailment and eliminating the risk of over-delivery minimize the dry-up of the river by creating a live stream all the way to the state line. Maintaining a live stream and eliminating dry-up locations, in addition to the environmental and recreational benefits, also ensures the ability to maintain deliveries to downstream users in the Basin and Compact deliveries by not having to replenish the stream alluvium that was drained during periods of dry-up.
- Releases can potentially be timed to provide for instream benefits.

A potential operational scenario that prevents injury to Basin water users and that also ensures Compact compliance and provides for benefits to water users and environmental and recreational interests is described as follows. This scenario was initially modeled as part of the Rio Grande Cooperative Project and refined as part of this Plan:

- Establish a reasonable but safe estimate of annual curtailment.
- Maintain, to the extent practicable, a constant curtailment percentage.
- Store a portion of the curtailment in upper reservoirs.
- If Compact deliveries are running lower than needed, release water from upper reservoirs.
- If the release of Compact water is not required, determine if the water should be held over until the following year or released to the river.

5.2.2.2 AUGMENTATION DELIVERIES

Well users throughout the Basin will increasingly need to consider augmentation requirements. Pumping from a well results in stream impacts that are lagged over many months or years, depending on the

Rio Grande Reservoir.
Photo: Rio de la Vista

location of the well and geology in the region. Under Colorado water law, any legally injurious lagged stream impacts must be replaced, or augmented, to the stream and the time and location of the impact. Currently in the Rio Grande Basin, the San Luis Valley Conservancy District (SLVWCD) provides augmentation water for many non-irrigation wells. Subdistrict No. 1 provides augmentation water for stream impacts due to pumping within its boundaries. As the new rules for pumping are promulgated, most well users, including irrigators, other subdistricts and towns that pump groundwater and industrial users will need to find a source of augmentation water.

The reservoirs in the Basin can act as regulating vessels for delivery of the augmentation water. Augmentation supplies can be stored in reservoirs and then released at the rate and to the location of the stream impact. For example, the SLVWCD has a storage account in Rio Grande Reservoir in which it stores transmountain water supplies. This water is released to the stream to augment the stream impacts from well pumping by District users. The use of reservoirs throughout the Basin will become increasingly important because impacts are anticipated along many different stream reaches. In a letter from the State Engineer dated May 2, 2014, the state anticipates that stream impacts will need to be augmented on the Rio Grande, Conejos River, Alamosa River, upper and lower reaches of La Jara Creek, Trinchera Creek, Saguache Creek, San Luis Creek and Crestone Creek. Reservoirs that may be utilized for these areas include Rio Grande, Santa Maria, Continental, Beaver Creek, Platoro, Trujillo Meadows, Terrace, La Jara, Mountain Home, Smith and potentially other smaller reservoirs. Most of these reservoirs are privately owned and water users needing storage for augmentation water will need to negotiate storage contracts with the reservoir owner.

5.2.3 : Improving Watershed Health

The watershed of the Rio Grande Basin encompasses forests, grassland, floodplains, wetlands, riparian areas, agriculture lands and rangelands. Currently, there are sites and functions of the Basin's ecosystems in an unhealthy state, due to a variety of causes including scarcity of water, over-density of hazardous fuels, decreasing biodiversity, insect infestations, severe wildfire, and improper past management practices, all of which are exacerbated by drought. Post wildfire floods and erosion also pose a threat to river function and downstream habitats.

Opportunities exist to restore and conserve the historical functions and vitality of the Rio Grande and Conejos River watersheds, as well as the other creeks and streams that flow into the SLV, for improved water quality, agricultural water use, riparian and wetland health, wildlife and aquatic species habitat, recreation and community safety. The following sections will discuss the potential for improvements to forest health, post wildfire enhancements, the importance of and improvements to wetlands,

riparian health, and habitat management as well as the opportunity to protect land and water through conservation easements.

5.2.3.1 FOREST MANAGEMENT AND IMPROVING FOREST HEALTH

Extensive research has been done about the ways in which forest thinning and restoration mitigate the severity of wildland fires. Many organizations are also researching the ecological effects of forest treatments on other aspects of the forest environment. Forest management has evolved from large-scale timber cutting to the current landscape-scale efforts to restore forests to more vigorous, healthy conditions. While fire prevention provided part of the original motivation to begin this shift in approaches, the driving forces behind this move toward forest restoration have been watershed management and the escalating costs of catastrophic fire, both in financial terms and in the loss of natural resources.

The costs of wildfire suppression today are unprecedented. Each season brings larger, more damaging, and more expensive fires (Lynn, 2003). The social concerns associated with both wildfire and prescribed fire use are well documented. While prescribed fire is not a new tool in forest management, it remains controversial. At the planning level, public input will have a key role in identifying socially acceptable levels of prescribed fire (Weldon, 1996). The investments in mitigation practices, including prescribed fire, are essential, but these activities must be coupled with sound science that takes a broader view of the resulting ecological and social effects.

Forest restoration, the more recent approach to forest management, has many aspects. To name just a few of the factors involved, it requires attention to vegetation, wildlife, air quality, soil conditions, watershed effects, and fire mitigation. Environmental research examining these segments has been ongoing for more than thirty years and continues in forested areas around the world. A wide variety of scientific disciplines are looking closely at the overall changes that follow these forest treatments and are finding that many positive results can be achieved through management coupled with the use of low-intensity prescribed fire. Even though the research is ongoing, action must be taken now in order to counteract declining forest conditions and to lessen damage from the looming dangers of insect and disease outbreaks and of catastrophic fire. Scientists are making recommendations for Best Management Practices (BMPs) by combining this forest restoration research with current climate shift projections.

Turkey in Alamosa Valley.
Photo: Juanjo Segura

There is a consensus among forest professionals that a century of aggressive fire suppression and insufficient funding for extensive management of the resources has resulted in unhealthy forest conditions throughout the West. Overstocked, stunted, and stressed trees are competing for limited water, nutrients, and sunlight. Changing climate conditions are being verified. Catastrophes such as insect and disease epidemics and high intensity wildfires are more prevalent. Healthy forests directly correlate to a healthy watershed. The opposite is also the case. Wildlife habitats quality is declining and, as a result of poor forest conditions, so are wildlife populations.

In order to have a sustainable forest and a healthy watershed and all it entails for the future, every effort must be made to use the best science available to slow and reverse the decline of forest health. One of the existing opportunities is prescribed thinning of ponderosa and mixed conifer forests. Thinning obviously reduces the risk and severity of wildfires yet has influence on other aspects of the forest environment as well. The many other results of thinning are interconnected, with each influencing the rest.

Forest health and restoration benefits the whole ecosystem.

Some of the aspects of the environment that are affected by forest restoration include, but are not limited to, air quality, water quality/quantity and use, tree health, soils and the understory, and wildlife habitats and populations. As with any best practices, when planning forest management, it is critical to manage for long-range objectives, not just immediate results, and to take into account non-market and external benefits and costs, such as watershed and habitat protection, biodiversity, and carbon mitigation. Far-sighted forest management, combined with restoration, can play a large part in improving future forests (Viers, 2005).

5.2.3.1.1 WATERSHEDS AND WATER SUPPLIES

Supplies of water, one of the essentials of life, can be enhanced in many ways by forest restoration. Monitoring the effects of the water cycle within arid and semi-arid regions is most critical, because limited supplies have widespread and serious repercussions. Most city dwellers don't think to trace the fact that they can turn on a faucet and have clean water pour out back to how the forest promotes, or inhibits, the accumulation of a deep snowpack during the winter. This is where thinning can play an important role. At the most basic level, snow that piles up in branches above the ground provides little moisture to the tree or the soil. In climates of low humidity, the suspended snow sublimates, or evaporates into the air, instead of seeping into the soil. In contrast, snowpack on the ground slowly releases moisture that enters the ground and surface water systems. Thinning the forest to provide more space between tree crowns allows for development of a deeper snowpack. This ultimately increases the soil moisture, because it increases the opportunity for water to be absorbed by the soil and by reduces surface evaporation.

In addition, the deeper the snowpack, the longer it provides water during the spring melt. Going beyond the obvious positive effects of increased water supplies, snowpack storage of water is a valuable ecosystem service and surface water in the Rio Grande Basin has a significant value and provides multiple benefits to downstream users.

5.2.3.1.2 THE PLANTS' WATER USE

Tree roots draw in soil moisture and release it through the tree crown by evapo-transpiration (Kolb, 2009). Restoring ponderosa and mixed conifer forests by thinning them to historic conditions (Abella and Denton, 2009), followed by prescribed fire, not only allows surface snowpack to develop and water to be absorbed by the soil, it also makes more water available to the remaining vegetation (North et al., 2005).

These paired forest-restoration treatments influence many environmental variables of the understory. In addition to soil moisture, shifts are noted in litter depth, bare ground, and understory sunlight. Following treatment, more soil moisture and nutrients are available to the trees, shrubs, and ground vegetation, and understory diversity increases (Wayman & North, 2007). Changes in the understory need to be taken into account during the planning process, because other research shows that increased understory shrubs might eventually consume more soil moisture than conifers (Royce & Barbour, 2001). The comprehensive plan needs to consider understory management so that the long-term outcomes of treatments produce the intended results.

5.2.3.1.3 TREE HEALTH AND VIGOR

A combination of climatic influences (increasing temperatures and expanding drought conditions) and environmental pressures (competition for water and nutrients, excessive tree density, and the absence of fire) is contributing to a decline in the general overall vigor of our forests. This decline in vigor is associated with many forest health complications including insect epidemics, over-crowding, and competition for limited resources. For more information about the effects of insect epidemics and competition for limited resources on tree health and vigor see Appendix F: Forest Health.

5.2.3.2 FOREST RESTORATION ON THE RIO GRANDE

According to current research, the most successful restoration treatments involve carefully planned thinning of specific areas to the pre-settlement (1880s) number of trees, followed by prescribed fire to reduce the litter and fuels on the forest floor (needles and small branches), which also releases the nutrients necessary for recovery. In terms of timing, these treatments appear to be most beneficial after the herbs and grasses die

back or senesce for the winter and before the spring resurgence (Wayman & North, 2007). Prescribed fire during this period produces the least damage in terms of soil, vegetation, and wildlife disturbance and offers the quickest recovery.

Fireweed growing near Little Squaw Creek after the West Fork Complex Fire. Photo: Heather Dutton

In early July 2013 and in the midst of the West Fork Complex Fire (WFCF), RWEACT (Rio Grande Watershed Emergency Action Coordination Team) was formed. By USFS Policy, the Forest Service BAER (Burned Area Emergency Response) Team is not deployed until a wildfire is determined to be at a 50% containment level. The WFCF was described by firefighters to have exhibited some very intense and uncharacteristic fire behavior. Largely due to the expansive acreage of beetle infested timber, the fire burned at a very intense level. As a result, the WFCF was not determined to be at a 50% containment level for many weeks. It was during that time lag that the need for RWEACT to assist the FS BAER Team in determining and addressing Values at Risk came into play. RWEACT and the BAER Team worked side-by-side in protecting human life and the critical infrastructure as a first response and priority during and post wildfire for the entire first year since the WFCF ignited. The BAER Team was deployed for a short 30 day window and was composed of fire, engineering and natural resource experts from around the Rocky Mountain Region of the FS.

The WFCF was determined by the USFS to be at a 100% containment level on January 1, 2014. Since that time, RWEACT and, now the Rio Grande National Forest has worked in the partnership capacity that was born out of the WFCF in determining post-wildfire hazard mitigation and short as well as long-term forest restoration priorities.

5.2.3.3 FOREST RESTORATION NEED AND ECONOMICS

Current studies support the belief that it is less expensive to maintain, conserve, and sustainably use biologically diverse and naturally functioning ecosystems than to restore them. However, given the present state of ecosystem degradation, restoration is now an imperative. Ecosystem restoration activities can significantly increase job opportunities and improve livelihoods in rural areas that have been drastically impacted by wildfire and insect infested forests. During and after the WFCF of 2013 in the Upper Rio Grande, the town of Creede

reported a 75% reduction of tourist-based revenue for that summer and a 40% reduction in revenue for the time period of July 2013-June 2014. While the first priority for conducting forest restoration is to improve the health of the forest, restoration contracts with private vendors can stimulate the economy by creating jobs and keeping the funding within the local area. Additionally, a 2010 study by Northern Arizona University demonstrated that federal spending for ecological restoration treatments could generate a substantial economic stimulus in northern Arizona (Ecological Restoration Institute, 2009).

Additional benefits also result from restoration treatments. Restoration reduces the risk that lives and property will be lost to wildfires, and also decreases the amount of money needed to fight fires. Estimated minimum net benefits range from $600 per acre, for moderate-risk forests, to $1400 per acre, in high-risk forests (Ecological Restoration Institute, 2009).

Beetle-infested forest in Wolf Creek Pass. Source: Center for Snow and Avalanche Studies, Colorado Dust on Snow program

Ecological restoration is a sound economic development strategy. It improves the quality of the natural environment. It provides greater and more diverse employment opportunities. It reduces the enormous costs associated with wildfire. It creates long-term stability by helping to maintain economic resiliency in the rural, local communities that rely on the forests and watersheds for a tourism-based economy.

At times, the human element of natural resource management can make obvious conservations difficult specifically when each scientific discipline is engaged in research on very specific, measurable topics relating to issues of forest restoration. There is a critical need for consistent collaboration among people who are studying all of the aspects of this subject: conservation and ecology, forest health and fire mitigation, insect infestations, water supplies and communities, and many others. It becomes increasingly important to develop forest-restoration best-management practices from a broad, partnership perspective that encompass more segments, and we need to identify the many consequences of proposed treatment actions.

Some conditions are out of human control, particularly changes brought about by climate shifts and catastrophic events. No single answer will fit all forests or forest conditions. In both policy and project design, we need to identify priorities with regard to desired conditions for the forest structure, understory,

and flora and fauna habitats. People from all the related disciplines agree that the need for action is urgent. Fire prevention strategies that treat beetle-infested forests pre-wildfire, are crucial in an effort to prevent high intensity fires such as was experienced in the West Fork Complex Fire. Successful forest restoration projects must be ecologically and environmentally responsible, socially acceptable, and economically feasible and sustainable.

5.2.3.4 POST WILDFIRE, BEETLE KILL, CLIMATE CHANGE, AND DROUGHT IMPROVEMENTS

There is an opportunity to improve post wildfire, beetle kill, and drought treatment and recovery of the forest and watershed in the Rio Grande Basin. As has been discussed in Sections 5.1.2.1, 5.1.2.3, and 5.1.2.1, beetle kill, wildfires, droughts, and climate change, alone and in combination, have a direct and immediate impact on snow accumulation, ablation and melt, water runoff quantity and quality, flooding and drought. However, little is known about how these factors affect water quality and quantity in the Rio Grande Basin headwaters.

In January 2014, after the West Fork Complex Fire was determined to be "fully contained," RWEACT conducted a literature review of existing post-wildfire water quality studies that have been conducted in Colorado. It has become apparent that very little information currently exists. During the year following the ignition of the West Fork Complex fire, RWEACT team members were engaged in hundreds of conversations regarding water quality, post-wildfire potential affects to aquatic life and particularly to fish in the Rio Grande and its tributaries. As a result, RWEACT has engaged the Colorado School of Mines to develop a Watershed Health and Water Quality study on the Upper Rio Grande watershed in conjunction with a preliminary Water Quality study that has been undertaken by RWEACT separately.

Over the past year, RWEACT has conducted a plethora of post-West Fork Complex Fire treatments, rehabilitation measurements, monitoring systems, and public safety measures including:

Hydrology

- Modeling of hydrological impacts and projections related to the burn scar
- Landscape-wide instrumentation process for storm forecasting, early warning system related to public safety
- Deployment/installation of temporary Doppler radar system contracted through the Center for Severe Weather Research
- Post-wildfire Flood Risk Analysis map

Natural Resources

- Initial field verification of July 3rd Burn Severity mapping to identify levels and locations
- Coordination with BAER team to identify Values at Risk
- Review, initial field studies and design research for high-value, no BAER treatment areas
- Release of findings for the USGS Debris Flow Mapping study
- In coordination with DWR, installation of 6 water quality probes to monitor dissolved oxygen, pH, temperature, dissolved solids and sediments
- Design work for debris flow abatement structures and trash rack and boom structures on important reservoirs in the Basin
- Installation of Rosgen-designed check dam and initial dredging at key areas within the burned forest
- Installation of 6 test plots within the burn scar for research on best practices and continued monitoring
- Fuels and hazard tree mitigation in key areas, and fuels biomass project research, feasibility and design
- Aerial helicopter recognizance, monitoring flights over the burn scar area
- Hazard tree removal with hydro-axe at high public use recreation sites

Emergency Management

- Development of approved Three County Flood Plan & Emergency Management Protocol with mapping zones for emergency notification and response
- Creation of Weather Spotter Program Checklist, volunteer recruitment and spotter training
- Creation / implementation of a County deployment plan for contacting high-risk residencies
- Sandbagging Workshop with the Army Corps of Engineers
- Installation of high powered weather radio transmitter and distribution of weather radios in key areas
- Debris trash removal at high-hazard bridges and culverts
- Installation of manual Rain Gauges

Economic Recovery

- Identification of a National Disaster Area
- Small Business Agency meetings with individual business owners and offerings of low-interest loans (South Fork, Del Norte, Creede, Lake City)
- El Pomar Foundation emergency assistance grant application for “Immediate Needs” such as mortgage, utilities, emergency assistance for Rio Grande / Mineral residents
- Timber Sale Replacement discussions / public meeting with timber contractors

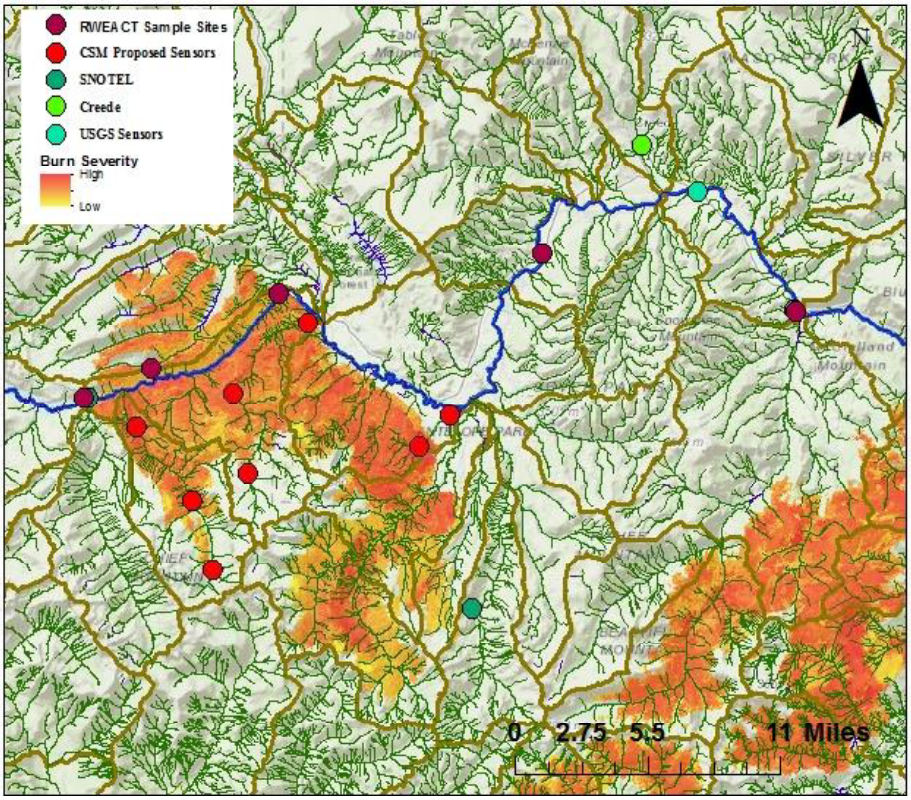


FIGURE 56.

Current and proposed instrumentation in the Papoose burned area.

Farmland and riparian areas along the Rio Grande in the San Luis Valley. Photo: Erich Schlegel

- Flood Insurance Workshop for public residents
- Release of information of Colorado Wildlife & Parks for big-game hunting impacts and fishing
- Discussions about impacts and pro-active volunteer projects to address fire-caused hazards on trails and with other recreational assets
- Participation in Agricultural & Forest Products Forum and discussions about biomass industry development
- Research and discussions about economic diversification within recreation-based activities to generate additional tourism

It is essential to understand and predict the effects climate variability and forest disturbances such as wildfires, bark beetle infestation, and prolonged drought have on environmental processes and develop relevant mitigation strategies for current and future conditions. This is especially pertinent in the Rio Grande Basin in southern Colorado, which has experienced prolonged drought, decade long spruce beetle presence, and a recent major wildfire (West Fork Complex fire, June 2013), burning more than 109,000 acres surrounding the headwaters of the Rio Grande. The Rio Grande and its tributaries are a significant source of water to the farmers in the San Luis Valley and further downstream to the driest regions of North America. Additionally, it provides excellent recreational fishing opportunities for trophy trout from the reservoirs at the headwaters through the miles of Gold Medal Stream as designated by the Colorado Parks and Wildlife (CPW).

There is major concern regarding the combination of drought, beetle infestation, and the compounded impact of severe wildfire on the integrity of the Rio Grande headwaters and ultimately the tourism and agricultural industries that rely on its water. Specific concerns include:

1. How will these forest disturbances affect seasonal water supplies, especially in regards to irrigation and agriculture?
2. Will changes in water chemistry affect local trout populations?
3. Are regions directly along the Rio Grande more likely to be affected by flood events in the following years?
4. How long will these effects persist throughout the region?

The overarching goal of RWEACT and the School of Mines long-term work in the Rio Grande is to better understand landscape disturbance, including climate change, wildfire, and spruce beetle kill, on water supply (both quantity and quality) in the headwaters of the Rio Grande. In order to achieve this goal, high spatial and temporal streamflow and water quality data during the spring runoff season immediately following the West Fork Complex fire needs to be captured. This data set is crucial in attempting to understand and quantify the effects fire has on hydrologic processes during subsequent seasons in the Rio Grande headwaters region. Fish, insect and habitat sampling to monitor post-fire effects on aquatic organisms also needs to be conducted as well as water quality monitoring to guide Rio Grande Reservoir releases.

The key data attained over the summer following the West Fork Complex Fire are planned to be integrated into specific hydrologic models such as WRF-Hydro and USGS PRMS-SN Temp hydrologic-stream temperature model. WRF-Hydro is a newly developed hydrologic coupling architecture linking weather and climate models with hydrological component models. It is designed to enable improved simulation of land surface hydrology and energy states and fluxes at a fairly high spatial resolution (1km or less) using a variety of physics-based and conceptual approaches. Under an existing NASA Applied Science project, the National Center for Atmospheric Research (NCAR), in collaboration with the NASA LIS group, has coupled the WRF-Hydro architecture into the LIS system (a land surface modeling and data assimilation framework) and has used the system to model flash flood events in the Colorado Front Range. The goal is to implement this model over the headwaters of the Rio Grande watershed, using improved spatial and temporal ground data acquired through work during the summer of 2014 to enhance model calibration and validation. The goal is that this model can be used to better understand the processes taking place during various forest disturbances and offer improved seasonal water supply and streamflow forecast. The USGS PRMS-SN Temp hydrologic-stream temperature model is a widely used model to predict stream temperature. Data collected in this study will test and validate this model with the overarching goal of creating a detailed temperature model specifically for the Upper Rio Grande and its tributaries. This will have significant impacts to Rio Grande Cutthroat Trout habitats as cool stream temperatures are critical to trout survival. Stream temperature response to the West Fork Fire Complex as well as future climate could be evaluated.

To learn more about the School of Mines project, see Section 6.

5.2.3.5 IMPROVING WETLANDS AND RIPARIAN HEALTH

Implementation of strategies to improve riparian areas and wetlands in the Basin will include methods aimed at enhancing existing conditions, restoring historic conditions or shifting conditions towards a new habitat type to help meet limiting resources. Restoration of riparian areas throughout the Basin requires a watershed-scale approach in order to restore a functioning and dynamic hydrologic regime integral to these systems (Hubert 2004). Management of these systems is an essential part of their maintenance and sustainability as they continue to be impacted from a variety of factors (Mitsch and Gosselink 1993).

Opportunities exist to improve the riparian areas in the Rio Grande Basin. The RGHRP has experienced a flux of interest in riparian restoration and agriculture infrastructure cost-share improvement projects. As such, the RGHRP, in close partnership with the NRCS, has projects lined up in differing stages of funding, design, implementation and monitoring. The WCRC also has opportunities to complete the critical Salomon Wetland Project to improve water quality from the Salomon Audit. The WCRC has

partial funding in place and is working with Good Samaritan legislation to move the project forward. Many other entities, such as the NRCS, USFWS, USFS and BLM are working toward developing and implementing wetland and riparian improvement projects.

An integral component of wetland management is the ability to have and control water resources. Water management plans should be developed and implemented based on water delivery capabilities, topography, soils, and climatic conditions. The development of SLV general water management plans would help managers make informed decisions relating to changes or disturbance of various habitat types based on how the entire system will function and provide resources to wildlife over the landscape. Maintenance of water delivery infrastructure should occur as needed to ensure that water resources can be efficiently and effectively utilized throughout the wetland complexes.

Management and monitoring plans that are adopted should be dynamic and by design informed by the observed changes to habitats over time resulting from a variety of management strategies. Ultimately a diverse composition of vegetation communities at various successional stages offers the greatest amount of resources to a wide range of wildlife and aquatic species. Climatic conditions play an important role in the timing of management activities requiring strategies to adapt to current conditions. Potential management strategies may include burning, mowing/haying, grazing, tilling, herbicide treatments, seeding, drought, and flooding. Each method may provide some similar results although most will have different impacts on the vegetation communities and potentially the hydrologic regime. Other types of strategies may include the installation of new water control structures, delivery ditches, and levees or the alteration of existing infrastructure including potentially removing these structures in order to allow sheetflow across the landscape.

The final and critical step in implementing any habitat management plan is the evaluation and monitoring of the plan after methods have been applied. Monitoring of the strategy should occur to determine how each community responds to the prescription and resultant use by wildlife and aquatic species over time. For example, locations of weeds treated with herbicide should be mapped in order to determine changes in cover, density, and extent over time and re-growth of native plants. As each management method is applied, changes in management may be prescribed given monitoring results that may or may not indicate that objectives have been met. Overall, management of wetland and riparian ecosystems has biological, political, and socio-economic impacts (Naiman et al 2005.)

5.2.3.6 CONSERVATION EASEMENTS

Section 2.6.8 included information about the history and momentum of Conservation Easements in the Rio Grande Basin. Citizens of the San Luis

Valley recognize that conservation easements are a tool to keep working farms and ranches and water rights intact, along with protecting critical wildlife habitat.

The many partners implementing conservation easements in the Basin see ongoing interest and demand for conservation from landowners, both along the river and stream corridors and in other key areas.

In addition to protecting important attributes on private lands, there are many complementary opportunities to enhance and restore working lands through management methods, restoration projects, water infrastructure improvements, public access developments, and much

Historic barn reflected in pond on the conserved Gilmore Ranch, along the Rio Grande wets of Alamosa. Photo: Rio de la Vista

more. These opportunities are implemented by additional partnerships with many collaborating agencies, districts and organizations, as discussed throughout this Plan.

5.2.4 : Groundwater Management Subdistricts

In 2004, Senate Bill 222 (SB 04-222) was passed that addressed declining aquifer levels in the San Luis Valley and potential injury to senior water rights caused by stream depletions from well pumping in the Basin. In response to SB 04-222, water users in the Basin are in the process of forming groundwater management subdistricts. The overall objective of the subdistricts is stated in Subdistrict No. 1's Plan of Water Management (Rio Grande Water Conservation District 2009):

> "The overall objective of this Plan is to provide a water management alternative to state-imposed regulations that limits the use of irrigation wells within the Subdistrict, that is, a system of self-regulation using economic-based incentives that promote responsible irrigation water use and management and insure the protection of senior surface water rights. "

So far, Subdistrict No. 1 is the only established legal subdistrict. It encompasses much of the irrigated acreage in the Closed Basin, except for lands along Saguache and San Luis Creeks. Subdistrict No. 1 has estimated that a reduction in 40,000 irrigated acres will be needed in order to reduce pumping from wells within its borders such that aquifer sustainability can be achieved. Other subdistricts are being formed, and the State has developed preliminary estimates of the locations and amounts of depletions to streams within the Basin that are anticipated to approximately align with the future subdistrict borders.

In addition to its plan of water management that outlines overall subdistrict objectives, responsibilities and general policy, Subdistrict No. 1 generates an annual replacement plan, which details the amount of water delivered to the river to offset stream depletions and the economic incentives used to reduce pumping. The incentives are a combination of increased costs to pump and voluntary pumping reductions through conservation programs such as the Conservation Reserve Enhancement Program and others programs that pay famers to fallow land, thereby reducing overall Basin pumping. Farmers in Subdistrict No. 1 have voluntarily reduced their acreage by 10,000 acres through the fallow programs.

The State's groundwater modeling computes depletions from different geographic regions called *response areas*. These areas are geologically similar and were formed by determining where stream depletions caused by pumping can be reasonably grouped together. The proposed response areas are discussed in Section 2.5.4 and shown in Figure 33. As noted, preliminary modeling by the State has shown that stream depletions

caused by pumping in one region can impact multiple streams, including streams distant from the pumping.

If the subdistricts fail to meet their stream depletions or create a sustainable aquifer system, the State may promulgate additional rules with regard to use of the unconfined aquifer and require all wells to augment their own depletions and be subject to a currently unknown and unspecified curtailment of well use in the San Luis Valley. The subdistricts represent a proactive opportunity for water users to avoid potentially onerous administration.

5.2.5 : Alternative Cropping and Increased Irrigation Efficiency for Agriculture

Agriculture is the primary economic driver in the Rio Grande Basin. The amount of water available to some irrigators is projected to decrease due to numerous factors, including aquifer sustainability and climate variability. The planting of alternative crops that consume less water and changes to farming methods that reduce the consumptive use per irrigated acre may be viable in the long-term and provide a more reliable economic future for San Luis Valley farmers that are facing reductions in water supply.

Field of crops in the Rio Grande Basin. Photo: Julie Messick

5.2.5.1 ALTERNATIVE CROPS

Potatoes and hay comprise the majority of crop production in the San Luis Valley. As noted in Section 2.2.7, alfalfa water consumption per quarter is estimated at 306 AFY while grass hay consumption is estimated at 2737 AFY. In comparison, barley and potatoes consume less per quarter at 181 and 150 AFY, respectively.

The average potential consumptive use (CU) is shown in Table 16, represented in inches per year and acre-feet per quarter section, assuming 125 irrigated acres per quarter-section. This table also shows the difference in CU per quarter-section compared to alfalfa. A change from alfalfa to grass hay would reduce annual CU by 33 AF per quarter, while a change to barley of potatoes would decrease the CU, as compared to alfalfa, by 125 and 156 AF, respectively, per quarter. Due to irrigation inefficiencies, the amount of water applied to crops is higher than the CU amounts shown in Table 16. Fields with sprinklers are normally assumed to be 80% efficient, and flood irrigated fields are normally assumed to be 60% efficient. For example, a potato field irrigated with sprinklers will apply approximately 190 AF so that the crops will consume 150 AF (190 AF times 80% is 150 AF of CU). A flood irrigated alfalfa pasture will have 510 AF of irrigation water applied in order for the crop to consume 306 AF. Most of the water not consumed returns to the hydrologic system.

TABLE 16.

Annual consumptive use (CU) in San Luis Valley by crop type.

Crop	Annual Consumptive Use, Inches	Annual Consumptive Use per quarter, AF	Difference in Consumptive Use per quarter compared to Alfalfa
Alfalfa Hay	29.4	306	
Grass Hay	26.2	273	(33)
Barley	17.4	181	(125)
Potatoes	14.4	150	(156)

As detailed in this Plan, there has been an increase in the irrigated acres planted with alfalfa, resulting in an increase in CU. This Plan has also described the unsustainability of the current agricultural consumptive use that is occurring. A change to lower CU crop type can help address the sustainability issue.

There are other crops that consume less water than barley or potatoes, but the change to a different crop can be a risky and complicated issue, as different planting and harvesting equipment may be required. Moreover, there must be a market for the alternative crop, along with the infrastructure to store and deliver the crop to market. If farmers do not have the long-term water rights to grow hay or potatoes using conventional approaches, they may consider alternative crops that have been identified as offering a potential opportunity, described below in this section.

According to the 2013 Comprehensive Economic Development Strategy (CEDS) produced for the San Luis Valley, about 3,000 acres of sorghum-sudan, a type of sugarcane, are currently being grown as an excellent rotation crop that uses half the water (San Luis Valley Development Resources Group 2013). Sorghum-sudan, also referred to as "green manure," will probably be expanding in use; it can be plowed under as mulch and soil amendment, and can also control potato nematodes. Presently in the SLV, Rockey Farms has adopted biotic approaches that include adding soil primers, such as companion crops like legumes and green manure crops that enrich the soil, in rotation with potato crops. The water savings from using green manure crops are substantial, saving up to six inches of water for the rotation crops and up to four inches of water for the potatoes. Using less water protects potatoes against blight and rot, and keeps fields from getting waterlogged, helping to safeguard the crop while saving money on sprinkler and pumping costs. For more information about soil health development to increase soil water-holding capacities, see Section 5.2.6.

A market also exists for quinoa, a South American high-altitude crop introduced to the Valley over 25 years ago. Quinoa is extremely high in protein, serves as a popular gluten-free alternative and offers great potential for profitability, since few growers — one is White Mountain Farms in Mosca — now produce the crop. Sunflowers also do very well in the Valley and could be used for the production of sunflower oil. There has been some very limited growing of sunflowers for Costilla County biodiesel.

Sunset over a barley field in the San Luis Valley. Photo: Heather Dutton

As interest in and demand for locally grown, organic food grows, more growers are entering the marketplace. Organic food markets offer considerable potential for the Valley. In general, more promotion is needed to expose organic market opportunities, and more assistance from qualified agencies is needed to assist farmers in adapting to the new organic technologies. Grower cooperatives for entering the organic markets provide a number of advantages, but a greater level of assistance is also needed in forming and managing cooperatives.

Within the last four years, local food producers, most of them raising or processing organic products, have coalesced into a cooperative community to promote and create a sustainable local foods system. Organized as the San Luis Valley Local Foods Coalition, the group publishes a guide to locally grown and sold meat, poultry, dairy, produce and other food goods. The guide includes information on over 60 local food producers. More information on the San Luis Valley Local Foods Coalition is available on its blog at www.sanluisvalleylocalfoods.blogspot.com or at www.slvlocalfoods.org.

Local farmers' markets have become a major source of local foods and are now a regular summer-into-fall feature in towns throughout the Valley. Markets with locations and dates include:

- Alamosa Farmers' Market – downtown; Saturdays, mid-July through early October
- Crestone Farmers' Market – downtown; Saturdays, Earth Day through mid-October
- Del Norte Farmers' Market – Spruce and Hwy 160; Thursday afternoons, July through September.
- La Jara Farmers' Market – town hall; Friday afternoons, end of July to September
- Monte Vista Sunshine Market – Fullenwider Park; Fridays, June through August
- San Luis Farmers' Market – Main Street; Thursdays, July to mid-August
- Saguache Farmers' Market – downtown pocket park; Fridays, mid-July to mid-October
- South Fork Farmers' Market – intersection of highways 160 and 149; Fridays, July through August

5.2.5.2 INCREASED IRRIGATION EFFICIENCY

The reality is that there is less water to irrigate with than in the past. Conversion from flood irrigation practices to pressurized sprinkler, micro spray and drip systems can decrease the amount of diversions from specific reaches of rivers, but may not reduce the overall consumptive use. A careful analysis is required when evaluating the savings from increased efficiency. Increased efficiency may not result in additional water savings and may have the unintended consequence of reducing return flows, some of which recharge the unconfined aquifer. There are water savings through

methods such as drip irrigation that will be realized through reduced evaporation losses. In addition to more efficient water use, the subsurface irrigation system may produce a higher quality of crop with less herbicides and pesticides required. For example, drip-irrigation systems do not wet the entire field as do sprinkler systems, so there should be fewer weeds and less need for herbicide. In addition, such technologies as surge valves and low-energy precision application make water usage more efficient and uniform. Better management techniques, such as irrigation scheduling, can also boost efficiency and yields. Finally, such practices as deficit irrigation — giving crops just enough water to produce a minimal profit — may be a noteworthy technique for water rights holders on the cusp of getting deliveries.

5.2.6 : Improving Soil Health

5.2.6.1 SOIL HEALTH OPPORTUNITIES IN THE RIO GRANDE BASIN

As soil health degradation becomes more apparent and interest in and information on rebuilding soil health rises, a local group of farmers, agency personnel and agronomists have formed an active Soil Health group that meets regularly, shares information and hosts farm tours. A number of local SLV farmers have started moving away from "modern" practices of using herbicides, fungicides, insecticides and other "cides" to address threats and help improve their crops. They have found that many of the chemicals farmers have been using over the years were not only eliminating the pests that caused problems for potato growers, but also killing off beneficial insects, fungi, plants and worms, which are able to control disease and kill other harmful pests. In contrast, they have found that successful soil health rehabilitation entails an ecosystem approach.

For three generations, Rockey Farms has been operating in the San Luis Valley, but over the past few years it has changed its practices to create an entire ecosystem for beneficial predators to fight harmful insects, such as aphids. They have experimented with planting diverse flowers along with their potato crop to help keep beneficial predators, such as ladybugs and lacewings, in their fields longer. The farming family has also adopted biotic approaches, including adding soil primers, such as companion crops like legumes and green manure crops that enrich the soil in rotation with potato crops. The water savings from using green manure crops are substantial, saving up to six inches of water for the rotation crops and up to four inches of water for the potatoes. Using less water protects potatoes against blight and rot and keeps fields from getting waterlogged, helping to safeguard the crop while saving money on sprinkler and pumping costs. Rockey Farms and members of the Soil Health group have offered to share their best practices, which have not adversely affected potato production and literally made their soil stronger and more resilient, with

other farmers wishing to improve their soil health and reduce water consumption.

Other SLV farmers and ranchers have focused on soil health through grazing management on rangelands and pastures, and where possible, reintegrating livestock into crop land management. Using livestock to harvest crop residue helps to break down plant material and to provide natural fertilizer that helps return nutrients to the land to complete several nutrient cycles. As shown in Figure 57, livestock leave residue that replaces nitrogen in the soil and organic matter. Livestock deposits also contribute to the carbon and phosphorus cycles; animal respiration provides carbon dioxide for the carbon cycle.

In addition to local farmer actions, the Rio Grande Conservation District (RGCD) is partnering with the Center Conservation District on the Soil Health Project. The Soil Health Project obtained property that allows the organization to put in place soil health improvement practices, including rotating crops of potatoes and various cover crops. The RGCD wants to illustrate to agricultural producers in the San Luis Valley and elsewhere that by having healthy soil, farmers and ranchers can achieve numerous conservation practices, including minimizing soil erosion, protecting water and air quality, and enhancing water quantity, while protecting agricultural yields (State of Colorado, Department of Agriculture, Rio Grande Conservation District Office 2010). The Soil Health Project also shows that healthy soils require application of less water when growing crops and reduce wind erosion blowing soil into local streams and water bodies (and onto snow).

Moving cattle on the conserved Rio Oxbow Ranch, above Creede. Photo: Rio de la Vista

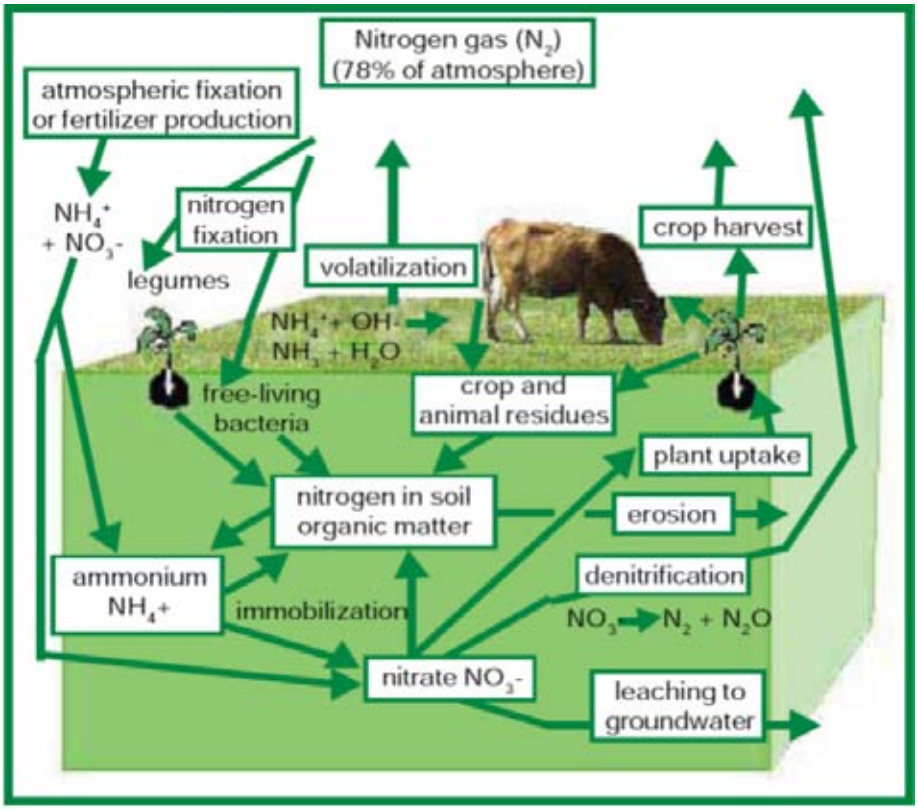


FIGURE 57.

