RECLAMATION

Managing Water in the West

Arkansas Valley Conduit and Long-Term Excess Capacity Master Contract

FINAL ENVIRONMENTAL IMPACT STATEMENT

Prepared by:
United States Department of the Interior
Bureau of Reclamation
Great Plains Region
Eastern Colorado Area Office

August 2013

MISSION STATEMENTS

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Final Environmental Impact Statement Arkansas Valley Conduit and Long-Term Excess Capacity Master Contract, Fryingpan-Arkansas Project

Bent, Chaffee, Crowley, Custer, El Paso, Lake, Pueblo, Fremont, Kiowa, Otero, and Prowers counties, Colorado

Prepared by the U.S. Department of the Interior, Bureau of Reclamation

Cooperating Agencies:

- Bent County
- Board of Water Works of Pueblo
- City of Pueblo
- Colorado Department of Natural Resources
- Colorado Department of Transportation
- Colorado Division of Water Resources
- Colorado Division of Parks and Wildlife
- Fountain Creek Watershed and Flood Control District
- Kansas Division of Water Resources
- Lower Arkansas Valley Water Conservancy District
- Otero County
- Prowers County
- Pueblo County
- Southeastern Colorado Water Conservancy District
- U.S. Army Corps of Engineers
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service

Abstract:

The Bureau of Reclamation has made available the final environmental impact statement for the Arkansas Valley Conduit and Long-Term Excess Capacity Contract, Fryingpan-Arkansas Project, Colorado. The proposed Arkansas Valley Conduit, conveyance contract for the Pueblo Dam north-south outlet works interconnect, and long-term excess capacity master contract to store water in available space in Pueblo Reservoir would deliver water that would meet Environmental Protection Agency and state drinking water quality requirements and help water providers throughout the Arkansas River Basin in Colorado reliably meet existing and future water demands.

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Abbreviations and Acronyms

AVC	Arkansas Valley Conduit
CCR	Code of Colorado Regulations
CFR	Code of Federal Regulations
Compact	Arkansas River Compact
CORADS	Colorado Radionuclide Abatement and Disposal Strategy
Corps	U.S. Army Corps of Engineers
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EPT taxa	Mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) taxa
Fry-Ark	Fryingpan-Arkansas
Health Department	Colorado Department of Public Health and Environment
GIS	geographical information system
IMPLAN	IMpact Analysis for PLANing
Interconnect	Pueblo Dam north-south outlet works interconnect
JUP	Joint Use Pipeline
Master Contract	long-term excess capacity master contract
MODSIM	MODSIM generalized river basin modeling software
NEPA	National Environmental Policy Act
NPANIW	not previously allocated non irrigation water
NPDES	National Pollutant Discharge Elimination System
OM&R	operation, maintenance, and replacement
PHABSIM	Physical Habitat Simulation System
Reclamation	Bureau of Reclamation
SDS	Southern Delivery System
SHPO	State Historic Preservation Office
Southeastern	Southeastern Colorado Water Conservancy District
STAG	State and Tribal Assistance Grant
TMDL	Total Maximum Daily Load
USGS	U.S. Geological Survey
WUA	weighted usable area

Units of Measurement

µg/L	microgram per liter	gpcd	gallon per capita per day
µS/cm	microsiemen per centimeter	gpm	gallon per minute
ºF	degree Fahrenheit	lb/acre	pound per acres
ºC	degree Celsius	mg/L	milligram per liter
ac-ft	acre-foot	mgd	million gallons per day
cfs	cubic foot per second	pCi/L	picocurie per liter

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Chapter 1 Purpose and Need

This Final Environmental Impact Statement (EIS) discloses potential environmental consequences associated with constructing and operating the proposed Arkansas Valley Conduit (AVC), entering into a conveyance contract for the Pueblo Dam north-south outlet works interconnect (Interconnect), and entering into a long-term excess capacity master contract (Master Contract). These facilities and contracts, or proposed actions, are needed in the Arkansas River Basin to deliver water that meets federal and state drinking water standards, meet existing and future water demands, and provide system redundancy for water deliveries.

The U.S. Department of the Interior, Bureau of Reclamation (Reclamation) is the lead federal agency for preparation of this EIS. All proposed actions would be part, or use features, of the Fryingpan-Arkansas (Fry-Ark) Project, which is owned by the United States, and operated by Reclamation.

Photo 1–1. Pueblo Dam and Reservoir is the terminal storage facility of the Fry-Ark Project

Reclamation has defined the AVC, Interconnect contract, and Master Contract to be major federal actions where environmental effects are potentially significant. Although the AVC, Interconnect contract, and Master Contract are independent actions, Reclamation chose to evaluate the environmental effects of these proposed actions in the same EIS because of overlap in area, timing, and participants.

This EIS discloses direct, indirect, and cumulative effects of the proposed actions connected to a range of reasonable alternatives, including a No Action Alternative. The proposed 50-year repayment period for AVC would begin following construction in about 2020. Therefore, this EIS considers potential AVC effects through 2070. The 40-year period being considered for the Interconnect contract would commence before 2020 or when AVC is completed. The 40-year period being considered for the Master Contract would commence about 2014, after the EIS and contract negotiations are completed. Because of uncertainty in the timing of the Record of Decision and contract negotiations, this EIS considers potential effects of the Interconnect contract and Master Contract through 2060. The EIS also evaluates best management practices and mitigation measures to avoid, minimize, or rectify identified environmental effects.

Fryingpan-Arkansas Project Description

The Fry-Ark Project is a multipurpose, transbasin water diversion and delivery project in Colorado, built between 1964 and the mid-1980s by the United States government. It diverts an annual average of 48,500 acre-feet (ac-ft) of water from the Fryingpan River and other tributaries of the Roaring Fork River on the West Slope of the Rocky Mountains to the Arkansas River Basin on the East Slope. The Fry-Ark Project also stores Arkansas River Basin water that is primarily available during wet years, and other non-Fry-Ark supplies through contracts with water users. Fry-Ark yield is a supplemental water supply for municipal, industrial, and irrigation use in the Arkansas River Valley of Colorado.

> 1 **acre-foot (ac-ft)** equals 325,851 gallons. 1 ac-ft is approximately the size of a football field filled with water 1 foot deep, and meets the needs of a family of 4 for about 1 year.
>
> **Yield** is water available from untreated water collection systems, expressed primarily in acre-feet per year (ac-ft/yr). Yield can vary depending on demands in the service area and on the level of service assumed.

The Fry-Ark Project consists of a series of diversion structures, pipelines and tunnels on the West Slope, a tunnel beneath the Continental Divide, five dams and reservoirs, a powerplant, and a municipal and industrial pipeline. Ruedi Dam and Reservoir on the Fryingpan River downstream from the Fry-Ark collection system stores water for use on the West Slope. The Boustead Tunnel diverts water from the West Slope collection system to Turquoise Lake on the East Slope. Sugar Loaf Dam (which impounds Turquoise Lake), Mount Elbert Forebay Dam and Reservoir, and Twin Lakes Dam and Reservoir are in the Upper Arkansas River Basin and store Fry-Ark water. The Mount Elbert Pumped Storage Powerplant, located on the banks of Twin Lakes Reservoir downstream from the Mount Elbert Forebay, generates hydroelectric power. Pueblo Dam and Reservoir, the largest Fry-Ark reservoir, is on the Arkansas River immediately upstream from Pueblo (Figure 1–1), and is the reservoir from which most Fry-Ark municipal, industrial, and irrigation deliveries are made. The Fountain Valley Conduit is a Fry-Ark feature that conveys municipal and industrial water from Pueblo Reservoir to users in the Fountain Creek basin.

The Southeastern Colorado Water Conservancy District (Southeastern) was formed in 1958 to develop, administer, and repay the Fry-Ark Project. Its boundaries extend along the Arkansas River from Buena Vista to Lamar, and along Fountain Creek from Colorado Springs to Pueblo.

Source: Courtesy of Colorado State University Water Resources Archive.
Photo 1–2. Pueblo Dam construction in the early 1970s

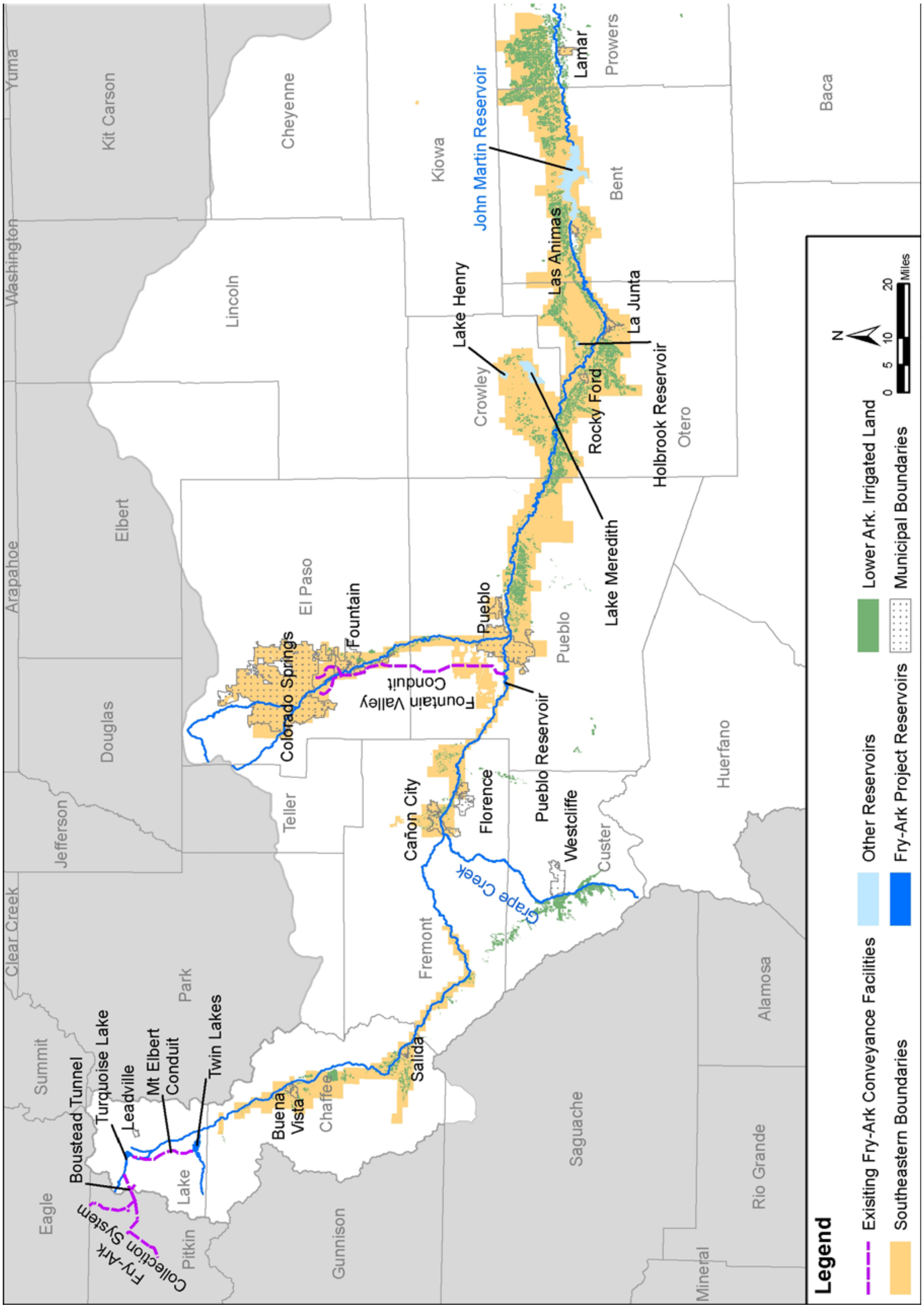


Figure 1–1. Fryingpan-Arkansas Project

Proposed Federal Actions

Three proposed federal actions by Reclamation are analyzed in this EIS (Table 1–1): AVC construction, operation, and repayment; entering into a conveyance contract for use of the Interconnect, which would be constructed as part of AVC; and entering into a Master Contract with Southeastern to store water in Pueblo Reservoir. While serving similar water supply and delivery purposes, the federal actions are independent of each other. Because the Interconnect is an engineering feature of AVC, it would only be constructed if AVC were constructed.

Table 1–1. Proposed Federal Actions

Proposed Action	Purpose	Participants	Reclamation Contract(s)
AVC construction and operation	Bulk water supply pipeline and related facilities for municipal and industrial water delivery	Southeastern (or a duly authorized Enterprise) and Forty AVC participants within Southeastern's boundaries	AVC Repayment, Operation and Maintenance, and Conveyance Contract; Term: 50 years
Issuance of a Pueblo Dam North-South Outlet Works Interconnect Long-Term Conveyance Contract to participants	Construction of a pipeline connection as part of AVC to allow flexibility in delivering water between the north or south outlets, if either outlet is temporarily shut down	AVC participants, Board of Water Works of Pueblo, Pueblo West, Southern Delivery System participants, and Fountain Valley Authority	Pueblo Dam North-South Outlet Works Interconnect Conveyance Contract; Term: 40 years
Issuance of a Long-Term Excess Capacity Master Contract to Southeastern	Long-term excess capacity storage in Pueblo Reservoir to improve water supply	Twenty-five AVC participants and twelve other entities within Southeastern's boundaries	Long-Term Excess Capacity Master Contract; Term: 40 years

Arkansas Valley Conduit Construction

AVC is a congressionally authorized Fry-Ark feature that was not completed during original Fry-Ark construction. AVC would be a bulk water supply pipeline designed to meet existing and future municipal and industrial water demands in the Lower Arkansas River Basin. Physical features that would be constructed include about 230 miles of buried pipeline, a water treatment facility, water storage tanks, pumping plants, and other related facilities. Operational components involving proposed water supplies would include water exchanges, storage, transfers, water deliveries, and other actions necessary to operate the conduit.

Forty water providers, most of whom signed a memorandum of agreement with Southeastern, would participate in AVC. Participants in AVC are referred to as "AVC participants" and are located within Southeastern's boundaries (Figure 1–2). AVC would not serve all water supply providers or users within Southeastern's boundaries; only AVC participants are evaluated in this EIS.

Photo 1–3. The AVC would be a buried pipeline, similar to the one shown in this photo, and would convey water from Pueblo Reservoir east to Lamar

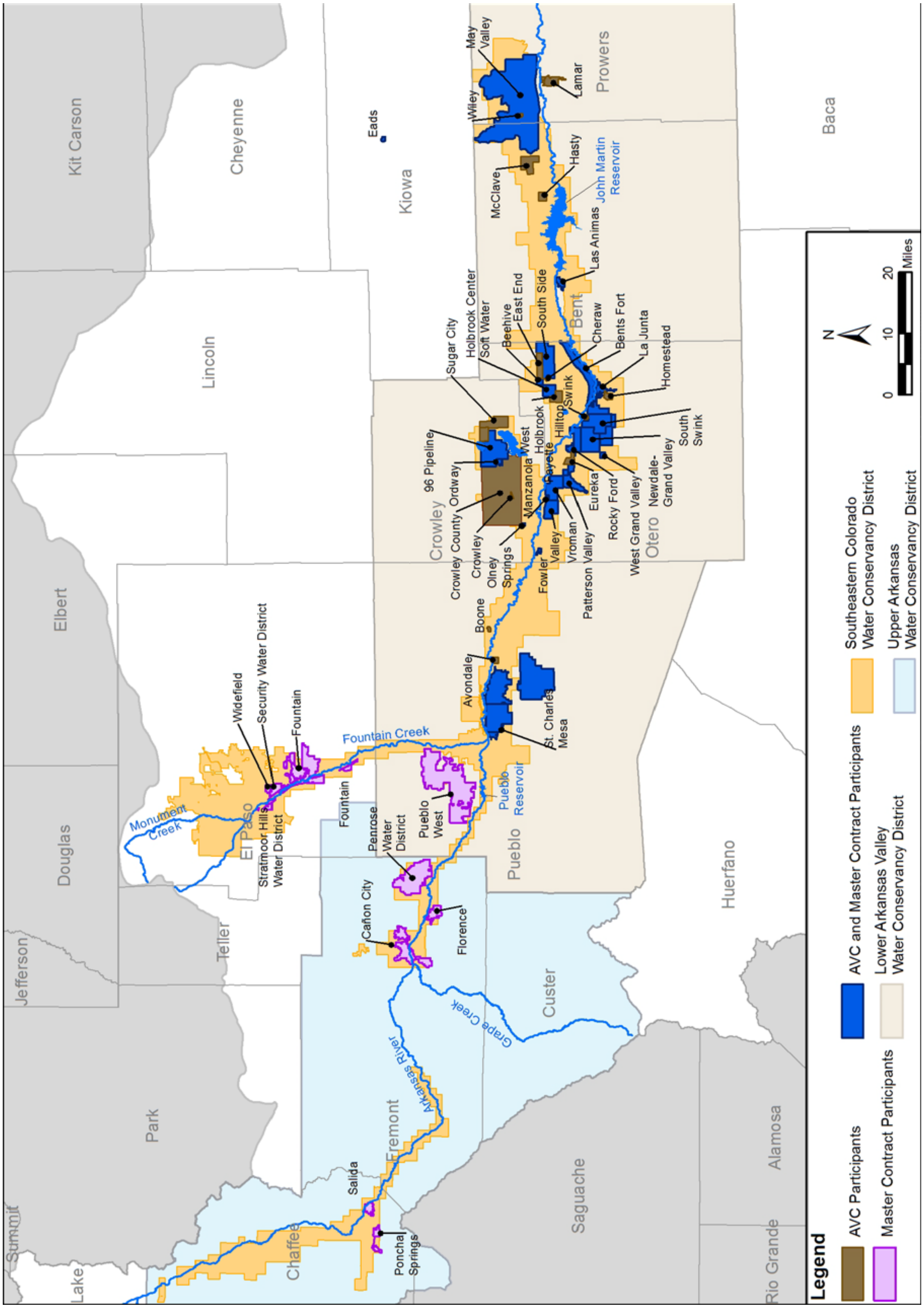


Figure 1–2. Arkansas Valley Conduit and Master Contract Participants

AVC participants include towns and rural domestic water supply systems in Pueblo, Crowley, Otero, Bent, Prowers, and Kiowa counties. Agricultural irrigation water users are not AVC participants and use of agricultural water is not a congressionally authorized purpose for AVC. A few industrial livestock operations are customers of AVC participants and would be served by the pipeline. AVC would deliver about 10,250 ac-ft per year to meet 82 percent of 2070 water demands for 74,255 people. AVC participants and their level of participation are in Table 1–2.

AVC was authorized by Congress in the original 1962 Fry-Ark legislation (Public Law 87-590). However, AVC was not constructed with the project primarily because of the beneficiaries' inability to repay construction costs. In 2009, Congress amended the original Fry-Ark legislation in Public Law 111-11, which authorized annual appropriations, as necessary, for constructing AVC, and included a cost sharing plan with 65 percent federal and 35 percent local funding.

The locally funded portion would be repaid by Southeastern to the federal government over a period of 50 years. Thus, constructing AVC would require a repayment, operation and maintenance, and conveyance contract between Reclamation and Southeastern to address responsibilities and payment, and conveyance of Fry-Ark and non-Fry-Ark water. If Southeastern is not the entity performing the actual operation, maintenance, and replacement than Reclamation would require that a separate contract be executed with the appropriate entity such as a Water Enterprise. The locally funded portion of AVC would be repaid after construction, estimated to be completed in about 2020. Therefore, this EIS analyzes effects of the AVC repayment and conveyance contract through 2070.

Table 1–2. AVC Participants and Requested Water Deliveries in 2070

AVC Participant	Annual AVC Deliveries (ac-ft)	AVC Participant	Annual AVC Deliveries (ac-ft)
Pueblo County		**Otero County (continued)**	
Avondale	164	Bents Fort Water Company	81
Boone	94	Cheraw	30
St. Charles Mesa Water District	2,651	East End Water Association	13
Crowley County		Eureka Water Company	86
96 Pipeline Company	27	Fayette Water Association	14
Crowley County Water Association	617	Fowler	220
Crowley	51	Hancock Inc.	18
Olney Springs	59	Hilltop Water Company	40
Ordway	366	Holbrook Center Soft Water	22
Sugar City	127	Homestead Improvement Association	9
Bent County		La Junta	2,299
Hasty Water Company	33	Manzanola	50
Las Animas	602	Newdale-Grand Valley Water Company	60
McClave Water Association	59	North Holbrook Water	8
Prowers County		Patterson Valley	17
Lamar	1,241	Rocky Ford	576
May Valley Water Association	222	South Side Water Association	5
Wiley	28	South Swink Water Company	92
Kiowa County		Swink	49
Eads	116	Valley Water Company	39
Otero County		Vroman	37
Beehive Water Association	10	West Grand Valley Water Inc.	15
		West Holbrook Water	9
			Total: 10,256 ac-ft

Pueblo Dam North-South Outlet Works Interconnect Conveyance Contract

The Interconnect would be a short section of pipeline that would convey water between the newly constructed (2012) north outlet works and existing south outlet works at Pueblo Reservoir during short-term maintenance and emergency outages. Participants in the Interconnect are referred to as the "Interconnect participants" and all are located within Southeastern's boundaries. Interconnect operations would require a long-term (40-year) conveyance contract between Reclamation and the Interconnect participants for use during periodic maintenance or emergency activities. The Interconnect would be constructed as part of AVC, and is proposed to meet the need for a redundant water delivery option from Pueblo Reservoir for about 1.5 million people when either the north or south outlet works from Pueblo Reservoir are temporarily out of service. The Interconnect contract would allow partial deliveries of water to water connections at Pueblo Reservoir for AVC, Colorado Parks and Wildlife Pueblo Fish Hatchery, Board of Water Works of Pueblo, Pueblo West Metropolitan District, Southern Delivery System (SDS), and Fountain Valley Authority.

Photo 1–4. The Interconnect pipeline would connect the existing Pueblo Reservoir south outlet works manifold (bottom-right of photo, below ground) to the north outlet works

Master Contract

Reclamation is proposing to enter into a 40-year contract with Southeastern to store non-Fry-Ark water in Pueblo Reservoir and other Fry-Ark reservoirs. The contract would be for use of excess capacity storage space in Pueblo Reservoir when this space is not filled with Fry-Ark water. The non-Fry-Ark water stored in Fry-Ark reservoirs would be subject to spill priorities in accordance with an existing contract between the United States and Southeastern (Reclamation 1965; see Chapter 3). Participants in the Master Contract are referred to as "Master Contract participants" and all are located within Southeastern's boundaries. Because Pueblo Reservoir is owned by the United States and operated by Reclamation, storage in Pueblo Reservoir by entities other than Reclamation requires a contract with Reclamation. Chapter 2 and Appendix B.6 discuss a range of potential costs participants may pay to store water in Pueblo Reservoir excess capacity accounts. While the storage rate would not be known until the

Photo 1–5. The Master Contract would allow storage of non-Fry-Ark Project water within available storage space in Pueblo Reservoir (shown in photo)

contract is negotiated, Appendix B.6 lists costs of other existing excess capacity contracts for illustration purposes.

The Master Contract would provide a portion of needed future water supply to about 465,000 people (including AVC participants). Southeastern would subcontract with the Master Contract participants to divide the requested storage space, as shown in Table 1–3. The Master Contract would not serve all entities within Southeastern's boundaries; only those entities who signed a memorandum of agreement with Southeastern to participate in the Master Contract are included in this EIS. Some AVC participants are also Master Contract participants and would store non-Fry-Ark water in Fry-Ark storage space for delivery through AVC.

Table 1–3. Master Contract Participants and Requested Storage

Water Provider [1]	Storage Request (ac-ft)	Water Provider [1]	Storage Request (ac-ft)
Chaffee County		**Otero County**	
Poncha Springs	200	*Beehive Water Association*	*18*
Salida	2,000	*Bents Fort Water Company*	*10*
Upper Arkansas Water Conservancy District	1,000	*Fayette Water Association*	*16*
Fremont County		*Fowler*	*50*
Cañon City	1,000	*Hilltop Water Company*	*35*
Florence	2,250	*Holbrook Center Soft Water*	*12*
Penrose	900	*Homestead Improvement Association*	*6*
El Paso County		*La Junta*	*2,000*
Fountain	1,000	Lower Arkansas Valley Water Conservancy District	5,000
Security	1,500	*Manzanola*	*60*
Stratmoor Hills	200	*Newdale-Grand Valley Water Company*	*50*
Widefield	650	*Patterson Valley*	*40*
Pueblo County		*Rocky Ford*	*1,200*
Pueblo West	6,000	*South Side Water Association*	*8*
St. Charles Mesa Water District	*2,000*	*South Swink Water Company*	*80*
Crowley County		*Valley Water Company*	*47*
96 Pipeline Company	*25*	*Vroman*	*41*
Crowley County Water Assn.	*1,000*	*West Grand Valley Water Inc.*	*15*
Olney Springs	*125*	**Bent County**	
Ordway	*750*	*Las Animas*	*300*
Kiowa County		**Prowers County**	
Eads	*50*	*May Valley Water Association*	*300*
			Total: 29,938 ac-ft

Note:
[1] Water providers in *italics* are participating in both AVC and Master Contract.

Purpose and Need

Each proposed federal action has a specific purpose and associated participant needs:

- The purpose of AVC is to deliver water for municipal and industrial water use within Southeastern's boundaries (Figure 1–2). This water supply is needed to supplement or replace existing poor quality water and to help meet AVC participants' projected water demands.
- The purpose of the Interconnect is to provide redundancy in water delivery to Interconnect participants. The Interconnect contract is needed through 2060 to convey water during short-term disruption of service from either the north or south outlet works at Pueblo Reservoir by transferring water to the working outlet.
- The purpose of the Master Contract is to provide excess capacity storage in Pueblo Reservoir for Master Contract participants within Southeastern's boundaries. A long-term storage contract provides surety and convenience not found in a short-term contract. The Master Contract secures a reliable water supply for participants to help meet projected demand through 2060.

Need for Arkansas Valley Conduit

There are two general needs for AVC: needs associated with drinking water quality and the need to meet existing and future water demands. These needs were identified from information gathered during a State and Tribal Assistance Grant (STAG) report (Black & Veatch 2010), information obtained through questionnaires submitted by each AVC participant, and other information gathered from AVC participants during the National Environmental Policy Act (NEPA) process.

Water Quality Need for Arkansas Valley Conduit

AVC participants generally have a need to meet federal and state drinking water standards and provide better quality water to customers. Currently, all but one of the AVC participants rely primarily on groundwater as their water supply source. AVC participant groundwater supplies consist of two types: water from alluvial aquifers and water from deep bedrock aquifers. The largest AVC participants rely almost exclusively on alluvial groundwater, making these supplies the highest use by volume, even though the majority of AVC participants rely on bedrock groundwater. St. Charles Mesa, which delivers surface water from the Bessemer Ditch and the Arkansas River, in addition to its

An **alluvial aquifer** is a shallow aquifer within sand and gravel layers and, in the Arkansas River Basin, is typically adjacent to the river and tributaries. Water quality in its alluvial aquifers can be influenced by a variety of factors, including surface streamflow water quality, land use, and geology. The aquifer is recharged from the surface and stream systems, resulting in "renewable" water sources.

A deep **bedrock aquifer** is contained within consolidated sedimentary material and does not receive surface water inflows except where exposed to the surface. Surface exposure is limited and frequently occurs along mountain fronts and other bedrock outcrops, resulting in extremely slow natural recharge of the aquifer. Surface land uses typically have less effect on bedrock aquifer water quality than on alluvial aquifers; water quality is instead primarily a function of geology. Slow recharge of the aquifer results in these aquifers typically being categorized as "nonrenewable" water supplies.

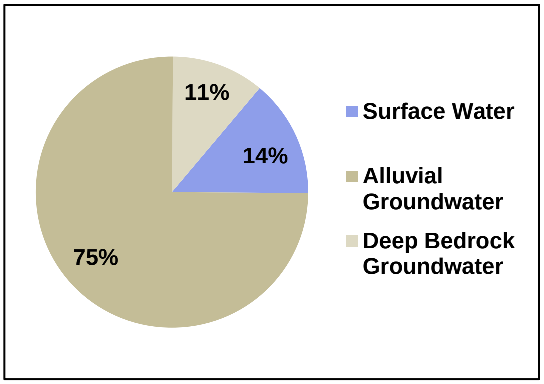
More information can be found in the Colorado Groundwater Atlas. (http://geosurvey.state.co.us/water atlas/) (Topper et al. 2003).

groundwater supplies, is the only AVC participant who directly diverts surface water as a primary drinking water supply. Figure 1–3 shows AVC participant water sources by volume.

While only 15 of 40 AVC participants rely on alluvial groundwater, it accounts for 75 percent of current total use (Black & Veatch 2010). In general, alluvial groundwater quality in the Lower Arkansas River has high levels of total dissolved solids (a measurement of salinity), selenium, sulfate, hardness, manganese, and uranium that exceed water quality standards. Although these constituents exhibit seasonal changes, water quality standards are typically exceeded year-round. With the exception of uranium, these constituents do not present substantial health issues, but they do affect water taste, color, and odor.

Twenty-nine AVC participants rely on the Dakota-Cheyenne aquifer. This deep bedrock aquifer is present in large portions of Colorado. The foremost water quality concern of AVC participants using the Dakota-Cheyenne aquifer is radionuclides. Radionuclides found in the Dakota-Cheyenne aquifer are present because of erosion and chemical weathering of naturally occurring mineral deposits (Malcolm Pirnie 2009a). Other constituents, such as total dissolved solids and sulfate, also exceed water quality standards. Deep bedrock aquifers are not influenced by seasonal changes and these water quality standards are exceeded year-round.

All but two AVC participants use conventional water treatment processes. These processes can be as simple as adding chlorine for disinfection, but can also include filtration or chemical addition to remove suspended solids. While conventional water treatment plants are relatively simple and inexpensive to operate, they cannot remove salt or radionuclides from water. Two AVC participants, Las Animas and La Junta, use reverse osmosis to treat their water. While reverse osmosis can treat source water to meet both primary and secondary drinking water standards, brine (salt) disposal is an environmental concern and operating costs are high. For these reasons, Las Animas and La Junta are interested in either abandoning or limiting the use of these facilities in the future.



Data Source: Black & Veatch 2010

Figure 1–3. Arkansas Valley Conduit Participant Water Sources by Volume

Radionuclides are radioactive atoms, such as radium or uranium. Drinking water sources often have very low levels of radionuclides, most of which are naturally occurring. Most radionuclides in drinking water are at levels low enough to not be considered a public health concern. At higher levels, long-term exposure to radionuclides may cause cancer (5 Code of Colorado Regulations (CCR) 1003-1).

Most AVC participants use **conventional water treatment** processes. Typical processes include filtration and disinfection. Conventional treatment can remove contaminants such as suspended solids, bacteria, and viruses, but cannot remove salt or radionuclides. Conventional water treatment plants are relatively simple and inexpensive to operate.

Reverse Osmosis is a water treatment process that can remove contaminants from water that conventional treatment cannot. It involves forcing water through a membrane under high pressure, leaving dissolved salts, other contaminants, and a small amount of water behind the surface of the membrane. This waste is called “brine.” While reverse osmosis can produce clean drinking water, disposing of the brine (which can be considered a hazardous waste) and high energy requirements are challenging issues in use of these systems.

Need to Meet Primary Drinking Water Standards The Colorado Department of Public Health and Environment (Health Department) is responsible for monitoring the ability of water providers to meet the Colorado primary drinking water standards (5 Colorado Code of Regulations (CCR) 1003-1). The primary drinking water standards are legally enforceable standards that apply to public water systems. Primary drinking water standards protect public health by limiting the levels of contaminants in drinking water.

Radionuclides, including alpha activity, radium, and uranium, have maximum contaminant levels established in the primary drinking water standards. Maximum contaminant levels for radionuclides are as follows:

- Adjusted gross alpha activity: 15 picocuries per liter (pCi/L)
- Combined radium 226/228: 5 pCi/L
- Uranium: 30 micrograms per liter (µg/L)

> Common units of radioactivity are **curies** (Ci) or **picocuries** (pCi). A picocurie is equivalent to 10^{-12} Ci. Radionuclide activities measured in water are most often reported in units of pCi per liter of water (pCi/L).

Fourteen AVC participants using deep bedrock aquifers have been placed under enforcement action by the Health Department over the last several years because levels of combined radium and/or gross alpha particle activity violated primary drinking water standards (Table 1–4). The enforcement actions were issued after consistent violation of maximum contaminant levels for combined radium and/or gross alpha particle activity. Each enforcement action outlines a timeline for the water provider to identify methods to achieve long-term compliance with the maximum contaminant levels and implement a solution. Failure to comply with an enforcement action can result in fines and criminal penalties. Homestead Improvement Association complied with its enforcement action by purchasing water from La Junta. Additionally, Rocky Ford recently purchased the Hancock water system, which will satisfy Hancock's enforcement action. The remaining 12 participants under enforcement action must identify and implement a new source of water or treatment technology within a specified time to become compliant.

Seven additional AVC participants have elevated levels of radionuclides, but have not consistently exceeded maximum contaminant levels and, therefore, are not currently under an enforcement action. The Health Department will continue to monitor AVC participants for compliance with the primary drinking water standards and also will continue to issue enforcement actions, as necessary, to water providers.

The magnitude of radionuclide water quality problems for several AVC participants, and issues with existing source water treatment, were identified in a Colorado Radionuclide Abatement and Disposal Strategy (CORADS) report (Malcolm Pirnie 2009a). Table 1–4 lists AVC participants with radionuclide water quality issues and their participation in the CORADS study.

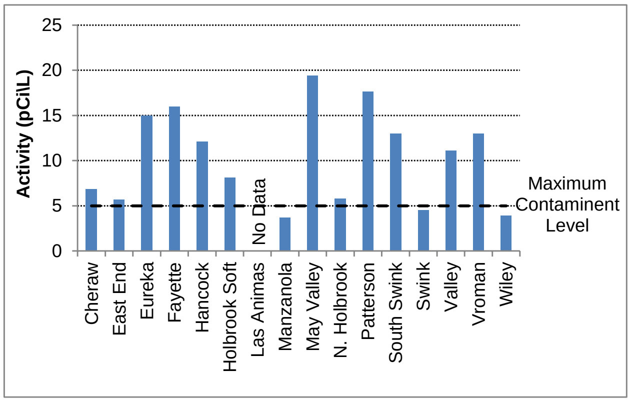
Table 1–4. Arkansas Valley Conduit Participants with Radionuclide Contaminated Water

County	Participant	Water Quality Constituent of Concern	Violation Resulting in Enforcement Action	Participated in CORADS?
Otero	Cheraw	Radionuclides	Combined radium	No
	East End Water Association	Radionuclides	Combined radium	No
	Eureka Water Company	Radionuclides	Gross alpha particle activity, combined radium	Yes
	Fayette Water Association	Radionuclides	Combined radium	Yes
	Hancock, Inc.	Radionuclides	Gross alpha particle activity, combined radium (1)	Yes
	Hilltop Water Company	Radionuclides	None	No
	Holbrook Center Soft Water	Radionuclides	Combined radium	No
	Homestead Improvement Association	Radionuclides	Gross alpha particle activity, combined radium (2)	No
	La Junta	Total dissolved solids, radionuclides	None	No
	Manzanola	Radionuclides	None	Yes
	Newdale-Grand Valley Water Company	Radionuclides	None	No
	North Holbrook Water	Radionuclides	Combined radium	Yes
	Patterson Valley	Radionuclides	Gross alpha particle activity, combined radium	Yes
	South Swink Water Company	Radionuclides	Gross alpha particle activity, combined radium	Yes
	Swink	Radionuclides	Combined radium	Yes
	Valley Water Company	Radionuclides	Combined radium	Yes
	Vroman	Radionuclides	Combined radium	Yes
Bent	Las Animas	Total dissolved solids, sulfate, radionuclides	None	Yes
	McClave Water Association	Radionuclides	None	No
Prowers	May Valley Water Association	Radionuclides	Gross alpha particle activity, combined radium	Yes
	Wiley	Radionuclides	None	Yes

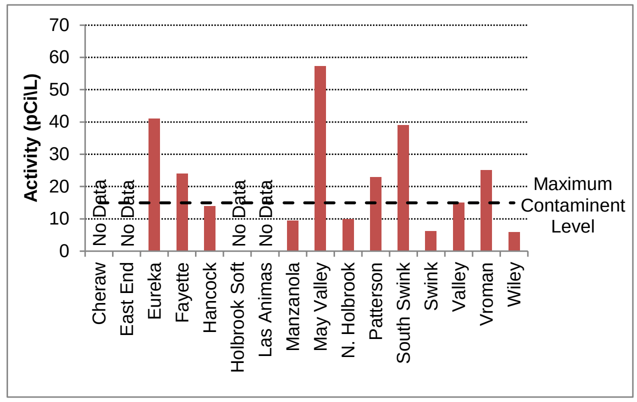
Notes:
(1) Enforcement action for Hancock Inc. will be satisfied by combining with Rocky Ford's system.
(2) Enforcement action for Homestead Improvement Association was satisfied by purchasing water from La Junta. This enforcement action occurred in the past and is no longer in effect.

Figure 1–4 through Figure 1–6 present radionuclide concentrations of raw water supplies for AVC participants currently under a Health Department enforcement action or who participated in the CORADS study (Table 1–4). AVC participants who use deep groundwater supplies have levels of gross alpha participle activity and combined radium in excess of or near the primary drinking water standards. Las Animas is the only CORADS participant who currently uses alluvial groundwater for its water supply. The Las Animas raw water supply is above the maximum contaminant level for uranium (Figure 1–6). The probability of exceeding water quality standards for uranium are greatest in Otero, Kiowa, and Prowers counties, where probabilities commonly ranged from 30 to 60 percent (Miller et al. 2010). Las Animas and La Junta use reverse osmosis treatment; other AVC participants' conventional water treatment methods do not remove radionuclides from water.

Historical uranium levels at the Arkansas River above Pueblo gage have typically been below 10 µg/L, well below the maximum contaminant level, and none of the current municipal entities that

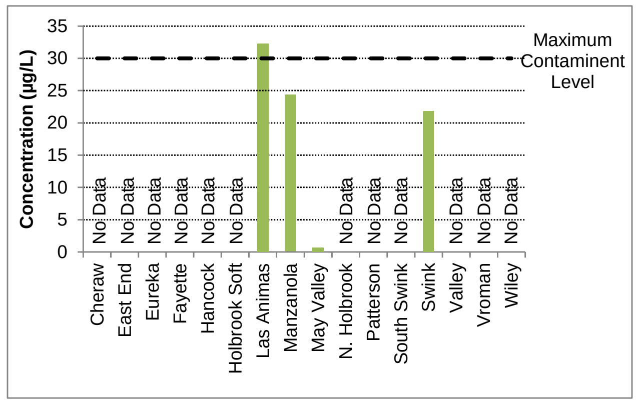


Data Source: Malcolm Pirnie 2009b; EPA 2012
Figure 1–4. Average Combined Radium Concentration for Select AVC Participants



Data Source: Malcolm Pirnie 2009b; EPA 2012
Figure 1–5. Average Gross Alpha Particle Activity Concentration for Select AVC Participants

use water directly from Pueblo Reservoir (Board of Water Works of Pueblo, Pueblo West Metropolitan District, and Fountain Valley Authority) have had issues with, or enforcement actions related to, radionuclides. If the AVC intake is located at Pueblo Reservoir, AVC water quality would be similar to that of the Arkansas River above Pueblo gage. See Appendix F.1 for additional information on water quality at and near Pueblo Reservoir.

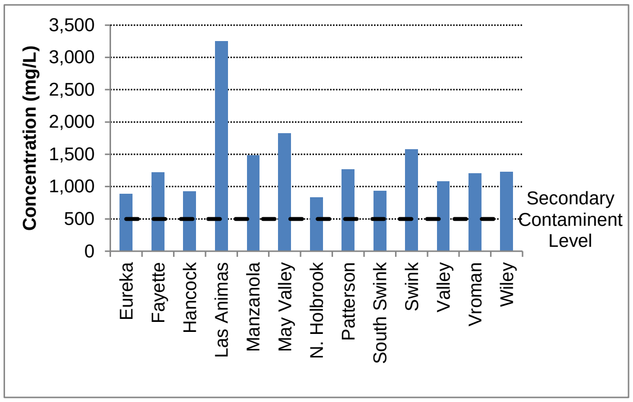


Data Source: Malcolm Pirnie 2009b; EPA 2012
Figure 1–6. Average Uranium Concentration for Select AVC Participants

Need to Follow Secondary Drinking Water Standards The Health Department adopted secondary drinking water standards that set nonmandatory water quality standards for contaminants such as total dissolved solids and sulfate. The secondary drinking water standards are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the standard (EPA 1992). Secondary drinking water standards for total dissolved solids and sulfate are as follows:

- Total dissolved solids: 500 milligrams per liter (mg/L)
- Sulfate: 250 mg/L

AVC participants generally have difficulties meeting the secondary drinking water standards for total dissolved solids and sulfate. Some AVC participants also are not meeting the secondary drinking water standard for iron. Median total dissolved solids concentration over the past 40 years is about 3,400 mg/L in lower Arkansas River Basin alluvial groundwater (Miller et al. 2010), which is nearly seven times greater than the water quality standards.



Data Source: Malcolm Pirnie 2009b

Figure 1–7. Average Total Dissolved Solids Concentrations for Select AVC Participants

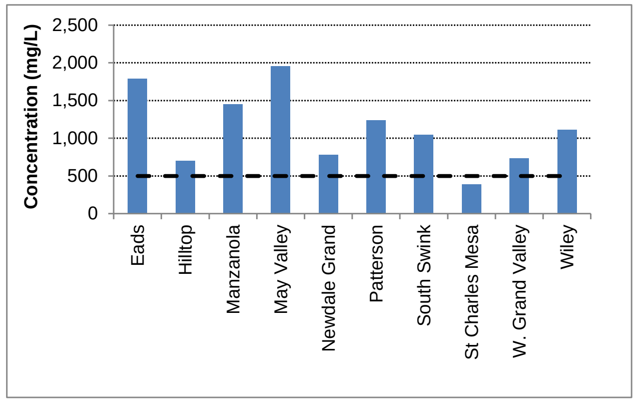
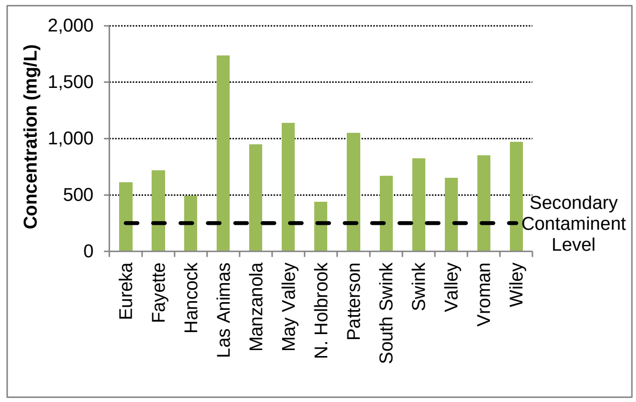


Figure 1–8. Average Total Dissolved Solids Concentrations for Select AVC Participants (as reported by participant)

Like radionuclides, total dissolved solids and sulfate are also constituents that are not removed by conventional water treatment methods. Therefore, except for Las Animas and La Junta, AVC participants' customers are delivered water exceeding secondary drinking water standards. As previously discussed, Las Animas and La Junta use reverse osmosis to reduce concentrations of total dissolved solids and sulfate below secondary drinking water standards. Representative water quality data for total dissolved solids and sulfate for AVC participants with available data are presented in Figure 1–7 through Figure 1–9.



Data Source: Malcolm Pirnie 2009b

Figure 1–9. Average Sulfate Concentrations for Select AVC Participants

Need to Meet Existing and Future AVC Participant Water Demands

AVC participants are responsible for acquiring and developing safe and reliable water supplies to meet customer needs (Figure 1–10). Acquiring reliable water supplies to meet anticipated future needs requires long-term planning because of the time needed to secure water supplies, satisfy permitting and regulatory requirements, and construct infrastructure.

AVC participant water demands were studied in depth in the STAG report (Black & Veatch 2010). Subsequently, estimated current and future water demands presented in the STAG report for each AVC participant were assessed and revised to evaluate the need for future water supplies (Figure 1–10) (Reclamation 2010a). Projected water demand for AVC participants is described below. Additional information on each AVC participant is in Appendix A.

Water Demand AVC participants include a variety of water providers and users, such as cities, towns, and rural domestic water providers throughout the lower Arkansas River Basin. Water users served by these providers comprise residential, commercial, and industrial customers. Estimated existing (2010) water demand for AVC participants is 10,461 ac-ft. The following sections contain information on population growth, current water use, and conservation efforts; this information is then used to estimate future water demand of AVC participants (Figure 1–10).

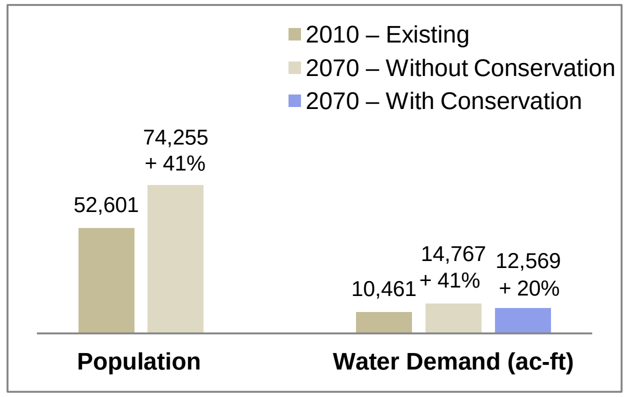


Figure 1–10. Population and Water Demand in 2010 and 2070 for AVC Participants

Population Growth Estimates of future population are a key factor in estimating future water demands. Historical population trends and future population projections from the Colorado State Demography Office and Colorado Water Conservation Board were used to estimate future county populations. U.S. Census Bureau historical population estimates from 1950 to 2009 were combined with Colorado State Demography Office and Colorado Water Conservation Board population projections to compare historical trends with projected future trends. Figure 1–11 and Figure 1–12 illustrate historical population trends from 1950 through 2010 (represented by a solid line) and population projections through 2035 (represented by dashed lines) for counties within the AVC service area through 2035. These population projections are for the entire county, and include people that would not be served by AVC.

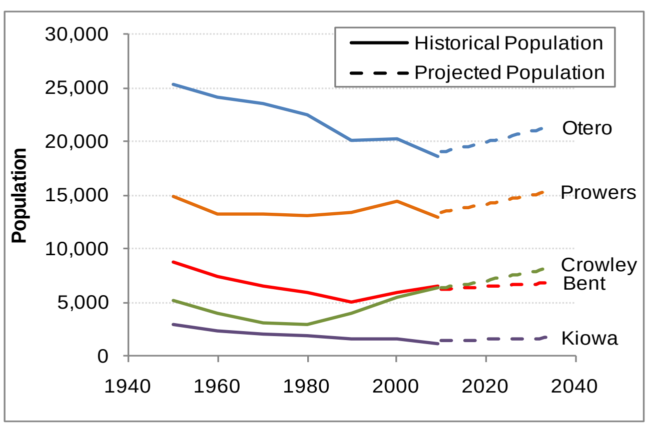


Figure 1–11. Historical and Projected Population of Bent, Crowley, Kiowa, Otero, and Prowers Counties

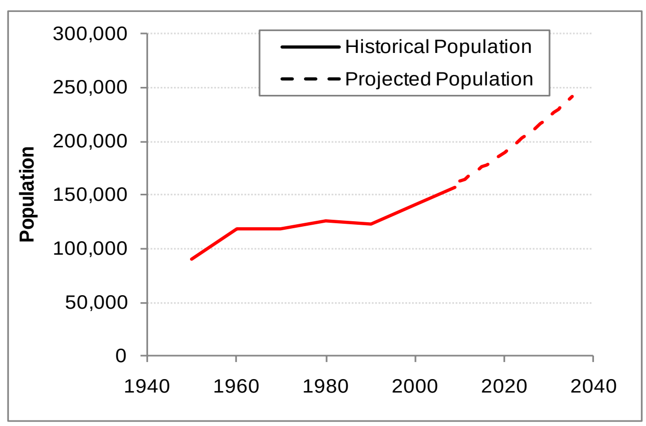


Figure 1–12. Historical and Projected Population of Pueblo County

To evaluate the accuracy of the Colorado State Demography Office and Colorado Water Conservation Board population forecasts, growth trends resulting from model assumptions were compared to historical growth patterns and the likelihood of changes in the growth patterns. The population of Bent, Kiowa, Otero, and Prowers counties has decreased from 1950 to 2009. Although this decline was not constant in all cases, the likelihood of a sudden reversal of this trend to one of rapid population growth caused by abrupt change in social or economic variables would be small; therefore, modest growth is assumed. The population of Crowley and Pueblo counties grew historically; therefore, similar levels of future population growth would be justified. Based on these observations, the population growth rates shown in Table 1–5 were applied to AVC participants to estimate 2070 populations.

It is challenging to accurately forecast future population because it is influenced by fertility, mortality, and migration, which change over time for many reasons, including economic conditions. Although uncertainties are associated with future population projection, the assumptions for future population growth were made with the best available information, and the population estimates are reasonable for projecting future water needs.

Table 1–5. Projected Growth Rates Used for AVC Demand Estimates

County	State Demographer and Conservation Board Projected Growth Rate (%)	Projected Growth Rate Used for AVC Demand Estimates (%)	Source/Rationale
Pueblo	0.615 to 0.972	0.97	Colorado Water Conservation Board mid-growth estimate/very close to historical rate
Crowley	0.772 to 1.097	0.77	Colorado Water Conservation Board low-growth estimate
Otero	0 to 0.418	0.42	Colorado Water Conservation Board low-growth estimate/historical growth moderately negative
Bent	0 to 0.558	0.37	Colorado State Demography Office estimate
Prowers	0 to 0.252	0.25	Colorado Water Conservation Board low-growth estimate/historical growth slightly negative
Kiowa	0 to 0.382	0	Historical growth negative

Per Capita Water Use One measure of water use is evaluating customer water use rates, expressed in gpcd. Participant water use, which includes residential, commercial, and industrial water uses, averaged 148 gpcd when summed for each individual participant (Figure 1–13) or 154 gpcd when weighted by total population and water use in 2010. Weighted average per capita water use reflects differences among AVC participants in climate, outdoor water use, and municipal and industrial water use. Using this methodology, per capita use for individual entities with smaller populations can be greatly affected by deliveries of water to large commercial or industrial water users, such as livestock feeding operations or food packaging facilities.

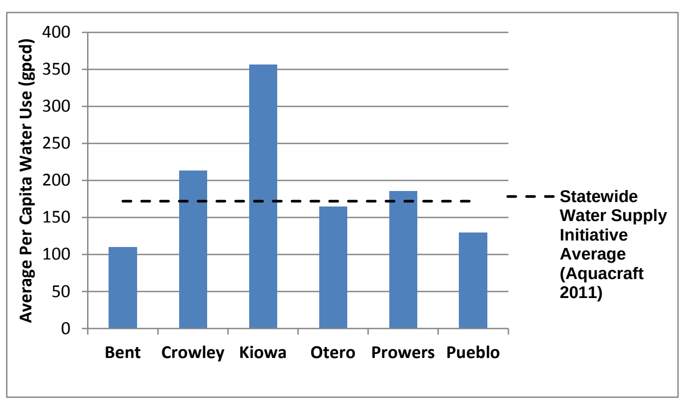


Figure 1–13. Existing Average Per Capita Water Use for AVC Participants by County

Overall, AVC participants generally exhibit lower or comparable per capita water use rates compared with other Colorado water users, recognizing geographic and service area differences. The *Statewide Water Supply Initiative Municipal and Industrial Water Conservation Strategies* (Aquacraft 2011) found that statewide per capita water use ranged from 155 to 314 gpcd; the Metro Denver Basin had the lowest use in the state, with 155 gpcd. The statewide average for this study was 172 gpcd; the Arkansas River Basin averaged 185 gpcd.

AVC participants with per capita water use values higher than 200 gpcd are listed in Table 1–6. The most common reasons for higher than typical per capita water use was livestock watering at commercial livestock facilities, which are important industrial businesses in the Lower Arkansas River Basin, and leaking distribution systems. As noted above, Southeastern included water leaks as the first step of its AVC regional water conservation plan to identify and correct problems.

Table 1–6. AVC Participants with High per Capita Water Use and Reasons

County	AVC Participant	2010 Deliveries (ac-ft)	2010 Population	2010 Per Capita Water Use (gpcd)	Reasons for High Per Capita Water Use
Crowley	96 Pipeline Company	56	160	311	Unknown
	Sugar City	82	280	261	Unknown
Otero	Cheraw	48	193	222	Unknown
	Eureka Water Company	74	330	200	Leaking distribution lines
	Holbrook Center Soft Water	18	50	321	Livestock watering, leaking distribution system
	La Junta	2,040	7,102	256	Outdoor irrigation, reverse osmosis backwashing, large commercial users
	West Grand Valley Water Inc.	25	84	266	Livestock watering
	West Holbrook Water	14	23	543	Livestock watering
Prowers	Lamar	2,400	8,171	262	Leaking distribution system, large commercial users
	May Valley Water Association	410	1,500	244	Livestock watering, leaking distribution system
Kiowa	Eads	250	626	357	Livestock watering, large commercial users, bulk water station used by summer residents and campers

Water Conservation As a condition to the requested contracts, Reclamation requires that AVC participants have a water conservation plan in place at the time of contracting. Conserving water through the efficient use of water supplies and demand management programs is becoming standard operating practice among water providers and consumers in Colorado and the Western United States. Recent drought conditions in Colorado have emphasized the need to continually evaluate methods to conserve water resources, not only during droughts but also during “normal” years.

Water conservation includes both supply-side and demand-side management. Supply-side conservation includes a variety of measures to make the most of existing supplies, such as detecting and repairing leaks to reduce losses, metering water use, and reusing water. Demand-side conservation includes changes in landscaping and watering practices, use of water efficient indoor appliances, education programs, water rate structure incentives, and rebates.

Water conservation is an important strategy used by AVC participants to improve water delivery and use efficiency to reduce overall demand. All participants have incentives to use water efficiently, such as reduced costs associated with water supply, treatment, and distribution.

The Water Conservation Act of 2004 (Colorado House Bill 04-1365) requires water providers who sell 2,000 ac-ft or more of retail water annually to have a water conservation plan on file with the state that is approved by the Colorado Water Conservation Board. Three AVC participants, St. Charles Mesa, Lamar, and La Junta, sell more than 2,000 ac-ft of retail water annually. St. Charles Mesa and Lamar have state approved water conservation plans. La Junta's plan is in the process of being approved. Because several AVC participants are small, rural water providers without resources to fund comprehensive conservation plans, Southeastern prepared a Regional Water Conservation Plan (Southeastern 2013) that will serve AVC participants who do not currently have a water conservation plan (see Appendix B.7). Master Contract participants would also prepare a water conservation plan.

The nature of water conservation goals for the AVC Regional Water Conservation Plan is based on the fact that Southeastern does not allocate Fry-Ark water for retail sale; instead Southeastern has an administrative role that includes being the local contracting agency with Reclamation who would be responsible for repayment of locally funded construction costs of the AVC. Southeastern has developed broad goals for improved water use efficiency by the participants (for example, improvements to water loss control and overall system water management), but Southeastern does not directly control how local water providers and their customers would leverage the benefits of local water conservation programs to reduce water demand. Southeastern is committed, however, to provide financial and technical resources to support local water conservation efforts being planned and implemented by the participants. Southeastern may also be in the position in the future to collect and report AVC delivery data from participants, including total water deliveries and customer water sales, which could be used to track future benefits of water conservation and water use efficiency programs being implemented by local water providers.

The AVC Regional Water Conservation Plan (see Appendix B.7) outlines potential components of a conservation toolbox for AVC participants. Participants can work with Southeastern to identify the most applicable and useful tools to apply to their water system to reduce customer use on a gallons per capita per day (gpcd) basis. Water conservation toolbox components in the AVC regional water conservation plan include the following:

- Meter testing and replacements
- System-wide audits/assessments
- Leak detection support
- Leak and line repair
- Customer technical support to improve water efficiency
- Evaluation of water rates
- Education (of customers, K-12 students, management, partnerships)
- Drought management and planning
- Data management
- Future project/implementation funding options

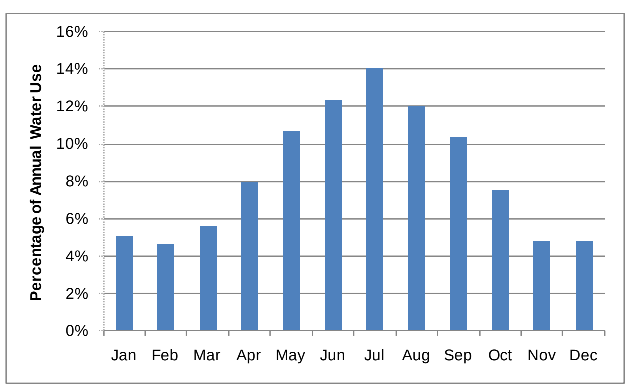
Additionally, Southeastern identified the short-term need to audit all AVC participant water systems for evaluating and characterizing losses. Audit results are included in the AVC regional water conservation plan. Assessments to evaluate and characterize losses consider the following:

- Status and accuracy of distribution system mapping
- Age of meters and past meter replacements
- Age of piping and existing materials
- Number and effectiveness of valves
- Balance of water production/deliveries to water billed and/or sold
- Characteristics of water company databases for tracking water production and delivery
- Status of nonrevenue water (quantity and ability to measure and track nonrevenue water)
- Use of audits by Southeastern to prioritize resources to access grant funds, perform upgrades to systems, and track impacts of upgrades

Passive water conservation savings result from replacing older, less efficient appliances with newer, more water efficient models. These conservation savings are called "passive" savings because water utilities typically do not actively fund and implement programs that produce these savings (CDM 2004).

It is fully anticipated that participant water conservation programs would evolve as data collection improves, and management systems and technology changes. For this reason, some participants may choose water conservation plans that focus on data collection and interpretation activities before developing longer term plans that address water loss management or customer demand reductions. For this EIS, it was assumed that AVC participants could at a minimum save additional water based on passive conservation. Overall passive savings were estimated to range from 7 percent to 9 percent of total forecasted 2070 water demand (Great Western Institute 2010a). However, on a per-participant basis, the variability was found to be substantially greater – from no additional conservation to as much as 41 percent depending on housing stock age, predicted service population growth rate, and current per capita water use. Some participant per capita water use rates are well below the statewide average, and no additional conservation was assumed. Overall, the reduction in forecasted 2070 water demand associated with passive savings was estimated to be between 1,000 and 1,300 ac-ft for all AVC participants combined.

Future Water Demand Estimated future (2070) demand is 12,569 ac-ft. Future demand was estimated by applying Reclamation's projected population growth rates to each AVC participant. Future per capita water use rates are reduced from current per capita water use rates based on estimated passive water conservation savings. Future population and future per capita water use rates were multiplied to estimate future water demands. This methodology assumes that municipal and industrial demands would grow at the same rate.



Source: Black & Veatch 2010
Figure 1–14. Monthly Water Use of AVC Participants

Similar to other Colorado municipal water providers, AVC participants exhibit higher water use in the summer and lower water use in the winter. Figure 1–14 presents weighted existing monthly water use of nine AVC participants who were able to supply monthly water use data (Black & Veatch 2010). It is assumed that these monthly trends would continue into the future and would be reflected in AVC delivery timing.

AVC would deliver about 10,250 ac-ft per year to AVC participants (Figure 1–15 and Table 1–7) to help meet 2070 water demands. AVC would deliver AVC participant Fry-Ark allocations, including not previously allocated nonirrigation water (NPANIW) and reusable return flows, plus a portion of existing and future non-Fry-Ark water supplies that are required to meet future demand. It is assumed that participants with enforcement actions for radionuclides would abandon their current supply because of treatment difficulties and would be served exclusively by AVC. Other AVC deliveries are based on each participant's requested AVC delivery as contained in the STAG report and subsequent evaluations in this EIS. More details on AVC participant future demands, AVC supplies, and integration of AVC into existing water systems are in Appendix A.

"Not previously allocated nonirrigation water," or **NPANIW supplies,** became available in 2007 when Southeastern began permanently allocating to municipal use a portion of the 49 percent unallocated Fry-Ark yield that was no longer being used for irrigation (Southeastern 2007).

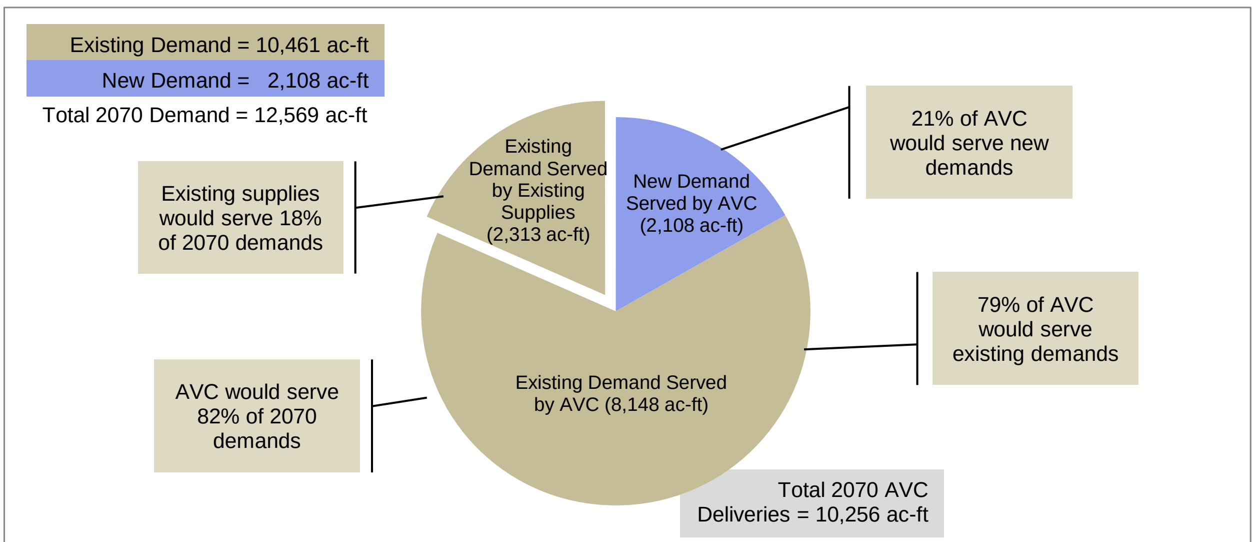


Figure 1–15. Arkansas Valley Conduit Participant Existing and Future Water Supplies

Other Needs for AVC

In addition to supplying better quality water and meeting existing and future demands, some AVC participants have identified more specific needs for AVC, including the need for more efficient use of current water supplies (i.e., reduced transit losses) and the need for more reliable sources than current water supplies. Some participants pump water from the Dakota and Cheyenne aquifers and have noted well water levels dropping to an unsustainable level. These specified needs for AVC by participant are further discussed in Appendix A.