Nitrogen Cycle.

Source: Bellows 2001

http://attra.ncat.org/attra-pub/nutrientcycling.html

The Colorado NRCS has funded two projects submitted by the Rio Grande Watershed Association of Conservation Districts to promote use of multi-species cover crops and the use of compost to benefit soil health and lower water use through better soil health and structure. The projects, sponsored by the RGHRP and the Rio Grande Watershed Association of Conservation Districts, will also introduce lower-consumptive-use crops into cropping rotations, as well as address aging diversion and headgate structures, streambank erosion, water quality, wildlife habitat and grazing management within the Rio Grande and Conejos River basins.

The majority of the Rio Grande Basin's headwaters are public lands, so watershed health and forest management lie largely within the realm of the National Forest and BLM managers, along with their private partners who have grazing allotments across much of the uplands. The West Fork Complex Fire of 2013, however, brought a new level of partnership between public land agencies, counties and many organizations, as outlined elsewhere in this Plan. The soil health of the forests and uplands is every bit as vital as that on the farmlands of the Valley floor for sustaining vital wildlife habitat and livestock grazing and for serving as nature's reservoir for the water supply for the Basin.

The potential of enhancing soil health in the Rio Grande Basin and across Colorado and the West is a vital and often-overlooked component of water management. It has a proven track record of providing many benefits, from enhancing agricultural production and reducing the use of

chemicals in farming, to reducing groundwater pumping for well-based crops and increasing water-holding capacity of farm and rangeland soils. Other benefits include reducing sediment movement that shortens the lifespan of reservoirs and other infrastructure and worsens water quality; reducing wind erosion; and increasing resiliency of farm and rangelands to drought and extreme weather variations. This Plan encourages Rio Grande Basin public land managers, farmers and ranchers to learn and implement these practices in order to sustain the very basis of our natural systems that we rely upon for our quality of life and our livelihoods.

5.3 : Basin Planning Model

The State of Colorado began development of a surface water model through the Rio Grande Decision Support System (RGDSS) in 1999 using the State's surface water model platform called StateMod. Work on the surface water model stopped in the mid-2000s while certain legal matters were decided through the court system. The decisions from those court cases changed the focus of the RGDSS modeling effort to the groundwater model, and the surface water model has not been completed. A portion of the data needed for a surface water model was assembled and is available through the RGDSS and the State's hydrologic database, HydroBase. For the purposes of the Basin Water Plan, a simplified surface water model was developed in order to better characterize various constraints and opportunities that face the Rio Grande Basin in the future, including identification of supply and demand imbalances. To that end, an existing RiverWare model that was developed as part of the Rio Grande Cooperative Project was adapted for use on the Rio Grande and Conejos River systems, incorporating data developed through the RGDSS where available and appropriate.

RiverWare is a river and reservoir modeling platform developed by the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado (http://www.riverware.org/). Through this Basin modeling effort, characteristics of the Basin with regards to hydrology, physical infrastructure, demands, and legal and administrative policy are captured. By changing these inputs to the model, future conditions can be assessed, including:

- climate change
- wildfires
- dust on snow events
- infrastructure projects
- changed water rights
- changes in administrative policy

A brief description of the model configuration, testing and calibration is presented in this section. A more thorough description of the model development and components is contained in Appendix C: RiverWare

Model Description. Use of the model under various future conditions is described in subsequent subsections, including potential changes to hydrology due to dust on snow, beetle kill, forest fires and climate change (Section 5.1.2). The RiverWare model is intended to be a tool that is sufficiently flexible and useful to incorporate other projects and methods described in Section 5.3 of this Plan if and when additional analysis is required.

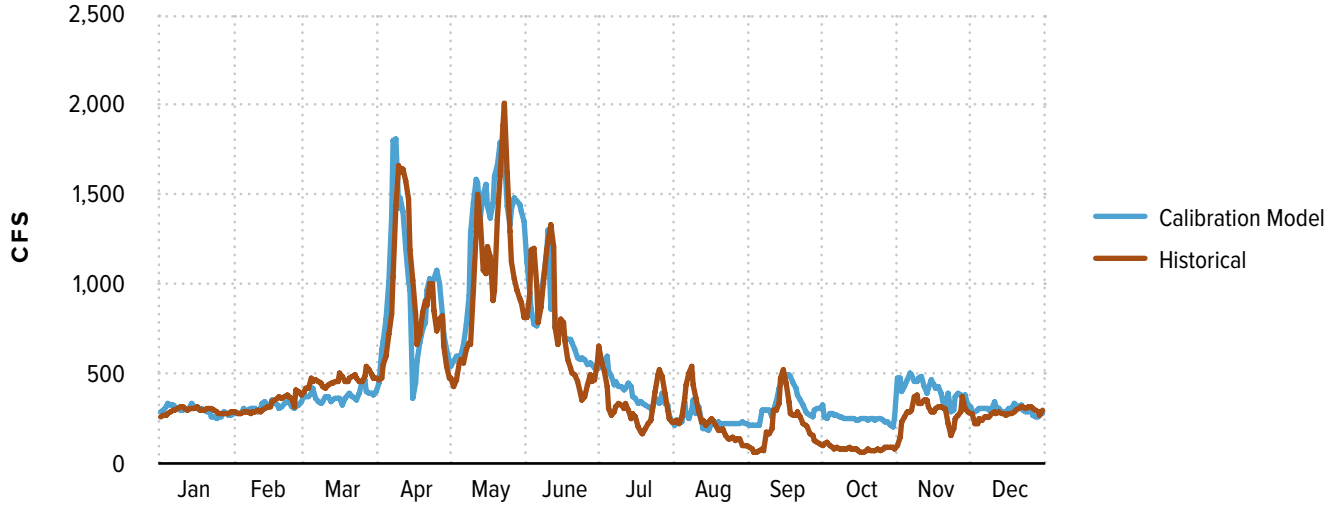
The model was initially configured to simulate historical conditions on the Rio Grande and Conejos Rivers. The process of re-creating historical conditions is known as *model calibration*, and provides a way to test the model and determine whether it can accurately simulate observed conditions, before it is relied on to simulate changed or future conditions. By their very nature, models are meant to simplify the natural system and water management decisions so that reasonable predictions can be made, but no model will exactly predict the future. There is a saying common to model developers that "all models are wrong, but some are useful" (quote attributed to British mathematician George Box). The purpose of the RiverWare model for this Plan is not to exactly simulate the complex interaction of natural and man-made processes on the hydrologic system, but to provide a reasonable and useful representation of how conditions may change under a variety of scenarios.

The RiverWare model simulates the Rio Grande from above Rio Grande Reservoir, Continental Reservoir, Santa Maria Reservoir and Beaver Reservoir, downstream to the Lobotos gage near the New Mexico state line. The model also includes the Conejos system from the Los Pinos and San Antonio gages near Ortiz, Colorado, and from Platoro Reservoir on the Conejos River, downstream to the confluence with the Rio Grande near Los Sauces. The model includes inflows from the Closed Basin Project and simulates irrigated lands located within the Alamosa and La Jara basin that are irrigated from ditches that divert from the Rio Grande or Conejos. The current version of the model does not simulate the smaller basins, such as the Trinchera, Costilla, Alamos or La Jara creeks. These basins could be added in the future to evaluate various projects and methods to address needs in those basins.

The model does not simulate the interaction with the groundwater system or any streamflow impact on groundwater pumping. Results from the recent Subdistrict No. 1 Annual Plan for Replacement derived from the RGDSS groundwater model are simply used as a water demand in the RiverWare model, and this model is unsuitable for determining streamflow impacts from pumping. Data obtained from the State of Colorado developed as part of the RGDSS was used as model inputs, including water rights tabulations, irrigation demand for all ditches, assumed conveyance and irrigation efficiencies, stream gage data, historical Compact curtailment data and interviews with water commissioners and the Division Engineer's office to help understand operations and administration.

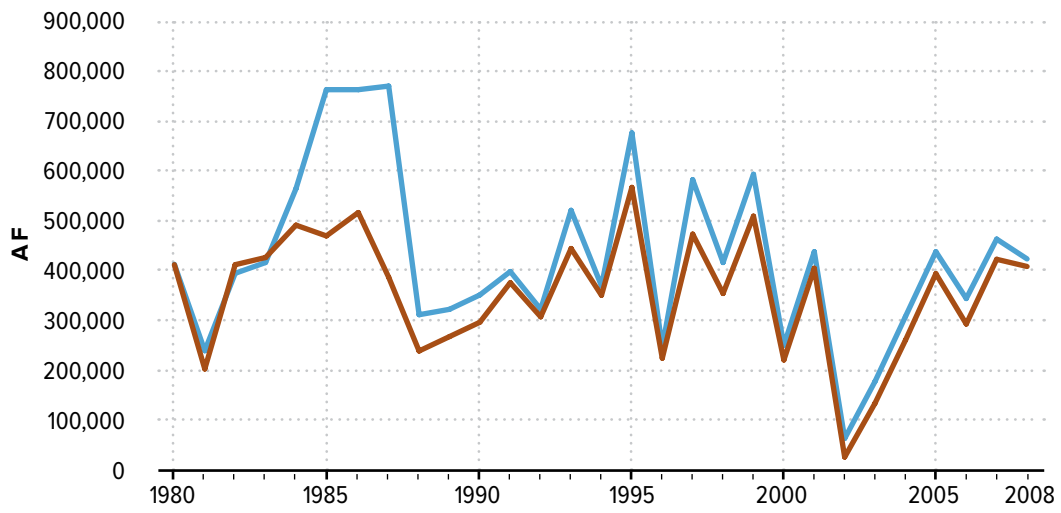
The model operates on a daily timestep and determines diversions at river headgates based on the prior appropriation system. The majority of the water demand in the Basin is for irrigation, whether recharged first and later withdrawn through sprinklers, or directly applied to crops. The model determines the water rights that are in priority on each day, and delivers water to these water users. The model then consumes a fraction of the diverted water based on the RGDSS model's irrigation water requirement (IWR), and routes ditch losses and on-field return flows back to the stream. Return flows from water users are lagged en route to the stream, and a loss can be applied to the returns to represent a number of processes, including re-diversion by other ditches through drain systems, subirrigation of pastures, evapotranspiration from native vegetation, or recharge of the aquifer. Comparing the simulated streamflow to observed streamflow at a number of gaged locations guided decisions on the lagging timeframes and loss amounts. Simulated flow at the Rio Grande near Lobatos gage is critical as it reflects the diversions, return flows, and Compact deliveries from the Rio Grande and Conejos River systems. Figure 58 shows an example year (1991) of simulated and historical flow at the Rio Grande near Lobatos gage. Differences between the flows are largely attributable to inaccuracies in modeled diversions, return flows, ungaged gains and losses, and compact curtailment as these factors dominate the hydrology upstream of the gage. Comparing historical diversions at several diversion structures allowed for verification of reasonable and useful simulation of the water rights system. The sum of diversions to the Big 6 canals over the modeled period of record (Figure 59) indicates a small over-estimation of diversions in most years. Large differences exist in the years 1984–1987 due to a voluntary bypass of water by many water users in the Colorado Rio Grande Basin in an effort to spill

FIGURE 58. Comparison of flows at the Rio Grande near Lobatos gage between the RiverWare model calibration run and historical flow in 1991.



Elephant Butte Reservoir in New Mexico that eliminated Colorado's debt to New Mexico under the terms of the Rio Grande Compact. These were years of very high flow in the Basin and the model predicted high rates of diversions as a result, not considering the unique historical decision-making. The model has attained a level of calibration that reasonably simulates historical observations which supports the use of the model to

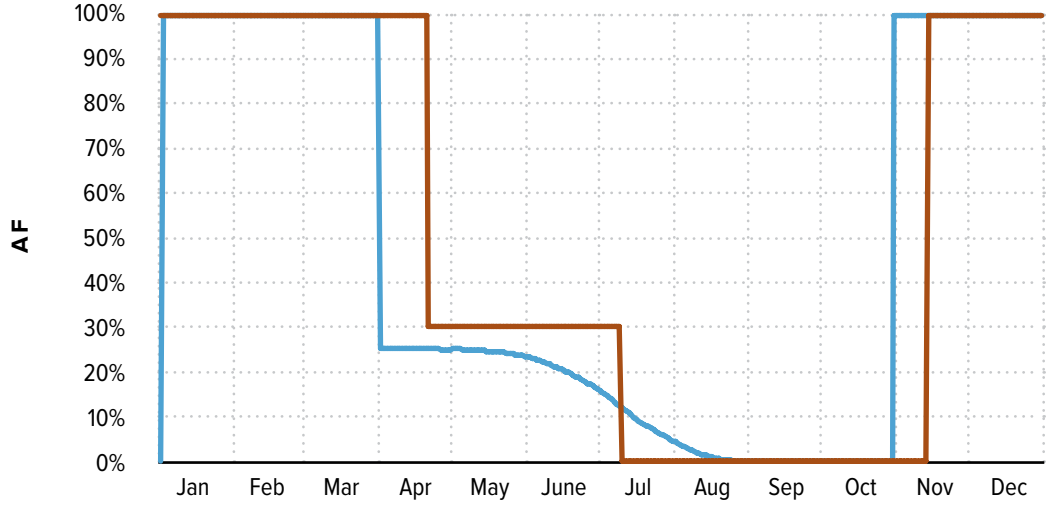
FIGURE 59. Comparison of annual diversions to the "Big 6" canals between the RiverWare model calibration run and the historical diversions.



The "Big 6" canals include the Rio Grande Canal, Farmers Union Canal, San Luis Valley Canal, Empire Canal, Monte Vista Canal, and the Prairie Ditch.

Calibration Model
Historical

FIGURE 60. Comparison of the modeled and historical Rio Grande curtailment in 1980.



Calibration Model
Historical

make reasonable and useful predictions about the system response under changed future hydrologic conditions.

Major differences in the years 1984–1987 are due in part to voluntary bypassing of water to spill Elephant Butte Reservoir in New Mexico that eliminated the large Compact debt that existed.

RiverWare was originally designed to simulate multiple reservoir systems that may have complex policy and logic associated with their operations. This flexibility in the RiverWare modeling platform allows for the simulation of variable reservoir operations and administration of the Rio Grande Compact. The model simulates multiple reservoir accounts in Rio Grande, Continental, Santa Maria, Beaver Creek and Platoro Reservoirs, and is able to simulate exchanges between reservoirs. The model also includes much of the logic used by the Division Engineer to determine the curtailment (see Section 2.5.2). Calibration of the model involved comparing the historical curtailment amount to a simulated curtailment using historical NRCS streamflow forecasts. An example year of the calibration results (shown in Figure 60) indicate that differences exist between the modeled and historical curtailment due to the Division 3 Engineer's determination of the start and end of the irrigation season, the rate at which updates are made to the curtailment, and the Division 3 Engineer's on the ground assessment of runoff conditions. In a conversation with Division 3 Engineer Craig Cotten (Cotten 2014), Mr. Cotten stated that there is a high amount of uncertainty between runoff projections from the NRCS and the National Weather Service, and that his office is developing a model to help make better streamflow projections in the later part of the irrigation season. Despite the differences between modeled and historical curtailment, the model matches the Division Engineer's ability to deliver an appropriate amount of water annually to New Mexico under the terms of the Rio Grande Compact without accruing a large debit or credit.

The modeled irrigation season extends from April 1 to October 31 in all years, which is inaccurate in some years. It also makes daily adjustments to the curtailment based on a continuously updated obligation forecast and delivery to New Mexico whereas the actual curtailment is updated every 10 days and includes adjustments based on the Division 3 Engineer's discretion.

5.3.1 : Adjusted Hydrology

The historical hydrology of the Upper Rio Grande Basin was adjusted in several ways to account for climate change, dust on snow, beetle kill, and forest fire. These adjusted hydrologic inflows were then used as input to the RiverWare model to assess how these changes to the river inflow affect irrigation, reservoir operations, the Rio Grande Compact, and all other modeled components of the Basin's surface water.

Adjusting the naturalized inflows was accomplished slightly differently for each phenomena based on the available information, location of the projections, and time-scale and time-step of the projections. As was done for the historical flow, projections of naturalized flow at river gages under different climatic and environmental scenarios was spatially disaggregated upstream by subtracting the effects of upstream diversions and reservoir storage. See Appendix C: RiverWare Model Description for more information on data sources and spatial and temporal disaggregation of naturalized flows.

Figure 61 shows an example model year (1982) of different inflows to Rio Grande Reservoir used in the RiverWare model under historic, climate change, and a dust on snow event. The climate change scenario starts in 2038 and the RiverWare model starts in 1980, so model year 1982 uses projected flows in 2040. The historic record in 1982 has a maximum naturalized inflow of 1488 cfs while the climate change projection has a maximum inflow of 803 cfs. The dust on snow scenario reduces historical inflow by 5%, so the maximum flow is 1414 cfs. Peak flow in the historical record occurred on June 25 while peak flow in the climate change scenario occurs on June 1. The dust on snow scenario shifts historical flow earlier by 21 days, so peak flow occurs on June 4. As this is just an example year at one inflow location, not all years and locations of inflow hydrology show the same pattern in timing and volume of flow.

The blue region shows historic inflow, the brown region shows projected inflow in 2040 from CMIP-3 run 20 (cool and dry), and the green region shows historic flow adjusted for a dust on snow event.

FIGURE 61. Example inflow hydrology to Rio Grande Reservoir in model year 1982.

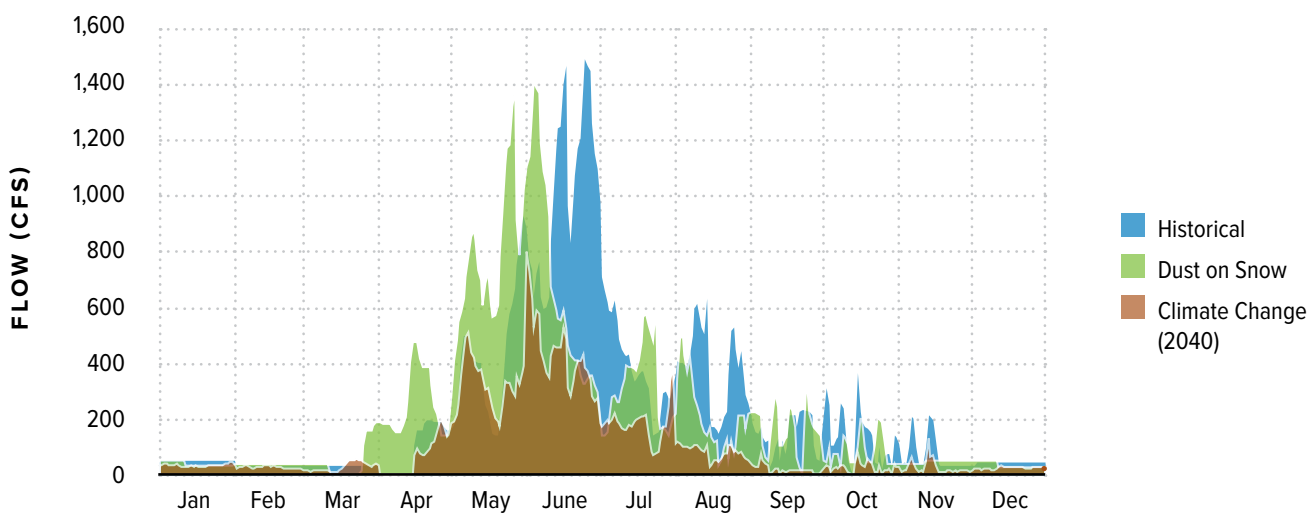


Table 17 shows average changes from historic inflow hydrology to the Rio Grande and Conejos River with adjusted hydrologic inflows. The Rio Grande inflow volume is impacted the greatest from climate change and decreases as time goes on through the 21st century. By 2067–2096, Rio Grande inflow volume is projected to decrease by 42% from the 1980–2008 historical period. Dust on snow events are estimated to reduce snowfall runoff by 5% due to increased evaporation, and beetle kill and forest fire-affected areas may see increases in runoff volume due to reduced evapotranspiration and canopy loss. The Conejos River Basin is anticipated to experience less of a decline in runoff volume due to climate change (20% by 2067–2096 as compared to 1980–2008), but still sees increasing decline over time. The same changes in runoff volume are anticipated due to dust on snow, beetle kill, and forest fire as seen in the Rio Grande Basin.

All of the climatic and environmental changes modeled cause an average shift to earlier runoff than experienced from 1980–2008. Dust on snow events are estimated to cause a 3–6 week shift to earlier runoff due to higher albedo and higher rates of evaporation. Similarly, forest fire and beetle kill cause a decrease in canopy cover and higher rates of insolation resulting in a 1–3 week shift to earlier runoff. Climate change projections in the Rio Grande Basin predict an average 6 day earlier runoff early in the 21st century and 12 day earlier runoff later in the 21st century. The Conejos River Basin is expected to experience an even greater shift with runoff arriving 10 days earlier in the early 21st century and 14 days earlier in the later 21st century.

TABLE 17.

Statistics from projected hydrologic inflows used in the RiverWare surface water model.

The climate change projections are the average of the 5 CMIP-3 runs described in Appendix C: RiverWare Model Description.

	Rio Grande Inflow Volume	Rio Grande Inflow Timing	Conejos Inflow Volume	Conejos Inflow Timing
Climate Change 2009–2038	-18%	6 days earlier	-16%	10 days earlier
Climate Change 2038–2067	-32%	9 days earlier	-16%	13 days earlier
Climate Change 2067–2096	-42%	12 days earlier	-20%	14 days earlier
Dust on Snow	-5%	21 days earlier	-5%	21 days earlier
Beetle Kill	+5%	7 days earlier	+5%	7 days earlier
Forest Fire	+5%	14 days earlier	+5%	14 days earlier

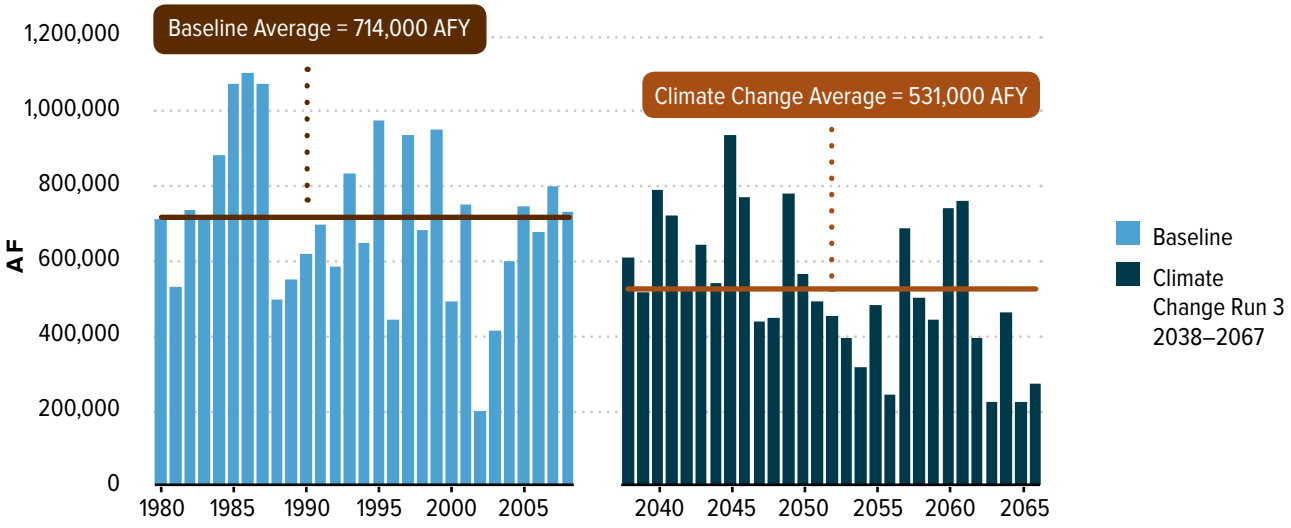
5.3.2 : Model Runs of Different Hydrologic Scenarios

The RiverWare surface water model described in Section 5.3 was used in conjunction with the predicted hydrologic inflows described in Section

2.3.1 to model the effects of predicted climatic and environmental changes in the Rio Grande Basin and their effects on the surface water system. Described below are select model results comparing the Baseline model developed to reflect historical conditions from 1980–2008 to a model run using one set of climate change projections (run 3) for 2036–2067. This particular climate change projection was chosen as its forecasted temperature and precipitation projections were representative of all of the climate change projections. A summary of all results including projected changes due to climate change, dust on snow, beetle kill, and forest fire can be found in Appendix C: RiverWare Model Description.

Under climate change conditions, average flows in the Rio Grande Basin are forecasted to decrease, so diversions for agriculture will also decrease. In Climate Change Run 3 from 2036–2067, diversions in District 20 (Rio Grande Basin) are anticipated to average 531,000 AF/year. In the Baseline scenario, diversions in District 20 averaged 714,000 AF/year (Figure 62). This is a decrease of 26% from the Baseline 1980–2008 run under Climate Change run 3 conditions. Average inflows into the Rio Grande Basin decreased by 35% between the same two model runs, showing that average diversions do not decrease as much as might be expected based on the inflows. Reasons for this may be related to a better ability to use reservoir storage under low flow conditions and the Rio Grande Compact structure. As seen in Figure 63, obligations to New Mexico under the Rio Grande Interstate Compact decrease from an average of 105,000 AF/year to 61,000 AF/year (a 42% decrease) due to the 35% lower flows at the Rio Grande near Del Norte gage. This 42% lower obligation results in a lower curtailment to diversions and hence a higher average rate of diversions

FIGURE 62. Comparison of annual diversions in District 20 (Rio Grande Basin) in the Baseline run and Climate Change run.



than if obligations to New Mexico under the Rio Grande Compact fell linearly with lower flow.

Flows in the Conejos River Basin are projected to decrease less on average under Climate Change Conditions than in the Rio Grande Basin. However, in Climate Change Run 3 from 2036–2067, projected flows in the Conejos Basin decreased by 28% compared to historical conditions from 1980–2008, a larger decrease than the average of all the climate change models. Diversions in the Conejos Basin during the same period decreased from 365,000 AF/year in the Baseline run to 294,000 AF/year in the climate change run, a decrease of 19% (Figure 64). The reasons for the discrepancy between the decrease in flow and decrease in diversions may be similar to the Rio Grande Basin, though there is less reservoir storage in the Conejos Basin than in the Rio Grande Basin. Another possible reason for the relatively small decrease in diversions is the high rates of return flows in the Conejos Basin. Under higher flow conditions (reflected in the 1980–2008 hydrology), many of the downstream water users return large amounts of water to the Conejos River, Rio Grande, and various drains that cannot be re-diverted within the Conejos Basin. Under low flow conditions, however, there is a well-known dryup point at Highway 285 near Antonito. Water users upstream of the dryup may still experience high rates of return flows, but these returns can be re-diverted or provide additional irrigation through drains and subirrigation to downstream water users. This re-diversion of return flows may help explain how rates of diversions within the Conejos Basin don't decrease as drastically as the decrease of inflows may suggest.

FIGURE 63. Rio Grande Compact obligation in the Baseline run and Climate Change run.

The obligation excludes the Conejos obligation.

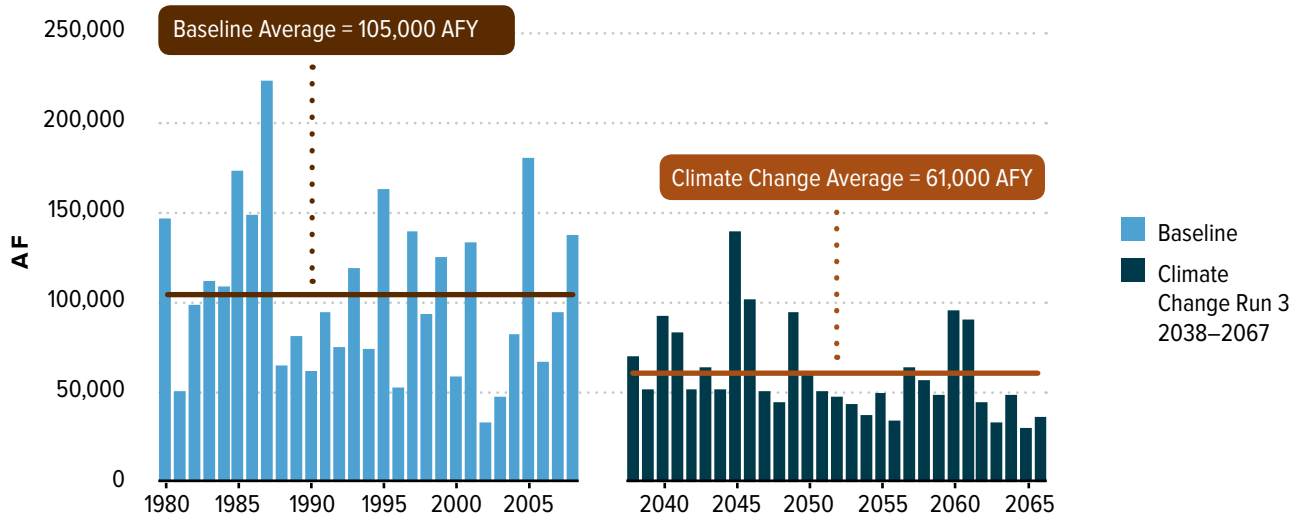
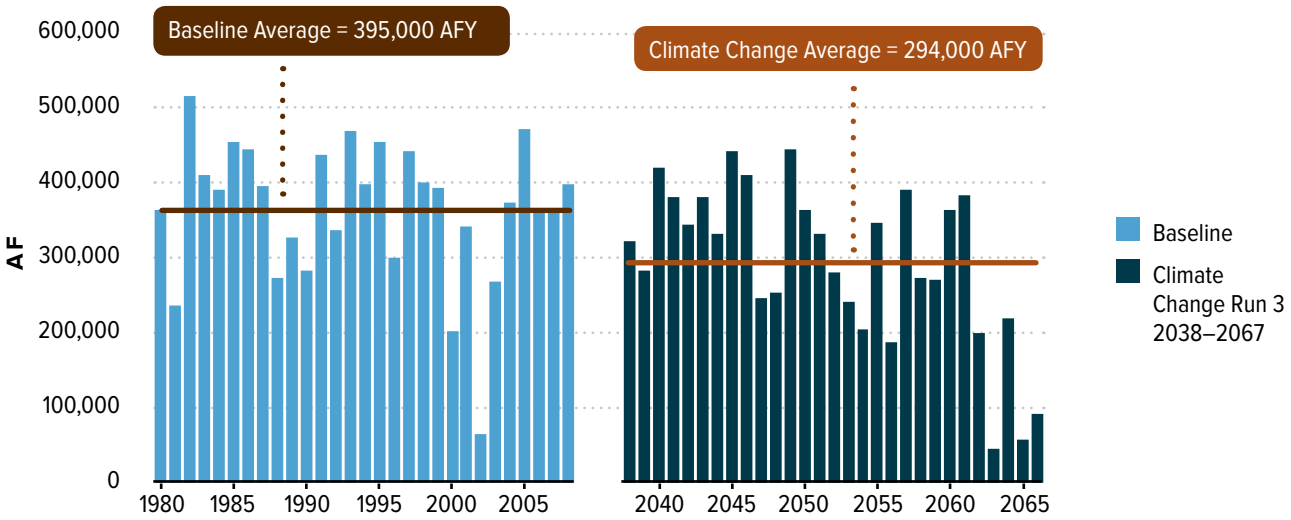


FIGURE 64. Comparison of annual diversions in District 22 (Conejos River Basin) in the Baseline run and Climate Change run.



The "Big 6" canals along the Rio Grande (Rio Grande, Farmers Union, San Luis Valley, Empire, Monte Vista, and Prairie) are responsible for the majority of the diversions in the Rio Grande Basin and are vitally important to farming in the San Luis Valley. They have many unique water rights and can take advantage of different accounts in reservoirs through storage water rights and direct flow water rights with alternative delivery locations. Under various alternative hydrology scenarios, each canal will respond differently based on the priority of its water rights and storage accounts. For example, very senior water rights will not be affected by an average reduction in flow and very junior water rights may also be in priority nearly as often if high flow events happen as often as they have historically. Water rights that come in and out of priority near historically average flows may be the most seriously affected by an average decrease in flow expected under climate change conditions as the hydrograph will rise above the priority threshold for a smaller amount of time each year. Similarly, with an increase in flow and change of timing expected in Beetle Kill and Forest Fire affected areas, some water rights stand to benefit greatly from a small increase in average flow as they will be in priority more frequently.

The Rio Grande, San Luis Valley, Empire, Monte Vista, and Prairie Canals and Ditches respond very similarly to the changes in hydrology expected from Beetle Kill, Forest Fire, and Dust on Snow (Figure 65). With Beetle Kill, they experience a 2% to 7% average increase in diversions and with Forest Fire, they experience a 1% decrease to 6% increase in average diversions. Both of these environmental changes are expected to cause an increase in the volume of flow and a shift to earlier runoff. In the Dust on snow scenario (lower volume and much earlier runoff) diversions to

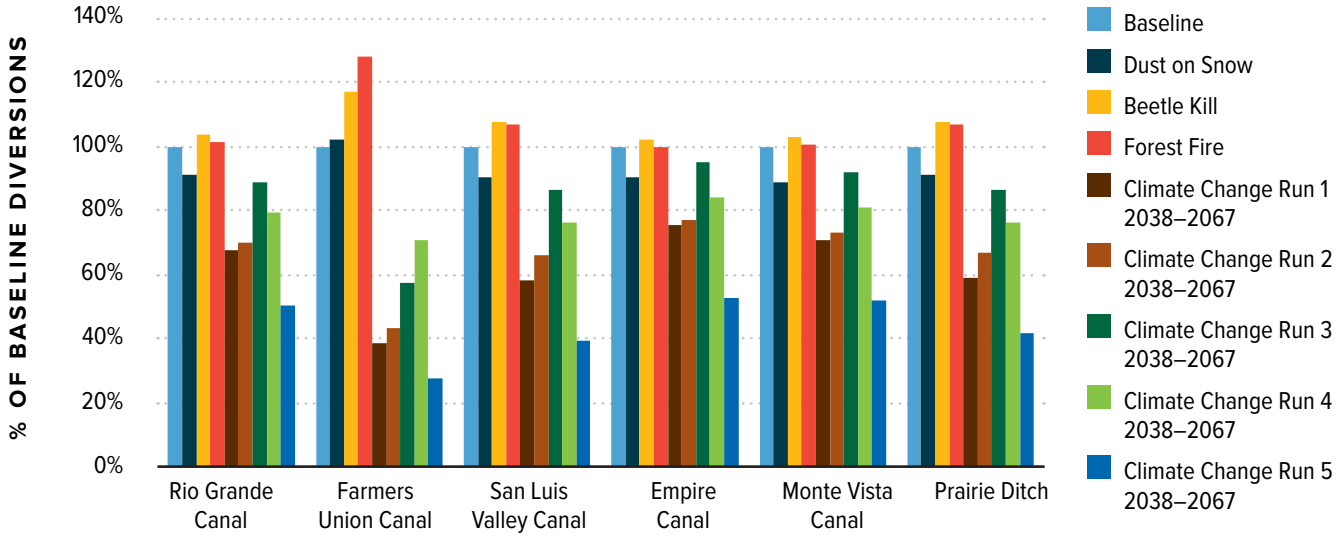
these five canals decrease by 9 to 11%. The Farmers Union Canal responds differently than the other five canals to these three environmental changes. With Beetle Kill, it diverts 17% more on average than the Baseline run and with Forest Fire, it diverts 28% more. In the Dust on Snow scenario, it diverts 2% more than the Baseline run despite there being a lower volume of flow in the Basin. These increases in diversions are most likely due to the earlier timing of flow and the San Luis Valley Irrigation District's storage rights in Rio Grande Reservoir that are in priority outside of the irrigation season. With earlier flow, there is more available water in the late winter to be stored in Rio Grande Reservoir, and then released to the Farmers Union Canal later in the year.

Under the five Climate Change scenarios in the years 2036–2067, all of the Big 6 Canals see reductions in diversions. On average, the six Canals under the five climate change scenarios decrease their diversions by 33%. The Empire Canal only experiences an average reduction of diversions by 23% under the 5 scenarios while the Farmers Union Canal experiences an average reduction of 53%. Under climate change run 5 from 2036–2067, the Farmers Union Canal only diverts 27% as much as it did in the Baseline run. Its water rights are positioned in such a way that it benefits the most from an earlier shift in timing of runoff, but suffers the most from a decrease in the volume of flow above the 5% decrease expected with Dust on Snow events.

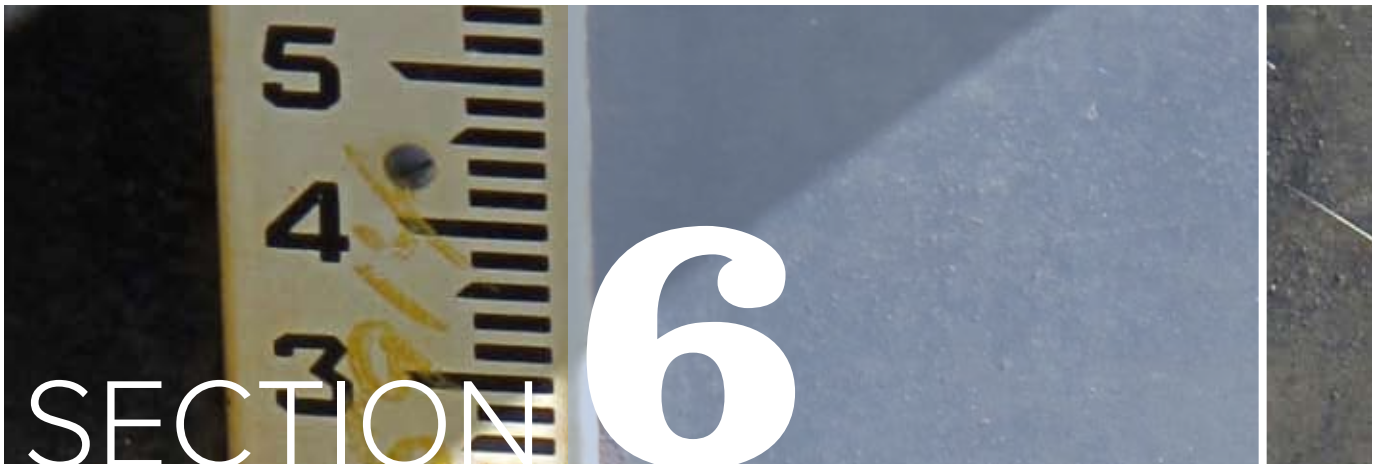
FIGURE 65.

Percentage of diversions made to the "Big 6" canals compared to the Baseline run under all alternative hydrology scenarios.

Diversions from in-priority water rights and project water releases from reservoirs are included.



Measuring flow. Photo: Rio de la Vista



SECTION 6

Projects and Methods

This section identifies numerous projects and methods that meet the goals and measurable outcomes listed in Section 3.

6.1 : Introduction

As part of this Water Plan an initial list of projects have been identified that meet the Basin needs and the goals formulated in Section 3.3. The Goals listed represent the needs that future projects should meet. These goals are restated below.

The following are the Rio Grande Basin Goals. Immediately following each goal is a list of the subcommittees that identified the goals. The list also corresponds to the needs that are met by the goal.

This Plan represents the process of identifying the Basin's future water needs and the constraints and opportunities in meeting those future needs. The identification of projects and methods to meet those water needs is a vital step in the development of the Basin's path forward.

The Basin recognizes that other projects will be developed in the future and that the projects listed in this Plan should be considered as potential projects since there has not been time for formal evaluation of these projects by the RGBRT. Projects that meet multiple Basin needs and a greater number of goals will likely have a higher priority for funding. While criteria do not currently exist for project ranking, they may be developed in the future as part of the next Phase of Plan development process. The identification and prioritization of projects will be dynamic as opportunities and constraints present themselves. As an example, a project could become a higher priority if it can be partnered with another

Sunset on the Monte Vista Canal. Photo: Erich Schegel

funding source that becomes available or a project that has been funded and is scheduled to commence construction. This is a dynamic Plan that will be updated periodically as additional information is collected and new focus areas are identified.

Ag = Agriculture
M&I = Municipal and Industrial
Env&Rec = Environmental and Recreational
WAdm = Water Administration

	Goal	Needs Met			
1.	Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.	Ag	M&I	Env&Rec	WAdm
2.	Protect and preserve the doctrine of prior appropriation and vested water rights and fully utilize Colorado's compact entitlements as specified under the Rio Grande and Costilla Creek compacts.	Ag	M&I		WAdm
3.	Sustain the confined and unconfined aquifer in accordance with Senate Bill 04-222 and operate within the State Engineer's new Rules and Regulations for the San Luis Valley.	Ag	M&I	Env&Rec	WAdm
4.	Operate, maintain, rehabilitate and create necessary infrastructure to meet the Basin's long-term water needs, including storage.	Ag	M&I	Env&Rec	WAdm
5.	Manage water use to sustain optimal agricultural economy throughout the Basin's communities.	Ag	M&I	Env&Rec	WAdm
6.	Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.	Ag	M&I	Env&Rec	WAdm
7.	Meet new demands for water, to the extent practicable, without impacting existing water rights and compact obligations.	Ag	M&I	Env&Rec	WAdm
8.	Establish a long-term education and outreach effort for water use and needs in San Luis Valley/Rio Grande Basin.	Ag	M&I	Env&Rec	WAdm
9.	Make progress toward meeting applicable water quality standards throughout the Basin.	Ag	M&I	Env&Rec	
10.	Promote water management and administration practices that are adaptive, flexible and responsive to optimize multiple benefits.	Ag	M&I	Env&Rec	WAdm
11.	Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.			Env&Rec	
12.	Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.	Ag	M&I	Env&Rec	
13.	Work to establish active river flows throughout the year in cooperation with water users and administrators to restore and sustain ecological function of the rivers and floodplain habitats within the context of existing water rights and compact obligations.			Env&Rec	
14.	Maintain and enhance water-dependent recreational activities.			Env&Rec	

6.2 : Project Fact Sheets

The Basin recognizes that other projects will be developed in the future. Projects that meet multiple Basin needs and a greater number of goals will have a higher priority for funding. While ranking criteria do not currently exist for project ranking, they may be developed in the future. The identification and prioritization of projects will be dynamic as opportunities and constraints present themselves. As an example, a project might become a higher priority if it can be partnered with another funding source or construction project. This is a dynamic plan that should be updated periodically as additional information is collected and new focus areas are identified.

Project sheets were completed for certain projects. These fact sheets include the following information:

- Project Name
- Location and Map
- Sponsor(s)
- Uses / Needs Met – based on the goals and measurable outcomes in Section 3, the following basin water uses were identified. The project fact sheet lists which of the Basin water needs are met by the specific project.
- BIP Goals / Needs Met – based on the goals and measurable outcomes in Section 3, the following basin water uses were identified. The project fact sheet lists which of the Basin water goals are met by the specific project.
- Description and Picture
- Estimated Project Costs (2014) – estimated total project costs and timeline
- Potential Funding Collaboration / Sources
- Project Schedule and Budget – estimated project costs for funding purposes for the following general categories:
  - Preliminary Design Analysis
  - Permitting
  - Land Acquisition
  - Final Design
  - Construction
  - Surveying, Inspection, Legal, and Administration
  - Contingency or Fiscal Agent Fee if applicable
- WSRA Funding
- Project Beneficiaries

Project Fact Sheet

Consolidated Ditch Diversion and Headgate Rehabilitation Project

The Consolidated Ditch diversion dam and headgate are aging and poorly functioning. The Project includes replacing the existing diversion with a more stable dam that includes fish and boat passage, and replacing the headgates with a new concrete gate structure with automated gates. Riparian areas in the project reach will be stabilized and vegetation will be restored.

LOCATION

Rio Grande in Rio Grande County, upstream of Stoeber Lane.

SPONSORS

Colorado Rio Grande Restoration Foundation, NRCS, Private Landowners

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$1,500,000
POTENTIAL FUNDING COLLABORATIONS / SOURCES	NRCS, Private Landowners, In-kind
PROJECT TIMELINE	2014–2017
PROJECT START DATE	Fall 2014
WSRA FUNDING OPTION	– Statewide – Basin

PROJECT BENEFICIARIES *(Direct and Indirect)*

The will improve diversion efficiency, reduce ditch maintenance, enhance riparian and aquatic habitat, improve recreation, enhance water quality, and improve Compact accounting. In addition to providing great benefits to the nine ditch companies that are served by the diversion and headgates, the project will benefit the local habitat and economy.

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Project Design	2014–2015	$200,000
Diversion Replacement	2016	$820,000
Headgate Replacement	2016	$325,000
Riparian Restoration	2016	$100,000
Monitoring	2017	$10,000
Administration	2014–2017	$45,000
Total		**$1,500,000**

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

2) Protect and preserve the doctrine of prior appropriation and vested water rights and fully utilize Colorado's compact entitlements as specified under the Rio Grande and Costilla Creek compacts.

4) Operate, maintain, rehabilitate and create necessary infrastructure to meet the Basin's long-term water needs, including storage.

5) Manage water use to sustain optimal agricultural economy throughout the Basin's communities.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

9) Make progress toward meeting applicable water quality standards throughout the Basin.

10) Promote water management and administration practices that are adaptive, flexible and responsive to optimize multiple benefits.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

14) Maintain and enhance water-dependent recreational activities.

USES / NEEDS MET

- ✓ **Agricultural**
- – Municipal & Industrial
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- – Other

Project Fact Sheet

Doppler Radar Weather Forecasting Project

Develop and deploy a mobile Doppler on Wheels (DOW) program for the upper Rio Grande Basin

LOCATION

Upper Rio Grande River Basin

SPONSORS

RWEACT, CWCB, USFS, NWS

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$ 75,000 per year for 5 years. Approximately $375,000 total.	
POTENTIAL FUNDING COLLABORATIONS / SOURCES	RWEACT, CWCB, USFS, NWS	
PROJECT TIMELINE	2014–2018	
PROJECT START DATE	September 2013	
WSRA FUNDING OPTION	✓ **Statewide**	✓ **Basin**

PROJECT BENEFICIARIES *(Direct and Indirect)*

The residents of the Basin and all water users and administrators, water recreationists, and natural resource agencies and organizations, NWS.

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2014–18	
Permitting	N/A	
Land Acquisition	N/A	
Final Design	2014	
Construction/deployment	2014–18	$375,000
Surveying, Inspection, Legal, and Administration		
Fiscal Agent Fee	5%	$18,750
Total		**$393,750**

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

2) Protect and preserve the doctrine of prior appropriation and vested water rights and fully utilize Colorado's compact entitlements as specified under the Rio Grande and Costilla Creek compacts.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

7) Meet new demands for water, to the extent practicable, without impacting existing water rights and compact obligations.

10) Promote water management and administration practices that are adaptive, flexible and responsive to optimize multiple benefits.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

13) Work to establish active river flows throughout the year in cooperation with water users and administrators to restore and sustain ecological function of the rivers and floodplain habitats within the context of existing water rights and compact obligations.

14) Maintain and enhance water-dependent recreational activities.

USES / NEEDS MET

- ✓ **Agricultural**
- ✓ **Municipal & Industrial**
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- ✓ **Other (Public Safety)**

Project Fact Sheet

Humphreys Reservoir Debris Mitigation Project

Remove (dredge) post-fire sediment and debris from Humphreys Reservoir. Construct debris boom and trash rack at the dam of Humphreys Reservoir.

LOCATION

Humphreys Reservoir

SPONSORS

RWEACT, CWCB, USFS, NWS

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$180,000 is the estimated cost for the full project. RWEACT is a funding partner, providing $10,000 of the total cost which was first estimated to be $50,000. Draining the Reservoir revealed a much more robust sediment load in need of being removed.
POTENTIAL FUNDING COLLABORATIONS / SOURCES	Brown Family and RWEACT
PROJECT TIMELINE	Spring 2014–2015
PROJECT START DATE	Spring 2014
WSRA FUNDING OPTION	✓ **Statewide** ✓ **Basin**

PROJECT BENEFICIARIES *(Direct and Indirect)*

Brown Family Ranch, all downstream water users, recreationists, electric consumers on the grid, the public of Colorado waters.

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2014	
Permitting	2014	
Land Acquisition	N/A	
Final Design	2014	
Construction	2014–2015	$180,000 (RWEACT $10,000)
Surveying, Inspection, Legal, and Administration	N/A	
Fiscal Agent Fee	5%	$500 for RWEACT only
Total		**$180,500**

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

4) Operate, maintain, rehabilitate and create necessary infrastructure to meet the Basin's long-term water needs, including storage.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

7) Meet new demands for water, to the extent practicable, without impacting existing water rights and compact obligations.

9) Make progress toward meeting applicable water quality standards throughout the Basin.

10) Promote water management and administration practices that are adaptive, flexible and responsive to optimize multiple benefits.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

13) Work to establish active river flows throughout the year in cooperation with water users and administrators to restore and sustain ecological function of the rivers and floodplain habitats within the context of existing water rights and compact obligations.

14) Maintain and enhance water-dependent recreational activities.

USES / NEEDS MET

- ✓ **Agricultural**
- ✓ **Municipal & Industrial**
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- ✓ **Other (Public Safety)**

Project Fact Sheet

Jim Creek Riparian Protection and Restoration Project

LOCATION

La Jara Creek, Conejos County

SPONSORS

Conejos County, Trout Unlimited, State Land Board, Colorado Mountain Club, Volunteers for Outdoor Colorado

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$30,000
POTENTIAL FUNDING COLLABORATIONS / SOURCES	GOCO, Rio Grande Basin Roundtable
PROJECT TIMELINE	2–3 years
PROJECT START DATE	2014
WSRA FUNDING OPTION	– Statewide ✓ **Basin**

PROJECT BENEFICIARIES *(Direct and Indirect)*

Conejos County, Colorado Parks and Wildlife, State Land Board, Trout Unlimited

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2014	In-Kind
Permitting	N/A	
Land Acquisition	N/A	
Final Design	2014	<$1,000
Construction	2014–2016	$29,000
Surveying, Inspection, Legal, and Administration	2015	In Kind
Contingency	2014–2016	Carryover
Total		**$30,000**

Approximately 5 miles of fencing will protect 2.5 miles of Jim Creek from continued erosion and habitat loss caused by cattle grazing activities, and the fence will create a riparian buffer area of at least 30 acres. By eliminating cattle grazing in the riparian buffer area and the damage caused by trampling in the stream channel and along its banks, the stream and its riparian area will begin a natural recovery. The fence will be designed with input from grazing lessees to ensure that their operations are not adversely affected, allowing for appropriately spaced access to the stream for watering and crossing of livestock. The Rio Grande Cutthroat is a candidate for ESA listing, and this partnership with ranchers will protect the stream while allowing ranching operations to continue, and therefore provide a higher level of security for the future of their operations and the conservation population of native trout that resides in Jim Creek.

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

USES / NEEDS MET

- ✓ **Agricultural**
- – Municipal & Industrial
- ✓ **Environmental & Recreational**
- – Water Administration
- ✓ **Other**

Project Fact Sheet

Little Squaw Creek Hazard Tree Removal

Hydro-axe approx. 10 acres of burned high risk trees

LOCATION

Little Squaw Creek, above Creede

SPONSORS

RWEACT

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$48,000
POTENTIAL FUNDING COLLABORATIONS / SOURCES	RWEACT
PROJECT TIMELINE	July 2014
PROJECT START DATE	July 2014
WSRA FUNDING OPTION	– Statewide ✓ **Basin**

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

13) Work to establish active river flows throughout the year in cooperation with water users and administrators to restore and sustain ecological function of the rivers and floodplain habitats within the context of existing water rights and compact obligations.

14) Maintain and enhance water-dependent recreational activities.

USES / NEEDS MET

- – Agricultural
- – Municipal & Industrial
- ✓ **Environmental & Recreational**
- – Water Administration
- – Other

PROJECT BENEFICIARIES *(Direct and Indirect)*

USFS, owners of Little Squaw Creek Resort, public land users, water administrators downstream, environmental attributes

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2014	
Permitting	2014	
Land Acquisition	N/A	
Final Design	2014	
Construction/Implementation	July 2014	
Surveying, Inspection, Legal, and Administration		
Fiscal Agent Fee	5%	$2500
Total		**$30,000**

Project Fact Sheet

Mountain Home Reservoir Dam Repair

Rehabilitation of the Mountain Home Reservoir dam outlet works will improve dam safety and reliable water level management of the reservoir. The State is now requiring TIC to repair or upgrade the gates and to restore full operating capability at Mountain Home Reservoir. The project will also provide improved water storage management and reduced storage loss which currently amount to 1,350 to 2,250 AF annually. Finally, improved outlet works will provide protection of the CPW conservation pool and enhancement of environmental, recreational, and wildlife habitat assets.

LOCATION

Costilla County, Colorado

SPONSORS

Trinchera Irrigation Company

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$ 500,000
POTENTIAL FUNDING COLLABORATIONS / SOURCES	CWCB/WSRA + a loan component + NRCS + CPW
PROJECT TIMELINE	2015–2016
PROJECT START DATE	2015
WSRA FUNDING OPTION	✓ **Statewide** ✓ **Basin**

PROJECT BENEFICIARIES *(Direct and Indirect)*

T.I.C. Farmers and Ranchers
CPW, General Public Recreation & Sport Fishing
Riparian areas and wildlife habitat

BASIN PLAN GOALS / NEEDS MET

4) Operate, maintain, rehabilitate and create necessary infrastructure to meet the Basin's long-term water needs, including storage.

5) Manage water use to sustain optimal agricultural economy throughout the Basin's communities.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

7) Meet new demands for water, to the extent practicable, without impacting existing water rights and compact obligations.

14) Maintain and enhance water-dependent recreational activities.

USES / NEEDS MET

- ✓ **Agricultural**
- – Municipal & Industrial
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- – Other

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2015	$20,000
Permitting	n/a	n/a
Land Acquisition	n/a	n/a
Final Design	2015	$20,000
Construction	2015–2016	$350,000
Surveying, Inspection, Legal, and Administration	2015–2016	$100,000
Contingency	2015–2016	$10,000
Total	**2015–2016**	**$500,000**

Project Fact Sheet

Optimized Streamflow Enhancements and Retiming

The Rio Grande Basin Roundtable, TU, CPW, RGHRP, and the boating recreationists would like to optimize water management to the greatest extent possible to provide late-season releases which would augment flows to extend boat-floating season for fishing later into the summer. This would be managed similar to the "Flow Program" administered by the Department of Natural Resources, which functions on the Upper Arkansas River through the Arkansas Headwaters Recreation Area State Park near Salida. It is important to recognize that this concept would require the coordination of water use and release by numerous water users working in a partnership to make this idea a reality. An overview of rafting needs and opportunities is desired, along with identifying flow information for rafters in the different reaches. The possibility of doing in-channel work to increase floatability at lower flow levels would be a component of the evaluation.

*A fact sheet for this project will be developed in the next phase of this Plan.

Project Fact Sheet

Post-Fire Archeological Studies

Conduct advanced Archeological studies that will facilitate and expedite forest and watershed project on the RGNF and burn scar of the WFCF.

LOCATION

Rio Grande National Forest

SPONSORS

USFS, CRGRF and RWEACT

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$5000 (RWEACT's cost share) On-going costs for USFS staff effort
POTENTIAL FUNDING COLLABORATIONS / SOURCES	RWEACT and Basin WSRA funds
PROJECT TIMELINE	2014–2016
PROJECT START DATE	2014
WSRA FUNDING OPTION	– Statewide ✓ **Basin**

PROJECT BENEFICIARIES *(Direct and Indirect)*

USFS, RWEACT, RGBRT, all water administrators and users of the RGB, the public.

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

8) Establish a long-term education and outreach effort for water use and needs in San Luis Valley/Rio Grande Basin.

9) Make progress toward meeting applicable water quality standards throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

USES / NEEDS MET

- ✓ **Agricultural**
- ✓ **Municipal & Industrial**
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- ✓ **Other**

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2014	
Permitting	N/A	
Land Acquisition	N/A	
Final Design	2014	
Construction	On-going	
Surveying, Inspection, Legal, and Administration	On-going	
Fiscal Agent Fee	5%	$250
Total		**$5,250**

Project Fact Sheet

Post-Fire Test Plot Project

Burned tree removal, seeding, mulching, and monitoring of 1 acre test plots on USFS lands.

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

USES / NEEDS MET

- Agricultural
- Municipal & Industrial
- ✓ **Environmental & Recreational**
- Water Administration
- Other

LOCATION

FS 520 Road and Crooked Creek

SPONSORS

RWEACT/USFS and CRGRF

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$5000
POTENTIAL FUNDING COLLABORATIONS / SOURCES	RWEACT, cost share with mulch company.
PROJECT TIMELINE	2014–2015
PROJECT START DATE	October 2013
WSRA FUNDING OPTION	– Statewide ✓ **Basin**

PROJECT BENEFICIARIES *(Direct and Indirect)*

USFS, private landowners, public land users.

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2014	
Permitting	N/A	
Land Acquisition	N/A	
Final Design	2014	
Construction	2014–2015	
Surveying, Inspection, Legal, and Administration		
Fiscal Agent Fee	5%	$200
Total		**$5200**

Project Fact Sheet

Rio Culebra Community Watershed Plan

Rio Culebra Watershed stakeholders have attempted several times to create a comprehensive watershed plan, but lack of local capacity has hindered the completion of these efforts. The Sangre de Cristo Acequia Association has taken the lead, forming the Culebra Watershed Working Group, and has partnered with the Colorado Watershed Assembly to complete The Rio Culebra Community Watershed Plan. Building on previously identified goals and priorities, the Plan will identify culturally appropriate solutions to improve natural resource values of the Rio Culebra Watershed.

LOCATION

Culebra Creek Subbasin, Costilla County, Water District 24

SPONSORS

Sangre de Cristo Acequia Association

ESTIMATED PROJECT COSTS *(2014 Dollars)*	TBD (rough estimate of $150 –200,000)
POTENTIAL FUNDING COLLABORATIONS / SOURCES	Bureau of Reclamation WaterSMART program, Costilla County Conservation District
PROJECT TIMELINE	2014–2016
PROJECT START DATE	Fall 2014
WSRA FUNDING OPTION	– Statewide ✓ **Basin**

USES / NEEDS MET

- ✓ **Agricultural**
- – Municipal & Industrial
- ✓ **Environmental & Recreational**
- – Water Administration
- – Other

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2014	
Permitting		
Land Acquisition		
Final Design	2016	
Construction		
Surveying, Inspection, Legal, and Administration	2014–2016	
Contingency		
Total		

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

4) Operate, maintain, rehabilitate and create necessary infrastructure to meet the Basin's long-term water needs, including storage.

5) Manage water use to sustain optimal agricultural economy throughout the Basin's communities.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

8) Establish a long-term education and outreach effort for water use and needs in San Luis Valley/Rio Grande Basin.

9) Make progress toward meeting applicable water quality standards throughout the Basin.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

PROJECT BENEFICIARIES *(Direct and Indirect)*

23,000 privately held acres, mostly farmed under the traditional Hispanic acequia system of irrigation (of national cultural/historic interest). The Town of San Luis and several smaller communities. The watershed supports significant riparian habitat, including habitat for the Rio Grande Cutthroat Trout, as well as a variety of ecosystem services and recreational interests. Project design analysis will begin in 2014 with final Plan completion in 2016.

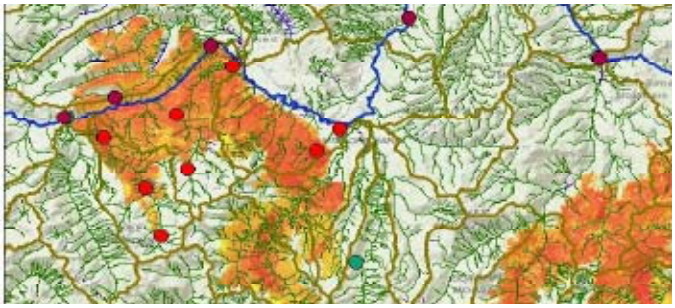
Project Fact Sheet

Rio Grande Basin Hydrology Study (Long-Term)

Funds provided by RWEACT for the 2014 summer season and analyzed data will offer the first step to better understanding and quantifying long-term effects forest fires, beetle infestations, and prolonged drought have on stream health and seasonal water supply in the Rio Grande headwaters region. Continued field work will be extended in the Rio Grande. Key data will be attained beginning the2015 summer to be integrated into specific hydrologic models such as WRF-Hydro and USGS PRMS-SN Temp hydrologic-stream temperature model.

LOCATION

Rio Grande River (Headwaters to Del Norte)



Current and proposed instrumentation in the Papoose burned area.

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$115,000	
POTENTIAL FUNDING COLLABORATIONS / SOURCES	RGB Funds (WSRA), RWEACT	
PROJECT TIMELINE	2015–2019	
PROJECT START DATE	June 2015	
WSRA FUNDING OPTION	✓ **Statewide**	✓ **Basin**

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2014–2015	
Permitting	2015	
Land Acquisition	N/A	
Final Design	2015	
Construction/Implementation	2015–2019	
Surveying, Inspection, Legal, and Administration		
Fiscal Agent Fee	5%	$7,000
Total		**$125,000**

SPONSORS

RWEACT and CRGRF

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

9) Make progress toward meeting applicable water quality standards throughout the Basin.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

14) Maintain and enhance water-dependent recreational activities.

USES / NEEDS MET

- ✓ **Agricultural**
- ✓ **Municipal & Industrial**
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- – Other

PROJECT BENEFICIARIES *(Direct and Indirect)*

All water rights owners, users, recreationists, and the public of the state of Colorado, US Forest Service and ultimately, the integrity of the watersheds of the Rio Grande Basin.

Project Fact Sheet

Rio Grande Cooperative Project

LOCATION

Rio Grande Reservoir on main stem in Hinsdale County upstream of Creede and Beaver Park Reservoir on Beaver Creek upstream of South Fork

SPONSORS

San Luis Valley Irrigation District
Colorado Division of Parks and Wildlife (CPW)

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$22 Million
POTENTIAL FUNDING COLLABORATIONS / SOURCES	CWCB and project participants
PROJECT TIMELINE	4 years
PROJECT START DATE	2014
WSRA FUNDING OPTION	✓ **Statewide** ✓ **Basin**

USES / NEEDS MET

- ✓ **Agricultural**
- ✓ **Municipal & Industrial**
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- – Other

PROJECT BENEFICIARIES *(Direct and Indirect)*

San Luis Valley Irrigation District, Colorado Parks and Wildlife, San Luis Valley Water Conservancy District, Groundwater Management Subdistricts, Town of Monte Vista and other towns and users requiring augmentation or storage

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2012	Completed
Permitting	2014–2016	$300,000
Land Acquisition	2014–2016	$200,000
Final Design	2014–2016	$1,000,000
Construction	2016–2017	$16,000,000
Surveying, Inspection, Legal, and Administration	2014–2017	$1,000,000
Contingency		3,500,000
Total		**$22,000,000**

The Project's primary objectives are to store and regulate decreed water rights to better meet irrigation and augmentation demands, maximize the use of certain CPW water rights and to provide storage space in Rio Grande Reservoir for river administration. It is anticipated these objectives can be accomplished through the rehabilitation of the pre-compact 54,000 AF Rio Grande and 4,500 AF Beaver Park Reservoir as well as coordination of future operations both within and between these two reservoirs.

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.
2) Protect and preserve the doctrine of prior appropriation and vested water rights and fully utilize Colorado's compact entitlements as specified under the Rio Grande and Costilla Creek compacts.
3) Sustain the confined and unconfined aquifer in accordance with Senate Bill 04-222 and operate within the State Engineer's new Rules and Regulations for the San Luis Valley.
4) Operate, maintain, rehabilitate and create necessary infrastructure to meet the Basin's long-term water needs, including storage.
5) Manage water use to sustain optimal agricultural economy throughout the Basin's communities.
6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.
7) Meet new demands for water, to the extent practicable, without impacting existing water rights and compact obligations.
9) Make progress toward meeting applicable water quality standards throughout the Basin.
10) Promote water management and administration practices that are adaptive, flexible and responsive to optimize multiple benefits.
11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.
12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.
13) Work to establish active river flows throughout the year in cooperation with water users and administrators to restore and sustain ecological function of the rivers and floodplain habitats within the context of existing water rights and compact obligations.
14) Maintain and enhance water-dependent recreational activities.

Project Fact Sheet

Rio Grande Cutthroat Trout (RGCT) County Coalition Project

The RGCT County Coalition was established to serve on behalf of the Colorado project sponsor Counties. The Coalition was developed with the purpose of creating one, unified entity that will operate to consistently interact with, communicate with and make official comments to the US Fish and Wildlife Service during the Rio Grande Cutthroat Trout Species Assessment process, potential Proposed Listing Decision Process and any subsequent actions regarding listing of the species under the ESA. The Coalition intends to ensure that reasonable and adequate work is being conducted and shall continue to be conducted to reach the goal of increasing the current abundance, viability and vitality of the Rio Grande Cutthroat Trout and its habitat.

LOCATION

All counties within the Rio Grande Basin (Hinsdale, Mineral, Rio Grande, Conejos, Costilla, Alamosa, Saguache, Archuleta, San Juan) and Las Animas County

SPONSORS

Colorado Counties of Hinsdale, Mineral, Rio Grande, Conejos, Costilla, Alamosa, Saguache, Archuleta, San Juan and Las Animas

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

USES / NEEDS MET

- Agricultural
- Municipal & Industrial
- ✓ **Environmental & Recreational**
- Water Administration
- Other

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$40,000
POTENTIAL FUNDING COLLABORATIONS / SOURCES	CWCB and project participants
PROJECT TIMELINE	2–3 years
PROJECT START DATE	December 2013
WSRA FUNDING OPTION	– Statewide – Basin

PROJECT BENEFICIARIES *(Direct and Indirect)*

Rio Grande Cutthroat Trout (RGCT) species, habitat and other species within the RGCT habitat

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	N/A	
Permitting	N/A	
Land Acquisition	N/A	
Final Design	N/A	
Construction	N/A	
Surveying, Inspection, Legal, and Administration (Tasks 1.1- 1.4)	2014–2016	$38,000
Fiscal Agent Fee	2014–2016	$2,000
Total		**$40,000**

Project Description, Page 1 of 2

The Rio Grande Headwaters Restoration Project (RGHRP) (www.riograndeheadwaters.org) was formed to implement the recommendations of a restoration master plan for the 91-miles of the Rio Grande, completed in 2001. The 2001 Study was initiated by local stakeholders who recognized the deterioration of the historical functions of the Rio Grande. Sponsored by the San Luis Valley Water Conservancy District and funded with a $200,000 grant from the CWCB, the study analyzed the condition of the riparian area and structures along the project reach and provided recommendations for improvement.

In 2004, the Colorado Rio Grande Restoration Foundation was established to serve as the governing body and fiscal agent for the Rio Grande Headwaters Restoration Project. In 2007 the RGHRP completed a Watershed Restoration Strategic Plan for the entire Rio Grande Basin in Colorado. The Strategic Plan highlighted additional restoration priorities and the need for continued efforts to implement the recommendations from the 2001 Study.

The Mission of the RGHRP is: to restore and conserve the historical functions and vitality of the Rio Grande in Colorado for improved water quality, agricultural water use, riparian health, wildlife and aquatic species habitat, recreation and community safety while meeting the Rio Grande Compact.

The Rio Grande Headwaters Restoration Project works with landowners and local, state, and federal partners to implement the following programs:

Riparian Restoration and Streambank Stabilization Program:

The principal program of the RGHRP is the Riparian Restoration and Streambank Stabilization Program. The main environmental goals of the riparian stabilization projects are to improve stabilization of the streambanks, improve riparian and fish habitat, enhance the function of floodplains, and increase capacity of the river to transport sediment. Benefits of the projects are reduced sediment loading, improved water quality, enhanced and increased fish and wildlife habitat, and reduced damage during flood conditions. A typical riparian stabilization project includes bank shaping and installation of streambank stabilization structures. Structures include willow bundles and clump plantings, rock structures, including “J” hooks, weirs, and rock barbs, and log structures. These structures move the flows away from the bank, thereby halting lateral movement of the stream channel and reducing sediment loading; this allows for vegetation to become reestablished in the riparian zones. Grazing management and bioengineering enhance the riparian habitat and further stabilize the streambank. The RGHRP has worked with partners and 50 landowners on six projects to improve the condition of over nine miles of streambanks on the Rio Grande. By implementing the recommendations from the 2001 Study across different sections of the Rio Grande, overall continuity and function of the river is improved. Directly, these projects benefit the participating landowners, local water users, and downstream water users. Indirectly, local, state, and regional communities benefit from the enhanced water quality, river function, riparian condition, wetlands, and habitat. These benefits stem from increased land value, water availability and quality, tourism opportunities, and habitat potential.

Project Description, Page 2 of 2

Watershed Stewardship Program:

The RGHRP has recognized the need to play a significant role in regional efforts to safeguard the Upper Rio Grande Watershed as a source of water, habitat, and extraordinary natural and cultural resources. As such, the RGHRP is working with stakeholders and partners through RWEACT to complete wildfire restoration and hazard mitigation projects and will include future projects to improve water security through efforts to reduce the threat of catastrophic wildfire and improve forest health.

In-stream Infrastructure Improvement Program:

One of the priorities highlighted by the 2001 Study was the need to address aging and poorly functioning diversion dams and headgates. Many of the existing structures are inefficient, hazardous, and impassible by boats, fish, and wildlife. Through the In-Stream Infrastructure Improvement Program, the RGHRP is working with ditch companies and irrigators to improve and replace poorly functioning diversion dams and headgates. New structures improve diversion efficiency, include state of the art automated headgates, provide fish passage or barriers (as the location indicates), boat passage (where possible and in collaboration with willing landowners), and enhanced wildlife habitat.

Outreach and Education Program:

The RGHRP administers a robust Outreach and Education Program. Informative press releases are provided to local and regional media with project updates. Talks and tours are routinely given to Rio Grande Basin schools, community groups, and water related organizations. The volunteer and youth events encourage community members to be involved and connected with the Rio Grande in a direct way. The content of the Outreach and Education program includes details about projects, partnerships, funding entities, and the importance of protecting and conserving the Rio Grande.

Riparian restoration projects are a critical component of the BWP as they improve the overall function of the river by improving water quality, floodplain connectivity, riparian and wildlife habitat, agriculture infrastructure, recreation opportunities, and the ability to meet the Rio Grande Compact obligations. In addition, restoration projects indirectly benefit the broader community by increasing land value, water availability and quality, and tourism opportunities.

Overall, the demand for the restoration work on the ground, the studies, and the partnership with other watershed restoration efforts continues to be strong and growing. Thanks to their successes, credibility and abilities, the RGHRP is evolving into one of the overarching watershed organizations for the Rio Grande Basin. They contribute on many levels to the sustainability of the Basin's water management and the demand for their services, and thus needs for future funding, is expected to be high for the foreseeable future.

The project sheet for the Consolidated Ditch Diversion and Headgate Rehabilitation Project (in Section 6.2.1) is an example of a RGHRP Project.

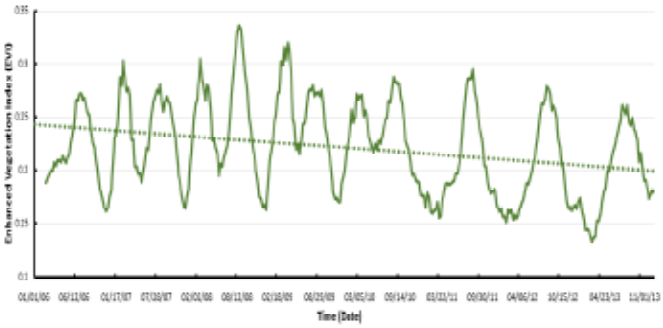
Project Fact Sheet

Rio Grande Hydrology Study, Colorado School of Mines (Preliminary Field Study)

The overarching goal of the study in the Rio Grande is to better understand landscape disturbance, including climate change, wildfire, and spruce beetle kill, on water supply (both quantity and quality) in the headwaters of the Rio Grande.

LOCATION

Upper Rio Grande River Basin



Climate induced decrease in enhanced vegetation index (vegetation biomass) over the last 7 years (RGB).

SPONSORS

RWEACT and CRGRF

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$21,000
POTENTIAL FUNDING COLLABORATIONS / SOURCES	RWEACT and CO School of Mines
PROJECT TIMELINE	Summer/Fall 2014
PROJECT START DATE	June 2014
WSRA FUNDING OPTION	– Statewide – Basin

PROJECT BENEFICIARIES *(Direct and Indirect)*

All water rights owners, users, recreationists, the public of the state of Colorado and ultimately the integrity of the watersheds of the Rio Grande Basin.

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

9) Make progress toward meeting applicable water quality standards throughout the Basin.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

14) Maintain and enhance water-dependent recreational activities.

USES / NEEDS MET

- ✓ **Agricultural**
- ✓ **Municipal & Industrial**
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- – Other

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2013–14	
Permitting	N/A	
Land Acquisition	N/A	
Final Design	2014	
Construction/Implementation	Summer 2014	
Preliminary Reports to RWEACT	Fall 2014	$14,000
Fiscal Agent Fee	5%	
Total		**$21,000**

Project Fact Sheet

Rio Grande Initiative (Conservation Easements)

This photo was taken on the Haywood Ranch, which was supported by the RGBRT and received WSRA funding. The conservation easement was completed at the end of 2013 and protects over 400 acres on the Rio Grande, including a portion of the #1 water right on the river. (Photo: Rio de la Vista)

RiGHT is continuing its work to implement voluntary, incentive based conservation easements with willing landowners on working lands, along the Rio Grande and Conejos River corridors and elsewhere across the Rio Grande Basin that may protect important conservation values such as wildlife habitat. These projects provide multiple benefits to sustaining agriculture, protecting wetlands and wildlife habitat, and, in some cases, assisting with water administration through keeping senior water rights and historical water use patterns intact. The photo illustrates the kind of productive agricultural land, with important riparian wildlife habitat, that RiGHT is working to protect.

LOCATION

Rio Grande and/or Conejos River corridor

SPONSORS

Rio Grande Headwaters Land Trust (RiGHT)

ESTIMATED PROJECT COSTS *(2014 Dollars)*	Overall: $14 million +
POTENTIAL FUNDING COLLABORATIONS / SOURCES	GOCO, CPW, North American Wetlands Conservation Act, NRCS's Agricultural Land Easements, private foundations, landowners, and others
PROJECT TIMELINE	3–5 years
PROJECT START DATE	Overall project started in 2007
WSRA FUNDING OPTION	✓ **Statewide** – Basin

USES / NEEDS MET

- ✓ **Agricultural**
- – Municipal & Industrial
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- – Other

PROJECT BENEFICIARIES *(Direct and Indirect)*

Direct beneficiaries are the landowners who chose to conserve their land. The overall watershed, a number of wildlife species, the community at large, and DWR (who has supported past projects) all benefit through the completion of these projects.

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

8) Establish a long-term education and outreach effort for water use and needs in San Luis Valley/Rio Grande Basin

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore, and maintain wetlands and riparian areas for the benefit of a healthy watershed.

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	On-going	
Permitting		
Land Acquisition-Easement Acquisition	When funding secured & due diligence is completed	Approximately $14 million total—typically at least a 70% or more match for WSRA funds
Final Design		
Construction		
Surveying, Inspection, Legal, and Administration		
Contingency		
Total	**3 to 5 years for next phase of RGI**	

Project Fact Sheet

Trujillo Meadows Reservoir Storage

This project will create operational storage in Trujillo Meadows Reservoir through either an enlargement or acquisition and re-operations of the existing reservoir pool. The purpose is to preserve and enhance agriculture in the Conejos Water Conservancy District and provide a reliable supply of augmentation water for the Towns. In addition, the project will also provide multiple-objective benefits including enhanced recreational opportunity (primarily angling) at Trujillo Meadows Reservoir and environmental benefits through enhanced riparian habitat, re-timing and sustained streamflows on the Rio De Los Pinos and the on the Conejos below Platoro due to the release of augmentation water to the Towns, and meeting Compact delivery requirements.

LOCATION

Conejos River Basin, Trujillo Meadows Reservoir in the headwaters of the Rio de Los Pinos, Rio San Antonio, Platoro Reservoir in the headwaters of the Conejos River

SPONSORS

Conejos Water Conservancy District

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$15,550,000
POTENTIAL FUNDING COLLABORATIONS / SOURCES	CWCB and project participants
PROJECT TIMELINE	5 years
PROJECT START DATE	January 2015
WSRA FUNDING OPTION	✓ **Statewide** ✓ **Basin**

PROJECT BENEFICIARIES *(Direct and Indirect)*

The towns of Sanford, Manassa, La Jara, and Romeo; San Antonio agricultural users; Colorado Parks and Wildlife and the riparian and aquatic environment

BASIN PLAN GOALS / NEEDS MET

This project meets all goals listed.

USES / NEEDS MET

- ✓ **Agricultural**
- ✓ **Municipal & Industrial**
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- – Other

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Project Schedule	**Years**	**Proposed Budget**
Preliminary Design Analysis	2015	$500,000
Permitting	2015–2018	$700,000
Land Acquisition	2014	$250,000
Final Design	2016	$700,000
Construction	2018–2020	$9,200,000
Surveying, Inspection, Legal, and Administration	2015–2020	$700,000
Contingency	N/A	$3,500,000
Total		**$15,550,000**

Project Fact Sheet

USGS Debris Flow Study

Develop post-wildlfire Debris Flow Prediction Model for the Upper Rio Grande, Little Squaw Creek drainage. This prediction model will be used by RWEACT, USFS etc. in determining the potential level of debris that can be expected to come off of the burn scar associated with the West fork Complex Fire into the future.

LOCATION

Upper Rio Grande, Little Squaw Creek

SPONSORS

USGS, CRGRF, and RWEACT

ESTIMATED PROJECT COSTS *(2014 Dollars)*	$26,000
POTENTIAL FUNDING COLLABORATIONS / SOURCES	USGS $13,000 and RWEACT $13,000
PROJECT TIMELINE	2014-future
PROJECT START DATE	July 2013
WSRA FUNDING OPTION	– Statewide ✓ **Basin**

PROJECT BENEFICIARIES *(Direct and Indirect)*

All water rights owners, users, recreationists, the public of the state of Colorado and ultimately the integrity of the watersheds of the Rio Grande Basin.

PROJECT SCHEDULE	YEARS	PROPOSED BUDGET
Preliminary Design Analysis	2014	
Permitting	N/A	
Land Acquisition	N/A	
Final Design	2014–2016	
Construction/development of mapping	2014–2016	
Surveying, Inspection, Legal, and Administration		
Fiscal Agent Fee	5% (RWEACT)	$650
Total		**$28,650**

BASIN PLAN GOALS / NEEDS MET

1) Protect, preserve and/or restore the sustainability of the Rio Grande Basin watersheds by focusing on the watershed health and ecosystem function.

5) Manage water use to sustain optimal agricultural economy throughout the Basin's communities.

6) Support the development of projects and methods that have multiple benefits for agricultural, municipal and industrial, and environmental and recreational water needs.

7) Meet new demands for water, to the extent practicable, without impacting existing water rights and compact obligations.

9) Make progress toward meeting applicable water quality standards throughout the Basin.

10) Promote water management and administration practices that are adaptive, flexible and responsive to optimize multiple benefits.

11) Protect, preserve and enhance terrestrial and aquatic wildlife habitats throughout the Basin.

12) Conserve, restore and maintain wetlands and riparian areas for the benefit of a healthy watershed.

13) Work to establish active river flows throughout the year in cooperation with water users and administrators to restore and sustain ecological function of the rivers and floodplain habitats within the context of existing water rights and compact obligations.

14) Maintain and enhance water-dependent recreational activities.

USES / NEEDS MET

- ✓ **Agricultural**
- ✓ **Municipal & Industrial**
- ✓ **Environmental & Recreational**
- ✓ **Water Administration**
- – Other

6.3 : Comparison of Projects to Basin's Goals and Measurable Outcomes

The following table includes a preliminary evaluation of each of the projects identified in Section 6.2. For each of the identified projects the table shows which of the agricultural, municipal and industrial, environmental and recreational and water administration water needs will be met. This table also includes which of the 14 Basin goals are met by each project. Ten of the 17 projects meet all four of the needs. Multiple Basin goals are met by 16 of the 17 projects.

TABLE 18. Needs and Basin goals met by identified projects.