Table 1–7. Arkansas Valley Conduit Participant Future Water Demands and Supplies

County	Participant	2010 Water Demand (ac-ft)	2070 Water Demand (ac-ft)	2070 Supplies: AVC Deliveries[1] (ac-ft)	2070 Supplies: Continued Use of Existing Supplies (ac-ft)
Pueblo	Avondale	160	238	164	74
	Boone	66	111	94	17
	St. Charles Mesa Water District	1,660	2,651	2,651	0
Crowley	96 Pipeline Company	56	85	27	58
	Crowley County Water Association	580	883	617	266
	Crowley	34	51	51	0
	Olney Springs	40	59	59	0
	Ordway	240	366	366	0
	Sugar City	82	127	127	0
Otero	Beehive Water Association	8	10	10	0
	Bents Fort Water Company	63	81	81	0
	Cheraw	48	57	30	27
	East End Water Association	11	13	13	0
	Eureka Water Company	74	86	86	0
	Fayette Water Association	12	14	14	0
	Fowler	210	223	220	3
	Hancock Inc.	17	18	18	0
	Hilltop Water Company	45	50	40	10
	Holbrook Center Soft Water	18	22	22	0
	Homestead Improvement Association	7	9	9	0
	La Junta	2,040	2,421	2,299	122
	Manzanola	39	50	50	0
	Newdale-Grand Valley Water Company	57	60	60	0
	North Holbrook Water	7	8	8	0
	Patterson Valley	15	17	17	0
	Rocky Ford	890	1,031	576	455
	South Side Water Association	7	7	5	2
	South Swink Water Company	86	92	92	0
	Swink	38	49	49	0
	Valley Water Company	38	39	39	0
	Vroman	32	37	37	0
	West Grand Valley Water Inc.	25	30	15	15
	West Holbrook Water	14	17	9	8
Bent	Hasty Water Company	32	33	33	0
	Las Animas	570	602	602	0
	McClave Water Association	56	70	59	11
Prowers	Lamar	2,400	2,157	1,241	916
	May Valley Water Association	410	435	222	213
	Wiley	24	28	28	0
Kiowa	Eads	250	232	116	116
Total		**10,461**	**12,569**	**10,256**	**2,313**

Note:
(1) AVC deliveries include Fry-Ark allocations, NPANIW supplies, Fry-Ark return flows, and non-Fry-Ark supplies. Southeastern requires by resolution that all participants take their Fry-Ark allocations through AVC.

Need for Interconnect

Interconnect participants need redundancy at north and south outlet works of Pueblo Reservoir. If a short-term outage of either outlet occurs, the Interconnect would allow Interconnect participants to receive water from Pueblo Reservoir through the remaining working outlet. The following Interconnect participants normally take water from the existing south outlet works at Pueblo Reservoir:

- Pueblo West
- Fountain Valley Authority (serves Colorado Springs, Fountain, Security, Widefield, and Stratmoor Hills)
- Board of Water Works of Pueblo
- Colorado Parks and Wildlife Pueblo Fish Hatchery (uses separate outlet near south outlet works)
- AVC (if AVC would take water directly from Pueblo Reservoir)

The estimated population that would be served by the Interconnect is in Figure 1–16. This population was estimated using the Colorado State Demography Office county growth projections through 2035, followed by a consistent growth rate through 2060. For El Paso County, all participants were assumed to grow at the overall county growth rate.

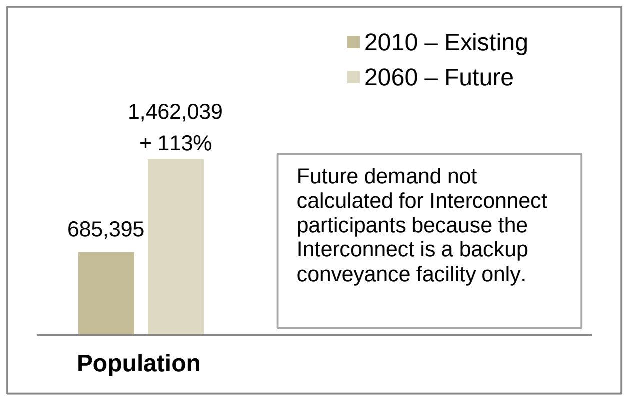


Figure 1–16. Population in 2010 and 2060 for Interconnect Participants

The SDS is currently under construction and will deliver water from Pueblo Dam to Colorado Springs, Fountain, Security, and Pueblo West. The SDS pipeline will normally take water through the north outlet works at Pueblo Dam.

Photo 1–6. North Outlet Works and SDS connection at Pueblo Dam.

Interconnect participants deliver water for municipal and industrial use. Municipal and industrial uses are vulnerable to any outlet works outage as these outages often result in a disruption to customers.

The Interconnect's purpose is to take water from either outlet without loss of service. The Interconnect would be used during intraday to multiday outages that occur during emergencies and routine maintenance activities, and longer multiple-week outages for occasional substantial maintenance activities. Maintenance activities could include maintenance or replacement of outlet works valves, meters, piping, and other related facilities by Reclamation. It is difficult to estimate the frequency of these outages. However, it is likely that during normal years, the Interconnect would only be used for a few weeks per year or less. Allocation of Interconnect capacity will be addressed in Interconnect contracts. No Interconnect participant would expand deliveries beyond normal allocated capacity using the Interconnect.

Interconnect participants each have a specific need for redundant deliveries from Pueblo Reservoir, as described in documents provided by each entity as part of this EIS. A detailed description of Interconnect participant needs is in Appendix A. The following summarizes these needs:

- For entities taking water directly from Pueblo Reservoir without substantial terminal storage (i.e., storage immediately upstream from a water treatment plant), redundancy is needed to prevent disruption of water service from outages as short as 12 hours.
- For entities who already have redundant river diversion facilities in addition to their direct connection to Pueblo Reservoir, the Interconnect is needed to increase source water quality and reduce operational costs during outlet works emergencies and maintenance activities.
- For systems with more extensive terminal storage availability, redundancy supplied by the Interconnect may not be needed during shorter term outages because of stored water. However, longer term interruptions for more extensive maintenance activities would require Interconnect use.
- The Pueblo Fish Hatchery needs redundancy if the hatchery outlet at Pueblo Reservoir shuts down. Hatchery flows may be needed at any time but would be most critical during the summer. Groundwater wells are insufficient to support these flows.

Need for Master Contract

Master Contract needs are primarily related to needs to meet existing and future water demands by each Master Contract participant. These needs vary by participant, from the need to provide additional supply every year to the need for drought protection in dry years.

Need to Meet Existing and Future Water Demand for Master Contract

Like AVC participants, Master Contract participants are responsible for developing and acquiring safe and reliable water supplies to meet customer needs. Water demand for Master Contract participants is quantified similar to AVC. To avoid repetition, methods and assumptions presented in the previous section, when applicable, are not repeated here. For AVC participants also participating in the Master Contract, please refer to the section Chapter 1 – *Needs for Arkansas Valley Conduit*.

Estimated current and future water demand for each Master Contract participant were used to assess contract need. This evaluation of water demand was prepared using the same methods as for the AVC water demand evaluation (Reclamation 2010b). Master Contract participants would meet their demand by storing water during times of surplus and subsequently releasing stored water during times of water shortage, or by storing water for augmentation purposes when using groundwater. Additional information on each Master Contract participant is in Appendix A.

Water Demand Master Contract participants include a variety of water providers located throughout the Southeastern district. Customers served by these providers are residential, commercial, and industrial water users. In addition, the Lower Arkansas Valley Water Conservancy District would use Master Contract storage space for releases to meet agricultural return flow obligations (e.g., Rule 10 plans implemented as part of the Irrigation Improvement Rules). The following sections discuss population growth, current water use and conservation efforts, and future water demand of Master Contract participants (Figure 1–17).

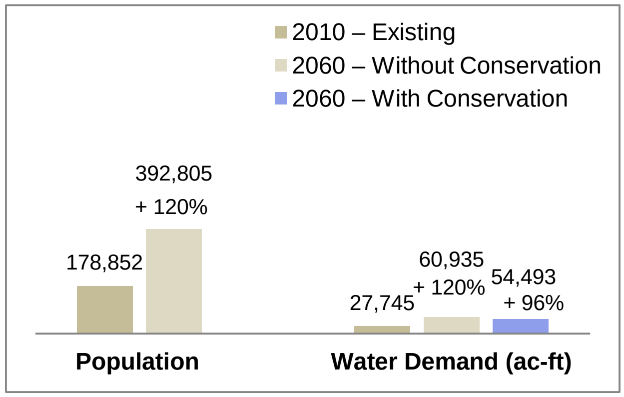


Figure 1–17. Population and Water Demand in 2010 and 2060 for Master Contract Participants (AVC participants excluded)

Population Growth Reclamation compared historical population trends with projected trends and changes in components of population to forecast future populations. Figure 1–18 and Figure 1–19 illustrate population trends for counties within the Master Contract service area. These figures show historical populations and the range of population projections through 2035 from the Colorado State Demography Office and Colorado Water Conservation Board. Pueblo County is addressed in Chapter 1 - *Needs for Arkansas Valley Conduit*.

Figure 1–18 and Figure 1–19 indicate only minor changes in the pace of growth projected from 2010 to 2035 for Chaffee and El Paso counties, while the pace of growth for Fremont County is projected to increase from 2010 to 2035. Table 1–8 presents growth rates applied to estimate 2060 populations for Master Contract participants.

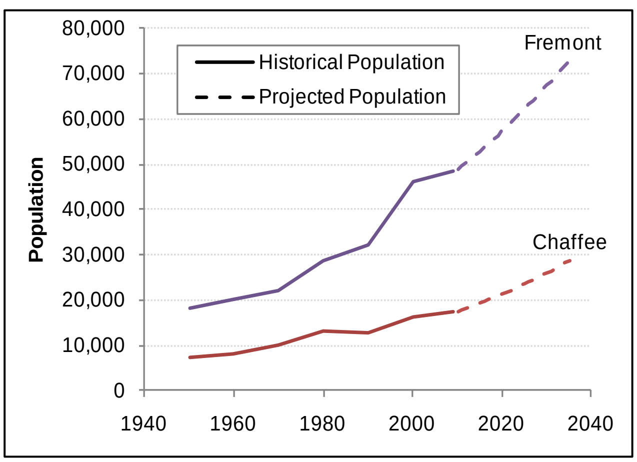


Figure 1–18. Historical and Projected Population of Fremont and Chaffee Counties

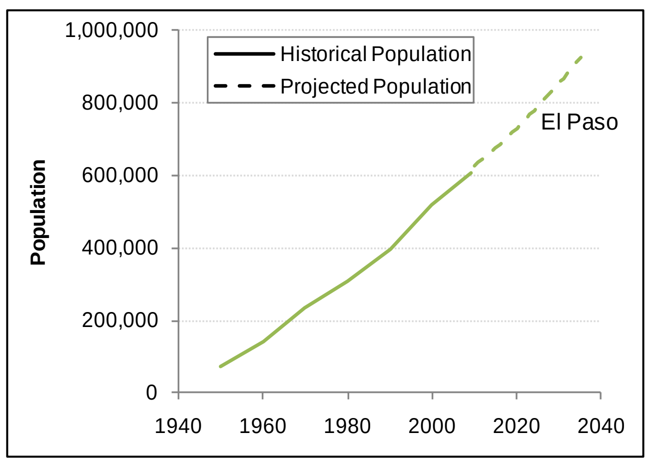


Figure 1–19. Historical and Projected Population of El Paso County

Table 1–8. Projected Growth Rates Used for Master Contract Demand Estimates

County	State Demographer and Conservation Board Projected Growth Rate (%)	Projected Growth Rate Used for AVC Demand Estimates (%)	Source
Chaffee	1.507 to 1.996	1.646	Combination of projected growth rates
Fremont	1.617 to 1.655	1.635	Combination of projected growth rates
El Paso	1.585 to 3.612	3.007	Combination of projected growth rates (applicable only to El Paso County Master Contract participants)

Water Conservation Reclamation requires as a condition to the requested contracts that Master Contract participants have a water conservation plan in place. Six Master Contract participants have current water conservation plans, as required by the Water Conservation Act of 2004, including Cañon City, Florence, Pueblo West, Fountain, Security, and Widefield. Wholesale water providers such as the Upper Arkansas Water Conservancy District and Lower Arkansas Valley Water Conservancy District do not have formal water conservation plans. Other Master Contract participants have guidelines or ordinances for conserving water. Common conservation measures implemented by Master Contract participants include incentives or regulations to reduce outdoor watering use, including limits on the number of watering days and the times of day. Most Master Contract participants use an increasing block rate structure to promote conservation.

Master Contract participant total water use, which includes municipal and industrial water uses, averaged 155 gpcd when summed for individual participants (Figure 1–20) or 168 gpcd when weighted by total population and water use in 2010. No Master Contract participants have per capita water use rates significantly higher than the average use rate. Overall, Master Contract participants exhibit lower or comparable water use rates per capita compared with other Colorado water users, recognizing geographic and service area differences.

It was assumed that several Master Contract participants could save additional water based on passive conservation. Great Western Institute (2010b) calculated potential passive water savings depending on housing stock age, population growth rates, current and future per capita water use, and timing of fixture and appliance replacement. Great Western Institute's water saving projections showed rapid gains in passive savings from 2005 through 2017 due to replacement of clothes washers and dishwashers. Appendix A describes Master Contract participant conservation plans, if available, and assumed additional passive savings.

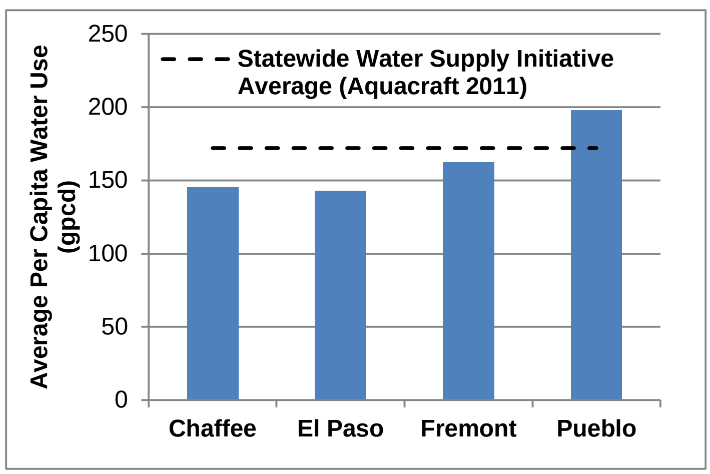


Figure 1–20. Existing Average Per Capita Water Use for Master Contract Participants by County

Future Water Demand For Master Contract participants not participating in AVC, current 2010 water demand is about 27,700 ac-ft (Appendix A). Demand is projected to increase to 54,493 ac-ft by 2060 (Table 1–9). AVC participant Master Contract storage requests total 29,938 ac-ft (previously shown in Table 1–3). It should be noted that 1 ac-ft of storage does not produce 1 ac-ft of additional yield. Water yield based on additional storage depends on stream hydrology and is presented in more detail in Chapter 4.

Table 1–9. Master Contract Future Water Demand

Master Contract Participant	Existing Annual Firm Yield (ac-ft)	2060 Demand (ac-ft)	Master Contract Storage Request (ac-ft)
Poncha Springs	165	360	200
Salida	10,012	3,418	2,000
Upper Arkansas Water Conservancy District	1,381	960	1,000
Cañon City	28,196	11,070	1,000
Florence	4,147	2,975	2,250
Penrose	0	1,679	900
Pueblo West	8,280	10,000	6,000
Fountain	4,698	13,156	1,000
Security	3,599	4,930	1,500
Stratmoor Hills	1,055	750	200
Widefield	1,381	5,195	650
Lower Arkansas Water Conservancy District	(1)	(1)	5,000
Total	**62,913**	**54,493**	**21,700**

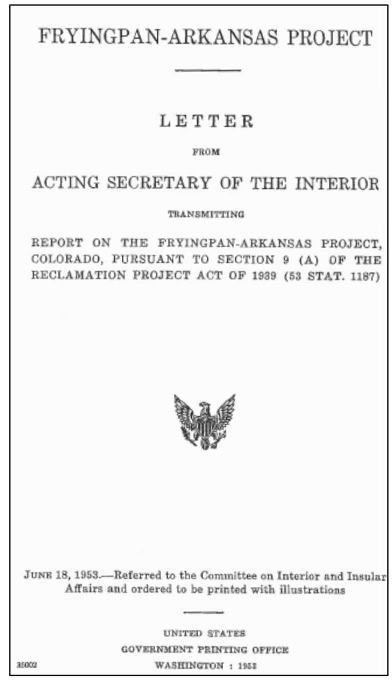
Note:
(1) Lower Arkansas Valley Water Conservancy District is a wholesale water provider who would use Master Contract storage space to employ a rotational fallowing and leasing program. Customers of Lower Arkansas Valley Water Conservancy District could include the Upper Arkansas Water Conservancy District, Widefield, Security, Fountain, and various AVC participants up to 7,800 ac-ft per year.

Although some Master Contract participants, such as Salida, have sufficient supplies to meet future demand on an annual basis, these participants need the Master Contract to fulfill demand in winter months when direct flow rights are limited. Cañon City has sufficient senior water rights to fulfill its future demand, but is requesting the Master Contract to store water for use in drought and emergency situations. Cañon City has no storage for its supplies and relies solely on a few direct flow water rights to serve its customers. Additional information on these participants' water needs is in Appendix A.

Previous Studies

In 1953, House Document 187 (Fry-Ark Project Letter from Acting Secretary of the Interior) led to congressional approval of the Fry-Ark Project. The document included a pipeline from Pueblo Dam to Lamar, now known as AVC. The document stated needs for the Fry-Ark Project to include "additional quantity and better quality of domestic and municipal water" and additional electricity (supplied by hydroelectric facilities). The Fry-Ark Project was authorized for construction in 1962 (Public Law 87-590) in accordance with House Document 187.

The original Fry-Ark Project Final EIS was completed in 1975 (Reclamation 1975). This document describes AVC as a Fry-Ark feature that would carry "a maximum of 38 cubic feet per second in pipes ranging in diameter from 42 to 21 inches through 110 miles of trunkline and various smaller flows through 108 miles of laterals." Annual flow through AVC would be 12 percent of the Fry-Ark allocation or an average of about 10,000 ac-ft annually. Although actual Fry-Ark allocations for AVC have been less than 10,000 ac-ft annually, given historical hydrology since 1975, much of AVC, including general routes, size, and participants, remains the same as described in the original Fry-Ark EIS.


FRYINGPAN-ARKANSAS PROJECT

LETTER

FROM

ACTING SECRETARY OF THE INTERIOR

TRANSMITTING

REPORT ON THE FRYINGPAN-ARKANSAS PROJECT, COLORADO, PURSUANT TO SECTION 9 (A) OF THE RECLAMATION PROJECT ACT OF 1939 (53 STAT. 1187)

JUNE 18, 1953.—Referred to the Committee on Interior and Insular Affairs and ordered to be printed with illustrations

UNITED STATES
GOVERNMENT PRINTING OFFICE
35002 WASHINGTON : 1953

Photo 1–7. House Document 187, Fry-Ark Project Letter from Acting Secretary of the Interior

Based on renewed AVC interest, Southeastern conducted a study in 2003 to evaluate water needs, alternative alignments, costs, and financing options (GEI 2003). In 2005, Reclamation conducted a Re-Evaluation Study (Reclamation 2005) that confirmed AVC construction viability, but concluded that supplies in addition to Fry-Ark allocations would be needed.

In 2009, Southeastern obtained STAG funding from the U.S. Environmental Protection Agency (EPA) to aid in preliminary planning and pre-NEPA activities for AVC. The overall STAG purpose was to prepare for the NEPA process, gather data, and conduct evaluations necessary to allow the NEPA process to begin. Specific tasks included AVC alignment and technical evaluations, environmental issue identification, permitting needs evaluations, and participant water supply planning evaluations. The work culminated in the STAG report (Black & Veatch 2010), as well as survey information from each participant, geographical information system (GIS) data layers (such as preliminary pipeline conduit alignments), hydraulic analysis spreadsheets, permitting forms, water supply evaluations, and other pertinent information.

After the STAG report was completed and the NEPA process commenced, Reclamation undertook a Value Planning Study (Reclamation 2010c). The study incorporated the Value Method process, which creatively develops proposals that satisfy essential functions at the highest value. The Value Planning team examined component features and suggested alternative solutions to perform those functions consistent with identified criteria at a lower cost or with an increase in long-term value. Four proposals resulted from the process, including eliminating storage tanks; adding total organic carbon removal to the water treatment process; using the Arkansas River from Pueblo Reservoir to a location upstream from Fountain Creek for a portion of conveyance; and using excess conduit capacity to deliver agricultural water. These proposals were considered in the alternatives development process described in Chapter 2.

In conjunction with the AVC EIS, Reclamation conducted an Appraisal Study for the EIS alternatives (Reclamation 2012a, 2013a). The Appraisal Study built on information collected in the STAG report, and used additional alternatives information developed for this EIS (see www.usbr.gov/avceis).

Lead and Cooperating Agencies

Reclamation is the lead agency for the federal actions, and is responsible for preparing this EIS and a Record of Decision. Reclamation would be responsible for constructing AVC and entering into the Interconnect contract and Master Contract if identified in the Record of Decision as actions to be implemented.

Southeastern is a cooperating agency and has an administrative role that would include being the local contracting agency responsible for repayment and working with Fry-Ark beneficiaries. Repaying the reimbursable portion of AVC to Reclamation would be Southeastern’s responsibility. In addition, Reclamation would enter into the Master Contract with Southeastern, who in turn, would administer the contract to the Master Contract participants.

Federal, state, and local agencies provided data, assisted in reviews, helped analyze effects, and contributed to this EIS. Agencies were invited to be cooperating agencies if they had jurisdiction by law or special expertise with respect to the environmental effects of the proposed federal action. The cooperating agencies for this EIS are shown in Table 1–10.

Table 1–10. Arkansas Valley Conduit Environmental Impact Statement Cooperating Agencies

Agency	Jurisdiction and Expertise
Bent, Otero, Prowers, and Pueblo counties	Land use permitting and regulatory authority over land use in the county
Board of Water Works of Pueblo	Owner of Joint Use Pipeline and Whitlock Water Treatment Plant (options considered in alternatives)
City of Pueblo	Land development permitting, special use permitting, rights-of-way, building permitting, and Pueblo Flow Management Program
Colorado Department of Natural Resources	Colorado natural resources, regulatory authority over water administration and wildlife mitigation planning, state parks, wildlife, and Arkansas River Compact
Colorado Department of Transportation	Colorado transportation and roads, regulatory authority over road crossings and pipeline alignments within highway rights-of-way
Colorado Parks and Wildlife	Fish and wildlife mitigation planning, state-listed species
Colorado Division of Water Resources	Water rights administration, Arkansas River Compact administration
Fountain Creek Watershed and Flood Control District	Operation of Fountain Creek and flood control mitigation planning
Kansas Division of Water Resources	Kansas water resources and Arkansas River Compact
Lower Arkansas Valley Water Conservancy District	Water supplies from within the district
Southeastern	Fryingpan-Arkansas Project operations and allocations, development and financing of AVC, representation of AVC beneficiaries, and Master Contract applicant
U.S. Army Corps of Engineers	Clean Water Act Sections 402 and 404, Rivers and Harbors Appropriations Act of 1899 Section 10, and operation of John Martin Reservoir
U.S. Environmental Protection Agency	Clean Water Act, Clean Air Act, and NEPA compliance
U.S. Fish and Wildlife Service	Endangered Species Act, Fish and Wildlife Coordination Act, Migratory Bird Treaty, and Executive Order 13186

Geographic Scope of EIS

Resource analyses presented in this EIS consider the study area, which includes substantial portions of the Arkansas River Basin, and parts of the Roaring Fork River and Fryingpan River headwaters on the West Slope (Figure 1–21). Constructing and operating the proposed actions would affect various environmental resources and geographical areas differently. For example, effects on vegetation may be localized, corresponding to physical disturbances associated with construction. Conversely, effects on streamflow may be more widespread because of water diversions, storage, and releases. Each resource has a defined analysis area used to evaluate effects that encompass all or part of the study area. Chapter 3 and Chapter 4 further describe analysis areas. The EIS study area includes the following areas:

> The **study area** encompasses the analysis areas of all EIS resources. Most effects or impacts of the proposed federal actions would occur in the study area.
>
> An **analysis area** is a geographical area used to evaluate effects or impacts of a specific resource. A resource analysis area may overlap or be independent of other resource analysis areas.

- West Slope: Hydrologic effects could occur on West Slope streams that feed the Fry-Ark Project. Streams include the Roaring Fork River upstream from Aspen, the Fryingpan River upstream from Thomasville, and Homestake Creek upstream from Gold Park. Tributaries of these three streams reaches are also included.
- Fountain Creek: Hydrologic, groundwater, water quality, aquatic, and recreation effects could occur on Fountain Creek. The study area includes Fountain Creek from approximately Stratmoor Hills (the most upstream Master Contract participant) to its confluence with the Arkansas River. The study area does not include Colorado Springs or adjacent stream segments.
- Upper Arkansas River Basin: Hydrologic, groundwater, water quality, aquatic, and recreation effects could occur on the Arkansas River upstream from Pueblo Reservoir. The study area includes the Arkansas River from its confluence with Lake Fork to Pueblo Reservoir, Grape Creek, Lake Fork, Lake Creek, Turquoise Lake, and Twin Lakes.
- Lower Arkansas River Basin: Hydrologic, water quality, aquatic, groundwater, and recreation effects are expected in the Arkansas River from Pueblo Reservoir to John Martin Reservoir, Pueblo Reservoir, Lake Meredith, Lake Henry, and Holbrook Reservoir. Physical ground disturbances from construction could affect recreation, vegetation and wetlands, wildlife, the human environment, socioeconomics, environmental justice, historic properties, and Indian trust assets.
- John Martin Reservoir and Downstream: Hydrologic effects could occur in the Arkansas River from John Martin Reservoir to the area of influence of the most downstream AVC participant. The study area includes the Arkansas River from John Martin Reservoir to the Arkansas River near Granada gage near the Colorado state line. Physical ground disturbances from construction could affect resources similar to the Lower Arkansas River Basin. No water- or land-based effects are expected downstream from Granada and, therefore, no studies were performed downstream from Colorado.

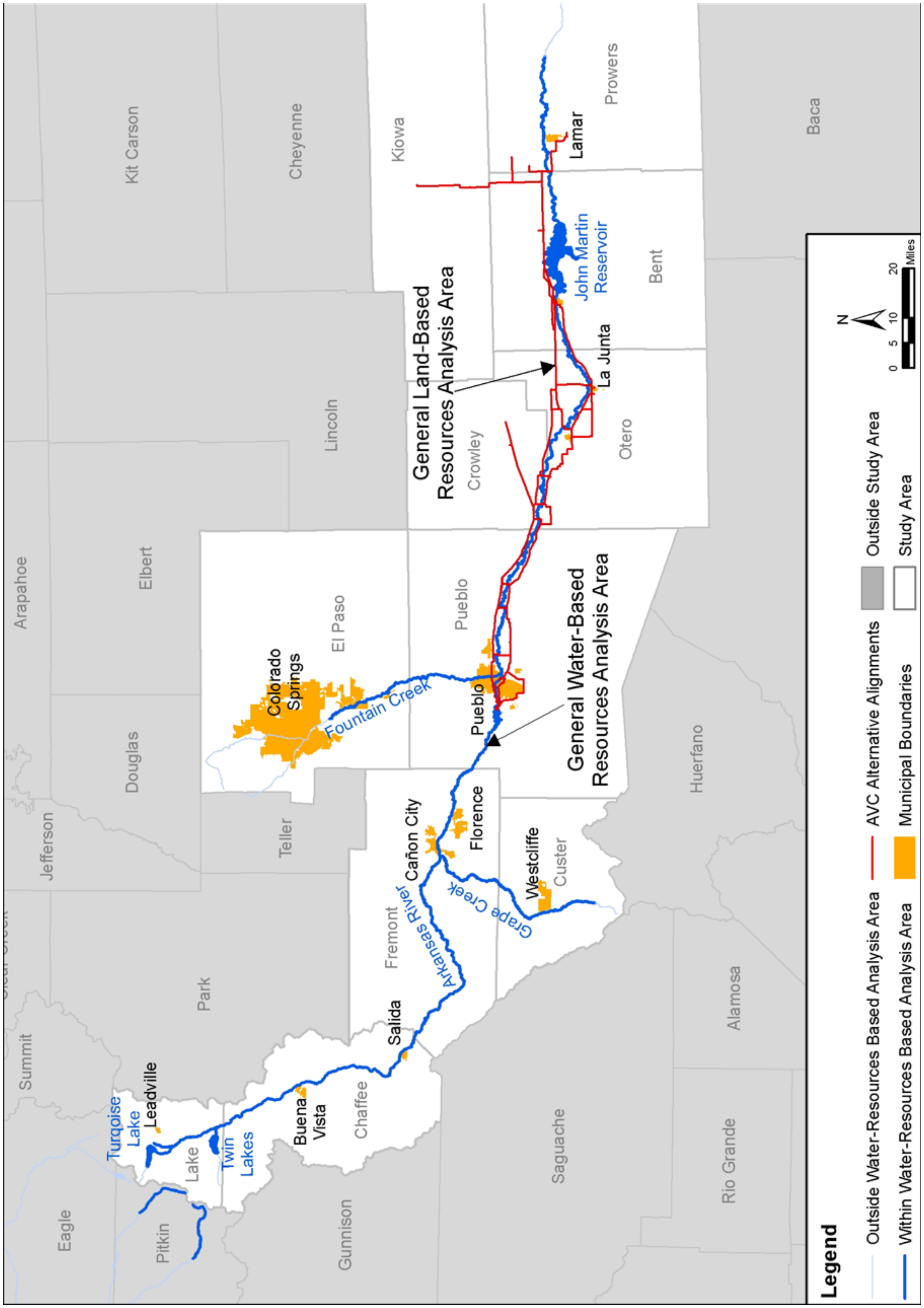


Figure 1–21. Arkansas Valley Conduit Environmental Impact Statement Study Area

Revisions Included in the Final Environmental Impact Statement

The Draft EIS was released for public review in August 2012. Reclamation solicited comments from the public, agencies, and interested parties during the 60-day comment period that ended October 30, 2012. During the comment period, Reclamation held five public hearings from September 24 to 27 in Salida, Pueblo, La Junta, and Lamar to inform people about the proposed actions and to solicit verbal or written public comments on the Draft EIS. Reclamation received a total of 27 letters and e-mails in addition to oral comments at the five public hearings. A total of 200 comments were recorded. Comments were received from reviewing state and federal agencies, organizations, and interested and potentially affected members of the public.

The Final EIS includes revisions based on response to substantive comments on the Draft EIS regarding alternative actions and environmental impacts. In addition, new information became available since completion of the Draft EIS, and analyses relevant to environmental concerns and issues were revised or clarified. The Comanche South Alternative evaluated in the Draft EIS was revised in response to public comments and to reduce resource effects and cost. Reclamation evaluated all of the alternatives based on key criteria to identify a preferred alternative. Reclamation addressed substantive comments received on the Draft EIS in the revised text of the Final EIS or appendixes and in the response to comments (Appendix P).

Primary changes from the Draft EIS include the following:

- The Comanche South Alternative’s AVC alignment and water treatment plant location were revised. The alternative was renamed Comanche North to reflect alignment changes and to maintain consistency with alternative naming conventions. The Comanche North Alternative includes use of the existing Joint Use Pipeline (JUP) and an expanded and integrated operation with Board of Water Works of Pueblo’s Whitlock Water Treatment Plant (Chapter 2, Appendix B.1).
- A preferred alternative was identified (Chapter 2).
- Mitigation for moderate resource effects was revised in response to cooperating agency and public comments (Chapter 4, Appendix B.5).
- Southeastern prepared the Final Regional Water Conservation Plan (Appendix B.7).
- The Arkansas River Compact (Compact) description was revised in consultation with the states of Kansas and Colorado (Chapter 3, Chapter 4, Appendix D.3)
- Floods and water quality effects analyses were updated using new information (Chapter 4, Appendix F.1, Appendix F.2).
- Discussion of effects on West Slope streamflow was expanded (Appendix D.5).
- Effects on the Santa Fe National Historical Trail were clarified (Chapter 4).
- In consultation with the Colorado State Historic Preservation Office, National Park Service, and other consulting parties, Reclamation prepared a National Historic Preservation Act Section 106 Programmatic Agreement to address potential impacts to historic properties (Appendix N).

- Reclamation submitted a Biological Assessment to the U.S. Fish and Wildlife Service (Appendix O)
- Reclamation responded to substantive Draft EIS public comments (Appendix P).

Concerns and Issues Related to the Proposed Actions

Reclamation identified public and agency concerns and issues relevant to the proposed actions to be considered and analyzed in the EIS. Concerns were raised by members of the public and agencies at scoping meetings held August 16 – August 19, 2010, in Salida, La Junta, Lamar, Fountain, and Pueblo, Colorado (Reclamation 2010d). Concerns and issues were also identified through consultation meetings with federal, tribal, state, and local agencies in and from written comments submitted by agencies, tribes, organizations, and the public. A Draft EIS was released for public review on August 29, 2012. Public hearings on the Draft EIS were held September 24 – September 27, 2012, in Salida, Pueblo, La Junta, and Lamar, Colorado.

The scope of analysis for this Final EIS focuses on responding to the following statement:

- If Reclamation constructs and operates the proposed actions, then the effect(s) on other relevant resources/issues would be…

Based upon information obtained through scoping, discussion with interested and affected parties, and existing laws and regulations, Reclamation identified the following resources, issues, or concerns as potentially relevant to the proposed actions. The Final EIS proceeded with analysis of effects for the following resources:

- Surface water hydrology
- Groundwater hydrology
- Water quality
- Geomorphology
- Aquatic life
- Recreation
- Vegetation and wetlands
- Wildlife
- Human environment
- Socioeconomic resources
- Environmental justice
- Historic properties
- Indian trust assets

Issues and concerns that were raised during the public comment period on the Draft EIS and are relevant to the alternatives analyzed in this Final EIS are listed in Table 1–11. Other potentially relevant resources, issues, or concerns may be identified during the process of completing this EIS and would be considered and analyzed as appropriate.

Table 1–11. Issues and Concerns Identified During the Draft EIS Public Comment Period

Topic	Location Where Addressed in Final EIS
Alternatives	Chapter 2, Chapter 4, Appendix B.1, Appendix B.2, Appendix B.3
Aquatic life	Chapter 4, Appendix B.5, Appendix D.5
Consultation and coordination	Chapter 5, Appendix N, Appendix O
Cumulative effects	Chapter 1, Chapter 4, Appendix B.4, Appendix D.3
Geographic scope	Appendix P
Groundwater	Chapter 1
Historic properties	Chapter 4, Appendix N
Human environment	Chapter 3, Chapter 4, Appendix B.5, Appendix N
Surface water hydrology	Chapter 2, Chapter 3, Chapter 4, Appendix B.1, Appendix D.1, Appendix D.2, Appendix D.3, Appendix D.4, Appendix D.5, Appendix D.6
NEPA process	Chapter 4, Appendix B.4, Appendix B.5, Appendix P
Proposed actions	Appendix P
Purpose and need	Chapter 1, Appendix A.1, Appendix A.2, Appendix A.3, Appendix P
Recreation	Chapter 3, Chapter 4, Appendix B.5
Socioeconomics	Chapter 4, Chapter B.5, Chapter D.4
Vegetation	Chapter 4, Chapter B.5
Water conservation	Appendix B.7
Water quality	Chapter 1, Chapter 3, Chapter 4, Appendix B.3, Appendix F.1, Appendix F.2
Wildlife	Chapter 4, Appendix O

Overview of EIS

Analyses in this EIS comply with NEPA, the Council on Environmental Quality regulations that implement NEPA (40 (Code of Federal Regulation (CFR) 1500) and Reclamation's NEPA Handbook (Reclamation 2012b). The EIS contains the following chapters:

- Chapter 1 describes the purpose(s) of each proposed federal action and why each is needed.
- Chapter 2 summarizes the No Action Alternative and six action alternatives, and best management practices to avoid or minimize effects.
- Chapter 3 discusses the environment that would be affected by implementing the alternatives.
- Chapter 4 discloses the potential environmental effects of alternatives, including mitigation measures for the action alternatives.
- Chapter 5 discusses applicable laws and regulations, and consultation and coordination with the public, agencies, and tribes.

Next Steps

Reclamation has made no final decisions regarding the proposed actions at the time of publication of the Final EIS. Accordingly, it is important for the reader to understand that mere identification of a federally preferred alternative does not indicate that Reclamation has made any final decisions with respect to the proposed actions identified in this Final EIS. Any final decisions by Reclamation with respect to the proposed actions will be included in a Record of Decision.

No sooner than 30 days after the EPA has published the notice of availability for the Final EIS, Reclamation will issue a Record of Decision. The Record of Decision will identify the following:

- Significant comments received and issues raised in the Final EIS
- Reclamation's selected alternative for implementation
- Alternative(s) considered environmentally preferable

The Record of Decision will also discuss factors considered with respect to the alternatives and how these considerations entered into the decision. Reclamation will include environmental commitments, means to avoid or minimize environmental harm, and any monitoring or enforcement activities to ensure that environmental commitments would be met, if proposed action(s) is/are selected, constructed, and put into operation.

Chapter 2 Alternatives

Alternatives were developed using a structured alternative development and screening process. The goal of this process was to identify a range of reasonable alternatives to meet the purpose and needs of the AVC, Interconnect, and Master Contract. NEPA regulations do not specify the number of alternatives to be considered in an EIS, but describe a range of reasonable alternatives as "those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant" (Council on Environmental Quality 1986). NEPA regulations also require that all reasonable alternatives, including No Action, and those for which an agency lacks authority to implement, are rigorously explored and objectively evaluated, and that the reasons for eliminating alternatives are discussed (40 CFR 150.14).

Seven Alternatives were identified for evaluation in this EIS:

- No Action
- Comanche North
- Pueblo Dam South
- JUP North
- Pueblo Dam North
- River South
- Master Contract Only

NEPA regulations require analysis of a No Action Alternative to serve as a basis of comparison to other alternatives. U.S. Department of the Interior regulations interpret the No Action Alternative one of two ways. No Action could either be "no change" from a current management direction or level of management intensity, or "no project" when a new project is proposed for implementation (43 CFR Part 46.30(1)). For this EIS, No Action means that AVC and the Interconnect would not be built and the associated contracts would not be issued, and would result in other future actions by the various participants as described in this chapter. Note that the No Action Alternative need not meet the purpose and need of the project (U.S. Department of the Interior 2005).

In addition to satisfying NEPA requirements, projects subject to permitting by the U.S. Army Corps of Engineers (Corps) under Section 404 of the Clean Water Act also must comply with Section 404(b)(1) Guidelines (40 CFR 230) for discharging dredge and fill material into waters of the United States. These guidelines specify "no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse effect on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences." An alternative is considered practicable if "it is capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes." The guidelines assume "practicable alternatives that do not involve special aquatic sites are available, unless clearly demonstrated otherwise." The guidelines also assume that "all practicable alternatives to the proposed discharge which do not involve a discharge into a special aquatic site are presumed to have less adverse effect on the aquatic ecosystem, unless clearly demonstrated otherwise."

The alternatives analysis required under the 404(b)(1) Guidelines can be conducted either as a separate analysis during the Section 404 permitting process, or incorporated into the NEPA process. Reclamation's NEPA procedures encourage integrating NEPA analyses with other permitting and approval processes (Reclamation 2012b). Although this EIS is not intended to fulfill the Corps' Section 404 permitting requirements, these guidelines were considered in Reclamation's alternative development and screening process.

This chapter summarizes the alternatives development process and identifies and describes six action alternatives and a No Action Alternative identified for detailed analysis. The final portion of this chapter briefly compares the environmental effects of each alternative. These effects are described in detail in Chapter 4. Alternatives development and details are presented in Appendix B.

Alternatives Development and Screening Process

A structured alternative development and screening process identified a wide range of technical and conceptual options and formulated them into a set of alternatives that address key issues. To develop a range of reasonable alternatives, the proposed actions were first separated into components. *Components* are discrete activities or facilities (e.g., a water intake location) that, when combined with other components, form an alternative. Then, options were identified for each component. An *option* is an alternate way of completing a component activity, or an alternate geographic location for a facility, such as alternate methods for diverting water or alternate geographic locations for a water intake. Options consist of the differences among alternatives. An *alternative* is a complete project that has all the components and related options necessary to fulfill the purpose and need of the proposed actions. Each alternative fulfills one or more *alternative themes*, which address key scoping issues.

A schematic of the alternatives development process is presented in Figure 2-1. The first step was component and options development, with the Interconnect construction as an engineering subcomponent of AVC. Six components were identified that would form the alternatives:

- AVC and Master Contract Water Supply
- Master Contract Regulating Storage
- AVC Intake Location
- AVC Conveyance Through Pueblo
- AVC Conveyance East of Pueblo
- AVC Water Treatment

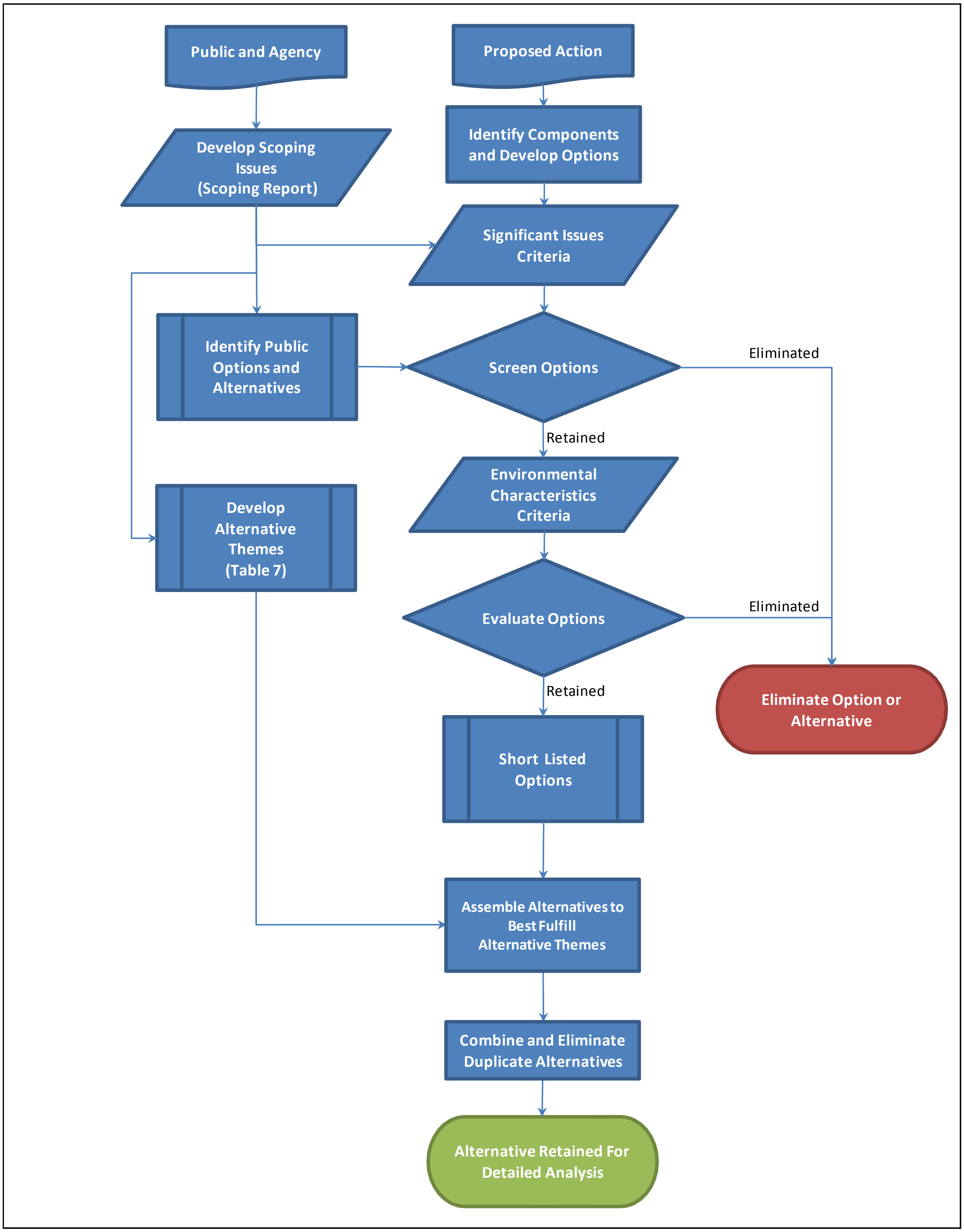


Figure 2–1. Alternatives Screening and Development Process

Specific and conceptual options were developed that potentially could be used to implement each component. This initial long list of options was consolidated into a short list using a two-step screening and evaluation process that considered significant technical, economical, and logistical issues and environmental characteristics. The significant issues screening was a pass/fail screening to quickly eliminate options that could not meet the purpose and need or had other fatal flaws. The environmental characteristics of each option were then evaluated to determine which options best met certain criteria.

Next, alternative themes were identified. Alternative themes addressed recurring issues that arose during the scoping process, comments made by cooperating agencies, requirements in the NEPA process, and purpose and need for the project. Fourteen alternative themes were identified:

- Take no action
- Minimize cost
- Minimize wetland acres disturbed
- Maintain highest minimum flow in the Arkansas River through Pueblo
- Minimize farmland disturbance
- Minimize construction disturbance
- Minimize urban construction disturbance
- Maximize route along existing rights-of-way
- Avoid U.S. Highway 50 expansion corridor
- Maximize nonstructural options
- Maximize source water quality and yield
- Maximize operational flexibility
- Enter into Master Contract only
- Construct AVC only

Based on environmental characteristics and other information, options that best met each alternative theme were identified. Alternative themes were then consolidated based on common combinations of options (i.e., some themes were combinations of the same short-listed options, and thus were combined into one alternative). These alternatives were evaluated in the Draft EIS.

In response to several public comments and recommendations on the Draft EIS, the alternatives were reexamined to see if mixing components (for example, pipeline routes, water treatment options, other engineering features) would decrease costs and minimize environmental effects (specifically infrastructure effects within Pueblo). As a result the JUP, Interconnect, Master Contract, and various routes of pipeline segments were incorporated into a hybrid alternative called Comanche North (Reclamation 2013a). The Comanche North Alternative replaced Comanche South and is evaluated in the Final EIS. The alternative meets the same alternative themes as developed in the original alternatives analysis described in this appendix. Comanche North Alternative pipeline sizes (diameter) are smaller than other alternatives with AVC because the alternative meets maximum month demand, which is less than peak day demand met by other alternatives. Annual AVC deliveries, however, would be the same as other alternatives with AVC.

The following six action alternatives are evaluated in this Final EIS:

- **Comanche North Alternative** minimizes cost and urban construction disturbance, avoids the U.S. Highway 50 expansion corridor, and maximizes source water quality and yield
- **Pueblo Dam South Alternative** minimizes wetland acres disturbance and maximizes use of existing rights-of-way
- **JUP North Alternative** minimizes cost, farmland disturbance, and construction disturbance, avoids the U.S. Highway 50 expansion corridor, and includes only AVC

The **Joint Use Pipeline (JUP)** is an existing pipeline that currently delivers water from Pueblo Reservoir to the Whitlock Water Treatment Plant. The Comanche North and JUP North alternatives would use excess capacity available in the JUP.

- **Pueblo Dam North Alternative** avoids the U.S. Highway 50 expansion corridor and maximizes operational flexibility
- **River South Alternative** minimizes wetland acres disturbed (similar to the Pueblo Dam South Alternative), has the highest minimum flow in the Arkansas River through Pueblo, and maximizes use of existing rights-of-way
- **Master Contract Only Alternative** fulfills the Master Contract only theme

Photo 2–1. The River South Alternative would maintain the highest minimum flow in the Arkansas River through Pueblo

Information used to identify options that best met each alternative theme was based on the best information available at the time the alternatives were formulated. Effects analyses conducted as part of this EIS evaluate the effects of each alternative, and oftentimes use additional or updated data not used to identify options and alternative themes.

Alternatives Identified for Further Study

Seven alternatives were identified for detailed evaluations: the No Action Alternative and six action alternatives. These alternatives provide a range of reasonable and practicable alternatives for meeting the purpose and need of the project. The alternatives are responsive to scoping issues, satisfy the requirements for alternatives selection under NEPA and U.S. Department of the Interior regulations, and are consistent with the 404(b)(1) Guidelines.

The alternatives with AVC also satisfy the Colorado Water Quality Control Division Surface Water Treatment Rules by delivering filtered water, which would require residual chlorination at each participant delivery point, or filtered and disinfected water, which would maintain a chlorine residual in AVC (Health Department 2011a). Water treatment levels are further described in Chapter 2 – *Common Elements*. St. Charles Mesa Water District could receive raw, untreated water if the AVC water treatment plant is built east of Pueblo, but filtered water would lower their water treatment costs (Simpson 2012). Delivery of AVC water to St. Charles Mesa Water District would also reduce the district’s transit losses by avoiding canal or river deliveries (Simpson 2012). The St. Charles Mesa Water District delivery option varies between alternatives, as described in this chapter.

The No Action Alternative does not include any contracting actions by Reclamation, other than possible consideration of temporary contract renewal. Throughout this EIS, effects of each action alternative within each specific resource area are evaluated against the No Action Alternative.

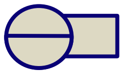
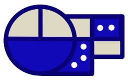
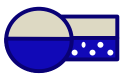
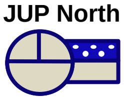
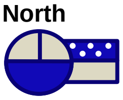
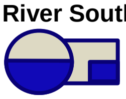
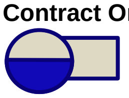
Throughout this EIS, the Comanche North, Pueblo Dam South, JUP North, Pueblo Dam North, River South, and Master Contract Only alternatives are referred to as the “action alternatives.” All action alternatives would include at least one of the contracts with Reclamation discussed in Chapter 1. Major Reclamation contracting actions required for each action alternative are identified in Table 2-1.

Table 2–1. Major Federal Construction and Contracting Actions Required for Each Alternative

Alternative	AVC Construction, Repayment, and Conveyance Contract	Interconnect Conveyance Contract	Long-Term Excess Capacity Master Contract
No Action			
Comanche North	√	√	√
Pueblo Dam South	√		√
JUP North	√	√	
Pueblo Dam North	√	√	√
River South	√		√
Master Contract Only			√

This EIS presents summary level descriptions of the alternatives, including general component options, locations, and conceptual operations. Components of each alternative are in Table 2-2. A key to the symbols used to represent the alternatives in this chapter is presented in Figure 2-2. For more detailed information about alternative components, refer to Appendix B.1, Appendix B.2, Appendix B.3, and Reclamation’s appraisal design reports for AVC (Reclamation 2012a, 2013a).

Table 2–2. Alternatives Identified for Evaluation in EIS

Alternative	AVC	Interconnect	Master Contract
No Action 	AVC participants would regionalize or continue current operations. Water treatment would meet primary drinking water standards (including radionuclides), but not necessarily secondary drinking water standards.	No Interconnect	No Master Contract: Continue existing short-term If-When contracts in Pueblo Reservoir
Comanche North 	Water would be diverted from the existing Pueblo Reservoir JUP. AVC would be constructed south of Pueblo and then north of the Arkansas River to Lamar. The existing Board of Water Works of Pueblo Whitlock Water Treatment Plant would be expanded to filter water.	Interconnect	Master Contract: 29,938 ac-ft of long-term excess capacity storage in Pueblo Reservoir
Pueblo Dam South 	Water would be diverted from the existing Pueblo Reservoir south outlet works. AVC would be constructed along the Bessemer Ditch through Pueblo, then south of the Arkansas River and east to Lamar. A new water treatment plant would be built near South Road and 21st Street in St. Charles Mesa to filter water. [1]	No Interconnect	Master Contract: 29,938 ac-ft of long-term excess capacity storage in Pueblo Reservoir
JUP North 	Water would be diverted from the existing Pueblo Reservoir JUP. AVC would be constructed north of the Arkansas River through Pueblo to Lamar. New water facilities would be built near the existing Whitlock Water Treatment Plant to filter water.	Interconnect	No Master Contract: Continue existing short-term If-When contracts in Pueblo Reservoir
Pueblo Dam North 	Water would be diverted from existing Pueblo Reservoir south outlet works. AVC would be constructed north of the Arkansas River through Pueblo to Lamar. A new water treatment plant would be built at Pueblo Reservoir to filter water.	Interconnect	Master Contract: 29,938 ac-ft of long-term excess capacity storage in Pueblo Reservoir
River South 	Water would be diverted from the Arkansas River upstream from Fountain Creek. AVC would be constructed south of the Arkansas River to Rocky Ford and east to Lamar. A new water treatment plant would be built near the existing St. Charles Mesa Water District facilities to filter and disinfect water.[1]	No Interconnect	Master Contract: 29,938 ac-ft of long-term excess capacity storage in Pueblo Reservoir
Master Contract Only 	AVC would not be built. AVC participants would operate as described in the No Action Alternative.	No Interconnect	Master Contract: 29,938 ac-ft of long-term storage in Pueblo Reservoir

Note:
[1] For the Pueblo Dam South and River South alternatives, St. Charles Mesa Water District would be delivered raw water rather than filtered or filtered and disinfected water.

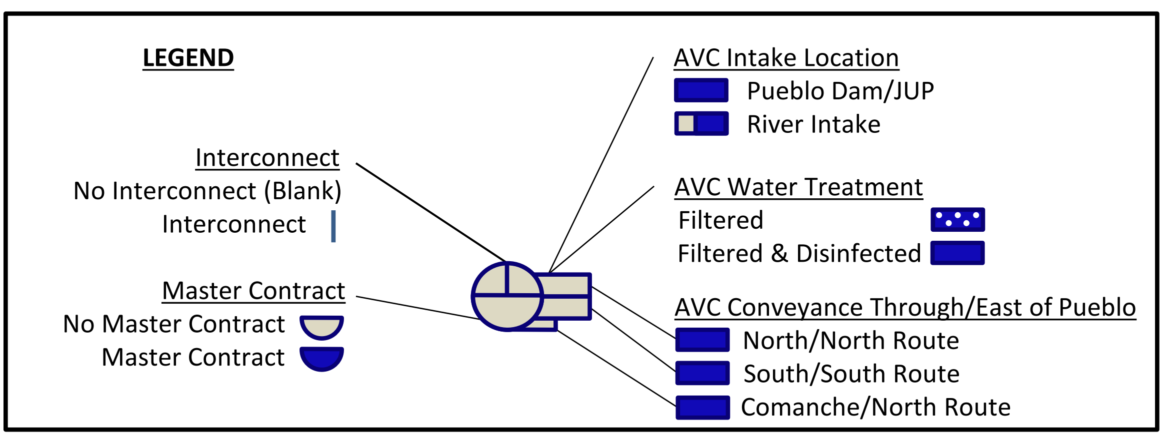


Figure 2–2. Legend Describing Alternatives Symbols

Appraisal-level cost estimates were prepared for use in planning, evaluating, and comparing alternatives and their features. Construction and operating, maintenance, and replacement (OM&R) costs for the alternatives are summarized in Table 2-3. The cost estimates should only be used for comparative purposes when evaluating the differences between alternatives. Following a Record of Decision, Reclamation would assess the proposed actions from a funding standpoint. At that time, Reclamation would develop final design and construction cost estimates. It is only these updated and detailed estimates that Reclamation would use to seek appropriations from Congress. For more detailed information about cost estimates, refer to Reclamation's appraisal design reports for AVC (Reclamation 2012a, 2013a).

Table 2–3. Costs of Alternatives

Cost Description	Costs ($ million) [1]						
	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Construction [2]	192	400	495	495	505	475	192
Annual OM&R [2]	5.0	3.5	3.4	3.8	3.8	4.2	5.0
Annual Master Contract [3]	0.1 - 0.2	0.8 - 1.1	0.8 - 1.1	0.1 - 0.2	0.8 - 1.1	0.8 - 1.1	0.8 - 1.1

Notes:

(1) Costs are in 2011 dollars.

(2) Costs include both AVC and Interconnect. Interconnect construction costs would be about $7 million, and annual maintenance costs would be about $1,600. AVC and Interconnect construction and OM&R costs for Comanche North, Pueblo Dam South, JUP North, Pueblo Dam North, and River South costs from appraisal design reports (Reclamation 2012a, 2013a). Construction and OM&R costs for No Action and Master Contract Only alternatives from Appendix B.3.

(3) Master Contract costs are described in Appendix B.6. Table presents range of costs.

No Action Alternative

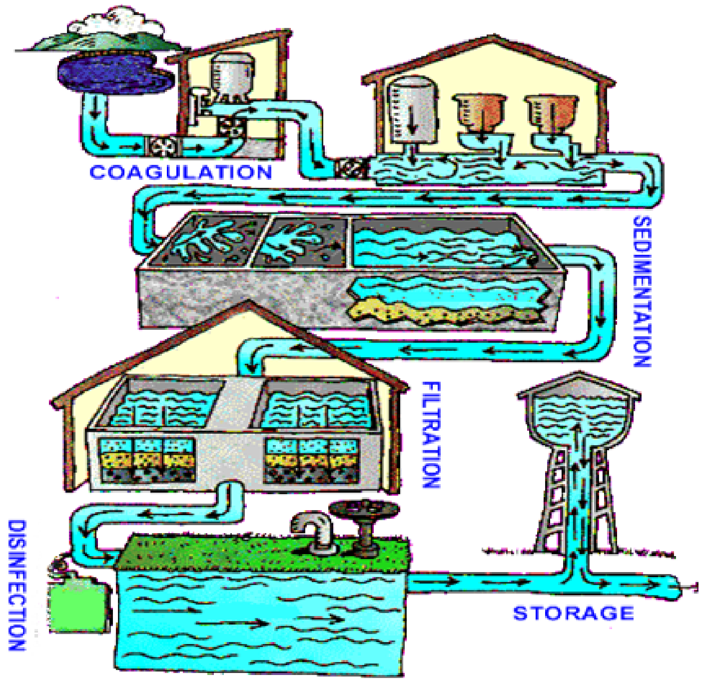
The No Action Alternative represents how all participants would meet future water needs without the AVC, Interconnect, or Master Contract. Separate No Action Alternative components have been developed for each proposed federal action, including water treatment and delivery, backup delivery, and temporary excess capacity contracts for storage in Pueblo Reservoir. The No Action Alternative was developed using data, plans, and preferences gathered from questionnaires provided by participants. Interviews were conducted with various participants to further clarify actions under this alternative. The estimated construction cost of the No Action Alternative option is $192 million. Estimated annual OM&R costs are $5.0 million, and estimated annual costs for the short-term excess capacity contracts are $0.1 to $0.2 million.

No Action for Arkansas Valley Conduit Participants

If AVC is not implemented, AVC participants would likely meet water supply and water quality needs with a combination of regional and local independent water treatment systems. Regional systems are combinations of smaller AVC participants who would be served by a larger neighboring utility's water treatment plant. Local independent systems would include participants with the ability to meet primary drinking water standards who are not providers for a regional system. The No Action Alternative was developed to meet primary drinking water standards and address existing enforcement actions using existing surface and groundwater supplies, and to meet full 2070 demands. The No Action Alternative may or may not meet secondary drinking water standards, depending on individual treatment systems, as secondary drinking water standards are not mandatory standards.

Each component of the No Action Alternative was independently evaluated, and engineering configurations and cost estimates were developed for the treatment and distribution systems (see Appendix B.3). Table 2-3 summarizes the construction, operation, maintenance, and replacement costs of the No Action Alternative. Regional and local independent water treatment systems would be funded by the AVC participants. No federal cost share has been identified at this time.

Regional Systems Smaller AVC participants who identified regionalization as the most likely No Action Alternative, or who have not identified other treatment methods to address Health Department enforcement actions, would likely connect to a nearby larger AVC participant. Regional water system providers and participants appear in Table 2-4. These regional groupings are based on participant surveys and best professional judgment. If the No Action Alternative is pursued, the regional system configurations could change based on contract negotiations and engineering considerations. Additional pipeline infrastructure to deliver water from regional water treatment plants to customers would be required (Figure 2-3).



Source: Courtesy of U.S. EPA
Drawing 2–1. Typical regional conventional water treatment facility

Table 2–4. Regional AVC Participants Under No Action Alternative

County	Regional Service Provider	Regional Participants	Participant Identified Regionalization As No Action	Participant with Current Health Department Radionuclide Enforcement Action
Otero	Fowler	Fowler		
		Valley Water Company		√
Otero	Rocky Ford	Hancock, Inc.	√	√
		Hilltop Water Company	√	
		Rocky Ford		
		Vroman		√
		West Grand Valley Water, Inc.	√	
Otero	La Junta	Bents Fort Water Company [1]	√	
		Cheraw		√
		East End Water Association		√
		Holbrook Center Soft Water		√
		Homestead Improvement Association	√	
		La Junta		
		Swink		√
Prowers	Lamar	Lamar		
		May Valley Water Association		√

Note:
[1] Bent's Fort Water Company currently receives a portion of its water from La Junta.

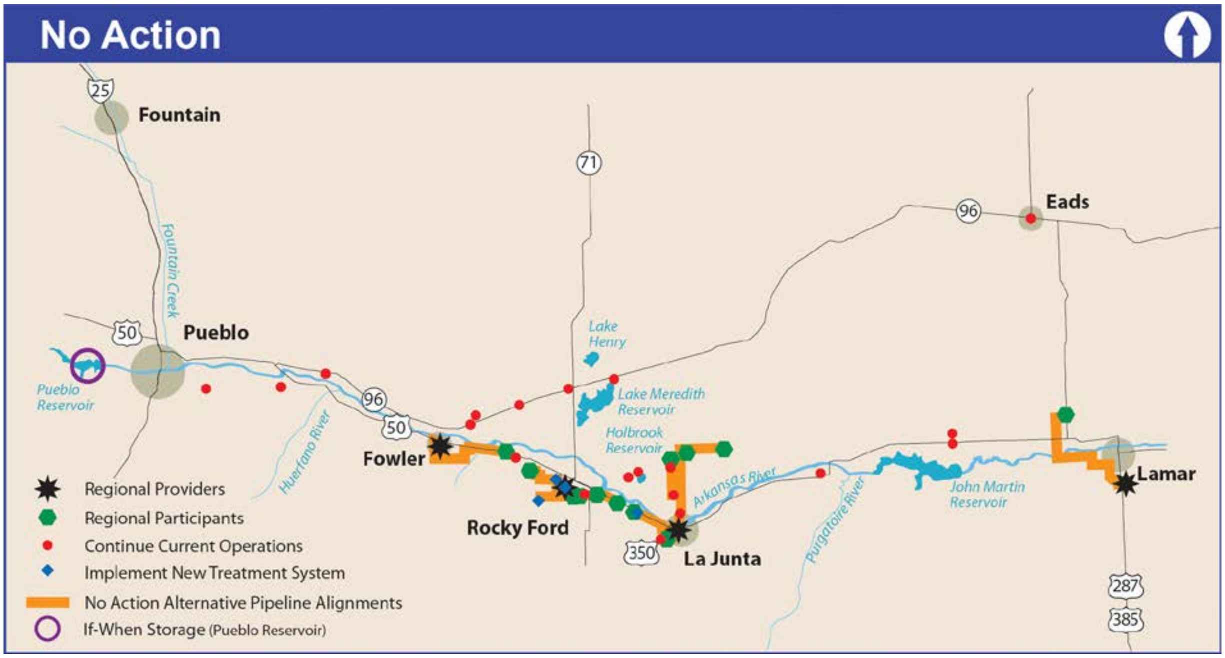


Figure 2–3. No Action Alternative Map

Water Supplies for Regional Systems Existing water supplies that meet primary drinking water standards (primarily alluvial groundwater) would continue to be used. Regional AVC participants under enforcement action due to radionuclide contamination (primarily deep bedrock groundwater) would abandon those sources. To replace water sources that can no longer be used, and to meet future water demands in 2070, additional water sources would be acquired.