	Project or Method	Needs Met				Basin Goals Met													
		Ag	M&I	Env/ Rec	Water Admin	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Consolidated Ditch Diversion and Headgate Rehabilitation Project	✓		✓	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓		✓
2	Doppler Radar Weather Forecasting Project	✓	✓	✓	✓	✓	✓				✓	✓			✓	✓	✓	✓	✓
3	Humphreys Reservoir Debris Mitigation Project	✓	✓	✓	✓	✓			✓		✓	✓		✓	✓	✓		✓	✓
4	Jim Creek Riparian Protection and Restoration Project	✓		✓		✓					✓					✓	✓		
5	Little Squaw Creek Hazard Tree Removal			✓		✓					✓					✓	✓	✓	✓
6	Mountain Home Reservoir Dam Repair	✓		✓	✓				✓	✓	✓	✓							✓
7	Optimized Streamflow Enhancements and Retiming	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
8	Post-Fire Archaeological Studies	✓	✓	✓	✓	✓					✓		✓	✓			✓		
9	Post-Fire Test Plot Project			✓		✓										✓	✓		
10	Rio Culebra Community Watershed Plan	✓		✓		✓			✓	✓	✓		✓	✓		✓	✓		
11	Rio Grande Basin Hydrology Study (Long-Term)	✓	✓	✓	✓	✓					✓			✓		✓	✓		✓
12	Rio Grande Cooperative Project	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
13	Rio Grande Cutthroat Trout County Coalition Project			✓												✓			
14	Rio Grande Headwaters Restoration Project	✓	✓	✓	✓	✓	✓		✓		✓		✓	✓	✓	✓	✓	✓	✓
15	Rio Grande Hydrology Study, Colo. School of Mines	✓	✓	✓	✓	✓					✓			✓		✓	✓		✓
16	Rio Grande Initiative Conservation Easements	✓		✓	✓	✓					✓			✓		✓	✓		
17	Trujillo Meadows Reservoir Storage	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
18	USGS Debris Flow Study	✓	✓	✓	✓	✓				✓	✓	✓		✓	✓	✓	✓	✓	✓
	Total	**14**	**10**	**17**	**12**	**15**	**5**	**2**	**7**	**6**	**15**	**7**	**3**	**11**	**7**	**15**	**14**	**8**	**11**

6.4 : Anticipated Funding Needs for Identified Projects

To assist in the development of funding needs, the estimate total annual costs for the majority of projects with fact sheets were compiled and are summarized in Table 19. Based on these 16 projects alone, there is a financial need of $54 million dollars through the year 2020. However, this is only a partial list which will be refined in the next phase of this Plan effort.

Clockwise from top left: Mule deer in the Alamosa Valley, . photo: Juanjo Sergura; the Santa Maria pipeline, photo: Heather Dutton; camping on Stony Pass, photo: Erich Schlegel Rio Grande Reservoir with 100 years celebration sign, photo: Rio de la Vista

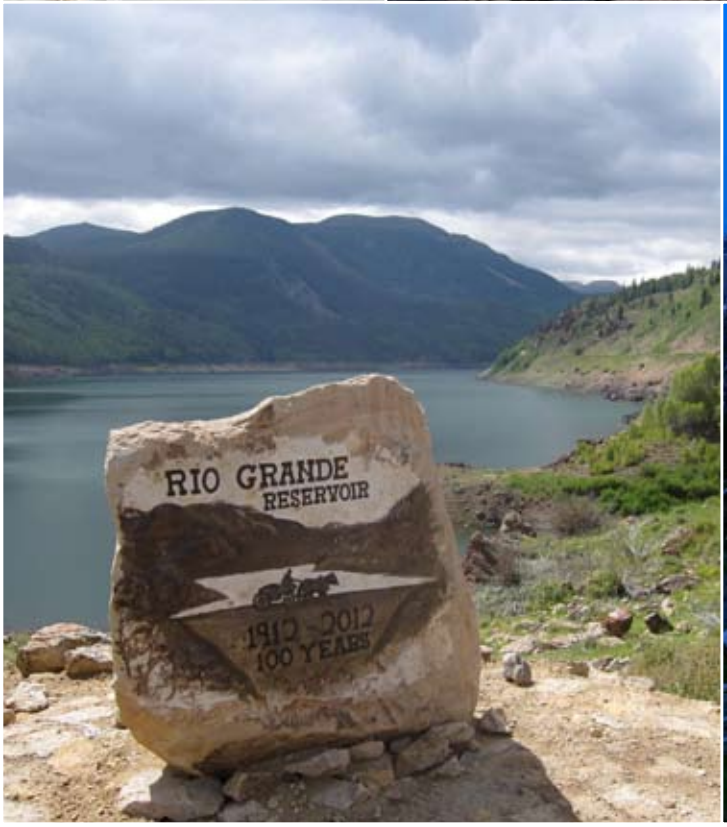


TABLE 19. Total annual costs for identified site-specific projects.

ID	Project	Sponsor	Cost							
			Total	2014	2015	2016	2017	2018	2019	2020
1	Consolidated Ditch Diversion and Headgate Rehabilitation Project	Colorado Rio Grande Restoration Foundation, NRCS, Private Landowners	$1,500,000	$111,250	$111,250	$1,256,250	$21,250			
2	Doppler Radar Weather Forecasting Project	RWEACT, CWCB, USFS, NWS	$393,750	$78,750	$78,750	$78,750	$78,750	$78,750		
3	Humphreys Reservoir Debris Mitigation Project	RWEACT and Brown Family Ranch	$180,000	$90,000	$90,000					
4	Jim Creek Riparian Protection and Restoration Project	Conejos County, TU, State Land Board, Colorado Mountain Club, Volunteers for Outdoor Colorado	$30,000	$10,000	$10,000	$10,000				
5	Little Squaw Creek Hazard Tree Removal	RWEACT	$48,000	$48,000						
6	Mountain Home Reservoir Dam Repair	Trinchera Irrigation Company	$500,000		$270,000	$230,000				
7	Post-fire Archaeological Studies	USFS, CRGRF, and RWEACT	$4,998	$1,666	$1,666	$1,666				
8	Post-fire Test Plot Project	RWEACT, USFS, and CRGRF	$5,200	$2,600	$2,600					
9	Rio Culebra Community Watershed Plan	Sange de Cristo Acequia Association								
10	RGB Hydrology Study (Long-Term)	RWEACT and CRGRF	$115,000		$23,000	$23,000	$23,000	$23,000	$23,000	
11	Rio Grande Cooperative Project	SLVID, CPW	$22,000,000	$1,625,000	$1,625,000	$9,625,000	$9,125,000			
12	Rio Grande Cutthroat Trout County Coalition Project	Colorado Counties of Hinsdale, Mineral, Rio Grande, Conejos, Costilla, Alamosa, Saguache, Archuleta, San Juan, and Las Animas	$20,579	$11,345	$4,617	$4,617				
13	Rio Grande Hydrology Study, Colo. School of Mines	RWEACT and CRGRF	$21,000	$10,500	$10,500					
14	Rio Grande Initiative Conservation Easements	RiGHT	$14,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000
15	Trujillow Meadows Reservoir Storage	Conejos Water Conservancy District	$15,550,000		$1,000,000	$1,250,000	$1,300,000	$4,000,000	$4,000,000	$4,000,000
16	USGS Debris Flow Study	USGS, CRGRF, and RWEACT	$28,650	$9,550	$9,550	$9,550				
Total			$54,397,177	$3,998,661	$5,236,933	$14,488,833	$12,548,000	$6,101,750	$6,023,000	$6,000,000

6.5 : Other Projects and Methods

The time allotted for the completion of this draft Plan did not allow a complete analysis of potential projects that could meet the Basin's goals. The next phase of the Plan will include analysis of these projects including, project costs and timeline and the development of project fact sheets.

6.5.1 : Basin Roundtable Identified Projects and Methods

The projects and methods listed in Table 20 were preliminarily identified by the Roundtable for future consideration as part of this Plan effort. Time did not permit the development of project fact sheets or the discussion and evaluation of these projects as part of the Plan effort or BRT process.

TABLE 20. Basin Roundtable identified projects and methods.

Project or Method	Needs Met				Basin Goals Met													
	Ag	M&I	Env/ Rec	Water Admin	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Acquisition of Replacement Supplies for M&I Pumping Depletions	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓		✓		
Acquisition of Replacement Supplies for Subdistricts' Pumping Depletions	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓		✓		
Adaptive Management to Mitigate Climate Change Impacts	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Alternative Agriculture Methods and Improved Irrigation Efficiency to Reduce Consumptive Use	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓		✓				
Alternative Cropping Education and Promotion Program	✓		✓			✓	✓	✓	✓		✓	✓						
Basin-wide Water Public Education Program	✓	✓	✓	✓	✓	✓	✓			✓		✓		✓	✓	✓	✓	✓
Blanca Wetlands Water Exchange			✓		✓	✓		✓						✓	✓	✓		
Capital Improvements for Recreation Facilities			✓							✓								✓
Conejos Confluence Management	✓	✓	✓	✓														
Conejos Fish Habitat project			✓		✓										✓	✓		✓
Conejos Whole River Strategy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dam and Cutthroat trout specieis reclamation project - Haypress Dam and Roaring Fork			✓															
Development of an Extreme Precipitation Dam Spillway Sizing Tool	✓	✓		✓				✓		✓								

TABLE 20. Basin Roundtable identified projects and methods.

Project or Method	Needs Met				Basin Goals Met													
	Ag	M&I	Env/ Rec	Water Admin	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Formation of Remaining Subdistricts	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓		✓		
Improved Calibration of RGDSS Groundwater Model	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓		✓		
Improvements to Ditch and Canal Diversion Structures	✓		✓	✓		✓	✓	✓	✓	✓		✓			✓		✓	✓
Increasing the Water Holding Capacity of Soils	✓		✓		✓		✓		✓		✓	✓	✓	✓				
Lone Tree Creek Riparian Restoration Projects	✓	✓	✓	✓	✓		✓			✓		✓	✓		✓	✓	✓	✓
Low Head Hydropower on exisiting diversion structures	✓	✓						✓										
Protect and Enhance Watershed Health	✓	✓	✓	✓	✓		✓			✓		✓	✓		✓	✓		✓
Rehabilitation of Reservoirs	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓		✓	✓
Restoration of West Fork Complex Fire Burned Areas	✓	✓	✓	✓	✓					✓			✓		✓	✓		✓
Retirement of Irrigated Lands Necessary to Comply with Aquifer Sustainability Rules	✓	✓	✓	✓		✓	✓			✓				✓		✓		
Rio Grande Initiative Conservation Easements	✓		✓	✓	✓					✓		✓			✓	✓		
Riverbank Stabilization	✓	✓	✓	✓	✓		✓						✓		✓	✓		
San Luis Valley Wetland LiDAR Survey project			✓		✓									✓	✓			
Soil Health Education and Promotion Program	✓		✓		✓					✓		✓	✓					
Streamflow Forecast Improvements	✓	✓	✓	✓		✓	✓		✓	✓				✓			✓	
Wetland and Riparian Enhancement and Restoration	✓	✓	✓	✓	✓		✓			✓		✓	✓		✓	✓	✓	✓
Total	**24**	**18**	**27**	**20**	**15**	**14**	**18**	**13**	**12**	**19**	**10**	**12**	**9**	**14**	**14**	**16**	**8**	**11**

6.5.2 : RWEACT Projects

The following is a list of projects that have been initiated by RWEACT and cooperatively funded and implemented amongst RWEACT, USFS, CRGRF, RGHRP, CSFS, NRCS, USGS, NWS, DWR, TU, etc.

1. Water Quality study;
2. NRCS, CSFS private land Ptarmigan Meadows forest health/ mitigation project;
3. FS/RWEACT partner project on post-fire lynx habitat assessment study;
4. RGNF Forest Plan Revision project;
5. Great Divide Forest Health project;

6. RG Basin Public/Private Forest Biomass Industries Partnership;
7. Post-Wildfire Economic Resiliency study and project;
8. RGB Water 101 information pamphlet;
9. Flood Prediction mapping project;
10. Burn scar Hydrologic Impacts and Projections modeling effort;
11. Hydrologic Instrumentation (Stream/Rain gauge) Project;
12. RWEACT/BAER Team Values at Risk project related to forest/watershed health;
13. RGNF/RWEACT Saw Crew VOC project to address post-fire impacts to the forest and watershed;
14. Recreation-related projects for trails, campgrounds etc. in the Divide Ranger District public lands;

These projects are still under development and project fact sheets or costs have not been finalized.

6.5.3 : Projects that Address Environmental and Recreational Information Gaps

Specific projects that begin to address the information needs outlined above within the SLV include:

1. Recharge study within publicly owned wetland complexes documenting water table fluctuations over the long-term in regard to surface and groundwater irrigation practices
2. Restoration of surface hydrologic connectivity within perennial and ephemeral streams in the Closed Basin including San Luis, Saguache, and La Garita Creeks and their floodplains during naturally wet periods
3. The use and effect of winter sheet ice on wetland areas to improve water tables locally and reduce loss of water through evaporation
4. The importance of early spring water (prior to the irrigation season) to provide resources for a variety of bird species including the greater sandhill crane
5. Complete Rio Grande Functional Wetland project Annual wetland water management plan among natural resource agencies for the SLV
6. Monitor wetland and riparian conservation projects to document changes over time in relation to habitat and wildlife population use
7. Continue to improve water delivery capabilities to and within public and private wetland areas to effectively and efficiently improve the condition of habitats
8. Work with local, state, and federal agencies and organizations to address large weed infestations, determine the best and most resilient seed mixes, and manage areas naturally to reduce weeds and increase native plant competitiveness

Wetland workshop on the conserved Gilmore Ranch, along the Rio Grande west of Alamosa. Photo: Rio de la Vista

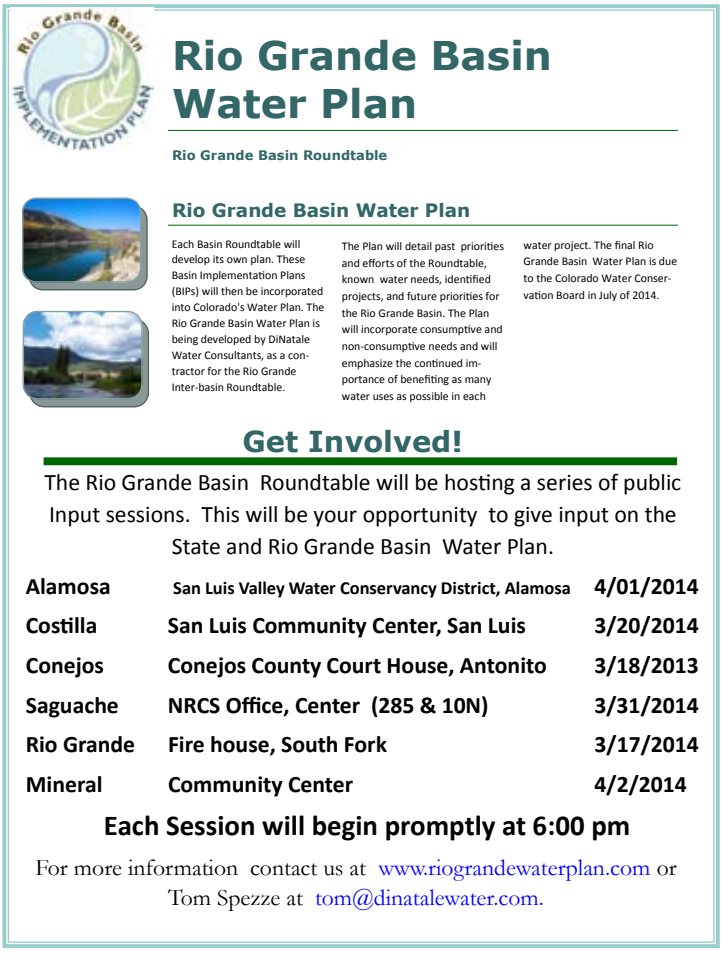
SECTION 7

Outreach and Education

This section details the extensive public outreach effort that was conducted in the preparation of this Plan.

7.1 : Summary of Outreach Completed During Basin Implementation Plan Draft Process

The Rio Grande Basin Water Plan was developed at the local level through the Rio Grande Basin Roundtable, with guidance from the Colorado Water Conservation Board. To ensure widespread public recognition and to request public input, the Outreach and Education Subcommittee developed and implemented the initial phase of a comprehensive outreach program on the Rio Grande Basin Water Plan using numerous media platforms. The outreach program entailed PowerPoint presentations at various public and organizational meetings throughout the Basin (Table 21 through Table 25), newspaper articles, radio programs, the Rio Grande Basin Water Plan website (www.riograndewaterplan.com) and a "Water 101" booklet developed specifically for the Rio Grande Basin. Details of each of these outreach efforts are summarized by category below.



Rio Grande Basin Water Plan

Rio Grande Basin Roundtable

Rio Grande Basin Water Plan

Each Basin Roundtable will develop its own plan. These Basin Implementation Plans (BIPs) will then be incorporated into Colorado's Water Plan. The Rio Grande Basin Water Plan is being developed by DiNatale Water Consultants, as a contractor for the Rio Grande Inter-basin Roundtable.

The Plan will detail past priorities and efforts of the Roundtable, known water needs, identified projects, and future priorities for the Rio Grande Basin. The Plan will incorporate consumptive and non-consumptive needs and will emphasize the continued importance of benefiting as many water uses as possible in each water project. The final Rio Grande Basin Water Plan is due to the Colorado Water Conservation Board in July of 2014.

Get Involved!

The Rio Grande Basin Roundtable will be hosting a series of public Input sessions. This will be your opportunity to give input on the State and Rio Grande Basin Water Plan.

Alamosa	San Luis Valley Water Conservancy District, Alamosa	4/01/2014
Costilla	San Luis Community Center, San Luis	3/20/2014
Conejos	Conejos County Court House, Antonito	3/18/2013
Saguache	NRCS Office, Center (285 & 10N)	3/31/2014
Rio Grande	Fire house, South Fork	3/17/2014
Mineral	Community Center	4/2/2014

Each Session will begin promptly at 6:00 pm

For more information contact us at www.riograndewaterplan.com or Tom Spezze at tom@dinatalewater.com.

Notice of Basin Plan outreach sessions flyer.

TABLE 21. Outreach sessions for general community.

Location	Meeting Date	Venue	Attendees	Demographic
South Fork	March 17, 2014	South Fork Fire House 0028 Mall Street South Fork, CO 81154	3	general public
La Jara	March 18, 2014	Conejos County Court House 6683 County Road 13 Conejos, CO 81129	4	general public
San Luis	March 20, 2014`	San Luis Community Center 233 Main Street, Suite C San Luis, CO 81152	32	general public water users
Center	March 31, 2014	NRCS – Center Field Office 0048 W. County Road 10 N Center, CO 81125	6	general public farmer/rancher
Alamosa	April 1, 2014	San Luis Valley Water Conservancy District Office 623 Fourth Street Alamosa, CO 81101	5	general public
Creede	April 2, 2014	Creede Community Center 503 Forest Service Road #9 Creede, CO 81130	3	general public
Crestone	April 16, 2014	Crestone Charter School 330 Lime Ave Crestone, CO 81131	34	general public farmer/rancher water users

Tour of wetlands improvements. Photo: Heather Dutton

TABLE 22. Outreach sessions for county commissioners.

Location	Meeting Date	Venue	Attendees	Demographic
Rio Grande	March 5, 2014	Rio Grande County Court House 925 6th Street #207 Del Norte, CO 81154	6	county commissioners
La Jara	March 14, 2014	Conejos County Court House 6683 County Road 13 Conejos, CO 81129	6	county commissioners
San Luis	April 1, 2014`	San Luis County Building 325 Main Street San Luis, CO 81152	10	county commissioners
Saguache	March 18, 2014	Saguache County Court House PO Box 655 Saguache, CO 81149	7	county commissioners
Alamosa	March 12, 2014	Alamosa County Building 8900 Independence Way Alamosa, CO 81101	8	county commissioners
Creede	April 7, 2014	Mineral County Building PO Box70 Creede, CO 81130	8	county commissioners
Lake City	March 19, 2014	Hinsdale County Building 311 Henson Street Lake City, CO 81235	12	county commissioners

Wetland workshop on the conserved Gilmore Ranch, along the Rio Grande west of Alamosa. Photo: Rio de la Vista

TABLE 23. Outreach sessions for interested groups.

Presenter	Meeting Date	Venue	Attendees	Demographic
Paul Tigan	March 26, 2014	USFS, BLM, AND USFWS 46525 Highway 114 Saguche, CO 81149	30	federal agency
Kevin Terry	March 27, 2014	SLV Trout Unlimited PO Box 503 Alamosa, CO 81101	12	Trout Unlimited
Nathan Coombs	April 8, 2014	Conejos Water Conservancy 318 Main Street Manassa, CO 81141	50	Conejos water users
Judy Lopez	April 8, 2014	Rio Grande Watershed Assoc. of Conservation Districts 101 South Craft Drive Alamosa, CO 81101	45	farmer/ ranchers
Rick Basagoita	March 12, 2014	Colorado Parks and Wildlife 0722 South Road 1 East Monte Vista , CO 81144	38	CPW staff
Mike Gibson	March 20, 2014	SLVWCD Office 623 4th Street Alamosa, CO 81101	12	Board members
Mike Gibson	March 18,2014	RGWCD 10900 US Highway 160 Lake City, CO 81235	72	Board members general public
Rio de la Vista	March 15, 2012	Great Outdoors Trail Group 101 South Craft Drive Alamosa, CO 81101	25	group members
Rio de la Vista	March 8, 2013	Wetlands Focus Group 101 South Craft Drive Alamosa, CO 81101	30	group members

TABLE 24.

Rio Grande Roundtable meetings.

Location	Meeting Date	Venue	Attendees	Demographic
Alamosa	December 10, 2013	SLVWCD Office 623 4th Street Alamosa, CO 81101	29	general public Roundtable members
Alamosa	January 14, 2014	SLVWCD Office 623 4th Street Alamosa, CO 81101	37	general public Roundtable members
Alamosa	February 18, 2014	SLVWCD Office 623 4th Street Alamosa, CO 81101	42	general public Roundtable members
Alamosa	March 11, 2014	SLVWCD Office 623 4th Street Alamosa, CO 81101	53	general public Roundtable members
Alamosa	April 8, 2014	SLVWCD Office 623 4th Street Alamosa, CO 81101	53	general public Roundtable members
Alamosa	May 13, 2014	SLVWCD Office 623 4th Street Alamosa, CO 81101	44	general public Roundtable members

TABLE 25.

Basin Plan Subcommittee meetings.

Group	Number of Meetings	Location
Agriculture	4	SLVWCD Office 623 4th Street Alamosa, CO 81101
Environmental and Recreational	4	NRCS Office 101 South Craft Drive Alamosa, CO 81101
Municipal and Industrial	5	SLVWCD Office 623 4th Street Alamosa, CO 81101
Water Management	2	RGWCD Office 10900 Hwy 160 Alamosa, CO 81101
Outreach and Education	2	SLVWCD Office 623 4th Street Alamosa, CO 81101
Steering Committee	4	SLVWCD Office 623 4th Street Alamosa, CO 81101

7.1.3.1.1 NEWSPAPER ARTICLES

The Rio Grande Basin Roundtable is publishing bi-weekly articles in the *Valley Courier*. The articles will cover all aspects of the Basin Plan: Basin and Colorado Plan processes, deadlines and all aspects of water that will be discussed in the Plan.

TABLE 26. Schedule of newspaper articles related to the Basin Plan.

Published	Newspaper Articles	Date	Author
X	Overview of the State and Basin Plans	12/20/2014	Judy Lopez
X	Agricultural Water	1/31/2014	Judy Lopez
X	The Rio Grande Basin Water Plan Addresses Water Needs	2/15/2014	Judy Lopez
X	The Rio Grande Basin Water Plan Addresses Water Administration	3/1/2014	Judy Lopez
X	Working Together to Plan Our Water Future	3/15/2014	Kevin Terry
X	Public Land, Public Water	3/21/2014	Paul Tigan
X	Municipal Water	4/4/2014	Charlie/Judy
X	Conservation Districts	4/26/2014	Brenda/Judy
X	Conserving Land and Water: A Long-Term Tool	4/25/2014	Rio de la Vista
X	Reservoirs in the San Luis Valley	5/23/2014	Travis Smith
X	Ranching with Drought	June	Pete Clark
	Wildlife Water CPW	June	Rick Basagoita
	River Restoration	July	Heather D./Mike G
	Draft Basin Plan	July	Tom/Judy/Kelly
	RWEACT and Watershed Health	August	Tom/Heather
	USFS and Water	August	Mike B.
	Draft State Water Plan	September	Tom/Kelly
	Alternative Agriculture	September	Brendon/George
	Water Admin Subdistricts	October	Rob Phillips
	Water Economics	October	Cory Off
	Farming with Drought	November	Brendon/Judy
	Need for Education	November	Judy Lopez
	Water Economics	December	To be determined
	State Water Plan	December	Tom/Kelly

7.1.3.1.2 RADIO PROGRAMS

The radio shows are being done monthly through KSLV Radio in Monte Vista, Colorado. The programs are designed to provide information about water needs now and in the future. The interviews are with local folks, who are involved in all aspects of the Basin planning process. It helps to engage citizens in the Rio Grande Basin, by keeping them current on relevant water issues. WATER 101 BOOKLET

Taking a lead from the Gunnison Basin, the Rio Grande is putting together a Basin-specific water facts booklet. Our hope is that the booklet will meld state, regional and local water facts into an informational guide that will be used by community members. The Roundtable will send out 11,000 in the local newspapers, *Valley Courier* and the Valley Publishing weeklies, and then distribute an additional 3,000 to water organizations, county governments and chambers of commerce.

TABLE 27. Schedule of radio programs related to the Basin Plan.

Aired	Radio KSLV	Date	Speakers
X	Basin/State Plan	December 2013	Judy/Tom/Mike
X	Agriculture	January 2014	Judy/Nathan
X	Basin Plan Update	February 2014	Tom/ Judy
X	Municipal & Industrial	April 2014	Charlie/Nicole
X	Environmental & Recreational	April 2014	Rio/Kevin
	Water Administration	May 2014	DWR
	Final Basin Plan Update	June 2014	Tom/Kelly/Travis
	Rules and Regulations	July 2014	Craig
	Parks and Water	August 2014	Fred
	Subdistrict	September 2014	Steve
	Augmentation	October 2014	Mike
	Final Plan Update	November 2014	Tom/Travis/Kelly

7.1.3.1.3 WEBSITE

The Rio Grande Basin Roundtable developed a website that is specific to the Rio Grande Basin Water Plan at www.riograndewaterplan.com. It provides information about all aspects of the Plan and serves as an archive for all Basin Plan products. Most importantly, the site is a way that the public can interact with the Plan, since comments can be sent directly to the oversight committees for their review and consideration.

7.2 : Action Plan for Education, Participation and Outreach Beyond 2014

Rio Grande Basin Roundtable Education Action Plan (2014–2015)

Article VII of the Interbasin Compact Committee (IBCC) bylaws addresses the formation of workgroups to assist it in its deliberations and functions. The Public Education, Participation and Outreach (PEPO) Workgroup is charged with creating a process to inform, involve and educate the public on the IBCC's activities and progress of the Interbasin Compact negotiations and to create a mechanism by which public input and feedback can be relayed to the IBCC and compact negotiators. It is the only workgroup written into the legislation (C.R.S. 37-75-106).

The PEPO Workgroup will assist the basin roundtables in strengthening their education and outreach activities. Each roundtable is expected to have a functioning education and outreach committee tasked with creating an education action plan (EAP). The EAP will detail the educational goals and tasks most effective for the Basin roundtable. It will identify roundtable member education activities that promote a well-informed and high-functioning Basin roundtable. It will also define public participation objectives and appropriate implementation methods.

Tour of Rio Grande, Little Mogotes and Piñon. Photo: Paul Tigan, BLM

To assist the basin roundtables in implementing their completed EAPs, the Colorado Water Conservation Board has created an application-based education fund.

i. **Subcommittee members**: All roundtable members are encouraged to provide input and suggestions to the subcommittee. The subcommittee seeks to represent fully the agricultural, municipal and industrial, education and recreational and public outreach interests of the Basin. The names and affiliations of current and contributing Rio Grande Basin PEPO Subcommittee members are:

1. Mike Gibson, Chair of Rio Grande Basin Roundtable, San Luis Valley Water Conservancy
2. Judy Lopez, education liaison/education representative for Rio Grande Basin Roundtable, Rio Grande Conservation and Education Initiative
3. Rio de la Vista, Vice Chair of Rio Grande Basin Roundtable, Director of RiGHT
4. Nathan Coombs, member of Rio Grande Basin Roundtable, and General Manager, Conejos Water Conservancy District
5. Charlie Speilman, municipal representative of Rio Grande Basin Roundtable
6. Kevin Terry, liaison for National Trout Unlimited
7. Heather Dutton, recreation representative of Rio Grande Basin Roundtable, and Executive Director of Rio Grande Headwaters Restoration Foundation

ii. **Annual meeting plan for Subcommittee**: The Subcommittee will meet at a time that is convenient for members. Members agree to meet more often, if needed to complete a project. The Subcommittee will make efforts to structure its meetings to occur in the month following regularly scheduled IBCC meetings, so as to maximize the transfer of information between the PEPO Workgroup and the Roundtable.

ii. **Educational priorities and implementation**: The ultimate goal of the Rio Grande Basin PEPO Subcommittee is to have greater participation by all interests in the Roundtable process.

iii. **Partnerships**: The following is a list of educational groups and efforts already existing in the Rio Grande Basin to potentially help with Rio Grande Basin PEPO activities:

1. Rio Grande Water Conservation District
2. San Luis Valley Water Conservancy District
3. San Luis Valley Irrigation District
4. Conejos Water Conservancy District
5. RiGHT
6. Alamosa Riverkeeper
7. Alamosa River Foundation

TABLE 28. Specific education and outreach goals of the Rio Grande Basin PEPO Subcommittee.

Objective	Tasks	Leads	Timeline
TOPIC 1: Outreach	Monthly articles by Roundtable members	Judy Lopez Partners	FY 2014–2015
	Web page to provide latest Roundtable information and events, plus interactive opportunities	Emma Reiger Judy Lopez Partners	FY 2014–2015
TOPIC 2: Education	Outreach events designed for agriculture water users, public officials and community members	Judy Lopez Heather Dutton Partners	FY 2014–2015
TOPIC 3: Multiple-Use Project Implementation Discussion	Forum that bring stakeholders together to maximize multi-use projects	Judy Lopez Heather Dutton Emma Reiger Partners	FY 2014–2015
TOPIC 4: Payment for Education and PEPO Liaison	Funding to educational liaison for implementation of outreach and education	Judy Lopez	FY 2014–2015

8. Bureau of Reclamation
9. Bureau of Land Management
10. The Nature Conservancy
11. Division of Water Resources
12. Rio Grande Restoration Foundation
13. Rio Grande Watershed Conservation and Education Initiative
14. Trout Unlimited
15. Conservation districts
16. State agencies: Colorado State Forest Service, Colorado Parks and Wildlife
17. Federal agencies: Natural Resources Conservation Services, U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service

iv. **Budget**: Resources needed to complete each task, detailed in an overall budget, assuming a $7,500 annual inflow of state funds from EAP and WRSA. The budget listed below is for FY 2014–2015.

TOPIC 1:	**Outreach Events:**
FY 20142015 TOTAL =	$ 500
TOPIC 2:	**Water Education Program**: Predicted expenses include travel, publication of hard copy handouts and meals
FY 20142015 TOTAL =	$1,000
TOPIC 3:	**Projects Program**: Expenses will be used to provide tours, presenters and meals of multi-use projects

FY 20142015 TOTAL =	$ 500
TOPIC 4:	**Projects Program**: Expenses will be used to pay for the Roundtable education liaison and website maintenance
FY 20142015 TOTAL =	$7,500

v. **Assessment**: An assessment of public events will be conducted briefly following the event to determine if: a) attendees left the event with a greater understanding of the Roundtable's purpose and activities; and b) attendees felt the event was worth their time. This assessment will be conducted using a web survey or digital equivalent.

7.3 : Rio Grande Basin Long-Range Outreach Strategies

The Rio Grande Basin recognizes the importance of a balanced and ongoing Outreach Plan. The Basin has built its public communications on three key ideals — outreach, education and participation — across all demographics, including water users, public officials, communities and water leaders.

TABLE 29. Rio Grande Basin Long-Range Outreach Strategies

Year	Goals	Strategies
2015–2016	Outreach, education and participation that furthers the purposes of the Roundtable, IBCC and CWCB as they relate to the preservation and sustainability of the Rio Grande Basin and State of Colorado's water resources	Active and diverse Roundtable members, news articles, website pages, e-letters, educational opportunities, strategic planning forums and the use of an active educational liaison who participates in the CWCB public education public outreach (PEPO) process
2016–2017	Outreach, education and participation that furthers the purposes of the Roundtable, IBCC and CWCB as they relate to the preservation and sustainability of the Rio Grande Basin and State of Colorado's water resources	Active and diverse Roundtable members, news articles, website pages, e-letters, educational opportunities, strategic planning forums and the use of an active educational liaison who participates in the CWCB public education public outreach (PEPO) process
2017–2018	Outreach, education and participation that furthers the purposes of the Roundtable, IBCC and CWCB as they relate to the preservation and sustainability of the Rio Grande Basin and State of Colorado's water resources	Active and diverse Roundtable members, news articles, website pages, e-letters, educational opportunities, strategic planning forums and the use of an active educational liaison who participates in the CWCB public education public outreach (PEPO) process
2018–2019	Outreach, education and participation that furthers the purposes of the Roundtable, IBCC and CWCB as they relate to the preservation and sustainability of the Rio Grande Basin and State of Colorado's water resources	Active and diverse Roundtable members, news articles, website pages, e-letters, educational opportunities, strategic planning forums and the use of an active educational liaison who participates in the CWCB public education public outreach (PEPO) process
2019–2020	Outreach, education and participation that furthers the purposes of the Roundtable, IBCC and CWCB as they relate to the preservation and sustainability of the Rio Grande Basin and State of Colorado's water resources	Active and diverse Roundtable members, news articles, website pages, e-letters, educational opportunities, strategic planning forums and the use of an active educational liaison who participates in the CWCB public education public outreach (PEPO) process

Meanders, oxbow lakes, and ranches on La Jara Creek. Photo: Adriel Heisey

SECTION 8

Implementation Strategies

This section provides a framework for meeting the challenges to successful implementation of the projects and methods.

8.1 : Project Specific Strategies

Implementation Techniques:

- A local stakeholder group, such as the Rio Grande Watershed Emergency Action Coordination Team (RWEACT), is maintained to address emergent and future impacts to watershed health.

- Rio Grande Forest Plan is implemented and includes ecosystem resiliency.

- Water right users and storage right holders coordinate and cooperate with each other to comply with the Groundwater Rules and Regulations and augmentation plans to benefit wildlife and recreation to the extent possible.

- Identify need for additional/updated hydrogeological studies.

- Provide information to enhance the ability of the Rio Grande Decision Support System (RGDSS) groundwater model to accurately predict impact from well-pumping.

- Soil erosion is minimized within the NRCS "Tolerance" recommendations for a given area.

- Existing agriculture efficiencies are documented.

- While M&I and SSI water use will remain a small percentage of overall Basin water use, it is important to provide additional resources to M&I water providers to assist them in meeting future needs by identifying and assisting in the development of:
  - measures to manage water demands and return flows and develop methods to receive augmentation credits for wastewater discharges and lawn irrigation return flows.
  - water rights, storage and augmentation supplies, either directly or through the groundwater management subdistricts.

8.2 : Strategies to Ensure Public Education and Acceptance

- Reciprocal public information
  - Announcements through Roundtable
  - As appropriate, Roundtable meetings hosted at various locations around the Basin

- Annual water education plan is implemented
  - Education plan includes watershed management components that include drought, flooding and fire restoration.
  - Quarterly water education and information newsletter
  - Radio spots

- Public Education and Outreach
  - Communication with county commissioners, elected officials, State and Federal agencies, agricultural and M&I users, environmental and recreational users through consistent messaging.
  - Educational outreach regarding land and water management that benefits agricultural and environment / wildlife habitat.

Confluence of the Conejos River (right) with the Rio Grande (left) east of La Jara, looking south. Photo: Adriel Heisey

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Geese on the Rio Grande in Antelope Park. Photo: Adriel Heisey

Appendices

Appendix A: Demographic Information

Population in each county by ethnicity and Hispanic origin is shown in Table 30.

	Alamosa	Conejos	Costilla	Mineral	Rio Grande	Saguache	Rio Grande Basin
Total	**15,570**	**8,241**	**3,556**	**702**	**11,925**	**6,189**	**46,363**
Non-Hispanic	8,565	3,657	1,223	687	6,827	3,633	24,592
White	7,767	3,490	1,105	671	6,523	3,413	22,969
Afro-American	110	6	12	9	69	20	226
Native American	32	22	0	5	37	35	131
Asian	59	13	23	1	37	13	146
Pacific Islander	14	0	0	0	0	4	18
Other Race alone	112	8	7	0	0	7	134
Two or More Races	474	118	76	1	161	141	971
Hispanic Origin	7,185	4,584	2,333	15	5,098	2,556	21,771

Source: San Luis Valley Development Resources Group 2013

TABLE 30.

Population by ethnicity and Hispanic origin.

The density of population per square mile is shown in Table 31.

	Alamosa	Conejos	Costilla	Mineral	Rio Grande	Saguache	Rio Grande Basin
Total Square Miles	723	1,287	1,227	876	911	3,168	8,192
Persons/ square mile	21.4	6.4	2.9	0.81	13.1	1.9	5.6

Source: San Luis Valley Development Resources Group 2013

TABLE 31.

Population density of the San Luis Valley.

Appendix B: Environmental and Recreational Needs

SWSI Phase 2 and SWSI 2010

The mapping conducted as part of SWSI Phase 2 for the Rio Grande Basin identified numerous environmental and recreational attributes within seven subcategories:

1. Whitewater and flat water boating
2. Important cold- and warm-water fishing
3. Waterfowl hunting
4. State/federal endangered, threatened, and species of concern
5. Special value waters (CWCB in-stream flow waters, eligible/suitable wild and scenic, WQCD outstanding waters)
6. Rare plants and significant riparian wetland plant communities
7. Wetlands (National Wetlands Inventory)

The previous analysis included the identification of projects and methods through a detailed outreach and survey process that resulted in a list of 59 projects and methods for the Rio Grande Basin, all of which were within the Basin's designated focus areas at the time. The following data was collected for each of the projects: name, location, type (project, information and flow protection), status (completed, ongoing, planned, or proposed), project ID and reach ID. All identified projects were documented and mapped.

The resulting identified projects and methods contained:

- Projects identified by CWCB surveys and workshops
- CWCB watershed restoration projects
- Projects funded by CWCB's Water Supply Reserve Account grant program
- CWCB Instream Flows

Over half of the projects identified in the Phase 2 process were already complete. Table 32, Completed Environmental and Recreational Projects, provides details on the completed, ongoing and planned projects.

TABLE 32. Completed Environmental and Recreational Projects

Past Environmental Projects Identified in SWSI 2010 - Completed

Project ID	Project Name	Location	Project Category	Project Type	Project Status	Protections
2	"Rio Grande Main stem (Fern Creek to Cliff Lake) Tree planting, and Fishery structures"	Rio Grande Main stem (Fern Creek to Cliff Lake)	NCNA Interviewed	Project	Completed	Direct
3	Rio Grande Main stem (Fern Creek to Cliff Lake) Stream Rechanneling		NCNA Interviewed	Project	Completed	No Know Protection
5	Shallow Creek Stream Restoration & Structures	Shallow Creek	NCNA Interviewed	Project	Completed	Direct
6	Sheep Creek Rock Dams	Sheep Creek - Trib to Saguache Creek	NCNA Interviewed	Project	Completed	Direct
7	Trout Creek above Creede	Trout Creek above Creede	NCNA Interviewed	Project	Completed	Direct
9	Willow Creek Reclamation Committee Mine Tailings	Willow Creek	NCNA Interviewed	Water Quality Protection	Completed	Indirect
38	South Fork of Rio Grande Park Creek Campground	South Fork of Rio Grande at Park Creek Campground	NCNA Interviewed	Project	Completed	Direct
39	Gravel Pond Wetlands project	South Fork of Rio Grande	NCNA Interviewed	Project	Completed	Direct
151	Hot Springs restoration project	Hot Springs Creek	NCNA Interviewed	Project	Completed	Direct
152	San Luis Creek Conservation Initiative	San Luis Creek	NCNA Interviewed	Project	No project	Direct / Indirect
391	Multiple conservation easements on Saguache Creek corridor ranches that tie water to the land.	Saguache Creek	NCNA Interviewed	Flow Protection	Completed	Direct / Indirect
392	Conservation easement with TNC including 2 miles of stream flow restoration on creek (unnamed)	Valley View Hot Springs	NCNA Interviewed	Flow Protection	Completed	Direct
393	"Conservation easements and fee title covering about 3,000 acres"- Mishak Lakes	Mishak Lakes Wetland Complex	NCNA Interviewed	Conserved habitat / land	Completed	Direct
394	Hydrologic assessment (Sanderson et al 2008) simulated natural hydrologic regime- Mishak Lakes wetland complex	Mishak Lakes Wetland Complex	NCNA Interviewed	Information	Completed	No Know Protection
676	Culvert replacements/ Migration Barriers	Big Springs Creek	NCNA Interviewed	Project	Completed	Direct
677	Culvert replacements/ Migration Barriers	Big Springs Creek	NCNA Interviewed	Project	Completed	Direct
678	Culvert replacement		NCNA Interviewed	Project	Completed	

Comments/ Rationale	Status	Contact Organization
	On private land - Rio Oxbow	RiGHT can contact owner of Rio Oxbow Ranch-www.riograndelandtrust.org
	On private land - Rio Oxbow	RiGHT can contact owner of Rio Oxbow Ranch-www.riograndelandtrust.org
Stream Restoration and Enhance Structures (drops, weirs, etc.) for fisheries.		On private land - RiGHT can contact
Installed approximately 40 rock dam structures in stream.		Private landowner. Sheep Creek flows into upper Saguache Creek. Note that some of these may have been illegal and removed.
Installed checks, weirs, j-hooks, and rock structures to improve fisheries and stop bank erosion. Planted trees.		On private land - RiGHT can contact
Portions of mine tailing sites restored		WCRC: www.willowcreede.org
six instream structures (J-hooks, weirs, etc) for fish habitat and 0.2 acres of riparian wetlands		CDOT, Wetland Program Manager
Filled gravel ponds in floodplain creating ground level wetlands.		CDOT, Wetland Program Manager
easement on land, restoration of Rio Grande Chub in Creek	Orient Land Trust	Orient Land Trust: www.olt.org
working with land management agencies and private landowners to protect the river corridor	This was a concept by the Orient Land Trust, but never develoepd into a project.	Orient Land Trust: www.olt.org
		Colorado Cattlemens Agricultural Land Trust- www.ccalt.org
		Valley View Hot Springs-Orient Land Trust (www.olt.org). Contact the Nature Conservancy (TNC) Boulder office for more information
		The Nature Conservancy (TNC) and Rio Grande Headwaters Land Trust (RiGHT). TNC is landowner, RIGHT holds easement
		The Nature Conservancy (TNC)
38° 05´ 14˝N; 106° 21´ 12˝W	Big Springs Creek	U.S. Forest Service
38° 05´ 05˝N; 106° 21´ 10˝W	Big Springs Creek	U.S. Forest Service
38° 05´ 07˝N; 106° 21´ 10˝W	Big Springs Creek	U.S. Forest Service

TABLE 32. Completed Environmental and Recreational Projects

Past Environmental Projects Identified in SWSI 2010 - Completed

Project ID	Project Name	Location	Project Category	Project Type	Project Status	Protections
679	Culvert replacements	Prong Creek	NCNA Interviewed	Project	Completed	Direct
680	Culvert replacement	Perry Creek	NCNA Interviewed	Water Quality Protection	Completed	Direct / Indirect
681	Culvert replacements	Groundhog Creek	NCNA Interviewed	Project	Completed	Direct
682	Culvert replacements	Benino Creek	NCNA Interviewed	Project	Completed	Direct
683	Culvert replacements	Middle Fork Carnero Creek	NCNA Interviewed	Project	Completed	Direct
684	Culvert replacements	North Fork Carnero Creek	NCNA Interviewed	Project	Completed	Direct
685	Culvert removal	Cave Creek	NCNA Interviewed	Project	Completed	Direct
686	Stream restoration	South Fork of Rio Grande	NCNA Interviewed	Project	Completed	Direct
687	Stream restoration	Conejos River	NCNA Interviewed	Project	Completed	Direct
688	Stream restoration		NCNA Interviewed	Project	Completed	
689	Stream restoration		NCNA Interviewed	Project	Completed	
690	Stream restoration	Alamosa River	NCNA Interviewed	Project	Completed	Direct
691	Road Relocation	North Fork Carnero Creek	NCNA Interviewed	Project	Completed	Indirect
692	Road obliteration-closure	Park Creek	NCNA Interviewed	Project	Completed	Indirect
693	Migration Barriers					
694	Migration Barriers	North Fork Carnero Creek	NCNA Interviewed	Project	Completed	Direct
696	Migration Barriers	Lake Fork Conejos	NCNA Interviewed	Project	Completed	Direct
697	Million Reservoir Diversion Improvements	Mill Creek	NCNA Interviewed	Project	Completed	No Know Protection
700	Fish habitat improvement	Conejos River	NCNA Interviewed	Project	Completed	Direct

Past Environmental Projects Ide

Comments/ Rationale	Status	Contact Organization
37° 57′ 25″N; 106° 30′ 04″W	Prong Creek	U.S. Forest Service
37° 54′ 10″N; 106° 35′03″W	Perry Creek	U.S. Forest Service
37° 51′ 53″N; 106° 35′36″W	Groundhog Creek	U.S. Forest Service
37° 53′ 00″N; 106° 36′ 05″W	Benino Creek	U.S. Forest Service
37° 57′ 29″N; 106° 25′ 55″W	Middle Fork Carnero Creek	U.S. Forest Service
37° 55′ 26″N; 106° 23′ 25″W	North Fork Carnero Creek	U.S. Forest Service
37° 54′ 08″N; 106° 30′ 42″W	Cave Creek	U.S. Forest Service
37° 35′ 46″N; 106° 43′ 37″W	South Fork of Rio Grande	U.S. Forest Service
37° 20′ 24″N; 106° 29′ 27″W	Conejos River	U.S. Forest Service
	Conejos River	U.S. Forest Service
	Conejos River	U.S. Forest Service
37° 22′ 45″N; 106° 20′ 44″W	Alamosa River	U.S. Forest Service
37° 55′ 21″N; 106° 23′ 25″W	North Fork Carnero Creek- FS. Road closed. Dead ends.	U.S. Forest Service
13 0349151; 4158262. 13 0350004; 4156819. 13 0349831; 4151822.	Park Creek	U.S. Forest Service
	Middle Fork Carnero Creek	U.S. Forest Service
37° 54′ 42″N; 106° 23′ 26″W	North Fork Carnero Creek	U.S. Forest Service
37° 19′ 05″N; 106° 30′ 06″W		U.S. Forest Service
13 0352960; 4165715	Was on FS land, but may be be completed by private reservoir owner. Million Reservoir provides water for South Fork.	U.S. Forest Service
37° 09′ 48″N; 106° 26′ 16″W	Conejos River - Conejos Campground at Spectacle Lake, on FS Rd 250.	U.S. Forest Service
entified in SWSI 2010 - Ongoing		

TABLE 32. Completed Environmental and Recreational Projects

Past Environmental Projects Identified in SWSI 2010 - Completed

Project ID	Project Name	Location	Project Category	Project Type	Project Status	Protections
102	Alamosa River Instream Flow	Alamosa River (from Terrace Reservoir to County Rd 10)	NCNA Interviewed	Flow Protection	Ongoing	Direct
217	Rio Grande Restoration Project	Rio Grande upstream of Alamosa	NCNA Interviewed	Project	Ongoing	Direct
389	USFWS/CPW water diversion/ water control structures to maintain water levels	Lower Crestone Creek	NCNA Interviewed	Flow Protection	Ongoing	Direct / Indirect
395	Alamosa River Upgrades	Alamosa River	NCNA Interviewed	Flow Protection	Ongoing	Direct / Indirect
674	Barrier installation and non-native removal habitat restoration project	La Garita Creek	NCNA Interviewed	Project	Ongoing	Direct
11	Kerber Creek Restoration	Kerber Creek	NCNA Interviewed	Project	Ongoing/ Many projects Completed	Direct
4	Rio Grande Reservoir Rehabilitation	Rio Grande Reservoir	NCNA Interviewed	Flow Protection	Planned	Direct
8	Rio Grande Natural Area Riparian Restoration	Rio Grande from Alamosa Wildlife National Refuge to Colorado state line	NCNA Interviewed	Project	Ongoing	Direct / Indirect
10	Willow Creek Reclamation Committee Channel Restoration	Mineral County above Creede to Rio Grande	NCNA Interviewed	Project	Ongoing	Direct
342	Fully utilize transmountain return flows - Rio Grande		NCNA Interviewed	Information	Ongoing	No Know Protection

Comments/ Rationale	Status	Contact Organization
Alamosa River Instream Flow	Flow acquisition-CWCB acquired in water court transfer. 3 out of 10 cfs acquired to date	Alamosa Riverkeepers and CWCB
Justification of projects based on 2001 Study of reach between South Fork and Alamosa/Costilla County. Projects address habitat for SW Willow Flycatcher, stabilizing riparian zones and improvement of fisheries. Opportunities for flood plain management and diversion structure improvements.		Rio Grande Headwaters Restoration Project
Lower Crestone Creek - large remnant population of Rio Grande Suckers	Completed structures as needed for Sucker and Chub. Many more infrastructure improvements needed. Working with CPW to learn more about needs of species and how to address. May be additional actions in the future.	U.S. Forest Service
Upgrades to Terrace Reservoir, river, water acquistions and habitat restoration. Should be the Alamosa River Restoration Project.	Bank stabilization will start in 2014. NRCS is assisting with landowners. Planting willows, trees, shrubs for bank stabilization.	Alamosa Riverkeepers and NRCS
	CPW project. Landowner issues and may be moved to a different location.	Colorado Parks and Wildlife
Stream Restoration. Mine reclamation and stream improvements, bank stabilization.	Ongoing. Collaboration of BLM, FWS, TU and many creek corridor landowners.	USFWS at Saguache Public Lands Office. Americorps coordinator changes annually. See: www.kerbercreek.org
Enhanced storage providing retiming of Rio Grande flows. See Travis Smith for studies.	Dam rahabilitation complete. Outlet works improvement on-going.	San Luis Valley Irrigation District
1/4 mile strip on both sides of Rio Grande from south end of Alamosa NWR to NM state line--to develop a plan for the riparian corridor. RGWCD initiated the legislation that created it. Feral horses and trespass cattle grazing are among the major issues for the area-- decimating riparian vegetation.	Working on a plan for entire area, including private land and BLM (on south end, west side of river). Also a study is underway by Rio Grande Headwaters Restoration Project to evaluate riparian health and restoration needs.	Bureau of Land Management and Rio Grande Natural Area Commission. See: www.blm.gov/co/st/en/fo/slvfo/rio_grande_natural.html
Restoring natural channel, reduce sediment and heavy metal pollution through stabilization of old mine impacts	Ongoing.	Willow Creek Reclamation Committee. See www.willowcreede.org
CPW has developed the accounting tool necessary for the determination of available transmountain return flows and is using the preliminary data	Ongoing	Colorado Parks and Wildlife

TABLE 32. Completed Environmental and Recreational Projects

Past Environmental Projects Identified in SWSI 2010 - Completed

Project ID	Project Name	Location	Project Category	Project Type	Project Status	Protections
344	Platoro Reservoir minimum flow modification		NCNA Interviewed	Flow Protection	Planned	Direct / Indirect
345	Dredging of conservation pools		NCNA Interviewed	Project	Planned	Direct / Indirect
390	Fish studies by USFWS and CPW	Lower Crestone Creek	NCNA Interviewed	Information	Planned	No Know Protection
396	Alamosa River Upgrades	Alamosa River	NCNA Interviewed	Flow Protection	Planned	No Know Protection
698	Stream crossing restoration work	La Garita	NCNA Interviewed	Project	Planned	Direct
699	Stream crossing restoration work	La Garita	NCNA Interviewed	Project	Planned	Direct
701	Culvert replacement	Beaver Creek	NCNA Interviewed	Project	Planned for summer 2014	Direct

Comments/ Rationale	Status	Contact Organization
CPW has transmountain water sources that may be suitable for exchange to cover evaporative losses. Potential exists for leasing Joint Use Pool Water sources. While trying to retrofit outlet structure, worked figuring out a way to get 10 cfs out of the 7 cfs congressional mandated flow for winter flows downstream of Platoro. Repair of structure resulted in less flows. CPW has done some fish habitat work. To significantly improve habitat need more than 3 cfs. Trujillo Meadows or similar multi-purpose project could assist.	Stalled. Tried to work with the CWCD and CPW.	Bureau of Land Management
CPW has identified silt problems in Big Meadows, Beaver, Road Canyon, Upper and Lower Browns. Losing storage capacity. Any within the burned watersheds will have sedimentation issues. Mountain Home conservation pool is effectively silted in. Reoperating gates could help flush sediment.	Stalled. Need an inventory of needs and status.	Colorado Parks and Wildlife
	Ongoing. Baca NWF just completed a population survey.	Baca Nationa Wildlie Refuge and Great Sand Dunes National Park
Upgrades to Terrace River, water acquisitions and habitat restoration	Maintaining or improving water quality. Working on Superfund remediation.	Alamosa Riverkeepers
37° 50´ 18˝N; 106° 22´ 35˝W	La Garita , FS Road 670	U.S. Forest Service
37° 50´ 14˝N; 106° 21´ 34˝W	La Garita , FE Road 670	U.S. Forest Service
37° 29´ 35˝N; 106° 36´ 39˝W	Beaver Creek, FS Road 332.1D	U.S. Forest Service

At Risk and Indicator Species

The following species are either at risk or are indicator species and have a presence in the Rio Grande Basin of Colorado. The sections below address the characteristics of the species, their status as endangered, threatened, or at risk, and a summary of the actions being taken through recovery plans or otherwise to address them. Links to additional information are included.

Bird Species At Risk or Indicators

Southwestern Willow Flycatcher

Characteristics: The southwestern willow flycatcher (SWF) (Empidonax traillii extimus) is a small Neotropical migratory bird, whose nesting habitat is restricted to relatively dense growths of trees and shrubs in riparian ecosystems in the arid southwestern United States. These riparian habitats are associated with rivers, swamps, and other wetlands, including lakes and reservoirs (Bent 1960). Most of these habitats are classified as wetlands in the legal sense: palustrine and lacustrine forested wetlands and scrub-shrub wetlands (Cowardin et al. 1979). Some are non-wetland riparian forests. Surface water or saturated soil are typically, but not always, present year-round or seasonally and groundwater is generally at a depth of less than 2 or 3 meters (6.5 to 9 ft) within or adjacent to nesting habitat.

The flycatcher is about 5 to 6 inches long, with distinctive features including a lighter olive-green breast, a pale yellowish belly, and two indistinct wing bars. The flycatcher is confirmed by its wheezy "fitz bew" or "fit-za-bew," song during nesting season.

According to recent research, within its probable range of in Colorado, flycatchers appear to be very localized and uncommon. Breeding flycatchers within the probable range have only been confirmed on tributaries of the San Juan River and within the SLV (Owen and Sogge 1997; Sogge et al. 2001). However, considerable potential flycatcher habitat remains to be surveyed, and undiscovered breeding populations may exist.

Status: Pursuant to Colo. Rev. Stat. §33-2-105 (2013), the Colorado Wildlife Commission listed the southwestern willow flycatcher as endangered in May 1998. 2 Colo. Code Regs. §1002-A-2.

There are two specified recovery unit sites for southwestern willow flycatcher in Rio Grande Basin: the Rio Grande Alamosa National Wildlife Refuge and the BLM managed site on the Conejos River and the McIntire-Simpson Property (Southwest Willow Flycatcher Recovery Plan, 2002). Within the management units, there are 34 known territories in the SLV. A minimum of 50 territories is needed to warrant reclassification (pg 85, SWFRP, 2002). Within the SLV the Rio Grande and tributaries from Baxterville (CO) to the Colorado/New Mexico State line, including

Alamosa National Wildlife Refuge, Conejos River from Fox Creek to the Rio Grande (CO) are specific river reaches within the management units where recovery efforts should be focused. Substantial recovery value exists in these areas of currently or potentially suitable habitat. The SWFC requires habitat protection on private lands and enhancement on all lands.

The RGWCD has developed and is implementing the SLV Regional Habitat Conservation Plan for this species, in collaboration with the six counties of the SLV and Colorado Parks and Wildlife. As described at the website for the plan www.slvhcp.com:

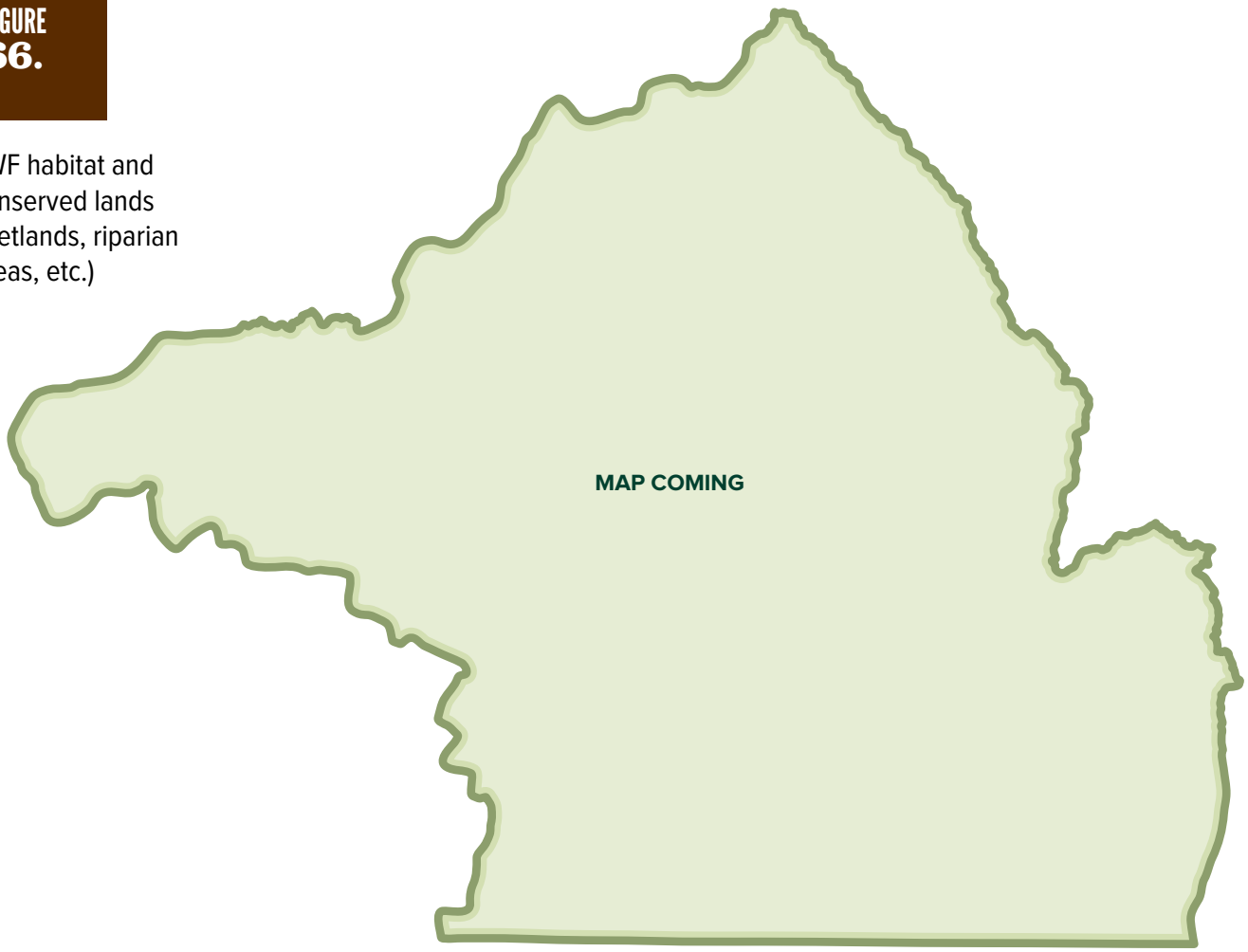
> "The SLV Regional HCP is a community-based effort to provide landowners and local units of government with a self-governing process for compliance with Endangered Species Act regulations through the voluntary conservation and enhancement of riparian habitat. The endangered southwestern willow flycatcher, as well as other federally-protected species, are found along rivers and streams in the Valley, creating the need for a proactive approach."

> "The HCP is designed to improve habitat for the flycatcher and other wildlife species while also giving landowners and communities the assurances to conduct routine agricultural and infrastructure activities without the threat of federal regulation. The activities to be covered, their impacts, and mitigation measures are documented in an HCP and an associated Incidental Take Permit issued by the U.S. Fish and Wildlife Service."

There is extensive Southwestern Willow Flycatcher habitat located on private land, as can be seen in Figure 66 below. The SLV HCP includes the voluntary protection of habitat on private lands through conservation easements as a core strategy, with additional voluntary agreements with the willing landowners who wish to participate. In addition to State and Federal lands that provide habitat, these conserved private lands provide a pool of habitat to protect the species and meet the requirements of the plan. Ensuring adequate water and protection on these riparian lands is a significant need for the Rio Grande Basin.

FIGURE 66.

SWF habitat and conserved lands (wetlands, riparian areas, etc.)



Yellow-billed Cuckoo

Characteristics: The cuckoo is a medium-sized bird about 12 inches (30 cm) in length, and weighs about 2 ounces (60 grams). The species has a slender, long-tailed profile, with a stout and slightly down-curved bill, which is blue-black with yellow on the basal half of the lower mandible (bill). The tail feathers are boldly patterned with black and white below. Adults have a narrow, yellow eye ring. Males and females differ slightly, as males tend to have a slightly larger bill (Hughes 1999).

In general, the cuckoo nests in a variety of habitats including open woodlands, parks, and riparian woodlands (AOU 1998). The western

subspecies of cuckoo has a more restricted habitat requirement than its eastern counterpart (Ehrlich et al. 1992). The western subspecies is restricted to cottonwood and willow woodlands with a dense understory and large blocks of riparian habitat (Carter 1998; Franzreb and Laymon 1993).

Status: In 1998, a petition was filed with the Forest Service to list the western subspecies of yellow-billed cuckoo as a threatened subspecies or a distinct population segment. In 2001, the Service noted that listing was warranted as a distinct vertebrate population segment west of the Continental Divide, but precluded the listing due to higher priority listing actions (66 FR 38611, July 25, 2001). As of the writing of the HCP, the yellow-billed cuckoo was not federally protected, but was considered a species of special concern by the State. Currently, the USFWS has proposed to list this species as threatened under the Endangered Species Act with a final rule expected on September 30, 2014.

The loss, degradation, and fragmentation of riparian habitat have been identified as the primary factors causing cuckoo declines in the western U.S. (Carter 1998; Service 2001). In Colorado, riparian habitats cover approximately 3% of the land area (Kittel et al. 1999), but estimates of riparian habitat loss are unavailable.

Cuckoos were only recently recorded in the SLV along the Rio Grande and Conejos River, but little is known about the specific habitat affinities or productivity of the few individuals observed in the SLV. Surveys to detect cuckoos on publicly owned lands in the Valley have been very limited. Cuckoos have only been documented in the Valley three times prior to 2004; one near Del Norte and two separate observations in 1980 near Monte Vista and the Great Sand Dunes. This species was observed along the Rio Grande near Del Norte in 2008 and 2011 (Ireland, pers. comm. 2010, 2011), and was observed consistently on the Conejos River with as many as four individual cuckoos detected in 2005 (Lucero and Cariveau 2004). Detections of cuckoos along the Conejos River occur in mature cottonwood forests with a tall, dense, willow understory with pools of standing stagnant water (Lucero and Cariveau 2004). Breeding (active nests) in the Valley has never been confirmed, but the behavior and frequency of sightings indicate the birds are nesting (Lucero and Cariveau 2004).

In order to protect this species and its habitat, the yellow-billed cuckoo is included in the SLV Regional Habitat Conservation Plan being implemented by the RGWCD for the Southwestern Willow Flycatcher. As of the writing of the SLV HCP, the population trends/estimates and distribution were unknown. Cuckoos are usually found at elevations less than 6,600 feet (2,011 meters) (Service 2001), although the entire Valley is above 7,000 feet and the cuckoos found near Del Norte are at about 7,900 feet. Additional habitat protection is needed on private lands along with enhancement of habitat on all identified lands.

Sage Thrasher

Characteristics: The sage thrasher is brown-gray above and buff below with conspicuous black streaks with two white wing bars (often worn away by spring) and a strongly curved bill . It typically inhabits dry sagebrush plains and arid areas such as the floors of rocky canyons and winters in dense thickets and lowland scrub. The sage thrasher is a good songster from a conspicuous perch or in flight. The flicking of its tail and its general appearance, except for the streaked underparts, recall a mockingbird, but its generally terrestrial habits, and particularly its habit of diving into a bush for cover when alarmed, are reminiscent of a thrasher. It feasts on fruits and vegetables in gardens of desert towns, but also eats many damaging insects in alfalfa fields near its sagebrush nesting area. The sage thrasher typically lays four or five brown-blotched, blue-green eggs in a stick nest lined with rootlets and grass, and often with fur or feathers, and placed in a bush, usually with thorns. http://birds.audubon.org/birds/sage-thrasher

Status: http://www.blm.gov/pgdata/etc/medialib/blm/wy/wildlife/animal-assessmnts.Par.91172.File.dat/SageThrasher.pdf The sage thrasher, a sage brush-steppe obligate that relies on large expanses of sagebrush-steppe for successful breeding, is recognized by Canada and several U.S. state agencies as a sensitive species. The sage thrasher is a Colorado State Species of Concern. The species is apparently at risk based on loss or alteration of breeding habitat and decreasing population trends. In this context, habitat alteration refers to modification of any component of the required habitat mosaic, (e.g., presence and quality of tall big sagebrush (Artemesiaspp.), adequate cover, and increased vertical and horizontal heterogeneity) that might directly decrease suitability for nesting habitat. Primary threats to Thrasher habitat are agricultural field cultivation, domestic grazing, invasion of exotic plant species, change in fire frequency, fragmentation from oil and gas development, and increased recreational use.

In the SLV, the sage thrasher utilizes chico or greasewood (Sarcobatus vermiculatus) shrubs in addition to sagebrush. The sage thrasher, along with the Brewer's sparrow, is an IWJV Priority Species that can be found throughout the SLV in healthy greasewood and sagebrush habitat.

To maintain populations of sage thrasher, it is important to protect and maintain extensive, intact shrub-steppe habitats and rehabilitate sagebrush habitats that have been lost, fragmented, or degraded. Loss of wet meadow habitat is of particular concern as it affects Sage Thrasher populations. In

addition, it is essential to understand the impacts of habitat alteration on local and range wide Sage Thrasher populations. http://www.fs.fed.us/r2/projects/scp/evalrationale/evaluations/birds/sagethrasher.pdf

Gunnison Sage Grouse:

Characteristics:

http://www.fws.gov/mountain-prairie/species/birds/gunnisonsagegrouse/

The Gunnison sage grouse (GUSG) is a species of sage grouse found south of the Colorado River in Colorado and Utah. They are about one-third smaller than the greater sage-grouse, and males have more distinct, white barring on their tail feathers, longer and more dense filoplumes on their necks. Female Gunnison and greater sage grouse have nearly the same plumage, but the female Gunnison is again about one-third smaller than the greater sage grouse. Male Gunnison sage grouse conduct an elaborate display when trying to attract females on breeding grounds, or leks in the spring. They will strut, flap their wings against their white pouches and utter a distinct series of sounds by vocalizing and popping two air sacs within their pouches. Nesting begins in mid-April and continues into July.

Historically, GUSG were found in the southwestern portion of Colorado, southeastern Utah, northeastern Arizona, and northwestern New Mexico. Approximately 5000 breeding GUSG occur among seven separate populations in SW Colorado and SE Utah. The population in the Rio Grande Basin is located at the north end of the SLV, at and near Poncha Pass in Saguache County and is centered about ten miles northwest of Villa Grove. The known population is distributed in the sagebrush habitat from the summit of Poncha Pass extending south for about eight miles on either side of U.S. Highway 285. The estimated range of the population is about 20,400 acres and varies in elevation from about 8,020 - 9,020 feet, with vegetation dominated by mountain big sagebrush, with some black sagebrush and oakbrush, especially in drainages. San Luis Creek runs through the area, and until recent drought conditions, it provided a year-round water source and lush, wet meadow riparian habitat.

The BLM manages 48% of the area, the USFS manages 26%, 24% is in private holdings, and 2% is managed by the Colorado State Land Board. Land uses across most of the area include domestic livestock grazing, wildlife, recreation, and watershed values. Gunnison Sage Grouse Rangewide Conservation Plan 2005 (available at https://wildlife.utah.gov/uplandgame/sage-grouse/pdf/gunnison_management_plan_2005.pdf).

Status: The GUSG is currently "Proposed for Listing" as Threatened or Endangered and critical habitat has been delineated by the USFWS, with a final rule expected on November 12, 2014. GUSG conservation strategies have been implemented throughout the range of the species since 1995, when the first Gunnison Sage Grouse Working Group was formed in the Gunnison Basin. The GUSG Rangewide Conservation Plan is a working document that was developed in 2005 as a collaborative effort between the Colorado Division of Wildlife, BLM, US Bureau of Land USFS, NRCS, National Park Service, USFWS North American Mediation Services and the Utah Division of Wildlife Resources.

In 2013, a 12-County Memorandum of Understanding was signed by the counties (including Saguache County) that have sub-populations of GUSG, to support on-going conservation efforts and state/local control of long-term GUSG conservation and management. Public land Candidate Conservation Agreements (CCA's) and private land Candidate Conservation Agreement with Assurances (CCAA's) have been implemented in sensitive GUSG habitat areas across the range of GUSG, but not in the Poncha Pass population to date.

GUSG habitat in the Rio Grande Basin faces continued pressure from habitat fragmentation that can be caused by residential development, expansion of roads and power facilities, and poorly timed or excessive livestock grazing. Gunnison Sage Grouse and livestock grazing are not incompatible as long as the grazing is conducted in an ecologically responsible manner. The prolonged drought across the western United States is further depressing reproductive output and at Poncha Pass may be a critical variable in the ability of GUSG to thrive.

Additional information, including about the Poncha Pass Population is available in the GUSG Rangewide Conservation Plan 2005. For the complete plan,

The Poncha Pass Gunnison Sage-grouse Working Group was formed in 1998 and is a local, multi-interest group of landowners, citizens, NGOs and agencies working toward conservation of Gunnison sage grouse at Poncha Pass. The Poncha Pass Conservation Plan (PPCP 2000) was finalized on March 21, 2000 and the complete plan is available at http://grazingforgrouse.com/sites/default/files/2000%20Poncha%20Pass%20Plan-Gunnison.pdf.

The PPCP (2000) does not outline any specific habitat goals or objectives but it lists three general conservation objectives:

to discover (through field research and monitoring) issues that positively or negatively affect the well-being of sage-grouse and incorporate this information into management actions to their benefit;

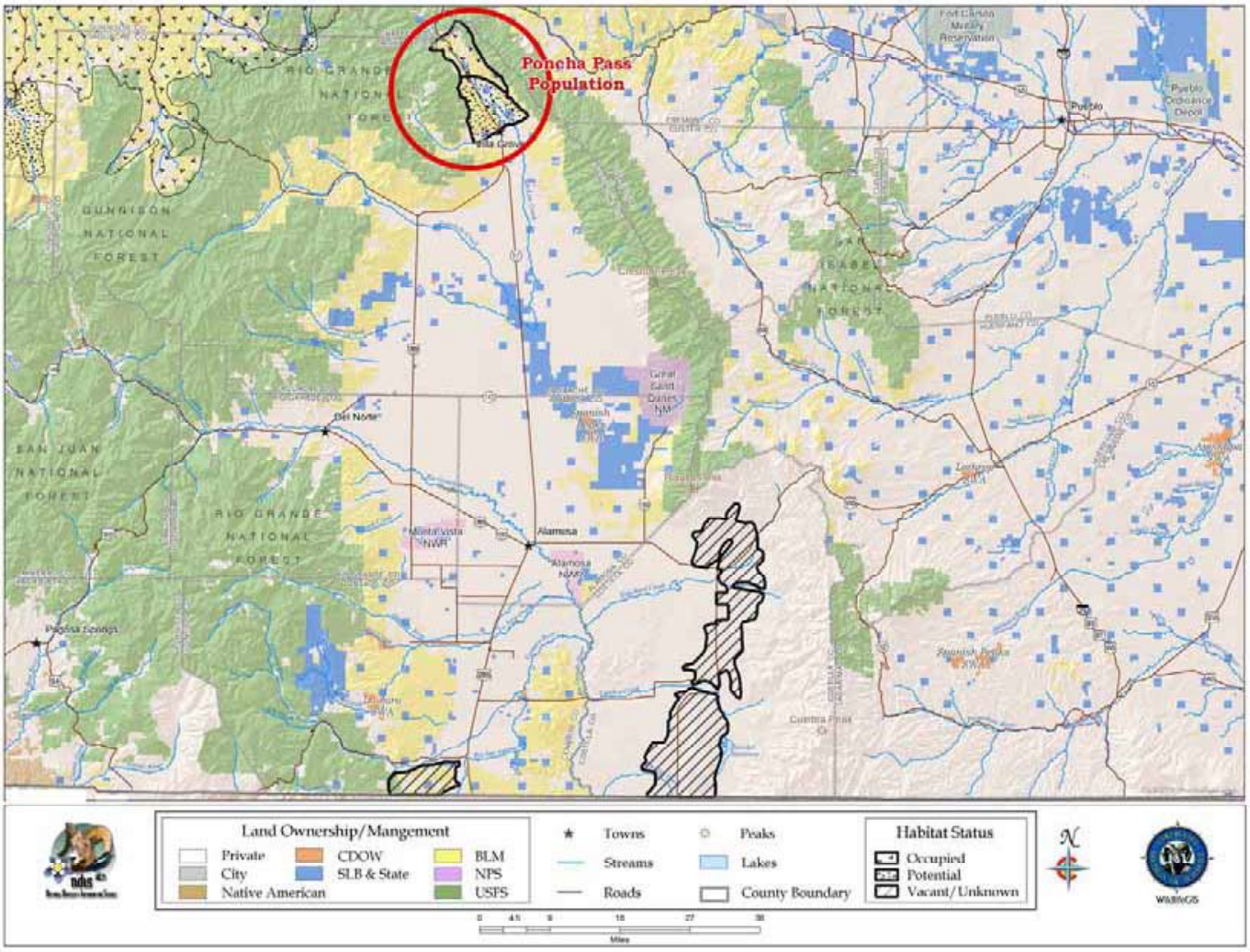
to protect and improve sage-grouse habitat, as appropriate by reduction, prevention and/or mitigation of habitat fragmentation; and

to identify and manage physical disturbances to reduce adverse effects to GUSG (PPCP 2000:8).

Recommended conservation actions in the PPCP (2000) are divided into the following categories: inventory and mapping, research, monitoring, habitat quality, information/education/coordination, permanent habitat loss, and physical disturbance.

The NRCS has worked with two landowners and livestock producers at Poncha Pass under their Sage-grouse Initiative (http://www.sagegrouseinitiative.com), investing over $100,000 to date in habitat improvements and grazing management to benefit GUSG. Currently a riparian restoration project in the Lone Tree drainage at Poncha Pass is in planning stages with the BLM and CPW and there is a high degree

FIGURE 67. Gunnison Sage Grouse Population in Rio Grande Basin.



of interest for riparian treatments throughout the area on public and private property. There is also the need for continued collection of grouse distribution and habitat use data to focus habitat restoration efforts.

A 640-acre easement that includes sagebrush habitat was finalized in the spring of 2014 and is the first conservation easement on private land in the Poncha Pass area, shown in Figure 67. Several other landowners with property in wet meadow habitat along San Luis Creek and in sagebrush habitat along the Lone Tree drainage are currently exploring land protection through voluntary conservation easements.

Greater Sandhill Crane

Characteristics: Greater sandhill cranes are an IWJV priority species and are widely distributed throughout North America. The Rocky Mountain Population (RMP) of cranes is a sub-population that occurs throughout the IWJV, migrating through the SLV during the spring and fall migrations. New Mexico supports a majority of the wintering population of RMP. Estimates of the population average just over 20,000 birds (IWJV 2013 Implementation Plan).

These cranes are large wading birds with long necks and legs with a red patches on their head and a wing-span of six to seven feet. Adults are predominantly gray while juveniles may be more brown in color. Cranes travel in family groups of between five and seven individuals and have a mean life expectancy of seven years. Courtship dances often occur during spring migration among sub-adults that have not yet formed pairs. Cranes form monogamous breeding pairs that nest in primarily Wyoming, Montana, and portions of Idaho, Utah, and Colorado in wetlands. Cranes build their nests of vegetation from the surrounding area into mounds with a moat around them. Both the male and female incubate an average of two eggs for 29 to 32 days, from early April to late May. The chicks are precocial and leave the nest soon after hatching. They remain with parents for up to nine or ten months.

Habitat requirements for cranes vary by season and location. Roosting areas consist of shallow wetlands near foraging areas. Cranes are omnivores and may opportunistically forage on a variety of food sources

including invertebrates, corms, roots, seeds, tubers, berries, amphibians, reptiles, small mammals, and cultivated grains.

Status: The greater sandhill crane is an important indicator species in regards to the wetland habitat health in the SLV and as an attraction for tourists and birders, with an annual Crane Festival held in Monte Vista that attracts birders from across Colorado and beyond. It is vital that the water needs of the greater sandhill crane are met for future populations to thrive.

Currently the IWJV is launching a large scale project related to the Greater Sandhill Crane Wetland Conservation Initiative that seeks to "catalog relevant scientific knowledge associated with greater sandhill cranes and to document steps needed to overcome key information gaps which will lead to developing range-wide habitat conservation objectives" (Donnelly and Vest, 2014- see http://iwjv.org/sites/default/files/iwjv_3_science_wetlands_2013-2018.pdf). Information gleaned through this process will be used to develop a comprehensive habitat conservation plan that will guide conservation projects that address limiting factors regionally and continentally. Results from this project should help direct conservation in the efforts in the SLV for this species.

As described in the preface for the plan: "This plan is a continuation of 2012 science planning, characterizing the scope and context of the Intermountain West Joint Venture's (IWJV) science investments. The information presented here is the first in a series of documents outlining the implementation of the Greater Sandhill Crane Wetland Conservation Initiative as identified in, Identifying Science Priorities 2013–2018: Wetland Focal Strategies and approved by the Intermountain West Joint Venture (IWJV) Management Board (Fall 2012). This initiative is intended to serve as an important catalyst and compliment to partner efforts in filling critical broad-scale information needs for wetland birds throughout the Intermountain West.

"Specifically, the intent of this plan is to catalog relevant scientific knowledge associated with greater sandhill cranes and to document steps needed to overcome key information gaps which will lead to developing range-wide habitat conservation objectives. This approach will, across all annual cycle events and relevant geographies: 1) define potential habitat extent, 2) characterize associated ecological drivers, catalog land-use practices, and landownership patterns, 3) measure and summarize the magnitude and distribution of near-term (e.g., 30 year) landscape change, and 4) identify potential landscape stressors by linking ecological and anthropogenic trends to changes in sandhill crane distribution and abundance. This information will be used by the IWJV Sandhill Crane Working Group and IWJV Staff to develop a comprehensive range-wide habitat conservation plan. The plan will include spatially explicit habitat conservation objectives, decision support tools, and a framework to monitor and evaluate conservation actions.

"This strategic approach is expected to facilitate local conservation investments which address primary habitat limiting factors and affect regional and continental population goals for greater sandhill cranes. Additionally, this initiative will provide a crucial foundation of information regarding wetland processes, conditions, and trends across a large portion of the Intermountain West. The Information and conservation outcomes developed through this initiative are anticipated to have far- reaching ancillary benefits for other wetland associated species and support the long-term viability of wetlands and associated working lands throughout the region."

White-faced ibis

Characteristics: http://www.allaboutbirds.org/guide/white-faced_ibis/id

Species Description: The white-faced ibis is a wading bird and colonial nester that has a down-curved bill, red eye, dark body that appears iridescent, and a pale whitish ring around the base of its bill. The ibis are late spring migrants that breed in the SLV and fly south in late August.

Nesting: The ibis form monogamous pairs for one season with the male arriving first on the breeding grounds to defend the territory until the female arrives and courtship begins. Nests are large pile/platforms of plant material near or over water in colonies; males brings materials to the female to build the nest and both parents incubate the eggs. Approximately 2 to 4 pale blue eggs are laid taking 21 to 22 days to hatch. The young are semi-altricial and may leave the nest in 10–12 days but first flight may not occur up to 49 days after hatching.

Status: The white-faced ibis is a NAWCA and IWJV priority species. Ibis colonies declined throughout the 1960s and 1970s potentially due to DDT in Mexico while wintering there. Populations have rebounded since then in other IWJV states (IWJV 2013 Implementation Plan).

Location: The ibis nest in tall emergent vegetation surrounded by open water in colonies from Oregon to New Mexico and east to Louisiana. Large colonies occur at the Russell Lakes State Wildlife Area, and the Alamosa and Monte Vista National Wildlife Refuges with other smaller colonies located on other public wetland complexes making the SLV the most significant breeding area in Colorado (Natural Diversity Information Source, CPW website). Wintering occurs in the southern United States to Mexico. Habitats include freshwater marshes including tall emergent

and open water areas, short emergent and seasonal wetlands, and wet meadows.