Each regional service provider (Fowler, Rocky Ford, La Junta, and Lamar) currently uses alluvial groundwater. Rocky Ford also uses surface water supplies during various times of year. The most likely new water source would be additional alluvial groundwater for compatibility with existing systems. Because alluvial groundwater affects surface water flows in the Arkansas River, alluvial groundwater pumping must be offset by releasing augmentation water to the river to compensate for depletions to surface water flows. Regional participants would need to release their Fry-Ark allocations and/or other non-Fry-Ark supplies to the Arkansas River for augmentation. (See later sections of this chapter and Appendix A for more detail on non-Fry-Ark supplies that could be used for augmentation.)

Water Treatment for Regional Systems Regional water treatment plants would be located at the regional service provider's current site, although expansion may be required to accommodate additional demands for regional participants. The current treatment processes would continue, with possible minor modifications to account for changes in source water quality or regulations:

- Fowler uses filtration and disinfection water treatment processes. At its North Springs facility, chlorine is the only treatment. At the Hammond Springs facility, chlorine and bag filter treatment are used. Treatment using chlorine disinfection and possibly filtration would continue.

- Rocky Ford uses a conventional treatment plant (sedimentation, filtration, and disinfection) for water diverted from the Catlin Canal in the spring to early fall months. Rocky Ford also uses chlorine disinfection on alluvial well supplies throughout the year. These treatment methods would continue.
- La Junta uses reverse osmosis water treatment. This treatment facility was constructed in 2004 and uses reverse osmosis and pressure filters to remove iron and manganese. La Junta currently mixes brine from the reverse osmosis process with its wastewater treatment plant effluent and discharges it to the Arkansas River. The CORADS report (Malcolm Pirnie 2009a) indicated that this type of discharge would likely not be allowed to continue in the future, although no time frame was given. In the future, brine disposal techniques could include residuals minimization strategies and zero liquid discharge techniques. Zero liquid discharge is assumed in this EIS.

Photo 2–2. Tubular modules and pump at La Junta's existing reverse osmosis water treatment facility

- Lamar uses conventional water treatment processes, which include chlorination, fluoridation, and use of a sequestering agent to remove iron and manganese. This treatment method would continue.

Independent Systems AVC participants who could meet primary drinking water standards using existing supplies would continue to operate their independent water systems. Some participants (Eureka, Fayette Water Association, Patterson Valley, and South Swink Water Company) are currently under an enforcement action by the Health Department for radionuclides and would upgrade their treatment facilities to come into compliance. All other independent system participants would use their existing water treatment facilities that meet primary drinking water standards, but may or may not meet secondary drinking water standards. Table 2–5 presents AVC participants who would continue to operate independently under the No Action Alternative.

Independent Systems Water Supplies Independent system AVC participants either have water sources meeting primary drinking water standards, or would treat their existing sources to meet primary drinking water standards. To meet future water demands in 2070, most participants would acquire additional water sources.

Table 2–5. Independent System AVC Participants Under No Action Alternative

County	Independent System Participants	Participant with Current Health Department Radionuclide Enforcement Action	Upgrade Treatment of Existing Supplies [1]	Use Existing Treatment System
Pueblo	Avondale			√
	Boone			√
	St. Charles Mesa Water District			√
Crowley	96 Pipeline Company			√
	Crowley County Water Association			√
	Crowley			√
	Ordway			√
	Olney Springs			√
	Sugar City			√
Otero	Beehive Water Association			√
	Eureka Water Company	√	√	
	Fayette Water Association	√	√	
	Manzanola			√
	Newdale-Grand Valley Water Company			√
	North Holbrook Water [2]	√		√
	Patterson Valley	√	√	
	South Side Water Association			√
	South Swink Water Company	√	√	
	West Holbrook Water			√
Bent	Hasty Water Company			√
	Las Animas			√
	McClave Water Association			√
Prowers	Wiley			√
Kiowa	Eads			√

Note:
(1) AVC participants under enforcement actions would upgrade their treatment systems and continue to use deep bedrock groundwater supplies.
(2) North Holbrook Water was not included in the No Action Alternative regional system formulation because the status of the participant's enforcement action was unclear. North Holbrook Water may be included in a regional system in the Final EIS, but this change is not anticipated to change the No Action Alternative effects in this EIS.

Independent system AVC participants use either deep bedrock groundwater or alluvial groundwater. St. Charles Mesa is the only participant who also uses surface water in addition to its alluvial well supplies. Except for St. Charles Mesa, the most likely source of additional water supplies in the future would be additional groundwater. Independent system AVC participants would most likely use the same type of groundwater already available to them; AVC participants who use deep bedrock groundwater would seek additional deep bedrock groundwater supplies, and AVC participants who use alluvial groundwater would seek additional alluvial groundwater supplies. St. Charles Mesa likely would use additional surface water supplies and would require storage to use its Bessemer Ditch shares. Olney Springs and Ordway have identified a need for storage, even if AVC were not built to facilitate leases of their excess supplies to other entities.

Because alluvial groundwater affects surface water flows in the Arkansas River, alluvial groundwater pumping must be offset by releasing augmentation water to the river to compensate for depletions to surface water flows. Independent system AVC participants using alluvial groundwater would release their Fry-Ark allocations to the Arkansas River for augmentation use.

Crowley County Water Association, 96 Pipeline Company, and Las Animas would likely need storage in Pueblo Reservoir for augmentation or use of non-Fry-Ark supplies (see *No Action for Master Contract Participants*, below). Independent system AVC participants who would continue to use deep bedrock groundwater that does not require augmentation would likely not require their Fry-Ark allocation and would make that Fry-Ark water available to other AVC participants who require additional augmentation water.

Independent Systems Water Treatment All independent system AVC participants would continue using their existing water treatment processes except South Swink Water Company, Eureka Water Company, Patterson Valley, and Fayette Water Association. These participants would upgrade their existing water treatment plants to use preformed hydrous manganese oxide filtration technology. This technology is effective at removing radium from water and, presumably, would bring these independent system AVC participants into compliance with primary drinking water standards. Spent filter media from these water treatment plants likely would contain high levels of radionuclides and would require specialized disposal. A radioactive materials license may be required for these water treatment plants. Preformed hydrous manganese oxide filtration technology is not designed to remove dissolved solids from water. Thus, water quality for these participants still might not meet secondary drinking water standards despite upgraded radionuclide treatment systems.

Except Las Animas, all remaining independent system AVC participants would use existing conventional treatment technology. Las Animas uses reverse osmosis water treatment facilities constructed in 1996. Similar to La Junta, Las Animas currently mixes brine from the reverse osmosis process with its wastewater treatment plant effluent and discharges it to the Arkansas River. In the future, brine disposal techniques could include residuals minimization strategies and zero liquid discharge techniques. Zero liquid discharge is assumed for the No Action Alternative evaluated in this EIS.

No Action for Interconnect Participants

The Interconnect, which is an engineering feature of AVC (see Chapter 2 – *Common Elements*), would not be constructed under the No Action Alternative. The Interconnect participants would take other measures to increase redundancy (Table 2-6). Most would use existing systems, but Pueblo West would construct a pump station from the Arkansas River immediately below Pueblo Dam, and the fish hatchery would construct a diversion from Bessemer Ditch.

Table 2–6. No Action Alternative if Interconnect Is Not Built

Interconnect Participant	No Action Alternative
AVC Participants	Varies by participant; manage systems to minimize disruptions Increase or revert to groundwater pumping Release augmentation water from Pueblo Reservoir
Board of Water Works of Pueblo	Use existing emergency Arkansas River intakes Release water from Pueblo Reservoir
Colorado Springs Utilities	Continue current operations
Fountain, Security, Widefield, and Stratmoor Hills	Secure agreements with other water providers
Pueblo Fish Hatchery	Build diversion from Bessemer Ditch
Pueblo West	Build pump station to divert water from Arkansas River Release water from Pueblo Reservoir

No Action for Master Contract Participants

In the absence of a Master Contract for long-term storage of water in Pueblo Reservoir, Master Contract participants indicated that they would do one of the following:

- Continue current operations without storage
- Continue applying or apply for new temporary excess capacity (If-When storage) contracts with Reclamation for storage of non-Fry-Ark water in Fry-Ark reservoirs

A few Master Contract participants indicated they might build additional storage reservoirs in the absence of the Master Contract. The No Action Alternative assumed that no new infrastructure would be built to provide storage because the proposed reservoirs are speculative at this point.

> **Temporary excess capacity contracts** are temporary (typically 1 year) excess capacity contracts for storage of non-Fry-Ark Project water in Fry-Ark storage facilities if and when space is available. **These contracts are also known as "If and When Contracts."** When storage is unavailable to accommodate both Fry-Ark and non-Fry-Ark water, non-Fry-Ark water is "spilled" or released from the reservoir. Temporary excess capacity accounts spill before long-term excess capacity accounts (i.e., the Master Contract). In 2010, Reclamation issued a Finding of No Significant Impact to enter into 1-year temporary excess capacity storage accounts for up to 80,000 ac-ft per year as long as conditions do not change significantly from conditions analyzed in the 2006–2010 Environmental Assessment. This short-term contract currently provides storage for some Master Contract participants.

The No Action Alternative without the Master Contract is summarized in Table 2-7. Master Contract participants who have had temporary excess capacity contracts in the past would continue to apply individually for these temporary contracts. Temporary excess capacity contracts undergo NEPA review, either annually or in multiyear cycles, and are not guaranteed to be issued every year. These contracts also have a lower spill priority than long-term excess capacity contracts and would be subject to spill more often than the Master Contract (spill priorities are covered in Chapter 3). Master Contract participants' need to meet existing and future water demands may not be fully met by the No Action Alternative.

Final contract terms and costs for use of Pueblo Reservoir excess capacity would be determined during contract negotiations. Cost estimates are in Table 2-3 and Appendix B.6.

Table 2–7. No Action Alternative Without Master Contract

Master Contract Participant [(1)]	AVC Participant	No Action Alternative [(1)]
Chaffee County		
Poncha Springs		Continue Current Operations – No Storage
Salida		Temporary Excess Capacity Contracts (625 ac-ft)
Upper Arkansas Water Conservancy District		Temporary Excess Capacity Contracts (1,000 ac-ft)
Fremont County		
Cañon City		Continue Current Operations – No Storage
Florence		Continue Current Operations – No Storage
Penrose		Continue Current Operations – No Storage
El Paso County		
Fountain		Continue Current Operations – No Storage
Security		Continue Current Operations – No Storage
Stratmoor Hills		Temporary Excess Capacity Contracts (100 ac-ft)
Widefield		Temporary Excess Capacity Contracts (400 ac-ft)
Pueblo County		
Pueblo West		Continue Current Operations – No Storage
St. Charles Mesa	√	Temporary Excess Capacity Contracts (500 ac-ft)
Crowley County		
96 Pipeline Company	√	Continue Current Operations – No Storage
Crowley County Water Association	√	Continue Current Operations – No Storage
Olney Springs	√	Continue Current Operations – No Storage
Ordway	√	Continue Current Operations – No Storage
Otero County		
Beehive Water Association	√	Continue Current Operations – No Storage
Bents Fort Water Company	√	Continue Current Operations – No Storage
Fayette Water Association	√	Continue Current Operations – No Storage
Fowler	√	Continue Current Operations – No Storage
Hilltop	√	Continue Current Operations – No Storage
Holbrook Center Soft Water	√	Continue Current Operations – No Storage
La Junta	√	Continue Current Operations – No Storage
Lower Arkansas Valley Water Conservancy District		Temporary Excess Capacity Contracts (2,500 ac-ft)
Manzanola	√	Continue Current Operations – No Storage
Newdale-Grand Valley Water Company	√	Continue Current Operations – No Storage
Patterson Valley	√	Continue Current Operations – No Storage
Rocky Ford	√	Continue Current Operations – No Storage
South Side Water Association	√	Continue Current Operations – No Storage
South Swink Water Company	√	Continue Current Operations – No Storage
Valley Water Company	√	Continue Current Operations – No Storage
Vroman	√	Continue Current Operations – No Storage
West Grand Valley Water Inc.	√	Continue Current Operations – No Storage
Bent County		
Las Animas	√	Continue Current Operations – No Storage
Prowers County		
May Valley Water Association	√	Continue Current Operations – No Storage
Kiowa County		
Eads	√	Continue Current Operations – No Storage

Note:
[(1)] Temporary Excess Capacity Contracts would be pursued independently by Master Contract participant.

Comanche North Alternative

Photo 2-3. Comanche North Alternative alignment south of Pueblo (Comanche Powerplant on horizon)

The Comanche North Alternative includes constructing the AVC and Interconnect, and issuing the Master Contract for storing water in Pueblo Reservoir. Water would be diverted from the existing JUP immediately upstream from Pueblo Boulevard, north of the Arkansas River. This existing pipeline delivers water from Pueblo Reservoir to the Board of Water Works of Pueblo Whitlock Water Treatment Plant. Reclamation would purchase excess capacity available in the JUP upstream from the wye (a three-way pipeline connection) from Board of Water Works of Pueblo, and would construct a new pipeline downstream from the wye to the existing Whitlock Water Treatment Plant. From the Whitlock Water Treatment Plant, new pipeline would be constructed along a route south of Pueblo to St. Charles Mesa and Avondale, crossing Interstate 25 southwest of the Xcel Energy Comanche Powerplant (Figure 2-4). East of Avondale, the pipeline would generally be located north of the Arkansas River except between Manzanola and Rocky Ford. The pipeline for the Comanche North Alternative, including spurs, would be about 227 miles long. The Comanche North Alternative pipeline does not include a loop between Rocky Ford and La Junta like other alternatives with AVC. This reduces pipeline length, size, and cost, but could affect redundancy during pipeline maintenance work. Primary spur pipelines would be constructed from Fowler north to State Highway 96, then east to Sugar City; between Rocky Ford and La Junta; and a spur to serve Eads. Shorter spur pipelines would deliver water to AVC participants located near the main pipeline, including communities south of the pipeline. Spurs crossing the Arkansas River and perennial streams would be bored under the river. Pipeline sizes would range from 30 inches in diameter at the wye on the JUP to 4 inches at some AVC participant tie-in locations.

Pumping stations would be built at the Whitlock Water Treatment Plant and on the south end of the pipeline spur to Eads. Surge tanks would be built near Fowler and La Junta.

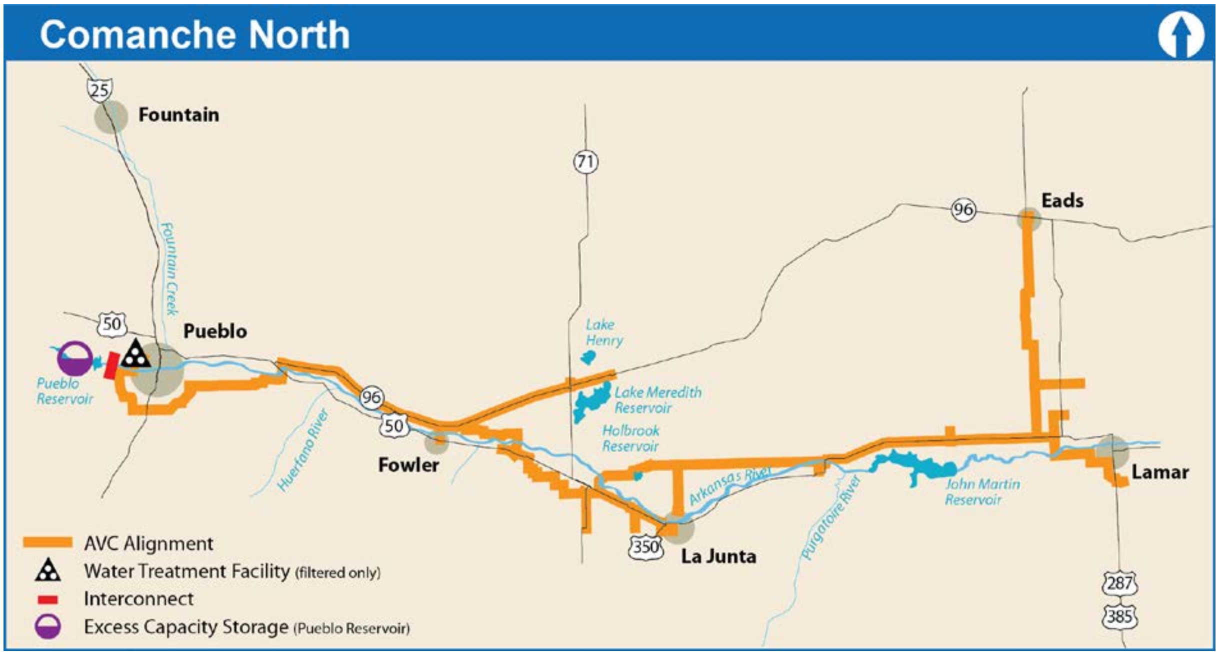


Figure 2–4. Comanche North Alternative

New water treatment plant components would be integrated into the existing Whitlock Water Treatment Plant. The integrated water treatment plant would filter water; residual disinfection would be the responsibility of AVC participants at their delivery point. Under this alternative, the St. Charles Mesa Water District would receive filtered water.

Photo 2-4. Existing Whitlock Water Treatment Plant

The Master Contract would allow participants to store up to 29,938 ac-ft of water in Pueblo Reservoir. This water would be delivered to Master Contract participants via AVC or other existing or future delivery systems, exchanged upstream, or released to the Arkansas River, depending on the participants' needs (Appendix A). Spill priorities for Fry-Ark reservoirs, including Pueblo Reservoir, would not change under any alternative (spill priorities are described in Chapter 3). Each Master Contract participant would request that Reclamation release water from their portion of storage space independently. Water could be stored and released if and when space is available after other Fry-Ark commitments have been met.

The estimated cost of constructing the Comanche North Alternative is $400 million (includes Interconnect). Estimated annual OM&R costs are $3.5 million, and estimated annual costs for the Master Contract are $0.8 to $1.1 million (Table 2-3).

Pueblo Dam South Alternative

The Pueblo Dam South Alternative includes constructing AVC without building the Interconnect, but issuing the Master Contract (Figure 2-5). Water would be diverted from the existing Pueblo Reservoir south outlet works. A new pipeline would be constructed from Pueblo Dam, generally following Bessemer Ditch through Pueblo to a new water treatment plant in the St. Charles Mesa area. East of the water treatment plant, the pipeline would be built generally parallel to U.S. Highway 50 south of the Arkansas River to Lamar. The pipeline for the Pueblo Dam South Alternative would be about 230 miles long. Primary spur pipelines would be constructed from Fowler north to State Highway 96, then east to Sugar City; a spur loop providing redundancy between Rocky Ford and La Junta; and a spur to serve Eads. Shorter spur pipelines would deliver water to AVC participants located near the main pipeline, including communities north of the pipeline. Spurs crossing the Arkansas River and perennial streams would be bored under the river. Pipeline sizes would range from 48 inches in diameter at the intake to 4 inches at some AVC participant tie-in locations.

Photo 2–5. Pueblo Dam South Alternative alignment along Bessemer Ditch in Pueblo

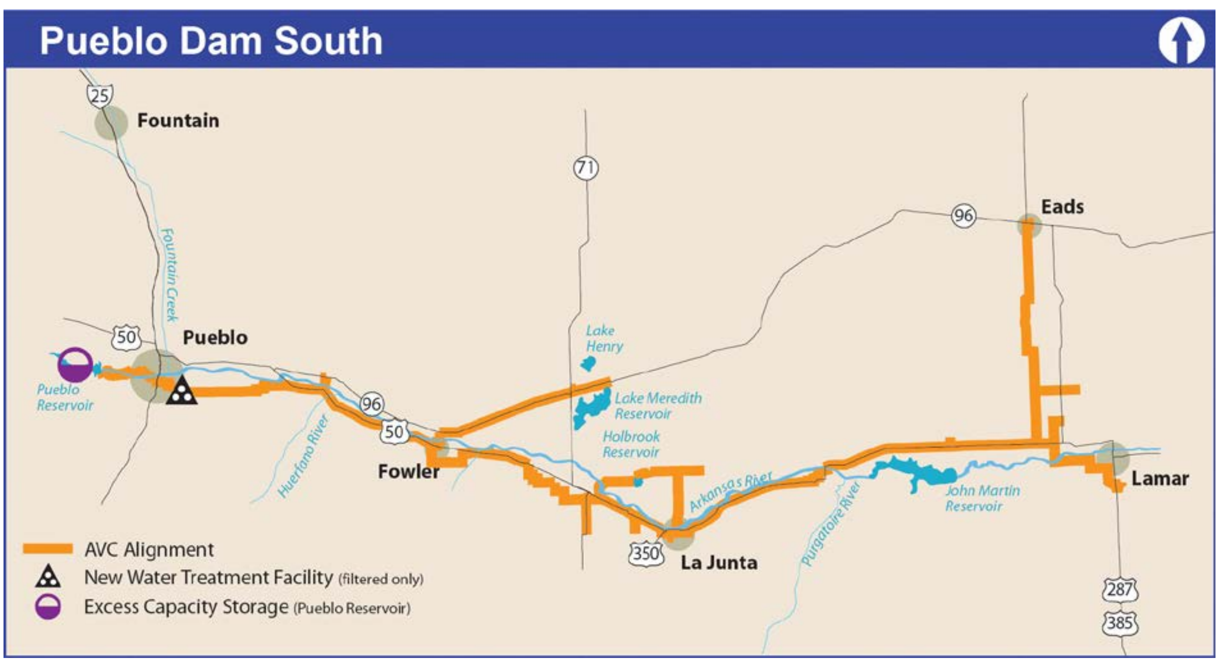


Figure 2–5. Pueblo Dam South Alternative

One pumping station would be installed on the south end of the pipeline spur to Eads. Except the spur to Eads, the Pueblo Dam South Alternative is the only alternative that moves water in the pipeline via gravity and does not require extra pumping. Storage tanks would be built near Fowler and La Junta.

A new water treatment plant would be constructed near South Road and 21st Lane in St. Charles Mesa. The water treatment plant would filter water; residual disinfection would be provided by the participants at their delivery points. Under this alternative, the St. Charles Mesa Water District would receive unfiltered water.

The Master Contract would include 29,938 ac-ft of excess capacity storage in Pueblo Reservoir. This water would be delivered to participants via AVC or other existing or future delivery systems, exchanged upstream, or released to the Arkansas River, depending on the participants' needs (Appendix A). Each Master Contract participant would request that Reclamation release water from their portion of storage space independently. Water could be stored and released if and when space is available after other Fry-Ark commitments have been met.

The estimated cost of constructing the Pueblo Dam South Alternative is $495 million. Estimated annual OM&R costs are $3.4 million, and estimated annual costs for the Master Contract are $0.8 to $1.1 million (Table 2-3).

JUP North Alternative

The JUP North Alternative would include constructing AVC and the Interconnect, without the Master Contract (Figure 2-6). Water would be diverted from the existing JUP immediately upstream from Pueblo Boulevard, north of the Arkansas River. This existing pipeline currently delivers water from Pueblo Reservoir to the Whitlock Water Treatment Plant. Reclamation would purchase excess capacity available in the JUP upstream from the wye (a three-way pipeline connection) from Board of Water Works of Pueblo, and would construct a new pipeline downstream from the wye to a new separate water treatment plant near the existing Whitlock Water Treatment Plant. From the water treatment plant, new pipeline would be built through downtown Pueblo, generally following 11th, 14th, and 13th streets. East of Pueblo, the pipeline would be located north of the Arkansas River, with a loop in Otero County south of the Arkansas River. The pipeline for the JUP North Alternative would be about 233 miles long. Spurs would be similar to the Pueblo Dam South Alternative, except the loop spur would be larger and provide redundancy to participants located between Manzanola and La Junta. Pipeline sizes would range from 36 inches in diameter at the wye of the JUP to 4 inches at some AVC participant tie-in locations.

Photo 2–6. JUP North Alternative alignment through Pueblo

Two pumping stations would be constructed; one would be located just downstream from the water treatment plant, and another on the south end of the pipeline spur to Eads. One storage tank would be built near Fowler, and a second near La Junta.

A new water treatment plant would be constructed adjacent to the existing Whitlock Water Treatment Plant. The water treatment plant would filter water from AVC; residual disinfection would be provided by AVC participants at their delivery points. Under this alternative, the St. Charles Mesa Water District would receive filtered water.

This alternative includes constructing the Interconnect between the Pueblo Dam north and south outlet works to allow for maximum operational flexibility.

The Master Contract was not included in this alternative to provide a range of alternatives. Without the Master Contract, Master Contract participants would meet their needs as described under the No Action Alternative.

The estimated cost of constructing the JUP North Alternative is $495 million. Estimated annual OM&R costs are $3.8 million, and estimated annual costs for the short-term excess capacity contracts are $0.1 to $0.2 million (Table 2-3).

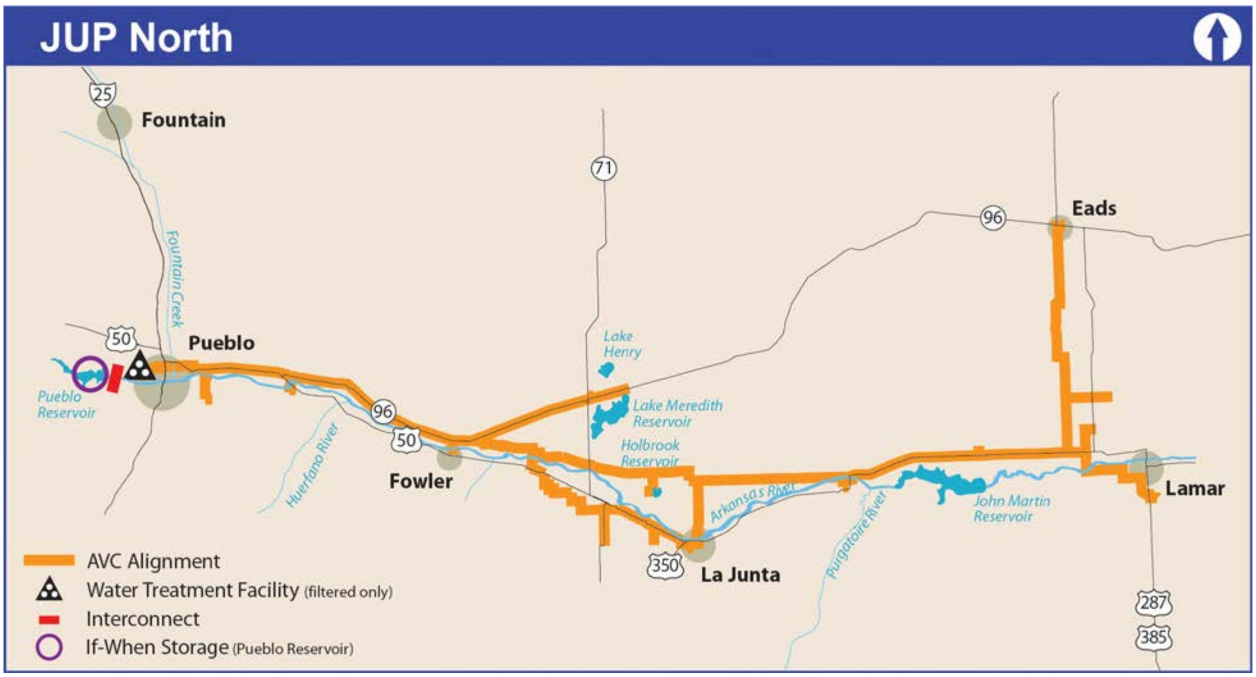


Figure 2–6. JUP North Alternative

Pueblo Dam North Alternative

The Pueblo Dam North Alternative would include constructing the AVC and Interconnect, and issuing the Master Contract (Figure 2-7). Water would be diverted from the Pueblo Reservoir south outlet works and treated at a new water treatment plant at Pueblo Dam. AVC would then follow a route through downtown Pueblo, generally following 11th, 14th, and 13th streets, and north of the Arkansas River. East of Pueblo, the pipeline would be built just north of the Arkansas River, with a loop in Otero County south of the Arkansas River similar to the JUP North Alternative. The pipeline for the Pueblo Dam North Alternative would be about 236 miles long. Pipeline sizes and spurs would be similar to the JUP North Alternative.

Pumping stations would be built at the foot of Pueblo Dam, at the water treatment plant, and on the south end of the pipeline spur to Eads. Storage tanks would be located near Fowler and La Junta.

A new water treatment plant would be constructed below Pueblo Reservoir on Reclamation property, immediately south of the fish hatchery. The new water treatment plant would filter water; AVC participants would be responsible for adding residual disinfection at their delivery point. Under this alternative, the St. Charles Mesa Water District would receive filtered water.

Photo 2–7. Pueblo Dam North Alternative alignment is near the Raptor and Nature Center of Pueblo, along the existing JUP

The Master Contract would include up to 29,938 ac-ft of excess capacity storage in Pueblo Reservoir. This water would be delivered via AVC or other existing or future delivery systems, exchanged upstream, or released to the Arkansas River, depending on the participants' needs (Appendix A). Each Master Contract participant would request that Reclamation release water from their portion of storage space independently. Water could be stored and released if and when space is available after other Fry-Ark commitments have been met.

The estimated cost of constructing the Pueblo Dam North Alternative is $505 million. Estimated annual OM&R costs are $3.8 million, and estimated annual costs for the Master Contract are $0.8 to $1.1 million (Table 2-3).

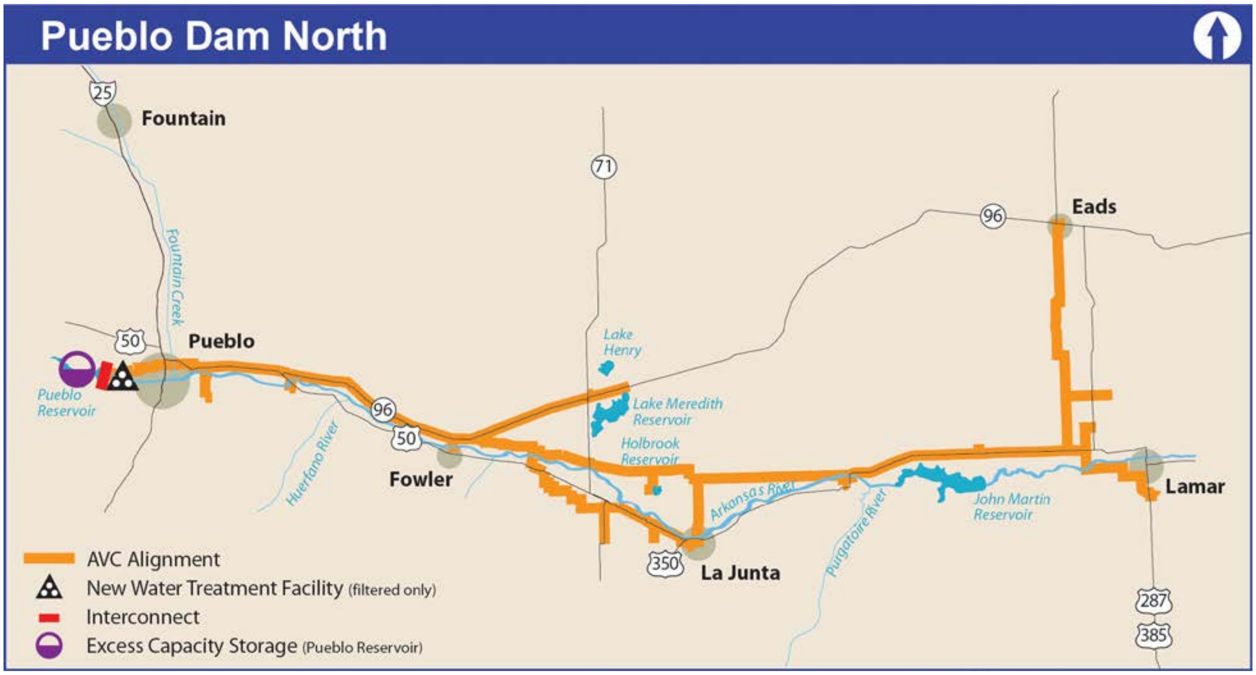


Figure 2–7. Pueblo Dam North Alternative

River South Alternative

Photo 2–8. The River South Alternative river intake location would be near the Arkansas River at Moffat St. gage. A new diversion structure may be needed.

The River South Alternative includes constructing AVC and issuing the Master Contract, but not constructing the Interconnect (Figure 2-8). AVC would divert water from the Arkansas River just upstream from Fountain Creek near the existing St. Charles Mesa diversion structure and pump station. A new pipeline would be constructed from the Arkansas River generally parallel to the existing St. Charles Mesa Water District pipeline to a new water treatment plant in St. Charles Mesa. From the water treatment plant, the pipeline route would generally be south of the Arkansas River along U.S. Highway 50 to La Junta, and north of the Arkansas River to Lamar. The pipeline for this alternative would be 216 miles long. Pipeline spurs would be as described for the Pueblo Dam South Alternative. Pipeline sizes would range from 42 inches in diameter at the intake to 4 inches at some AVC participant tie-in locations.

Three pumping stations would be built: one would be located near the intake to pump water to the water treatment plant, the second would be located just downstream from the new water treatment plant, and the third would be located on the south end of the pipeline spur to Eads. One storage tank would be constructed near Fowler, and a second near La Junta.

A new water treatment plant would be constructed adjacent to the existing St. Charles Mesa Water Treatment Plant. The new water treatment plant would both filter and disinfect water. Under this alternative, the St. Charles Mesa Water District would be delivered unfiltered water.

The Master Contract would include up to 29,938 ac-ft of excess capacity storage in Pueblo Reservoir. This water would be delivered via AVC or other existing or future delivery systems, exchanged upstream, or released to the Arkansas River, depending on the Master Contract participants' needs (Appendix A). Each Master Contract participant would request that Reclamation release water from their portion of storage space independently.

The estimated cost of constructing the River South Alternative is $475 million. Estimated annual OM&R costs are $4.2 million, and estimated annual costs for the Master Contract are $0.8 to $1.1 million (Table 2-3).

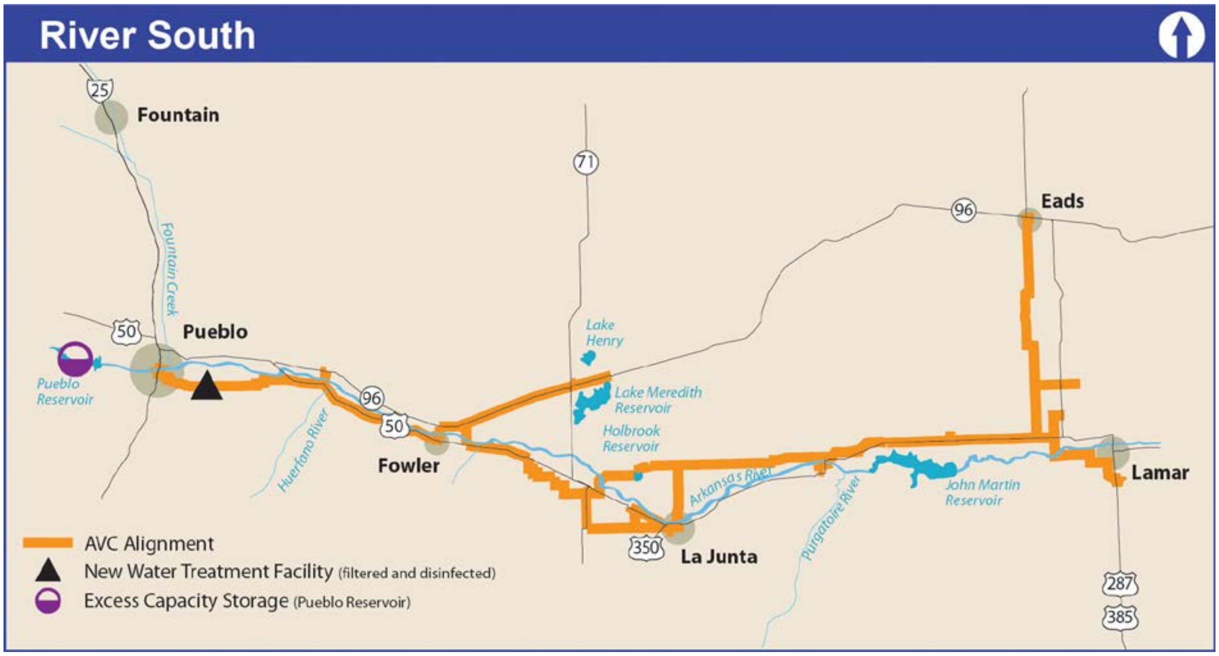


Figure 2–8. River South Alternative

Master Contract Only Alternative

To provide a range of reasonable and practicable alternatives for evaluation in this EIS, the Master Contract Only Alternative does not include federal actions to build AVC or the Interconnect. The Master Contract would include up to 29,938 ac-ft of excess capacity storage in Pueblo Reservoir. Each participant would request that Reclamation release water from Pueblo Reservoir to either the Arkansas River or to an existing or future water delivery system, or exchange water to an upstream location (Appendix A). Water could be stored and released if and when space is available after other Fry-Ark commitments have been met. Contract terms and costs for using Pueblo Reservoir excess capacity would be determined during contract negotiations. See Appendix B.6 for a list of costs of other Pueblo Reservoir excess capacity contracts.

Photo 2-9. The Master Contract Only Alternative would use excess capacity storage space in Pueblo Reservoir

Without AVC or the Interconnect, AVC and Interconnect participants would pursue actions similar to those previously described in the No Action Alternative to meet water supply and water quality needs (Figure 2-9).

The estimated cost of constructing the Master Contract Only Alternative is $192 million. Estimated annual OM&R costs are $5.0 million, and estimated annual costs for the Master Contract are $0.8 to $1.1 million (Table 2-3).

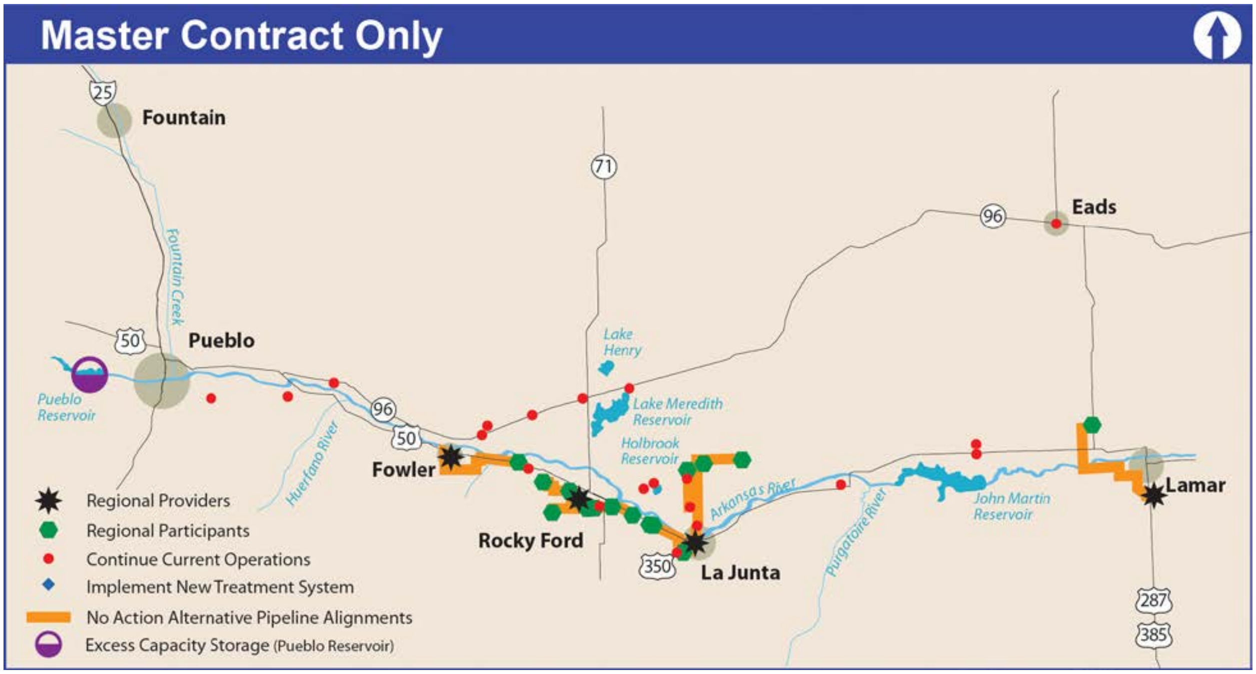


Figure 2–9. Master Contract Only Alternative

Common Elements

This section describes elements common to the alternatives, including water supplies and construction activities.

Water Supplies

Multiple sources of water would be needed for the AVC or Master Contract. AVC would deliver about 10,250 ac-ft per year to AVC participants (Chapter 1). Because of estimated water loss of up to 5 percent through the proposed water treatment plant, up to about 10,800 ac-ft of total supply would be required to deliver that amount. Transit losses from evaporation would also slightly reduce water supply yield.

Master Contract participants would require sufficient water supply to meet the intended use of the Master Contract storage space. This use would vary by Master Contract participant. For instance, participants using Master Contract water supplies for drought protection may only need enough water to initially fill the storage space, fill storage following a drought or spill, and maintain water levels to account for evaporative losses. In comparison, participants using Master Contract storage space for average annual supply may need enough water to fill the storage space one or more times per year.

All alternatives, including the No Action, are designed to meet water demands in 2060 (Master Contract) or 2070 (AVC) and would use the following water supplies:

- **Fry-Ark Water.** Fry-Ark water includes supplies diverted from the West Slope as well as water diverted from the Arkansas River Basin under its East Slope water rights decrees. The "East of Pueblo" Fry-Ark allocation and NPANIW supplies would be allocated to each AVC participant by Southeastern. AVC participants could use an average of about 7,500 ac-ft per year of Fry-Ark water. Fry-Ark water does not require Master Contract storage space. Fry-Ark supplies are a supplemental irrigation and municipal supply, and operations evaluated in this EIS assumed that non-Fry-Ark supplies were used first (see Appendixes D.2 and D.3 for additional information).
- **Fry-Ark Return Flows.** Return flows generated from uses of Fry-Ark water could be reused. Measured municipal Fry-Ark return flows purchased from Southeastern by the entity that generated the return flows could be exchanged under Southeastern's existing 1939 exchange decree or proposed 01CW151 decree. Return flows from first use of AVC Fry-Ark supplies could be up to about 4,000 ac-ft. Fry-Ark return flows could be used and reused multiple times to extinction, which would provide additional water supply yield.
- **Existing Agricultural Water Rights.** Several AVC and Master Contract participants have proposed using existing decreed agricultural-to-municipal water rights transfers. These water rights are from a variety of sources upstream and downstream from Pueblo Reservoir and in the Fountain Creek Basin. AVC participants could use about 6,400 ac-ft of existing agricultural water rights, while Master Contract participants could use about 20,000 ac-ft of this water.
- **New Agricultural Water Rights.** Several AVC and Master Contract participants are proposing new agricultural water right transfers. These water supply transfers are in a variety of stages, with some sources just being identified and others in the transfer process. These water rights are from a variety of sources upstream and downstream from Pueblo Reservoir and in the Fountain Creek Basin. AVC participants could use about 1,100 ac-ft of this water and Master Contract participants could use about 1,500 ac-ft of new agricultural water rights.
- **Water Rights Made Available by Lower Arkansas Valley Water Conservancy District.** Through its Master Contract application, the Lower Arkansas Valley Water Conservancy District is proposing to make up to 7,800 ac-ft per year available to AVC and Master Contract participants in addition to other beneficiaries within Southeastern district boundaries. This water would come from existing water rights or a proposed rotational fallowing program among several ditches in the Lower Arkansas River Basin (see Appendix D.3 for additional details).
- **Conservation.** Active and passive conservation projects by water supplier customers to reduce overall demand have been identified, and contracts with Reclamation will require that these projects be implemented (Southeastern's Regional Water Conservation Plan is in Appendix B.7). Although not specifically a water supply, conservation has the potential to serve as a water supply through reduced demands, as documented in Chapter 1.

No new water supplies would be used in the Interconnect. The Interconnect would only be used to temporarily convey water supplies that are normally delivered through the north or south outlet works.

A complete list of water rights proposed for use in AVC and the Master Contract is in Appendix A. Water supplies operations are discussed in Chapter 3.

Water Treatment

AVC water supplies would be treated at a centralized water treatment plant that produces either filtered water or filtered and disinfected water (Reclamation 2012a, 2013a). Filtered water treatment includes the following processes, and meets all requirements of the Health Department Surface Water Treatment Rules, with the exception that a disinfectant residual is not provided:

- Presedimentation (removes large particles such as sand) if the AVC intake is from the Arkansas River (River South Alternative only)
- Full conventional pretreatment (removes finer particles)
- Dual-media filtration
- Powdered activated carbon addition for taste and odor control
- Primary disinfection with chlorine (does not provide residual disinfection in the pipeline)

For filtered water treatment, a disinfectant residual would be added at each AVC participant delivery point, and would be the responsibility of the participant. Filtered and disinfected water treatment receives the same treatment as filtered water, but a disinfectant residual is also added at the centralized water treatment plant for AVC. Reclamation has begun discussions with the Health Department regarding water treatment processes, and has incorporated Health Department suggestions into appraisal-level plant designs. The water treatment plant has been assigned Public Water Supply Identification Number CO0151120 by the Health Department. A water loss of up to 5 percent through the proposed water treatment plant was assumed in this EIS.

Participant’s existing water treatment facilities would not be decommissioned, but would be maintained to provide additional disinfection for distribution systems, treat groundwater or surface water for blending with AVC supplies (see Appendix A for participants that would blend supplies), or for treatment during emergency situations.

The No Action, River South, and Master Contract Only alternatives would not meet the goal of achieving secondary water quality standards because water supplies diverted from the Arkansas River or groundwater wells are poorer in quality than supplies in Pueblo Reservoir. Costly advanced treatment (for example reverse osmosis) was not included in these alternatives because these treatment types have been investigated by the Health Department as part of the CORADS study (Malcolm Pirnie 2009a), and are not a preferred method for treatment because of residuals management and high energy use (see the Chapter 2 - *Alternatives Considered but Eliminated from Further Study* section).

Construction Activities

All alternatives involve constructing either the AVC, Interconnect, or No Action Alternative pipelines. Many construction activities and restoration methods would be similar across all alternatives. All construction activities would be performed in accordance with conditions contained in construction permits that would include best management practices and mitigation measures described in Chapter 4 and Appendix B.5.

Land Acquisitions and Easements

Land for facilities and construction would primarily be acquired in two ways: easements and fee title purchases. The terms and conditions to purchase these rights would be negotiated with landowners according to federal land acquisition laws and regulations. Existing rights-of-way, such as U.S. Highway 50, would not be used for construction.

Permanent easements would be obtained for constructing, operating, maintaining, and replacing pipelines and small appurtenant facilities. Short-term easements would be acquired for equipment operation and staging areas during construction, and would terminate after construction. Easements areas would be restored to a preconstruction condition, if feasible. The easement grantor would retain land ownership, but Reclamation would have rights to access and use the easement for project purposes at any time.

Land for facilities such as intakes, pump stations, and water treatment plants would be obtained by Reclamation through fee title purchases. Fee title means the ownership of land, free and clear of encumbrances. Ownership would transfer from the present owner to Reclamation.

Interconnect

The Interconnect is an engineering subfeature of AVC that would be constructed under the Comanche North, JUP North, and Pueblo Dam North alternatives. The Interconnect between the Pueblo Reservoir north and south outlet works would be constructed to allow maximum operational flexibility for operational or maintenance purposes during outages (planned or unplanned). If either the Pueblo Reservoir north or south outlet works shuts down, the Interconnect would allow participants to continue receiving water through the remaining working outlet. As discussed in Chapter 1 and Appendix A, Interconnect participants would need to use backup water systems, including the Interconnect, to maintain water service to their customers. The Interconnect would be a 90-inch-diameter pipe about 2,000 feet long (Figure 2-10). The Interconnect construction cost would be about $7 million, and annual maintenance costs would be about $1,600 (Reclamation 2012a, 2013a).

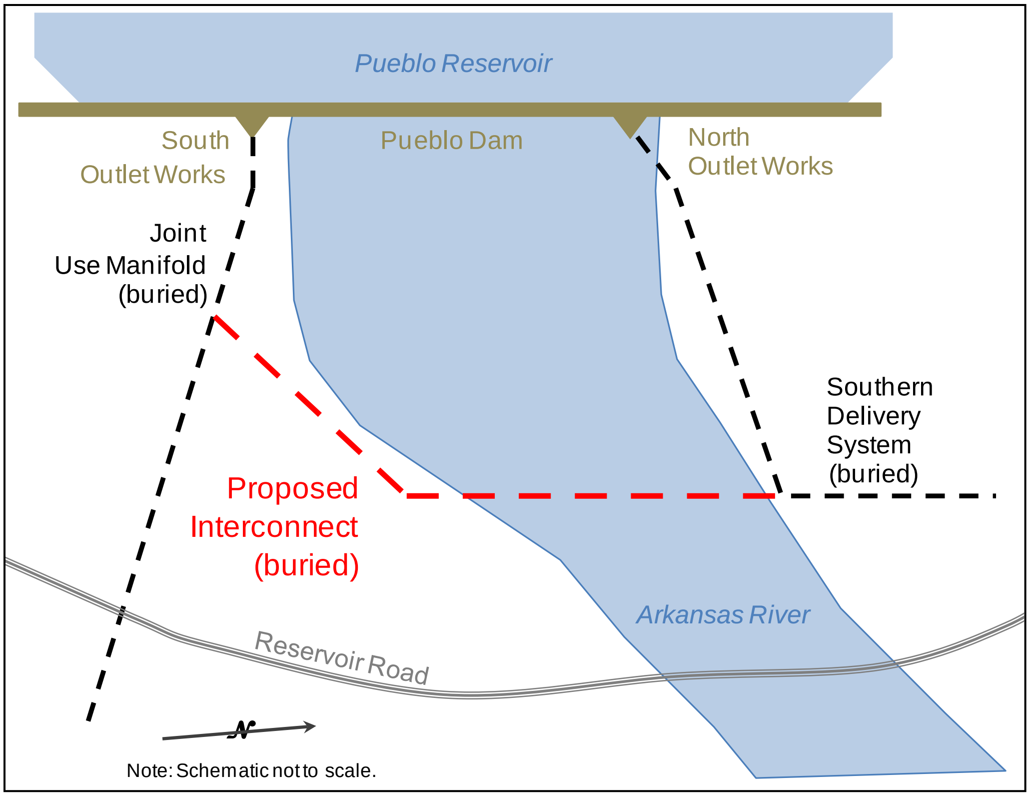


Figure 2–10. Proposed Interconnect Schematic

Intakes

All alternatives that include AVC would have a water intake. These facilities would consist of either a pipeline connection to existing structures at Pueblo Reservoir or the JUP, or a new or modified river intake. Intakes involving connections to existing structures at Pueblo Reservoir and the JUP would be constructed and restored using the same general methods as described below for pipelines. Installing flow control and measurement equipment and performing some concrete work would also be required.

For new or modified intakes on the Arkansas River, a cofferdam would be constructed to dewater portions of the river, as needed, to allow construction. Flows would pass by the construction area to prevent any effects on downstream flows during construction. Work would be performed during the low-flow season and coordinated with Reclamation's operations at Pueblo Reservoir. Riprap and geotextile material would be installed along the riverbanks for erosion protection.

Photo 2–10. AVC supplies under the River South Alternative would be diverted near the St. Charles Mesa intake structure on the Arkansas River

Pipelines

The open trench method would be used for most pipeline construction. Street and driveway pavements would be cut and temporarily covered during pipeline construction to maintain access. Pipe segments would be delivered to the site and stored in the easement. The pipeline would be buried with approximately 5 feet of cover. Excavated material would be stored in the easement and used for pipe or trench backfill. Topsoil would be preserved and replaced.

Pipe segments would be lowered into place in the trench and assembled to form the continuous pipeline. The pipe zone (the area from the bottom of the trench up to several inches above the top of the pipe) would be filled with controlled low-strength material. Controlled low-strength material is a cement-like substance designed to stabilize pipe to prevent deflection. After the controlled low-strength material has hardened sufficiently, the remainder of the trench would be backfilled with the excavated trench material. In roadways and other public use areas, open trenches would be covered with steel plates when no active construction was occurring.

Photo 2–11. Trenchless construction techniques could be used to avoid disturbing major roadways, streams, and other resources

Disturbed areas would be restored to original grade and reseeded with native vegetation or species appropriate for previous land use or ecological condition. Typically, trenchless construction would be used to cross beneath major roadways and perennial streams and associated wetlands. These techniques allow continued use of roads and avoid effects on streams and wetlands. During final pipeline design, discussions with agencies that maintain or own the crossing features would be required to establish the need for trenchless crossings.

Some AVC participant delivery location would require a pressure-reducing valve that participants would supply. The pressure-reducing valves would be needed to limit the pressure of water delivered to AVC participants. Flow rates would be communicated to a central control center, likely located at the water treatment plant.

AVC would require appurtenances, including isolating valves, air/vacuum relief valves, blowoff valves, pressure-sensing devices, and chlorination/ cleaning points, depending on the disinfection level required. Pressure-reducing valves would be installed upstream from each storage tank to prevent overflow and to maintain pressure in the pipeline upstream from the tanks.

Photo 2–12. Pipeline appurtenances, such as valves, would be required along AVC

Pipeline construction, excluding revegetation, would typically require 2 to 4 weeks per mile;

however, affected areas could be revegetated at a later time depending on the season of construction. Construction in difficult areas, such as in rock, could require 8 to 10 weeks per mile.

Storage Tanks

Online storage tanks would be located along AVC. The tanks would be used for operational storage and to provide a minimal amount of water if a system outage were to occur (pipeline break). Each storage tank would be enclosed to prevent changes to water quality. A bypass would be provided at each tank to allow AVC to continue to operate if the tank were taken out of service for maintenance or repair. Storage tanks would be sized to hold about 1 day of water under maximum month conditions. The number and size of storage tanks at each site would be finalized during design of the preferred alternative.

Photo 2–13. Water storage tanks, such as this tank on the existing Fountain Valley Conduit, would be used for operational storage and to provide a minimal amount of water if a system outage were to occur

Power Supplies and Utility Relocations

All alternatives would require power to operate pump stations, treatment plants, and other equipment. Pump stations would be required to pump water over high ground (for example, the Comanche North Alternative pipeline crosses high ground south of Pueblo) or out of a low-lying water treatment plant. A pump station would also be required to deliver water to Eads from the main pipeline. Power supplies would consist of two primary types: new transmission lines or connections to existing supplies. The need for new power supplies would be evaluated during final design. If new power supplies are required, footings for new power poles or towers would be installed and the power poles or tower erected. Conductors would be hung on the new poles or towers and connected to the power source and facility. Some conductors may be placed underground.

Some existing utilities (water, sewer, natural gas, liquid petroleum, electric, telephone, and other cables or conduits) would require relocation during construction. All affected utilities would be identified during final design. Utilities would generally be relocated during facility construction rather than as an independent activity. Site clearing, grading, dewatering, excess material disposal, and restoration methods for utilities would be the same for the proposed facility being constructed. Effects on utilities are further discussed in Chapter 4.

Schedule

Figure 2-11 presents a summary-level schedule of AVC NEPA compliance, design, and construction. NEPA compliance for the AVC, Interconnect contract, and Master Contract is anticipated to be completed in 2013. If an action alternative is selected in the Record of Decision, it is anticipated that design and construction would take about 10 years, depending on funding. If funding, design and construction stay on schedule, initial water deliveries through AVC are anticipated in 2023.

This general schedule would be the same for all action alternatives, except Master Contract Only, which would proceed on a schedule determined by individual participants. Reclamation contracting for the Master Contract could start following the Record of Decision and contracting for excess capacity water storage if the Master Contract is included in the selected action alternative. However, some AVC participants likely would not begin using Master Contract storage until 2 to 3 years before AVC is completed in 2022 to allow storage space to be filled before AVC startup. If an alternative is selected in the Record of Decision that includes both AVC and Master Contract, it is assumed that the Master Contract would be implemented before construction of the AVC would be completed. During the interim, prior to AVC operation, effects would be the same as or less than the Master Contract Only Alternative, depending on how much water participants store in the Master Contract during those initial years. Once AVC deliveries begin, effects would be as disclosed in this EIS for the complete alternative.

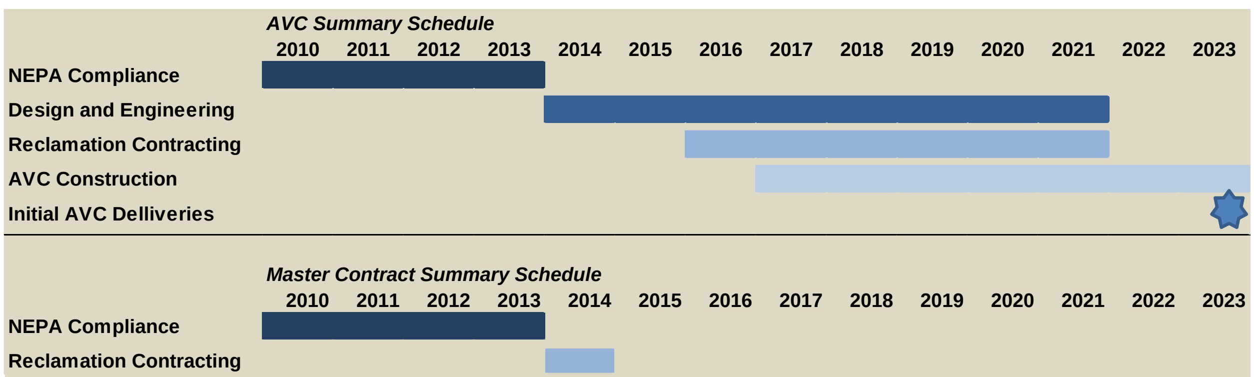


Figure 2–11. Schedule Summary

Interim Measures

AVC participants under enforcement actions would need to implement measures between now and 2023 to comply with primary drinking water standards. The Health Department has identified a number of possible interim measures such as point-of-use reverse osmosis, point-of-use ion exchange, and use of bottled water to comply with standards (Malcolm Pirnie 2009a). Each individual AVC participant under an enforcement action would be responsible for coordinating interim measures with the Health Department independent of this EIS and Reclamation.

Point-of-use treatment systems are installed inside individual homes or businesses at the point of use, such as under a kitchen sink. AVC participants could choose to use these treatment systems until AVC was built to comply with primary drinking water standards.

Best Management Practices and Resource Protection Measures Incorporated into Project Design and Operation

Many best management practices were identified and incorporated into the action alternatives to avoid and reduce adverse effects. Resource effects assessments described in Chapter 4 assumed that the best management practices in Table 2-8 would be implemented under each action alternative. Because the No Action Alternative and construction activities under the Master Contract Only Alternative would not be federal actions, best management practices for these alternatives were limited to those required by applicable federal, state, and local regulations and commonly accepted construction practices.

A comprehensive list of best management practices is in Appendix B.5. Significant effects remaining after implementation of best management practices would be addressed, where possible, by specific mitigation measures, as described in Chapter 4 and Appendix B.5 for each resource.

Table 2–8. Best Management Practices Summary

Resource	Best Management Practices Summary
General	Construction limits would be clearly defined to minimize disturbance area and effects on buildings, structures, roads, canals, and environmental resources. Any affected structures would be replaced, repaired, or restored following construction.
Surface Water	Participants would continue voluntary commitment to the Upper Arkansas Flow Management Program. Participants would participate and comply with Southeastern's commitments in the Pueblo Flow Management Program, as outlined in the Six Party Intergovernmental Agreement, and continue according to current agreements under the No Action Alternative.
Groundwater	Established groundwater monitoring wells would be avoided or repaired if damaged.
Aquatic Life	Effects on aquatic life would be minimized by boring under perennial streams. Other stream crossings would be conducted during low flow, and streamflow would be maintained downstream from the construction zone.
Recreation	Construction would be timed to minimize effects and disruption to parks and trails during the peak recreation season (May–September), where feasible.
Wetlands and Riparian Areas	Effects on wetlands and other waters would be avoided to the extent practicable, including pipeline borings under perennial streams and associated wetlands. In areas of unavoidable temporary wetland effects, appropriate erosion control methods would be employed, and wetlands and streambeds would be restored following construction.
Vegetation	All temporary disturbances to vegetation would be revegetated after construction. Disturbance to sensitive plant communities and sensitive plant species would be avoided as much as practicable, and where effects are unavoidable, the area would be restored to a similar type and quality of native vegetation. Introduction and spread of noxious weeds would be minimized by surveying areas before construction; using accepted weed control practices during construction; and monitoring and controlling weeds after construction.
Wildlife	Habitat for federally or state threatened, endangered, and sensitive species, including raptors, would be avoided to extent feasible. Construction work would comply with U.S. Fish and Wildlife Service and Colorado Parks and Wildlife seasonal restrictions and buffer zones pertaining to these species. Effects on migratory birds would be avoided or minimized by implementing a migratory bird management plan as part of the Fish and Wildlife Coordination Act Report.
Noise and Vibration	Construction and operation activities would comply with state and local noise ordinances. Night work and large equipment traffic would be limited in highly populated areas.
Visual Resources	Construction-related disturbance to the landscape and structures would be restored following construction. Permanent aboveground structures, facilities, and features would be designed to blend with local surroundings. Lighting during night work would be directed downward to minimize effects on surrounding residents.
Traffic	Construction contractors would coordinate with local and county jurisdictions, and the Colorado Department of Transportation on traffic plans, lane closures, and detours. Borings would be used for crossings of interstate or divided highways, railroads, and other highly traveled roadways to minimize disruptions to traffic.
Socioeconomics	Landowners would be compensated for crop damage caused by construction activities. Structures damaged by construction would be repaired or replaced, or owners would be compensated.
Historic Properties	Surveys to identify potential historic properties would take place before construction. Historic properties would be avoided to the extent feasible, and any unanticipated discoveries during construction would be treated according to a predetermined process. A programmatic agreement was developed to address cultural resource survey requirements and treatment of any adverse effects on historic properties (Appendix N).
Air Quality	A control plan for fugitive dust would be developed and implemented to minimize particulate and dust emissions during earth work.
Hazardous Materials	Before construction, a site assessment would be conducted to identify undocumented areas of contamination. Pipeline or facility locations would be adjusted, as feasible, or appropriate remediation work would be conducted. A hazardous material spill plan would be developed and implemented to address any inadvertent spills of fuel, oil, hydraulic fluid, or other hazardous material during construction.
Floodplains	No structures would be constructed that would cause floodwater surface elevation rises.
Unique or Prime Farmland/ Agricultural Lands	Construction activities on irrigated lands would be avoided during the growing season to the extent feasible. Croplands disturbed by construction would be restored with topsoil to the same depth, quality, and grade as the original surface.

Alternatives Considered but Eliminated from Further Study

Reclamation considered a number of alternatives that were eliminated from further study in this EIS. Alternatives were eliminated that did not meet the purpose and need of the project; were not technically, economically, or logistically feasible; or had less favorable environmental characteristics. This section summarizes the alternatives considered and eliminated, and the reasons for their elimination. The alternatives analysis process is discussed in detail in Appendix B.