Western Snowy Plover

Characteristics: The snowy plover (Charadrius alexandrinus nivosus) is a small shorebird distinguished from other plovers (family Charadriidae) by its small size, pale brown upper parts, dark patches on either side of the upper breast, and dark gray to blackish legs. Snowy plovers weigh between 1.2 and 2 ounces. They are about 5.9 to 6.6 inches long.

Snowy Plovers breed along the West and Gulf coasts, throughout much of Nevada, southern Washington, northern Utah, southeastern Kansas, the Oklahoma and Texas panhandles, and southeastern New Mexico. Within the Central Shortgrass Prairie in Colorado, they breed on the shores of reservoirs near the Arkansas River between La Junta and Lamar and at the Blanca Wildlife Habitat Area in the SLV. Snowy Plovers nest on sandy beaches or alkaline flats with little or no vegetation; nests are located within 150 m (500 ft) of water.

Snowy Plovers arrive in Colorado in mid-April. They initiate nests as early as mid-April and as late as early July; the later dates are probably renesting attempts after failed nests rather than second clutches after successful nests. Most birds have left the state by the end of September. The diet consists of terrestrial and aquatic invertebrates.

Status: The Western Snowy plover was selected as a focal breeding species by the IWJV because the Intermountain West is considered 'critical to supporting hemispheric populations' of Snowy Plover (AI = 5, USSCP). This species also was selected because relatively current breeding densities per site are available from the results of a comprehensive, range-wide survey of breeding plovers conducted in 2007. Large saline lakes, ephemeral wetlands/playas, and man-made impoundments with a relatively consistent source of water and little to no vegetative cover are important habitat components. Changes in water management practices, drought or flooding, and vegetative encroachment may limit habitat availability.

Bald Eagle

Characteristics: The bald eagle dwarfs most other raptors, including the turkey vulture and red-tailed hawk. It has a heavy body, large head, and long, hooked bill. In flight, a Bald Eagle holds its broad wings flat like

a board. Adult bald eagles have white heads and tails with dark brown bodies and wings. Their legs and bills are bright yellow. Immature birds have mostly dark heads and tails; their brown wings and bodies are mottled with white in varying amounts. Young birds attain adult plumage in about five years. Bald eagles soar high in the sky, flapping low over treetops with slow wingbeats, or perched in trees or on the ground. Bald Eagles scavenge many meals by harassing other birds or by eating carrion or garbage. They eat mainly fish, but also hunt mammals, gulls, and waterfowl.

http://www.allaboutbirds.org/guide/bald_eagle/lifehistory

Status:

The Bald Eagle's recovery is a spectacular conservation success story. Partners in Flight estimates the global breeding population at 250,000, with 88% spending some part of the year in the U.S., 31% in Canada, and 8% in Mexico. They rate a nine out of 20 on the Continental Concern Score and are not on the 2012 Watch List, but are a U.S.-Canada Stewardship Species. Once abundant in North America, the species became rare in the mid-to-late 1900s — the victim of trapping, shooting, and poisoning as well as pesticide-caused reproductive failures. In 1978 the bird was listed for protection under the Endangered Species Act. By the late 1990s, breeding populations of Bald Eagles could be found throughout most of North America. In June 2007, the bird's recovery prompted its removal from the Endangered Species list.

Continuing threats to Bald Eagle populations include lead poisoning from ammunition in hunter-shot prey, collisions with motor vehicles and stationary structures, development-related destruction of shoreline nesting, perching, roosting and foraging habitats, and environmental pollution.

Fish Species At Risk

Rio Grande Cutthroat Trout

Characteristics: As is true of other subspecies of cutthroat trout, Rio Grande cutthroat trout are primarily found in clear cold streams but occasionally occur in lacustrine (lake or reservoir) habitats. They spawn as high water flows from snowmelt recede. Rio Grande cutthroat trout (RGCT) are one of three recognized subspecies of native trout in Colorado. Their range is confined to the headwaters and tributaries of the Rio Grande surrounding the SLV.

Status:

The RGCT has been a candidate for listing under the federal Endangered Species Act since 2008. In 2003 and then updated in 2013, federal and state agencies in Colorado and New Mexico, as well as Trout Unlimited in both states, developed an in depth Conservation Agreement for Rio Grande Cutthroat Trout." (See the full document at: http://cpw.state.co.us/Documents/Research/Aquatic/CutthroatTrout/2013RGCTConservationAgreement.pdf).

Rio Grande cutthroat trout, are the third recognized subspecies of native trout in Colorado. Their range is confined to the headwaters and tributaries of the Rio Grande surrounding the San Luis Valley. The trout has been a candidate for listing under the federal Endangered Species Act since 2008. In the meantime, in an effort to provide additional political and public support for the RGCT Conservation Team and Strategy, the "RGCT County Commissioners Coalition" has formed and the counties have all entered into a Memorandum of Understanding (MOU) in this regard. The counties of Hinsdale, Mineral, Rio Grande, Conejos, Alamosa, Costilla, Saguache, Las Animas, San Juan and Archuleta have all come together in this important MOU in the interest of the long-term conservation of the RGCT and support of the Conservation Team, Conservation Strategy and Conservation Agreement for RGCT. The Rio Grande cutthroat is classified as a "species of special concern" in Colorado and, at the time of this writing, is undergoing a "species status review" by the USFWS with a decision for a "Proposed Listing" under the ESA due in July 2014. A final decision by the U.S. Fish and Wildlife Service on whether the species will be listed as threatened or endangered is scheduled for September 2014. The agencies are working cooperatively to protect the populations to keep the species healthy and viable long-term with a goal of a decision by the USFWS as "not warranted" for listing and maintaining state and local control and involvement in the long-term conservation of RGCT.

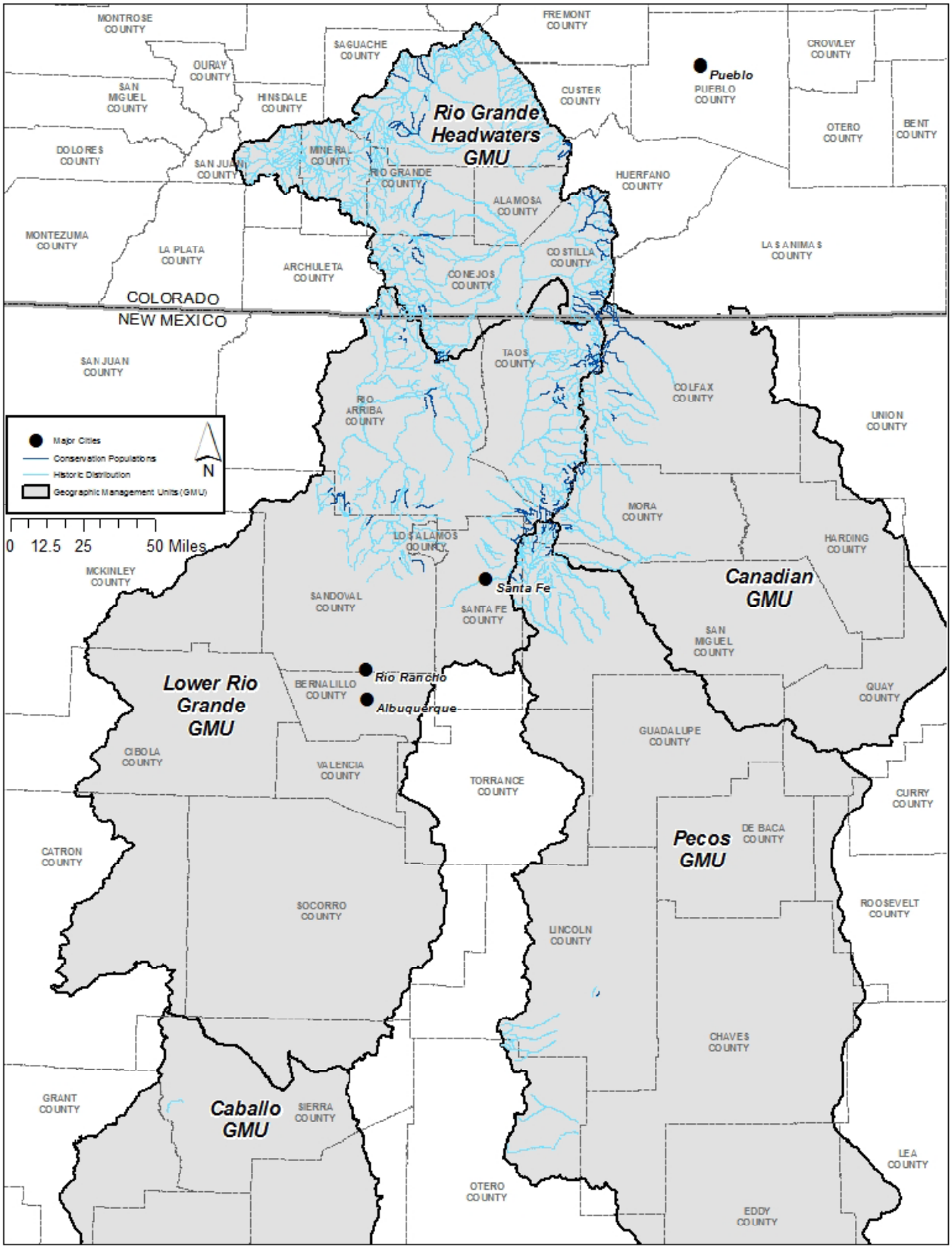
The fish is found primarily in high elevation streams and lakes of the Rio Grande. It now occupies just 12% of its historical habitat in approximately 800 miles of streams. Biologists estimate that 127 conservation populations now exist in the two states, and 57 of those populations are considered to be secure.

A number of strategies to protect and enhance the species have been implemented over the past decade. In 2014, in an effort to provide additional political and public support for the ongoing RGCT Conservation Team and Strategy, a "RGCT County Commissioners Coalition" has formed. Hinsdale, Mineral, Rio Grande, Conejos, Alamosa, Costilla, Saguache, Las Animas, San Juan and Archuleta counties have all have all entered into a Memorandum of Understanding (MOU) in in the interest of the long-term conservation of the RGCT and support of the Conservation Team, Conservation Strategy and Conservation Agreement for RGCT.

FIGURE 68.

Map of Historic Range of RGCT in Colorado and New Mexico

Source: Colorado Parks and Wildlife. Map courtesy of New Mexico Department of Game and Fish and US Fish and Wildlife Service



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Found primarily in high elevation streams and lakes of the Rio Grande in Colorado and New Mexico, the RGCT now occupies just 12% of its historical habitat in approximately 800 miles of streams. Biologists estimate that 127 conservation populations now exist in the two states, and 57 of those populations are considered to be secure.

The historical range (see map above) Figure 68 of RGCT has been reduced over the last 150 years due to many changes on the landscape, including: drought, water infrastructure, habitat changes, hydraulic changes, hybridization with rainbow trout and other species of cutthroat trout, and competition with brown trout and brook trout. As a result of these changes, RGCT populations are restricted primarily to headwater streams, which are above the habitat range of competing species or are protected and separated by a natural barrier such as a dam or water fall.

"RGCT are facing many issues, including habitat loss, competition from the introduction of non-native trout, drought, fire and other changes. A major, coordinated effort like this one is what is required to maintain this important species" (John Alves, Senior Aquatic Biologist for CPW, SW Region).

As indicated, additional protected stream miles could be beneficial to the RGCT, which could be achieved on private lands through voluntary conservation easements with willing landowners. Habitat improvement projects are also a priority on public lands, especially in stream reaches impacted by wildfires.

Rio Grande Chub

Characteristics: The Rio Grande chub is commonly found in pools of small to moderate-sized perennial streams at higher elevations, where substrate particles are sand, gravel, or cobble (Koster 1957, Bestgen and Platania 1990, Sublette et al. 1990, Platania 1991, Bestgen and Platania 1991, Calamusso 1993, Swift -Miller et al. 1999). They are usually associated

with undercut banks, overhanging vegetation or brush, aquatic plants, and deep water in stream reaches cool enough to support trout (Platania 1991, Rinne 1988, Rinne 1995, SwiftMiller et al. 1999). A common inhabitant of cool or cold lakes and ponds, particularly in the SLV, Colorado, Rio Grande chub survived in Kerr Lake at an elevation of 3,468 m (11,377 ft.) in southern Colorado (reported in Zuckerman 1984). Rio Grande chub is a mid-water carnivore that includes zooplankton, aquatic and terrestrial insects, crustaceans, juvenile fish, as well as a limited amount of detritus in its diet (Sublette et al. 1990).

Rio Grande chub exhibit orange-red coloration along the mouth, lower fins, and the lower sides of the head and body during the reproductive season (Koster 1957). Rio Grande chubs reproduce mostly in spring and early summer, but autumn spawning has been documented in Hot Creek, Colorado, in the Native Species Recovery Facility, Alamosa, Colorado (1. Alves , pers. obs.), and was likely in one year in the Rio de las Vacas, NM, suggesting that autumn spawning may occasionally occur when environmental conditions are suitable (Rinne 1995). Spawning occurs in riffles and embryos develop without parental care (Koster 195 7). Hybridization with longnose dace has been documented (Cross and Minckley 1960, Suttkus and Cashner 1981). One hybrid specimen was collected in 1968 in the Rio Grande north of Monte Vista (Suttkus and Cashner 1981). Hybridization may have been associated with fish crowding in limited habitat which was enhanced by drought and irrigation diversions (Cross and Minckley 1960, Suttkus and Cashner 1981).

Contact CPW for information on and a copy of the 2005 report prepared for the U.S. Forest Service, Region 6: Rio Grande Chub (*Gila Pandora*): A Technical Conservation Assessment by David E. Rees, Ryan J. Carr, and William J. Miller. (Reese et. al, 2005) http://www.fs.fed.us/r2/projects/scp/assessments/riograndechub.pdf

Status: The Rio Grande chub were once the most common fish in the Rio Grande Basin and San Luis Closed Basin, existing at high levels that were harvested as a food source by pre-Columbian residents of the SLV (Zuckerman and Langlois 1990). Although there are currently small populations in many parts of its historical range in US Forest Service Region 2 (Rocky Mountain Region), the overall numbers of Rio Grande chub are reduced by as much as 75% (Bestgen et al. 2003). Probable factors contributing to the decline of Rio Grande chub include competition with and predation by non-native brown trout and brook trout habitat fragmentation due to impoundments, destruction of habitat due to improper cattle grazing and other land use practices (e.g., road building, timber harvesting, mining) (Bestgen et al. 2003). Sedimentation of stream habitats is a documented factor affecting abundance/distribution.

Rio Grande Sucker

Characteristics:

The Rio Grande sucker is a stout fish with a large head, broud snout and overhanging mouth. Adults are dusky to dark or greenish brown dorsally, fading to yellow or white on the belly. The sides may be mottled. A small species, the few know Colorado specimens are normally 2.5 to 3.5 inches in length.

This species is found in areas near rapidly flowing water. Backwaters or banks adjacent to fast waters provide holding areas during the day. These suckers move to swifter water at night (Minckley 1973). The Rio Grande sucker feeds on diatoms, detritus and aquatic invertebrates. The species is an early spring spawner, February through April, but may go through a second reproductive cycle later in the summer (Koster 1957).

http://ndis.nrel.colostate.edu/wildlifespx.asp?SpCode=010579

Status:

https://fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5295266.pdf Endemic to the Rio Grande Basin in Colorado, the Rio Grande Sucker has only one historical population remaining in the Rio Grande National Forest. Several transplants have occurred in the last three years. The Rio Grande Sucker is listed as state endangered by Colorado Wildlife Commission Regulation (Article II-1002-A-1), and the Colorado Natural Heritage ranks the sucker as "critically imperiled" (S1). The Rio Grande Sucker is currently on the USFWS list along with 250 other "candidate species" to be reviewed by the Service as to the need for protection under the Endangered Species Act (ESA.) The Rio Grande sucker was historically very abundant throughout its range. In the Rio Grande Basin in Colorado, the species was "very abundant everywhere" (Jordan, 1891). The McIntire Springs population (second to the last population in Colorado) declined from an abundant, stable population to extirpated in less than 10 years.

http://www.nps.gov/grsa/naturescience/fish.htm

An additional population exists in Hot Creek, including habitat on the Hot Creek State Wildlife Area. However, that population may also be declining. A subsequent population was located on Crestone Creek in 2004, on the Baca National Wildlife Refuge. See: http://crestoneeagle.com/archives2006/headlineA2.feb06.html

The Rio Grande Sucker has declined rapidly, now occupying only a fraction of its historical range (one historical population remains). Habitat conditions are threatened by stream dewatering, spring development, habitat degradation from stream bank erosion caused by grazing and other factors as well as roads, etc. still occurring in places. Lower elevation habitats on private lands are also impacted and declining in many places. Some improvements in habitat are occurring on public land as a result of improved management practices and restricted use as compared to historic use levels. Habitat is very vulnerable to modification from management activities including public land use, recreation, grazing, road construction, dewatering, logging, etc. It is listed as a State Endangered Species (http://cpw.state.co.us/learn/Pages/SOC-ThreatenedEndangeredList.aspx). See also: http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=353

Contact CPW additional information and a copy of the 1994 Rio Grande Sucker Recovery Plan prepared for the Colorado Department of Natural Resources, by David Langlois, John Alves and Jerry Apker.

Amphibian Species at Risk

http://www.fws.gov/mountain-prairie/species/amphibians/borealtoad/QuestionsAndAnswers04112012.pdf Amphibians are sensitive to changes in their environments, and can serve as an ecological indicator of contamination or other environmental changes that can affect humans. Their presence can be an indication of a healthy ecosystem. Amphibians also are a key part of the food chain, both as prey and as predators. Boreal toads are insect eaters, so they can assist in the control of insect pests, such as mosquitos. Additionally, amphibians are preyed upon by several species of mammals, birds, fish, and reptiles.

Boreal Toad

Characteristics:

http://www.fws.gov/mountain-prairie/species/amphibians/borealtoad/ In the southern Rocky Mountain population of the boreal toad, female boreal toads may reach a length 4.3 inches, while males seldom exceed 3.7 inches. Both sexes have warty skin and oval parotoid glands. Although more prominent in females, both sexes often have a distinctive light mid-dorsal stripe. Unlike other species in the same genus, the male boreal toad has no vocal sac and, therefore, has no mating call. In the southern Rocky Mountains adult boreal toads emerge from hibernacula when snowmelt has cleared an opening from their burrow and daily temperatures remain above freezing. Breeding may begin in the lower altitudes in May and

in the higher altitudes in July or early August. Females may skip 1 to 3 years between breeding attempts, depending on their physical condition. Females deposit up to 16,500 eggs in 2 strings, which are ordinarily laid in shallow 6 inches water. Egg and tadpole development is temperature dependent; in high, cold locations, development from hatching to metamorphosis can take 75 days.

The southern Rocky Mountain population occurs from south-central Wyoming southward through the mountainous regions of Colorado to extreme north-central New Mexico. The toads inhabit a variety of wet habitats (i.e., marshes, wet meadows, streams, beaver ponds, glacial kettle ponds, and lakes interspersed in subalpine forest) at altitudes primarily between 8,000–11,500 feet.

Status: On May 25, 2011, the Service received a petition from the Center for Biological Diversity, Center for Native Ecosystems, and Biodiversity Conservation Alliance, requesting the agency list either the Eastern population or Southern Rocky Mountain population of the boreal toad as a threatened or endangered distinct population segment (DPS) under the Endangered Species Act (Act). A 90-day petition finding for the Eastern population and Southern Rocky Mountain population of the boreal toad has been completed by the Service. The USFWS has determined that there is substantial information in the petition and in data files that the Eastern population of the boreal toad may qualify as a DPS (Distinct Population Segment) and that listing under the Act may be warranted. Additionally, it has been determined that the petition and data files did not contain substantial information that the Southern Rocky Mountain population of the boreal constitutes a DPS. However, the Southern Rocky Mountain population, which includes New Mexico, Colorado, and southeastern Wyoming, is part of the larger Eastern population. The Eastern population of this amphibian occurs in portions of Colorado, Idaho, New Mexico, Nevada, Utah, and Wyoming.

Northern Leopard Frog

Characteristics: Northern leopard frogs are green or brown frogs, about 3 to 4 inches long with two to three irregular rows of dark spots running vertically along their back, which is characterized by two conspicuous skin folds bordering the rows of spots.

This frog is common in North America, inhabiting twenty-six states and much of Canada. The leopard frog occurs throughout Colorado, excluding most of the southeastern and east-central portions of the state from 3,500

to 11,000 ft. in elevation (Natural Diversity Information Source, CPW website- dis.nrel.colostate.edu/wildlifespx.asp?SpCode=020191 and http://ndis.nrel.colostate.edu/herpatlas/coherpatlas/cdow_herpetofaunal_atlas_species_frogs_ranapiiens.htm).

Leopard frogs hibernate in the mud, gravel, sand or similar substrate under a body of water such as a pond or stream. Depth of water covering a hibernating frog is generally 33 inches or greater. However, active frogs have been found throughout the winter in pools formed by warm artesian wells in the SLV (Hammerson. 1999).

During the winter, northern leopard frogs hibernate at the bottom of bodies of water emerging March-April and remain active until October-November. The male uses mating calls to attract females and establish territories. Copulation generally occurs between March and June. Egg laying sites generally need mats of algae, or dense underwater vegetation to attach the eggs and shelter from predators. The females release eggs while swimming and the male, who attaches himself to the female with specialized thumbs, fertilizes the eggs. The egg masses are attached to vegetation just below the water surface in relatively warm shallows typically 3–10 inches deep. Each female lays a dark egg mass up to 3,000 eggs, which hatch 10–20 days after fertilization. Larvae (tadpoles) emerge and metamorphose into frogs throughout summer and fall. Occasionally, larvae will hibernate and finish metamorphosis the following spring. Leopard frogs have been documented moving as far as 1.8 miles within a year (Hammond. 1999). They tend to travel from water during mild wet weather or in search of suitable water sources. Foraging adults feed largely on invertebrates, snails, and smaller vertebrates such as chorus frogs. The diets of larvae differ from those of adult, with the young consuming algae and microscopic animals.

Status: State Special Concern

Rare Plant Species

Slender Spiderflower

Characteristics: The slender spiderflower is an annual herb that occurs in saline and alkaline soils, commonly associated with wet meadow species such as inland saltgrass. The largest population of this plant occurs in the SLV of Colorado but it may also be found in Wyoming, Arizona, New Mexico, and Texas from 1098 to 2666 meters in elevation.

The spiderflower may be found in wetlands that are shallowly flooded early in the spring but are commonly saturated and not flooded throughout most of the growing season. Typical wetland locations throughout the SLV include meadows, shorelines of ponds and playas, and old lake beds. The plant also occurs in transition areas from shorelines or wet meadows into greasewood areas. The Baca and Monte Vista National Wildlife Refuges, Blanca Wetland Management Area, and the Russell Lakes State Wildlife Area represent several public wetland complexes where this species exists in the SLV. Cover and density of this community may shift annually due to climate and wetland management regimes. The plant usually flowers in July and August with fruits remaining viable in the soil for years.

Available habitat has decreased over time as a result of development in wetland areas that shifts hydrologic regimes causing the conversion of vegetation communities or has been altered for agricultural production or expansion of municipalities.

Status: This species has been classified by the Colorado Natural Heritage Program (CNHP) as globally imperiled and is listed as state imperiled in Colorado.

Mammal Species at Risk

Canada Lynx

Characteristics:
Although commonly called the Canada lynx, this 20 to 30 pound cat with a bobbed tail and tufted ears occurred historically throughout the northern reaches of North America as well as northern Eurasia. The lynx resembles the bobcat, though the lynx is generally larger, with gray rather than the more typically reddish fur of the bobcat. Its large, furry feet adapt it to walking or running on snow. In Canada its primary prey is the snowshoe hare, a species that follows regular 10-year cycles of alternating low and high populations.

When hare numbers are up, Canada lynx populations tend to increase, and when hares die off, cat numbers dwindle too. In Colorado, the lynx prey base includes other types of rabbits as well as squirrels and other rodents. Biologists suspect that this diversity in the cat's diet may make Colorado populations more stable than those in Canada.

Status:

Colorado listed the lynx as endangered in 1973, and it was federally listed in 2000 as threatened in 14 states, including Colorado. However, when the U.S. Fish and Wildlife Service designated critical habitat for the lynx in 2006, habitat in Colorado was not included. In 1997, the Colorado Division of Wildlife undertook what was to become one of North America's most high-profile carnivore reintroductions to date. The goal of DOW's lynx reintroduction program was to establish a self-sustaining lynx population within Colorado, where biologists felt quality lynx habitat still existed. The SLV is the core conservation area for Canada lynx, and water is necessary to maintain the forest and watershed health for lynx habitat. The Rio Grande National Forest Plan is under revision, and additional needs of the lynx habitat will be further discussed in that document including water resources issues.

River otter

Characteristics:

River otters are semi-aquatic members of the weasel family. They have long, torpedo-shaped bodies with short legs, a short snout and small, round ears. They have light to dark brown fur that can appear almost black when wet, and a silver-brown underbelly. Otters weigh between 15 and 25 lbs. They are about 3 to 4 1/2 feet in length from their nose to the tip of their long furry, cylindrical tail. Their thick, muscular tail tapers toward the tip, and comprises about one-third of their length, at 12" to 17".

Several Colorado mammals, including mink, beaver and muskrats, share the same habitat as river otters and are commonly confused with otters. All have dark brown fur and can be particularly difficult to distinguish from each other when they are swimming on the surface, partially submerged, especially when viewed from a distance. When viewed on land, however, their body shape, weight, size and tails are all quite distinctive.

Otters are carnivores that live in riparian habitats, where aquatic animals like fish, crayfish, frogs, young muskrats and beavers are favored foods. They are active mostly at dawn and dusk, and appear to spend large amounts of time just playing sliding on ice, snow and mud, and swimming gracefully for no apparent reason beyond swimming. Webbed toes and water-resistant fur suit the animal to a life spent largely in water. Otters sometimes paddle, but the force for swimming comes mostly from eel-like movements of the body and tail. They usually live in bank dens abandoned by beavers. Otters breed in the spring, however, embryo implantation is delayed until the following winter. One to four young are born in early spring. While the female is nursing one litter, mating occurs again.

Status: State Threatened

River otters were quite common in the 1800s, and probably occurred in major streams statewide in Colorado, although they apparently have never been abundant. With settlement, subsequent water pollution and control of streamflows, otters disappeared from the state by the early part of the 1900s century. In the 1970s, however, the Colorado Parks and Wildlife began to release otters and restore populations to several drainages, including the Upper Colorado, the Dolores, Piedra and the upper South Platte rivers. According to Area Wildlife Manager Rick Basagoitia, otters have been seen recently along the Rio Grande: "We do have otters on the valley floor and all along the river up to and likely above Creede. We are in a unique location in that otters were released years ago in the Piedra drainage on the Durango side, as well as in New Mexico just a few years ago. We are seeing otters here that likely came from one or both of those and they seem to be staying and making a living here."

The river otter's status in Colorado was recently changed from endangered to threatened. To learn more, see: http://cpw.state.co.us/learn/Pages/SpeciesProfiles.aspx?species=otter In order to learn more about the locations of river otters, the public is requested to report sightings to CPW, via a form available at their website at http://cpw.state.co.us/learn/Pages/RiverOtterObservationForm.aspx

Environmental Habitat Needs

Changes in Wetland and Riparian Health

The conditions of San Luis Valley wetlands and riparian areas are closely tied to the consumptive uses of water in the Basin. So while some of the following information may be repetitive from other sections of this Plan, it is included here to specifically address the effects of human alterations to the hydrology on these aspects of the overall system.

HISTORY OF WETLANDS AND RIPARIAN ALTERATIONS IN THE SAN LUIS VALLEY

The first European explorers to visit the SLV found extensive "marsh lands" across the center of the valley floor. Historic maps and aerial photos illustrate some of the early conditions and changes that have occurred in the Basin. (See http://www.blm.gov/pgdata/etc/medialib/blm/co/field_offices/slvplc/blanca_wetlands.Par.10962.File.dat/Historic%20Photos%20of%20the%20Blanca%20Wetlands%20ACEC%20and%20the%20Closed%20Basin%20Playa%20Systems.pdf)

Since the expansion of settlers into the Intermountain West, riverine ecosystems have been the most impacted resulting from concentrated

activities in and around these systems for water, transportation, crop production, livestock grazing, housing developments, hydropower, and recreation (Ehrhart and Hansen 2004). Inventories of wetlands and riparian areas in the 1780s indicated that only 7.9% of the 82 million hectares occurred throughout the West with only 46.5% of these areas still existing in the 1980s. Loss has been greatest in California, Colorado, and Idaho. In addition, almost all existing wetlands today have been altered in some way (Lauhban 2004).

In the Rio Grande Basin, water delivery infrastructure developed in the 1800s modified the natural distribution of water. Major changes occurred in the timing, distribution, and availability of water resources throughout the Rio Grande Basin when Rio Grande Compact regulations began to be enforced in the late-1960s (Emery 1996). The timing and amount of flows were altered, dampening high flow events while removing natural fluvial dynamics and processes from occurring in wetland and riparian areas throughout the SLV. Built in the early 1900s, a series of reservoirs near the headwaters of the Rio Grande provided even more control of downstream river flows, allowing for more management of both senior and junior surface water right appropriations. At times the Rio Grande itself has discontinuous flows resulting from the large diversions of river water for irrigation. In many locations, channelization of the river also has prevented natural overbank events from occurring, thereby altering the hydro-period (Laubhan 2004), changing sediment and deposition patterns within the active channel, and altering the flow and velocity of the river throughout its course. Studies performed for the Rio Grande Headwaters Restoration Project document substantial shortening of the river course due to straightening. Contact the RGHRP via their website at www.riograndeheadwaters.org for more information and or copies of the river corridor studies.

In addition to the alterations to and dewatering of Rio Grande Basin stream systems, groundwater resources began to diminish due to diminished inflow and the expansion of center-pivot sprinklers throughout the valley in the late-1900s (Emery et al. 1973; Emery 1996;). Wells in the unconfined aquifer are subject to annual variation related to variable recharge rates from infiltration of local precipitation and runoff. By 1980 about 2,300 pumped wells existed in the unconfined aquifer in the SLV (Emery 1996). In contrast, wells drilled into the confined aquifer are artesian and are buffered from climatic conditions. Artesian water under the SLV was discovered about 1887 and within four years about 2,000 flowing wells had been developed (Emery 1996). By 1904 more than 3,200 artesian wells had been drilled and by 1916 about 5,000 artesian wells were present and flowing in the SLV (Follansbee et al. 1915). By 1970 that number had increased to over 7,000 wells. Well pumping typically causes the unconfined aquifer to be seasonally lowered; the last time this aquifer was at or near capacity was the mid-1980s and the mid-1990s, coinciding with one of the wettest periods in the last 1,000 years (Grissino-Mayer et al 1998).

The Closed Basin Canal (Canal) project was originally proposed in 1936 (Natural Resource Committee 1938), but was not authorized for construction until the 1970s to help the state of Colorado meet Rio Grande Compact requirements for water delivery obligations to New Mexico and Texas. As part of the Closed Basin Project, a series of 170 shallow groundwater wells were drilled to provide "salvage" water through a conveyance canal constructed within the Closed Basin along the eastern portion of the SLV. The Closed Basin Project provides approximately 15,000 AF of water annually to the Rio Grande and helps meet Compact obligations. As mitigation for potential wetland loss throughout the area where salvage wells were drilled, several existing wetland areas were chosen to provide and maintain wetland conditions, including the BLM's Blanca Wildlife Management Area, the Alamosa National Wildlife Refuge and the San Luis Lakes and Russell Lakes SWA's.

As noted on the RGWCD web page about the Closed Basin Project: "The second priority of the project is to maintain the Alamosa National Wildlife Refuge (NWR), provided, that the amount of project salvaged water delivered to the NWR and the Blanca Wildlife Habitat Area (WHA) shall not exceed 5300 acre feet annually. The third priority is to apply to the reduction and the elimination of any accumulated deficit in deliveries by Colorado and is no longer applicable since the spill of Elephant Butte in 1985. The fourth and final priority is for irrigation or other beneficial uses in Colorado. The project also delivers mitigation water to the San Luis Lake complex and its recreational facilities."
http://www.rgwcd.org/page21.html

Alterations to hydrologic regimes throughout the Intermountain West, including the Rio Grande Basin, for agricultural production have been the greatest factor in the decline in health of wetland and riparian areas (Laubhan 2004, Laubhan et al). Streamflows throughout the SLV commonly peaked in May or June depending on their location and climatic conditions. High flow events caused over-banking of water onto the floodplain, providing seasonal and at times semi-permanent water conditions throughout the floodplain (Hubert 2004). Deeper floodplain depressions typically have more prolonged water regimes and contain persistent emergent wetland species such as soft stem bulrush and cattail. These deeper wetlands are located in backwater sloughs, oxbow lakes, and seeps (near alluvial fans; Figures x and x above). Historically, sloughs associated with creeks and rivers were seasonally flooded in late spring and early summer from snowmelt, spring rainfall, river and creek overflows, and groundwater discharge. Some of these deeper sloughs held water through June into July and in very wet years they may have held water year round (Ramaley 1929, 1942; Rees 1939).

Changes in wetland and riparian hydroperiods resulted from the diversion of water from the Rio Grande and its tributaries along with Compact requirements, and the installation of groundwater wells and other water-control infrastructure in the SLV that captured and diverted groundwater discharge and drainage. As center-pivot sprinklers became the primary

type of irrigation for crops, flood irrigation and the associated sub-irrigation declined in practice.

INSTREAM FLOW REACHES IN THE RIO GRANDE BASIN

Each year CWCB can file new appropriations with the Water Court, which are the most junior ISF water rights. New appropriation recommendations can come from any individual or government entity during an annual ISF workshop and are prioritized by CWCB staff based on resource value, data requirements and other criteria. Recommendations that meet the statutory requirements of presence of a natural environment and water available to preserve the natural environment are presented to the CWCB for appropriation. Once adjudicated in Water Court, the ISF right is administered within the state's water rights priority system. Although junior ISF rights may not be in priority during critical low flow periods, one important aspect of a junior ISF right is realized if a change of water right is sought for a senior water right within the water district. CWCB has standing in Water Court, just as any other water right owner, to ensure stream conditions are not altered to the detriment of decreed ISF water rights. This fundamental premise forms the basis for CWCB to file Statements of Opposition to potentially injurious change of water right applications, and to require protective terms and conditions in the applicant's decree. The CWCB has successfully negotiated terms and conditions to insure its ISF water rights are protected in over 99% of the cases it enters; thereby allowing the water right change to proceed and the stream to be protected. Existing CWCB ISF rights in the Basin are listed in Table 33.

The voluntary Water Acquisitions Program allows water right's owner through any contractual agreement to donate, sell, bequest, lease, exchange or loan existing decreed water rights to the CWCB on a permanent or temporary basis. In 2001, the ISF law was expanded to allow instream flows to be used for "improving" rivers, and not just protecting them at minimum streamflow levels. And provisions have since been added to allow the CWCB to lease water from private owners without it counting against an owner's "historical consumptive use" record — the core monetary value of a water right.

TABLE 33. Instream Flow Protections for Water Division 3 (Rio Grande Basin).

http://cwcb.state.co.us/technical-resources/instream-flow-water-rights-database/Pages/main.aspx

3-82CW234	Adams Fork Conejos River	Archuleta
3-82CW234	Adams Fork Conejos River	Conejos
3-13CW3013A	Alamosa River	Conejos
3-13CW3013B	Alamosa River	Conejos
3-13CW3014A	Alamosa River	Conejos
3-13CW3014B	Alamosa River	Conejos
3-82CW209	Alamosa River	Conejos
3-82CW209	Alamosa River	Rio Grande
3-07CW062	Alder Creek	Saguache
3-84CW139	Alder Creek	Rio Grande
3-84CW140	Bear Creek	Hinsdale
3-84CW140	Bear Creek	San Juan
3-84CW141	Bear Creek	Rio Grande
3-80CW095	Beaver Creek	Rio Grande
3-82CW235	Beaver Lake Creek	Conejos
3-84CW142	Bellows Creek	Mineral
3-76W3644	Benino Creek	Saguache
3-94CW048	Bennett Creek	Rio Grande
3-94CW054	Bennett Creek	Mineral
3-84CW143	Big Spring Creek	Hinsdale
3-94CW040	Big Spring Creek	Saguache
3-94CW041	Big Spring Creek	Alamosa
3-94CW042	Big Spring Creek	Alamosa
3-94CW042	Big Spring Creek	Saguache
3-80CW088	Black Creek	Mineral
3-12CW034	Brewery Creek	Saguache
3-84CW144	Burro Creek	Rio Grande
3-89CW020	Cascade Creek	Conejos
3-83CW051	Clear Creek	Mineral
3-82CW214	Conejos River	Conejos
3-82CW216	Conejos River	Conejos
3-82CW232	Conejos River	Conejos
3-82CW237	Conejos River	Conejos
3-84CW138	Conejos River	Conejos
3-89CW023	Cottonwood Creek	Saguache
3-83CW050	Crooked Creek	Hinsdale
3-80CW097	Cross Creek	Rio Grande
3-80CW094	Decker Creek	Mineral
3-84CW145	Deep Creek	Mineral
3-03CW035	Dorsey Creek	Saguache
3-03CW036	Eaglebrook Creek	Saguache
3-84CW146	East Bellows Creek	Mineral
3-84CW146	East Bellows Creek	Rio Grande
3-84CW147	East Fork Pinos Creek	Rio Grande
3-95CW034	East Middle Creek	Saguache
3-84CW148	East Willow Creek	Mineral
3-82CW233	El Rito Azul	Conejos
3-82CW206	Elk Creek	Conejos
3-84CW149	Elk Creek	Mineral
3-84CW149	Elk Creek	Rio Grande
3-12CW035	Elkhorn Gulch	Saguache
3-76W3647	Embargo Creek	Rio Grande
3-76W3647	Embargo Creek	Saguache
3-03CW037	Ford Creek	Saguache
3-03CW038	Fourmile Creek	Saguache
3-03CW039	Garner Creek	Saguache
3-83CW038	Goose Creek	Mineral
3-76W3646	Groundhog Creek	Saguache
3-82CW219	Grouse Creek	Conejos
3-80CW089	Hope Creek	Mineral
3-77W3808	Hot Creek	Conejos
3-84CW150	Ivy Creek	Mineral
3-77W3807	Jim Creek	Conejos
3-82CW225	Johns Creek	Saguache
3-80CW093	Kelly Creek	Mineral
3-80CW093	Kelly Creek	Rio Grande
3-12CW036	Kerber Creek	Saguache
3-12CW037	Kerber Creek	Saguache
3-80CW086	Kitty Creek	Mineral
3-03CW040	La Garita Creek	Saguache

Different case numbers on the same river signify separate reaches

TABLE 33. Instream Flow Protections for Water Division 3 (Rio Grande Basin).

http://cwcb.state.co.us/technical-resources/instream-flow-water-rights-database/Pages/main.aspx

3-76W3645	La Garita Creek	Saguache
3-76W3648	La Jara Creek	Conejos
3-82CW217	La Manga Creek	Conejos
3-80CW099	Lake Creek	Mineral
3-82CW236	Lake Fork Conejos River	Conejos
3-84CW151	Leopard Creek	Mineral
3-83CW046	Lime Creek	Mineral
3-84CW152	Little Squaw Creek	Hinsdale
3-80CW092	Lost Mine Creek	Mineral
3-80CW092	Lost Mine Creek	Rio Grande
3-84CW153	Lost Trail Creek	Hinsdale
3-84CW154	Mesa Creek	Hinsdale
3-84CW154	Mesa Creek	Mineral
3-82CW227	Middle Creek	Saguache
3-83CW048	Middle Creek	Mineral
3-82CW229	Middle Fork Conejos River	Archuleta
3-82CW229	Middle Fork Conejos River	Conejos
3-82CW228	Middle Fork Saguache Creek	Saguache
3-94CW051	Middle Fork San Francisco Creek	Rio Grande
3-84CW155	Miners Creek	Mineral
3-83CW047	North Clear Creek	Hinsdale
3-83CW047	North Clear Creek	Mineral
3-94CW047	North Clear Creek	Hinsdale
3-94CW044	North Crestone Creek	Saguache
3-94CW043	North Fork Carnero Creek	Saguache
3-82CW231	North Fork Conejos River	Conejos
3-82CW221	North Fork Saguache Creek	Saguache
3-89CW018	Osier Creek	Conejos
3-80CW091	Park Creek	Mineral
3-80CW091	Park Creek	Rio Grande
3-80CW090	Pass Creek	Mineral
3-94CW055	Pierce Creek	Mineral
3-94CW049	Pinos Creek	Rio Grande
3-94CW057	Pinos Creek	Rio Grande
3-84CW156	Pole Creek	Hinsdale
3-84CW156	Pole Creek	San Juan
3-84CW157	Quartzite Creek	San Juan
3-80CW096	Race Creek	Rio Grande
3-84CW158	Rat Creek	Mineral
3-83CW043	Red Mountain Creek	Mineral
3-82CW218	Rio de los Pinos	Conejos
3-84CW137	Rio de los Pinos	Conejos
3-83CW039	Rio Grande	Mineral
3-83CW040	Rio Grande	Hinsdale
3-83CW040	Rio Grande	Mineral
3-83CW041	Rio Grande	San Juan
3-83CW042	Rio Grande	Mineral
3-83CW042	Rio Grande	Rio Grande
3-83CW044	Rio Grande	Hinsdale
3-83CW049	Rio Grande	Mineral
3-82CW238	Saddle Creek	Conejos
3-82CW208	Saguache Creek	Saguache
3-82CW212	Saguache Creek	Saguache
3-94CW050	San Francisco Creek	Rio Grande
3-89CW016	San Isabel Creek	Saguache
3-82CW230	Sangre de Cristo Creek	Costilla
3-84CW159	Shallow Creek	Mineral
3-03CW034	Sheep Creek	Saguache
3-82CW226	Sheep Creek	Saguache
3-94CW056	Soda Creek	Mineral
3-83CW045	South Clear Creek	Hinsdale
3-83CW045	South Clear Creek	Mineral
3-94CW045	South Clear Creek	Hinsdale
3-94CW046	South Clear Creek	Hinsdale
3-89CW024	South Crestone Creek	Saguache
3-82CW211	South Fork Carnero Creek	Saguache
3-82CW215	South Fork Conejos River	Conejos
3-80CW087	South Fork Rio Grande	Mineral
3-84CW160	South Fork Rio Grande	Mineral
3-84CW161	South Fork Rio Grande	Mineral

Different case numbers on the same river signify separate reaches

TABLE 33. Instream Flow Protections for Water Division 3 (Rio Grande Basin).

http://cwcb.state.co.us/technical-resources/instream-flow-water-rights-database/Pages/main.aspx

3-84CW162	South Fork Rio Grande	Mineral
3-84CW162	South Fork Rio Grande	Rio Grande
3-84CW163	South Fork Rio Grande	Rio Grande
3-82CW222	South Fork Saguache Creek	Saguache
3-82CW223	South Fork Saguache Creek	Saguache
3-89CW021	Spanish Creek	Saguache
3-84CW164	Squaw Creek	Hinsdale
3-84CW165	Texas Creek	Hinsdale
3-84CW165	Texas Creek	Mineral
3-77W3806	Torsido Creek	Conejos
3-82CW210	Treasure Creek	Archuleta
3-82CW210	Treasure Creek	Conejos
3-80CW098	Trout Creek	Rio Grande
3-84CW166	Trout Creek	Mineral
3-82CW207	Tuttle Creek	Saguache
3-84CW167	Ute Creek	Hinsdale
3-82CW213	Valdez Creek	Conejos
3-82CW224	Wannamaker Creek	Saguache
3-84CW168	Weminuche Creek	Hinsdale
3-89CW017	West Alder Creek	Rio Grande
3-84CW169	West Bellows Creek	Mineral
3-89CW019	West Fork Pass Creek	Mineral
3-84CW170	West Fork Pinos Creek	Rio Grande
3-94CW052	West Fork San Francisco Creek	Rio Grande
3-84CW171	West Willow Creek	Mineral
3-84CW172	Willow Creek	Hinsdale
3-84CW172	Willow Creek	Mineral
3-89CW022	Willow Creek	Saguache
3-82CW220	Wolf Creek	Archuleta
3-82CW220	Wolf Creek	Conejos
3-94CW053	Woodfern Creek	Mineral

Different case numbers on the same river signify separate reaches

Current Recreation Status

San Luis Valley Great Outdoors (SLV GO) http://slvgo.com/
SLV GO Coalition is comprised of the region's counties, cities, educational institutions, state and federal agencies and non-profit organizations, operating under the auspices of the SLV Council of Governments. The effort came together as part of the SLV's designation as a priority area for America's Great Outdoors, an initiative of President Obama and (then) Secretary of Interior Ken Salazar. The Coalition is planning for the future enhancement and marketing of the San Luis Valley's diverse recreational resources, including water based recreation, from skiing to fishing and rafting. The Coalition participants include committed elected officials, civil servants, and community members; all dedicated to promoting and enhancing the SLV's Great Outdoors.

In 2013–2014, the SLV GO Coalition received a GOCO grant to create the San Luis Valley Trails and Recreation Master Plan. The Coalition

worked with SLV communities, organizations and residents to create a guide and tool for the future enhancement and expansion of outdoor recreation across the SLV's six counties, from the headwaters and high country wilderness to agritourism and local recreation facilities in the communities. The plan can be downloaded from the website.

The Lake (flat-water) Fisheries in the Rio Grande Basin include:

TABLE 34.

Lake Fisheries in Rio Grande Basin.

Alberta Park Reservoir	Lower and Upper Browns Lakes	Road Canyon Reservoir
Beaver Creek Reservoir	Mountain Home Reservoir	Sanchez Reservoir
Big Meadows Reservoir	Platoro Reservoir	Shaw Reservoir
Continental Reservoir	Pogue Lake	Smith Reservoir
Goose Lake	Regan Lake	Spruce Lakes
Hunters Lake	Rio Grande Reservoir	Trout Lake and San Luis Lake
La Jara Reservoir	Rito Hondo Reservoir	Trujillo Meadows Reservoir

CPW's water rights portfolio plays a significant role (either directly or indirectly) in all of these reservoirs. Although Sanchez, Mountain Home, and Smith reservoirs have siltation that limits the amount of water available for recreation.

The following table summarizes fishing recreation opportunities at these waters:

TABLE 35.

Total angler days at Rio Grande Basin fishing lakes.

Water	Recreation Days	Creel Date
Alberta Park Reservoir	3,333	1979–1981
Beaver Creek Reservoir	9,174	2005–2006
Big Meadows Reservoir	6,612	1997
Browns Lake, Lower	1,875	1987
Browns Lake, Upper	3,400	1987
Continental Reservoir	5,780	1980
Goose Lake	169	*
Hunters Lake	70	*
La Jara Reservoir	15,565	*
Mountain Home Reservoir	9,700	1989
Platoro Reservoir	7,278	*
Pogue Lake	1,233	*
Regan Lake	3,400	*
Rio Grande Reservoir	16,980	*
Rito Hondo Reservoir	4,753	1980
Road Canyon Reservoir	10,700	1987
Sanchez Reservoir	1,150	1990
San Luis Lake	1,156	*
Shaw Reservoir	2,975	*
Spruce Lakes	250	*
Smith Reservoir	9,540	1989
Trout Lake	150	*
Trujillo Meadows	5,544	*
Total	**120,787**	

* = Recreation days estimated from SW region creel surveys for waters of similar size and management category.

NOTE: = Recreation days estimates are for summer fishing season and do not include winter ice fishing recreation.

TABLE 36. State wildlife areas and parks in the Rio Grande Basin.

#1
Higel SWA

Game Management Unit #	791
Acreage	1,129 acres
Water Body	Rio Grande
County	Alamosa

#2
Playa Blanca SWA

Game Management Unit #	82
Acreage	749 acres
Water Body	Big spring creek, Sand creek supply, Head lake, wetlands and San Luis Lake with water
County	Alamosa

#3
San Luis Lakes SWA and State Park

Game Management Unit #	82
Acreage	1,691 acres
Water Body	San Luis Lakes
County	Alamosa

TABLE 36. State wildlife areas and parks in the Rio Grande Basin.

#4
Beaver Creek Reservoir SWA

Game Management Unit #	80
Acreage	114 acres
Water Body	Beaver Creek Reservoir
County	Rio Grande

#5
Home Lake SWA

Game Management Unit #	791
Acreage	Approximately 100 acres
Water Body	Rio Grande
County	Rio Grande

#6
Rio Grande (Del Norte Fishing Easement)

Game Management Unit #	79
Acreage	95 acres
Water Body	Rio Grande
County	Rio Grande

#7
Rio Grande SWA

Game Management Unit #	791
Acreage	820 acres
Water Body	Rio Grande
County	Rio Grande

TABLE 36. State wildlife areas and parks in the Rio Grande Basin.

#8
Shriver-Wright SWA

Game Management Unit #	791
Acreage	120 acres
Water Body	Rio Grande
County	Rio Grande

#9
Alberta Park Reservoir SWA

Game Management Unit #	80
Acreage	37 land acres plus Alberta Lake, which is 60 surface-acres in size and has an average depth of 13 feet.
Water Body	Alberta Park Reservoir
County	Mineral

#10
Big Meadows Reservoir SWA

Game Management Unit #	76
Acreage	117 acres
Water Body	Big Meadows Reservoir
County	Mineral

TABLE 36. State wildlife areas and parks in the Rio Grande Basin.

#11 Coller SWA	Game Management Unit #	76,79	
	Acreage	918 acres	
	Water Body	Rio Grande	
	County	Mineral	
#12 Creede SWA	Game Management Unit #	76	
	Acreage	12 linear acres along the Rio Grande	
	Water Body	Rio Grande	
	County	Mineral	
#13 Russell Lakes SWA	Game Management Unit #	682	
	Acreage	2,159 acres	
	Water Body	Groundwater dependent	
	County	Saguache	
#14 Conejos River SWA (Fishing Easements)	Game Management Unit #	81	
	Acreage		
	Water Body	Conejos River	
	County	Conejos	
#15 Hot Creek SWA	Game Management Unit #	81	
	Acreage	3,460 acres	
	Water Body	Hot Creek	
	County	Conejos	
#16 La Jara Reservoir SWA	Game Management Unit #	81	
	Acreage	2,613 acres	
	Water Body	La Jara Reservoir	
	County	Conejos	

TABLE 36. State wildlife areas and parks in the Rio Grande Basin.

#17
La Jara SWA

Game Management Unit #	81
Acreage	2,882 acres
Water Body	La Jara River
County	Conejos

#18
Sego Springs SWA

Game Management Unit #	81
Acreage	642 acres
Water Body	Sego Springs
County	Conejos

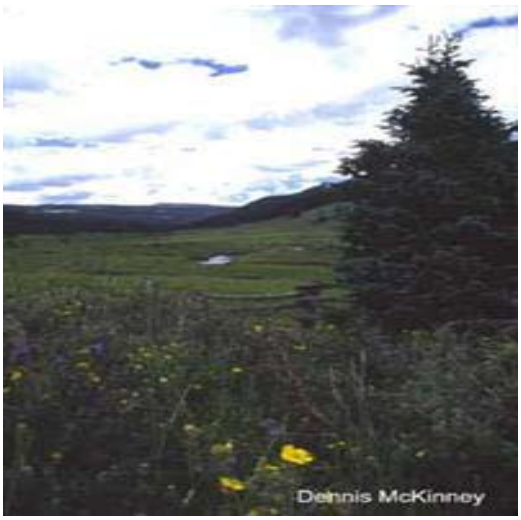
#19
Terrace Reservoir SWA

Game Management Unit #	80, 81
Acreage	240 acres
Water Body	Terrace Reservoir
County	Conejos

TABLE 36. State wildlife areas and parks in the Rio Grande Basin.

#20 Trujillo Meadows SWA

Game Management Unit #	81
Acreage	72 acres
Water Body	Trujillo Reservoir
County	Conejos



#21 Mountain Home Reservoir SWA

Game Management Unit #	83
Acreage	715 acres
Water Body	Mountain Home Reservoir
County	Costilla

#22 Sanchez Reservoir SWA

Game Management Unit #	83
Acreage	3,058 acres
Water Body	Sanchez Reservoir
County	Costilla

#23 Smith Reservoir SWA

Game Management Unit #	83
Acreage	956 acres
Water Body	Smith Reservoir
County	Costilla

Blanca Wildlife Habitat Area

The SLV has been identified as a primary Key Site for shorebird conservation in the Intermountain West (Table 7.) The IWJV's SST elected to use a bioenergetic approach to develop shorebird habitat objectives that are explicitly linked to national and regional shorebird population objectives. Blanca WHA is an important stopover site to passage shorebirds in the eastern IWJV. Blanca WHA was selected for testing the viability of bioenergetics modeling as an assumption-based decision support tool for local land managers, while contributing to the knowledge base of shorebird habitat use and supply in the IWJV. This effort was collaborative and included members of the SST, local BLM wetland managers, Colorado Division of Wildlife biologists, and BLM biologists. Shorebird survey and habitat data collected by the BLM from 2002 to 2007 were used to generate inputs to a bioenergetic model: population objectives, daily food requirement, habitat availability, and energy supplied by playas.

Analysis of shorebird counts suggests that Blanca WHA supports more passage shorebirds than previously recognized, particularly during post-breeding migration. The most abundant passage shorebird species included Wilson's Phalarope, American Avocet, and Baird's Sandpiper. Our results indicate that playas on Blanca WHA did not meet the bioenergetic needs of the observed population of passage shorebirds (47,108) and would not have meet the needs of a site-specific population objective of 49,226 shorebirds. Our results indicate that under all but the highest forage density, deficits in meeting the energetic requirements occurred during peak post-breeding migration in early to mid-August.

Appendix C: RiverWare Model Description

Model Domain

Spatial domain – The model encompasses the Colorado headwaters of the Rio Grande and the Conejos River systems including the major tributaries to each river. Although the model only includes the portions of the Rio Grande and Conejos that are in Colorado, reservoir conditions at Elephant Butte Reservoir near Truth or Consequences, NM are also considered as they pertain to the Rio Grande Interstate Compact and the ability of post-compact reservoirs in Colorado to store. Major headwaters river gages used in the model for hydrologic inflows include:

- Rio Grande at Thirty Mile Bridge near Creede
- Rio Grande near Del Norte
- North Clear Creek Below Continental Reservoir
- Conejos near Mogote
- Los Pinos near Ortiz
- San Antonio at Ortiz

Downstream gages that are used for calibration and administration of the Rio Grande Compact include:

- South Fork of Rio Grande at South Fork
- Conejos River near Lasauses (Los Sauces)
- Rio Grande near Monte Vista
- Rio Grande at Alamosa
- Rio Grande near Lobatos

The model also considers transbasin diversions from the Gunnison and San Juan basins into the Rio Grande. As the model only encompasses surface water, groundwater pumping is not considered in the model. In situations where groundwater enters the surface water system (the Closed Basin Project, return flows, natural gains, etc.) these sources are included as input to the model.

Modeled time period – Historical conditions from 1980–2008 are modeled. This time period was chosen as it contains a representative set of hydrologic conditions, historical records are fairly complete, diversions and water rights match present conditions, and the major reservoirs and infrastructure in the Basin were in place. The model is run using daily river flows and diversions.

Inflow Hydrology

Natural flows are estimated at the upstream end of each river and tributary in the model. Natural flows represent the hydrologic inflow (volume and timing) to each river or stream before the influence of manmade infrastructure. In order to estimate natural flows, flows at the uppermost gage in each reach are adjusted for known upstream diversions, transbasin inflows, returns, and reservoir operations (storage or release). At each subsequent downstream gage, natural flow, gains, and losses can be calculated using historical data from river gages, diversion structures, and reservoir inlet and outlet structures. Gains and losses represent non-measured hydrologic inflows and outflows from the river resulting from precipitation, evaporation and evapo-transpiration, un-gaged tributary inflow, groundwater inflow and outflow, and agricultural return flows.

Adjusted hydrologies were developed for climate change, dust on snow events, beetle kill-affected areas, and wildfire-affected areas. Climate change inflows were developed starting with projected naturalized flows at the 4 index Gages on a monthly timestep from 2008–2099. These flows were obtained from the Upper Rio Grande Simulation Model (URGSiM) (Llewellyn, 2013), which in turn developed these flow projections using spatially downscaled CMIP-3 projections. There are 112 GCM model runs used in the CMIP-3. In order to retain the variability that each individual model run offers, 5 representative GCM runs were chosen out of the 112 that represented climate scenarios that are combinations of wet and dry, warm and cool, and average (Figure 69).

The scatterplot shows standard deviations away from the mean forecasted temperature and precipitation in each of the 112 model runs over the Rio Grande Basin. The bottom right quadrant shows hot and dry model runs, the top right quadrant shows hot and wet, the top left quadrant shows cool and wet, and the bottom right quadrant shows cool and dry.

Once the 5 representative GCM runs were chosen, they had to be temporally disaggregated from a monthly timestep to a daily timestep. This was accomplished by using the historic daily variability from 1980–2008 at each of the 4 index Gages and applying this tracer variability to the projected monthly flows over the same number of months. In order to match the number of months to the tracer, the climate change projections were broken into 3 periods of 28 years each starting in 2009, 2038, and 2067. Before the tracer variability was applied to the climate change projections, a time shift was also performed on each year of the tracer data to match the center of mass of flows of the climate change and historical data. This ensured that any seasonal changes in variability were preserved and would come at the same point in the hydrograph regardless of any long-term changes in the timing of flow. Finally, these temporally

FIGURE 69.

Forecasted mean temperature and precipitation for 5 representative CIMP-3 GCM runs.

All 112 CMIP-3 GCM runs are shown in blue and the 5 representative runs are shown in red.

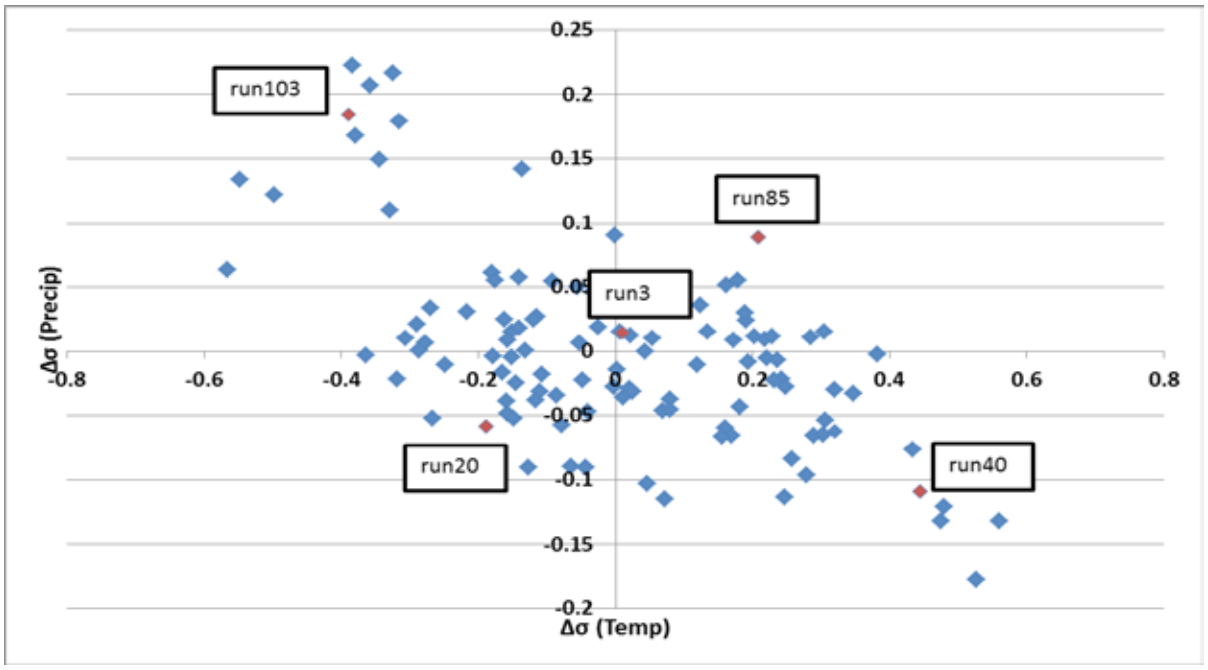
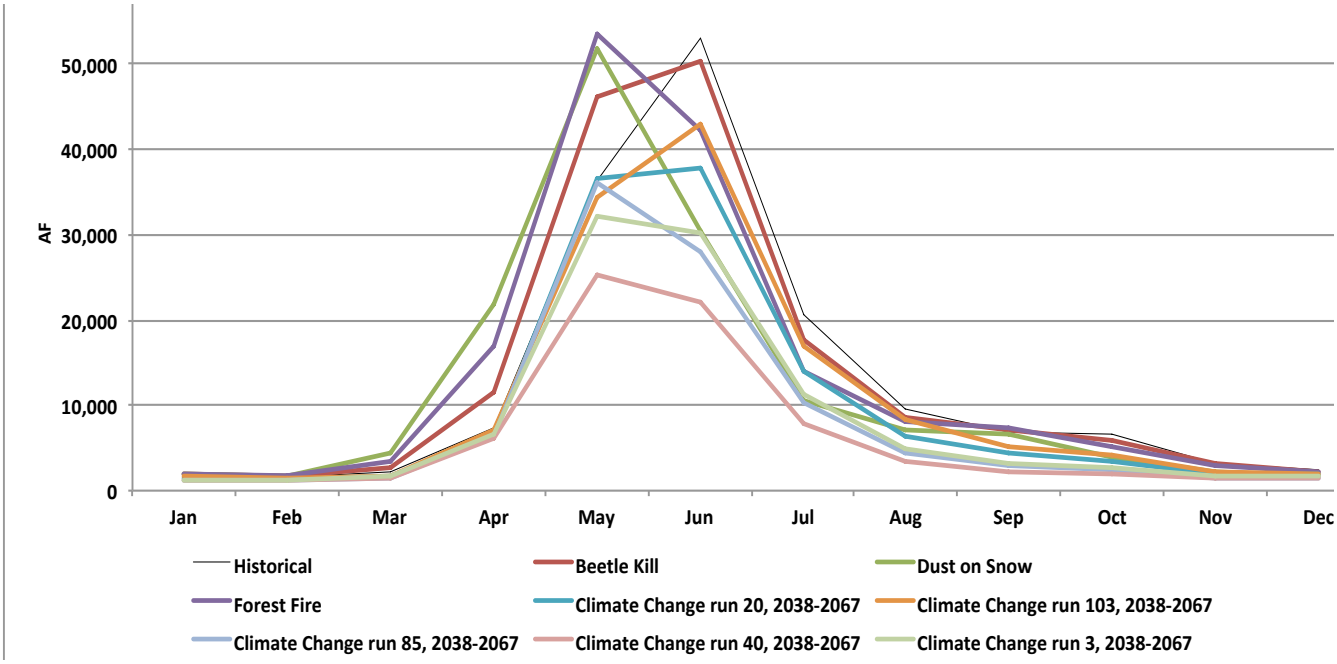


FIGURE 70.

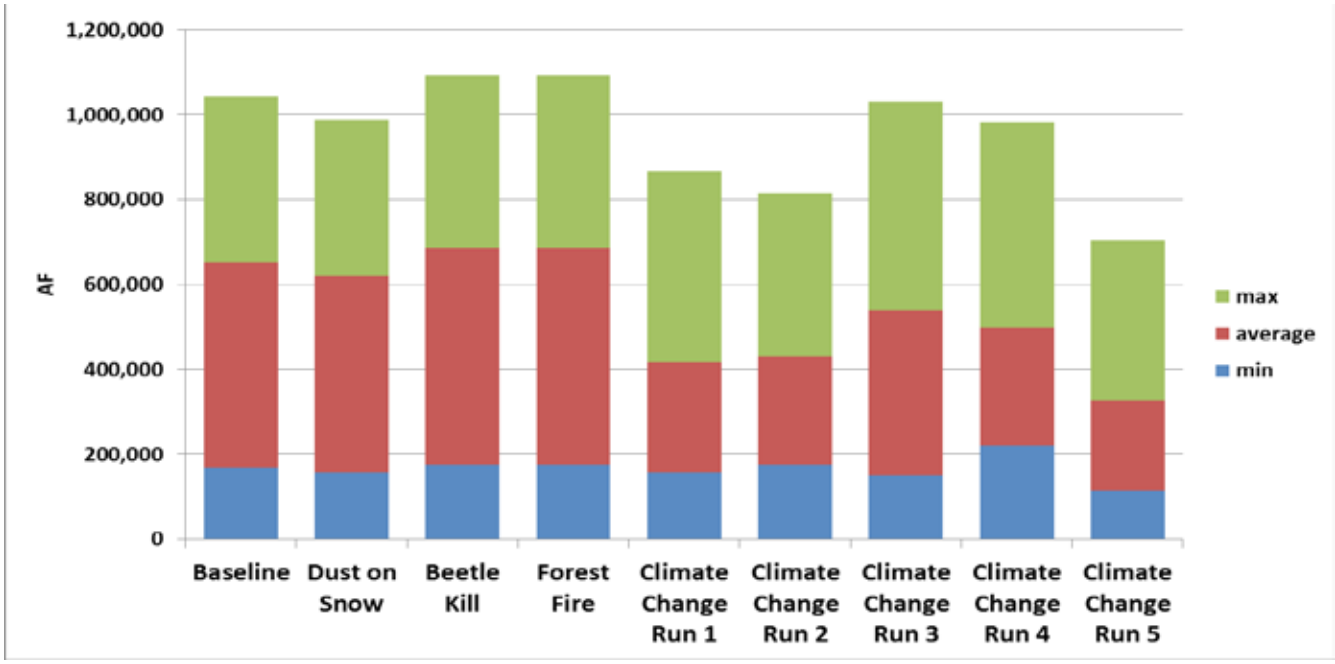
Average monthly inflows to Rio Grande Reservoir under various climatic and environmental scenarios modeled in RiverWare.



disaggregated index gage flows were spatially disaggregated in the same manner as the historical flow described above.

Projected changes in flow due to beetle kill, wildfire, and dust on snow events were synthesized by shifting the timing and volume of historic flow from 1980–2008. Section 5.1.2 describes the projected changes in hydrology in the Rio Grande Basin as a result of these environmental changes.

FIGURE 71. Projected annual flows at the Rio Grande near Del Norte gage.



The minimum, maximum, and average flows are over the 28 year period of record for each model run. This 28 year period is 1980–2008 for the Baseline, Dust on Snow, Beetle Kill, and Forest Fire runs and is 2036–2067 for the Climate Change runs.

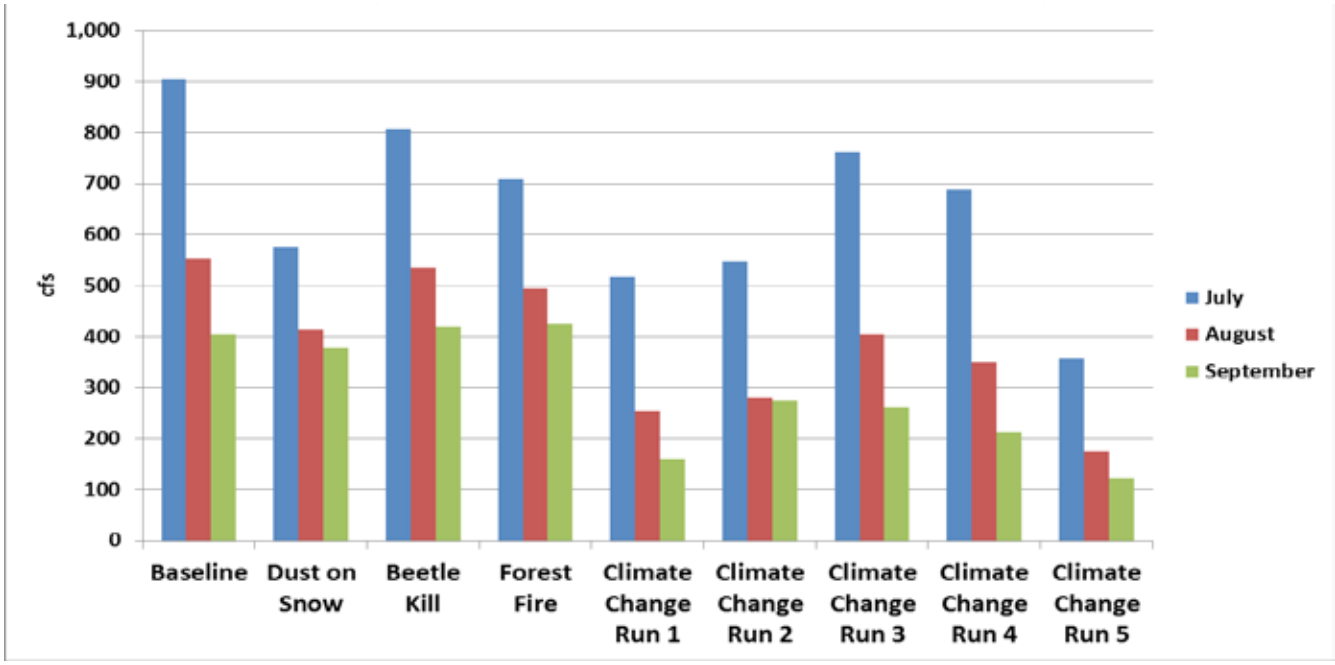
The average flow spans the 28 year period of record for each model run. This 28 year period is 1980–2008 for the Baseline, Dust on Snow, Beetle Kill, and Forest Fire runs and is 2036–2067 for the Climate Change runs.

Data sources and filling techniques:

- **Historical Streamflow** from 1980 to 2008 was obtained from HydroBase (release 20131028) and is compiled from data from the United States Geologic Survey (USGS) and Colorado

FIGURE 72. Average late summer flows at the Rio Grande near Wagon Wheel Gap gage.

Under the various climatic and environmental scenarios modeled in RiverWare.



Division of Water Resources (DWR). Data was obtained on a daily timestep.

- **Historical diversions** from 1980 to 2008 were obtained from HydroBase (release 20131028) for 1980–2008. These records are approved by the District 20 and District 22 Water Commissioners within the Colorado Division of Water Resources. Gaps in the data are filled by the DWR by assuming that the last known daily diversion continues until the next observed data point.

- **Historical reservoir inflows, outflows, and storage** were obtained from several sources. Bureau of Reclamation (Upper Colorado Division, Elephant Butte), CWCD, Hydrobase, and others.

- **Irrigation Water Requirements (IWR)** were obtained on a monthly scale from 1980–2002 from StateCU for each ditch modeled in the system. The StateCU input files were obtained from the 2011 Rio Grande Decision Support System (RGDSS), and more information regarding the assumptions can be found at (http://cdss.state.co.us/Modeling/Pages/ConsumptiveUseStateCU.aspx).

Climate change projections of gage flows were obtained for the 4 index Gages (Rio Grande near Del Norte, Conejos near Mogote, Los Pinos near Ortiz, and San Antonio at Ortiz) from the Upper Rio Grande Simulation

Model (URGSiM). These projections showed 112 traces for each gage from 1900–2100. Spatially downscaled CMIP-3 projections of temperature and precipitation over the Rio Grande Basin were obtained from "Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections" archive at http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/.

Physical Systems

The Rio Grande Basin model represents the physical state of the river with Simulation Objects connected by links in RiverWare. These Simulation Objects represent reservoirs, stream gages, diversion structures, return flows, and all other natural or manmade influences on the river flow. The model captures a subset of the actual innumerable physical influences on the river system by simulating the major influences. What constitutes a major physical influence on the river was determined by discussion with the Division 3 Engineer, the District 20 and 22 Water Commissioners, the Conejos Water Conservancy District, the San Luis Valley Irrigation District, the Bureau of Reclamation, water users, and other stakeholders in the Basin.

Agricultural demands, diversions, and return flows largely drive the flows in the Rio Grande Basin. There are 188 active ditches and canal diversion structures within Districts 20 and 22 alone, each with 1 to 22 active water rights per diversion structure. As such, it was decided that physically representing each diversion structure in the model was not practicable for this level of model development. In cases where diversion structures are geographically close and there are no other major intervening objects, canals and ditches were grouped together in the model. However, all of the decreed water rights are represented individually using RiverWare's accounting system and allocate water using the prior appropriation method.

Major reservoirs in the Rio Grande and Conejos River systems include Rio Grande Reservoir, Beaver Park Reservoir, Continental and Santa Maria Reservoir, and Platoro Reservoir. These reservoirs are owned and operated by numerous entities that divert and store water and make releases. In addition, Division 3 and Districts 20 and 22 can hold and release "compact storage" in the reservoirs when certain criteria are met. In the cases of Rio Grande, Continental, and Santa Maria Reservoirs, logical rules were written in RiverWare's Rule-Based Platform to simulate the operations of SLVID (operators of Rio Grande Reservoir) and the Santa Maria Reservoir Company (operators of Continental and Santa Maria Reservoirs). These operational rules were written based on personal communication with Travis Smith of SLVID and the Preliminary Engineering Report in Case No. 13CW3002 (Helton and Williamsen, 2013). The operations of Platoro Reservoir were more difficult to capture in rule-based logic since it is a post-compact reservoir and primarily stores direct-flow rights of CWCD shareholders. Diversions and releases are made at the discretion of

water users, CWCD, and the District 22 Water Commissioner. Historic storage and releases were therefore used in the model to capture CWCD operations.

Many of the irrigation return flows modeled in the system do not have simple return patterns, but instead are routed into various drains or aquifers that return water to different watersheds than where the diversion was made. Diversion structures in the model that had direct flow rights greater than 80 cfs were examined for the location of return flows. Major known return locations include the Norton Drain North of the Conejos River and the Closed Basin North of the Rio Grande. The Norton Drain is gaged and credited toward the Conejos River Compact, so a calibration could be performed to determine the fraction of diversions into the Hydrologic Unit (HUC) containing the Norton Drain and flow through the Norton Drain back into the Rio Grande. It was assumed that all diversions into the Closed Basin do not return back to the Rio Grande due to the hydrologic divide. Historic deliveries from the Closed Basin Canal were accounted for in the model, however, with 60% being applied toward the Rio Grande Compact and 40% being applied toward the Conejos River Compact.

Data sources:

- **GIS layers** with locations of diversion structures, gages, canals, and irrigated acreage were obtained from the Division of Water Resources' CDSS website. The Irrigated Lands 2010 layer was used for the entire period of record to determine general return flow location, but was not used in any analysis to determine IWR. GIS layers of Hydrologic Units (HUC) were obtained from the United States Environmental Protection Agency (EPA, 2014).

- **Straightline diagrams** and administration sheets were obtained from the District 20 and 22 Water Commissioners. They provide the relative location and side of the river of each ditch and water rights associated with each ditch. They were also used to determine the order of priority on each river system (Rio Grande and Conejos) and to determine any water rights that are no longer active.

- **Reservoir storage capacity and operational policy** was obtained from direct communication with the District 20 and 22 Water commissioners, the Bureau of Reclamation, and reservoir owners such as the Conejos Water Conservancy District and San Luis Valley Irrigation District and an engineering report prepared by Helton and Williamsen for Sana Maria and Continental Reservoirs.

Water Demands

As the Rio Grande Basin is largely an agricultural basin, the majority of the in-basin water demands are for irrigation. IWR was determined on a monthly timestep for each ditch as described in Section Inflow Hydrology and represents the historical water demand of the crops irrigated by that particular ditch. It is a function of the historical climate and the crop types and irrigated acreage served by the ditch. The farm headgate demand is equal to the IWR divided by the on-farm efficiency and the river headgate demand is equal to the farm headgate demand divided by the ditch efficiency. Diverted water that is lost due to ditch seepage, on-farm irrigation methods, or over-diversion of water is returned to the river or location determined using the analysis described above.

Instream flow demands were determined using decreed water rights and were included in the model where they appeared downstream of the highest object on each river or tributary. These instream flow rights are decreed and administered by the Colorado Water Conservation Board (CWCB) and the CWCB Instream Flow Water Rights Database (CWCB, 2014) was used to determine the location and priority date of these rights.

The Rio Grande Compact delivery obligation to New Mexico is the other major demand in the Rio Grande Basin. It is administered through a curtailment of diversions below the index Gages that is set by the Division 3 Engineer. Through personal communication with the Division 3 Engineer's office and analysis of 10 day reports and analysis sheets published by the Division 3 Engineer's office, the curtailment logic was written in RiverWare's rule-based platform. The rules used historic NRCS streamflow forecasts and historic gage flows at the index gages in order to set the curtailment. The model only used data known at the current timestep and used no forward knowledge.

Data sources and filling techniques:

- **Irrigation Water Requirements (IWR)** were obtained on a monthly scale from 1980–2002 from StateCU for each ditch modeled in the system. The StateCU input files were obtained from the 2011 Rio Grande Decision Support System (RGDSS), and more information regarding the assumptions can be found at (http://cdss.state.co.us/Modeling/Pages/ConsumptiveUseStateCU.aspx).

- **Historic NRCS streamflow forecasts** for April–September flow were obtained at the 4 index gages (Rio Grande near Del Norte, Conejos near Mogote, Los Pinos near Ortiz, and San Antonio at Ortiz) from the NRCS website. (NRCS, 2014)

Legal and Administrative Conditions

As there is insufficient flow in the Rio Grande and Conejos Rivers to meet all demands, there are several legal and administrative conditions within the Rio Grande Basin RiverWare model that affect the allocation of flow. These conditions, policies, and operations include:

- Prior appropriation system
- Rio Grande Compact
- Curtailment
- The Closed Basin Project
- Reservoir operations
- Federal Reserved and CWCB instream water rights

In order to model these legal and administrative constraints in the system, a combination of RiverWare's accounting system and rule-based policy system are utilized to accurately portray policy that is administered by the Colorado State Engineer and Division 3 Engineer. A combination of built-in functions and user-defined rules written in RiverWare Policy Language (RPL) allow for a flexible representation of any real-life policy. Instream flow rights are modeled using a combination of physical objects and the Water Rights solver accounting method, which satisfies the instream flow rights first with incidental flow through the reach and secondly with a priority demand.

Data sources:

- **Decrees** for each water right are filed with the State Engineer's office and are tabulated in HydroBase. The most recent lists of decrees, administration numbers, and decreed rates were obtained from the District 20 and District 22 Water Commissioners.

- **The Rio Grande and Conejos River Compacts** are administered jointly by Division 3 and Districts 20 and 22 of the Department of Water Resources. Understanding of their policy was accomplished through direct communication and planning level documents developed to guide their decision making with regards to curtailment and reservoir storage.

- **Reservoir operations** along the Rio Grande and Conejos River are administered by a variety of entities including the Conejos Water Conservancy District, the San Luis Valley Irrigation District, Colorado Parks and Wildlife, the Colorado Water Conservation Board, the Bureau of Reclamation, and others. An understanding of current and historical operational policy

was gained through direct communication and review of engineering reports that describe historic use and policy.

- **Instream Flow Rights** were obtained thorugh the CWCB Instream Flow Water Rights Database (CWCB, 2014) which was used to determine the location and priority date of these rights.

- **The Closed Basin Project** pumps groundwater from the unconfined aquifer and the water flows through the Closed Basin Project Canal to the Rio Grande. 60% of the flow is credited to the Rio Grande Compact and 40% is credited to the Conejos River Compact. As the canal outlet is gaged, historic gage data from HydroBase was used to determine these flows in the same manner as other gage data that went into the model.

Appendix D: Current Factors Affecting Hydrology

Dust on Snow

The paragraphs below provide additional information about the Deems et al. study.

Using the Variable Infiltration Capacity (VIC) hydrologic model for the Upper Colorado River Basin, Deems et al. used a sensitivity approach to examine the hydrologic impacts of different dust deposition/snow albedo (snow reflection coefficient) regimes. They found that decreased snow albedo (decreased albedo means less reflection and more absorption of solar radiation) from dust loading to the mountains of Colorado of the magnitude observed in 2005–2008, shortens snow cover duration by several weeks relative to conditions prior to westward expansion of the United States in the mid-1800s. The shortened snow cover duration causes peak runoff from the Upper Colorado River Basin (UCRB) to occur an average of three weeks earlier, leaving less water for use later in the year (Deems et al. 2013). A longer snow-free season increases evapotranspiration losses as seeds gain advance exposure to soils, resulting in earlier plant germination. Evapotranspiration losses were estimated to decrease annual runoff by about 5% of the annual average flow or approximately 800,000 acre-feet annually for the UCRB. This prior work was based on observed dust loadings during 2005–2008; however, during 2009 and 2010, scientists observed unprecedented levels of dust loading on Colorado snowpacks, on the order of five times the 2005–2008 loading. Categorized as extreme dust, depositions similar to 2009 and 2010 amounts absorb two to four times the solar radiation, and shift peak snowmelt an additional three weeks earlier to a total of six weeks earlier than in the mid-1800s (Deems et al. 2013).

In the three dust scenarios under historical climate conditions, scientists found that the highest snow accumulation areas (predominantly higher elevations) show the greatest sensitivity in date of snow melt-out or snow-all-gone date due to dust load and radiative forcing. Deeper snowpacks have a longer melt season and therefore a longer time period over which different melt rates can cause the snow water equivalent (SWE) amounts to diverge. Skiles et al. (2012) found that in the extreme dust years of 2009 and 2010, the snowpack melted out 50 and 43 days early, respectively, relative to a theoretical clean snowpack.