Alternatives Development and Screening Process Results

Options for alternatives components were developed from the STAG Report (Black & Veatch 2010), AVC Value Planning Report (Reclamation 2010c), public and agency input from public scoping (Reclamation 2010d), SDS EIS *Alternatives Analysis Report* (Reclamation 2006), and other studies. Overall, approximately 170 options were identified for screening, and approximately 117 options were eliminated from further analysis based on technical, economical, or logistical issues, or environmental characteristics (Appendix B). Table 2-9 shows the number of options eliminated based on technical, economical, and logistical issues.

Table 2–9. Options Eliminated Based on Technical, Economical, or Logistical Issues

Component	Number of Options Considered	Number of Options Eliminated	Reasons for Elimination
Water Supply	21	11	Water would not be decreed and available within a reasonable time; the project could not be implemented in a reasonable time; the source would not improve drinking water quality; did not use existing technology
Regulating Storage	92	82	Could not provide at least 10 percent of the required storage volume; use as a reservoir would not be consistent with permitted land use
Intake	10	4	Could not provide 100 percent of the required intake capacity
Conveyance – Through Pueblo	21	10	Would have inadequate capacity, would not improve drinking water quality; could not be implemented within a reasonable time, would not use existing technology
Conveyance – East of Pueblo	13	8	Would not improve drinking water quality; would have inadequate capacity; would not meet purpose and need to convey bulk water
Water Treatment	18	2	Would not improve drinking water quality; would not meet purpose and need to convey bulk water

Environmental characteristics were used to compare options that best met certain indicators. Options with the best environmental characteristics were retained. Approximately 11 options were eliminated during the environmental characteristics screening. Table 2-10 shows the number of options eliminated based on environmental characteristics and the reasons for elimination.

Table 2–10. Options Eliminated Based on Environmental Characteristics

Component	Number of Options Remaining After Technical, Economical, or Logistical Screening	Number of Options Eliminated Based on Environmental Characteristics	Reasons for Elimination
Water Supply	10	2	Would require substantial new infrastructure (resulting in substantial environmental disturbance)
Regulating Storage	10	1	Would significantly disturb surface area and wetlands
Intake	6	3	Would have a long distance between intake and delivery point, would have high streamflow effects through Pueblo, would be incompatible with existing Fry-Ark water rights and operations, would have high source water total dissolved solids
Conveyance – Through Pueblo	11	0	Not eliminated
Conveyance – East of Pueblo	5	0	Not eliminated
Water Treatment	16	5	Would have substantial permitting issues

Alternatives Proposed by Public and CORADS Study

Options and alternatives proposed by the public during public scoping were screened using the process described above. Results of screening options and alternatives proposed by the public are identified in Table 2-11.

The Health Department has provided assistance to some AVC participants by identifying potential water treatment alternatives for radionuclide removal, as published in the CORADS study (Malcolm Pirnie 2009a). The CORADS study focused on the following treatment alternatives to bring radionuclide levels under the primary drinking water standard:

- Anion Exchange
- Cation Exchange
- High Pressure Membranes
- Lime Softening
- Enhanced Coagulation
- Hydrous Manganese Oxide
- Activated Alumina
- Greensand Filtration
- Electrodialysis/Electrodialysis Reversal
- Coprecipitation with Barium Sulfate

Table 2–11. Alternatives Identified by Public and Screening Results

Option or Alternative	Screening Results
Develop new groundwater supplies in tributary alluvial aquifers and nontributary bedrock aquifers.	Eliminated from further analysis because of continued issues with drinking water quality and inability to convey bulk water supplies.
Central Colorado Project – Divert water from the Gunnison River Basin on Colorado's West Slope to the Arkansas River Basin on the East Slope.	Eliminated from further analysis because it is not implementable within the AVC permitting and construction time frame and would only meet additional water supply for AVC. The full AVC pipeline would still be required to convey bulk water to AVC participants.
Incorporate active and passive conservation projects by water provider customers to reduce overall demand.	A basic level of conservation is considered in the base demand calculations and is considered in all alternatives.
Construct new facilities for reuse of direct potable or nonpotable reclaimed water.	Eliminated from further analysis because large-scale reuse of water for potable purposes has not been implemented within the study area and likely would have the same source water quality issues as current water supplies. The nonpotable portion of this option potentially could be successfully implemented (and is currently implemented in many communities) but would not convey a bulk drinking water supply to AVC and Master Contract participants.
Construct separate nonpotable distribution systems for each AVC participant who would deliver nonpotable water for landscape irrigation, industrial supply, and other uses for which lower quality water could be used.	Eliminated from further analysis because in communities where these systems are not already in place, substantial infrastructure investments would be required. Because dual-use systems would only lower the amount of potable supply required and not eliminate the need for AVC, water supplies that do not require substantial infrastructure investment were determined to be a more reasonable supply for AVC.
Convey AVC water in individual spurs versus combined spurs to each participant.	This will be considered in design of the preferred alternative.
Construct reverse osmosis or nanofiltration water treatment plants to treat existing waters that require this level of treatment versus conveying AVC water to AVC participants.	Eliminated from further analysis because these types of treatment have already been investigated by the Health Department as part of the CORADS study (Malcolm Pirnie 2009a), and are not a preferred method for treatment because of residuals management and high energy use.

The CORADS study identified anion or cation exchange as the most promising treatment option for most AVC participants. The study noted radionuclide management implementation challenges that AVC participants would face with construction, operation, and maintenance costs and residuals management. Advanced treatment methods such as those identified in the CORADS study were screened in this EIS and eliminated from further analysis because of substantial permitting and logistical issues. Advanced treatment methods produce waste streams high in contaminants that could be challenging to permit and expensive to operate and maintain. Reverse osmosis and nanofiltration treatment techniques were eliminated from further analysis in the CORADS study because of the high cost of treatment, mostly associated with electricity usage and waste disposal. Nontreatment options, such as connecting to a neighboring system that is supplying water within primary drinking water standards, supplementing or replacing water with a new source, or point-of use or point-of-entry treatment systems, were not evaluated in the CORADS study.

Comparison of Alternatives

Three proposed federal actions are evaluated in this EIS (Chapter 1). While most alternatives include all three actions, each federal action is *not* included in at least one action alternative to provide a range of alternatives. Table 2-12 summarizes how each alternative does or does not meet the goals identified in the purpose and need statement. The Comanche North and Pueblo Dam North alternatives meet all purpose and need goals. The Pueblo Dam South Alternative meets all goals, except the goal of water system redundancy provided by the Interconnect. The JUP North Alternative does not meet the long-term storage goal provided by the Master Contract. The River South Alternative does not meet the goal of achieving secondary water quality standards or water system redundancy provided by the Interconnect. The Master Contract Only Alternative meets the long-term storage goal provided by the Master Contract, but does not meet the water quality of AVC or the redundancy goals of the Interconnect. The No Action Alternative would meet the goals of water supplies for 2070 demands of AVC participants, and meet primary drinking water standards, but would not meet any other purpose and need goals.

Table 2–12. Comparison of Alternatives

Purpose and Need Goals	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
AVC							
Water supply that meets 2070 demands	√	√	√	√	√	√	√
Water quality that meets primary drinking water standards	√	√	√	√	√	√	√
Water quality that meets secondary drinking water standards		√	√	√	√		
Interconnect							
Water system redundancy		√		√	√		
Master Contract							
Long-term storage that meets 2060 water demands		√	√		√	√	√

Summary of Environmental Consequences

Chapter 4 describes the predicted environmental effects of the No Action Alternative and action alternatives, using the best available information. It discusses in depth direct, indirect, and cumulative effects and quantifies these effects whenever possible. Mitigation measures for substantive effects are also described in Chapter 4. Table 2-13 and Table 2-14 summarize these effects.

Table 2–13. Summary of Direct and Indirect Effects for Affected Resource Topics

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
◉	◐	⦶	=	⊖	◒	●
Beneficial ↔ **Adverse**						
Increase ↔ **Decrease** (Surface Water Only)						

Resource Topic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Surface Water Hydrology (Average Annual)						
Streamflow – East Slope (except as noted)	=	=	=	=	=	=
Streamflow – Arkansas River above Pueblo	⊖	⊖	⊖	⊖	=	=
Streamflow – Arkansas River at Moffat St.	⊖	⊖	=	⊖	⊖	=
Streamflow – Arkansas River near Granada	=	=	=	=	=	=
Streamflow – West Slope	=	=	=	=	=	=
Storage Contents – Pueblo Reservoir	=	=	⊖	=	=	⦶
Storage Contents – Holbrook Reservoir (1)	◒	◒	=	◒	◒	◒
Surface Water Hydrology (Monthly Arkansas River above Pueblo Streamflow)						
Maximum normal year increase	(2)	(2)	(2)	(2)	⦶	⦶
Maximum normal year decrease	◒	◒	⊖	◒	⊖	⊖
Maximum dry year increase	(2)	(2)	(2)	(2)	⦶	=
Maximum dry year decrease	◒	◒	◒	◒	⊖	◒
Surface Water Hydrology (Monthly Pueblo Reservoir Storage)						
Maximum normal year increase	(2)	(2)	(2)	(2)	(2)	⦶
Maximum normal year decrease	⊖	⊖	◒	⊖	⊖	(2)
Maximum dry year increase	(2)	(2)	(2)	(2)	(2)	⦶
Maximum dry year decrease	⊖	⊖	◒	⊖	⊖	(2)
Groundwater Hydrology						
Groundwater Level – Upper Arkansas Alluvium	=	=	=	=	=	=
Groundwater Level – Lower Arkansas Alluvium	=	=	=	=	=	=
Groundwater Level – Fountain Creek Alluvium	⦶	⦶	⦶	⦶	⦶	⦶
Groundwater Level – Consolidated Bedrock Aquifer	=	=	=	=	=	=
Water Quality						
Total Maximum Daily Load Allocations – Upper Arkansas River	=	=	=	=	=	=
Salts, Selenium, and Nutrients – Lower Arkansas River	⊖	⊖	⊖	⊖	=	=
Sulfate and Uranium – Lower Arkansas River	⊖	⊖	⊖	⊖	=	=
Chronic Low Flows – La Junta	⊖	⊖	⊖	⊖	⊖	⊖
Bacteria – Fountain Creek	=	=	=	=	=	=
Selenium – Fountain Creek	⊖	⊖	=	⊖	⊖	⊖
Chronic Low Flows – Fountain Creek	=	=	=	=	=	=
Temperature – Arkansas River above Pueblo Gage	=	=	⊖	=	=	=
Salts and Selenium – Lake Meredith, Lake Henry, and Holbrook Reservoir	⊖	⊖	⊖	⊖	⊖	⊖
Geomorphology						
Erosion and Sedimentation	=	=	=	=	=	=
Aquatic Life						
Stream-Based	=	=	=	=	=	=
Pueblo Reservoir	=	=	◒	=	=	=
Holbrook Reservoir (1)	◒	◒	=	◒	◒	◒
Recreation						
Water-Based – Upper Arkansas River, Fountain Creek	=	=	=	=	=	=
Water-Based – Pueblo Reservoir	=	=	⊖	=	=	⦶
Water-Based – Arkansas River through Pueblo	=	=	=	=	=	=
Water-Based – Holbrook Reservoir (1)	◒	◒	=	◒	◒	◒
Land-Based – Short-Term Construction Related	⊖	⊖	⊖	◒	⊖	=

Table 2–13. Summary of Direct and Indirect Effects for Affected Resource Topics (continued)

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
⊙	◐		=	⊖	◒	●
Beneficial ↔ Adverse **Increase ↔ Decrease** (Surface Water Only)						

Resource Topic	**Comanche North**	**Pueblo Dam South**	**JUP North**	**Pueblo Dam North**	**River South**	**Master Contract Only**
Vegetation and Wetlands						
Upland and Riparian Vegetation	⊖	⊖	⊖	⊖	⊖	=
Wetlands	⊖	⊖	◒	⊖	⊖	=
Federal Threatened and Endangered Species	=	=	=	=	=	=
Colorado Species of Concern Potential Habitat	◒	◒	◒	◒	=	=
Wildlife						
Federal Threatened and Endangered Species	⊖	⊖	⊖	⊖	⊖	⊖
Colorado Threatened and Endangered Species	⊖	⊖	⊖	⊖	⊖	⊖
Game and Small Mammals, Amphibians, Reptiles	=	=	=	=	=	=
Birds of Conservation Concern, Other Birds	=	=	=	=	=	=
Human Environment						
Noise	⊖	◒	◒	◒	⊖	=
Vibration	=	⊖	⊖	⊖	=	=
Visual	⊖	⊖	⊖	⊖	⊖	=
Traffic	⊖	◒	◒	◒	⊖	=
Utility Services	=	=	⊖	⊖	=	=
Land Use	⊖	◒	◒	◒	⊖	=
Socioeconomics						
Construction Expenditures	⦶	⦶	⦶	⦶	⦶	=
OM&R Expenditures	⊖	⊖	⊖	⊖	⊖	=
Municipal Water Quality	◐	◐	◐	◐	⦶	=
Agricultural Dry-up	=	=	=	=	=	=
Recreation	=	=	=	=	=	=
Environmental Justice						
Minority Population Effects	=	=	⊖	⊖	=	=
Low Income Population Effects	=	=	=	=	=	=
Historic Properties						
Known Historic Properties	⊖	●	●	●	◒	⊖

All effects assume best management practices, but are before mitigation.

Resource Topics with No Notable Beneficial or Adverse Effects:

- Air Quality
- Floodplains and Flood Hydrology
- Geology and Paleontology
- Hazardous Materials
- Indian Trust Assets
- Farmland

Notes:

(1) Moderate effects on Holbrook Reservoir during certain months are not direct effects of AVC/Master Contract operations, rather the effects result from: (1) modeling switches that govern Colorado Springs operations, and the indirect effects of those operations on Holbrook Reservoir, are activated by small changes in the quantity and timing of streamflow and reservoir storage in the Lower Arkansas River Basin (see Appendix D.4); and (2) Holbrook Reservoir storage contents can get low historically and in the simulated existing conditions and No Action Alternative. During these times, a small change in volume can result in a large percent change and trigger a moderate significance level.

(2) No increases or decreases occur, respectively.

Table 2–14. Overview of Direct and Indirect Effects Associated with No Action and Action Alternatives

Resource Topic	No Action Alternative (Compared to Existing Conditions)	Alternatives That Include AVC (Compared to No Action Alternative)	Master Contract Only Alternative (Compared to No Action Alternative)
Surface Water Hydrology	Average annual and monthly streamflow in the Upper Arkansas River Basin would be nearly the same as existing conditions. Below Pueblo Reservoir, streamflow would typically be less than existing conditions due to increased use of Fry-Ark water by municipal entities, and increased exchanges of agricultural water from the Lower Arkansas Basin to Pueblo Reservoir. West Slope streamflow would typically be the same or less than existing conditions at all West Slope locations because of increases in transmountain diversions from existing conditions to meet future municipal demands. Upper Arkansas River Basin storage would be nearly the same as existing conditions. Storage in Pueblo Reservoir would be less than existing conditions due to increased releases for well augmentation to meet future municipal demands. Storage in John Martin Reservoir would be greater than existing conditions as the result of occasional accrual of unexchangeable reusable return flows and changed agricultural water rights to John Martin Reservoir.	Streamflow effects would be negligible to moderate at all locations. Effects would be most notable in the Arkansas River through Pueblo, for which all alternatives except River South would cause negligible to minor decreases in average annual and monthly streamflow. Because of its diversion location immediately upstream from the Fountain Creek confluence, the River South Alternative would typically result in negligible effects through this reach. During typical normal and dry years, there would be moderate decreases in streamflow during the winter months through Pueblo for all alternatives except River South. Effects on West Slope streamflow would be negligible. Average annual and monthly effects on Upper Arkansas River Basin storage would be negligible. Average annual and monthly effects in Pueblo Reservoir would be negligible to minor. Moderate decreases in storage would occur in the JUP North Alternative during typical dry and normal years because of a lack of Master Contract storage and associated increased use of Fry-Ark water. Effects would be negligible in John Martin Reservoir for all alternatives. Holbrook Reservoir would have moderate decreases in storage contents for all alternatives except JUP North during normal and dry years, although these decreases are due to complexities in modeling assumptions and not necessarily attributable to AVC.	Average annual and monthly streamflow effects would be negligible to minor at all locations. Reductions in streamflow below Pueblo Reservoir would be typically less than AVC alternatives because Fry-Ark releases for entities east of Pueblo would be made via the Arkansas River rather than AVC. Effects on West Slope streamflow would be typically negligible, with 1 month resulting in a minor increase in average monthly streamflow. Average annual and monthly effects in Upper Arkansas River Basin storage would be negligible. Average annual and monthly increases in Pueblo Reservoir would be minor because of less use of Fry-Ark storage by AVC participants without AVC. The Master Contract Only Alternative would have negligible to minor increases in storage at John Martin Reservoir because of minor increases in Pueblo Reservoir storage, which would result in a minor increase in spill volume from Pueblo Reservoir. Holbrook Reservoir would have moderate decreases in storage contents during typical and dry years, although these decreases are due to complexities in modeling assumptions and not necessarily attributable to the Master Contract.

Table 2–14. Overview of Direct and Indirect Effects Associated with No Action and Action Alternatives (continued)

Resource Topic	No Action Alternative (Compared to Existing Conditions)	Alternatives That Include AVC (Compared to No Action Alternative)	Master Contract Only Alternative (Compared to No Action Alternative)
Groundwater Hydrology	Increased future municipal pumping and decreased irrigated acreage would cause localized decreases in alluvial and consolidated bedrock groundwater levels. Changes in reservoir storage and streamflow would not result in measurable effects on alluvial groundwater.	All alternatives would cause negligible to minor beneficial effects. Decreased municipal groundwater use would result in localized increases in alluvial groundwater levels throughout most of the study area. Decreased irrigated acreage would decrease alluvial groundwater levels, similar to the No Action Alternative. These changes in alluvial groundwater levels would not measurably affect existing wells, irrigation practices, or structures (basements).	The Master Contract Only Alternative would have the same effects as alternatives that include AVC.
Water Quality	Total dissolved solids and selenium concentrations in Fountain Creek and the Lower Arkansas River would change very little, although some decreases in concentration would occur, depending on location. Streamflows would increase in Fountain Creek for the No Action Alternative and would be beneficial for diluting *E. coli* concentrations from nonpoint sources. TMDL allocations in the Upper Arkansas River would typically benefit from increased flows, although Lake Fork and Lake Creek streamflow decreases would occur in some years during the early summer months, especially in wet years. Chronic low flows in Fountain Creek would increase for the No Action Alternative and would be beneficial for permitted dischargers. Chronic low flows in the Lower Arkansas River would increase or decrease for the No Action Alternative, depending on location and month. Dilution percentages would decrease in segments of low flow.	Effects on TMDL allocations in the Upper Arkansas River would be negligible for all alternatives. Adverse effects on water quality from total dissolved solids, selenium, and nutrient concentrations through Pueblo would be negligible to minor. Adverse effects on water quality from sulfate and uranium concentrations through Pueblo would be minor for all alternatives except River South. Streamflow would increase in Fountain Creek for alternatives with the Master Contract. This increase in flow would have a negligible effect on *E. coli* concentrations from nonpoint sources. Chronic low flows in Fountain Creek for all alternatives would be similar to No Action Alternative chronic low flows. Chronic low flows in the Lower Arkansas River would increase or decrease for all alternatives, depending on location and month. There would be minor adverse effects on chronic low flow and dilution percentages near La Junta because of streamflow changes in that reach.	The Master Contract Only Alternative would have similar effects as the River South Alternative.

Table 2–14. Overview of Direct and Indirect Effects Associated with No Action and Action Alternatives (continued)

Resource Topic	No Action Alternative (Compared to Existing Conditions)	Alternatives That Include AVC (Compared to No Action Alternative)	Master Contract Only Alternative (Compared to No Action Alternative)
Geomorph-ology	Except Fountain Creek and the Arkansas River immediately below Fountain Creek, there would be no change in geomorphic conditions as part of the No Action Alternative. Fountain Creek historically has been a geomorphically unstable stream with erosion in the upper part of Fountain Creek leading to sedimentation in Lower Fountain Creek and at the confluence with the Arkansas River. This process is primarily due to increased return flows from municipal and industrial water use, and increased stormwater runoff. This existing erosion/sedimentation process would not change under No Action Alternative as urban development would continue.	Effects would be negligible when compared with the No Action Alternative. Urban development and associated runoff and return flows would be the same as the No Action Alternative.	The Master Contract Only Alternative would have the same effects as alternatives that include AVC.
Aquatic Life	Aquatic life populations upstream from Pueblo Reservoir would be the same as existing conditions. Lower streamflow downstream from Pueblo Reservoir would not generally affect aquatic life populations compared to existing conditions. Decreased storage in Pueblo Reservoir compared to existing conditions would not decrease aquatic life populations. The increased storage in John Martin Reservoir compared to existing conditions would increase aquatic life populations.	In the Arkansas River upstream and downstream from Pueblo Reservoir and on the West Slope, effects on aquatic life populations would be negligible. The moderate decreases in storage during normal and dry years in Pueblo Reservoir for the JUP North Alternative would cause moderate decreases in aquatic life populations. The negligible changes in storage for the remaining alternatives for Pueblo Reservoir and for all alternatives for John Martin Reservoir would result in negligible changes in aquatic life populations compared to the No Action Alternative. The moderate decreases in storage during normal and dry years in Holbrook Reservoir for all alternatives except JUP North would cause moderate decreases in aquatic life populations.	The Master Contract Only Alternative would have the same effects as alternatives that include AVC.

Table 2–14. Overview of Direct and Indirect Effects Associated with No Action and Action Alternatives (continued)

Resource Topic	No Action Alternative (Compared to Existing Conditions)	Alternatives That Include AVC (Compared to No Action Alternative)	Master Contract Only Alternative (Compared to No Action Alternative)
Recreation	The No Action Alternative would not change land-based recreation. The ability to meet target flows under the Upper Arkansas Voluntary Flow Management Program would not change, resulting in negligible effects on boating and angling opportunities above Pueblo Reservoir. At Pueblo Reservoir, the No Action Alternative would reduce Pueblo Reservoir water surface elevation less than 2 feet in normal and dry years during the summer recreation season. For the Arkansas River below Pueblo Reservoir, the number of days the No Action Alternative meets Pueblo Flow Management Program target flows during the summer recreation season would be reduced by 4 days from existing conditions.	The Pueblo Dam North Alternative would cause short-term moderate adverse effects on the Nature and Raptor Center of Colorado and Pueblo-area trail systems due to construction activities. The remaining alternatives would not affect the Raptor and Nature Center, and would result in short-term minor effects to Pueblo-area trail systems. The Comanche North Alternative would have short-term minor effects on City Park and the Elmwood Golf Course in Pueblo due to construction disturbance. Effects of other action alternatives on parks, golf courses, and open space would be negligible. The alternatives would have negligible effects on Arkansas River recreation. The JUP North Alternative would result in minor adverse effects on recreation at Pueblo Reservoir due to decreases in water surface elevation; effects of remaining alternatives would be negligible. All alternatives except JUP North would have moderate adverse effects on recreation at Holbrook Reservoir.	Land-based and water-based recreation effects of the Master Contract Only Alternative would be negligible compared with the No Action Alternative, except at Holbrook Reservoir, where the alternative would have moderate adverse effects on recreation.

Table 2–14. Overview of Direct and Indirect Effects Associated with No Action and Action Alternatives (continued)

Resource Topic	No Action Alternative (Compared to Existing Conditions)	Alternatives That Include AVC (Compared to No Action Alternative)	Master Contract Only Alternative (Compared to No Action Alternative)
Vegetation and Wetlands	Temporary disturbance to upland vegetation would occur during construction. Temporary wetland disturbance would be minimized by boring under wetlands associated with perennial streams. Disturbance to plant species of concern and potential spread of noxious weeds would be minimized by implementing best management practices. The No Action Alternative would permanently disturb more upland vegetation than AVC alternatives because of brine evaporation ponds needed for expanded reverse osmosis water treatment at La Junta and Lamar. The No Action Alternative would not permanently disturb wetlands or other riparian areas. The No Action Alternative would not disturb federally listed threatened and endangered species.	Construction would have temporary minor adverse effects on upland vegetation and wetlands. The JUP North and Pueblo Dam North alternatives would have greater adverse effects on upland vegetation communities and fewer effects on agricultural lands. Temporary adverse wetland effects would be minimized by boring under wetlands associated with perennial streams. Effects on plant species of concern and the spread of noxious weeds would be minimized through best management practices. Permanent effects on upland vegetation would be negligible. The JUP North Alternative would have a permanent moderate adverse effect from loss of 1 acres of wetlands at the water treatment plant site, and a minor effect on riparian shrubland and forest. The remaining alternatives would not permanently disturb wetlands and would have negligible permanent riparian effects. The Pueblo Dam North Alternative would permanently disturb potential sensitive species habitat. No alternatives would affect federally listed threatened and endangered species.	The Master Contract Only Alternative would have negligible effects compared with No Action.

Table 2–14. Overview of Direct and Indirect Effects Associated with No Action and Action Alternatives (continued)

Resource Topic	No Action Alternative (Compared to Existing Conditions)	Alternatives That Include AVC (Compared to No Action Alternative)	Master Contract Only Alternative (Compared to No Action Alternative)
Wildlife	Short-term disturbance of some upland wildlife habitat for game animals, migratory birds, and small mammals and reptiles would occur during pipeline construction activities. The amount of suitable habitat disturbed would be low compared to the generally abundant suitable regional habitat. Direct, long-term disturbance associated with construction and operation of facilities would be negligible. Hydrologic changes at John Martin Reservoir would be within the range of existing seasonal fluctuations in most years, resulting in little change to piping plover and least tern habitat. Agricultural dry-up would increase habitat for the Colorado blue buckwheat butterfly. Habitat for federally listed threatened and endangered species, and species of concern would not be disturbed.	Pipeline construction activities and aboveground facilities would have negligible effects on upland habitat for game animals, migratory birds, and small mammals and reptiles for all alternatives. None of the alternatives would directly disturb suitable habitat for federally listed threatened or endangered species, candidate species, or state-listed species of concern. John Martin Reservoir water levels would generally be slightly higher under all alternatives, which would have a minor effect on piping plover and least tern habitat. Adverse effects on upland state wildlife mammal and bird species of concern would be minor (small and localized) under all alternatives. Effects on limited-range reptiles would be negligible to minor for all alternatives.	The Master Contract Only Alternative would have the same effects as alternatives that include AVC.
Human Environment	Increases in effects on noise, vibration, traffic, and utility resources, and decreases in visual resources would be short-term during new pipeline and facility construction under the No Action Alternative. Expansion of existing water treatment plants, brine storage basins, and new wells would not substantially change the human environment.	The Comanche North and River South alternatives would have short-term negligible effects on vibration and utilities, and minor adverse effects on noise, visual, traffic, and land use resources. The remaining alternatives that include AVC would have short-term minor to moderate adverse effects on these resources within Pueblo County because of pipeline construction through urban areas. East of Pueblo, all alternatives would have short-term negligible to minor effects on the human environment. The JUP North Alternative would result in long-term minor adverse effects on visual resources at Pueblo Reservoir because of fluctuations in reservoir levels due to increased Fry-Ark use.	The Master Contract Only Alternative would have negligible effects compared with the No Action, with the exception of long-term minor beneficial effects on visual resources at Pueblo Reservoir due to higher reservoir levels from excess capacity storage.

Table 2–14. Overview of Direct and Indirect Effects Associated with No Action and Action Alternatives (continued)

Resource Topic	No Action Alternative (Compared to Existing Conditions)	Alternatives That Include AVC (Compared to No Action Alternative)	Master Contract Only Alternative (Compared to No Action Alternative)
Socio-economics	Construction and OM&R expenditures for the No Action Alternative would not substantially increase the regional economy. The No Action Alternative would improve municipal water quality compared to existing conditions, especially for radionuclides. Agricultural dry-up in the No Action Alternative would not decrease the regional economy as it would affect only a small portion of total agriculture in the basin. Changes in recreation revenue in the No Action Alternative would not decrease the regional economy.	Construction expenditures for alternatives that include AVC would have short-term minor beneficial effects to the regional economy. OM&R expenditures for all alternatives would be less than or equal to the OM&R expenditures under the No Action Alternative and would have minor adverse effects on the regional economy. Localized economic effects could be greater or less, depending on where direct expenditures occur in the region. Alternatives with a Pueblo Reservoir or JUP AVC intake would have a moderate beneficial effect on household costs due to improvements in municipal water supply salinity concentrations. The River South Alternative would have a less beneficial effect, because salinity concentrations at the river intake are higher than Pueblo Reservoir concentrations. Regional socioeconomic effects caused by agricultural dry-up would be negligible for all alternatives as the action alternatives would have agricultural dry-up similar to the No Action Alternative. Regional recreation economic effects for all alternatives would be negligible because effects on location-specific recreation activities would be negligible to minor and would not affect the regional economy.	The Master Contract Only Alternative is similar to the No Action Alternative and would have negligible socioeconomic effects.

Table 2–14. Overview of Direct and Indirect Effects Associated with No Action and Action Alternatives (continued)

Resource Topic	No Action Alternative (Compared to Existing Conditions)	Alternatives That Include AVC (Compared to No Action Alternative)	Master Contract Only Alternative (Compared to No Action Alternative)
Environ-mental Justice	Construction activities for the No Action Alternative would not affect a disproportional number of minorities, but would disproportionally affect low-income households.	Effects on minority and low-income populations under the Comanche North, Pueblo Dam South, and River South alternatives would be negligible because the affected minority and low-income populations would not exceed No Action minority and low-income populations (on a percent basis) and would not be disproportionate. The JUP North and Pueblo Dam North alternatives would affect more minority population than No Action, but the difference is less than 10 percent and would be minor.	Construction activities for the Master Contract Only Alternative would have a negligible disproportional effect on minority or low-income populations compared to No Action.
Historic Properties	The No Action Alternative would impact three known historic properties.	The alternatives that include AVC would have 17 to 65 known historic properties in the buffer corridor. Most known historic resources are within the built environment of Pueblo. The Pueblo Dam South Alternative would be near the greatest number of historic properties because of the pipeline alignment through Pueblo. The Comanche North Alternative would impact the least historic properties because it avoids Pueblo urban environment. Adverse impacts on most historic properties could be avoided or minimized by refining the pipeline alignment, and implementing best management practices and mitigation measures. Impacts on historic properties within the operation pool of Pueblo and John Martin reservoirs have already occurred from the ongoing effects of fluctuating reservoir levels, which would not be exacerbated by the minor changes in reservoirs. In unsurveyed areas east of Pueblo, the southern routes would have a higher probability of impacting prehistoric sites with potentially significant and intact cultural deposits. A programmatic agreement was developed to address cultural resource survey requirements and treatment of any adverse effects on historic properties.	The Master Contract Only Alternative would impact three known historic properties.

Table 2–14. Overview of Direct and Indirect Effects Associated with No Action and Action Alternatives (continued)

Resource Topic	No Action Alternative (Compared to Existing Conditions)	Alternatives That Include AVC (Compared to No Action Alternative)	Master Contract Only Alternative (Compared to No Action Alternative)
Indian Trust Assets	No Indian Trust Assets were identified in the AVC study area.	No Indian Trust Assets were identified in the AVC study area.	No Indian Trust Assets were identified in the AVC study area.

Note:

Effects on air quality, flood hydrology and floodplains, geology and paleontology resources, hazardous materials, and farmland were also examined. Further analysis determined that the effects of the proposed actions would be minimal. They are not discussed in detail in this EIS.

Identification of Preferred Alternative

According to Reclamation's 2012 NEPA Handbook, Reclamation shall identify an agency-preferred alternative in the Final EIS. In identifying a preferred alternative, Reclamation should consider:

- If an alternative exists which has the consensus of the affected community and it is reasonable and practicable, meets the purpose and need for action and is within Reclamation's statutory authority to implement, Reclamation should designate it as the preferred alternative.
- The preferred alternative should be an alternative that completes the action and that best meets the purpose and need for the action as defined in the EIS.

Reclamation compared all alternatives in terms of how well each addressed the purpose and need, relevant environmental and non-environmental issues identified by Reclamation during the EIS process, and estimated costs. Based on these considerations, Reclamation has identified the Comanche North Alternative as the preferred alternative. A final preferred alternative will be selected by Reclamation in a Record of Decision.

By diverting water from Pueblo Reservoir via JUP, the preferred alternative would deliver water meeting primary and secondary drinking water standards, and would deliver enough water to meet participants' 2070 water demands, assuming base levels of conservation. When coupled with proposed mitigation measures described in this Final EIS, the preferred alternative would have similar or fewer environmental effects compared to other alternatives. The preferred alternative's southern route around the City of Pueblo would have fewer construction effects on existing infrastructure, streets, businesses, and residents compared to alternatives that would construct pipeline in the city. East of Pueblo, aligning the AVC pipeline north of the river avoids most of the U.S. Highway 50 corridor. The preferred alternative would integrate new water treatment plant components into the existing Whitlock Water Treatment Plant, which would minimize water treatment plant construction costs and terrestrial effects. The integrated water treatment plant would filter water; AVC participants would be responsible for adding residual disinfection at their delivery point. The Interconnect would add system redundancy for participants receiving water from either the north or south Pueblo Dam outlets. The Master Contract would increase water supply reliability and drought protection for participants. Estimated present worth construction cost of the preferred alternative is $400 million. Estimated annual costs of operations, maintenance and replacement costs would be about $3.5 million. Estimated annual costs for the Master Contract account would range from about $0.8 million to nearly $1.1 million.

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Chapter 3 Affected Environment

This chapter describes the environment that could be affected by implementing the alternatives described in Chapter 2. The discussion focuses on resources that would most likely be affected by the alternatives, including resources identified during the public scoping process (Chapter 5). Resources less likely to be affected are also noted but are not discussed in this EIS. Memoranda addressing these resources are posted on the project website at www.usbr.gov/avceis.

Resources Analyzed in This EIS

Resources are grouped in this chapter as water-based resources (those that would primarily be affected by water supply and reservoir operations) and land-based resources (those that would primarily be affected by pipeline and facility construction) and are presented in the following order:

- **Surface Water Hydrology**: Flow patterns and water quantities in rivers and streams in the Arkansas River Basin and West Slope could be affected by the proposed actions. Storage in existing Arkansas River Basin reservoirs could also be affected.
- **Groundwater Hydrology**: Groundwater levels, volume or timing of recharge to an aquifer, and volume and timing of return flows to streams could be affected by changes in surface water flows, dry-up of existing irrigated land, and changes in municipal groundwater pumping associated with alternatives.
- **Water Quality**: Surface water and groundwater quality could be affected by the alternatives. Water quality issues identified in the scoping process include radionuclides, selenium, bacteria, total dissolved solids (including effects on crop yield), sulfates, temperature, and flow at permitted wastewater discharge locations.
- **Geomorphology**: Stream hydraulics (depth and velocity) and channel stability (erosion, deposition, and sediment transport) could be affected by changes in surface water flows.
- **Aquatic Life**: Fish and other aquatic life could be affected by construction and changes in surface water flows and quality.
- **Recreation**: Water-based recreation could be affected by changes in streamflow or reservoir levels, variation in the seasonal timing of water levels, changes in water quality, or changes to aquatic habitat and fishing opportunities. Land-based recreation could be affected by construction.
- **Vegetation and Wetlands**: Native vegetation, cropland, and wetland and riparian communities could be temporarily or permanently affected by ground disturbance from construction. Wetland and riparian communities could be affected by changes in streamflow and construction. Noxious weeds could potentially invade disturbed sites after construction.

- **Wildlife**: Wildlife habitat, movement, and activities could be temporarily affected by construction. The presence of permanent facilities could affect wildlife depending on facility location. Riparian habitat used by wildlife could be affected by changes in streamflow and construction.
- **Human Environment**: The quality of the human environment could be temporarily affected by mostly short-term disturbances during construction. Anticipated effects include noise and vibration associated with excavation and earthwork; disruption of traffic movement and increased traffic near construction zones; and temporary effects on visual quality from construction-related disturbances and permanent effects from new infrastructure.
- **Socioeconomics**: Socioeconomics could be affected by changes in construction-related spending, employment, water rates, and water use and conversion of irrigation water to municipal use.
- **Environmental Justice**: Effects on groups of people with respect to income, race, ethnicity, community, or some other group characteristic due to construction activities could vary. Environmental justice recognizes that no group of people should bear a disproportionate share of negative effects from an action based only on their group characteristics.
- **Historic Properties**: Archaeological, architectural, or historical resources could be affected by construction. These resources are protected by the National Historic Preservation Act and other federal laws.
- **Indian Trust Assets**: Indian Trust Assets, including trust lands, hunting, fishing, and gathering rights, and water rights, could be affected by construction. The United States has a “trust responsibility” to protect and maintain rights and property reserved by or granted to federally recognized American Indian tribes or to Indian individuals by treaties, statutes, and executive orders. This responsibility requires that all federal agencies, including Reclamation, take all actions necessary to protect Indian Trust Assets.
- **Other Resources**: Effects on flood hydrology and floodplains, air quality, hazardous materials, farmland, and geology and paleontology resources were also examined. Further analysis found that the effects of the alternatives on these resources would be minimal; they are not discussed in detail in this document (MWH 2013a; ERO 2012a, 2012b, 2012c, 2012d).

Environmental and Hydrologic Setting

Existing condition and characteristics of the EIS study area are generally described below. Past and present water, land, and development projects are used to help define existing conditions for each resource. The time frame considered for describing existing conditions generally corresponds to the time Reclamation issued the Notice of Intent in 2010 to prepare the EIS (2010e). Hydrologic, water quality, and land use changes from past and ongoing actions have influenced the existing condition of natural resources, including aquatic life, wildlife, wetlands, and vegetation. Activities that influenced the natural and human characteristics of the EIS study area are primarily related to agriculture, mining, and urban development, and include water projects, transportation infrastructure, energy projects, and associated organizations related to this development. A more comprehensive list and discussion of these activities is presented in Appendix B.4.

The proposed alternatives would be located within the Arkansas River Basin of Colorado. Although the following paragraphs describe the entire Arkansas River Basin, the EIS study area consists of only a portion of the basin. General environmental and hydrologic characteristics of the Arkansas River Basin in Colorado described below are largely excerpted from the Colorado Water Conservation Board (2004) and USGS (1998).

Geography

The Arkansas River is about 1,450 miles long, and is the fourth-longest river in the United States. About 316 miles of the river are within Colorado and contained in the EIS study area. The Arkansas River Basin in central and southeastern Colorado covers 28,268 square miles, or about 27 percent of the state area, making it the state’s largest river basin. The Arkansas River begins in the Mosquito and Sawatch ranges of the southern Rocky Mountains in Lake County, Colorado, near Leadville. The river flows south to Salida, through deep canyons near Cañon City, then east across the plains through Kansas, Oklahoma, and Arkansas until it joins the Mississippi River at its mouth in Napoleon, Arkansas (Figure 3–1). Several major tributaries enter the river before it reaches Kansas, including Fountain Creek, Timpas Creek, and the Purgatoire River.

The West Slope within the EIS study area includes a portion of the headwaters region of the Colorado River Basin, including the Fryingpan River and Roaring Fork River. These rivers begin on the west slope of the Sawatch Range east of Aspen. The Fryingpan River is tributary to the Roaring Fork River at Basalt, which is then tributary to the Colorado River at Glenwood Springs.

Topography

Fenneman (1931) divided Arkansas River Basin topography into two distinct areas relative to Cañon City: west of Cañon City is the Upper Arkansas River Basin and to the east is the Lower Arkansas River Basin. The Upper Arkansas River Basin is mostly mountainous, with elevations ranging from 5,000 feet to more than 14,000 feet, and is primarily located in Lake, Chaffee, Custer, and Fremont counties. The Lower Arkansas River Basin ranges in elevation from about

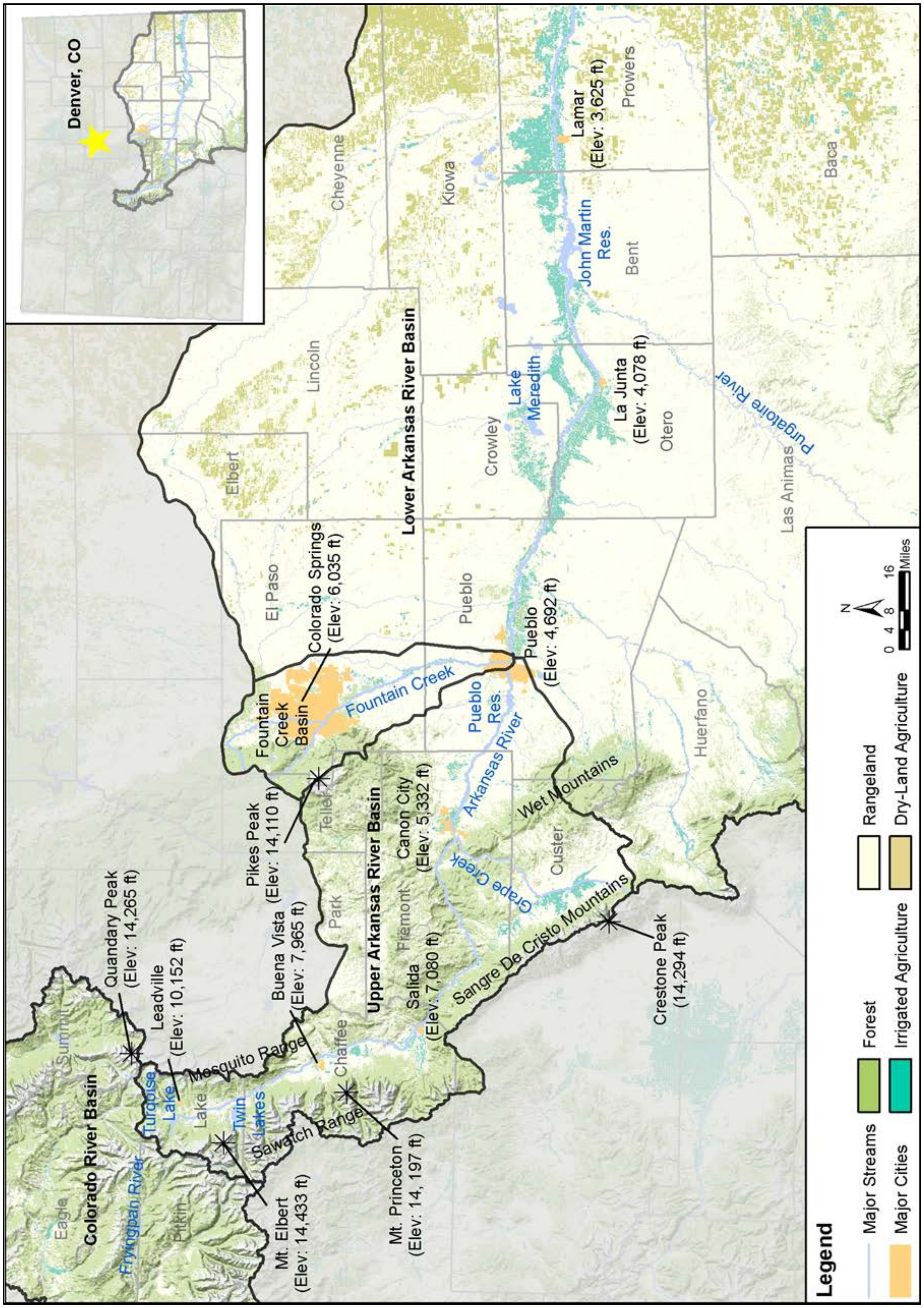


Figure 3–1. Arkansas River Basin

3,500 feet to 7,500 feet and, within the EIS study area, is primarily located in southern El Paso, Pueblo, Crowley, Otero, Bent, Prowers, and Kiowa counties.

The West Slope within the EIS study area is primarily a mountainous region with elevations ranging from about 8,000 feet to more than 14,000 feet (U.S. Forest Service 2007). The West Slope primarily located in Pitkin County, and includes the Fryingpan River Basin.

Population Centers

Population in the Upper Arkansas River Basin is concentrated along the river corridor. Major towns are Leadville (population 2,763), Buena Vista (population 2,134), Salida (population 5,396), and Cañon City (population 15,889). The Lower Arkansas River Basin's two largest population centers are Pueblo (population 104,951) and Colorado Springs (population 380,307). Other major towns include La Junta (population 7,046) and Lamar (population 7,953) (U.S. Census Bureau 2009). There are no major population centers on the West Slope within the EIS study area.

Land Use

Arkansas River Basin land use is primarily agricultural along the river corridor; other areas are predominately rangeland. Estimated irrigated land in counties within the EIS study area is about 284,000 acres (MWH 2011). Grassland and forest are the predominate land use types in the basin, with grasslands covering about 67 percent and forest covering about 13 percent of the basin. Grassland areas are concentrated in the central portion of the basin, whereas forest lands are located in western portions of the Arkansas River Basin. Most of the West Slope within the EIS study area is forested. Land area is about 1 percent developed (Colorado Water Conservation Board 2004), which includes urban and suburban land use.

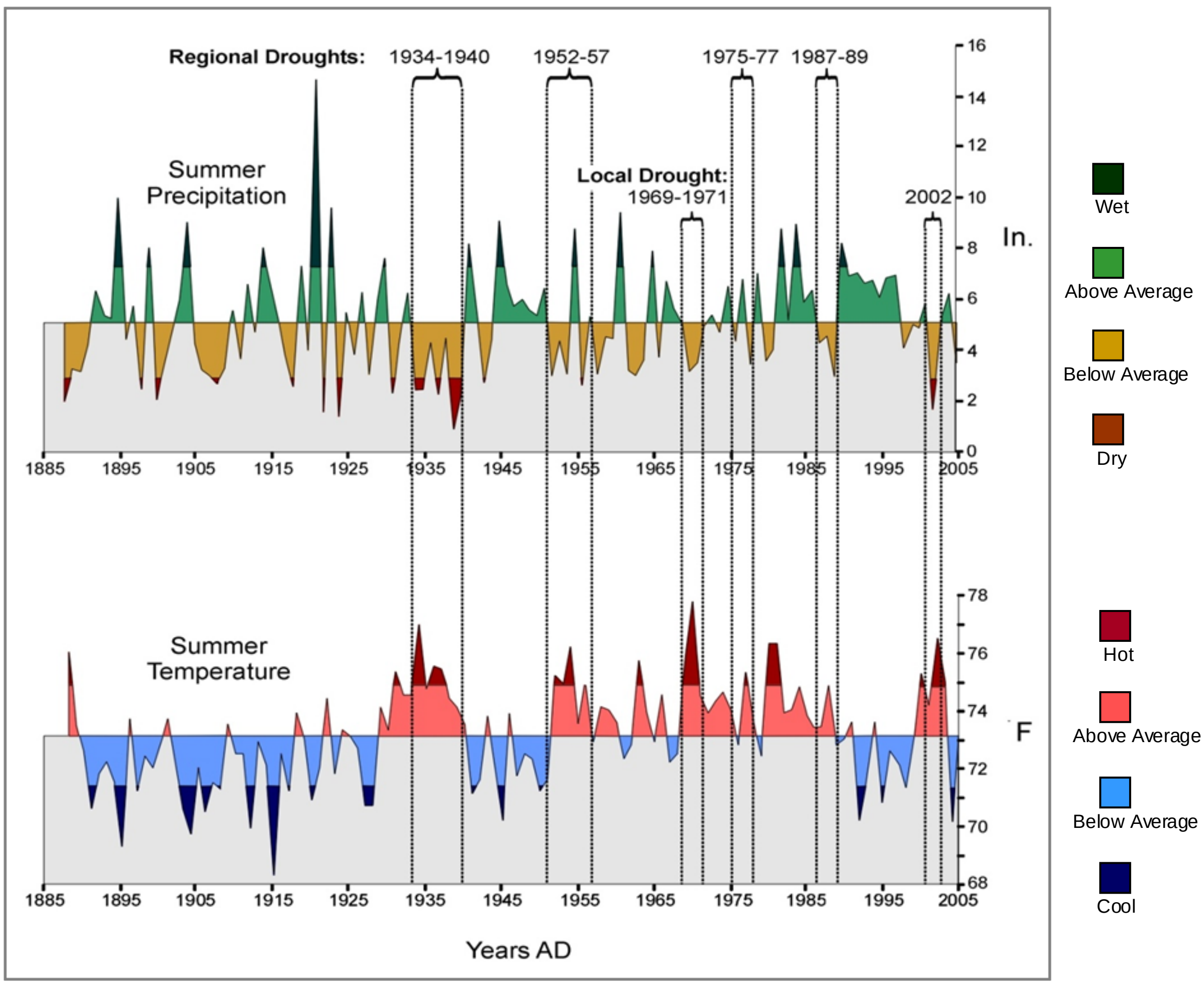
Climate

Photo 3–1. Typical snowpack telemetry (or SNOTEL) climate monitoring site

The Arkansas River Basin encompasses a wide range of topographical features that have a major impact on temperatures, wind patterns, and storms. Mean monthly temperatures of the Arkansas River headwaters range from 18°F in January to 55°F in July. In general, temperatures decrease with elevation. As the river flows east, the climate warms with generally hot summers and mild winters, and occasional extreme-cold events (Benke et al. 2005). Mean monthly temperatures on the plains range from 30°F in January to 78°F in July. Summer daily maximum temperatures are often above 95°F. Annual precipitation averages from 28 inches at the river's headwaters (Sanadhya et al. 2009) to less than 12 inches between Pueblo and Las Animas. Precipitation in mountain regions increases with elevation, with most precipitation occurring in winter months. On the eastern plains, precipitation cycles seasonally, with most falling during the growing season (April through September).

The Dust Bowl drought of the 1930s is the most significant drought in the instrument record for Pueblo and other areas of the Arkansas River Basin, and included a significant decrease in summer precipitation and a significant increase in summer temperature. Figure 3–2 shows temperature and precipitation records for Pueblo. Other major regional droughts of the 1950s, 1970s, and 1980s varied in their local impacts and were not as significant as local events such as droughts recorded in 1969–1971 and 2002. Analysis of reconstructed streamflow since the 1600s for the Arkansas River at Cañon City gage shows the observed record is fairly representative of long-term hydrologic conditions seen within the basin (Woodhouse 2004).

The Upper Colorado River Basin, from which Arkansas River Basin water users receive a portion of their supply, is a snowmelt-driven environment much like the headwaters region of the Arkansas River. Spring snowpack in the Upper Colorado River Basin has generally declined, less winter precipitation has occurred as snowfall, and snowmelt has runoff earlier (Knowles et al. 2006). Additional information on climate change in the study area can be found in Appendix C.1, C.2, and in Chapter 4.



Source: Gilmore 2008

Figure 3–2. Instrument Temperature and Precipitation Records for Pueblo, Colorado

Surface Water Hydrology

Surface water hydrology for this EIS includes rivers, creeks, and major reservoirs within the overall EIS study area. Streamflow and reservoir storage could be affected by changes in volume, timing, and location of surface water diversions and groundwater use by AVC and Master Contract participants. This section describes major existing conditions that influence surface water hydrology, such as water sources, water use, and administration, and also presents historical hydrologic data for key surface water features. Appendix D.1 presents supplemental information describing the surface water hydrology affected environment.

Methods

Surface water data were gathered for streamflow, diversions, water use, and reservoir storage. Selected locations highlighted in this section represent major streamflow gages and reservoirs on the Arkansas River. Additional gage information is in Appendix D.1.

Photo 3–2. Arkansas River at Cañon City gage (604 cubic feet per second (cfs))

Historical data were obtained from the Colorado Decision Support System database (2010), U.S. Geological Survey (USGS) gage records (2010a), Colorado State Engineer's Office Division 2 Engineer (2010), Reclamation Hydromet data system (2010f), Reclamation's Pueblo Area Office data records (Hopkins 2010), Reclamation's Fry-Ark Project *Annual Operating Plans* (2009a), and previous water resource planning reports for the area.

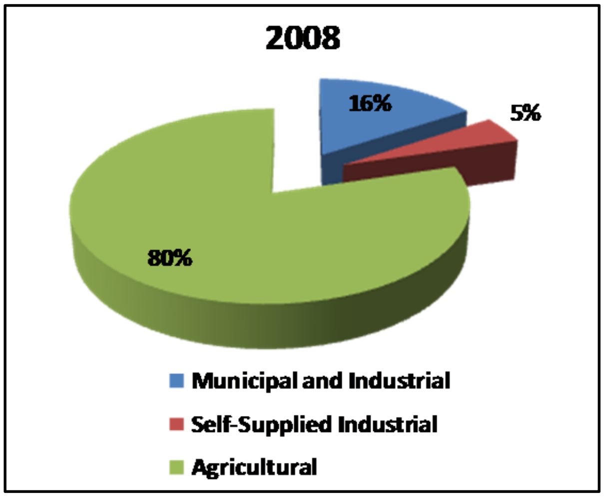
Hydrologic data presented in Chapter 3 and environmental consequences evaluation in Chapter 4 use a 1982–2009 hydrologic study period. This 28-year period was chosen because it characterizes typical hydrologic years, contains extreme low and high flow years, and includes operations of many important past actions that have affected hydrology in the overall EIS study area. A statistical summary of the study period compared to long-range statistics for the Arkansas River at Cañon City gage is presented in Appendix D.1.

Affected Environment

This subsection summarizes surface water information for the study area, such as water use and supply (including the Fry-Ark Project), flow management programs, historical streamflow for pertinent flow gages, and historical storage contents for major reservoirs.

Water Use

Water in the Arkansas River Basin is primarily used for agricultural, municipal, industrial, recreational, fisheries, and augmentation purposes (Colorado Water Conservation Board 2002). Irrigation is the single largest water use within the Arkansas River Basin, followed by municipal and industrial use. Figure 3–3 shows the relative distribution of water use in the Arkansas River Basin in 2008 (Colorado Water Conservation Board 2011). Self-supplied industrial water includes industrial users who are not connected to a public water system.



Source: Colorado Water Conservation Board 2011
Figure 3–3. Existing Water Use in Arkansas River Basin

The primary use of water in the study area is for irrigation of agricultural crops. Major agricultural diversions on the Arkansas River (greater than 50,000 ac-ft per year, on average) include the Fort Lyon Canal, Fort Lyon Storage Canal, Catlin Canal, Rocky Ford Highline Canal, Holbrook Canal, and Bessemer Ditch. Most land irrigated for crops other than pastures is in counties downstream from Pueblo Reservoir. There are 284,000 acres of irrigated land within the nine-county study area (MWH 2011). Using a basin-wide irrigation requirement of 2.3 ac-ft per acre (Colorado Water Conservation Board 2011), the total irrigation water demand is about 700,000 ac-ft per year. Crops grown within the study area are summarized in the Chapter 3 - *Socioeconomics* section.

Municipal and industrial water demand in the Arkansas River Basin was 196,000 ac-ft in 2008 (Colorado Water Conservation Board 2011). The two largest municipal water users are Colorado Springs Utilities and the Board of Water Works of Pueblo. Municipal and industrial water use consists of all water use from a typical municipal system, including residential, commercial, industrial, and firefighting. About 83 percent of municipal water use occurs in El Paso and Pueblo counties, with the balance of municipal water use occurring in the remaining rural counties.

Environmental and recreational uses are important nonconsumptive water uses within the basin, and several flow programs and instream flow water rights have been established to manage water to consider these interests. Flow programs and instream flow water rights are described later in this resource section.

Surface Water Supply

Rainfall and snowmelt runoff both produce native streamflow in the Arkansas River. Mountain precipitation occurs primarily as snowfall, resulting in snowpack accumulated during winter and early spring months. Rapid warming during late spring and early summer months results in high-intensity, short-duration runoff events (Abbott 1985). Native water supplies are supplemented by several transmountain projects, which divert water from the West Slope of Colorado (Colorado River Basin) to the Arkansas River Basin, including the Fry-Ark Project. This section summarizes major basin surface water supplies, shown in Figure 3–4 and Figure 3–5. Additional information can be found in Appendix D.1.

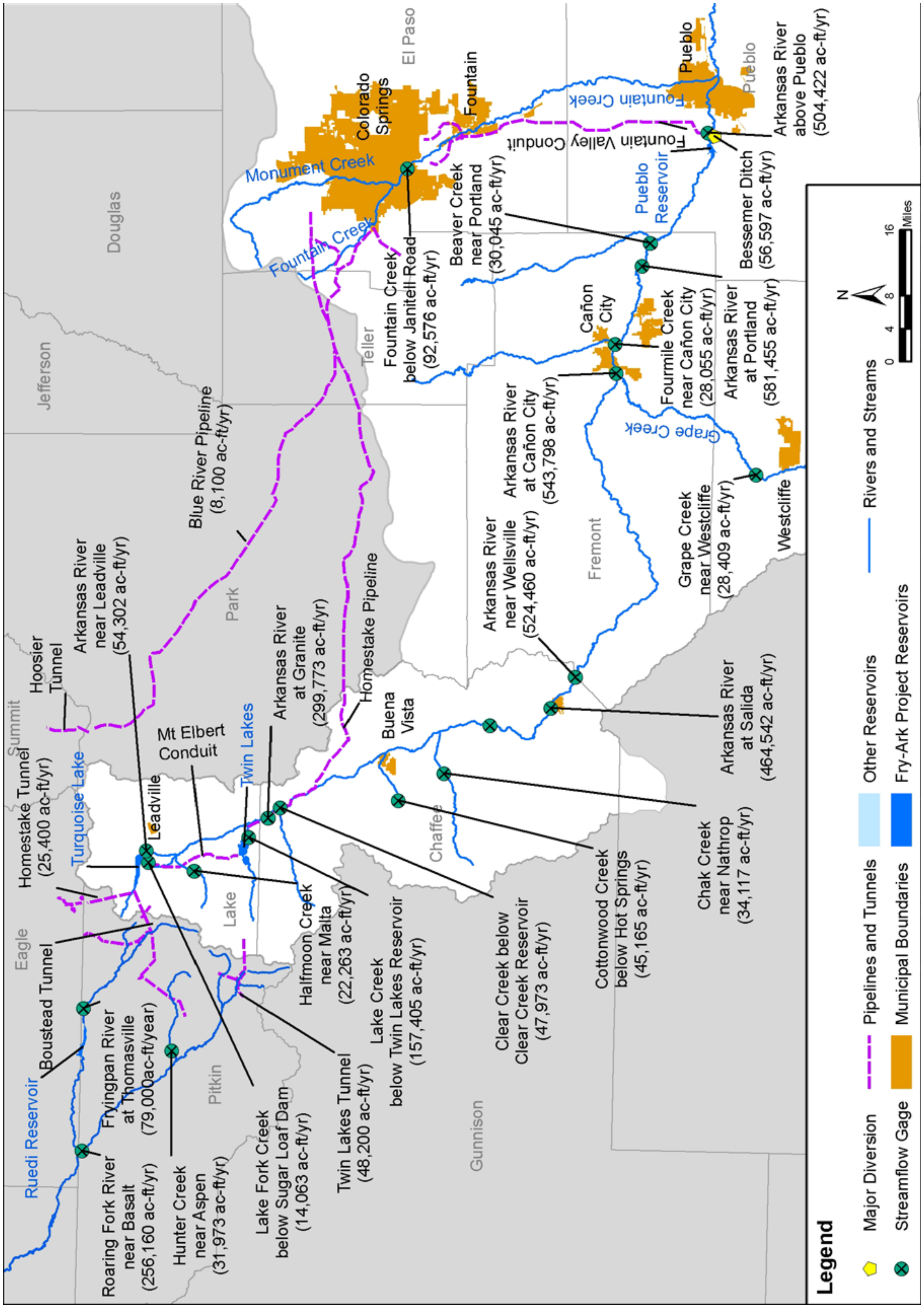


Figure 3–4. Annual Tributary Inflows, Major Diversions, and Water Quantities at Various Locations in Upper Arkansas River Basin (1982-2009 hydrologic study period)

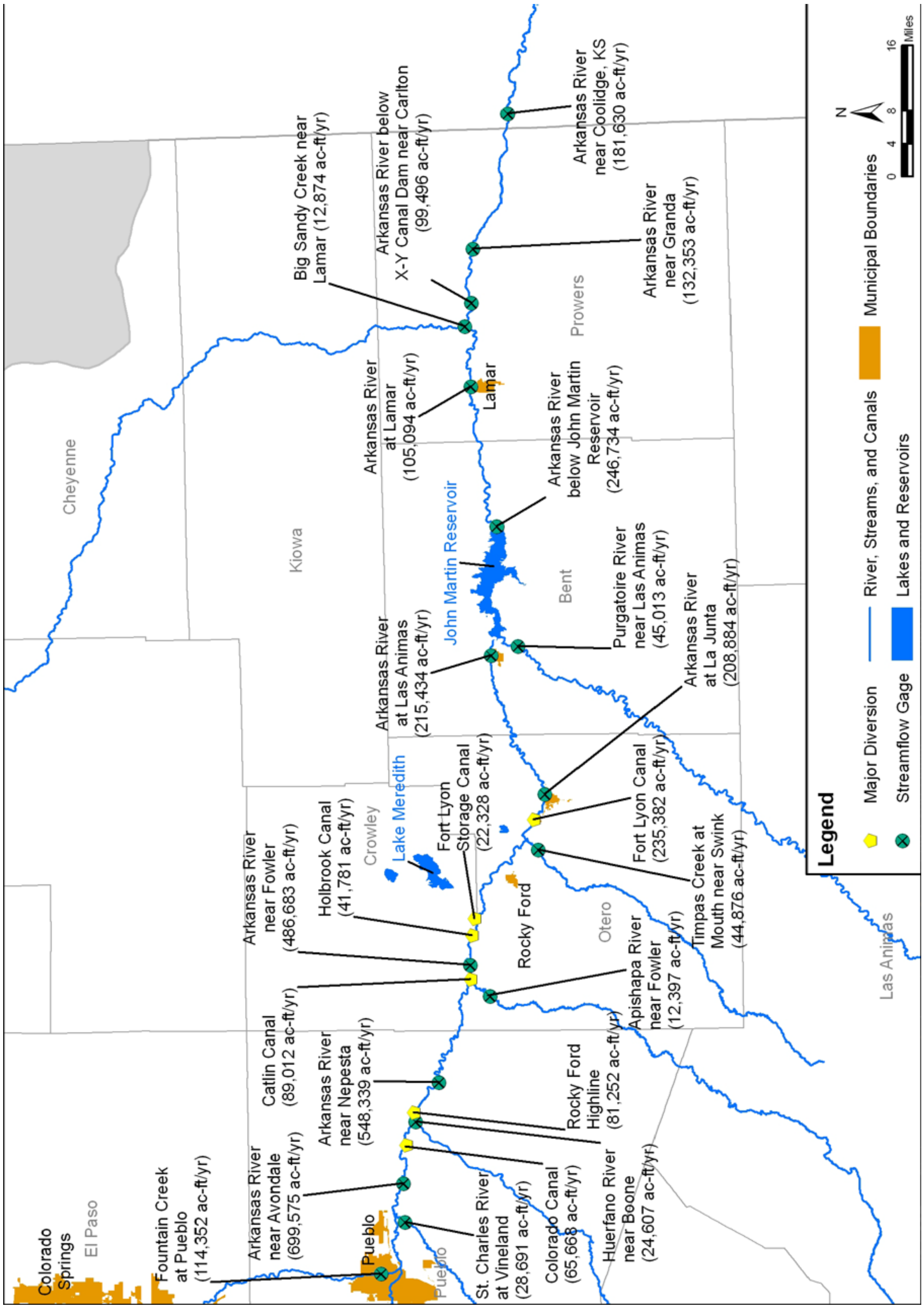


Figure 3–5. Annual Tributary Inflows, Major Diversions, and Water Quantities at Various Locations in Lower Arkansas River Basin (1982-2009 hydrologic study period)

Native Water Rights Native water in the Arkansas River Basin is administered using the prior appropriation doctrine, and Arkansas River Basin water is highly appropriated. When water is insufficient in the river to meet all water rights, a call is placed on the river, and diversions are satisfied in priority based on the date of the water right appropriation. Only in extremely wet periods is there a “free river,” with no call on the river. There has been no “free river” condition on the Arkansas River since 1999.

Historically, water rights with priority dates earlier than 1874 are in priority nearly 100 percent of the time. Water rights later than 1890 have historically been in priority 26 percent of the time. Water rights later than 1893 are typically reservoir storage rights that divert only a few days or weeks per year during the peak runoff season. The earliest priority date on the Arkansas River within the study area is the April 1861 water right owned by the Board of Water Works of Pueblo for 7 cfs.

Prior appropriation is the water law doctrine that gives priority to use water based on when the water rights were acquired. Holders of senior rights have first claim to withdraw water over holders who have filed or been granted later claims. Water rights **in priority** are able to divert according to their decreed amounts.

Colorado also is required to maintain compliance with the Compact, which was negotiated between Colorado and Kansas. This Compact apportioned the Arkansas River flows and the conservation benefits of John Martin Reservoir, which was constructed by the Corps between 1939 and 1948. The Compact was signed by the states' and the federal representatives in December 1948. The Compact was subsequently enacted as state law by Colorado and Kansas as well as being adopted as a federal statute (State of Colorado, C.R.S. 37-69-101; State of Kansas, K.S.A. 82a-520; and Federal Statute, 63 Stat. 145). Compact Article IV-D provides:

"This Compact is not intended to impede or prevent future beneficial development of the Arkansas river basin in Colorado and Kansas by federal or state agencies, by private enterprise, or by combinations thereof, which may involve construction of dams, reservoirs and other works for the purposes of water utilization and control, as well as the improved or prolonged functioning of existing works: Provided, that the waters of the Arkansas river, as defined in Article III, shall not be materially depleted in usable quantity or availability for use to the water users in Colorado and Kansas under this Compact by such future development or construction."

Photo 3–3. Arkansas River at Coolidge, Kansas gage

The Compact and related documents can be found on the Colorado Division of Water Resources (2011) Web site (www.water.state.co.us).

Winter Water Storage Program The Pueblo Winter Water Storage Program allows agricultural water users to store native Arkansas River flows during the winter in Pueblo Reservoir, John Martin Reservoir, and other off channel reservoirs below Pueblo Reservoir. Before Pueblo Reservoir was completed, agricultural entities would divert water during the winter using their normal conveyance systems to maintain soil moisture levels and for storage in pre-Compact off-stream facilities. Beginning in 1975, a program was developed to allow entities the option to divert water into storage for use during the following irrigation season. The Pueblo Winter Water Storage Program is in effect from November 15 through March 15 annually. Total program diversions are divided among participants using set percentages. Nonparticipants retain the right to divert water according to their priority date. The program is administered with a priority date of March 1, 1910, and typically stores between 30,000 and 50,000 ac-ft in Pueblo Reservoir each year, with additional storage in off-channel structures (Hopkins 2010). Winter Water Storage in John Martin Reservoir averaged 24,500 ac-ft during the study period (1982 to 2009).

Transmountain Projects Fry-Ark water supplies are derived from both the West Slope and East Slope of the Continental Divide. The Boustead Tunnel diverts water from the Roaring Fork River, a tributary to the Colorado River, on the divide's West Slope in the Sawatch Range (Photo 3–4). East Slope water rights are native Arkansas River water rights with a 1962 priority date, and are therefore rarely in priority.

Photo 3–4. Boustead Tunnel outlet

Since the Fry-Ark Project's substantial completion in 1982, historical yields have averaged about 72,000 ac-ft per year, which are made up of about 54,000 ac-ft of West Slope yield and 18,000 ac-ft of East Slope yield. Municipal entities are currently allocated about 54 percent of the Fry-Ark yield, while agricultural entities are allocated the remaining yield, including allocations not purchased by municipalities. Agricultural deliveries of Fry-Ark water are conveyed in the Arkansas River to ditch diversions downstream from Pueblo Reservoir. Municipal deliveries are typically from Pueblo Reservoir, either through pipelines to Fountain Valley Authority water users and the Board of Water Works of Pueblo, or via the Arkansas River to municipal water users east of Pueblo. The exception is delivery to municipalities west of Pueblo, from Twin Lakes or Turquoise Lake.

Other transmountain diversion projects include the Homestake Project (25,400 ac-ft), Twin Lakes Reservoir and Canal Company (48,200 ac-ft), Busk-Ivanhoe System (5,200 ac-ft), Columbine, Ewing, and Wurtz ditches (5,800 ac-ft), and Blue River Project (8,100 ac-ft) (Colorado Decision Support System 2010; Campbell 2010). Much of the imports from these projects are conveyed to the Cities of Aurora or Colorado Springs via the Otero Pump Station, Homestake Pipeline, and Blue River Pipeline. The remaining imports are conveyed to municipal and agricultural entities in the Arkansas River Basin via the Arkansas River.

> **Exchange** is when a water user makes an "out-of-priority" diversion at one location while at the same time returning a like amount of water to the stream at another location. This operation can be performed if no senior water rights on the river are injured.

Multiple Use Diversion Projects Multiple use diversion projects in the Arkansas River Basin are primarily projects formerly used for agriculture that are now agricultural, municipal, and industrial water supplies. Although a portion of the shares of most canal companies is owned by municipal or industrial entities, two systems in the Arkansas River Basin are currently being used nearly entirely for nonirrigation purposes: the Colorado Canal System (90 percent of ditch and reservoir shares owned by multiple municipal entities) and the Rocky Ford Ditch (95 percent of ditch shares owned by Aurora). Typically, municipal entities move transferred agricultural water rights upstream using exchanges. Additional information on existing and potential future transfers from agricultural to municipal and industrial use is in Appendix B.4.

Flow Management Programs and Minimum Flows

There are several legally binding flow management programs and decreed minimum flow requirements within the study area. These include in-stream flow water rights held by the Colorado Water Conservation Board, intergovernmental agreements among water agencies operating within the Arkansas River Basin, and Recreational In-Channel Diversion water rights. Major flow programs and minimum flows affecting streamflow within the study area are listed in Appendix D.1.

Two flow management programs with the most influence on Arkansas River Basin operations are the Upper Arkansas Voluntary Flow Management Program and Pueblo Flow Management Program. The Upper Arkansas program is designed to provide water for fisheries and recreation in the Upper Arkansas River by specifying timing of Fry-Ark reservoir releases and exchanges to meet target flows at the Wellsville streamflow gage (just downstream from Salida). In general, target flows are 700 cfs between July 1 and August 15 and a minimum of 250 cfs during the remainder of the year. The Pueblo Flow Management Program is designed to maintain target flows through Pueblo for recreation by curtailing exchanges. General components of the program include target year-round flows of 100 cfs and recreation flows of up to 500 cfs during summer months at the Above Pueblo gage (City of Pueblo et al. 2004a, 2004b). Memoranda of Agreement between Southeastern and AVC and Master Contract participants would require participation and compliance with Southeastern's commitments in the Pueblo Flow Management Program (see Chapter 4 – *Surface Water Hydrology* for additional details).

The Board of Water Works of Pueblo and Colorado Springs Utilities have also committed to the Arkansas River Low Flow Program to promote the biological health of the Arkansas River and the success of the Corridor Legacy Project. These entities have each agreed to release up to 1,500 ac-ft from Pueblo Reservoir when flow at the Above Pueblo location (Above Pueblo gage plus hatchery return flows) is less than 50 cfs. Participation for both entities will begin when the SDS begins water delivery (currently scheduled for 2016).

Streamflow

Photo 3–5. Typical Upper Arkansas River Streamflow Gage

The USGS and Colorado Department of Natural Resources maintain streamflow gages throughout the Arkansas River Basin. Figure 3–4 and Figure 3–5 show mainstem and tributary gage locations with average annual streamflow. The flows referenced in this section are for the 1982 to 2009 study period. Figure 3–4 shows that a large portion of Upper Arkansas River streamflow originates from tributary inflow, with 60 percent of total annual flow at the Portland gage comprising measured tributary inflows. Figure 3–5 shows the impact of agricultural diversions, with streamflow between Avondale and Las Animas decreasing nearly 70 percent. The Arkansas River contributes about 83 percent of measured inflows into John Martin Reservoir, while the Purgatoire River contributes about 17 percent. The Kansas water supply, as measured at the Colorado-Kansas state line, is composed of several sources, including Kansas account releases from John Martin Reservoir, irrigation return flows, and tributary inflows below John Martin Reservoir. For the 1982 to 2009 period, the Kansas account releases are about 18 percent of the water passing the Arkansas River below John Martin Reservoir gage.

Arkansas River near Wellsville Average daily flows, the range of daily flows, and target flows associated with the Upper Arkansas Voluntary Flow Management Program are shown in Figure 3–6. Flows range between 250 cfs and 700 cfs from mid-September through mid-April. Annual peak flows at the gage occur anytime from mid-May through mid-July. Summer flows can range between 250 cfs and 5,800 cfs. Target flows shown in Figure 3–6 are for absolute minimum flows only. Typically, winter target flows are higher based on aquatic conditions (see Appendix D.1). Reclamation releases water from Fry-Ark storage to meet target flows for the Upper Arkansas Voluntary Flow Management Program at this gage. In general, other water providers do not release water to meet the target flows. The Arkansas River near Wellsville gage at high and low flows is shown in Photo 3–6.

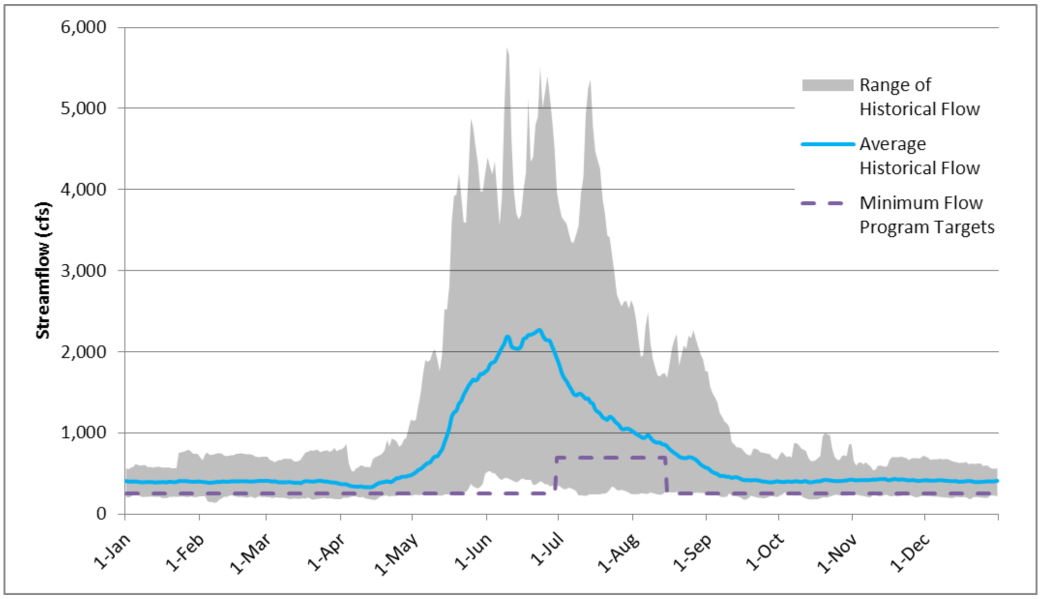


Figure 3–6. Arkansas River near Wellsville Gage Daily Flow Summary for Study Period

Photo 3–6. Arkansas River near Wellsville Gage (4,440 cfs, left; 543 cfs, right)

Arkansas River above Pueblo Streamflow at the Arkansas River above Pueblo gage is completely controlled by releases from Pueblo Reservoir. As shown in Figure 3–7, minimum daily flows during spring and late summer months are substantially higher than those at the Arkansas River near Wellsville gage. In addition, mean and median flows in the late summer are much higher and last for several weeks longer than those at the Arkansas River near Wellsville gage because releases are made from storage primarily for irrigation use. Pueblo Flow Management Program target flows shown in Figure 3–7 are for "above average" hydrological conditions. "Below average" target flows are slightly lower (see Appendix D.1). The Arkansas River above Pueblo gage at high and low flows is shown in Photo 3–7.

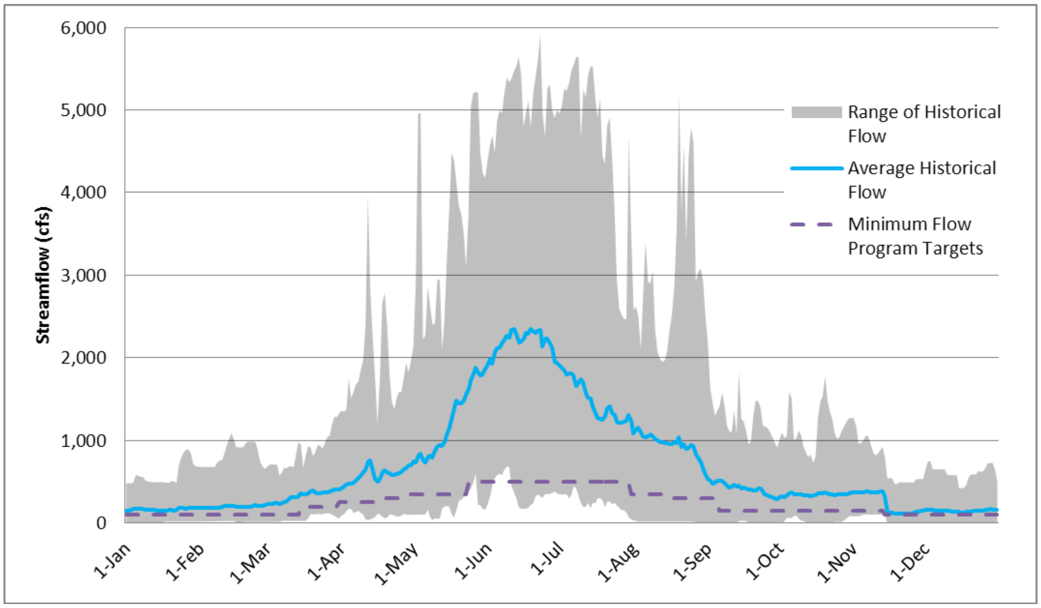


Figure 3–7. Arkansas River above Pueblo Gage Daily Flow Summary for Study Period

Photo 3–7. Arkansas River above Pueblo Gage (4,890 cfs, left; 119 cfs, right)

Arkansas River near Rocky Ford As expected, flows at the Arkansas River near Rocky Ford gage are lower than flows at the other gages discussed above (Figure 3–8) due to diversions for irrigation. Wintertime flows are lower because of the Winter Water Storage Program in Pueblo Reservoir, off-channel diversions to Colorado Canal System reservoirs and to Fort Lyon Canal Company reservoirs through the Fort Lyon Storage Canal. The Arkansas River near Rocky Ford gage at high and low flows is shown in Photo 3–8.

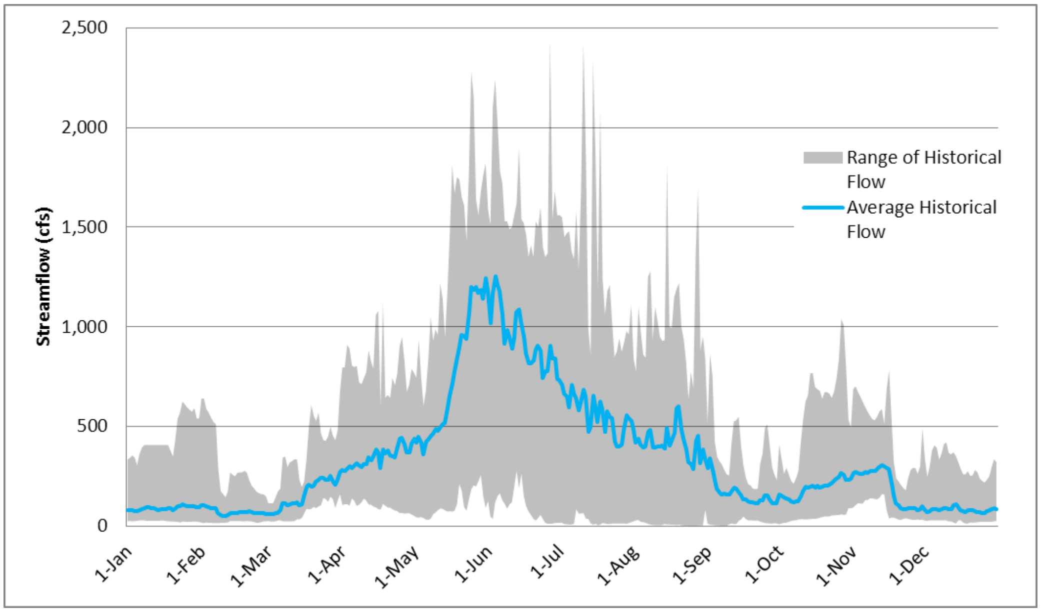


Figure 3–8. Arkansas River near Rocky Ford Gage Daily Flow Summary for Study Period

Photo 3–8. Arkansas River near Rocky Ford Gage (773 cfs, left; 148 cfs, right)

West Slope and Tributary Gages Potentially affected West Slope streams include the Fryingpan River and its tributaries, and Hunter Creek, a tributary to the Roaring Fork River. The Fryingpan River is a water source for the Boustead Tunnel collection system, and also for Ruedi Reservoir, both features of the Fry-Ark Project. Historical average daily flow for the Fryingpan River at Thomasville gage, downstream from Boustead Tunnel diversions and upstream from Ruedi Reservoir, is 109 cfs (79,000 ac-ft/year) and ranges from 14 cfs to 1,200 cfs. Hunter Creek serves as a water source for the Hunter Tunnel, which conveys water to the Boustead Tunnel. Historical average daily flow for the Hunter Creek near Aspen gage, downstream from Hunter Tunnel diversions, is 42 cfs (30,500 ac-ft/year) and ranges from 2 cfs to 800 cfs.

Average daily flow for the Grape Creek near Westcliffe gage is 39 cfs (28,400 ac-ft per year) and ranges from 3 to 1,000 cfs. Grape Creek originates in the Wet Mountain Valley in Custer County near Westcliffe, and is tributary to the Arkansas River near Cañon City.

Average daily flow for Fountain Creek at Pueblo is 158 cfs (114,400 ac-ft per year) and ranges from near zero to more than 11,000 cfs. Median flows remain fairly constant throughout the year between 80 and 150 cfs. Fountain Creek and its smaller tributaries originate on the north and east slopes of Pikes Peak in El Paso County. Fountain Creek is tributary to the Arkansas River within Pueblo. Much of the native flow in Fountain Creek is diverted for municipal use before the creek reaches Colorado Springs. Except during high snowmelt events, streamflow downstream from Colorado Springs is dominated by treated municipal effluent and municipal and rural stormwater runoff.

Reservoir Storage

As mentioned, the Fry-Ark Project includes one West Slope reservoir, and four East Slope reservoirs (includes Mount Elbert Forebay). Storage volumes for each reservoir are shown in Table 3–1, along with storage volumes for other important reservoirs within the study area. Turquoise Lake, Twin Lakes, Pueblo Reservoir, and John Martin Reservoir are discussed below. Information about all major study area surface water reservoirs can be found in Appendix D.1.

Table 3–1. Fry-Ark Project and Study Area Reservoir Storage Volumes

Reservoir	Reservoir Storage (ac-ft)					
	Dead	Inactive [1]	Active Conservation	Joint Use	Flood Control	Total Capacity
Fry-Ark Reservoirs						
Ruedi Reservoir [2]	63	1,095	101,278	0	0	102,373
Turquoise Lake	2,810	8,920	120,478	0	0	129,398
Twin Lakes	63,324	72,938	67,917	0	0	140,855
Mount Elbert Forebay	561	3,825	7,318	0	0	11,143
Pueblo Reservoir	2,329	28,121	228,828	66,000	26,991	349,940
Other Major Reservoirs in Study Area						
Lake Meredith	1,196	0	39,804	0	0	41,000
Lake Henry	1,039	0	8,691	0	0	9,730
Holbrook	0	200	6,200	0	0	6,400
John Martin Reservoir	0	0	344,000	0	449,400	793,400

Source: Reclamation 2009a
Notes:
(1) The volume shown for Inactive includes the volume shown for Dead storage; therefore, Total Capacity equals the sum of Dead, Inactive, Active Conservation, Joint Use, and Flood Control, minus Dead.
(2) West Slope Fry-Ark Reservoir.

Turquoise Lake Turquoise Lake is located on Lake Fork Creek west of Leadville, and is owned and operated by Reclamation as part of the Fry-Ark Project. In addition to Fry-Ark storage space, there are several long-term contracts to store non-Fry-Ark water within firm storage space in the reservoir. Turquoise Lake is drawn down to meet streamflow requirements along Lake Fork Creek, to supplement voluntary streamflow targets associated with the Upper Arkansas Voluntary Flow Management Program, and to make room for the summer transmountain imports through the Boustead Tunnel. Water from non-Fry-Ark storage space, which is primarily owned by municipalities, is released for delivery through the Homestake pipeline or delivery downstream in the Arkansas River. Historical storage contents in Turquoise Lake are shown in Figure 3–9.

> **Firm storage** is storage space available 100 percent of the time. The only firm accounts in Pueblo Reservoir are Fry-Ark accounts.
>
> **Excess capacity storage** is storage space provided on an as-available basis. When space is available, these accounts are used for non-Fry-Ark water.

Water stored in the reservoir is either released to Lake Fork to meet minimum flow requirements below the dam, or through the Mount Elbert Conduit to the Mount Elbert Forebay. Water from the forebay is used to generate power at the Mount Elbert Pumped-Storage Powerplant as it conveys water to Twin Lakes. Occasionally, water released to Lake Fork Creek is above minimum flow targets when available capacity is inadequate in the Mount Elbert Conduit to convey all imports, and when Turquoise Lake is full.

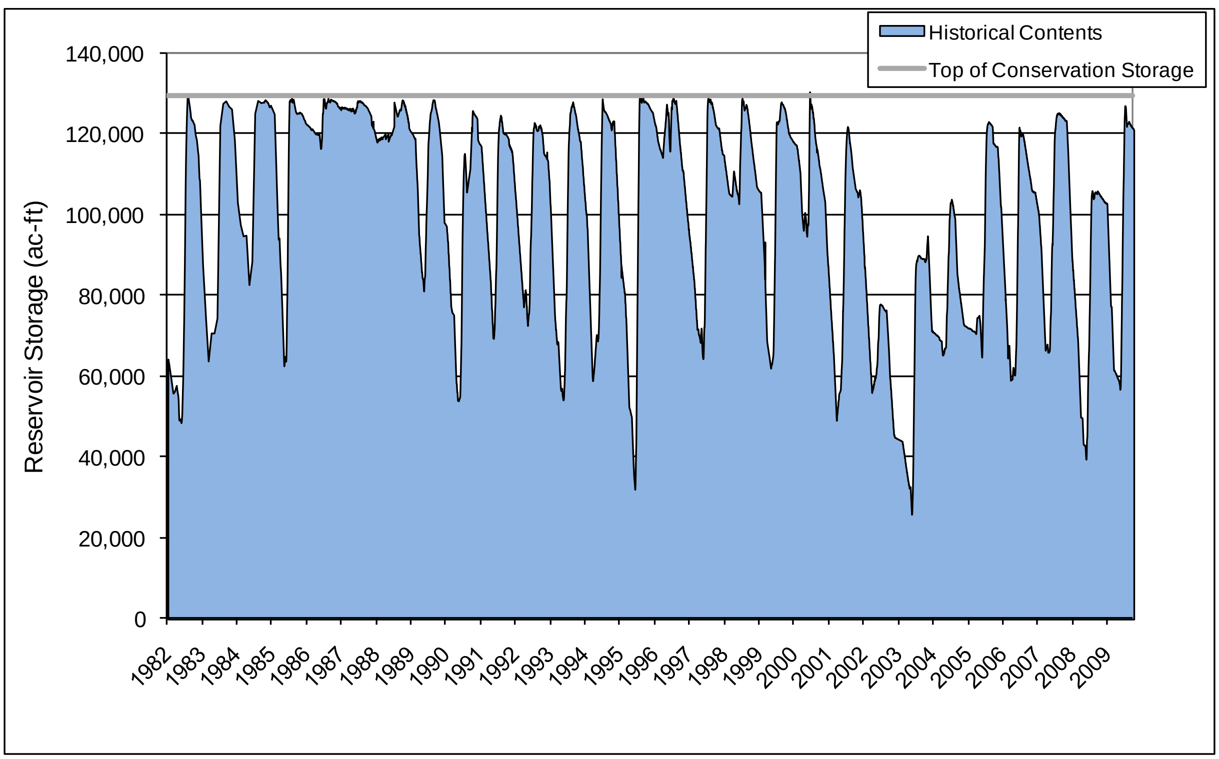


Figure 3–9. Turquoise Lake Historical Storage

Twin Lakes Twin Lakes is located on Lake Creek south of Leadville, and is the receiving reservoir for water used at the Mount Elbert Pumped-Storage Powerplant. As with Turquoise Lake, Twin Lakes is owned and operated by Reclamation as part of the Fry-Ark Project. The Twin Lakes Reservoir and Canal Company has a long-term contract to store non-Fry-Ark water within firm storage space in the reservoir. Although commonly reported together, historical Twin Lakes storage volumes (Figure 3–10) do not include the Mount Elbert Forebay storage volume.

Photo 3–9. Twin Lakes

Water is released from Twin Lakes either directly to Lake Creek or to the Otero Pump Station via the Twin Lakes pipeline. Historically, minimum releases of 15 cfs to Lake Creek have been made from Fry-Ark storage for fish habitat purposes during winter months, although winter releases are usually higher than this value. Typically, any operational releases of Fry-Ark water from Turquoise Lake or Twin Lakes (releases to maintain flow targets at the Arkansas River near Wellsville gage or to move water to Pueblo Reservoir) are made from Twin Lakes to Lake Creek.

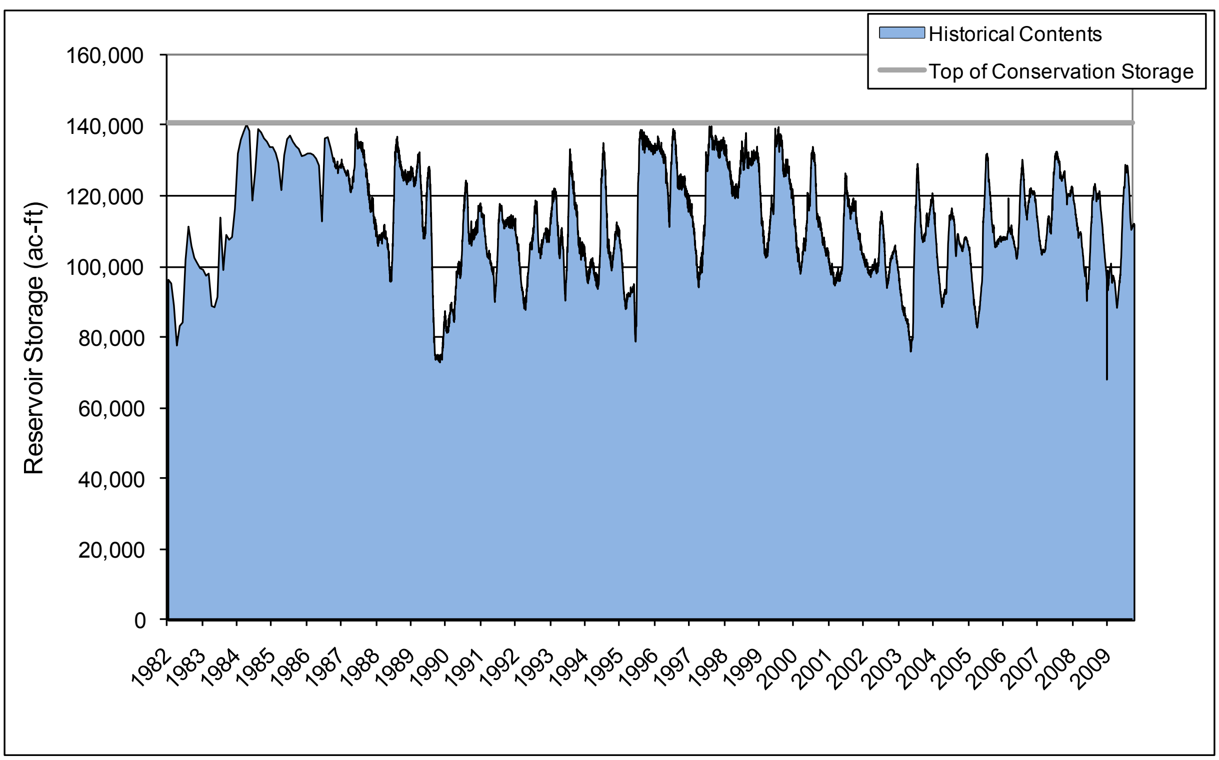


Figure 3–10. Twin Lakes Historical Storage

Pueblo Reservoir Pueblo Reservoir is located on the Arkansas River immediately upstream (west) from Pueblo. The reservoir was constructed in 1975, and Reclamation owns and operates all space as part of the Fry-Ark Project. There are no contracts to store non-Fry-Ark water in firm storage space within the reservoir.

Unlike Turquoise Lake and Twin Lakes, which normally refill to or near capacity on an annual basis, Pueblo Reservoir storage incurs longer cycles between reservoir fills (Figure 3–11). This is due to Fry-Ark operations, which tend to keep storage in the higher mountain reservoirs to reduce evaporation. Also, West Slope and East Slope yields of the Fry-Ark Project are not enough to completely fill the reservoir annually. By design, Pueblo Reservoir stores excess water during wetter years and delivers this water during drier years, resulting in higher contents during and immediately after wet years and lower contents during and immediately after dry years. Pueblo Reservoir also stores water during winter months as part of the Winter Water Storage Program.

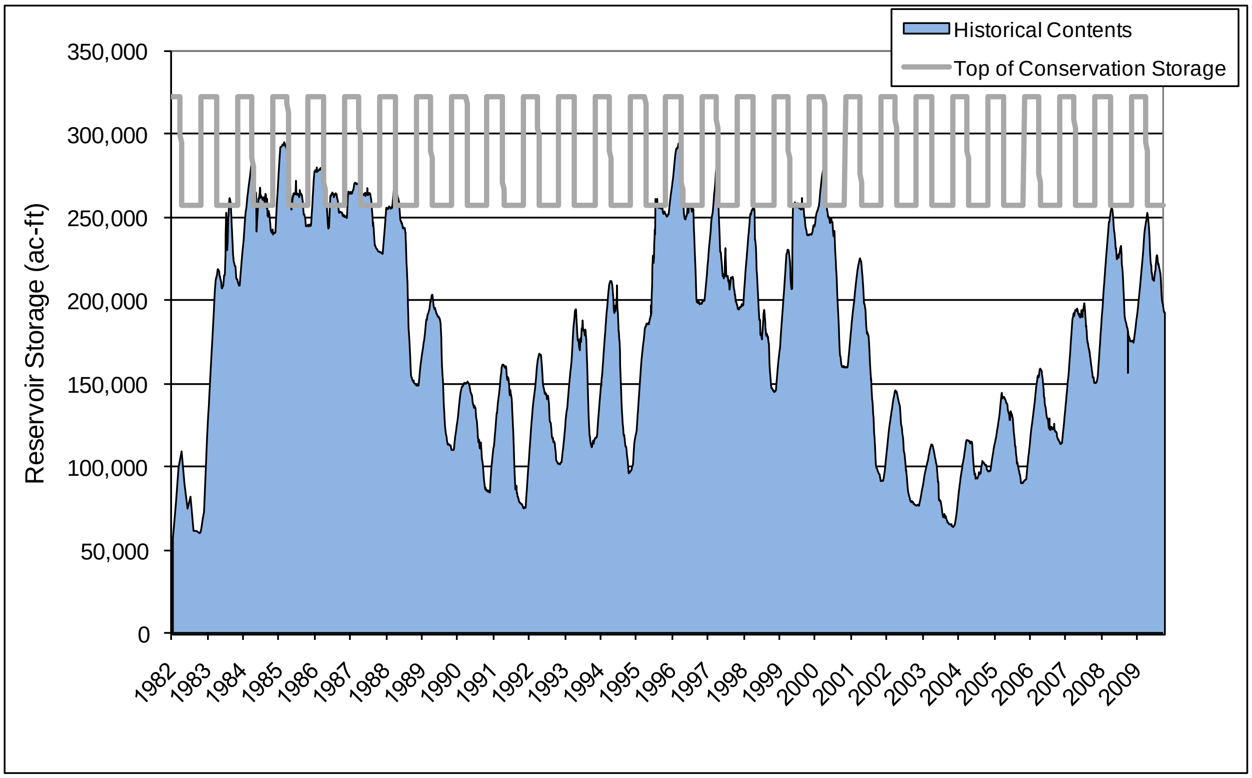


Figure 3–11. Pueblo Reservoir Historical Storage

Reclamation has historically contracted with entities to allow non-Fry-Ark water to be stored in Fry-Ark storage space on an as-available basis. The largest users of excess capacity contracts in Pueblo Reservoir have historically been Colorado Springs and Aurora, which have had excess capacity contracts since 1986. Tables of historical excess capacity contracts are presented in Appendix D.1.

Photo 3–10. Pueblo Dam

When storage space is unavailable to accommodate both Fry-Ark and non-Fry-Ark accounts, non-Fry-Ark water is "spilled" or released from the reservoirs. Spill priorities are specified in Article 13 of Contract No. 5-07-70-W0086, as amended, between Southeastern and the United States, which govern evacuation of water from Pueblo Reservoir. The spill order was enacted under the fourth amendment of the contract in 1984. Table 3–2 shows Fry-Ark reservoir spill priorities, as written in Article 13.

Table 3–2. Fry-Ark Reservoir Spill Priorities

Spill Order (1)	Category of Spill (from Article 13, Amendment 4 to Contract No. 5-07-70-W0086)
1	Against water stored under contracts for if-and-when available storage space for entities which will use the water outside the District boundaries
2	Against water stored under contracts for if-and-when available storage space for entities which will use the water within the District boundaries. This evacuation will be charged pro rata against water stored under all such like contracts at the time of the evacuation.
3	Against any winter storage water in excess of 70,000 acre-feet.
4	Against water stored under contracts with municipal entities within the boundaries of the District, which water is neither Project water nor return flow from Project water and which water is limited to 163,100 acre-feet less any Project water purchased and stored by municipal users. This evacuation will be charged pro rata against the water stored under all such like contracts at the time of evacuation.
5	Against winter storage in excess of 70,000 acre-feet.
6	Against Project water accumulated from the Arkansas River and its tributaries.

Note:
(1) First to spill is first in spill order.

John Martin Reservoir John Martin Reservoir is an on-channel reservoir primarily used for flood control, irrigation, and recreation purposes. The reservoir is located on the Arkansas River downstream from the town of Las Animas. John Martin Reservoir is owned and operated by the Corps (Figure 3–12). Although total capacity at the top of dam is 793,400 ac-ft, maximum capacity is limited to 603,465 ac-ft. The Compact Administration oversees operation of the conservation pool. The conservation pool has a capacity of 333,912 ac-ft based on the 1999 resurvey and there is no dead storage.

Photo 3–11. John Martin Reservoir

Starting on November 1st of each year, Compact inflows are stored in Compact conservation storage. Water in Compact conservation storage is transferred to accounts for Colorado and Kansas water users starting on the first demands of water on or after April 1st, but no later than April 7th of each year. While water is being transferred from Compact conservation storage, Compact inflows continue to accumulate in Compact conservation storage even as the water is transferred. When Compact conservation storage is emptied by these transfers, then Colorado reverts to the water right priority system, and senior water rights downstream from the reservoir may again place calls against their upstream juniors. When Compact conservation storage is first emptied after April 1st, water can be stored in Compact conservation storage if inflows exceed the downstream Colorado surface water irrigation demands by more than 1,000 ac-ft.

Post-Compact development is subject to Compact Article IV-D, which precludes any material depletion in usable quantity or availability for use to the water users in Colorado and Kansas under this Compact by such future development or construction. Water derived from pre-Compact water rights can be stored in the following separate accounts in John Martin Reservoir: (1) the Pueblo Winter Water Storage Program, (2) the Amity Canal Great Plains water rights, or (3) in the Offset Account.

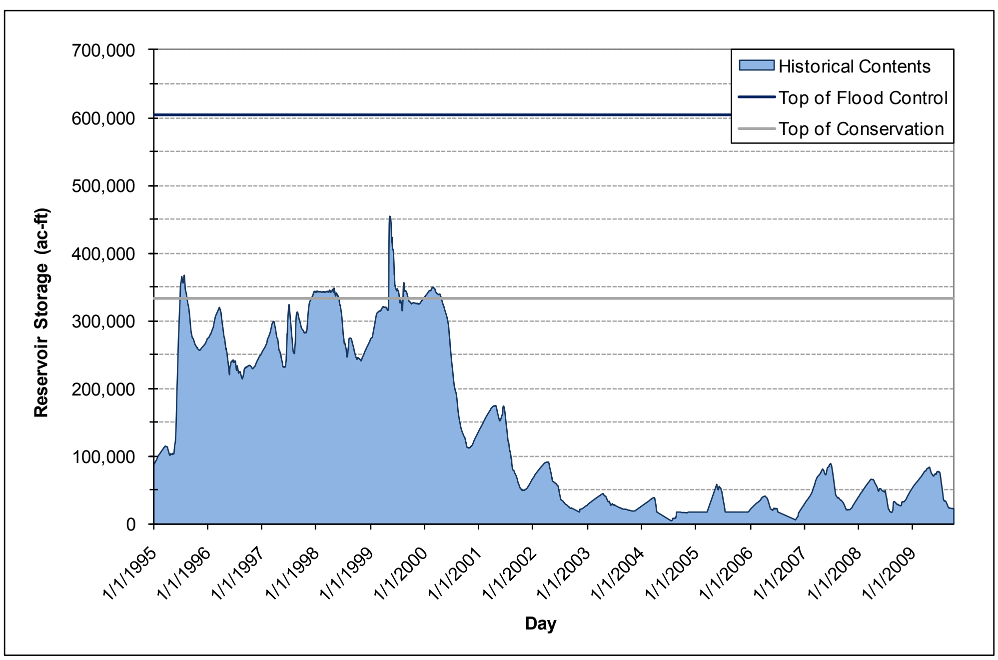


Figure 3–12. Historical John Martin Reservoir Storage

Groundwater Hydrology

Groundwater is an important resource in Colorado's Arkansas River Basin, providing about 6 percent of the total basin water supply in 2005 (USGS 2005). Alluvial aquifers and consolidated bedrock aquifers are current municipal, industrial, and agricultural water sources within the EIS study area, although alluvial aquifers are more prevalent in the Lower Arkansas River Basin and are used primarily for agricultural purposes. The Arkansas River is both a gaining and losing stream, relative to localized groundwater usage (Livingston 2011). Groundwater is being evaluated because of a variety of potential effects from proposed alternatives, including changes in streamflow, well pumping, and irrigated acreage. In addition, water quality within aquifers could be affected. Groundwater quality is discussed in the Chapter 3 - *Water Quality* section.

Methods

Existing reports for groundwater conditions in the Arkansas River Basin and Fountain Creek Basin were reviewed and used to prepare a summary of existing groundwater resources in the EIS study area. These reports described primary aquifers, groundwater levels, aquifer uses, recharge areas, and factors that affect groundwater conditions. No new groundwater-level measurements were collected for this task.

The groundwater analysis area includes the Upper Arkansas River alluvial aquifer, the Fountain Creek alluvial aquifer, Widefield alluvial aquifer, alluvium associated with Grape Creek, and Dakota-Cheyenne consolidated bedrock aquifer. The alluvial aquifers underlie much of the irrigated land in the Lower Arkansas River (Figure 3–13). In some cases, groundwater conditions throughout the Arkansas River Basin, including areas outside the groundwater analysis area, are discussed because of the interconnected nature of alluvial groundwater systems.

Alluvium is a deposit of clay, silt, sand, and gravel left by flowing streams or glaciers in a river valley or delta.

Alluvial aquifers are shallow sand and gravel deposits adjacent to a stream, and generally hydraulically connected, or tributary, to surface water. Alluvial aquifers are unconfined aquifers (the upper aquifer layer is the water table).

Consolidated bedrock aquifers have a lower potential rate of groundwater withdrawal, and are generally considered to be hydraulically disconnected, or nontributary, from surface water.

The Arkansas River alluvial aquifer between the Wildhorse Creek confluence and Fountain Creek confluence was not included in the groundwater analysis area because the Arkansas River is lined with concrete in this segment. As a result, the hydraulic connection between surface water and groundwater in this segment is reduced and unpredictable. Consequently, no detectable effects from the alternatives are anticipated (Reclamation 2008).

Smaller West Slope alluvial aquifers were not included in the groundwater analysis area because seepage from surface water streams to groundwater systems is minimal. West Slope streams are high-gradient mountain streams with coarse-grained bed material and are predominately underlain by consolidated bedrock material with minimal hydraulic connection to groundwater.

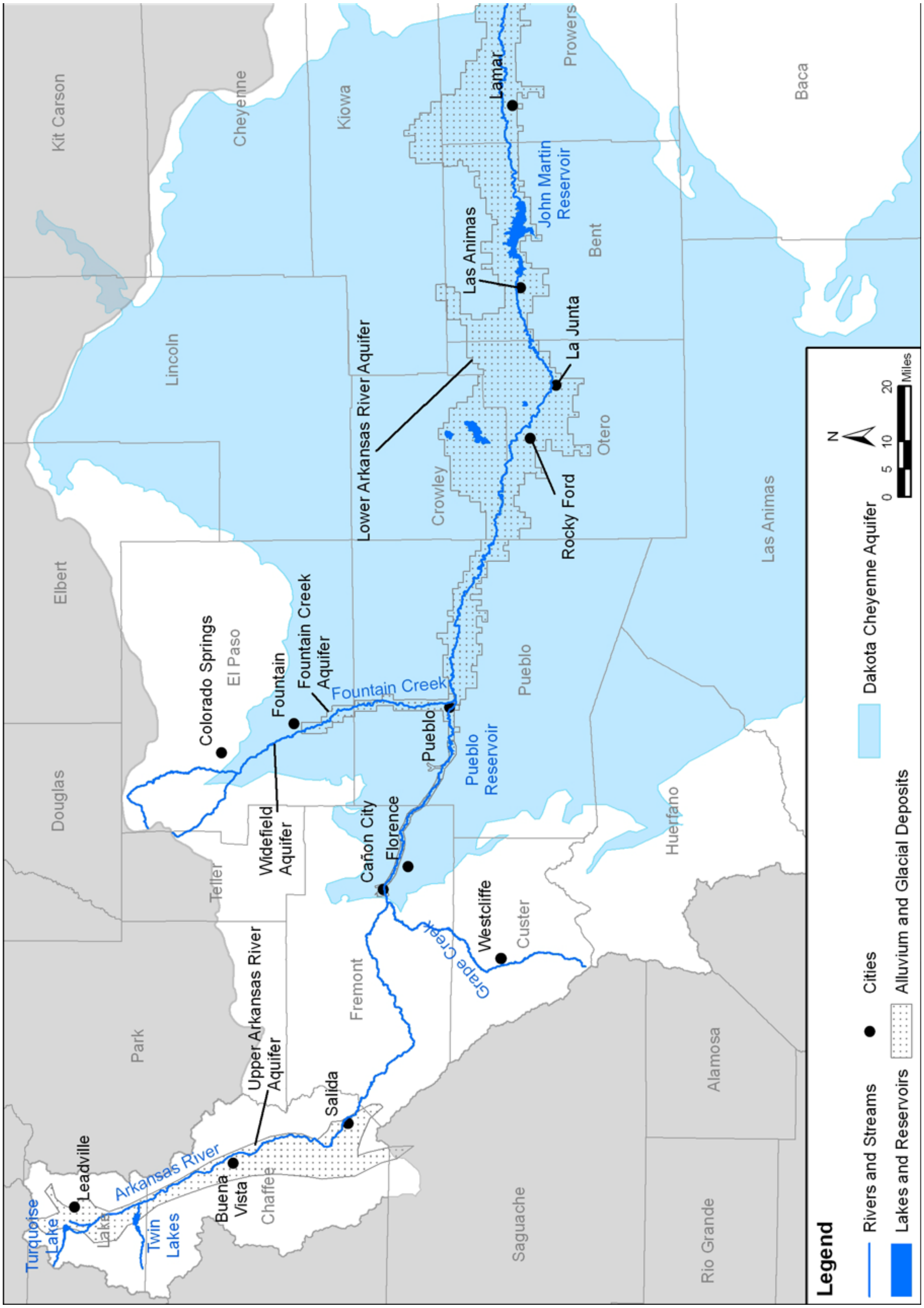


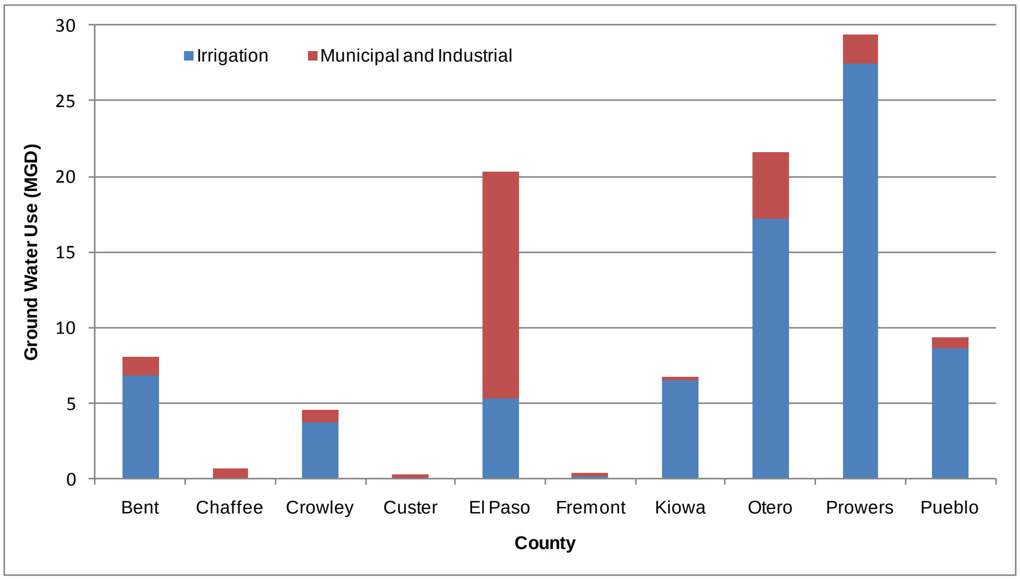
Figure 3–13. Location and Extent of Alluvium

Affected Environment

The groundwater affected environment section discusses groundwater use, alluvial aquifers, and consolidated bedrock aquifers.

Groundwater Use

Irrigation is the most prevalent groundwater use throughout the Arkansas River Basin, followed by municipal and industrial use (Figure 3–14). Within the Lower Arkansas River Basin, groundwater use in 2005 (the most recent year available) was greatest in El Paso, Kiowa, and Prowers counties. Groundwater withdrawals by county in 2005 ranged from 0.82 million gallons per day (mgd) (918 ac-ft) in Fremont County to 30 mgd (33,768 ac-ft) in Prowers County. Table 3–3 illustrates the percentage of total water use from groundwater, and the percentage of groundwater used for public supply. Counties in the EIS study area derived between 0.5 percent and 82 percent of total water supply from groundwater (USGS 2005).



Data source: USGS 2005

Figure 3–14. 2005 Groundwater Use for Municipal, Industrial, and Irrigation Purposes

Table 3–3. Percentage of Groundwater Use by County

County	Percent of Total Water Used from Groundwater (%)	Percent of Groundwater Used for Public Supply (%)
Bent	4	100
Chaffee	0.8	34
Crowley	14	100
Custer	1.3	100
El Paso	17	13
Fremont	0.5	1
Kiowa	82	100
Otero	6	86
Prowers	6	100
Pueblo	3	1

Source: USGS 2005

Alluvial Aquifers

Alluvial aquifer material is present along the Upper Arkansas River and its major tributaries except in the Salida-Cañon City area. Alluvium is not continuous because consolidated rock material outcrops in mountainous regions. Because of high streamflow velocity in the Upper Arkansas River Basin, alluvial aquifer sediments vary in size from silts to large boulders. By definition, alluvial aquifers are generally hydraulically connected to surface water, and provide water for wetlands and riparian vegetation. The Colorado Division of Water Resources Division Engineer applies transit losses to reservoir releases to account for the portion of those releases that accrue to the alluvial aquifers and are consumptively used by vegetation.

More than 1,600 groundwater wells are present in the Upper Arkansas River Basin alluvial aquifer, with a median depth of 50 feet (Colorado Division of Water Resources 2001). Alluvium is up to 100 feet thick, and well yields are reported up to 500 gallons per minute (gpm), with a median yield of 15 gpm. Large seasonal fluctuations in groundwater levels are common and are positively correlated with spring snowmelt runoff. Water levels in the Upper Arkansas River Basin alluvium ranged from 5 to 58 feet (below ground surface) during the 1990s (USGS 1997).

Aquifer characteristics vary widely for the Lower Arkansas River alluvium, depending on variations in soil type and saturated thickness. Quaternary age (1.8 million years ago) alluvium along the Arkansas River extends 150 miles from Pueblo Reservoir to the Kansas state line, is up to 250 feet thick (median depth of 42 feet), and is underlain by impermeable Cretaceous bedrock (Colorado Geological Survey 2003). As a result of lower river flow velocity, Lower Arkansas River Basin alluvial sediments are more uniform in size than in the Upper Arkansas River Basin, and are mostly gravel, sand, silts, and clays. There is little to no tributary alluvium along the southern tributaries of the Lower Arkansas River.

More than 3,400 wells are screened in the Lower Arkansas River alluvium (Colorado Division of Water Resources 2001). Alluvial groundwater use in the Lower Arkansas River Basin is primarily for agricultural irrigation, and well yields range from 10 gpm to 4,000 gpm. About 12 percent of wells have yields greater than 1,000 gpm. Domestic and stock wells with yields of less than 50 gpm comprise about 50 percent of wells in the Lower Arkansas River Basin.

Water level depths in alluvium along the Lower Arkansas River and its tributaries are generally 5 feet to 30 feet, with a shallower water table closer to the Arkansas River and its tributaries. Variation in water table depth is typically a function of proximity to the Arkansas River or variation in agricultural practices. Wells closer to the river have a shallower water table and less variation in depth to water from year to year. In Pueblo County, depth to water for wells close to the Arkansas River ranged from 7 feet to 19 feet. In Crowley and Otero counties, depth to water for wells close to the Arkansas River ranged from 6 feet to 25 feet, and for wells farther from the river, depth to water ranged from 21 feet to 44 feet. Depth to water in wells in the area in Bent County upstream from John Martin Reservoir ranged from 2 feet to 17 feet, and depth to water for wells downstream from the reservoir ranged from 5 feet to 11 feet (USGS 2002).

In general, during wet years, groundwater withdrawals are lower and infiltration is higher, resulting in a higher water table in the Lower Arkansas River Basin. Conversely, during dry years, groundwater withdrawals are greater and infiltration is lower, resulting in a lower water table. Recharge to the Arkansas River alluvium occurs mostly through river discharge to the aquifer, with localized recharge from irrigation canals and surface application of irrigation downstream from the Pueblo and Crowley county line. Transmountain diversion projects that import water to the basin and increase streamflow in the Lower Arkansas River Basin have enhanced recharge to the alluvium. The Winter Water Storage Program results in increased spring streamflow with a short-term effect on recharge to the alluvium immediately adjacent to the Arkansas River.

Fountain Creek alluvium is 0.75 miles to 1.5 miles wide, and varies from a few feet thick along valley margins to 80 feet thick on terraces. Figure 3–13 shows the approximate extent of alluvium in the Arkansas River Basin. Sand and gravel with thin silt and clay make up the alluvium. Infiltration is relatively rapid as a result of well-drained topsoil in the watershed. The unconfined alluvial aquifer exists in eroded ancestral channels in the underlying Pierre Shale. Maximum saturated thickness of the alluvial aquifer adjacent to Fountain Creek is up to 35 feet in the northern urban section of the basin and up to 50 feet in the southern agricultural section (Chafin 1996). The water table in the southern section is rarely greater than 30 feet below ground surface. Roughly half of groundwater use in El Paso County is for municipal purposes, with other groundwater withdrawals used for irrigation, agriculture, and thermoelectric purposes.

The Widefield aquifer is a shallow, permeable part of the surrounding Fountain Creek aquifer. The aquifer begins 5 miles south of Colorado Springs and runs southeast along Fountain Creek to the town of Widefield. USGS estimates the area of the aquifer as 3.5 square miles (USGS 1985). Water was historically used in the Widefield aquifer for agriculture, but expanding population in the mid- to late 1950s led to predominately municipal and industrial use. The communities of Security, Stratmoor Hills, Widefield, and Colorado Springs pump groundwater from the Widefield aquifer for municipal water supply.

Consolidated Bedrock Aquifers

The groundwater analysis area downstream from Cañon City and portions of the Fountain Creek Basin are underlain by the Dakota-Cheyenne aquifer. The Dakota-Cheyenne aquifer is an assemblage of sandstones, shales, and mudstones that were typically deposited in deltas along an ancient seaway that covered much of Colorado during the Cretaceous period (144 million years ago). The formation is a reliable and important aquifer in many locations (Colorado Geological Survey 2003). One major sandstone consolidated bedrock aquifer (Dakota-Purgatoire Formation) is present in the Upper Arkansas River Basin.

Colorado Division of Water Resources records show more than 27,500 potential wells of record completed in the Dakota-Cheyenne aquifer (statewide). Well depths range from 100 feet to greater than 1,000 feet (Colorado Geological Survey 2003). Yields from domestic wells completed in the Dakota-Cheyenne aquifer sandstones range from 5 gpm to 50 gpm; some irrigation wells have reported yields of up to 1,000 gpm (Colorado Geological Survey 2003). Groundwater from the Dakota-Cheyenne aquifer in the Lower Arkansas River Basin is used primarily for agricultural irrigation. However, several AVC participant wells currently withdraw water from this aquifer. In most cases, the groundwater contains levels of radionuclides that exceed the maximum contaminant levels for drinking water sources set by the Health Department (5 CCR 1003-1), which is a primary reason communities would participate in AVC. Radionuclides occur naturally in groundwater from erosion or leaching of bedrock minerals such as iron, arsenic, and quartz.

Water Quality

Water quality is important for aquatic life, drinking water, agriculture, recreation, and other uses. Changes in streamflow, inflows, and diversions could affect the ability of surface water to assimilate natural and human-caused pollutants. Changes in irrigation water use could affect water quality in alluvial groundwater systems and subsurface return flows to surface water streams. Changes in municipal water use could affect water quality of inflows to surface water or alluvial groundwater systems.

Reservoir water quality is determined by the water quality of the inflows; by physical characteristics of the reservoir such as depth, temperature, evaporation rates, and circulation patterns; and by the activity of aquatic organisms. Changes in magnitude and timing of inflows and outflows can alter reservoir stratification characteristics, which can in turn affect water quality. Reservoir water quality is greatly affected by nutrient levels in reservoir inflows as well as temperature and solar intensity. High temperatures and high nutrient levels lead to algae growth and reduced dissolved oxygen, which can inhibit the beneficial uses of a reservoir.

The thermal **stratification** of lakes and reservoirs refers to a change in the temperature at different depths and is due to the change in water's density with temperature (cold water is denser than warm water).

Water quality standards are narrative or numeric restrictions set by the state of Colorado's Water Quality Control Commission to protect the beneficial uses of water. Colorado's stated beneficial uses include domestic water supplies, agricultural and recreational uses, aquatic life, and others. Standards can be **acute** (short-term, high concentration) or **chronic** (generally the average of a 30-day period).

Total Maximum Daily Loads are written plans and analyses to help a water body attain and maintain water quality standards. Impaired water bodies on the 303(d) list require a TMDL, and can be removed from the impaired waters list once a TMDL is completed. Impaired water bodies are prioritized for TMDL development.

Methods

The Health Department is Colorado's lead agency for protecting the quality of the state's waters and the safety of drinking water systems. Water quality is evaluated as it pertains to the Federal Clean Water Act (33 U.S. Code 1251, et seq.), which governs and regulates surface and groundwater quality to improve watersheds nationwide. As part of the Clean Water Act, the Health Department assigns use classifications, establishes water quality standards, and reports on attainment of water quality standards. Nonattainment of water quality standards (impaired waters) is reported to the EPA via the state's impaired waters list, which meets the reporting requirements of Clean Water Act Section 303(d). Water bodies on the state's impaired water list require a Total Maximum Daily Load (TMDL). Water quality is also evaluated as it pertains to the Safe Drinking Water Act of 1974 (42 U.S. Code 300f), which protects public health by regulating the quality of the nation's public drinking water supply. Under the Safe Drinking Water Act, the

Health Department has adopted and enforces state drinking water standards, identical to federal maximum contaminant levels established by the EPA (Colorado Foundation for Water Education 2003).

The analysis area for water quality is the same as that for surface water hydrology and groundwater hydrology except for the West Slope, which was not assessed for water quality because hydrologic effects on the West Slope would be predominately negligible. Several published studies from USGS, the Health Department, EPA, Colorado State University, and others were reviewed for water quality information in the analysis area. To evaluate water quality in this EIS, existing data from USGS and the Health Department were reviewed and compared to the water quality standard thresholds for constituents that have standards. For some constituents, standards are not available, and other values were used for comparison. Water quality standards and thresholds are summarized in Appendix E.1.

Additional water quality sampling was not conducted as part of this EIS. Following Health Department guidelines, in most cases, the 85th percentile of the available data was compared to the numeric water quality standard to determine the attainment of water quality standards. The geometric mean was used for bacteria. Water quality constituents examined for this EIS were determined based on known areas of concern, and include the following:

- Total dissolved solids (salinity)
- Dissolved selenium
- Sulfate
- Radionuclides
- Bacteria (*E. coli)*
- Total recoverable iron
- Suspended sediment (muddy water)
- Temperature
- Nutrients
- Emerging contaminants

Percentiles are frequently used to summarize water quality data. Percentiles are not affected by a few extreme values in a data set. Statistics such as the average can be affected by extreme values.

The **50th percentile (or median)** is the value in a set of measurements in which 50 percent of the values are lower and 50 percent are higher.

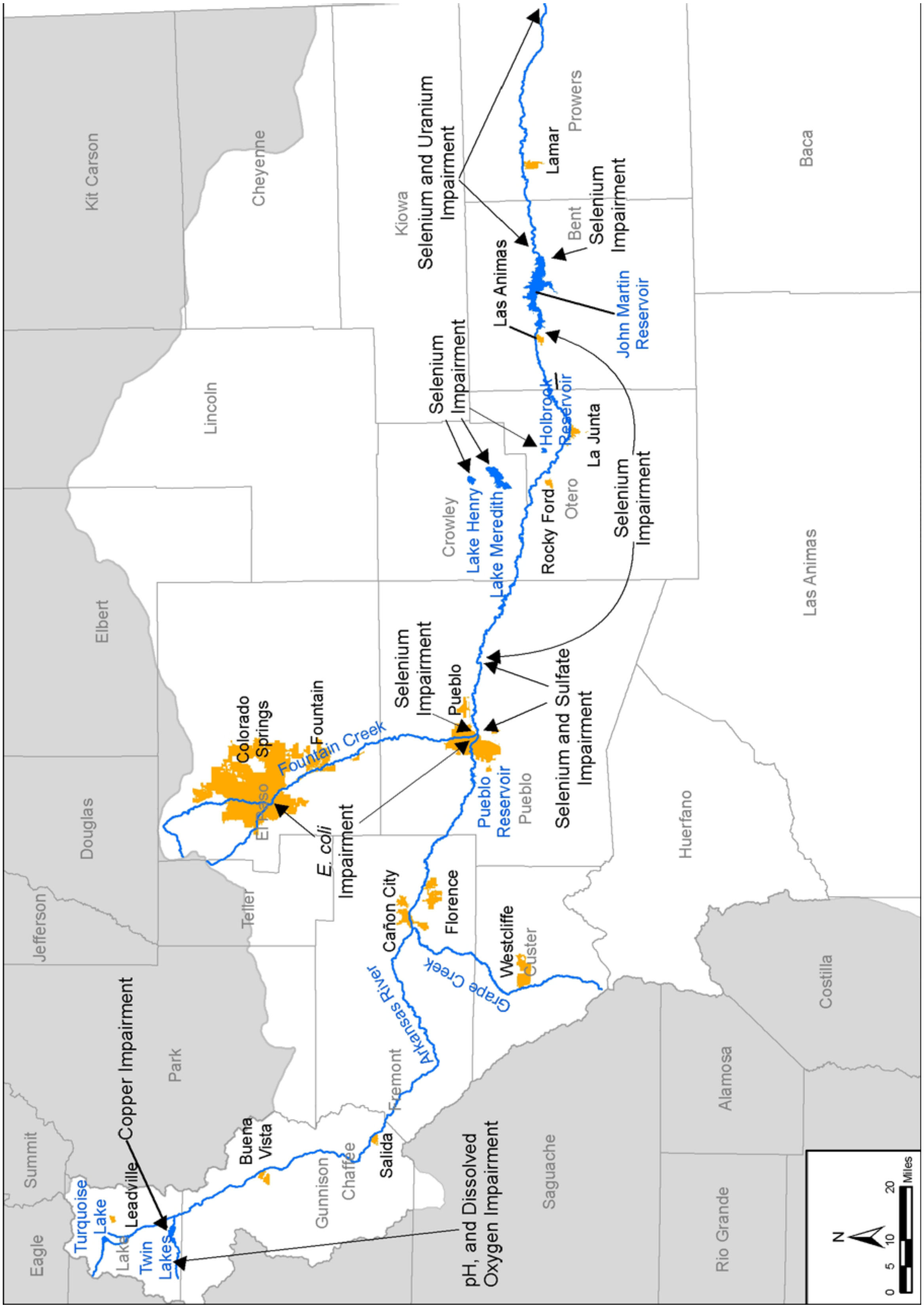
The **85th percentile** is the value in a set of measurements in which 85 percent of the values are lower and 15 percent are higher.

Affected Environment

Surface water stream segments, reservoir, and groundwater aquifers are evaluated in this EIS to assess how the proposed alternatives would affect water quality.

Stream Water Quality

Figure 3–16 summarizes current water-quality-limited stream segments and concerns in the analysis area. Additional water quality data and TMDL descriptions are in Appendix F.1.



Data source: Health Department 2012b
Figure 3–15. Location of Current Water Quality Impairments and Concerns in Analysis Area

Upper Arkansas River Water Quality Water quality in the Upper Arkansas River Basin is generally good as a result of low levels of development. There are some water quality concerns about heavy metals due to historical mining activity near the Continental Divide. Historical data suggest water quality standards have been exceeded for cadmium, copper, manganese, lead, and zinc on Lake Fork Creek (Walton-Day et al. 2005; Colorado Mountain College 2005). Lake Creek is on Colorado's 2012 impaired waters list for copper, pH, and dissolved oxygen. A TMDL for natural geologic copper sources was recently completed for Lake Creek. The Upper Arkansas River is not on the 2012 impaired waters list, although several TMDLs have been completed for this river segment to manage cadmium, zinc, and lead from mine drainage.