Documentation of Dust on Snow Events in the Rio Grande Basin

The Center for Snow and Avalanche Studies (CSAS) is home to the Colorado Dust-on-Snow (CODOS) program, located in the Senator Beck Basin, an applied science effort on behalf of Colorado and regional water management agencies. With direct funding from stakeholders, CSAS monitors the presence/absence of dust layers at 11 mountain pass locations throughout Colorado including Spring Creek and Wolf Creek in the Rio Grande Basin. For 2012 and 2013 Dust on snow events and snow water equivalent from Wolf Creek Pass and Spring Creek stations are compared with the 1971–2000 average snow water equivalent at the stations in Figure 73. Spring Creek Pass is located at the northern edge of main stem watershed, between the towns of Creede and Lake City and is associated with the Slumgullion Pass Snotel station. The Senator Beck Basin is only 30 miles to the west of Spring Creek Pass, and the Rio Grande headwaters, at Stony Pass, are just 12 miles southeast of Senator Beck Basin. Using those observations, data from nearby Snotel sites, and weather forecasts, the CODOS program issues a series of update analyses of how dust-on-snow is likely to influence snowmelt timing and rates during the runoff season.

South- and east-facing terrain above US Highway 160 showing dust widely exposed at the snowpack surface. Source: Center for Snow and Avalanche Studies, Colorado Dust on Snow program

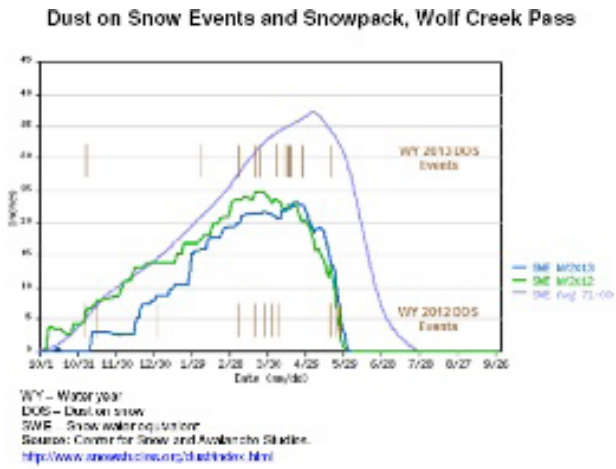
Wind stripping had removed recent snow and exposed the latest dust layer below the ridgeline at Wolf Creek Ski Area. Source: Center for Snow and Avalanche Studies, Colorado Dust on Snow program

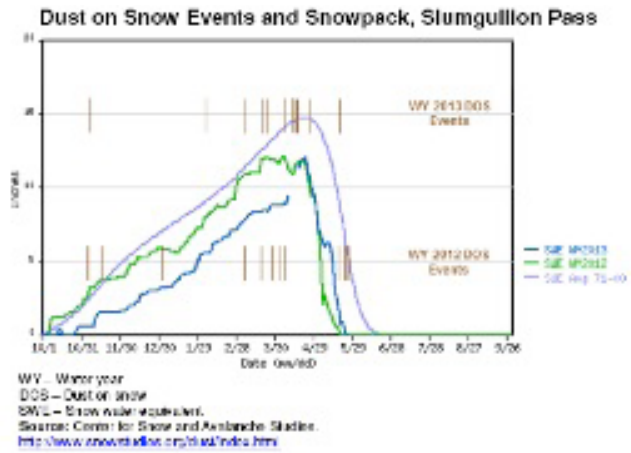
In May 2014, the Snotel sites in the Rio Grande Basin provided clear examples of the impacts of dust on snow and tree cover. While the vast majority of snow water equivalent (SWE) remained at a well-shaded, north facing Snotel site, located in the trees immediately behind roadside CDOT snow stakes, farther south a very exposed Upper San Juan Snotel site had lost more than half of its very poor Peak SWE. Because of the loss of tree cover at that site, the Upper San Juan Snotel experienced a comparatively high level of direct solar radiation compared to the well-shaded Wolf Creek Summit Snotel site. As a direct result, Upper San Juan Snotel snowmelt rates more accurately reflect the impact of dust-on-snow and reduced snow albedo.

FIGURE 73.

Dust on Snow Events and SWE for Wolf Creek and Spring Creek Snotel Stations.

From CEDS 2013, Figures F-10 and F-11.





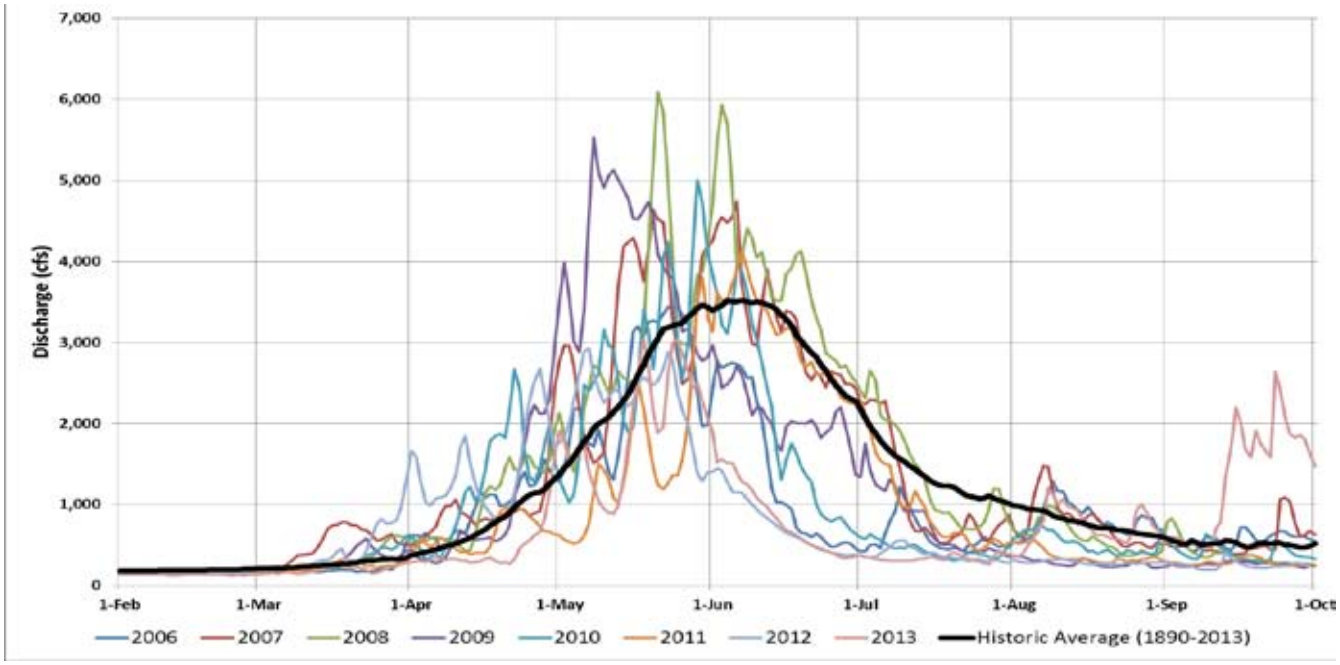
Unlike the Upper Colorado River Basin, there have not been any long term studies conducted and there are not any data for the amount of water lost due to dust on snow in the Rio Grande Basin. Hydrographs from the past seven years of stream flow data at the gage near Del Norte on the Rio Grande show that in general the timing of runoff is shifting to earlier in the year compared to the median record of the past 114 years, shown in Figure 74. However, this short record of data does not provide enough information to calculate a mean number of days for which snowmelt runoff is advancing, since there have been periods of earlier runoff in the past record.

The wide open Upper San Juan Snotel site. The solar panels face south. Patches of merged dust layers are seen between rapidly melting patches of recent new snow. US Hwy 160 is seen behind the Snotel.

FIGURE 74.

Streamflow at Rio Grande near Del Norte.

2006–2013. Source: Colorado Division of Water Resources



Appendix E: Climate Change in Colorado

Climate Change in Colorado

Several scientific publications, documents, reports, and studies have been produced by international bodies, federal agencies, the State of Colorado, and municipalities within Colorado that document anticipated impacts of climate change within Colorado. Available science regarding climate change projections is included in this Plan to analyze the potential impacts these changes in climate would have on hydrology and water supply. The results are not exhaustive and show findings from larger areas that include the Rio Grande Basin or are from areas that do not include the Rio Grande Basin but are nearby within Colorado.

Key information and findings from these data sources not specific to the Rio Grande Basin include:

- Temperatures are rising globally and may accelerate in the coming decades (National Academies 2008, IPCC 2001, National Research Council [NRC] 2001).

- Longer drought periods are expected (National Academies 2008, IPCC 2001, NRC 2001).

- Existing infrastructure may not be sufficient to meet water needs under climate change conditions. In particular in the western United States, water managers may no longer be able to reliably count on winter storms and spring runoff to fill their reservoirs. A balance between using reservoirs for flood control and for water supply must be struck (Wallis et. al 2008).

- The hydrologic cycle will likely change, bringing longer periods of drought alternating with spells of heavy rainfall. This may reduce the reliability of water storage and could increase reliance on groundwater potentially changing the interface between groundwater and surface water (Miller and Yates 2005).

The State of Colorado has published several studies that project climate change in Colorado and its implications for water resources in the state (CWCB 2008, CWCB 2010, State of Colorado 2007, and State of Colorado 2011). In general, conclusions from these studies include:

- Changes in temperature

- Average temperatures will increase by 2.5 degrees Fahrenheit to 5.5 degrees Fahrenheit by 2050 relative to 1950 to 1999 baseline conditions (CWCB 2008).
- Summers will warm more than winters (average of 3 degrees Fahrenheit to 7 degrees Fahrenheit summer increases, average of 2 degrees Fahrenheit to 5 degrees Fahrenheit winter increases) (CWCB 2008).
- Winters will be shorter and warmer with less snowpack (State of Colorado 2007).

- Changes in precipitation
  - Climate models do not agree on whether precipitation will increase or decrease on an annual basis in Colorado, but seasonal trends emerge in some areas (CWCB 2008).
  - Current year-to-year and decade-to-decade variations are larger than potential changes in precipitation due to climate change (CWCB 2008).
  - Throughout the Western United States, more observed winter precipitation has fallen as rain instead of snow resulting in reduced snowpack below 8,200 feet between 1949 and 2004. However, since most of Colorado's snowpack is above 8,200 feet, the snowpack changes have been smaller and less significant than other locations in the Western United States (CWCB 2008).
  - Snowpack in Colorado is projected to decline by 10 to 20% by 2050 (CWCB 2008).
  - In the Colorado River Basin, it is expected that there will be more precipitation during the winter months (November to March) and less precipitation during the summer months (April to October). The largest winter increases and smallest summer decreases are likely to be located in the northeast portion of the Colorado River Basin adjacent to the South Platte River Basin (CWCB 2010).

- Changes in hydrology
  - Study and modeling of climate change impacts on hydrology in the South Platte, Arkansas, and Rio Grande Basins is not as extensive as efforts to date on the Colorado River Basin (CWCB 2008).
  - Streamflow runoff will shift in timing and intensity with runoff beginning earlier in the spring and reduced late-summer flows (CWCB 2008).
  - Lower streamflows are projected in summer months (State of Colorado 2007).
  - Modeling from multiple studies predict that Colorado River flows will decrease by 6 to 20% from the 20th Century average by 2050 (CWCB 2008).
  - The Colorado River Water Availability Study shows basin-wide reduction of flows of 7 to 11% by 2040 except in the Yampa River, where flows are projected to increase by 4%.

However, upper Colorado River (above Kremmling) flows are projected to increase by 4 to 5% (CWCB 2010, Appendix E).
  - Longer periods of drought are predicted (State of Colorado 2007).
  - Statewide and regional water shortages and heat stress for irrigated agriculture will increase. Soil moisture will decline, crops will require more irrigation and some crops may not survive mid-summer droughts and heat spells (State of Colorado 2007).

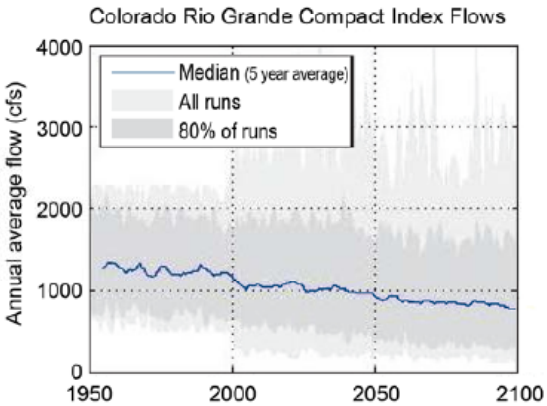
The Upper Rio Grande Impact Assessment (URGIA)

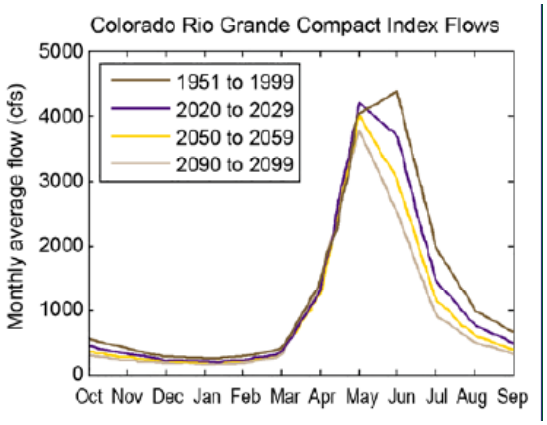
The study used downscaled CMIP-3 data (http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html) to project temperature and precipitation in the Basin until 2100 using several GCMs. Then, using the Upper Rio Grande Simulation Model (URGSiM), these climatic projections were translated into projections of natural inflow and gage flow. URGSiM incorporates precipitation, runoff patterns, Rio Grande and Conejos Compact administration, and water rights administration in a simplified manner in order to produce these results. As with any climate change study, there is a high degree of uncertainty associated with making quantitative predictions. Sources of uncertainty include assumptions, simplifications, and lack of sophistication in the GCMs, the downscaling procedure to a very heterogeneous area of the Rio Grande Basin, and assumptions and simplifications in URGSiM. General qualitative trends in the modeling results bear a higher degree of certainty and offer useful insights for planning.

Key results from the report include:

- Flows at the index gages (Rio Grande near Del Norte, Conejos River near Mogote, Los Pinos River near Ortiz, San Antonio River at Ortiz) will decrease by approximately one-third overall by 2100
  - The median of native inflows at the 4 gages decreases by 33% from 1,200 cfs between 1950–1999 to 800 cfs by 2100. This decreasing trend is seen for all flows between 10th and 90th percentile of model runs.
  - Increased variability (overall annual low and high flows) is seen starting in 2000

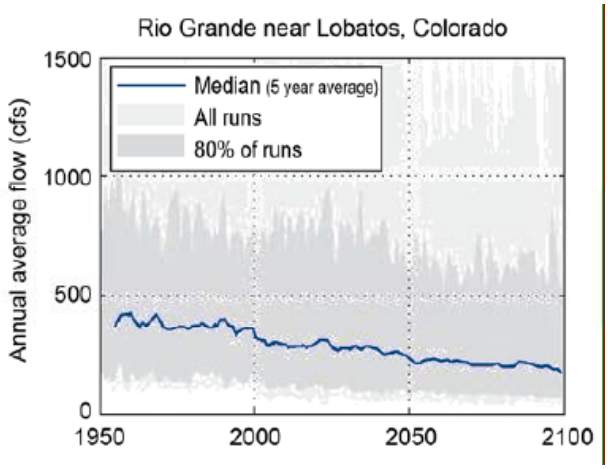
- The peak flows shift earlier — from June to May
  - Variability in timing of peak flow increases through time
  - April and May are more likely to see flows greater than the maximum flows from 1950 through 1999 even as overall flow decreases

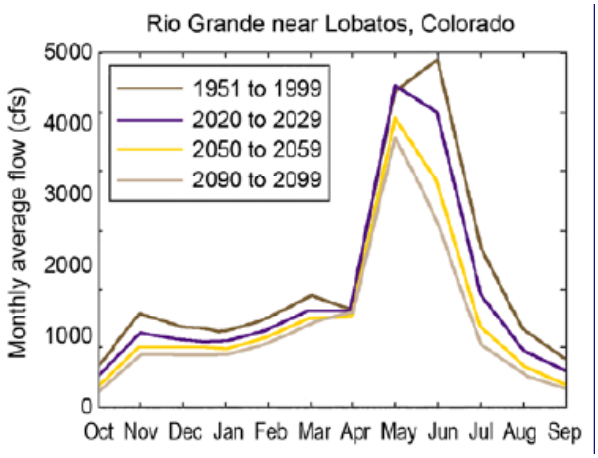




- The greatest decreases in flow occur between June and September

- Downstream, flows would decrease by 50% at Rio Grande near Lobatos
  - Average flow will decrease from 400 cfs to 200 cfs by 2100
  - This reduction is greater than the reduction at the index gages, suggesting Rio Grande Compact structure may buffer consumptive use in San Luis Valley at the expense of downstream deliveries to New Mexico
  - Colorado remains compliant of Rio Grande and Conejos Compacts



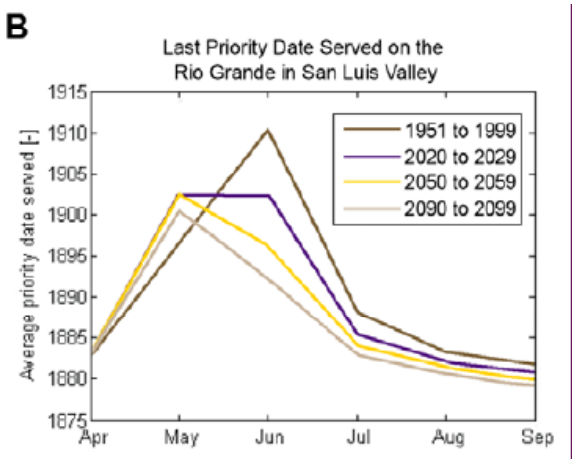


- Fewer water rights are served on average as a result of the decreased flow
  - From 1950 to 1999 the average junior-most water right to be served in June on the Rio Grande was a 1910 priority whereas by 2100 it is anticipated to be an 1890 water right. The junior-

most priority in May is predicted to increase from 1895 to 1900 due to earlier runoff.

Further, the water supply to the Upper Rio Grande will be subject to increased variability and uncertainty. We are already experiencing increases in extreme temperatures. Looking ahead, we anticipate greater year-to-year variability in all aspects of our climate and hydrology.

There will also be changes in the geographic distribution and timing of runoff. Although the projections here do not portray it, other studies (e.g., Asmerom et al. 2013) have indicated some potential for strengthening of the summer monsoons, with corresponding increases in the portion of the Basin's precipitation that falls downstream of our current water storage infrastructure. The projections suggest a somewhat more reliable supply from the San Juan-Chama Project than for the native Rio Grande supply (as long as there is no across-the-board decrease in available supply in the Upper Colorado River system). A greater reliability of the imported water supply than the native supply, which has the most senior users, could have significant socio-economic implications. (Llewellyn, 2013)



Appendix F: Forest Health

Formation of the Forest

Predating the formation of the Rio Grande National Forest (RGNF) in 1908, an Act of Congress, dated March 3, 1891, authorized the President to establish reservations of timber lands (State of Colorado 1983). The reasons for this authorization were a growing concern by the public and by newly formed forestry groups for conservation of timber resources. The concern included watershed protection and maintaining the forests for recreational purposes (Robinson 1975).

Public sentiment pertaining to formation of the original Forest Reserves was varied. Generally, the local communities were in favor of the reserves. Farmers wanted protection of the watershed from fire to insure water for irrigation. Miners wanted a continuous supply of timber for their mines, and cattleman wanted the reserves to protect their ranges from overuse by sheep. Local business people were in favor of whatever was good for the general welfare of the community (DuBois 1903).

Sheep men opposed the formation of the reserves because they felt that, possibly, the summer range would become closed to sheep grazing altogether. Lumbermen were also worried about restrictions on cutting, although some realized the benefit in the long run (DuBois 1903).

Spruce Bark Beetle Infestation

The Rio Grande National Forest is undergoing a big change in the high elevation forests as literally millions of trees are succumbing to the spruce bark beetle. More than 480,000 acres of spruce-fir forest have been infested by spruce beetle since 2005 and the beetles are continuing to spread. The native spruce beetle primarily attacks mature Engelmann spruce, although it sometimes infests blue spruce too. The tiny beetle is killing trees down to 5 inches in diameter. Luckily, smaller spruce and all sizes of subalpine fir will continue to survive and they will provide the base for creating the next forest.

Results from the 2013 Forest Health Aerial Survey on the Rio Grande National Forest indicate a spruce beetle infestation increase of 98,000 acres – growth of the spruce beetle infestation on the Rio Grande National Forest (RGNF) in 2013. Aerial survey data is generally at least one year behind the actual spread of the spruce beetle infestation because it takes a year or more from the time of infestation for the needles of the trees to die,

thus allowing detection from the air. Close to 85% of the spruce-fir forest on the RGNF has been infested with spruce beetle since 2005.

Direction of spread beyond the RGNF – the beetles continued to spread on the east side of the La Garita Mountains and have infested most of the spruce forests on the west side of the Saguache Ranger District. Pockets of spruce beetle infestations are expanding throughout the Sangre de Cristo Mountains. Beetle infestations are also expanding throughout the South San Juan Mountains west of La Jara and Antonito, and in the mountains south of Del Norte and South Fork. Not all areas are infested equally. In some areas, all the spruce trees larger than 5 inches in diameter have been killed by spruce beetles. In other areas, there is a mixture of dead and living spruce trees of all sizes. Luckily, subalpine fir and many of the young spruce will survive the infestation.

Spruce beetles kill the trees by burrowing under the bark and eating tunnels through the cambium and phloem layers just underneath the bark. These layers are responsible for transporting nutrients and sugars throughout the tree. The beetles and their larva will create tunnels encircling the tree, thus stopping the flow of nutrients and sugars. As a result, the trees essentially starve. In addition, the beetles often carry a fungus on them which spreads into the sapwood of the tree and clogs the vessels that transport water throughout the tree. In the Rocky Mountains, spruce beetles primarily infest Engelmann spruce, which grow in our high elevation forests. Spruce beetles can infest and have been found in some of the blue spruce on the RGNF.

Forest Management and Improving Forest Health

Air

For more than a decade, carbon sequestration and carbon effects on climate and temperature have been in the spotlight. Improved forest management can make a difference in carbon efficiencies and capacity. Carbon is stored in vegetation, soils, oceans, the atmosphere, and fossilized remains of carbon-based organisms (forming fossil fuels) (Viers, 2005). Carbon dioxide (CO2) is the most abundant of the "greenhouse" gases, which have acquired that name because they trap heat instead of allowing it to escape into the upper levels of the atmosphere. Research indicates that accumulation of these gases close to the earth's surface is increasing global temperatures.

A significant percentage of the earth's carbon is stored in forests, particularly rainforests and old-growth forests. Simply put, as trees grow, they take in carbon, and as they die they release it. Carbon release is

typically a long-term cyclical process, but it can be accelerated by the deterioration of forests through fire, disease, or pest infestation. One strategy to increase the amount of carbon that forestland can absorb or sequester is restoring the forests to healthier conditions. Optimum forestry practices can shape forest structure; influence forest growth rates, and increases carbon up-take and storage efficiencies.

Watershed and Water Supplies

In 2011, results were released of a study in the Sierra Nevada regarding watershed enhancement as a result of forest treatments (Bales et al., 2011). According to this report, preliminary estimates, based on average climate information, suggest that reducing forest cover by 40% across watersheds in the Sierra Nevada could increase water yields by about 9% and extend snow storage — that is, delay snowmelt — by days or even weeks. This study cautions that results are very site-specific; slope, aspect and, elevation are major contributing factors to snowpack moisture content and longevity.

Plants' Water Use

The Arizona Water Institute (Kolb, 2009) supported a study to measure water loss by tree foliage following restoration-thinning treatments to reduced tree density and fire risk in ponderosa pine. Reducing tree basal area by 35% reduced evapo-transpiration by 17% the first year after thinning, and by 15% the following year (Kolb, 2009). Measurements of soil water storage were consistently greater starting the first spring after thinning, indicating that tree density reduction resulted in increased available soil moisture. This increase soil moisture has a direct effect on understory growth and regeneration.

Tree Health and Vigor

One of the indicators of reduced tree vigor is that the insect epidemics are readily visible in many forested locations throughout the Rocky Mountains from Mexico north through Canada. This condition obviously exists in the RGNF. Endemic (low-level) damage from insects and disease is common and natural in the forest. However, epidemic outbreaks involve larger areas, and result in more extensive decline, and the widespread death of trees. A great deal of research is underway on the current insect activity — for example, of bark-beetle infestations. Yet little can be done to stop a bark-beetle outbreak that is in progress. Colorado alone has seen 3.5 million acres (5468 square miles) affected by Mountain Pine Beetle as of 2011, according to the Colorado State Forest Service (2011 Forest Health Aerial Survey Results, CSFS).

Utah State University is researching the resistance of conifers to bark-beetle infestation as related to tree health (Christiansen, Warning, & Berryman, 1987). Coniferous trees have two major defense mechanisms against bark-beetle attacks. Several genera (such as Pinus, Picea and Larix) have a system of resin ducts within the phloem and the xylem (which, respectively, carry food downward, from needles to roots, or carry water and dissolved minerals upward, from roots to needles). If adequate amounts of stored resin are exuded from these ducts, intruding beetles may be repelled or "pitched out." A conifer's ability to resist or repel a beetle attack is directly related to the amount of resin produced by the individual tree, and the tree's ability to exude resin depends on the storage capacity of the duct system and the viscosity (thickness) of the oleoresin, which seems related to tree vigor. Resin production and viscosity are reduced in stressed forest conditions, such as drought and overstocking.

If the resin flow fails to stop the beetles, the insects infect the host tissues with a variety of microorganisms, (such as fungi, bacteria or viruses) among which are usually the wood-staining fungi. These fungi can kill healthy trees by penetrating their sapwood and blocking the flow of fluids within the tree. Most plants respond to an infection produced by microorganisms with a hypersensitive reaction and form a necrotic area (a scar of dead wood) around the point of infection to deprive the invader of living tissue and to thus restrict its growth. In conifers, this scar is also impregnated with resinous and phenolic compounds that are highly toxic to bark-beetle eggs and larvae and that inhibit fungal growth. This wound reaction defends against the attack.

Results of a northern Arizona ponderosa study indicated old pre-settlement trees (established before 1880s) exhibited improved condition and vigor following a restoration thinning treatment (Wallin, Kolb, Skov, & Wagner, 2008). There were measurable increases in canopy growth and uptake of water, nitrogen and carbon, a current environmental concern (Kolb, 2009; Tang, Qi, Misson, & Goldstein, 2005). Another study showed that, in turn, with improved vigor these pre-settlement trees recovered their healthy resistance to insects and disease (Stone, Kolb, & Covington, 1999). Younger trees that had grown under intense competition caused by tree density showed even greater beneficial effects, in terms of increased growth rates, when restoration thinning and prescribed burning altered their environment. A study published by the Society of American Foresters (Skov, Kolb, & Wallin, 2003) found that old-growth, pre-settlement ponderosa trees (trees between 150 and 450 years old) showed less response to restoration thinning and broadcast burning than post-settlement ponderosa (those approximately 80 years old). Based on bole radial growth, the growth rates of the older trees were not significantly affected by treatment, perhaps because these trees had reached their peaks, with growth rates stabilized or declining. The average growth of the younger post-settlement trees was significantly higher in the heavily thinned plot. Measurements taken one and two years after treatment indicated that the restoration measures implemented in this study (thinning followed by low-intensity prescribed burn) had larger

positive effects on the photosynthesis of younger post-settlement trees than on old-growth pre-settlement trees. These beneficial effects were most pronounced during periods of drought.

Wildlife Populations and Habitats

The food sources available to wildlife are very limited in areas where tree crowns touch, producing overwhelming shade on the forest floor. Historic fires provided forest openings where a variety of types of vegetation thrived, and so did birds and wildlife. Thinning followed by low-intensity prescribed fire can recreate these openings. Native plants return quickly, particularly to the bare soil (Wayman & North, 2007). Increased understory light and reduced litter, slash, and shrub cover were most associated with increases in species richness and herb cover.

Populations of most bird species associated with grassland, shrub-scrub habitats and with disturbed areas in forested habitats (referred to as disturbance-dependent species) have declined sharply (Hunter, Buehler, Canterbury, Confer, & Hamel, 2001).

Many of these disturbance-dependent species are now extinct, rare, threatened, or endangered. This raises a question of balance between conservation efforts for birds dependent on disturbance and birds more closely associated with mature forests. Populations of most bird species associated with grassland, shrub-scrub habitats and with disturbed areas in forested habitats (referred to as disturbance-dependent species) have declined sharply (Hunter, Buehler, Canterbury, Confer, & Hamel, 2001). Many of these disturbance-dependent species are now extinct, rare, threatened, or endangered. This raises a question of balance between conservation efforts for birds dependent on disturbance and birds more closely associated with mature forests.

A study undertaken by the Institute for Bird Populations (2002) evaluated the ecological effects of thinning on breeding-bird populations in stands of Sierran mixed conifer forest. Bird counts demonstrated that populations of many species expanded dramatically in thinned areas. Shrub-nesting species were more abundant on the thinned plots, while species that are generally considered to be resident in forest interiors were detected in similar densities on both thinned and non-thinned plots. The overwhelming majority of nests were located in the thinned plots and nest success rates (fledglings) were nearly equivalent in both plot types.

Concern for the spotted owl, an endangered species, has played prominently in forest-management decisions in the western United States, including Colorado. According to research completed by the US Forest Service, Pacific Southwest Research Station, modest fuel treatments in the Sierra Nevada would not be expected to reduce canopy cover enough to have measurable effects on owl occupation and reproduction (Lee & Irwin, 2005). This research indicated that habitat needs for the spotted owl can

be incorporated in developing fire- and fuels-management strategies in ways that also lessen the chances of extreme wildfire.

In the big picture, changing forest conditions and availability of wildlife habitat (terrestrial or aquatic) will increase the diversity of plants, birds, and wildlife to maintain healthy populations in larger areas. Small mammals also thrive in thinned forests and quickly repopulate newly created openings (Converse, Block, & White, 2006). However, a decrease in shrub cover and slash was negatively associated with some small mammal species. No two wildlife species are affected by habitat changes in the same way or to the same degree. Enhancement of habitat for all species within a given area is not always practical or possible. Key wildlife species must be identified and projects designed and implemented to meet the needs of those key species. Overall, productive wildlife habitat depends on diversity in space, cover, food, and water (Stevens, 2004).

Appendix G: Soil Health

With the overall health of the watershed as a top priority goal for the Rio Grande Basin's Water Plan, and with the reality of ongoing drought, wind erosion, climate change and the required dry-up of groundwater-dependent agricultural lands to replenish the groundwater aquifer, the improvement of soil health across the entire region provides a significant opportunity for the Basin. Soil condition, management and monitoring are critical factors for land managers, from the high country and forested lands in the headwaters (including fire-impacted areas) to the rangelands at mid-elevation to the farmlands and riparian areas and wetlands on the Valley floor.

In the Rio Grande Basin, an extended drought has exacerbated other impacts on soil health. Within the Basin, wind-transported sediment has clearly existed for millennia, as evidenced by the Great Sand Dunes. However, excessive wind erosion from disturbed farmlands also affects air quality and reduces soil health. As in many farming areas, the health of soils in the San Luis Valley has been deteriorating in quality with farming practices that rely upon annual plowing and increasing use of chemicals to maintain farm yields. Rangelands are likewise an important component of the hydrology of the Basin. The condition of the vegetation, watercourses and soil over these large areas of the land base are important to water infiltration, to wildlife habitat for many important bird species and to grazing wildlife and livestock for providing forage for grazing.

Thus, for many reasons, enhancing and maintaining soil health is of great importance in the Rio Grande Basin, where the community relies on agriculture for a large portion of its economy, where recreation depends upon a healthy watershed and where thousands of species rely on a healthy ecosystem.

Importance of Soil Health

The Natural Resources Conservation Service defines soil health as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans. The biotic communities within soil need basic necessities for life (food, shelter and water) in order to perform the functions required to keep soils functioning. Healthy soil is not an inert growing medium, but rather is teaming with billions of bacteria, fungi and other microbes that are the foundation of a symbiotic ecosystem. This ecosystem can be managed to provide nutrients for plant growth, to absorb and hold water for use during drier periods, to filter and buffer potential pollutants from leaving fields, to serve as a firm foundation for agricultural activities and to provide habitat for soil microbes to flourish

and diversify to keep the ecosystem running smoothly (U.S. Department of Agriculture, Natural Resources Conservation Service n.d. (b)).

Healthy soil provides numerous benefits including clean air and water, water and carbon storage, thriving forests, grasslands, and crops, productive grazing lands, diverse wildlife habitat and scenic landscapes. While providing these benefits, soil performs five essential functions:

- Regulating water. Soil helps control where rain, snowmelt and irrigation water goes. Water and dissolved solutes flow over the land or into and through the soil, recharging aquifers, keeping high-altitude streams flowing throughout the seasons and providing resiliency through drier periods.

- Sustaining life. Soil sustains plant and animal life, both above and below ground.

- Filtering and buffering potential pollutants. The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits.

- Cycling nutrients. Carbon, nitrogen, phosphorus and many other nutrients are stored, transformed and cycled in the soil. Healthy soils also "sequester" or hold carbon and water in the ground, where they are beneficial and can help mitigate climate change.

- Providing physical stability and support. Healthy soil structure provides a medium for plant roots and keeps soils more securely in place, vs. being mobilized by water or wind (U.S. Department of Agriculture, Natural Resources Conservation Service n.d. (b)).

Figure 75 shows a simplified soil food web and all of the different types of species responsible for soil health.

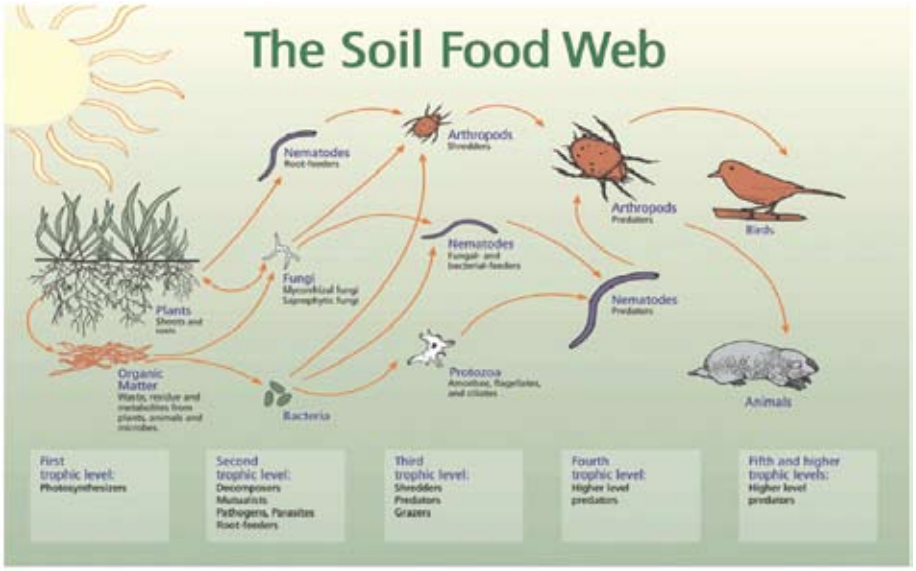


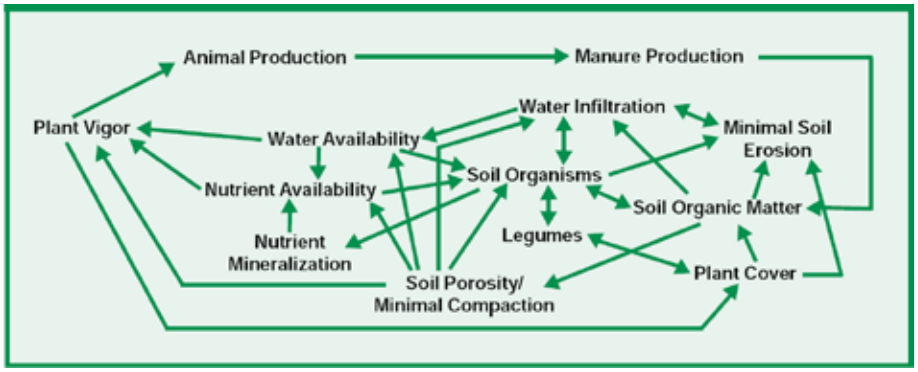
FIGURE 75.

The Soil Food Web

Source: U.S. Department of Agriculture, Natural Resources Conservation Service n.d. (a)

http://www.riograndefarm.org/wordpress/wp-content/uploads/2013/01/rgcf-usda.pdf

In addition to the importance of soil health on farms, soil is a vital component of rangelands, which comprise much of the uplands that connect the high country of Colorado and the lower-altitude farmlands and urban areas. Grazing of livestock can be managed to produce healthy, diverse stands of forage that provide habitat for a wide array of wildlife as well as food for livestock. It is critical to manage grazing in ways that improve soil health for improved forage production while also maintaining vegetative cover and plant litter to help capture precipitation in the soil and maintain soil moisture for longer periods. This also protects rangeland soil from erosion and fluctuating soil temperatures, as well as enhances soil biodiversity (San Luis Valley Wetlands Focus Area Committee 2012). Figure 76 provides another view of how range animals, in combination with soil organisms, nutrients, organic matter and plants, can contribute to creating a healthy soil ecosystem.



Healthy plant growth provides plant cover over the entire pasture. Cover from growing plants and plant residues protects the soil against erosion while returning organic matter to the soil. Organic matter provices food for soil organisms that mineralize nutrients from these materials and produce gels and other substances that enhance water infiltration and the capacity of soil to hold water and nutrients.

FIGURE 76.

Nutrient Cycles in Pastures

Source: Bellows 2001

http://attra.ncat.org/attra-pub/nutrientcycling.html

Ways to Improve Soil Health

There are many causes of soil degradation and erosion. However, in general, managing for soil health and improving soil function on farms and rangelands involves maintaining suitable habitat for the myriad creatures that comprise the soil food web. Some common practices that help land managers prevent soil erosion and build soil quality fall into four main categories, according to NRCS (U.S. Department of Agriculture, Natural Resources Conservation Service n.d. (c)), which are key to improving soil health:

1. **Keep soil covered as much as possible.** Whether it's with green manure, cover crops, mulch or decomposing crop residue, maintaining a soil cover prevents soil erosion, reduces temperature, intercepts raindrops (to reduce their destructive impact), suppresses weed growth, and provides habitat for members of the soil food web that spend at least some of their time above ground. Keeping soil covered also provides for improved stream flows, decreases sedimentation, and improves overall water quality.

2. **Disturb the soil as little as possible**. Physical soil disturbance, such as tillage, results in bare and/or compacted soil that is destructive and disruptive to soil microbe communities and creates a hostile environment for them to live. It also increases evaporation of moisture held within soil spaces, thus requiring water replenishment. Poorly managed grazing that does not allow adequate recovery time for grazed plants tends to reduce root mass, expose soil leading to increased runoff and result in greater fluctuations in soil temperature. Annual plowing of farm soils and lack of ground cover on rangelands reduces habitat for soil microbes and results in a diminished soil food web. No-till or minimum tillage practices are encouraged in farm production. Well-managed grazing on rangelands is encouraged to enhance ground cover and forage production.

3. **Keep plants growing throughout the year to feed the soil**. Living plants maintain a rhizosphere, an area of concentrated microbial activity close to the root. The rhizosphere is the most active part of the soil ecosystem because it is where the most readily available food is and where peak nutrient- and water-cycling occurs. Plant roots exude microbial food to attract and feed microbes that provide nutrients (and other compounds) to the plant at the root-soil interface where the plants can take them up. Since living roots provide the easiest source of food for soil microbes, on farmland, growing long-season crops or a cover crop following a short-season crop, feeds the foundation species of the soil food web as much as possible during the growing season. Healthy soil is dependent upon a well-fed soil food web. Providing plenty of easily accessible food to soil microbes helps them cycle nutrients that plants need to grow. Sugars from living plant roots, recently dead plant roots, crop residues and soil organic matter all feed the many and varied members of the soil food web.

4. **Diversify as much as possible using crop rotation and cover crops**. Plants also interact with specific soil microbes by releasing carbohydrates (sugars) through their roots into the soil to feed the microbes in exchange for nutrients and water. A diversity of plant carbohydrates is required to support the diversity of soil microorganisms in the root zone. In order to achieve a high level of diversity, different plants must be grown. The key to improving soil health is ensuring that food and energy chains and webs consist of several types of plants or animals, not just a few. A diverse and fully functioning soil food web provides for nutrient, energy and water cycling that allows a soil to express its full potential. Increasing the diversity of a crop rotation and cover crops increases soil health and soil function, reduces input costs and increases profitability.

Photo: Rio de la Vista

Back cover: Rio Grande flows through the San Luis Hills in southern Colorado. Looking south, with Ute Mountain on the center horizon. Photo: Adriel Heisey

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