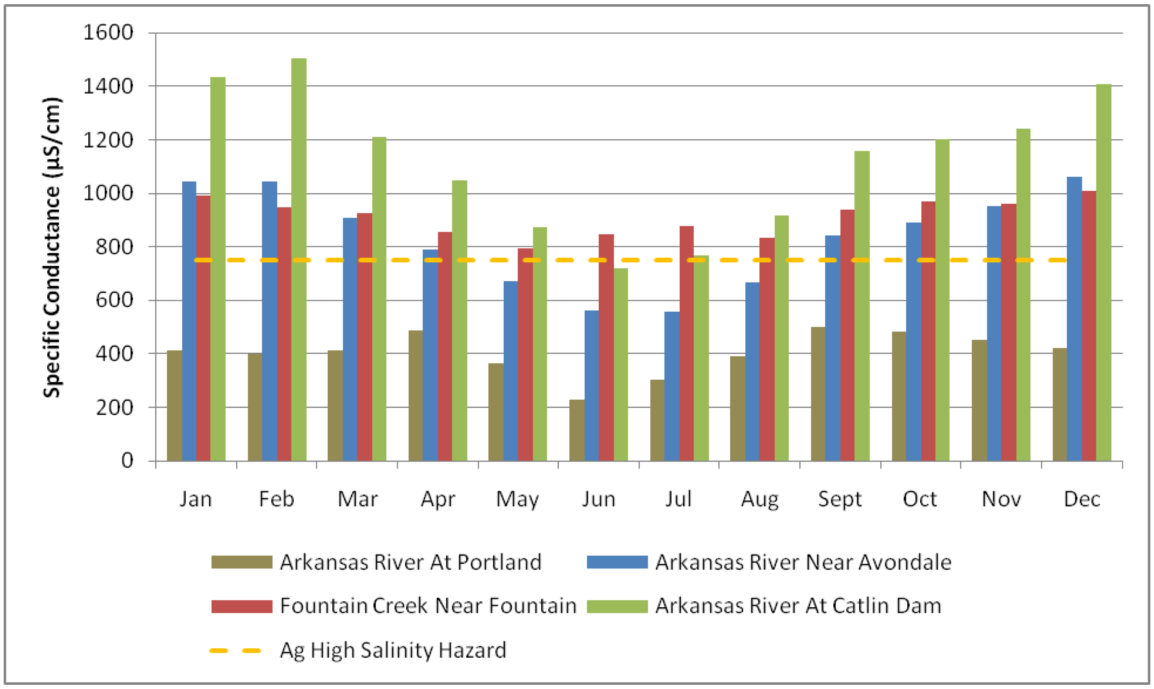
> **The most common measure of salinity is specific conductance**, which is continuously measured at many locations in the analysis area. Specific conductance is a measure of the ability of water to conduct electrical current, and its value is related to the type and concentration of ions in solution. Typically, the concentration of **total dissolved solids** (in mg/L) is about 65 percent of the specific conductance (in microsiemens per centimeter (µS/cm)), although site-specific relationships are usually more accurate.

The Arkansas River from its source downstream to Wildhorse Creek is classified for coldwater aquatic life beneficial uses. Average weekly water temperatures in the Upper Arkansas River are less than the coldwater aquatic life water quality standard of 20 degrees Celsius (ºC) at all gages except the Arkansas River at Portland gage, at which 75th percentile and maximum average weekly temperatures exceed 20 ºC.

Grape Creek appears on the state's impaired waters list for dissolved oxygen, although it is likely other applicable water quality standards are being met. Water quality data on Grape Creek are not readily available. The Custer County Conservation District has reported issues with erosion and sedimentation, nutrients, and temperature, which are being addressed through best management practices (Non Point Source Colorado 2004).

Lower Arkansas River Water Quality Several constituents are either on the state's impairment list or are a concern in the Arkansas River downstream from Pueblo Reservoir (including Fountain Creek), and TMDLs are pending.

Total Dissolved Solids Total dissolved solids can affect drinking water quality and crop yield. Figure 3–16 shows that average total dissolved solids levels tend to exceed agricultural high salinity hazard guidelines in the Lower Arkansas River and Fountain Creek, particularly downstream from the Arkansas River near Avondale gage. There is no water quality standard for total dissolved solids in surface waters. Therefore, the water quality assessment relies on federal secondary drinking water standards and agricultural high salinity hazard guidelines for total dissolved solids effects analyses. Total dissolved solids concentrations tend to be inversely related to streamflow, with the highest concentrations occurring during periods of low flow, generally in the winter months, and the lowest during the summer agricultural season.



Source: USGS 2011
Note: Agricultural (Ag) High Salinity Hazard is generally a total dissolved solids level similar to the secondary drinking water standard, but the standard is measured in total dissolved solids, and the conversion to specific conductance varies by location.

Figure 3–16. Average Monthly Total Dissolved Solids Concentration at USGS Gages

Selenium The Arkansas River from Fountain Creek to Kansas is impaired for selenium. High amounts of selenium and other metals are toxic to fish. High levels of selenium can also result in human health problems.

Sulfate and Iron The Arkansas River from Fountain Creek to the Colorado Canal is impaired by sulfate, and several tributaries to the Arkansas River from Pueblo Reservoir to John Martin Reservoir, such as Timpas Creek and Horse Creek, are impaired for total recoverable iron. Sulfate is a naturally occurring substance that affects the aesthetics (taste and odor) of drinking water. High amounts of iron are toxic to fish and can contribute to “hard” water problems.

Uranium Uranium is notably present in several areas of the Arkansas River Basin. The Arkansas River from John Martin Reservoir to Kansas is impaired by uranium. Dissolved-uranium concentrations typically increase downstream in the Arkansas River. The largest increase in median dissolved-uranium concentrations occurs between Rocky Ford and La Junta, where it more than doubles. The probabilities of exceeding the primary drinking water standard for uranium of 30 µg/L in groundwater are greatest in Otero, Kiowa, Cheyenne, and Prowers counties. These areas coincide with those where bedrock formations (suspected sources of uranium) are present at the surface or are directly overlain by alluvial deposits (Miller et al. 2010).

E. coli Most segments of Fountain Creek are impaired by *E. coli*. Birds are the suspected dominant source of *E. coli* in Upper Fountain Creek (upstream from Monument Creek), although human sources were sporadically indicated to be important sources of *E. coli* (USGS 2009). It is unknown whether these findings are transferable to the downstream segments. *E. coli* is an indicator organism for the presence of fecal matter in water, and can cause serious food poisoning, gastroenteritis, urinary tract infections, anemia, and kidney failure in humans.

Nutrients Nutrient water quality standards for the Arkansas River are not expected to be enacted until after May 2022. Regulated nutrients proposed for the analysis area include ammonia, total nitrogen, total phosphorus, and chlorophyll *a*. Concentrations of nutrients are generally below interim water quality standards that currently apply in select stream segments in Colorado (see Appendix F.1).

Temperature Water temperature generally increases in the downstream direction in the Arkansas River Basin. The Lower Arkansas River is classified for coldwater aquatic life beneficial uses downstream to Wildhorse Creek. The remaining segments support warmwater aquatic life. Historical maximum weekly average stream temperatures for the Arkansas River at the Portland gage (above Pueblo Reservoir) and Above Pueblo gage (just below Pueblo Reservoir but above Wildhorse Creek) exceed the interim coldwater aquatic life water quality standard of 20 ºC. Lower Fountain Creek and the Arkansas River below Fountain Creek are designated for warmwater aquatic life, with an interim chronic water quality temperature standard of 30°C. Historical maximum weekly average stream temperatures in these segments are well below the state's warmwater quality standard. Interim temperature standards are expected to be replaced by numeric standards specific to time of year and fish species sometime in 2013 (see Appendix F.1).

Reservoir Water Quality

Turquoise Lake and Twin Lakes water quality is generally good, because these reservoirs are located at high elevations with snowmelt runoff from the West Slope (via transbasin diversions) and tributary watersheds as the main water sources. However, Twin Lakes is impaired for copper.

Pueblo Reservoir stratifies during the summer, which can cause some metals, particularly manganese, and nutrients to dissolve out of the sediments. Stratification reduces mixing and can lead to periods of low dissolved oxygen near the reservoir bottom. The low dissolved oxygen causes metal and nutrient dissolution. Historically, this dissolution has not been widespread enough to affect water quality in the reservoir as a whole or releases downstream from the reservoir (Lewis and Edelmann 1994). The quality of inflows to Pueblo Reservoir from the Upper Arkansas River tends to be good, with no impairments for streamflow into the reservoir on the state's 2010 impaired waters list. Algae levels in Pueblo Reservoir are low to moderate; historical and simulated data have shown that phosphorus can be a limiting nutrient for algae growth (USGS 2008). Colorado's Water Quality Control Commission is considering designating Pueblo Reservoir as a Direct Use Water Supply with 5 µg/L chlorophyll *a* standard.

Lake Meredith and Lake Henry typically exceed agricultural tolerances and the federal secondary drinking water total dissolved solids standard. Both lakes are on the state's impaired waters list for selenium, and both are eutrophic (having relatively low clarity and high phosphorus concentrations) (Health Department 2010a). Neither lake stratifies for much of the year because of their shallow depth. Few water quality data are available for Holbrook

Reservoir, but its similar location, size, and water supply suggest that water quality is similar to Lake Meredith and Lake Henry.

John Martin Reservoir inflows are high in total dissolved solids and affect reservoir water quality, although no total dissolved solids standards have been set for the reservoir. The reservoir is impaired for selenium due to upstream loading from natural sources. Total recoverable iron tends to adsorb to sediments and be transported to John Martin Reservoir, especially during storm events in the reservoir watershed.

Groundwater Quality

Groundwater quality issues exist for localized areas in the Upper Arkansas River Basin, alluvial aquifers downstream from Pueblo Reservoir, and consolidated bedrock aquifers.

Localized Groundwater Quality in Upper Arkansas River Basin Groundwater quality in the Upper Arkansas River Basin meets water quality standards for agricultural and domestic use, with a few exceptions associated with acid rock drainage and septic system effluent contamination. Localized contamination due to acid mine drainage and industrial contamination has been documented (Crouch et al. 1984; Walton-Day et al. 2005). Three groundwater sites in the Upper Arkansas River Basin are on the EPA's National Priorities List (hazardous waste sites eligible for cleanup under the federal Superfund program). All three sites are either actively being remediated, or have moved into the maintenance and monitoring stages of cleanup (EPA 2007a, 2007b, 2010a, 2010b, 2010c, 2010d; HDR 2007):

- California Gulch, near Leadville – Contamination from historical mining activities; contaminants include lead, arsenic, other metals, and acid mine drainage.
- Smeltertown, near Salida – Contamination from lead/zinc smelting, wood treatment, and zinc-sulfate manufacturing; contaminants include arsenic, cadmium, copper, lead, manganese, zinc, pentachlorophenol, and creosote.
- Lincoln Park, near Cañon City – Contamination from uranium milling; contaminants include molybdenum and uranium.

Lower Arkansas River Basin Alluvial Aquifer Water Quality Alluvial groundwater along the Arkansas River between Pueblo Reservoir and John Martin Reservoir generally meets water quality standards for agricultural and domestic use (Health Department 2006a). However, total dissolved solids are a concern for the agricultural and municipal users of alluvial groundwater. Total dissolved solids concentrations in Lower Arkansas River Basin alluvial groundwater are typically higher than concentrations in deep bedrock aquifers, and these high total dissolved solids concentrations have caused some municipalities, such as Las Animas and La Junta, to invest in advanced drinking water treatment technology. In groundwater, total dissolved solids levels are highly variable and increase in the downstream direction, with values ranging from about 20 to 50,000 microsiemens per centimeter (µS/cm) in the Arkansas River Basin (Miller et al. 2010). Cain (1985) found that groundwater pumped from the alluvial aquifer adjacent to the Arkansas River showed a large downstream increase in total dissolved solids, and total dissolved solids in groundwater was generally higher than in the river upstream of Lamar. However, total dissolved solids values in groundwater and in the Arkansas River were similar in the segment between Lamar and the Kansas state line. Both elevated total dissolved solids and the related problem of elevated groundwater tables have been shown to affect crop yield in the Arkansas River Basin between Pueblo Reservoir and John Martin Reservoir (Gates et al. 2002).

Alluvial groundwater along lower Fountain Creek and the Arkansas River near Pueblo can have concentrations of dissolved selenium on the order of 100 to 1,000 μg/L, 20 to 200 times greater than the chronic surface water quality standard of 4.6 μg/L (Keller 2006). Alluvial groundwater from Fountain Creek to the Colorado Canal headgate is impaired for total recoverable iron (USGS 2011).

Dakota-Cheyenne Aquifer Water Quality Fourteen AVC participants using deep bedrock aquifers have been served enforcement actions by the Health Department because levels of radioactivity violated primary drinking water standards (Chapter 1). In Colorado, radionuclides are common in crystalline rocks and are naturally present in many groundwater sources, although they can also be found in surface waters. Naturally occurring radionuclides found in drinking water are usually present due to erosion and chemical weathering of mineral deposits. Anthropogenic radionuclides are most often found in surface waters, resulting from activities such as mining, military weapons testing, and industrial processes (Malcolm Pirnie 2009a).

Total dissolved solids in the Dakota-Cheyenne aquifer vary along the Arkansas River, and concentrations of dissolved selenium increase downstream. Total dissolved solids in the Dakota-Cheyenne aquifer downstream from Pueblo Reservoir range from 500 to 2,000 mg/L, with a small pocket with concentration greater than 2,000 mg/L north of Lamar. Total dissolved solids decreases to less than 500 mg/L downstream from Lamar due to recharge mixing (Colorado Geological Survey 2003). Median selenium values range from about 5 μg/L in the Upper Arkansas River and Fountain Creek to 16.2 μg/L in the Arkansas River between Pueblo Reservoir and John Martin Reservoir, and 14.8 μg/L in the Arkansas River downstream from John Martin Reservoir (Miller et al. 2010).

Other Water Quality Concerns

Las Animas uses reverse osmosis in its water treatment process and discharges its brine reject concentrate to the Arkansas River. The reverse osmosis treatment is applied to 80 percent of water pumped by the city’s supply wells to remove radionuclides and other constituents. Las Animas’ reverse osmosis waste stream water contains uranium, selenium, and other metals. Currently, the concentrate is combined with treated domestic wastewater effluent at the Las Animas wastewater treatment plant and is discharged to the Arkansas River. The Las Animas discharge permit (which expires July 31, 2015) regulates discharge at the outfall of the water treatment plant, wastewater treatment plant, and combined outfall before discharge into the Arkansas River (Health Department 2010b). Radionuclides are not regulated under the Las Animas discharge permit. The Las Animas water and wastewater treatment plants are permitted to discharge combined flow of 1.531 mgd (2.4 cfs) to the Arkansas River. Average annual streamflow in the Arkansas River near this discharge is 218 cfs, making Las Animas discharge about 1 percent of the average annual flow. During low flow events, wastewater discharge can contribute up to 40 percent of streamflow downstream from the gage.

La Junta also uses reverse osmosis in its water treatment process and discharges its brine reject concentrate to the Arkansas River. No data are readily available on La Junta’s reverse osmosis process waste stream characteristics. Similar to Las Animas, La Junta mixes its waste stream from the reverse osmosis process with its wastewater treatment plant effluent and discharges it to the Arkansas River. The La Junta discharge permit (which expired November 30, 2009, but has been extended) regulates discharge of the reverse osmosis waste stream, following chlorine contact of wastewater effluent, and after mixing of the two waste streams (Health Department 2004). La Junta's wastewater discharge (2.3 mgd or 3.6 cfs) makes up about 1.5 percent of the average annual flow in the Arkansas River (232 cfs). During extremely low flow events, wastewater discharge can contribute up to half of the streamflow downstream from the gage. Given the geographic proximity and similar profile of the two cities, La Junta's rejection water would likely be of similar composition.

Other major municipal wastewater treatment plants (surface water permitted discharges greater than 1 mgd) are shown in Figure 3–17. Each discharger has been issued a permit by the Health Department that outlines effluent limitations to protect the water quality of the discharge stream. Discharge streams include Fountain Creek, the Arkansas River, and nearby tributaries. Every 5 years, these permits are renewed and effluent limits are reevaluated based on existing streamflows and water quality. Twenty-two minor wastewater treatment plants (surface water permitted discharges less than 1 mgd) are also shown in Figure 3–17. These minor permits have a combined effluent of 2.4 mgd, and discharge into various tributaries and canals throughout the Arkansas River Basin.

Concentrations of emerging contaminants are similar in both the upper and lower portions of the Arkansas River. Emerging contaminants include disinfectants and disinfection byproducts, insect repellants, nonprescription drugs, and steroids either directly or indirectly disposed of in streams and reservoirs. Emerging contaminants are typically found in higher concentrations downstream from wastewater treatment plants. More study is necessary to determine effects on human health from, and safe levels for consumption of, these contaminants; however, evidence suggests that some emerging contaminants may affect aquatic life, including causing changes in immune system and sexual development (Milla et. al. 2011).

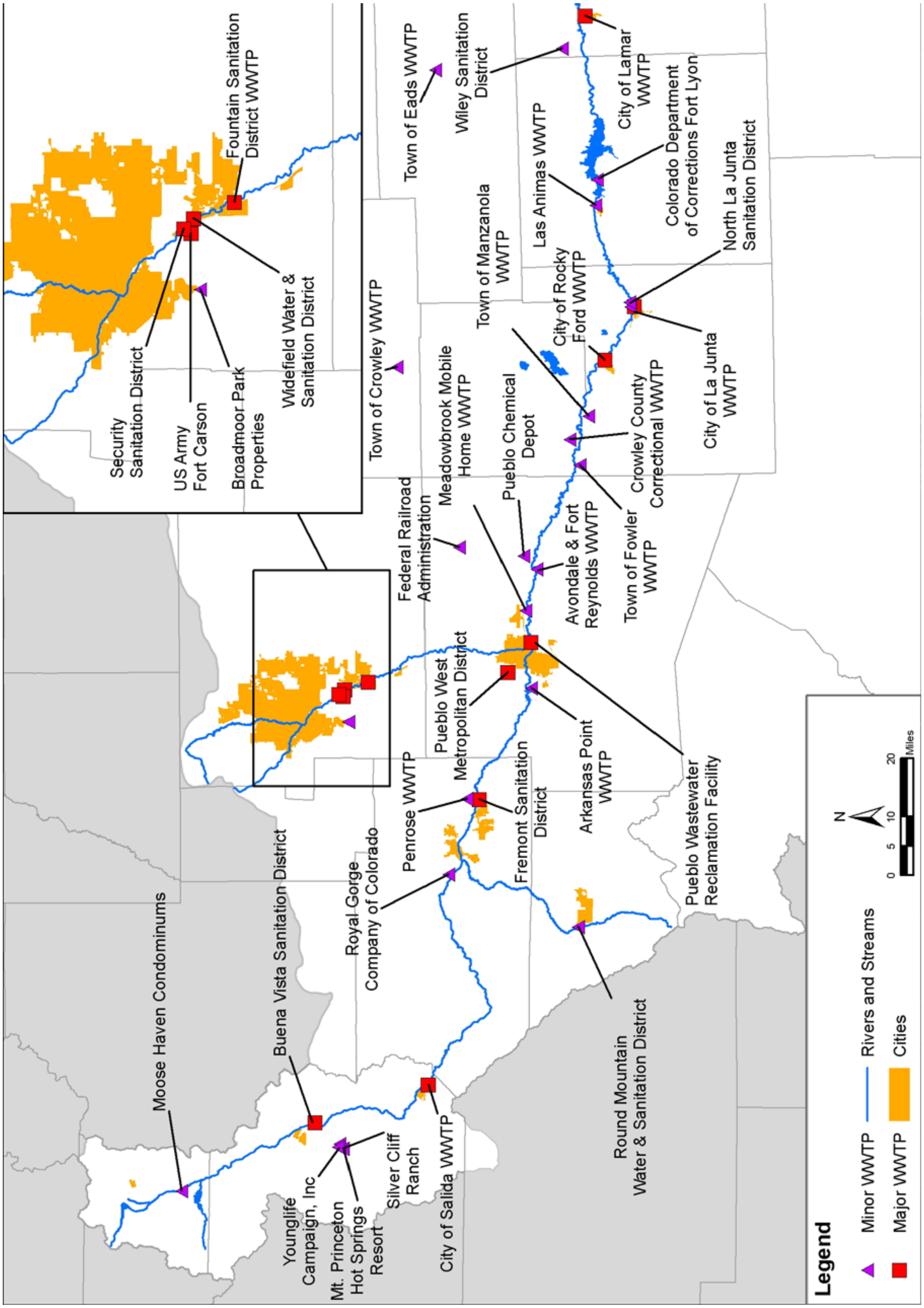


Figure 3–17. Major and Minor Wastewater Treatment Plants (WWTP)

Geomorphology

Stream geomorphology is a science based on the interaction between streamflow and sediment transport. Geomorphic effects could potentially occur at any location in the EIS study area where there is a change in peak flow, base flow, or average annual hydrology, or where there is a change in sediment inflow, transport, or channel geometry. Geomorphic effects could include bank and channel bed erosion (collectively called erosion or degradation) and sediment deposition (also referred to as sedimentation or aggradation). Reductions in channel stability could erode stream channels or banks, which could then cause the banks to collapse or stream meander patterns to change. Landowners and water users downstream from these changes could be affected because sedimentation could lead to reduced water quality or reduced diversion capacity in diversion structures, and erosion could cause loss of property.

Channel form is the shape and pattern of the path of a stream channel and its cross section.

Entrenchment is the ratio stream width at flood conditions to the width at bankfull flow (the flow at which the stream channel is full but does not overflow to the floodplain).

Erosion is the natural process usually caused by rock and soil being loosened from the earth's surface at one location and moved to another location.

Sedimentation is a tendency for particles in suspension to settle out of streamflow.

Sediment transport is the movement of streambed particles suspended in streamflow.

Stream power is the measure of the energy of a stream's water flow, and is commonly used to estimate the ability of flowing water to convey sediment.

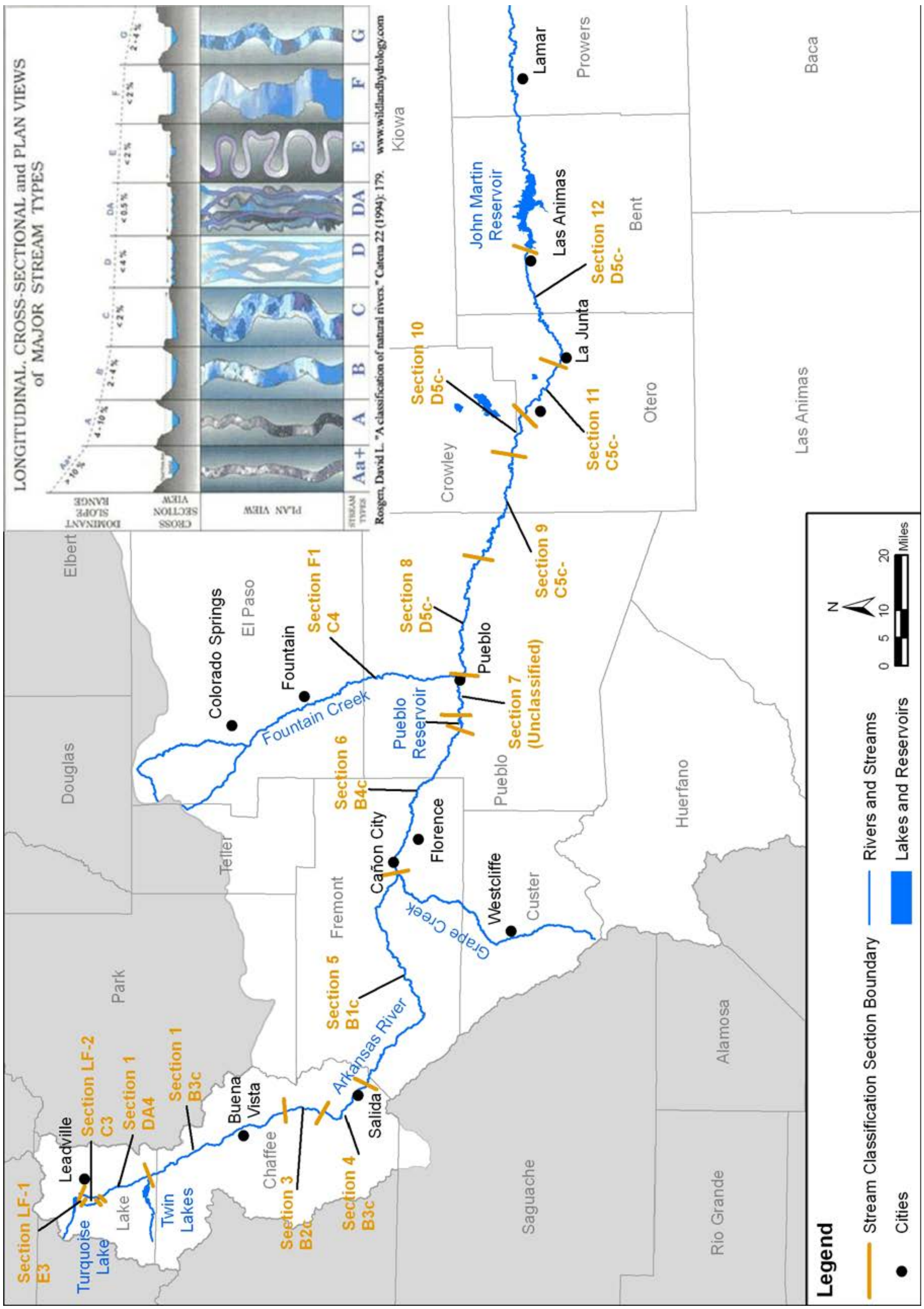
Methods

The analysis area for geomorphology generally encompasses the stream systems identified in the surface water hydrology analysis area, with the exception of reservoirs, stabilized segments of the Arkansas River between Pueblo Reservoir and Fountain Creek, the Arkansas River downstream from John Martin Reservoir, and West Slope streams since effects are anticipated to be minimal in these areas.

The Rosgen Stream Classification System (Rosgen 1996) and various stream characteristics were used to identify stream segments that may be geomorphically sensitive to a change in flow. Geomorphic sensitivity was determined using two primary characteristics: entrenchment and streambed material. In general, geomorphically sensitive segments have low to moderate entrenchment and/or sand or gravel bed material. These segments have the greatest potential for being eroded and changing their meander pattern as a result of changes in hydrology.

Affected Environment

Figure 3–18 shows the major Rosgen Stream Classifications for the analysis area (Reclamation 2008). This subsection summarizes existing general channel characteristics and other geomorphic information for potentially affected stream segments in the analysis area.



See Table 1 in Appendix G for description of classification numbering.
Figure 3–18. Arkansas River Basin Stream Sediment Classifications

Upper Arkansas River Basin Geomorphology

Lake Creek between Twin Lakes and the confluence with the Arkansas River varies from a sand bed, slightly entrenched stream in its upstream portion, to a gravel and boulder, moderately entrenched stream in the lower portion. The transition from a sand bed stream in the upstream portion of Lake Creek to a gravel and boulder stream in the downstream portion is likely a result of an increase in stream slope from upstream to downstream. Existing geomorphic data are not available for Grape Creek. The Arkansas River upstream from Pueblo Reservoir is a gravel-to-boulder bed stream with moderate entrenchment.

Source: Livingston 2011
Photo 3–12. Arkansas River near Rocky Ford gage

Lower Arkansas River Basin Geomorphology

The Arkansas River, downstream from its confluence with Fountain Creek, is primarily an alluvial sand bed stream with notable meandering and slight entrenchment. The bottom width varies from 100 feet to 250 feet (Corps 2009). Riparian vegetation plays a significant role in geomorphic stability for sand bed streams within the analysis area by reducing erosion (in streams such as Fountain Creek and the Arkansas River downstream from Fountain Creek).

Fountain Creek Geomorphology

Fountain Creek is primarily an alluvial sand bed stream with notable meandering and slight to moderate entrenchment. The width of Fountain Creek varies from 100 feet to 250 feet with side slopes of 18 degrees. As presented in the *Fountain Creek Watershed Study*, historical changes in channel form were observed for Fountain Creek and the Arkansas River downstream from Fountain Creek based on photography from the 1950s and 1960s (Corps 2006). The changes in channel form are likely a result of channel migration over time, indicating the susceptibility of these segments to geomorphic change as a result of changes in streamflow.

Fountain Creek historically has been a geomorphically unstable stream, with erosion and sedimentation leading to changes in channel form as a result of natural changes in streamflow from year to year. However, changes in channel form have increased over the past 25 years as a result of changes in peak flow and base flow hydrology that have become more frequent and greater in magnitude. The changes in hydrology that have increased geomorphic instability are a result of development in the Fountain Creek Basin and increases in urban land use (USGS 2000). Over the past 25 years, Fountain Creek streamflow has increased, with land use changes from rangeland to urban and suburban use as the primary factor in the increase. Increased streamflow has exacerbated erosion in the upper portions of Fountain Creek and deposition in the lower portions of the creek.

Primary geomorphic instability issues in the analysis area are erosion and sedimentation in Fountain Creek. Erosion is occurring in the upstream portion of Fountain Creek near Colorado Springs, and sedimentation is occurring in Fountain Creek downstream near Piñon and Pueblo as well as in the Arkansas River downstream from Fountain Creek (Reclamation 2008; Corps 2006).

Source: Courtesy of U.S. Army Corps of Engineers
Photo 3–13. Arkansas River at Fountain Creek confluence in 2009 (upstream view from the state Highway 227 bridge showing sediment deposition at the confluence)

Channel scouring in the upper part of the watershed has led to channel deposition in lower Fountain Creek near its confluence with the Arkansas River. Although large amounts of sediment are being transported from upstream during peak flows, the stream cannot transport this same amount of sediment at downstream locations because of decreasing stream power from upstream to downstream along Fountain Creek. Stream power decreases because of reduced peak flows in lower Fountain Creek associated with temporary storage of streamflow within the channel near the Fountain Creek near Piñon gage. As stream power decreases (60 percent decrease in stream power during the 100-year peak flow event between the Fountain Creek near Fountain gage and the Fountain Creek at Pueblo gage), there is insufficient stream power to continue transporting sediment downstream. As a result, sedimentation occurs on Fountain Creek between Piñon and Pueblo (Reclamation 2008). Sedimentation also occurs in the Arkansas River downstream from Fountain Creek as a result of this process.

Aquatic Life

Aquatic resources are evaluated in this EIS because they could be affected by changes in streamflow, changes in reservoir storage patterns, water quality, flooding, channel geomorphology, or riparian vegetation. Proposed alternatives could potentially affect fish and benthic invertebrate communities and their habitat in the EIS study area. Benthic invertebrates are organisms such as insects, crustaceans, and worms that live on the bottoms of streams and reservoirs.

Methods

The analysis area for aquatic resources is the same as that for surface water hydrology except for the West Slope. All Fryingpan River tributaries on the West Slope are provisionally on the state's impaired waters list for aquatic life, which means the streams do not meet the aquatic life water quality standards. Data, however, are limited and needs to be collected (Health Department 2012b). Aquatic life effects on the West Slope, however, were not assessed because hydrologic effects on the West Slope would be negligible (see Appendix D.5).

Aquatic life information was acquired primarily through review of past studies by federal and state agencies to describe the analysis area's existing aquatic biological resources. Colorado Parks and Wildlife was the source of existing information for the Arkansas River and reservoirs and the USGS was the source for Fountain Creek. Colorado State University-Pueblo provided some benthic invertebrate data for the Arkansas River (Appendix F.2). Supplemental data were gathered specifically for the AVC EIS on fish, invertebrates, and habitat in several stream segments where data gaps were identified during a scoping process for public agencies. GEI Consultants, Inc., in cooperation with Colorado Parks and Wildlife, collected data on fish, habitat, and benthic invertebrates in the Lower Arkansas River. Numerous other game and nongame species in the analysis area are discussed in this section. Scientific names of fish species are listed in Appendix F.1.

Data collection and analysis focused on aspects of aquatic resources relevant for assessing potential effects on fish and invertebrate communities and their habitat. For fish and invertebrates, relevant parameters focus on measures of species composition and richness, and abundance (Table 3–4).

Table 3–4. Fish and Benthic Invertebrate Parameters Used as Indicators to Characterize Existing Conditions and Evaluate Effects

Water Body Type	Fish Community Parameters	Benthic Invertebrate Community Parameters
Coldwater streams	Number of self-sustaining and stocked species; biomass of self-sustaining and stocked species	Number of taxa; density
Warmwater streams	Number of self-sustaining and stocked species; abundance of self-sustaining and stocked species	Number of taxa; abundance
Reservoirs	Number of self-sustaining and stocked species; abundance of self-sustaining and stocked species	Qualitative effects

The Health Department assigns aquatic life designations for streams, rivers, lakes, and reservoirs with aquatic life uses. The four aquatic life designations for each river segment, lake, and reservoir in the analysis area are listed below (Health Department 2011b):

- Coldwater Class 1 – Capable of sustaining, or could be capable of sustaining but for correctable water quality conditions, a wide variety of coldwater aquatic biota, including sensitive species.
- Coldwater Class 2 – Not capable of sustaining a wide variety of coldwater biota, including sensitive species, because of physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species.
- Warmwater Class 1 – Capable of sustaining, or could be capable of sustaining but for correctable water quality conditions, a wide variety of warmwater aquatic biota, including sensitive species.
- Warmwater Class 2 – Not capable of sustaining a wide variety of warmwater biota, including sensitive species, because of physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species.

Abundance is the number of individuals collected.

Biomass is the mass of individuals per unit area collected, typically pounds per acre.

Biota is the animal and plant life characterizing a given area.

Coldwater habitats support fish species that require coldwater temperatures, such as trout.

Density is the number of individuals per unit area collected, typically the number per acre.

Self-sustaining fish species reproduce and maintain their population naturally.

Stocked fish have been raised in hatcheries and released, usually by Colorado Parks and Wildlife, to the water body for management or recreational purposes.

Taxa is a taxonomic group of any rank, such as species, genus, family, etc. It often is used for discussing benthic invertebrates because some individuals cannot be identified to the species level.

Warmwater habitats support fish species that can tolerate warmwater temperatures, like many suckers, minnows, and sunfish.

Affected Environment

The present status of aquatic biological communities in the analysis area is a result of historical and current activities and differs from the natural ecosystem that existed before settlement. Activities that have influenced the aquatic ecosystem have caused changes in hydrology, water quality, and channel morphology. The Arkansas River is one of the most highly managed rivers in the western United States, with transmountain diversions and reservoirs constructed beginning in the early 1900s (Gierard et al. 2000). Impacts from placer mining were noted on the Arkansas River in the Granite and Leadville areas as early as 1889 (Jordan 1891). Also, some fish populations are managed by Colorado Parks and Wildlife for recreational fishing. These activities have resulted in changes in species composition, species distribution, and habitat from presettlement conditions.

This section focuses on existing aquatic conditions in the analysis area's streams and reservoirs. However, differences from presettlement conditions are described, when appropriate.

Native Species

A historical native fish assemblage of the Arkansas River Basin was reconstructed by Fausch and Bestgen (1997) and Nesler (1997) because of limited historical information. Reconstruction studies resulted in 20 species being considered native and 21 species present before settlement. Eighteen of the species are common between the two studies. Of these species, the American eel and speckled chub have been extirpated (they are no longer present locally) from the Arkansas River Basin (Nesler 1997) and the yellowfin cutthroat trout, which was present only in Twin Lakes, is extinct as a species (Behnke 2002).

The native coldwater fish assemblage in the Arkansas River Basin, with the exception of Twin Lakes, consisted of greenback cutthroat trout, longnose dace (Photo 3–14), and white sucker. The greenback cutthroat trout has been displaced by nonnative brown, rainbow, and other trout. Longnose dace and white sucker persist, but the nonnative longnose sucker is also now prevalent in coldwater segments of the Arkansas River.

Photo 3–14. Longnose dace, a native species collected from the Arkansas River

Most of the native warmwater fish species are still present in the Arkansas River Basin and have been collected recently in the analysis area in at least low numbers. Exceptions include speckled chub and American eel, Arkansas River shiners, which were native but have never been collected in the state (Fausch and Bestgen 1997), and plains minnow, which were described as "not rare" in 1889 (Jordan 1891), but have not been documented recently.

Sensitive Aquatic Species

Colorado Parks and Wildlife (formerly the Colorado Division of Wildlife) is responsible for managing aquatic wildlife species in streams and reservoirs in Colorado. The division manages game and nongame species by setting regulations, stocking fish, protecting habitat, and other activities. Of the fish species in the analysis area, the division lists four as special status species:

Photo 3–15. Flathead chub adult, a Colorado species of special concern

- Suckermouth minnow (state-listed as endangered)
- Southern redbelly dace (state-listed as endangered)
- Arkansas darter (state-listed as threatened)
- Flathead chub (state species of special concern) (Photo 3–15)

These warmwater fish species live in the middle and lower segments of the Arkansas River and Fountain Creek.

No federally listed threatened or endangered aquatic species protected under the Endangered Species Act live in the analysis area. One fish species, the Arkansas darter, is a candidate for listing and is found in the analysis area. Candidate species are plants and animals for which there is sufficient information on biological vulnerability to support federal listing as endangered or threatened (63 Federal Register 13347), but listing is precluded by other, higher priority listing activities. The U.S. Fish and Wildlife Service confirmed the list of threatened and endangered species that should be considered in this EIS (U.S. Fish and Wildlife Service 2011).

The state threatened Arkansas darter is native to small tributary streams in the Arkansas River Basin from Colorado to Arkansas (Krieger et al. 2001). These darters are "normally found in small, shallow, clear, usually spring-fed streams with sandy substrate, slow currents of cool water, and abundant vegetation, such as watercress" (Krieger et al. 2001). In Colorado, darters are usually found in tributary streams to Fountain Creek and the Arkansas River. They are occasionally found in larger reaches of streams and rivers which may not support self-sustaining populations of darters but may act as a route for migration between populations in tributary streams or in off-channel areas. The Arkansas darter is probably a transient species in the main channels of the Arkansas River and Fountain Creek.

River Aquatic Resources

The aquatic life designation for each water body is based on the fish and invertebrate species present and is classified as either coldwater or warmwater, as described above. However, the fish species assemblages gradually transition from coldwater to warmwater along the Arkansas River (the coldwater fish assemblages do not change sharply to warmwater fish assemblages). Pueblo Reservoir and sections of the Arkansas River between Cañon City, Grape Creek, and Fountain Creek are in the transition zone and contain species typical of both coldwater and warmwater assemblages (Table 3–5). Coldwater species in the analysis area include brown and rainbow trout, which require coldwater temperatures throughout the year. Warmwater species include minnows, suckers, sunfish, and other species that can survive seasonally high water temperatures during summer. A few species, such as longnose dace, white sucker, and longnose sucker, are considered warmwater species but are commonly also found with trout in coldwater reservoirs and sections of the Arkansas River. Appendix F.2 contains additional detail and data on the species discussed in this subsection.

Table 3–5. Aquatic Life Classifications and Fish Species Assemblages in Rivers, Lakes, and Reservoirs in Analysis Area

	STATE CLASSIFICATIONS			FISH ASSEMBLAGE	
WATER BODY	COLDWATER CLASS 1	WARMWATER CLASS 1	WARMWATER CLASS 2	COLDWATER FISH	WARMWATER FISH
Turquoise and Twin Lakes					
Upper Arkansas River to Cañon City					
Arkansas River, Cañon City to Pueblo, and Grape Creek					
Pueblo Reservoir					
Arkansas River, Pueblo Reservoir to Wildhorse Creek					
Arkansas River, Wildhorse Creek to Fountain Creek					
Fountain Creek					
Arkansas River, Fountain Creek to John Martin Reservoir					
Lakes Henry and Meredith					
John Martin Reservoir					
Arkansas River, John Martin Reservoir to Colorado State Line					

Key: blue = coldwater; orange = warmwater

Upper Arkansas River Basin, Upstream from Cañon City Lake Fork Creek, Lake Creek, and the Upper Arkansas River upstream from Cañon City are classified as Coldwater Class 1 streams (Health Department 2011c). Brown trout (Photo 3–16) are the most abundant species in these streams. Rainbow trout comprise a much smaller proportion of the fishery and are stocked by Colorado Parks and Wildlife. Brook trout, cutthroat trout, cutthroat-rainbow (cutbow) hybrids, longnose sucker, white sucker, and longnose dace are also present in low numbers in this portion of the analysis area. Greenback cutthroat trout are native to the Upper Arkansas River Basin, but have been extirpated from the segment and replaced by nonnative trout. Greenback cutthroat trout currently persist in only a few small tributary streams, isolated from contact with nonnative trout (Behnke 2002).

Photo 3–16. Brown trout collected from the Arkansas River, upstream from Cañon City

Average brown trout biomass (pounds of fish per acre (lbs/acre)) for segments in this portion of the analysis area is typically 80 lbs/acre to 110 lbs/acre, which is greater than the average biomass of 69 lbs/acre for the Rocky Mountain Forest ecoregion (Platts and McHenry 1988). Brown trout biomass varies considerably among sites and years, ranging from 20 lbs/acre to 255 lbs/acre in this segment. Biomass for the other species is typically less than 5 lbs/acre.

Mayfly (*Ephemeroptera*), stonefly (*Plecoptera*), and caddisfly (*Trichoptera*) taxa, collectively referred to as **EPT taxa**, are sensitive to a wide range of pollutants, and the number and relative abundance of these taxa can be used as indicators of habitat and water quality. Impaired sites would be expected to have fewer EPT taxa and lower relative abundances than unimpaired sites.

Benthic invertebrate communities vary considerably among sites and by year. The proportion of sensitive species is relatively high, indicating a healthy benthic invertebrate community. Water quality and habitat conditions are suitable to support sensitive, intolerant species. The number of taxa in this segment ranges from 19 to 60 per site. The average number of taxa for a segment was typically between 35 and 45. Approximately 15 to 25 of these taxa are the more sensitive mayfly, stonefly, and caddisfly taxa (Photo 3–17).

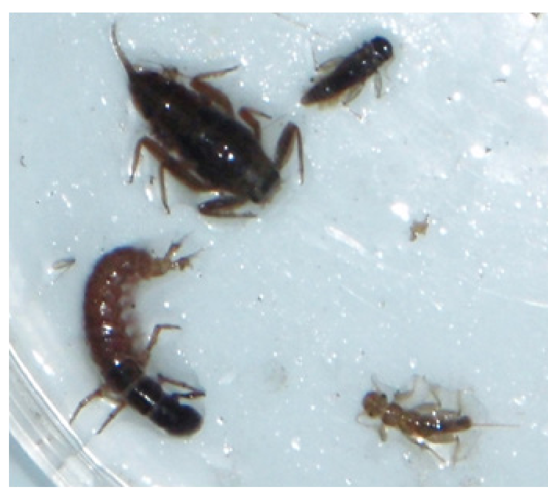


Photo 3–17. Mayflies (top two), stonefly (bottom right), and caddisfly (bottom left) specimens

Arkansas River Basin, Cañon City to Pueblo Reservoir Inlet, and Grape Creek The Arkansas River downstream from Cañon City to the inlet of Pueblo Reservoir is classified as Coldwater Class 1, but this segment is a transitional zone between coldwater and warmwater aquatic communities (Health Department 2011c). Historically, Cañon City marked the downstream extent of trout and the upstream extent of plains fishes (Jordan 1891). Only four species, including white sucker, central stoneroller, fathead minnow, and flathead chub, were present during a survey at Cañon City in 1889 (Jordan 1891).

Currently, a brown trout fishery is in the segment of the river near Cañon City with more of a warmwater fishery toward Pueblo Reservoir. Fish include coldwater species such as brown trout, species with wide temperature tolerances such as longnose dace and white sucker, and warmwater species such as black bullhead, green sunfish, and numerous minnow species. Flathead chub, a state species of special concern, is also in this segment. Southern redbelly dace, a state-listed endangered species, were stocked in this segment in 2002 and 2006, and Arkansas darters, a state-listed threatened species, were stocked in 2002. These species are still rare in the Arkansas River. Twelve fish species have been collected in this segment of the Arkansas River since 1979.

This river segment also contains fish that migrate upstream from Pueblo Reservoir, typically during spawning seasons. These fish include rainbow trout in early spring, walleye in mid-spring, wiper later in spring, and channel catfish in late spring and summer.

The invertebrate community is composed of a moderate proportion of sensitive organisms, indicating water quality and habitat sufficient to support numerous species, including tolerant and intolerant species. Data collected in 2003 and 2004 (Chadwick Ecological Consultants 2006) demonstrated the presence of an abundant and diverse benthic invertebrate community in this segment of the river. The benthic invertebrate community shifted to a slightly more tolerant community near the downstream end of this segment, with a smaller percentage of sensitive EPT taxa present. The samples contained between 26 and 42 taxa, with 9 to 16 of these being the more sensitive stonefly, mayfly, and caddisfly taxa.

Grape Creek is included in this section and is classified as Coldwater Class 1 upstream from De Weese Reservoir and downstream from the reservoir on National Forest land (Health Department 2011c). Downstream from De Weese Reservoir, Grape Creek is classified as Coldwater Class 2 when not on National Forest land (Health Department 2011c). The fish community was sampled in 1981 as part of a threatened fish survey, and the community was composed of coldwater and warmwater fishes, mostly white sucker (93 percent) with a few longnose dace, fathead minnow, brown trout, and rainbow trout (Loeffler et al. 1982).

Arkansas River, Pueblo Reservoir to Wildhorse Creek The Arkansas River from Pueblo Reservoir to Wildhorse Creek is classified as Coldwater Class 1 (Health Department 2011c). Historically, this was a warmwater segment of river before construction of Pueblo Reservoir, which allows water to stay colder. Eight species were collected during a survey in 1889, including black bullhead, white sucker, fathead minnow, red shiner, longnose dace, plains minnow, and speckled chub (Jordan 1891), all warmwater species. Plains minnow were described as not rare, whereas only one speckled chub specimen was collected (Jordan 1891). Plains minnow are currently classified as a state-listed endangered species and have not been collected in the analysis area during recent surveys. Speckled chub have been extirpated from the Arkansas River Basin in Colorado (Nesler 1997).

Photo 3–18. Rainbow trout collected from the river downstream from Pueblo Reservoir

This segment of the river currently contains a wide variety of fish species, ranging from stocked coldwater species (brown and rainbow trout) to native warmwater species. This segment also includes fish that have moved downstream with Pueblo Reservoir releases. Studies from 1979 through 2009 collected 20 species and 3 hybrids. Sixteen species and two hybrids of fish were collected at two sites in this segment in 2004 and 2009. These sampling events indicated that white sucker was the most common species, and the remaining fish community was composed of trout species, native warmwater species, and stocked warmwater game species, likely from Pueblo Reservoir. Rainbow trout were more abundant during the 2009 sample than in 2004 compared to most other species. Colorado Parks and Wildlife annually stocks this segment of the river with brown trout, rainbow trout (Photo 3–18), and occasionally cutthroat trout or cutbow hybrids. These fish are the basis for recreational fishing in this segment.

The benthic invertebrate community in this segment is abundant and diverse; however, the percentage of sensitive organisms was lower than in upstream segments, indicating the benthic invertebrate community in this segment may be impaired to some degree by water quality, water quantity, and/or habitat. Data collection in 2003 and 2004 at two sites in this segment found 26 to 36 different species, with 5 to 10 sensitive stonefly, mayfly, and caddisfly taxa. The number of taxa, and the number and percentage of stonefly, mayfly, and caddisfly taxa were lower at the upstream site, just downstream from Pueblo Reservoir, than at the site farther downstream, which is common for tailwater segments because conditions can favor a small number of species over others (Allan 1995). Changes in invertebrate communities in tailwater segments immediately downstream from dams are related to the altered chemical and physical environment, including reduced habitat complexity and reduced flow variability (Allan 1995).

Photo 3–19. Red shiner

Arkansas River, Wildhorse Creek to John Martin Reservoir Inlet This segment of the Arkansas River is classified as Warmwater Class 1 from Wildhorse Creek downstream to Fountain Creek, and as Warmwater Class 2 from Fountain Creek downstream to the inlet of John Martin Reservoir (Health Department 2011c). The segment contains a warmwater fish community that includes a mix of minnow, sucker, and sunfish. Since 1979, 28 fish species and 1 hybrid have been collected, including 24 species in 2005 alone. Red shiner (Photo 3–19) and sand shiner, two native species, are most abundant. Several other native species, including fathead minnow (Photo 3–20), flathead chub (a Colorado species of special concern), and plains killifish are also abundant. Sampling in 2005 found 19 Arkansas darters, a state-listed threatened species, and 12 suckermouth minnows, a state-listed endangered species.

Photo 3–20. Fathead minnow

Benthic invertebrate data collected in 2003 and 2004 indicated that the community has a moderate abundance and number of taxa, but less than in upstream segments. The community composition included a higher proportion of tolerant (less sensitive) invertebrates in this segment, compared to upstream segments, which indicate some habitat and/or water quality/quantity impairment. Between 19 and 41 species were collected in the samples, but typically only 4 to 8 of these were sensitive mayflies and caddisflies. Midges (a type of small fly) are the most abundant species at almost all sites in this segment of the river.

Arkansas River, John Martin Reservoir to Colorado State Line The Arkansas River downstream from John Martin Reservoir is classified as Warmwater Class 2 (Health Department 2011c). Many of the warmwater species collected during sampling in 1979 through 1981, 2003 through 2006, and 2009 were native to the Arkansas River drainage. A total of 21 species were collected from these sampling events. Sand shiner was the most abundant species collected during each sampling event, except in 2009, when mosquitofish (Photo 3–21) was the most abundant species. Red shiner and plains killifish were also abundant. Suckermouth minnow, a state-listed endangered species, was abundant during sampling in 1979 through 1981, and less abundant but present at most sites from 2003 through 2006, and in 2009. Flathead chub, a state-listed species of special concern, was collected during the 1979 through 1981 sampling event, but only 1 individual was collected during more recent sampling events. One Arkansas darter specimen, a state-listed threatened species, was collected during each of the 1999 and 2009 sampling events.

Photo 3–21. Mosquitofish

An inventory and status of Arkansas River native fish in 1999 suggested an increased abundance of nonnative mosquitofish (Photo 3–21) in this segment of the Arkansas River (Nesler et al. 1999). The abundance of mosquitofish during the 2009 survey further illustrates this trend.

No benthic invertebrate data are available for this segment. However, the benthic invertebrate community is likely similar to the benthic invertebrate community in the Arkansas River from Wildhorse Creek to the inlet of John Martin Reservoir, which contains a higher proportion of tolerant invertebrates compared to upstream segments, indicating some habitat and/or water quality/quantity impairment.

Fountain Creek The Fountain Creek segment from the Security gage downstream to the Arkansas River confluence contains a warmwater fish community and is classified as Warmwater Class 2 (Health Department 2011c). A site was sampled on Fountain Creek at Pueblo in 1889, and the water was described as being largely consumed by irrigation ditches, resulting in a stream that was 6 feet wide and 4 inches deep (Jordan 1891). Fathead minnow, red shiners, flathead chub, and plains killifish were present in the late 1800s (Jordan 1891).

Photo 3–22. White sucker

Most of the current species present in Fountain Creek at sites near Piñon and Pueblo are in the minnow family and are native species. Flathead chub (a state-listed species of special concern), white sucker (Photo 3–22), central stoneroller (Photo 3–23), and sand shiner were abundant in the entire segment, and red shiner and plains killifish were abundant in the downstream segment near the Arkansas River. Fountain Creek at sites near Piñon and Pueblo currently averages a wetted width of about 96 feet and a depth of 0.8 feet, based on USGS habitat surveys over the past 10 years.

Eighteen species were collected from Fountain Creek, and the species composition was similar between Fountain Creek segments. A few Arkansas darters were collected in Fountain Creek in Pueblo County between 1994 and 2010. This species is more common in small tributary streams but is occasionally found in Fountain Creek and the Arkansas River. Flathead chub was the most abundant species collected by USGS from 2003 through 2010 in both Fountain Creek segments.

Photo 3–23. Central stoneroller collected from Fountain Creek

Benthic invertebrate samples from Fountain Creek exhibit a wide range in community parameters among the various sites and years sampled. Diversity is low to moderate, and there are more tolerant taxa than sensitive taxa. Overall, the benthic invertebrate data indicate that the communities may be impaired by water quality, quantity, and/or habitat. The benthic invertebrate communities in Fountain Creek averaged 35 taxa for a segment during fall, and only 6 were sensitive mayfly and caddisfly taxa. There are trends toward higher abundance and more taxa in samples collected since 1998 compared to previous samples.

Reservoir Aquatic Resources

The aquatic life designation for reservoirs is similar to river segments, as discussed in the methods section above. Aquatic resources for major reservoirs in the analysis area are described below. Appendix F.2 contains additional detail and data on the species discussed in this subsection.

Turquoise Lake and Twin Lakes Turquoise Lake and Twin Lakes are classified as Coldwater Class 1 (Health Department 2011c) and are managed as coldwater fisheries. Historically, these lakes contained greenback cutthroat trout. Twin Lakes also contained the yellowfin cutthroat trout, which was present only in Twin Lakes and was first sampled in 1889 (Jordan 1891; Behnke 2002). This species was extinct by 1922, most likely the result of hybridization with rainbow trout (Behnke 2002).

Currently, these reservoirs are managed mainly for lake trout and rainbow trout, although sampling data indicate that longnose and/or white sucker are typically the two most abundant species. Lake trout populations are maintained primarily by stocking, with some natural reproduction. Rainbow trout are maintained by stocking. Since 1999, Colorado Parks and Wildlife has also stocked brown trout, cutthroat trout, and cutbow hybrids in one or both of these reservoirs. Longnose and white sucker maintain populations through natural reproduction and are not stocked.

The invertebrate communities of Twin Lakes are dominated by midges, worms, and clams (Reclamation 1993). Dragonflies, damselflies, beetles, and true bugs are also probably common in shallow areas. The benthic invertebrate community of Turquoise Lake is probably similar to that of Twin Lakes.

Opossum shrimp are not native to Colorado but were stocked in Twin Lakes in 1957 (Reclamation 1993). The shrimp population was abundant by 1970 and serves as an important part of the diet of lake trout in Twin Lakes. An established population of opossum shrimp also exists in Turquoise Lake (Martinez and Bergersen 1989).

Pueblo Reservoir Pueblo Reservoir is classified as Coldwater Class 1 (Health Department 2011c) and contains a mix of many different species of fish, including both coldwater and warmwater species. The fishery contains rainbow trout, cutthroat trout, and cutbow trout as the coldwater species, and numerous warmwater species. Since 1999, Colorado Parks and Wildlife has collected 18 fish species and 4 hybrids. Most of these species are game fish, providing opportunities for recreational fishing. Gizzard shad is the predominate forage fish species.

Colorado Parks and Wildlife annually stocks the reservoir with a variety of game fish species and hybrids. Channel catfish, rainbow trout, walleye, and wiper were stocked annually from 1999 through 2009. Largemouth bass (Photo 3–24) were stocked annually through 2008.

Photo 3–24. Largemouth bass

No data were available on the benthic invertebrate community of Pueblo Reservoir. The community is probably dominated by midges, worms, and clams typical of reservoirs. Dragonflies, damselflies, beetles, and true bugs are also probably common in shallow areas.

Lake Meredith and Lake Henry Lake Meredith and Lake Henry are classified as Warmwater Class 1 reservoirs and contain warmwater fisheries that are limited by water level fluctuations (Health Department 2011c). Both reservoirs have had very low water levels during 1 or more years since 2001 (a drought period), which has disrupted normal fisheries management. Both reservoirs are listed as impaired for exceeding the selenium water quality standard (see Appendix F.1); however, selenium levels are below those that would affect suitability of the water quality for sustaining fish.

The reservoirs are stocked by Colorado Parks and Wildlife with numerous species of warmwater game fish, including black crappie, blue catfish, channel catfish, saugeye, and wiper. Gizzard shad is also present as the main forage base.

No data were available on the two reservoirs' benthic invertebrate communities, which are probably dominated by midges, worms, and clams typical of reservoirs. Dragonflies, damselflies, beetles, and true bugs are also probably common in shallow areas.

John Martin Reservoir John Martin Reservoir is classified as a Warmwater Class 1 reservoir and is managed as a warmwater fishery (Health Department 2011c). Seventeen species of fish and two hybrids have been collected since 1999. Gizzard shad are typically the most abundant species sampled. Channel catfish, saugeye, wiper, and white bass have also been abundant periodically during sampling. The percentage of gizzard shad during sampling events was higher than desired during sampling from 1999 through 2004, and not conducive to a good sport fishery. The percentage of gizzard shad during sampling from 2006 through 2009 has been lower.

Nine species of fish and three hybrids have been stocked since 1999, including blue catfish, channel catfish, saugeye, smallmouth bass, and wiper. Saugeye and wiper have been stocked in the greatest abundances and are stocked as fry. Water level fluctuations have limited the fish population in John Martin Reservoir during some years by flushing small stocked fish out of the reservoir and by limiting the area of available habitat for sustaining fish.

No data were available on this reservoir's benthic invertebrate community, which is probably dominated by midges, worms, and clams typical of reservoirs. Dragonflies, damselflies, beetles, and true bugs are also probably common in shallow areas.

Nuisance Species

The Arkansas River Basin has tested positive for *Myxobolus cerebralis*, the causative agent of whirling disease, from the upper segments of the Arkansas River mainstem to as far downstream as John Martin Reservoir (Schisler 2000). Whirling disease limits natural reproduction of rainbow trout. In 2009, a strain of rainbow trout resistant to whirling disease was stocked in the Upper Arkansas River in an effort to increase the fish's future survival and reproduction (Policky 2009). While brown trout populations have persisted with the onset of whirling disease in the Arkansas River, *M. cerebralis* spore counts from brown trout samples in the Upper Arkansas River in 2008 may be high enough to result in decreased brown trout recruitment (Policky 2009).

Zebra mussels, including two adults, one juvenile, and one veliger (larva), were collected in 2007, and veligers were detected in 2008 and 2009. Quagga mussel veligers were collected in

2008 and 2011 from Pueblo Reservoir (USGS 2012a). According to the USGS's nonindigenous aquatic species Web site (http://nas.er.usgs.gov), New Zealand mud snails have not been detected in most of the Arkansas River Basin watershed (Benson 2011). However, they were recently (2013) found in Fountain Creek south of Colorado Springs. Zebra mussels, Quagga mussels, and New Zealand mud snails are invasive molluscs with the potential for detrimental ecological and economic effects. These species can invade a wide variety of aquatic habitats and are usually introduced into new waters by transfer from boats or anglers. They have recently begun invading western waters, especially in Pacific Coast states, and are currently more common in the Great Lakes states and along the Mississippi River.

Didymo or "rock snot," has not been documented in the Arkansas River, according to the most recent and extensive published data set by Kumar et al. (2009); however, modeling conducted by the authors suggests a high probability of didymo presence in the Arkansas River Basin (Kumar et al. 2009). Didymo is a stalked diatom that can form thick blooms and affect the ecological function and aesthetic appeal of rivers (Spaulding and Elwell 2007). Didymo has been reported in the western United States for more than 100 years, but expansive nuisance blooms have become more common recently (Kumar et al. 2009).

The Asiatic clam has been found in the Arkansas River mainstem near Pueblo, Lamar, and Caddoa, and in Pueblo Reservoir, John Martin Reservoir, and Lake Meredith (Chadwick Ecological Consultants 2006; Cordeiro et al. 2007). The impact of Asiatic clams on native mussels in Colorado is not known; however, some studies suggest that the species may compete for space and food (Cordeiro et al. 2007; Strayer 1999). The Asiatic clam was first introduced purposely on the west coast of North America in the 1900s (Vaughn and Spooner 2006) and has been documented in Colorado in the Arkansas, Colorado, Platte, and San Juan drainages (Cordeiro et al. 2007). These organisms are aggressive filter feeders that can reduce the amount of phytoplankton needed as food by native organisms. They also have the potential to increase ammonia levels (Cordeiro et al. 2007), which can be detrimental to native organisms.

Recreation

Recreation resources include water-based and land-based recreation facilities or opportunities. Water-based recreation primarily consists of boating and fishing, and may also include waterfowl hunting or other activities. Land-based recreation primarily consists of the use of parks, trails, golf courses, or other facilities. Effects on recreation resources are considered in this EIS because recreation facilities and recreational opportunities are important to both the quality of life and economic values for individuals and communities within the EIS study area, and could be affected by changes in streamflow, reservoir storage, and construction.

Methods

Water-based recreation resources can be affected by changes in streamflow and lake levels within the surface water hydrology analysis area. River and lake recreation, primarily boating and fishing, were identified from existing documents and reports, boating guide books, and Web sites published by government agencies and private outfitters.

Photo 3–25. Fishing along the Arkansas River

Land-based recreation resources consist of resources that may be affected by the proposed pipeline alignments and other constructed facilities between Pueblo Reservoir and the terminus of the proposed pipelines in Prowers and Kiowa counties. Land-based recreation resources were identified along the pipeline corridors, or analysis area, by reviewing published maps, Web sites, and other documents detailing public and private recreation facilities, such as parks, trails, golf courses, state wildlife areas, and Lake Pueblo State Park. It should be noted that only land-based recreation resources that fall within pipeline corridors, or the analysis area, are discussed. Land-based recreation resources in communities in the EIS study area, but outside the pipeline corridor, are not discussed.

Affected Environment

Multiple recreational resources exist in the analysis area, many unique to a specific location. The affected environment for recreation is described in four geographic locations: Upper Arkansas River Basin (above Pueblo Reservoir), Pueblo Area (within Pueblo County), Lower Arkansas River Basin (below Pueblo County line), and Fountain Creek.

Photo 3–26. Whitewater rafting and kayaking on the Arkansas River near Salida

Upper Arkansas River Basin Recreation

Recreational resources in the Upper Arkansas River Basin include the Arkansas River, Grape Creek, Turquoise Lake, and Twin Lakes. The Arkansas Headwaters Recreation Area encompasses much of the river in the Upper Arkansas River Basin (Figure 3–19).

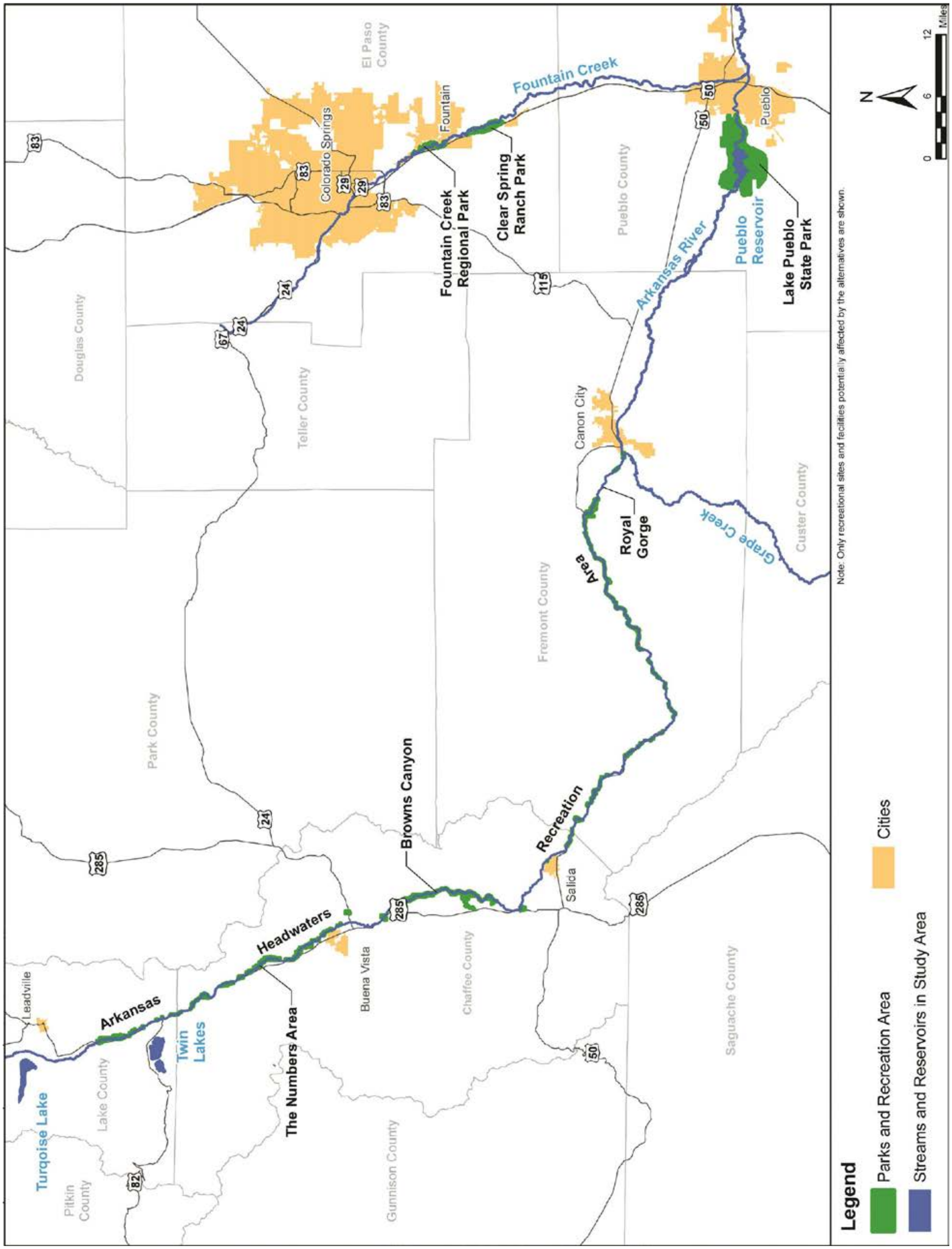


Figure 3–19. Upper Arkansas River and Fountain Creek Recreation Areas

Upper Arkansas River The Upper Arkansas River area includes several nationally recognized whitewater boating sections, including the Numbers, Browns Canyon, and Royal Gorge. Peak boating use occurs from mid-June to mid-August (ERO 2006a). Other activities include fishing, private kayaking, and private rafting. The Arkansas River below Cañon City is a slower moving plains river that provides a more tranquil experience for canoeists and other boaters. Wildlife viewing and angling from boat or shore occur throughout the Upper Arkansas River, including bighorn sheep viewing opportunities in the canyon east of Salida and along the Arkansas River west of Pueblo Reservoir.

Upper Arkansas Voluntary Flow Management Program recommendations set a minimum target of 700 cfs between July 1 and August 15, and 250 cfs the remainder of the year at the Arkansas River near Wellsville gage. Winter target flows vary based on several considerations as noted in Appendix D.1. The 2001 *Arkansas River Water Needs Assessment* evaluates water needs for recreation on the Arkansas River and its associated reservoirs (Colorado State Parks et. al 2001). River flow preferences for boating and angling are summarized in Table 3–6. Chaffee County also has a Recreational In-Channel Diversion water right for the Upper Arkansas River.

Table 3–6. Upper Arkansas River Recreation Flow Targets

Recreation Use	Acceptable Low Flow (cfs) (1)	Optimum Low Flow (cfs) (1)	Optimum High Flow (cfs) (1)	Acceptable High Flow (cfs) (1)
Rafting	750	1,500	2,000	2,500
Kayaking	650	1,300	1,500	2,500
Fly fishing	250	400	500	800
Spin fishing	500	700	1,200	2,000
Float fishing	550	900	1,200	2,500

Source: Smith and Hill (2000); Reclamation 2008
Note:
(1) Flows are measured at the Arkansas River near Wellsville gage.

Grape Creek Descending from the Wet Mountain Valley to Cañon City, Grape Creek, a tributary to the Upper Arkansas River (Figure 3–19), can provide a challenging Class III-V kayak run for expert boaters. However, favorable conditions for boating on Grape Creek are both rare and short-lived, and depend on a combination of high runoff and sufficient releases from De Weese Reservoir (Banks and Eckardt 1999; Southwest Paddler 2009).

Turquoise Lake and Twin Lakes Recreation facilities at Turquoise Lake and Twin Lakes are operated by the U.S. Forest Service (Figure 3–19). Turquoise Lake provides two boat ramps, eight campgrounds, and up to 780 acres of surface water. Recreation facilities at Twin Lakes include two boat ramps, two campgrounds, and up to 2,440 acres of surface water for boating and fishing. Major fish species at both reservoirs include rainbow trout, brook trout, and mackinaw trout. Although ice fishing is popular at Turquoise Lake and Twin Lakes, developed recreation facilities are closed in the winter months (Reclamation 2011a).

Pueblo Area Recreation

Recreational resources in the Pueblo area include Lake Pueblo State Park, the Arkansas River Corridor, the Nature and Raptor Center of Pueblo, and local parks and recreation amenities.

Photo 3–27. Southshore Marina at Lake Pueblo State Park

Lake Pueblo State Park The 11,300-acre Lake Pueblo State Park has both water- and land-based recreation facilities (Figure 3–20). Two marinas, two boat ramps, and a sailboard/canoe launch support water-based uses, including motorboating, sailboating, waterskiing, personal watercraft use, fishing (from boat and shore), sailboarding, and canoeing (Colorado State Parks 2010a, 2010b). The Rock Canyon portion of the park, located immediately below Pueblo Dam, provides additional water-based recreational uses, including a swim area, fishing pond, handicap-accessible fishing pier, and trails that connect to Pueblo greenway trails (Colorado State Parks 2010a). Land-based facilities include a visitor center, 53 miles of trails, 3 campgrounds, and 12 picnic areas.

Lake Pueblo State Park visits in fiscal year 2009–2010 numbered 1,804,805 (Colorado State Parks 2010b). It is consistently the most heavily visited state park in Colorado. More than half of the annual visitation occurs in the summer months, from June to August (Smith and Hill 2000).

Pueblo Reservoir is a popular destination for anglers, supporting a diversity of game fish species such as walleye, rainbow and brown trout, wiper, catfish, smallmouth and largemouth bass, and crappie (Colorado State Parks 2010a). While Pueblo Reservoir is used year-round for fishing, most of the fishing occurs between April and August (Smith and Hill 2000).

Arkansas River Corridor Recreational boating on the Arkansas River downstream from Pueblo Dam through Pueblo includes kayaks, canoes, and inner tubes. A popular whitewater park, with about a half-mile of constructed drops and other features, is located along the Arkansas River near downtown Pueblo (Figure 3–20). From a boater’s perspective, minimum desired flows for kayaking are about 450 cfs, while optimal flows are at or above 700 cfs (McCutchen and Stafford 2007).

The segment of the Arkansas River downstream from Pueblo Reservoir for about 8 miles is managed as a sport fishery. Colorado Parks and Wildlife stock this segment with rainbow and brown trout, and it is considered a regional fishing “hot spot” (Colorado Division of Wildlife 2011; McGree 2011). Other area game fish species include walleye and perch.

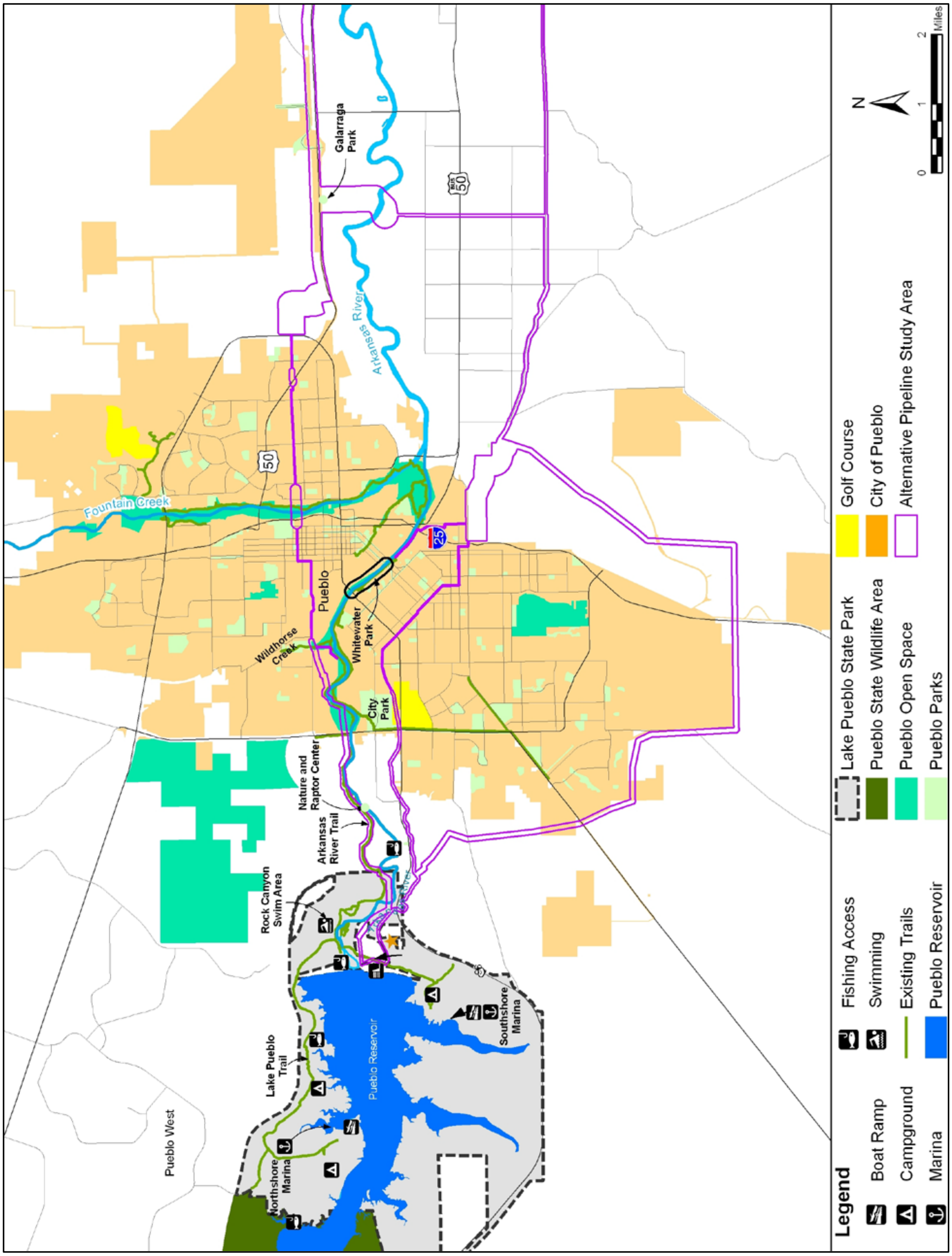


Figure 3–20. Pueblo Area Recreational Areas

The Pueblo Flow Management Program provides flow targets to support instream recreational uses. Target flows are administered at a point downstream from the Arkansas River above Pueblo gage (to include fish hatchery discharge). The Pueblo Flow Management Program flow targets range up to 500 cfs during most of the summer recreation season (see Appendix D.1). Pueblo also has a Recreational In-Channel Diversion water right for the boat course segment, which ranges from 250 to 1,800 cfs, depending on time of year.

Photo 3–28. Pueblo whitewater course (2,900 cfs)

Nature and Raptor Center of Pueblo The Nature and Raptor Center of Pueblo, located along the north bank of the Arkansas River west of Pueblo, is managed by a nonprofit entity that provides environmental education programs. The facility includes an office and gift shop, raptor rehabilitation center, picnic areas, picnic pavilion, fishing deck, nature trails, and connections to regional trails (Nature and Raptor Center of Pueblo 2010).

Photo 3–29. Pueblo whitewater course (700 cfs)

Other Pueblo Area Recreation Pueblo's trail system includes interconnected trails along the Arkansas River, Fountain Creek, and the smaller Wildhorse Creek corridor. Each of these trail corridors is also bordered by open space lands (Figure 3–20). Several other trail corridors provide additional connectivity throughout the city.

Other Pueblo parks and recreation amenities in the analysis area include portions of City Park, Elmwood Golf Course, Wildhorse Creek Park, and others. Outside Pueblo city limits, Galarraga Park is located south of U.S. Highway 50 near the Pueblo Airport. Designated Pueblo open space is also located adjacent to the Arkansas River, Wildhorse Creek, and Fountain Creek corridors.

Photo 3–30. Pueblo whitewater course (100 cfs)

Lower Arkansas River Basin Recreation

Recreational resources in the Lower Arkansas River Basin include the Arkansas River, multiple small irrigation reservoirs, John Martin Reservoir, and other land-based recreation amenities (Figure 3–21).

River Recreation Recreational use of the Arkansas River east of Pueblo primarily includes bank fishing and occasional canoeing. While fishing occurs along this segment of the river (particularly near pools associated with diversions), it is not stocked or managed as a sport fishery (Ramsay 2011). The Lower Arkansas River corridor is a major destination for hunting and wildlife viewing of big game, waterfowl, upland game, and wild turkey.

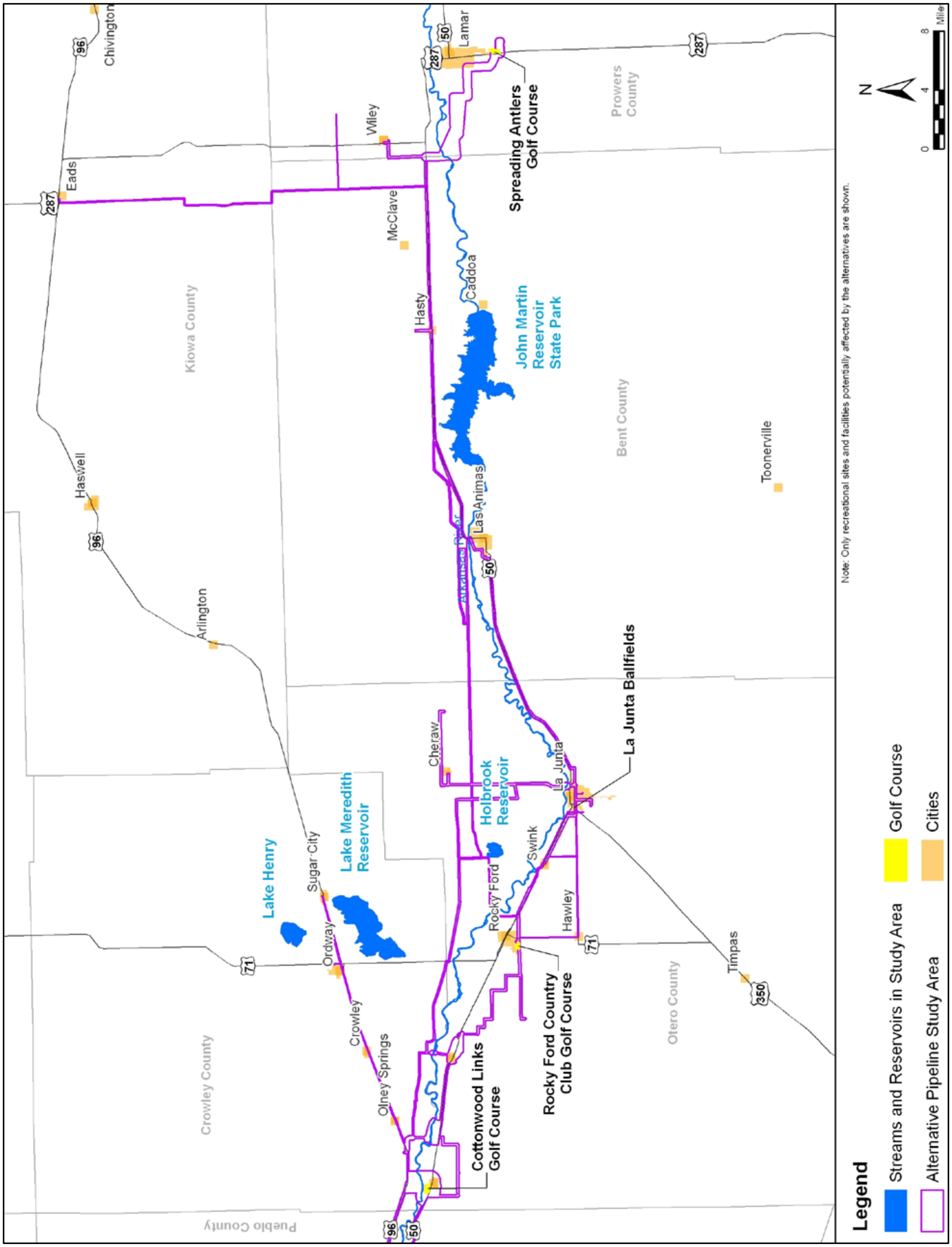


Figure 3–21. Lower Arkansas River Recreation Areas

Photo 3–31. Campground below John Martin Reservoir near Lake Henry

Reservoir Recreation Popular recreational uses at Lake Meredith, Lake Henry, and Holbrook Reservoir include powerboating, sailboating, fishing, and waterfowl hunting (Figure 3–21). Typical warmwater game fish species at these reservoirs include saugeye, crappie, channel catfish, and wiper. These reservoirs are primarily managed for municipal and irrigation purposes and historically, water levels have fluctuated widely, sometimes leaving the reservoirs entirely dry for extended periods. Recreation facilities at Lake Meredith and Lake Henry are managed by Crowley County, while Holbrook Reservoir is managed by Colorado Parks and Wildlife as a State Wildlife Area.

John Martin Reservoir, although built for flood management, provides recreational uses including powerboating, sailboating, canoeing, fishing, and bird watching. The reservoir is a year-round fishing destination, with warmwater game fish, including crappie, saugeye, bass, wiper, walleye, and bluegill. Recreation facilities include boat ramps, picnic areas, campgrounds, a fishing pier, and a swim beach. The 4.5-mile-long Red Shin trail extends from the Dam to the Santa Fe Trail Historic Site on the north side of the reservoir (Colorado State Parks 2010b). John Martin Reservoir State Park had 147,533 visitors during the 2009–2010 fiscal year (Colorado State Parks 2011). Colorado Parks and Wildlife manages recreation at John Martin Reservoir and land and facilities adjacent to and below the dam (North Shore and Lake Hasty areas), and owns a 10,000 ac-ft conservation pool used to preserve the fishery during drought or other periods when reservoir levels are low (Ramsay 2011).

Other Lower Arkansas River Basin Recreation

The analysis area includes or is immediately adjacent to several recreational amenities in Lower Arkansas River communities. The nine-hole Cottonwood Links golf course in Fowler and the nine-hole Rocky Ford Country Club golf course are immediately adjacent to the analysis area. In La Junta, the analysis area corridors include portions of a ballfield complex. In Lamar, the analysis area includes most of the land occupied by the nine-hole Spreading Antlers Golf Course. Portions of the Santa Fe National Historic Trail are located within the analysis area between La Junta and Lamar. Trail resources may include actual trail ruts, the general setting of the trail corridor, and specific sites along the trail (such as the historic site at John Martin Reservoir and Bent's Old Fort National Historic Site). The Santa Fe Trail is described in greater detail in the Chapter 3 – *Historic Properties* section.

Fountain Creek Recreation

The Fountain Creek corridor between Colorado Springs and Pueblo includes parks and trails, but is not a destination known for boating, fishing, or other water-based recreation. Fountain Creek Regional Park is north of Fountain and includes an active use area, fishing ponds, the Fountain Creek Nature Center, nature areas, and 5 miles of soft-surface trails. Clear Spring Ranch Park south of Fountain includes about 5.7 miles of trails. The Fountain Creek Regional Trail extends 10.5 miles south from Colorado Springs to Fountain Creek Regional Park.

Recreation Resources Developed with Federal Funds

Several recreation resources within or adjacent to the analysis area were partially or fully funded with assistance from the federal Land and Water Conservation Fund. Money and grants from the fund were used for portions of the Fountain Creek Trail, constructed in 1979, 1983, and 2002; Plaza Verde Park, constructed in 1972, 1974, and 1976 (U.S. National Park Service 2011); and recreation facilities at Holbrook Reservoir, constructed in 1985, 1987, and 1988 (U.S. National Park Service 2011).

Vegetation and Wetlands

Vegetation and wetland resources in the EIS study area include upland vegetation communities (such as agricultural lands), riparian and wetland vegetation communities, sensitive plant species, and noxious weeds. Vegetation plays a role in wildlife habitat, soil protection, and other ecosystem functions, and could be affected by construction and AVC and Master Contract operations.

Riparian vegetation grows along streams and ditches and around ponds and lakes. It relies on groundwater and/or floods for a water source.

Vegetation communities are a collection of plant species in a shared environment. The Colorado Vegetation Classification Project describes vegetation by growth form, moisture regime, and dominant species.

Wetlands, under normal circumstances, "support a prevalence of vegetation typically adapted for life in saturated soil conditions." (Corps 1987)

Playas are closed basins containing shallow seasonal ponds, often with wetland vegetation within and surrounding the pond. Playas are not associated with stream systems.

Methods

The analysis area for vegetation and wetland resources is the area of direct effects associated with ground-disturbing activities during construction, and areas that may be indirectly affected by changes in hydrology. Water bodies that may be affected by hydrology changes are the Arkansas River, Fountain Creek, Grape Creek, Turquoise Lake, Twin Lakes, Pueblo Reservoir, Lake Meredith, Lake Henry, Holbrook Reservoir, and John Martin Reservoir. The analysis area also includes agricultural areas that would be dried by changing water rights from agricultural use to municipal use for exchange to Master Contract storage (see Appendix A.1). This change in use includes periodic removal of irrigation water as part of rotational fallowing or retirement of irrigated lands with irrigation water permanently removed.

Vegetation Classification and Mapping

The method of classifying and mapping vegetation resources differs depending on whether effects would be direct or indirect. For areas potentially affected by construction (direct effects), the boundaries of vegetation communities were mapped for each alternative using a combination of the Colorado Vegetation Classification Project mapping (Colorado Division of Wildlife 2004), aerial photography interpretation, and site visits from publicly accessible areas. Vegetation community boundaries, including wetlands, were mapped onto aerial photography based on dominant plant species. Common and scientific names for the species described in this section are in Appendix I.1.

Wetlands were mapped based on the Corps definition of wetlands. Each wetland was classified under the Cowardin system, based on location, substrate, hydrology, vegetation type, and other characteristics (Cowardin et al. 1979). The Cowardin classification includes both wetlands with persistent vegetation and open water habitats. Open water habitats were not classified for this study. A jurisdictional wetland delineation per the Corps' *Wetland Delineation Manual* (1987) was not conducted at this stage of analysis. Playas, another type of wetland/water body, were mapped because these isolated, temporary ponds are important to migrating waterfowl and other wildlife. The locations of potential playas were obtained from existing data (Playa Lake Joint Venture 2010) and were then reviewed and verified in the field.

For areas potentially affected by changing hydrologic conditions (indirect effects), riparian and wetland vegetation is generally described based on Colorado Parks and Wildlife riparian mapping project (Colorado Division of Wildlife 2006) and knowledge of typical plant communities found along streams and around reservoirs, according to elevation and other ecological factors.

Reconnaissance field review from public roads and published data sources were used to map noxious weeds in the analysis area. The potential presence of sensitive species was based on the presence of suitable habitat identified from vegetation mapping and the Colorado Natural Heritage Program (2010a) database of known occurrences.

Affected Environment

The affected environment for vegetation and wetlands is described in the following sections according to four broad categories: upland vegetation, wetlands and riparian vegetation, sensitive plant species, and noxious weeds.

Upland Vegetation

Uplands are found on the plains and hillsides outside the Arkansas River floodplains and other stream systems. Uplands also include areas modified by humans, such as developed and agricultural lands.

Photo 3–32. Upland cholla grassland

Upland Grasslands Upland grasslands are common throughout the analysis area and are dominated by a variety of grass species, commonly with small shrubs and cacti. The specific species combination depends on the type of soils, previous and current land use, and other factors. At the western end of the analysis area, near Pueblo, upland grasslands dominated by blue grama, snakeweed, and dropseed occur on shaley hillsides. Blue grama and little bluestem grasslands are present on undisturbed shaley and sandy hills north of the Arkansas River. On both sides of the Arkansas River, blue grama and sand dropseed-dominated grasslands are common, especially in areas with some degree of previous disturbance. Grasslands with dense stands of tall cholla cacti (cholla grasslands) are found north of the Arkansas River.

Drawing 3–1. Blue grama grass

Upland Shrublands Upland shrublands are common throughout the analysis area, and include both mixed upland shrublands and sandhill shrublands. On shaley hillsides near Pueblo Reservoir, upland shrublands of four-winged saltbush and rubber rabbitbrush are present. Shaley and sandy hills north of the Arkansas River contain shrublands of sagebrush and sand sage.

Photo 3–33. Upland shrublands on shaley hillsides

East of Lamar, a series of small sandy hills are covered with a sandhills vegetation community dominated by sand sage with a sparsely vegetated understory of snakeweed, sand dropseed, and other species. Sandhill shrublands were mapped as a separate plant community because they contain potential habitat for prairie chickens and a sensitive plant species, sandhills goosefoot.

Upland Woodlands Open woodlands dominated by juniper trees occur on shaley hillsides and upper drainage slopes near Pueblo Reservoir. The understory ranges from a shrub layer of rubber rabbitbrush, cholla, and snakeweed to an herbaceous layer of sand dropseed and kochia.

Agricultural Land Lands modified for agriculture are found throughout the analysis area and include irrigated and nonirrigated agricultural fields of primarily winter wheat and corn, as well as vegetables, melons, and fallow fields (see Appendix D.1 for additional information on irrigated crops). Windbreak tree rows and plantings around houses are also included in this vegetation type. Agriculture is one of the most common land uses within the analysis area.

Developed and Disturbed Areas Developed areas are landscaped areas around towns, clusters of buildings, and along transportation corridors throughout the analysis area. Also scattered within the analysis area are previously disturbed areas between agricultural ditches, and other areas dominated by kochia and other weedy species.

Wetland and Riparian Vegetation

Wetlands and riparian areas are found along streams, reservoirs, canals, and ditches throughout the analysis area. The following summarizes composition of wetlands, riparian herbaceous communities, riparian shrubland, and riparian forests in the analysis area.

Wetlands Wetlands classified as palustrine scrub-shrub and palustrine emergent are found from Pueblo Dam to below Lamar and near Eads. Palustrine scrub-shrub wetlands dominated by sandbar willow occur in several places along the banks and within the channel of the Arkansas River in the analysis area. Saltcedar (also known as tamarisk) -dominated palustrine scrub-shrub wetlands are found scattered along the banks of the Arkansas River and on smaller tributaries. Saltcedar-dominated stands that occur on higher benches along the Arkansas River and at greater distances from the active channel are more often classified as riparian vegetation than wetlands.

Willow-dominated palustrine scrub-shrub wetlands occur along tributaries to the Arkansas River and as isolated stands along roadside ditches or near isolated water bodies.

Palustrine wetlands are dominated by trees, shrubs, and emergent vegetation. They are traditionally known as a marsh, swamp, or bog found in small, shallow, permanent, or intermittent water bodies, as well as ponds, lakes, river channels, or floodplains.

Emergent wetlands are characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens.

Scrub-shrub wetlands include areas dominated by woody vegetation less than 20 feet tall. Species include tree shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions.

Palustrine emergent wetlands dominated by cattail, common reed, threesquare, and other wetland grasses are found within the Arkansas River floodplain, along tributaries to the Arkansas River, in roadside ditches along highways, and in isolated, low-lying areas receiving irrigation runoff. Dense stands of common reed occur on the banks of the Arkansas River in Pueblo. Small tributaries that lack perennial flow, larger ditches with steep banks, and isolated ponds often lack wetland vegetation. Two playas with palustrine emergent wetlands are present in the analysis area east of Pueblo. Cottonwood-dominated forested areas are generally considered riparian habitat; however, one cottonwood-dominated palustrine forest wetland occurs along Gageby Creek, a tributary to the Arkansas River north of John Martin Reservoir along U.S. Highway 50. A Siberian-elm-dominated palustrine forested wetland occurs on a small Arkansas River tributary west of Lamar on U.S. Highway 50. All other forested areas are classified as riparian or upland vegetation communities.

Through the Wet Mountain Valley, Grape Creek has a fairly low gradient channel and receives irrigation return flows that support herbaceous wetlands and wet meadows. Downstream from De Weese Reservoir, Grape Creek flows through the De Weese Plateau and is confined by Temple Canyon. Isolated patches of herbaceous and willow-dominated wetlands occur along the banks and on terraces.

Photo 3–34. Scrub-shrub wetland along Arkansas River

Riparian Herbaceous The segment of the Arkansas River below Lake Fork to Cañon City is confined by landforms, resulting in a narrow corridor of patchy riparian vegetation. Near Cañon City and Florence, riparian herbaceous communities become more dominant (influenced more by agricultural return flows than by the river). Riparian herbaceous communities in the Upper Arkansas River Basin occur mostly along drainages that flow into Pueblo Reservoir.

Riparian herbaceous vegetation communities dominated by saltgrass, western wheatgrass, and other grasses grow along some of the intermittent drainages and depressions within the Lower Arkansas River Basin. Riparian herbaceous vegetation communities are also found on the high banks and outer edges of the Lower Arkansas River. The shores around Cheraw Lake are sparsely covered by riparian herbaceous vegetation.

Riparian Shrubland Patches of saltcedar shrublands occur near Cañon City and become more abundant closer to Pueblo Reservoir. Riparian shrublands (both willow and saltcedar) in the Upper Arkansas River Basin occur mostly along drainages that flow into Pueblo Reservoir.

Three types of riparian shrublands were identified in the Lower Arkansas River Basin: exotic, mixed, and greasewood flat. Saltcedar dominates the exotic riparian shrubland, with Russian olive also occurring in some areas. Mixed riparian shrublands have more than one dominant species, with sandbar willow/saltcedar shrublands commonly present. Greasewood flat riparian shrublands typically occur on higher benches or terraces above the streams, especially where the soils are clayey or alkaline. Greasewood flat riparian shrublands are present near the Arkansas River downstream from Pueblo Dam, along state Highway 96, along Arkansas River tributaries, and at an oxbow on the Arkansas River west of John Martin Reservoir. Areas dominated by sandbar willow, a common riparian shrub, are typically classified as wetlands for this EIS.

Exotic riparian shrublands are the most common riparian shrubland throughout the analysis area. The highest cover of exotic riparian shrubland grows along the Arkansas River as narrow bands on banks or as extensive stands dominating the floodplain and upper terraces. Exotic riparian shrublands also are found along smaller tributaries to the Arkansas River, including Fountain Creek. In addition, mixed riparian shrublands are found along the Arkansas River and smaller tributaries throughout the analysis area.

Photo 3–35. Exotic riparian shrubland composed of saltcedar

Riparian Forest Two types of riparian forest communities were identified in the analysis area: cottonwood riparian forests and introduced riparian forests. Cottonwood riparian forests in the Upper Arkansas River Basin grow mostly along drainages that flow into Pueblo Reservoir. Cottonwood riparian forests cover the banks and wide terraces of the Arkansas River and other stream systems throughout the analysis area. This vegetation community contains dense stands of plains cottonwoods with an understory of native sandbar willow, herbaceous vegetation, or exotic saltcedar. Narrow bands of plains cottonwoods live along ditches and around farmhouses. Introduced riparian forest, dominated by Siberian elm, is mostly found along ditches and drainages.

Near Stratmoor Hills, some segments of Fountain Creek are confined by urban development resulting in a narrow riparian corridor. In segments not confined by urban development and downstream from Security, the riparian corridor broadens, and cottonwood riparian forests, riparian herbaceous communities, and wetlands are found along the channel and throughout the floodplain.

Photo 3–36. Riparian cottonwood forest

Agricultural Lands Water supply development for the action alternatives would include periodic and permanent removal of irrigation water from various agricultural lands in the analysis area. While agricultural lands generally do not support wetland and riparian vegetation, irrigation ditches, canals, return flow ditches, ponds, or return flow into streams may support riparian and wetland vegetation. Species composition in these locations varies widely but may include willows, Siberian elm, saltcedar, cottonwoods, and herbaceous native and exotic species.

Reservoir Wetland and Riparian Vegetation Wetland and riparian vegetation near Turquoise Lake and Twin Lakes occur primarily where tributaries enter the reservoirs rather than along the shoreline, which is typical of high elevation reservoirs. Reservoir shorelines are generally steep with minimal riparian or wetland vegetation present below the high-water mark. Upland grasslands, shrublands, or coniferous forests generally grow to the high-water mark.

Wetland and riparian vegetation near Pueblo Reservoir is more commonly associated with small tributaries to the reservoir, and also exists near the inlet of the Arkansas River into the reservoir. Cottonwood, sandbar willow, and Siberian elm are found near the inlet. Pueblo Reservoir also has fairly steep slopes that create a band of unvegetated shore between the high-water mark and the current water level.

Riparian shrubland and forest vegetation of cottonwood, sandbar willow, and saltcedar grows infrequently along the shorelines of the Lower Arkansas River reservoirs (Meredith, Henry, Holbrook, and John Martin), although saltcedar is most common. Reservoir shores have gently sloping shorelines and experience significant seasonal water level fluctuations and areas of inundation. The large fluctuation in reservoir water levels favors deep-rooted saltcedars. From the inlet of the Arkansas River into John Martin Reservoir and upstream, extensive stands of saltcedar occur with some cottonwood in the overstory.

Sensitive Plant Species

Sensitive plant species include two categories: federally listed threatened and endangered plant species and Colorado plant species of concern. Federally listed threatened and endangered species are protected under the Endangered Species Act, which defines an endangered species as "a species in danger of becoming extinct throughout all or a large portion of its range" and a threatened species as "a species likely to become endangered in the foreseeable future" (50 CFR 17.3). The U.S. Fish and Wildlife Service has confirmed the list of threatened and endangered plant species that should be considered in the AVC EIS (2011).

Photo 3–37. Ute ladies'-tresses orchid

The only federally listed threatened or endangered plant species with potential habitat in the analysis area is the Ute ladies'-tresses orchid (U.S. Fish and Wildlife Service 2010). This species potentially occurs in El Paso County based on an 1896 record. The U.S. Fish and Wildlife Service considers the Fountain Creek drainage to possibly have Ute ladies'- tresses orchid habitat (1992). However, no populations are currently known within this drainage. None of the other counties within the analysis area have potential habitat for any threatened, endangered, or candidate plant species (U.S. Fish and Wildlife Service 2010).

A list of Colorado plant species of concern with potential habitat within or near the areas that would be physically disturbed was obtained from the Colorado Natural Heritage Program (2010b). Potential habitat within the analysis area for each species was determined during a site review using habitat descriptions from the *Colorado Rare Plant Guide* (Spackman et al. 1997), NatureServe (2011), and knowledge of known habitat for these species. Colorado State University's Colorado Natural Heritage Program classifies the rarity of plant species of concern based on known occurrences in the state. For this EIS, species listed as critically imperiled globally (typically only 5 known occurrences) or imperiled in Colorado (typically only 6 to 10 known occurrences) were considered.

Based on data from the Colorado Natural Heritage Program (2010b), five Colorado plant species of concern that are critically imperiled or imperiled in Colorado have potential habitat within the analysis area, as described below and listed in Table 3–7.

Table 3–7. Plant Species and Communities of Concern Potentially Occurring in Analysis Area

Common Name	Colorado Natural Heritage Program Rank	U.S. Forest Service/Bureau of Land Management Sensitive	Habitat	Flowering or Fruiting Period
Dwarf milkweed	G1G2/S1S2	U.S. Forest Service/Bureau of Land Management	Sandstone soils and gravelly/rocky slopes. Associated with juniper woodlands.	April-May
Golden blazingstar	G2/S2	Bureau of Land Management	Barren slopes of limestone, shale, or alkaline clay. Associated with juniper woodlands.	July–September
Pueblo goldenweed	G1G2/S1S2	No	Compacted silty clays to looser rocky and sandy soils in open grasslands.	July
Roundleaf four o'clock	G2/S2	No	Barren shale outcrops of the Smokey Hill member of the Niobrara Formation in sparse shrublands or piñon/juniper woodlands. Endemic in Fremont and Pueblo counties.	June
Sandhills goosefoot	G3G4/S1	U.S. Forest Service	Sandy soils. Frequently found on vegetated edge of sand blowouts.	Fruiting early summer to fall

Key: G1 = critically imperiled globally
G2 = imperiled globally
G3 = vulnerable throughout its range or found locally in a restricted range
G4 = Apparently secure globally, though it might be rare in parts of its range.
S1 = critically imperiled in Colorado
S2 = imperiled in Colorado
U.S. Forest Service = listed by the U.S. Department of Agriculture, Forest Service,
Bureau of Land Management = listed by the U.S. Department of the Interior, Bureau of Land Management

Dwarf Milkweed Dwarf milkweed is listed as critically imperiled/imperiled in Colorado. Potential habitat occurs in the juniper woodlands and grasslands south of the Arkansas River near Pueblo Reservoir. Other areas with potential habitat include the grasslands and shrublands on hills north of the Arkansas River. This tiny plant blooms in April and May and grows in shortgrass prairie on sandstone soils and gravelly/rocky slopes (Spackman et al. 1997). This species is often associated with juniper woodlands (NatureServe 2011).

Golden Blazingstar Golden blazingstar is imperiled in Colorado. Potential habitat is on shaley upland shrublands and grasslands on both sides of the Arkansas River near Pueblo Reservoir. Additional potential habitat occurs on hillsides north of the Arkansas River. This species blooms from July to September. Golden blazingstar thrives on barren slopes of limestone shale or alkaline clay (Spackman et al. 1997).

Pueblo Goldenweed Pueblo goldenweed is listed as critically imperiled/imperiled in Colorado. Potential habitat is in open grasslands in Pueblo County. Pueblo goldenweed is found only in Fremont and Pueblo counties. This species grows in open grasslands on compacted silty clays to looser soil (Spackman et al. 1997).

Photo 3–38. Golden blazingstar

Roundleaf Four-o'Clock Roundleaf four-o'clock is imperiled in Colorado. Potential habitat is on shaley outcrops on both sides of the Arkansas River west of Pueblo Reservoir, and on shaley hillsides north of the Arkansas River in Pueblo County. This species is found only in Fremont and Pueblo counties. Roundleaf four-o'clock occurs in barren shale outcrops on sparse shrublands and juniper woodlands.

Sandhills Goosefoot Sandhills goosefoot is imperiled in Colorado. Potential habitat for sandhills goosefoot is on sandhills near Lamar at the eastern end of the analysis area. Sandhills goosefoot grows on sandy soils and is frequently found in stabilized areas around sand blowouts.

Noxious Weeds

To prevent noxious weeds from impacting economic and environmental values of Colorado, the Colorado Department of Agriculture maintains lists of noxious weeds categorized by the severity of potential impacts and other factors (Colorado Department of Agriculture 2010). This EIS focuses on species classified as List A (requires eradication) and List B (requires implementation of plans to stop the spread of the species).

> **Noxious weeds** are aggressive, nonnative plants that invade an area, displacing desirable vegetation and potentially changing the ecosystem.

Three noxious weeds on List B of the State of Colorado Noxious Weed List (Colorado Department of Agriculture 2010) – saltcedar, Russian olive, and Canada thistle – are prevalent throughout the analysis area, based on field observation and available data sources (Tamarisk Coalition 2008). Saltcedar is a nonnative shrub that often aggressively invades riparian areas and is potentially affected by hydrologic changes.

Along the Arkansas River and its tributaries, saltcedar is the dominant shrub in many of the riparian shrubland and cottonwood riparian forests. The density of this noxious weed along the Arkansas River ranges from large expanses within the floodplain to scattered individuals (Tamarisk Coalition 2008). Saltcedar can also be found to a lesser extent in riparian shrublands dominated by sandbar willow and in herbaceous riparian vegetation communities. Russian olive is a small invasive tree that can be found in communities and densities similar to saltcedar. Canada thistle is found in agricultural lands, upland grasslands, and some riparian vegetation communities. No other List A or List B noxious weed species were noted, although there is potential for others.

Photo 3–39. Russian olive in foreground along Arkansas River

Wildlife

This section discusses terrestrial wildlife and associated habitat in the analysis area. Aquatic wildlife is discussed in Chapter 3 - *Aquatic Life*. Terrestrial wildlife resources include federally listed threatened and endangered species and species that are candidates or proposed for federal listing (federal species of concern). Other wildlife species of interest are state-listed threatened, endangered, and species of concern, and species identified by Colorado State University's Colorado Natural Heritage Program as rare or imperiled. This section also discusses other terrestrial wildlife and wildlife habitats found within the analysis area, such as game animals, migratory birds, small mammals, amphibians and reptiles, and wildlife migration and movement corridors. Wildlife could be affected by construction or changes in streamflow and reservoir storage caused by AVC operations.

Methods

The wildlife resource analysis area covers pipeline alignments and other proposed facilities below Pueblo Reservoir, and streams and reservoirs that could be indirectly affected by changes in hydrology. The wildlife resources analysis area also includes agricultural land that would be affected by rotational fallowing or permanent removal of irrigation water. Because wildlife species are mobile and can be influenced beyond the boundaries of construction footprints, the analysis area includes an approximate buffer of a half-mile around proposed facilities, including pipelines, pump stations, storage tanks, and treatment plants.

A literature search was performed to identify terrestrial wildlife species that could be present in the analysis area. Existing information was reviewed, and special concerns related to the project were identified through coordination and consultation with the U.S. Fish and Wildlife Service, Colorado Division of Parks and Wildlife, and Colorado Natural Heritage Program. The U.S. Fish and Wildlife Service has confirmed the list of threatened and endangered species to be considered in the AVC EIS (2011). Wildlife habitat was identified based on site reconnaissance from publicly accessible areas, vegetation mapping, aerial photography, and review of the best available published data and mapping. Wildlife habitat was based on the vegetation community types described in Chapter 3 - *Vegetation and Wetland*. Common and scientific names for the species described in this section are in Appendix J.

Affected Environment

The following affected environment section on wildlife resources gives an overview of wildlife habitat, then discusses specific federally listed endangered and threatened species, and species of concern; state-listed threatened and endangered species, and species of concern; birds of conservation concern in Colorado; other sensitive wildlife species; and other types of wildlife species. Wildlife migration and movement corridors are also discussed. Two geographic areas are addressed: the Upper Arkansas River (above Pueblo Reservoir) and the Lower Arkansas River (between Pueblo Reservoir and Lamar, including the proposed pipeline spur to Eads).

Overview of Wildlife Habitat in Analysis Area

Most of the analysis area consists of six terrestrial habitat types: upland grasslands, upland shrublands, upland woodlands, agricultural land, disturbed/developed lands, and wetlands and riparian habitat associated with the Arkansas River, tributaries to the Arkansas River, and reservoirs. The Upper Arkansas River is in the Southern Rocky Mountain subregion of the Rocky Mountain system. The Lower Arkansas River is within the High Plains subregion of the Great Plains system, which encompasses central portions of the United States (USGS 2010b).

Grassland and shrubland areas provide habitat for a variety of species, including small animals such as desert cottontail, black-tailed jackrabbit, vole, mouse, and ground-nesting birds, such as horned lark, meadow lark, lark sparrow, and killdeer. Larger mammals, such as mule deer, bighorn sheep, and pronghorn, are found in areas dominated by grassland and shrub species. Grasslands, shrublands, and upland juniper woodlands near Pueblo Reservoir are dominated by a series of bluffs and shaley hillsides that provide habitat for Mexican woodrat, northern rock mouse, fence lizard, and prairie rattlesnake. Several species considered state sensitive also use grasslands, including the black-tailed prairie dog, swift fox, mountain plover, ferruginous hawk, Texas horned lizard, massasauga rattlesnake, and Colorado buckwheat blue butterfly.

Species associated with agricultural and disturbed/developed lands consist mostly of generalist species that inhabit a variety of habitat. Small animals common in agricultural or disturbed areas include barn swallow, black-billed magpie, mourning dove, house and deer mouse, desert cottontail, and bullsnake. Predators common in these areas include raccoon and red fox. Some state sensitive species, such as ferruginous hawk, roundtail horned lizard, and swift fox, occasionally use agricultural areas.

Riparian and wetland habitats provide shelter and foraging areas for numerous amphibians and reptiles, birds, small and large mammals, and invertebrates. Common species in these areas are nonnative bullfrog, plains gartersnake, redwing blackbird, Lewis's woodpecker, great-blue heron, wild turkey, raccoon, beaver, meadow vole, and white-tailed deer. Sensitive bird species, including the federally listed piping plover and least tern, depend on playas and sandbar/shorelines along rivers and reservoirs in the area. State sensitive amphibians consist of Couch's spadefoot and plains and northern leopard frog, which depend on wetland areas for breeding.

Federally Listed Endangered and Threatened Species and Species of Concern

Potential habitat exists within the Lower Arkansas River analysis area for two federally listed species: the interior least tern and piping plover, and for the lesser prairie chicken, proposed for listing as a threatened species. Other federally listed species were evaluated and eliminated from further analysis because the analysis area lacks suitable habitat (Appendix J). Additionally, the Lower Arkansas River analysis area is within a black-footed ferret block clearance area for black-tailed prairie dog towns (U.S. Fish and Wildlife Service 2009). A block clearance area is an area of land in which the U.S. Fish and Wildlife Service has determined that a federally listed species no longer exists. An area that has been block cleared for a particular species does not require surveys for that species.

Federally listed species are defined in Chapter 3 - *Vegetation and Wetlands*. Candidate species are defined in Chapter 3 - *Aquatic Life*. Federally listed species and federal candidate species considered in this EIS are described below.

Interior Least Tern and Piping Plover The interior least tern (least tern) is the smallest of North American terns and is a federally and state-listed endangered species. The piping plover is a small shorebird and is a federally and state-listed threatened species. No critical habitat is designated for either species in the analysis area. Breeding habitat and threats to both the least tern and piping plover are similar, and often these species nest in the same general location. Threats to these species include habitat destruction; disturbance by humans and pets; high levels of predation on adults, eggs, and young; fluctuating water levels above and below dams; invasion of saltcedar; and contaminants (Corps 2007; Thompson et al. 1997; Burger and Gochfeld 1990; Figg 1993; Elliott-Smith and Haig 2004).

Source: Courtesy of U.S. Fish and Wildlife Service
Photo 3–40. Least tern

Nesting attempts by these species in Colorado frequently fail because of predation by rodents and carnivores, but both species will renest multiple times after failed attempts. In Colorado, least terns and piping plovers arrive on breeding grounds in early to mid-May. The breeding habitat consists of open, sparsely vegetated areas with alkali or unconsolidated substrates. The nests are shallow scrapes on sand or gravel beaches and islands of man-made reservoirs in the Lower Arkansas River Valley, including John Martin, Adobe Creek, and Neegronda reservoirs (Kingery 1998; Nelson 2010; Colorado Breeding Bird Atlas II 2011). Nesting habitat at reservoirs is unpredictable, and the distribution and abundance of the least tern varies annually among and within individual reservoirs in response to water levels and the distribution and extent of shoreline.

Source: Courtesy of U.S. Fish and Wildlife Service
Photo 3–41. Piping plover

The number of breeding pairs of least terns has fluctuated between 11 and 25 since 1990; piping plover pairs have fluctuated between zero and 9 since 1990. Breeding populations of both species suffered as a result of a severe hailstorm in 2009. In 2010, seven pairs of least terns nested at John Martin Reservoir, five pairs attempted to nest on islands at Adobe Creek Reservoir, and two pairs successfully nested at a new site: an active gravel pit 15 miles east of Lamar (Nelson 2010). Piping plovers in the Arkansas River Valley dropped from eight pairs to six pairs in 2010. Five pairs nested at John Martin Reservoir and one pair nested at Neegronda Reservoir.

Lesser Prairie Chicken The lesser prairie chicken was proposed for listing as a threatened species under the Endangered Species Act in November 2012 and is currently considered a threatened species by the state of Colorado. However, there are no known leks, or breeding grounds in the analysis area. This species is usually found in mixed-grass dwarf-shrub vegetation associations, typically on sandy soils with open, rolling topography (Robb and Schroeder 2005). In Colorado, this species is found in sandsage and sandsage-bluestem grasslands, and depends on these short and mixed grass prairies for breeding and winter forage. The distribution of the lesser prairie chicken in Colorado is primarily in southeastern Baca County, but it also occurs in Kiowa and Prowers counties. The decline in this species is primarily due to a loss of native prairie as a result of agriculture and overgrazing of livestock (Kingery 1998).

Source: Courtesy of USGS
Photo 3–42. Lesser prairie chicken

State Threatened and Endangered Species and Species of Concern

State-listed threatened and endangered species, and species of concern are protected under Colorado Statute 33 (Colorado Revised Statute Section 33-1-101-124), which defines the state's policy to protect, preserve, enhance, and manage wildlife species and their environment. Colorado maintains a list of species determined to be threatened, endangered, or of concern (Colorado Division of Wildlife 2010). The Colorado Wildlife Commission issues regulations and develops management programs for Colorado species; regulations and programs are then implemented by Colorado Parks and Wildlife.

In addition to state-listed species included on the federal list, potential habitat exists within the analysis area for 1 Colorado-listed threatened species (western burrowing owl) and 15 species of special concern. Although each of the state species has a unique set of habitat requirements, they can be placed into two broad categories based on their habitat affinities: upland species and riparian/wetland species (Appendix J).

Source: Courtesy of U.S. Fish and Wildlife Service
Photo 3–43. Burrowing owl

Upland Species State-listed upland species include the black-tailed prairie dog, western burrowing owl, ferruginous hawk, long-billed curlew, swift fox, common kingsnake, massasauga (rattlesnake), roundtail and Texas horned lizards, and triploid checkered whiptail. Most of these upland species are wide-ranging grassland species. Black-tailed prairie dogs occur in upland habitat throughout the analysis area; and several species, including the burrowing owl, ferruginous hawk, and swift fox, are often closely associated with the habitat provided by prairie dog colonies. Habitat for the massasauga, Texas horned lizard, and triploid checkered whiptail is found in Pueblo and Otero counties, near Fountain Creek, or along the Lower Arkansas River. These three species generally avoid urbanized areas (Colorado Natural Diversity Information System 2011). The common kingsnake and roundtail horned lizard occur in Otero County within the vicinity of La Junta. Townsend's big-eared bats could roost in upland rock outcrops surrounding Pueblo Reservoir and forage in nearby riparian woodlands along the Arkansas River. Townsend's big-eared bats are unlikely to roost and forage east of Pueblo.

Source: Courtesy of U.S. Bureau of Land Management
Photo 3–44. Mountain plover

In May 2011, the mountain plover was removed from federal listing consideration, but remains a state species of concern. Mountain plovers occur widely throughout southeast Colorado (Kingery 1998). Mountain plovers nest in areas with extensive patches (30 percent or more) of bare ground and are often found in disturbed habitats, burned prairie, fallow agricultural fields, and prairie dog colonies (Knopf and Wunder 2006). Mountain plovers avoid vegetation taller than 6 inches, and hillsides or steep slopes. Suitable habitat for plovers exists in low-growing vegetation with extensive bare ground and minimal shrubs in Pueblo, Crowley, Otero, Kiowa, and Prowers counties. Mountain plover have been recorded within or near the analysis area around North Avondale, La Junta and Lamar (Kingery 1998; Colorado Breeding Bird Atlas II 2011). Threats to the mountain plover include conversion of grassland, changing agricultural practices in wintering areas, energy and mineral development, loss of breeding habitat associated with burrowing mammals, human disturbance, direct and indirect effects of pesticides, and influences of annual weather variation.

Source: Courtesy of U.S. Bureau of Land Management
Photo 3–45. Leopard frog

Wetland/Riparian Species Wetland and riparian areas provide suitable habitat for the northern leopard frog and bald eagle throughout the analysis area, and for Couch's spadefoot and plains leopard frog along the Lower Arkansas River. Amphibians within the region require a temporary or permanent water source for breeding. The range of the plains leopard frog in Colorado includes the southeastern portion of the state. Habitat for this species occurs along the Arkansas River, tributaries, playas, wetlands, and reservoirs from eastern Pueblo County to the state border. The northern leopard frog occurs in wetlands, playas, and streams throughout northern and western Colorado, including Kiowa County. Couch's spadefoot requires a water source for breeding but may occur in upland areas far from water sources later in the season (Hammerson 1999). Couch's spadefoot is known to be in Otero and Bent counties in Colorado (Hammerson 1999).

Source: Courtesy of U.S. Fish and Wildlife Service
Photo 3–46. Bald eagle

The bald eagle is found in riparian areas throughout Colorado. Although the bald eagle was officially removed from the federal list of threatened and endangered species in 2007, it remains listed as a Colorado threatened species and continues to be federally protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. The Upper and Lower Arkansas River is considered winter range and winter foraging for the bald eagle (Colorado Natural Diversity Information System 2011). Additionally, Twin Lakes, Pueblo Reservoir, Lake Meredith, Lake Henry, John Martin Reservoir, and segments of the Upper Arkansas River are considered winter concentration areas for the bald eagle.

Winter concentration areas are sites (trees and islands) within an existing winter range where eagles concentrate between November 15 and April 1. These areas may be associated with roosting sites.

Winter foraging areas are frequented by wintering bald eagles between November 15 and March 15. These may be large areas radiating from preferred roosting sites.

Winter range areas are where bald eagles have been observed between November 15 and April 1.

The western snowy plover is a shorebird that nests along sandbars and sandy shorelines adjacent to wetland areas containing permanent water. Western snowy plovers often nest in the same areas as least terns and piping plovers. Known nesting sites in Colorado are on the shores of reservoirs in Bent, Otero, Crowley, and Kiowa counties, although western snowy plovers do not currently nest at John Martin Reservoir (Kingery 1998; Colorado Breeding Bird Atlas II 2011).

Birds of Conservation Concern in Colorado

The Birds of Conservation Concern lists birds of high priority for conservation within geographical regions having similar ecological and physical characteristics. Eastern Colorado is within Bird Conservation Region 18, the Shortgrass Prairie. Bird Conservation Region 18's list of Birds of Conservation Concern is provided in Appendix J. The 1988 amendment to the Fish and Wildlife Conservation Act mandates the U.S. Fish and Wildlife Service to "identify species, subspecies, and populations of all migratory non-game birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act of 1973." Birds of Conservation Concern (U.S. Fish and Wildlife Service 2008) is the most recent effort to carry out this mandate. The Bird Conservation Regions are useful to federal land-managing agencies in their efforts to abide by the bird conservation principles embodied in the Migratory Bird Treaty Act and Executive Order 13186, "Responsibilities of Federal agencies to protect migratory birds" (Clinton 2001).

Other Sensitive Wildlife Species

The Colorado buckwheat blue butterfly is considered imperiled by the Colorado Natural Heritage Program and occurs in the analysis area (Appendix J). The Colorado buckwheat blue butterfly inhabits grassland habitat containing the food plant *Erigonum effusum* (spreading buckwheat). This species has been found in grassland habitat between Pueblo and Lamar. The Colorado Natural Heritage Program tracks wildlife species that are critically imperiled, imperiled, vulnerable, or secure within Colorado (Colorado Natural Heritage Program 2010a). Species considered critically imperiled or imperiled in Colorado are labeled as S1 or S2 species.

Other Wildlife

The analysis area contains habitat for a variety of other more common species. Game animals are protected and regulated by state game laws. Migratory birds, which include most bird species, are protected by federal laws. All wildlife, including birds, large and small mammals, amphibians, and reptiles, are considered property of Colorado and are regulated by state statute.

Game Animals Game animals are considered economically important species in Colorado, particularly large game species such as elk and deer. Large game mammals found within the EIS study area include American elk (primarily limited to the Upper Arkansas River Basin), bighorn sheep (also limited to the Upper Arkansas River Basin), mule deer, white-tailed deer, and pronghorn. Important upland game birds found within the analysis area include introduced species such as wild turkey (Rio Grande subspecies), ring-necked pheasant, and northern bobwhite. Much of the Arkansas River floodplain provides high-quality waterfowl habitat and hunting in state wildlife areas, on leased properties, and at private hunting clubs. Most of the EIS study area also provides potential habitat for small game mammals, such as the cottontail rabbit and carnivores such as the coyote, red fox, and badger.

American elk primarily inhabit the western two-thirds of the state but are occasionally found east of the Front Range foothills. Although elk tend to migrate from lower elevations used in winter to higher elevations in spring and summer, some herds are relatively sedentary. Elk winter range and winter concentration areas occur within the Upper Arkansas River Basin west of Pueblo Reservoir (Colorado Natural Diversity Information System 2011).

Bighorn sheep primarily occur within mountain and foothill regions throughout the western two-thirds of the state. Bighorn sheep make short (generally 3 to 9 miles) seasonal migrations from summer to winter ranges (Fitzgerald et al. 1994). Bighorn sheep summer and winter range areas occur in the Upper Arkansas River Basin west of Pueblo Reservoir (Colorado Natural Diversity Information System 2011).

Mule deer occupy all ecosystems from grasslands to alpine tundra. They generally migrate seasonally, spending summer months at higher altitudes and moving to lower elevations during winter. Mule deer severe winter range and winter concentration areas occur east of Pueblo Reservoir and from John Martin Reservoir northward into southern Kiowa County (Colorado Natural Diversity Information System 2011).

White-tailed deer are less widespread and more secretive than mule deer. In Colorado, white-tailed deer occupy a variety of habitats but are typically associated with riparian woodlands and irrigated agricultural lands of the eastern plains (Fitzgerald et al. 1994). White-tailed deer also occupy shrublands that provide plentiful forage and cover. White-tailed deer do not typically make significant seasonal migrations. Their concentration areas occur within the Lower Arkansas River portion of the analysis area along the Arkansas River downstream from La Junta and near John Martin Reservoir (Colorado Natural Diversity Information System 2011).

American pronghorn inhabit grasslands and semidesert shrublands on rolling topography that provides good visibility (Fitzgerald et al. 1994). Pronghorn tend to favor vast open areas and are typically sensitive to human presence, including residential and commercial development (Sawyer et al. 2005). The Lower Arkansas River portion of the analysis area is within the overall range for this species. Pronghorn winter concentration areas are present in southern Kiowa County (Colorado Natural Diversity Information System 2011).

Photo 3–47. Pronghorn

Upland game birds, such as the wild turkey (Rio Grande subspecies), ring-necked pheasant, and northern bobwhite, have close association with riparian forests and may forage in cropland and rangelands along the Lower Arkansas River (Kingery 1998). The Lower Arkansas River is also an important waterfowl breeding and winter concentration area.

Raptors, Herons, and Other Migratory Birds Nearly all bird species in Colorado are protected under the Migratory Bird Treaty Act. Bird species use different habitat types in the analysis area for shelter, breeding, wintering, and foraging at various times of the year. The EIS study area contains habitat for migratory birds.

Raptors commonly occur year-round throughout the analysis area, and include red-tailed hawk, great horned owl, and American kestrel. Other raptors likely to occur in the analysis area are Cooper's hawk and Swainson's hawk in summer, and ferruginous hawk, northern harrier, and rough-legged hawk in winter. Raptors frequently return to the same nest each year or build two or more alternate nests that are used in different years. Raptors also may build new nests and abandon existing nests over time.

Source: Courtesy of U.S. Fish and Wildlife Service
Photo 3–48. Great blue heron

Great blue heron rookeries and communities are found at locations within both the lower and Upper Arkansas River portions of the analysis area. An extensive heron nesting area containing several active and alternate rookeries exists on the Arkansas River near the upper end of Pueblo Reservoir. Known or historical nesting areas occur at four locations near reservoirs and along the Lower Arkansas River, east of Las Animas. The great blue heron is a large, colonial nesting waterbird that inhabits reservoirs and rivers. Breeding colonies are in groves of live or dead trees standing in or near reservoirs and rivers (Colorado Natural Diversity Information System 2011). Great blue herons breed in Colorado from mid-March to August and return to the same nest annually. This species has an extended nesting period that spans nearly 5 months, from late March through July (Kingery 1998).

Common smaller songbirds likely to be in upland areas dominated by grasslands and shrublands include the killdeer, western meadowlark, lark sparrow, horned lark, Cassin's sparrow, lark bunting, American kestrel, and burrowing owl. Species likely to nest among trees in grassland or agricultural habitats in the analysis area include the mourning dove, eastern kingbird, Bullock's oriole, and black-billed magpie (Kingery 1998; Andrews and Righter 1992). Shale areas near Pueblo Reservoir that contain a mixture of grasslands, shrublands, and juniper woodlands provide habitat for the spotted towhee, scrub jay, dusky flycatcher, and chipping sparrow.

Trees and shrubs associated with riparian woodland vegetation along the Arkansas River and smaller tributaries provide nesting and foraging habitat for tree- and cavity-nesting bird species such as the American robin, house wren, Bullock's oriole, tree swallow, chickadee, flicker, woodpecker, and warbler. Wetlands and open water habitat in the analysis area provide potential breeding and foraging habitat for species such as the red-winged blackbird, yellow-headed blackbird, song sparrow, and common snipe. The American coot and various duck species, including the American widgeon, blue-winged teal, and mallard, may nest in cattail stands or along the shorelines of open water. Shorebirds, such as spotted sandpiper and American avocet, may also nest and forage on shorelines.

Small Mammals Small mammals are likely abundant within the analysis area, and include various small rodents and bats. Grassland, shrubland, and agricultural land within the analysis area provide habitat for black-tailed and white-tailed jackrabbit, desert cottontail rabbit, and Ord's kangaroo rat. Other small mammals that likely live in grassland and agricultural areas are the thirteen-lined ground squirrel, spotted ground squirrel, plains pocket gopher, olive-backed pocket mouse, silky pocket mouse, hispid pocket mouse, and deer mouse.

Photo 3–49. Cottontail

Wetlands and riparian areas along the Arkansas River, streams, and irrigation ditches provide potential habitat for a variety of mammals, such as the raccoon, white-footed mouse, muskrat, and western harvest mouse. Deciduous trees in riparian areas provide roosting sites for bats such as the hoary bat, little brown myotis, and silver-haired bat.

Photo 3–50. Prairie rattlesnake

Amphibians and Reptiles Most amphibian species in the analysis area are likely to inhabit wetlands and areas containing a water source throughout much of the year. The largest areas of suitable habitat for amphibians are wetlands in the Lower Arkansas River Valley. Rivers, lakes, playas, and stock ponds or tanks provide suitable breeding habitat for amphibians such as tiger salamanders and plains leopard frogs. Some amphibian species, including plains spadefoot, New Mexico spadefoot, Great Plains toad, and Woodhouse's toad, live in drier areas in shortgrass and midgrass prairie and shrublands; can tolerate extended dry periods; and may be found considerable distances from water (Hammerson 1999). Eighteen species of amphibians occur in Colorado, with the greatest diversity present in the extreme southeastern portion of the state.

Reptile species likely to occur in wetland areas within the Lower Arkansas River portion of the analysis area include the painted turtle, soft-shelled turtle, snapping turtle, northern water snake, and western terrestrial gartersnake. Wide-ranging reptile species that potentially occur within the EIS study area include the eastern fence lizard, short-horned lizard, bullsnake, western terrestrial gartersnake, and western rattlesnake. Colorado supports a number of reptilian species; the highest diversity of reptiles occurs along the West Slope and the southeastern corner of the state. Reptiles are not as dependent on water as amphibians, but wetter habitats tend to support a higher diversity of species (Hammerson 1999).

Wildlife Migration and Movement Corridors

Colorado Parks and Wildlife has identified areas throughout the state that are consistently used as corridors during migration or traveling between summer and winter ranges. As described above, no wildlife migration corridors have been identified within the analysis area (Colorado Natural Diversity Information System 2011). Movement corridors are areas that link two or more large habitat areas or provide for movements and exchange of genetic information between wildlife populations separated by geographic features or human activities. The Arkansas River, and tributaries such as Fountain Creek and irrigation canals, serve as wildlife movement corridors within the analysis area.

Human Environment

Photo 3–51. Typical pipeline construction activities

Several aspects of the human environment could potentially be affected by construction, including temporary effects on noise and vibration, visual quality, traffic, and utility service, and possible longer term effects on visual quality and land use. Noise and vibration are a concern because of the potential disturbance to residents, businesses, and other human activity from elevated noise levels and vibration from construction equipment and earthwork. Visual resources are a topic of concern because of the potential effect from construction-related ground disturbance, vegetation clearing, construction of new aboveground facilities, and potential changes in reservoir water levels and streamflow that could affect visual quality. Traffic is being evaluated because construction in some locations may result in temporary effects from traffic delays, detours, and increased construction traffic. Utilities are of concern because of the potential disruption in utility service to residents and businesses during construction. Land use is also considered because of potential effects on residents, business, agriculture, and other land uses from construction.

Methods

The human environment analysis area includes areas that could be affected by hydrologic operations and construction activities. Ambient noise characteristics for the analysis area are based on existing noise sources and receptors. Ambient vibration levels in the analysis area are typically associated with transient construction activities and vibration associated with mining, railroads, and roads. Noise is usually defined as unwanted or unacceptable sound, and is measured in terms of decibels scaled to approximate the hearing capability of the human ear. The decibel scale ranges from zero decibels at the threshold of human hearing to 120 to 140 decibels, where sound is typically painful. A peaceful residential neighborhood usually ranges from 40 to 50 decibels; a busy urban street or within 50 feet of a major freeway ranges from 70 to 80 decibels; and heavy machinery usually ranges from 85 to 90 decibels. Figure 3–22 illustrates human hearing ranges in decibels for various activities. The gradual change in color from green to red indicates the approximate decibels levels above ambient levels typical in the analysis area, as described below.

Visual resources include the proposed area of disturbance for constructing project components, as well as reservoirs and streams where potential changes in storage or flow are anticipated. The visual qualities of the analysis area can be separated into several primary categories: modified landscapes, including urban areas; rural areas; natural areas such as the Arkansas River; reservoirs; the Santa Fe Trail Scenic and Historic Byway; and the Santa Fe National Historic Trail.

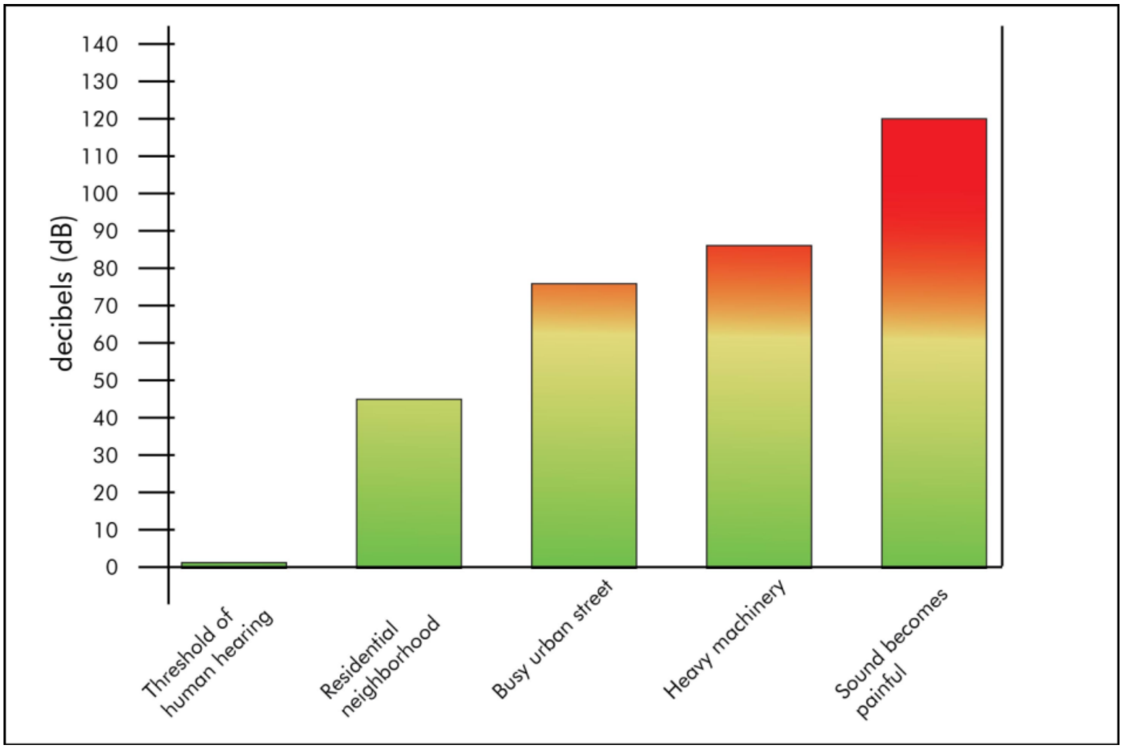


Figure 3–22. Human Hearing Ranges for Various Activities

The existing visual quality for the analysis area was evaluated from aerial photography, site visits, knowledge of scenic resources in the area, and existing published studies and plans (Santa Fe Trail Scenic and Historic Byway Colorado's Mountain Branch 2008; Reclamation 2008).

Traffic resources include existing highways, roads, and railroad lines within the analysis area. The location of existing transportation corridors was taken from publicly accessible GIS data layers.

Utilities in the analysis area include pipelines (water, sanitary, storm sewer, and natural gas), and power, telephone, telecommunication, fiber-optic, and overhead lines. Irrigation canals, ditches, pipelines, and other irrigation facilities are also included in this analysis. Information on the locations and quantities (miles) of existing utilities in the analysis area was taken from multiple city and county data sources.

Types of land use in the analysis area include agricultural, commercial, industrial, residential, and governmental. Information on land use was not available for areas east of Pueblo County; therefore, the effects analysis only includes Pueblo County. Zoning data were compiled from the Pueblo Web site (City of Pueblo 2012).

Affected Environment

The affected human environment in this EIS includes noise and vibration, visual resources, traffic, utilities, and land use.

Noise and Vibration

Pueblo is characterized as an urban area with typical negligible ambient vibrations and moderate ambient noise levels (55 to 70 decibels). Rural towns such as La Junta, Las Animas, and Lamar, typically have a low ambient noise level of about 45 to 55 decibels, except near major roads. Railroad tracks parallel state Highway 96 in the analysis area and U.S. Highway 50 between Fowler and Las Animas. Ambient noise and vibration increases in areas near railroad tracks when a train passes, although small towns typically have a negligible ambient vibration level from passing traffic and trains. State Highway 96 and U.S. Highway 50 are the principal highways east of Pueblo that parallel the alternative pipeline corridors. Both of these highways are classified by the Colorado Department of Transportation as rural regional highways. Cars and trucks using the rural highways result in ambient noise levels of about 55 to 65 decibels, while large agricultural equipment can generate noise levels up to 96 decibels.

Visual Resources

Modified landscapes include urban and suburban developments supporting residential, commercial, and industrial infrastructure, such as those found in and surrounding Pueblo. Residential areas contain landscaped yards with mowed grasses, shrubs, and mature trees. Commercial and industrial areas are dominated by paved parking areas, roads, and structures. Smaller rural communities generally have more confined areas of commercial development along major roads surrounded by residential neighborhoods.

Photo 3–52. Rural landscape near Pueblo, from U.S. Highway 50

The rural landscape within the analysis area extends from east of Pueblo to Lamar. Views offer subtle variations in landform, color, and texture. Rural area landforms include rolling low hills, flat agricultural fields, and prairies. Natural vegetation communities include sagebrush communities and native shortgrass prairie. Natural landscapes in the analysis area are nearly void of visible rock outcrops and trees except along creeks and rivers. Vegetation in natural areas is predominately low-growing grasses, wildflowers, and cacti. Rural agricultural landscapes include crops such as winter wheat or corn, fallow fields, or pastureland with low-growing nonnative vegetation and intermittent streams with narrow, linear, riparian areas composed of cottonwood and Russian olive trees, native willows, and saltcedars. Because of the flat topography, visual resources of the rural landscapes offer unobstructed views. Distant mountains are typically visible to the west, and large areas of the sky and changing weather conditions can be seen in all views.

The Arkansas River is bordered by modified landscapes west of Pueblo and by rural landscapes throughout most of the analysis area east of Pueblo. The Lower Arkansas River is a meandering stream with shallow flows most of the year and banks vegetated with mature cottonwood trees, willows, and saltcedar.

The visual landscape includes man-made reservoirs such as Pueblo Reservoir, Lake Meredith, Lake Henry, Holbrook Reservoir, and John Martin Reservoir. Pueblo Reservoir has relatively steep, unvegetated slopes. The slopes of the other reservoirs are less steep and infrequently vegetated. Riparian vegetation, including native cottonwood trees and willows and nonnative Russian olives and saltcedar, are typically seen near the tributaries to the reservoirs.

Photo 3–53. Pueblo Reservoir

Photo 3–54. Arkansas River downstream from Pueblo

A portion of the Santa Fe National Historic Trail lies within the analysis area, thus the State of Colorado Byways Commission designated a segment of Highway 50 as a Colorado Scenic and Historic Byway in 1998 (Santa Fe Trail Scenic and Historic Byway Colorado's Mountain Branch 2008). Within the analysis area, the Santa Fe Trail Scenic and Historic Byway extends west along the U.S. Highway 50 alignment from La Junta to Lamar. Scenic vistas, cultural experiences, historical and archaeological sites, recreational opportunities, and natural resources can all be encountered along the byway. Although most of the original trail itself is no longer intact or visible, the byway's scenic qualities include irrigated croplands and other characteristics of the rural landscapes that border the byway. According to the *Byway Corridor Management Plan* (Santa Fe Trail Scenic and Historic Byway Colorado's Mountain Branch 2008), significant scenic qualities in the analysis area include the following:

- Picturesque windmills and other evidence of homesteads and settlements
- Small-scale agriculture, including rural communities and quaint, roadside farm stands that sell locally grown produce
- Clear viewsheds and open vistas as a result of minimal commercial, industrial, or residential development over much of the byway

Traffic

The analysis area contains interstate highways, U.S. highways, and state highways, as well as county and local roads that could be affected by proposed construction activities. Principal highways within the analysis area include Interstate 25, which extends north-south through Pueblo; and U.S. Highway 50, which extends east from Pueblo along the south side of the Arkansas River through Avondale, Fowler, Rocky Ford, Swink, La Junta, Bents Fort, and Las Animas, to Lamar. U.S. Highway 287 extends north-south at the eastern edge of the analysis area through Lamar and Eads. U.S. Highway 96 travels east from Pueblo north of the Arkansas River through Boone and Olney Springs, to Ordway (Appendix B).

The analysis area also includes existing and abandoned railroads. Railroad lines parallel U.S. Highway 50 and state Highway 96 within the analysis area. The railroad lines within the analysis area are owned and operated by Burlington Northern Santa Fe, Union Pacific, and Colorado and Kansas Pacific railroads (Colorado Department of Transportation 2006).

Utilities

The highest concentration of utilities in the analysis area occurs within Pueblo County, particularly through Pueblo. In areas east of Pueblo, the highest concentration of utilities occurs in small, rural towns (Lamar, La Junta, etc.) and along highway rights of way, such as U.S. Highway 50 and state Highway 96. Irrigation canals, ditches, pipelines, and other irrigation facilities occur primarily in the agricultural portions of the analysis area.

Land Use

For the most part, development in Pueblo County has revolved around the growth of Pueblo. However, there is a fairly large population living in unincorporated areas immediately outside the city limits, in agricultural areas such as the St. Charles Mesa, or in more remote areas such as Avondale, Boone, Rye, Beulah, and the Metro Districts of Pueblo West and Colorado City (Pueblo Area Council of Governments 2002). Land use within Pueblo County is primarily residential in the analysis area, followed by governmental (federal, state, and local buildings and their associated properties, and federal, state, and locally managed lands), commercial, and industrial. While there is some agricultural use within Pueblo County, most agricultural use in the analysis area lies east of Pueblo County. Although land use and zoning maps are not available east of Pueblo County, agricultural and rural residential land uses comprise the majority of this portion of the analysis area outside of small communities.

Socioeconomic Resources

Construction and operation of the alternatives could affect socioeconomic conditions in the study area. Indicators of regional economic conditions discussed in this section include population, education, personal income, poverty rates, home ownership, employment and earnings by industrial sector, recreation, and agriculture.

Methods

The analysis area for socioeconomics is broader than for other land-based resources and includes Chaffee, Fremont, Custer, El Paso, Pueblo, Crowley, Otero, Bent, Prowers, and Kiowa counties. Socioeconomic data were gathered and summarized for each economic indicator. Data were obtained from the U.S. Census Bureau, U.S. Department of Labor, U.S. Department of Agriculture, U.S. Department of Commerce, and Colorado Department of Natural Resources.

Affected Environment

Larger cities in the analysis area include Pueblo, Fowler, Ordway, Rocky Ford, La Junta, Las Animas, and Lamar. Pueblo in Pueblo County is an important regional center and is the largest town within the analysis area. Colorado Springs in El Paso County is the second largest urban area in Colorado and an important regional center, although it is upstream from the analysis area. The largest sectors in the region based on earnings and employment are state and local government, agriculture, services, and retail trade.

Population

The analysis area east of Pueblo is mostly rural, with small urban centers in Bent, Crowley, Kiowa, Otero, and Prowers counties. Most of Chaffee, Custer and Fremont counties are also rural. The U.S. Census Bureau (2000) estimated the analysis area's population as 772,227 in 2000, and 895,326 in 2010, an increase of 15.9 percent. Population increased in Bent, Chaffee Crowley, Custer, El Paso, Fremont, and Pueblo counties, but decreased in Kiowa, Otero, and Prowers counties between 2000 and 2010. Table 3–8 shows population estimates for 2000 and 2010 by county (U.S. Census Bureau 2010).

Table 3–8. Population of Analysis Area Counties

Counties	2000 Census	2010 Census	Change (%)
Chaffee	16,242	17,809	9.6
Fremont	46,145	46,824	1.5
Custer	3,503	4,265	21.8
El Paso	516,933	622,263	20.4
Pueblo	141,472	159,063	12.4
Crowley	5,518	5,823	5.5
Otero	20,311	18,831	-7.3
Bent	5,998	6,499	8.4
Prowers	14,483	12,551	-13.3
Kiowa	1,622	1,398	-13.8
Total	**772,227**	**895,326**	**15.9**
Colorado	**4,302,015**	**5,024,748**	**16.8**

Source: U.S. Census Bureau 2010

Education

Education is one indicator of the labor force's skill level and is a measure of the analysis area's attractiveness to businesses and industries considering expanding or locating there. The high school graduation rate for each county in the analysis area ranges from 77 percent to 91 percent, and the average is 87 percent. The state average for high school graduates is also 87 percent, while the national average is approximately 80 percent.

The percentage of the population with a bachelor's degree or higher ranges from 12 percent to 32 percent; the average for the analysis area is 23 percent. The state average is 33 percent; the national average is about 24 percent.

Education levels tend to be higher and closer to state averages in the Upper Arkansas River and Fountain Creek basins than in the Lower Arkansas River Basin, where education levels are generally below state averages. However, the overall high educational attainment rates in most of the analysis area indicate the availability of a highly skilled work force and the potential for well-paying jobs in the future.

Median Household and Per Capita Income, Poverty Rates, and Home Ownership

Bent, Crowley, Otero, and Prowers counties have lower median and per capita income levels and a higher poverty rate compared to the state average (Table 3–9). Chaffee, Custer, Fremont, El Paso, Kiowa, and Pueblo counties are close to the state average for median household and per capita income as well as the poverty level. Home ownership rates for counties in the analysis area are close to the state average of 68 percent, except for Chaffee, Custer, and Fremont counties, which are about 5 to 6 percent higher than the state average. Table 3–9 presents median household income, per capita income, poverty rate, and home ownership rates for the counties in the analysis area (U.S. Census Bureau 2010).

Table 3–9. Median and Per Capita Income, Poverty Levels, and Home Ownership

Counties	Median Household Income ($) (2010)	Per capita Income ($) (2010)	Poverty Level (%) (2010)	Home Ownership rates (%) (2010)
Chaffee	42,602	26,572	12.00	74.3
Fremont	39,714	19,816	18.10	74.6
Custer	48,898	26,539	13.90	72.6
El Paso	55,621	27,750	11.50	67.3
Pueblo	39,016	21,149	16.90	70.0
Crowley	29,104	18,299	53.00	68.5
Otero	30,373	17,996	23.60	66.2
Bent	30,890	16,189	37.20	66.5
Prowers	33,646	17,934	23.10	68.2
Kiowa	36,931	23,502	14.80	67.5
Colorado	**55,735**	**29,679**	**12.6**	**68.2**

Source: U.S. Census Bureau 2010

Personal Income, Employment, and Unemployment

U.S. Bureau of Economic Analysis data for total personal income, total earnings, earnings by sector, total employment, and employment by sector were collected for counties within the analysis area (see Appendix J.1 for detailed data). From 2000 to 2009, personal income and total earnings generally increased for most of the counties in the analysis area. Crowley County showed an 8 percent decline in total earnings during this period. For Bent (22 percent), Crowley (9 percent) Kiowa (44 percent), Otero (9 percent), and Prowers (18 percent) counties, the agricultural sector was one of the largest contributors to total earnings in 2009. In Pueblo County, the manufacturing sector accounted for more than 10 percent of total earnings in the county, while services (36 percent) and retail trade (8 percent) also contributed significantly to total earnings. Earnings by sector (other than government) show that the services and retail trade sectors had the largest earnings by sector in Chaffee, Fremont, and El Paso counties. For El Paso County, the presence of large military installations serves as a strong economic base, resulting in a large service and retail sector. Transportation, utilities, and communication are important in El Paso County.

Total employment from 2000 to 2009 increased in Chaffee, Fremont, Custer, El Paso, Crowley, Kiowa, and Pueblo counties. Employment declined during this period for Bent, Otero, and Prowers counties. In 2009, agricultural jobs were one of the larger contributors to total employment for Bent, Crowley, Kiowa, Otero, and Prowers counties. From 2000 to 2009, agricultural jobs declined in Bent, Kiowa, and Prowers counties. Manufacturing jobs also declined during this period for Prowers, Otero, and Pueblo counties (U.S. Department of Commerce 2000, 2009).

Based on income and employment data, the economy is somewhat diverse but has a strong agricultural economic base in Bent, Crowley, Kiowa, Otero, and Prowers counties. The past economic recession (2007–2009) has impacted income and employment in the analysis area as well as in other regions of Colorado and the nation.

The average 2010 unemployment rate for the Lower Arkansas River Basin is 8.2 percent, and less than the state average of 8.9 percent, while the unemployment rate for the Upper Arkansas River and Fountain Creek basins is 10.1 percent, which is higher than the state average. Chaffee, Fremont, El Paso, Crowley and Pueblo counties have unemployment rates greater than the state average. In 2000, the average unemployment rate for the analysis area was 3.7 percent, and the state average was 2.7 percent; all counties in the analysis area had unemployment rates greater than the state average (U.S. Bureau of Labor Statistics 2000, 2010).

Recreation

Recreation is an important part of the analysis area's socioeconomic environment. Recreational opportunities include camping, boating, fishing, and other water-based activities, as described in Chapter 3 - *Recreation*. Three major recreation sites could be affected by actions under consideration in this EIS: Lake Pueblo State Park at Pueblo Reservoir, John Martin Reservoir State Park on the Arkansas River, and the Arkansas Headwaters Recreation Area in Chaffee and Fremont counties.

A marketing report on Colorado state parks (Colorado State Parks 2009) estimated visitor expenditures to be about $97,848,400 (for all visitors) and $67,057,000 (for nonlocal visitors) for Lake Pueblo State Park; about $7,175,300 (for all visitors) and $5,854,000 (for nonlocal visitors) for John Martin Reservoir State Park; and about $54,722,000 (for all visitors) and $44,607,000 (for nonlocal visitors) for the Arkansas Headwaters Recreation Area. Nonlocal expenditures are from visitors who traveled 50 miles or more to the state park. Nonlocal visitor expenditures reflect the external economic impact to the local economy from outside the area visited. Since nonlocal visitor expenditures are not broken out on a county basis, a certain amount of these would contribute to counties through which the Arkansas Headwaters Recreation Area extends, such as Chaffee, Fremont, and Pueblo counties.

The state parks and recreation area are linked to water resources and contribute to local and regional economies through nonlocal recreation visitor expenditures, as mentioned. Other lakes and reservoirs in the analysis area, such as Lake Meredith, Horse Creek, Adobe Creek, and Neeskah and Neeroshe reservoirs, may also provide water-based recreational opportunities.

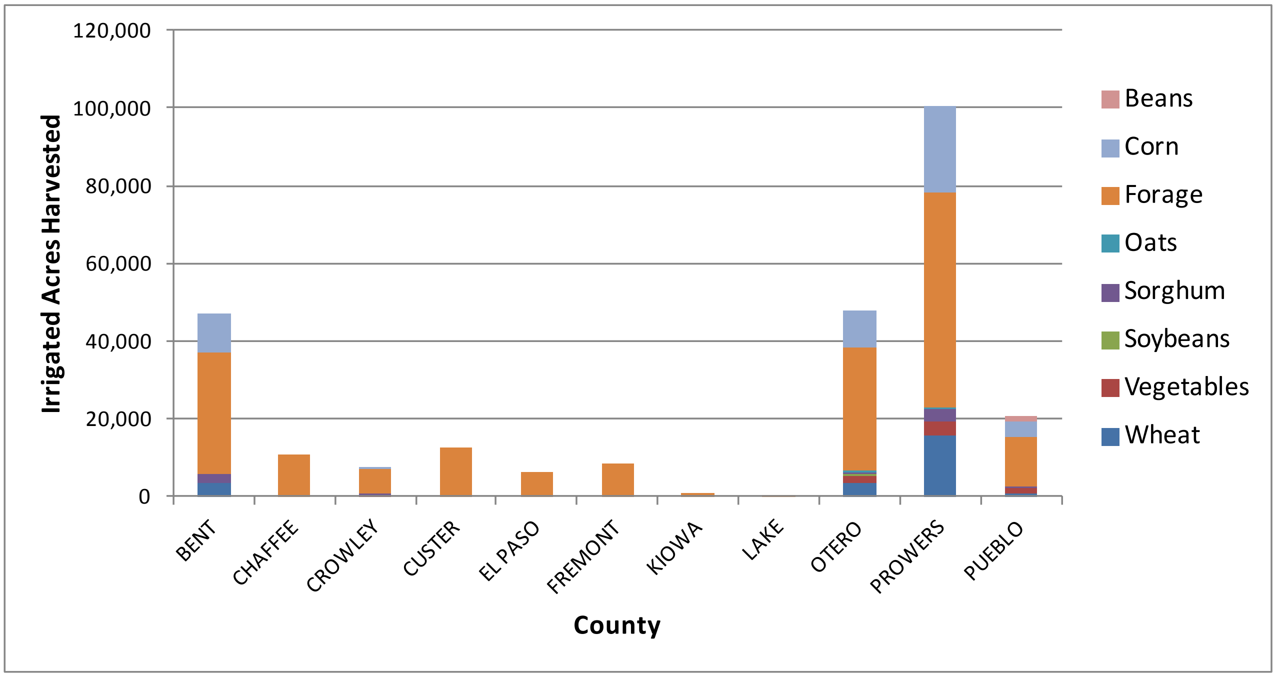
Agriculture

Agricultural production is an important component of the regional economy in the Lower Arkansas River Basin, and to some degree in the Upper Arkansas River and Fountain Creek basins. Total farmland (farmland, rangeland, and pastureland) in the analysis area in 2007 was 5,850,000 acres, about a 9.6 percent increase from 2002. Existing total irrigated land for the counties within the analysis area in 2007 was 284,436 acres, an increase of about 27 percent from 2002 (U.S. Department of Agriculture 2002, 2007). It should be noted that 2002 was a drought year that likely reduced agricultural productivity.

The number of farms rose between 2002 and 2007, with increases ranging from 43 percent (Custer County) to 10 percent (Pueblo County). The average size of farms during the same period generally declined for most of the counties (five of nine) in the analysis areas, from -2 percent (Otero County) to -42 percent (El Paso County). In 2007, the total number of farms was 4,442 (U.S. Department of Agriculture 2002, 2007). Tables summarizing agricultural and irrigation data from the 2007 and 2002 Census of Agricultural are presented in Appendix J.1.

The total market value of products sold in 2007 for counties in the analysis area was $660.5 million, an increase in total value of about 21 percent from 2002. All of the counties within the analysis area showed increases in total market values except Chaffee County, which had a 5 percent decline. In 2007, shares of crop and livestock sales included the following: 23 percent crop/77 percent livestock to 38 percent crop/62 percent livestock in Bent, Otero, Prowers, Pueblo, Chaffee, Custer, and Fremont counties. For Crowley County, the share of total sales was 1 percent for crops and 99 percent for livestock. El Paso County had a 50 percent split in total sales between crops and livestock.

Crops grown in the analysis area consist of corn (primarily for silage and grain but also for sweet corn); forage crops, such as alfalfa and other hay crops; wheat, soybeans, sorghum, beans, oats; and other specialty crops, such as melons, onions, and peppers. In counties upstream from Pueblo Reservoir and El Paso County, forage crops are primarily irrigated. Figure 3–23 shows acres harvested by county in 2007 (U.S. Department of Agriculture 2007). It should be noted that portions of each county are not within the physical footprint of the analysis area, but have irrigated land that would be included in the county-wide irrigated land estimates.



Data source: U.S. Department of Agriculture 2007

Figure 3–23. Arkansas River Basin Irrigated Crops

Environmental Justice

Environmental justice addresses the fair treatment of people of all races and incomes with respect to federal actions that affect the environment. Fair treatment implies that no group of people should bear a disproportionate share of negative impacts from an action. An evaluation of environmental justice impacts is mandated by Executive Order 12898 on Environmental Justice (February 11, 1994). The effects of an alternative can be considered disproportionately distributed if the percentage of total impacts imposed on a specific group is greater than the percentage of the total population represented by that group. Race, ethnicity, income, community, or some other characteristic can define a group.

Methods

Evaluating potential environmental justice concerns requires an understanding of where the effects are likely to occur and where potentially affected groups are located. The analysis relies on demographic data from sources such as the U.S. Census Bureau, individual counties, and municipalities, and local school districts to determine the location of different groups of people. Identifying the location of specific groups can be difficult when nonpermanent residents such as migrant workers are present because of poor demographic data availability. Census data do not account for all nonpermanent residents because some cannot be contacted or do not want to be counted. In addition, the 2010 Census tended to undercount the number of people in rural areas due to difficulties encountered with contacting residents in sparsely populated regions. However, census data are typically the most complete and comparable demographic and economic data available for individuals and households.

Affected Environment

The environmental justice analysis area includes alternative pipeline and facilities construction areas. Data for the analysis area (see Appendix L.1) indicate that the median household income was lower (by about 20 to 21 percent) in Bent, Crowley, and Prowers counties than the average median household income ($44,300) in the analysis area, as well as the state average of $56,222. Per capita income is lower than the analysis area average ($21,575) in Bent (-25 percent), Otero (-16 percent), Prowers (-17 percent), and Crowley (-15 percent) counties. Poverty rates were higher for Bent (31.7 percent), Crowley (25.3 percent), Otero (22.2 percent), and Prowers (30 percent) counties than the analysis area average of 18 percent, and significantly higher than the state average of 17.4 percent.

Table 3–10 presents the distribution of population by race and Hispanic/Latino origin from the 2010 U.S. Census in the analysis area. Data from this table indicate there is a significant Hispanic population, particularly in Bent, Crowley, Otero, Prowers, and Pueblo counties. These county-wide data provide general understanding of the analysis area, and will be examined in Chapter 4 at a smaller spatial scale to analyze potential effects.

Table 3–10. Race and Ethnicity for Analysis Area

County	% -White (not Hispanic)	%- African American (not Hispanic)	%- American Indian (not Hispanic)	%- Hispanic or Latino
Chaffee	86.6	1.5	0.8	9.4
Custer	92.0	1.0	0.5	4.7
Fremont	80.4	3.9	1.5	12.3
El Paso	72.0	5.8	0.6	15.1
Pueblo	54.1	1.7	0.6	41.4
Crowley	57.9	9.5	1.6	29.0
Otero	56.5	0.5	0.6	40.3
Bent	59.0	7.6	1.4	30.5
Prowers	62.7	0.4	0.5	35.2
Kiowa	93.3	0.2	0.2	5.6
Analysis Area Average	69.0	4.7	0.7	20.4
Colorado	70.0	3.8	0.6	20.7

Source: U.S. Census Bureau 2010

Historic Properties

Historic properties are significant cultural resources, including sites, buildings, structures, objects, districts, or properties of traditional religious and cultural importance to Native Americans, and are either included in or have been determined to be eligible for inclusion on the National Register of Historic Places. Historic properties could be affected by constructing AVC.

Archaeological sites and historic buildings and structures are the most common historic properties in the EIS study area. Districts are historic or archaeological groups of buildings, structures, or sites. The most common districts are those forming residential or commercial areas within cities such as Pueblo, and embodying architectural, engineering, design, and/or cultural significance.

Traditional cultural properties include "traditions, beliefs, practices, lifeways, arts, crafts, and social institutions of any community, be it an Indian tribe, a local ethnic group, or the people of the nation as a whole" (National Park Service Bulletin No. 38). Examples of traditional cultural properties include, but are not limited to, locations where Native Americans have performed ceremonies or have gathered resources; rural community land use patterns, such as farming and ranching; and urban neighborhoods particular to a cultural group.

Methods

The National Historic Preservation Act (1966, as amended) requires federal agencies to consider the effects of federal undertakings on historic properties. An undertaking refers to any federal action involving federal land, funding, or issuance of a permit. Cultural resource locations are exempt from public disclosure under the Freedom of Information Act and are stipulated for under Section 304 of the National Historic Preservation Act to protect a resource from potential vandalism and to retain confidentiality of resources culturally significant to American Indian tribes. Thus, specific locations for prehistoric cultural resources are not included in this discussion.

Archaeological site is the physical evidence or remains of past human activity at a specific location. Prehistoric archaeological sites predate written records, and historic archaeological sites are generally associated with European exploration and settlement.

Architectural site is a building or structure (such as a house, barn, church, or hotel) that is part of the built environment and composed of interdependent and interrelated parts in a definite pattern or organization (such as a bridge).

Cultural resource is the physical remains of a site, building, structure, object, district, or property that is of traditional religious and cultural importance.

Historic property is any prehistoric or historic district, site, building, structure, or object included in or eligible for inclusion on the National Register, such as artifacts, records, and material remains related to such a property or resource. (16 U.S. Codes Section 470w (5))

Isolated find is a location with fewer than five artifacts that shows little potential for additional finds. Finds are generally not considered to qualify as historic properties.

National Register of Historic Places is a registry maintained by the Secretary of the Interior of sites, buildings, structures, objects, or districts or properties that are of traditional religious and cultural importance to Native Americans that have local, state, regional, or national historic or prehistoric significance.

In general, the analysis area can be characterized by two distinct cultural environments. The built environment consists of areas within cities and towns, primarily Pueblo, La Junta, Boone, Eads, Las Animas, and Lamar. The second cultural environment is encompassed by the broad valley of the Arkansas River, which is dominated by agricultural and undeveloped lands.

The analysis area used to describe the affected environment is defined as a 2-mile-wide buffer area centered 1 mile on either side of the alternative pipeline alignments (Chapter 1). The analysis area was chosen to be sufficient in size to incorporate any potential design changes and to generate an adequate data set to assess the affected environment.

Cultural resources were identified by conducting a Class I file and literature review with the Colorado Office of Archaeology and Historic Preservation to identify previous surveys and documented cultural resources within the analysis area. Historic maps and Government Land Office records also were consulted to obtain information on known but undocumented resources. GIS data were used to identify cultural resources that intersect areas of potential effect. Data used for the Class I analysis included a 2-mile-wide buffer around the alternatives and a 200-foot-wide buffer within the built environment of Pueblo. A predictive model was completed using landform and geologic data to evaluate the potential for unknown cultural resources. Figures that depict the analysis area are included in the Class I document (ERO 2011a). This document includes proprietary information that is exempt from the Freedom of Information Act and is on file with Reclamation.

Cultural resources are evaluated for their eligibility (significance) to be listed on the National and State Registers of Historic Places (National and State Registers). The federal agency determines cultural resources that are historic properties (eligible for listing on the National Register) in consultation with the State Historic Preservation Office/Tribal Historic Preservation Office and appropriate tribes. Unevaluated sites are those that may conform to the eligibility criteria but require further work to determine their significance. In most cases, these are prehistoric sites with suspected buried cultural material, or historic sites where additional archival research is needed to determine historical context and overall significance. Resources that do not meet any of the eligibility criteria and/or have lost physical integrity are recommended as not eligible for inclusion on the National Register. Cultural resources qualified with the term “recommended” have not been formally reviewed by the State Historic Preservation Office but are considered potentially eligible for the National Register.

Affected Environment

A cultural resource overview is included in this section to provide context for resources discussed herein. The overview is followed by a discussion of previous cultural resource inventories in the analysis area.

Cultural Resource Overview

The following cultural overview is derived primarily from *Colorado Prehistory: A Context for the Arkansas River Basin* (Zier and Kalasz 1999). The chronological framework for southeastern Colorado is divided into five major prehistoric and historic stages: Paleoindian (11500 to 7800 before present), Archaic (ca. 7800 to 1850 before present), Late Prehistoric (A.D. 100 to 1450), Protohistoric (A.D. 1450 to 1860), and Historic (A.D. 1860 to 1960).

The Paleoindian stage is primarily identified through highly stylized projectile points such as Clovis and Folsom (Zier and Kalasz 1999). Paleoindians were highly mobile hunter-gatherers who left few imprints on the landscape. Subsistence strategies focused on big game, which included now-extinct large mammals such as mammoth and *Bison antiquus*. The Archaic stage is characterized by broad spectrum hunting and gathering reflected in the increase in use of ground stone technology, use of the atlatl, and increased diversity of fauna and flora used for subsistence (Zier 1999). The transition between the Archaic and Late Prehistoric stages is recognizable in the archaeological record because it was accompanied by changes in basic technology (replacement of the atlatl with the bow and arrow, and adoption of ceramics), population increase and decrease in residential mobility, more intensive processing of natural resources, and increased use of cultivated plants (Kalasz et al. 1999).

The Protohistoric stage represents the time of European arrival into what is now the southwestern United States, and the indirect flow of European goods into Native American culture. Although European contact occurs during this stage, Protohistoric sites continue to represent indigenous populations largely unaffected by European expansion. For the Arkansas River Basin, this period is when Central Plains Apishapa groups abandoned the area and Athapaskan groups (modern Navajo and Apache) arrived from the north. The end of the period coincides with the withdrawal of Athapaskan groups and an increase in Spanish and Comanche presence in the EIS study area.

Southeastern Colorado was Spanish Territory from 1540 to 1848, although Spanish occupation was never substantial within the EIS study area (Slaughter n.d.). Zebulon Pike led the first official American exploration of the Arkansas River Valley in 1806 after the Louisiana Purchase in 1803. The Bent brothers established Bent's Fort in 1833 on the north bank of the Arkansas River along the mountain branch of the Santa Fe Trail (Slaughter n.d.).

Photo 3–55. Bent's Fort along the Santa Fe Trail

Intensive settlement of the Arkansas Valley did not occur until the Colorado Gold Rush of 1859, the Homestead Act of 1862, and the relocation of Native Americans to reservations in the 1870s (Clark and Corbett 2007). The Colorado Territory was established in 1861, and became a state in 1876.

Dryland farming began in the 1870s, but it was not until the construction of large irrigation systems (canals and ditches) that intensive farming of the Arkansas River Valley began. With the completion of large irrigation systems by the late 1880s and the arrival of the railroad in 1876, the EIS study area's farming industry took hold and accelerated into the twentieth century. Despite the boom and bust cycle that is typical for an arid environment, farming and ranching remains the region's primary economy.

Previous Cultural Resource Inventories

Results of the Class I file search for the 2-mile-wide buffer area along the pipeline alternatives were used to determine types of recorded sites in previously surveyed areas and expected sites that may occur within areas not yet surveyed for cultural resources. Eighty-four intensive-level cultural resource inventories have been previously conducted within the combined area of potential effects for the analysis area for alternative pipeline alignments. These inventories surveyed between 4 and 19 percent of potential affected area. Cultural resource inventories and tribal consultations (see Chapter 3 - *Indian Trust Assets*) are the primary means for identifying potential historic properties.

Arkansas Valley Conduit Pipeline Alignments A total of 850 cultural resources are present within the 2-mile-wide buffer zone in the analysis area for all alternatives. Previously recorded cultural resources consist of 714 historic sites, 55 prehistoric sites, 10 multicomponent sites, 18 historic isolates, and 53 prehistoric isolates. Historic site types, in order of frequency, include residential, commercial, and government buildings; linear features (roads, railroads, and water conveyance systems); unknown features; public facility; historic district; trash scatter; agricultural complex; cemeteries; industrial; settlement; occupied land; and homestead. Prehistoric site types include open camps, open stone tool scatters, kill sites, open architectural, and rock art.

The majority of structural sites are buildings contributing or noncontributing to historic districts within the built environment of Pueblo, including East Corona Park; the East Northern Commercial Historic District; the Bessemer, Lakewood, and Northern Avenue districts; and the West Side Historic District. Significant cultural resources include National-Register-listed structures in Pueblo, such as the Avondale Bridge, Temple Emanuel, Frank Pryor house, and Rosemont/John A. Thatcher House. Other sites listed on the National Register include structures in La Junta, such as the Finney House, Wilson A. Heart House, and San Juan Avenue Historic District.

Sites listed on either the National or State Registers include the Huerfano Bridge and the Manzanola and Boone Santa Fe railroad depots. The town of La Junta lists several properties, including St. Patrick's Catholic Church, the Hart/Wilson House, and the San Juan Avenue Historic District.

Photo 3–56. Boone Railroad Depot

Officially eligible and recommended eligible cultural resources include supporting segments and six bridges of the Missouri Pacific Railroad, the Atchison, Topeka, and Santa Fe Railroad, the Santa Fe Trail, Fort Lyon Lateral, and the Bessemer Ditch; several prehistoric and historic archaeological sites (such as the Sand Hill site and the Robinson-Hadley Townsite); isolated structures such as the Hasty State Bank/Post Office and the Swink Pump House; and properties in Pueblo near the West Side Historic District (such as Mineral Place Park, the Kenworthy House), an unnamed structure, and the Overton-King House.

Photo 3–57. Huerfano Bridge

The mapped route of the Santa Fe Trail extends through the area of potential effect , following the Arkansas River along its north bank. The trail led to Bent's Fort, located near modern day La Junta and eventually to Santa Fe, New Mexico. Bent's Old Fort National Historic Site features a reconstructed trading post on the mountain branch of the Santa Fe Trail and is operated by the National Park Service. The Santa Fe Trail was used by explorers, traders, emigrants, and the U.S. military from 1821 to 1880, and was one of the primary routes for westward expansion during the 19th century. Bent's Old Fort was used from 1833 to 1849, when the fort was finally abandoned. The Santa Fe Trail was designated a National Historic Trail by Congress in 1987 and is managed by the National Park Service under a Comprehensive Management and Use Plan (NPS 1990). Although much of the mapped route is located on private lands within the area of potential effect, the National Park Service administers protection and interpretation of the trail regardless of ownership status. Bent's Old Fort National Historic Site and the National Park Service would work with Reclamation to identify existing trail segments within the area of potential effect for the preferred alternative in accordance with the programmatic agreement (Appendix N).

Pueblo Reservoir A total of 45 sites and 7 isolated finds are within the Pueblo Reservoir's 4,880-foot maximum pool elevation (Brant et al. 2010). Only two sites, the Bessemer Ditch and a segment of the Denver and Rio Grande Railroad, are recommended as eligible for the National Register. Remaining sites include 18 recommended as not eligible and 26 unevaluated sites. Thirty-three of these sites are prehistoric (open artifact scatters), 11 are historic, and 1 is a paleontological site. Twenty-three archaeological sites previously documented within the maximum pool elevation (before inundation) were unable to be relocated (Brant et al. 2010), presumably because they remain underwater.

John Martin Reservoir A total of 128 sites and 76 isolated finds have been documented within the 3,870-foot maximum pool elevation of John Martin Reservoir (Barclay 2003; Brown 1994; Eddy et al. 1982; Cordero et al. 2009; Cribbin et al. 2009; Everhart 2009; Jenks et al. 2011;

Tucker 2001). Documented cultural resource types include 89 prehistoric, 23 historic, 12 multicomponent, and 3 paleontological sites. Historic site types include 11 habitations, 1 segment of the Santa Fe Trail, 1 historic dam, a segment of a road, 2 fence lines, and 7 trash scatters. Prehistoric sites include 78 open artifact scatters, 7 open architectural sites, 1 sheltered artifact scatter, and 3 rock art sites. Multicomponent sites include four open architectural and historic trash scatters, one prehistoric open artifact scatter and historic town site, three open artifact scatters and historic trash scatters, and four open artifact scatters and historic habitations.

Twenty-nine sites at John Martin Reservoir are officially or recommended eligible for the National Register. The eligibility of 22 sites has not been evaluated, and the remaining 77 sites are officially or recommended as not eligible for the National Register. According to the Colorado Office of Archaeology and Historic Preservation, two large inventories were conducted at John Martin Reservoir by the Corps in 2010 (Everhart 2011), and at least 500 more cultural resources have been documented. The location of these resources in relation to the maximum pool elevation is currently unknown. A portion of the Santa Fe Trail was flooded by the reservoir.

Indian Trust Assets

Indian trust assets are legal interests in property held in trust by the United States for Indian tribes or individuals. The Secretary of the Interior acts as the trustee for the United States with respect to Indian trust assets. All Department of the Interior agencies share the Secretary's duty to act responsibly to protect and maintain Indian trust assets reserved by or granted to Indian tribes or individuals by treaties, statutes, and executive orders. These rights are sometimes further interpreted through court decisions and regulations. Examples of trust assets include lands, minerals, hunting and fishing rights, and water rights. The Department of the Interior carries out its activities in a manner that protects trust assets and avoids adverse impacts.

Methods

Indian trust assets were assessed in consultation with the Bureau of Indian Affairs and tribes that signed treaties covering areas in the Arkansas River Basin, including the Kiowa Tribe of Oklahoma, the Comanche Nation of Oklahoma, the Apache Tribe of Oklahoma, the Northern Cheyenne Tribe, the Northern Arapaho Tribe, the Cheyenne-Arapaho Tribe of Oklahoma, and the Jicarilla Apache Nation.

Affected Environment

To date, no Indian trust assets have been identified in the EIS study area.

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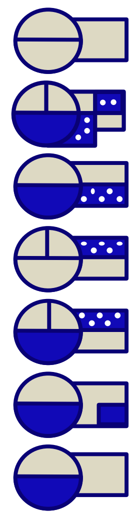
Chapter 4 Environmental Consequences

This chapter discusses environmental consequences of the proposed AVC, Interconnect contract, and Master Contract. The analysis describes direct, indirect, and cumulative effects of seven alternatives described in Chapter 2. In this analysis, the No Action Alternative is compared to simulated existing conditions to identify the consequences of not implementing the proposed actions. The analysis also compares the action alternatives to the No Action Alternative, the future without the project, to determine the net effects or impacts. Best management practices, as described in Chapter 2, are incorporated into the alternatives. Measures and commitments to mitigate adverse environmental effects are described in each resource section.

Seven Alternatives were identified for evaluation in this EIS (see Chapter 2):



- No Action
- Comanche North
- Pueblo Dam South
- JUP North
- Pueblo Dam North
- River South
- Master Contract Only

To ensure that project activities are completed concurrently and in full compliance with all environmental commitments specified in this EIS, an Environmental Review Team would be formed. Members of the team, as described below, would advise Reclamation regarding implementation of environmental commitments and would review any future proposed project changes (for example, pipeline routing, new participants, new water supplies, or changes in water rights administration). Any changes warranting additional NEPA or Compact compliance review, adaptive management, or other environmental compliance would be addressed by the Environmental Review Team. The Environmental Review Team would function during final design through one year after AVC and/or Master Contract operations begin, if an action alternative is selected in the Record of Decision.

The Environmental Review Team could include technical representatives of the following agencies:

- Bureau of Reclamation
- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- Southeastern Colorado Water Conservancy District
- Colorado Department of Transportation
- Colorado Parks and Wildlife
- Colorado State Historic Preservation Office
- Kansas Division of Water Resources
- City of Pueblo
- Pueblo County
- Other technical entities as deemed important to the process

The resources described in Chapter 3 and analyzed in this chapter are as follows:

- Surface Water Hydrology
- Groundwater Hydrology
- Water Quality
- Geomorphology
- Aquatic Life
- Recreation
- Vegetation and Wetlands
- Wildlife
- Human Environment
- Socioeconomics
- Environmental Justice
- Historic Properties
- Indian Trust Assets

Photo 4–1. Example of construction-related direct effects on a riparian area

Terms and Definitions

The following terms are used to describe effects the alternatives could have on the resources analyzed in this EIS.

Effects Analyses

To evaluate environmental consequences, two primary comparisons were made (43 CFR 46).

- **No Action Alternative to Existing Conditions:** This comparison shows the consequences that could be expected in the absence of an implemented action alternative.

- **Action Alternatives to No Action Alternative:** This comparison evaluates the "net effects or impacts" of each action alternative. It should be noted that the symbol "---" is inserted into tables for the No Action Alternative when comparisons are made to the No Action Alternative.

Some comparisons of the action alternatives to simulated existing conditions are necessary when relevant to quantifying or characterizing the magnitude of effects. For example, the projected effects on aquatic life from action alternatives were compared to existing conditions at the request of Colorado Parks and Wildlife. Because future demographics or percentages of minority and low-income populations are unknown, action alternatives are also compared to existing conditions to evaluate whether environmental justice effects would be disproportionate. These comparisons are briefly discussed in this chapter, with additional detail in the resource appendixes.

Simulated baselines, not historical data, are used for modeled effects analysis so that model error can be discounted, and so that other factors don't influence results (e.g. changing demand or operating rules). Additional discussion on simulated baselines is in Appendix D.4.

Two separate effects analyses are described in this EIS. Direct and indirect effects are grouped together into a "Direct and Indirect Effects" subsection for each resource, while cumulative effects are described in a separate subsection titled "Cumulative Effects" for each resource.

- **Direct and Indirect Effects:** Direct effects result from implementing an alternative (40 CFR 1508.08). Direct effects could occur from constructing pipelines or other permanent structures or changes in hydrology to provide water supply for the alternatives. For example, damaging a historic structure within the proposed AVC footprint would be a direct effect of pipeline construction. Indirect effects are project-induced, but would occur later in time or farther removed in distance (40 CFR 1508.08). For example, construction-related spending would cause an indirect socioeconomic effect. Throughout this EIS, unless otherwise specified, the effects of an alternative include both direct and indirect effects.
- **Cumulative Effects:** A cumulative effect is defined as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 CFR 1508.7). Cumulative effects could result from individually minor actions taking place over a period of time that collectively become significant actions. For example, the combined effects on streamflow in Fountain Creek from proposed Master Contract operations and increased urban and agricultural development in the Fountain Creek watershed would be a cumulative effect.

Effects Characterization

The following terms were used to assess and characterize effects associated with each alternative:

- **Context:** Context is the setting in which an effect would occur, such as local (in the construction area where facilities would be located), regional (by county or throughout the entire study area), or statewide.
- **Duration:** Duration is defined independently for each resource. Effects may last for the construction period, a growing season, a single year, or longer. For purposes of this analysis, effect duration is described as short-term or long-term. Short-term effects primarily would result from temporary construction disturbances that either would be restored (trenching for pipeline alignments), or would cease (construction noise). Long-term effects would last after construction was completed (building blocking a scenic view); some effects may be in perpetuity (permanent) or chronic (streamflow effects from reservoir operations).
- **Intensity:** Intensity is defined individually for each resource. There may be no effect, or effects may be negligible, minor, moderate, or major, as defined for each resource. Whether an alternative significantly affects natural or human environmental quality is assessed by considering the context, duration, and intensity of the action and its effects (40 CFR 1508.27).
- **Type:** Effects could be beneficial, neutral, or adverse.

Approaches for defining duration and intensity of effects vary by resource and may be described in quantitative or qualitative terms. Significance criteria were formulated by reviewing existing laws, policies, and guidelines. Criteria for defining negligible, minor, moderate, and major adverse effects are described in each resource section. Best management practices incorporated into alternatives to minimize or avoid effects are described in Chapter 2. Measures to mitigate moderate and major adverse effects are listed by resource section.

Reasonably Foreseeable Actions

The effects analysis time frame generally extends to 2070, the planning horizon for AVC (see Chapter 1). Each resource section's cumulative effects analysis evaluates reasonably foreseeable future actions combined with the alternatives. A list of potential reasonably foreseeable actions (Table 4–1) was developed for the cumulative effects analysis in consultation with cooperating agencies (see Appendix B.4). The following criteria defined the reasonably foreseeable actions:

- The action is expected to be implemented or to occur between 2010 and 2070 (within this EIS study period).
- If required, a known source of funding has been identified or is reasonably certain (not applied as a stand-alone criterion).
- The action is judged to contribute measurably to cumulative effects in the EIS study area and on the resources that would be affected by the alternatives.
- Sufficient information is available to define the action and conduct a meaningful analysis.
- If required, a permit application would be submitted to a federal, state, or local agency with jurisdiction over the action. The permitting process outcome also needs to be sufficiently defined to draw qualitative or quantitative conclusions regarding its cumulative effects.

The cumulative effects geographic area in this EIS has been defined broadly to incorporate actions that could potentially affect this EIS study area. A more detailed description of the cumulative effects geographic area is defined for each resource.

Table 4–1. Reasonably Foreseeable Actions

Action
General Water-Related Activities
Climate Change (1)
Urban and Suburban Development in Chaffee, Fremont, El Paso, Pueblo, Crowley, Otero, Bent, Prowers, and Kiowa Counties (2)
Water Development Projects
Fountain Water Supply Project (2)
SDS (2)
Excess Capacity Contracts
Short-Term Excess Capacity Contracts (2)
SDS Excess Capacity Contracts (2)
Wastewater, Flooding, and Flood Control Projects
Cherokee Metropolitan District – New Wastewater Treatment Facility (2)
Pueblo West Metropolitan District – Wastewater Discharge Pipeline (Wild Horse Dry Creek) (2)
Agricultural to Municipal Transfers
Lower Arkansas Valley Super Ditch Company (2)(3)
Transportation Projects
Colorado State Highway 194 Overlay (1)
U.S. Highway 287 at Lamar Project (1)
Peak to Prairie-Fountain Creek Conservation Project – Colorado Open Lands (1)

Notes:
(1) Effects on resources, if any, are described qualitatively.
(2) Included in the surface water hydrology modeling.
(3) Only portions of the Super Ditch program evaluated as part of the Master Contract in this EIS are considered reasonably foreseeable. See Chapter 1, Chapter 2, and Appendix D.3 for additional details regarding the extent of the Super Ditch program in this EIS. Other transfers under the Super Ditch program are not considered reasonably foreseeable.

Climate Change

U.S. Department of the Interior Secretarial Order No. 3289 requires Reclamation to “consider and analyze potential climate change impacts when undertaking long-range planning exercises” (2009). Climate change is also an important issue in environmental effects analysis. Two aspects of climate change are applicable to the action alternatives. The first is whether an action could contribute to climate change, particularly project-generated greenhouse gas emissions. The second is whether climate change could affect an action alternative (Sutley 2010). Climate change is discussed briefly in this section to provide context to the discussion. Information on the effects of the project on greenhouse gas emissions and the effects of climate change on water supply yields is described. More specific qualitative information regarding climate change and individual resources is presented in each resource section.

Background

Temperature in the western U.S. has increased during the twentieth century and is projected to warm further during the twenty-first century (Reclamation 2011b). Many major western U.S. river basins have warmed approximately 2ºF over recent decades, and average temperatures could continue to increase 5ºF to 7ºF by the end of the century (Reclamation 2011c). In Reclamation’s Great Plains region, which includes the Arkansas River Basin, all areas have become more temperate, and some have experienced a general increase in mean annual precipitation with a decline in spring snowpack, including reduced snowfall-to-winter precipitation ratios and earlier snowmelt runoff (Reclamation 2011b).

Climate change is expected to continue, and is considered reasonably foreseeable (see Appendix B.4). Climate change is qualitatively discussed in this chapter because of its broad geographic scope and its potential to affect many resources. Climate change may have cumulative effects on streamflow, water quality, geomorphology, wildlife habitat, wetlands, vegetation, aquatic life, recreation, cultural resources, and socioeconomics, and effects are individually assessed for each resource. This EIS describes climate change and general regional effects on climate and hydrology, and includes a quantitative analysis of how climate change could affect future AVC water supply yields, and a qualitative description of climate change effects for each resource within each resource section. Appendix C contains additional information on climate science and projections for the study area.

Arkansas River Basin Climate Projections

The recently released multi-agency derived climate data include projections within the Arkansas-Red River Basin (LLNL 2012). Climate change projections (112 projections) were analyzed at a location just above Pueblo Reservoir for the future (2060–2079) compared to current conditions (average between 1950 and 1999). The projections predict temperature increases of 3.3ºF to 9.4ºF. There is much less agreement on precipitation, and predictions range from 4.2 inches less precipitation per year to 6.6 inches more precipitation per year. The average prediction is no change in precipitation. Combined temperature and precipitation projections were evaluated in a hydrology model (LLNL 2012) and runoff was predicted to change between 49 percent less and 50 percent more. More climate projections predict less runoff, with the average prediction of the 112 projections being 13 percent less runoff in the future.

The *SECURE Water Act Report* assesses climate change risks and how these risks could affect water operations, hydropower, flood control, and fish and wildlife in the western United States (Reclamation 2011c). This report represents the first consistent and coordinated assessment of climate change effects and risks to future water supplies across eight major Reclamation river basins, including the Colorado, Rio Grande, and Missouri river basins. The study did not include the Arkansas River Basin, but did include several river basins that border the Arkansas River Basin.

The *SECURE Water Act Report* indicates increased climate change risks to western United States water resources during the twenty-first century, including the following (Reclamation 2011c):

- Average annual temperature increases of 5ºF to 7ºF
- Average annual precipitation decreases over the southwestern and south-central United States, including the study area
- Snowpack decreases
- Decreases in average annual streamflow in several river basins, especially in the southwestern United States

The report notes that projected changes in temperature and precipitation, and resulting effects on snowpack volume and melting patterns, evapotranspiration, and soil moisture content, are likely to affect timing and quantity of streamflow in all western basins. These changes could affect water available to farms and cities, hydropower generation, fish and wildlife, and other uses such as recreation (Reclamation 2011c). Figure 4–1 shows projected temperature and precipitation changes for the Arkansas River Basin consistent with the *SECURE Water Act Report*.

The greatest losses in snowpack are anticipated where baseline climate is closer to freezing thresholds, such as in valleys and lower altitude mountain ranges. In high-altitude, high-latitude areas, cool-season snowpack could increase during the twenty-first century (Reclamation 2011c). Not all locations in the western United States, such as the high-altitude Arkansas River headwaters, are expected to experience the same effects, and there is uncertainty with many existing analyses.

A more detailed assessment of climate change projections for the Arkansas River Basin was completed under the *Joint Front Range Climate Change Vulnerability Study* (Water Research Foundation 2012). This study concluded that changes in annual streamflow in the Arkansas River Basin could range from a 5 percent increase to a 21 percent decrease, assuming an annual 2°F to 10°F increase in temperature and an 18 percent decrease to a 28 percent increase in precipitation by 2070.

Colorado River Basin Climate Projections

The *SECURE Water Act Report* projects twenty-first century average annual temperature to increase in the Upper Colorado River Basin by 6ºF to 7ºF, depending on elevation and latitude (Reclamation 2011c). Precipitation is also projected to increase for the Upper Colorado River Basin, which is pertinent to West Slope water supply in this EIS. The Colorado Water Conservation Board’s *Colorado River Water Availability Study* also projects Upper Colorado River Basin winter precipitation to increase (Colorado Water Conservation Board 2010). The *SECURE Water Act Report* warns that increases in precipitation may not translate into increased runoff caused by temperature effects on soil moisture and snowpack melting timing (Reclamation 2011c).

Climate change effects on overall Colorado River Basin precipitation are projected to be minimal, but temperature changes with associated effects on soils, evapotranspiration, and agricultural and municipal demand could decrease runoff (Reclamation 2011c). This decrease could affect administration of the Colorado River Compact, which apportions water to seven western states that use Colorado River supplies. Colorado River Compact effects could include an increase in the magnitude and frequency of shortages in deliveries from Colorado and other Upper Basin states to the Lower Basin. This would decrease the legal ability to make transmountain imports to the Arkansas River Basin (including the Fry-Ark Project) because transmountain system water rights generally have lower priority than Colorado River Compact deliveries and other adjudicated water rights in the basin. The exact climate change effects on agricultural and municipal demands are uncertain and difficult to quantify. Many socioeconomic factors could also counteract or aggravate climate change effects on the Colorado River Compact (Reclamation 2011c).

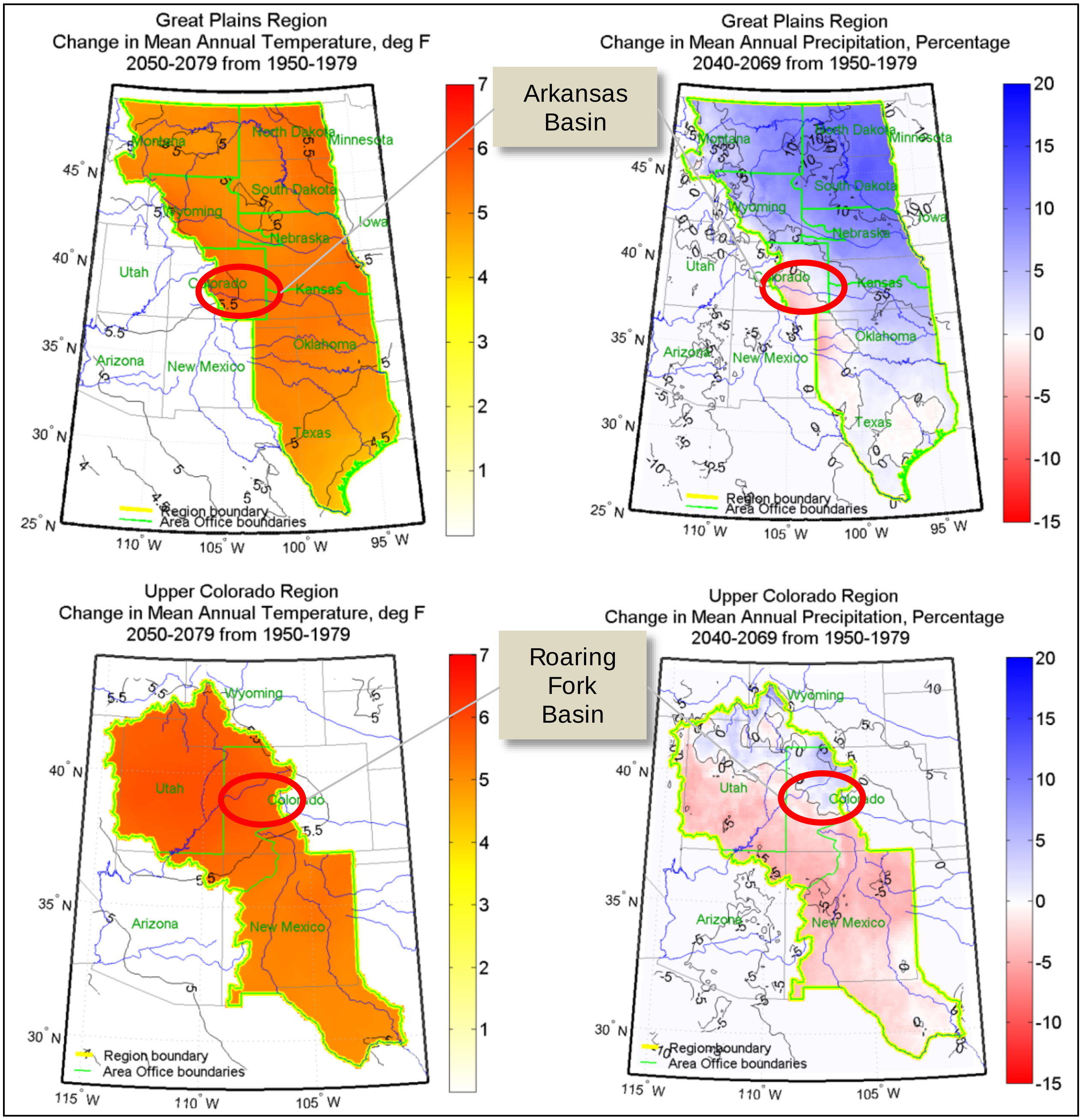
Effects of Alternatives on Greenhouse Gas Emissions

Construction activities would have a negligible effect on greenhouse gas emissions. For all alternatives, including the No Action Alternative, construction equipment, employee vehicles, and delivery vehicles would emit greenhouse gasses. These activities would be short-term, and would not be discernible at a regional scale (ERO 2012a).

Long-term contributions to greenhouse gas emissions from the proposed actions would be well below the Council of Environmental Quality threshold of 25,000 metric tons of carbon dioxide. This level of emissions is an indicator of a minimum level of greenhouse gas emissions from agency actions that may warrant some description in a NEPA analysis (Sutley 2010). Proposed action emissions would primarily result from energy needs of pumping plants and water treatment plant operations; annual carbon dioxide emissions (a key greenhouse gas) were estimated for these operations for each alternative (Table 4–2, ERO 2012a). No Action and Master Contract Only alternatives emissions would primarily result from water treatment plants (including reverse osmosis treatment), brine disposal, and pumping. Existing water treatment and groundwater pumping energy use may decrease for AVC participants, which would offset some AVC energy requirements.

Table 4–2. Estimated 2070 Carbon Dioxide Emissions

Alternative	Estimated Carbon Dioxide Emissions (metric tons/year)
No Action	13,455
Comanche North	4,220
Pueblo Dam South	1,084
JUP North	3,015
Pueblo Dam North	2,230
River South	4,976
Master Contract Only	13,455



Source: Reclamation 2011b

Figure 4–1. Simulated Temperature and Precipitation Changes for Great Plains Region and Upper Colorado Region

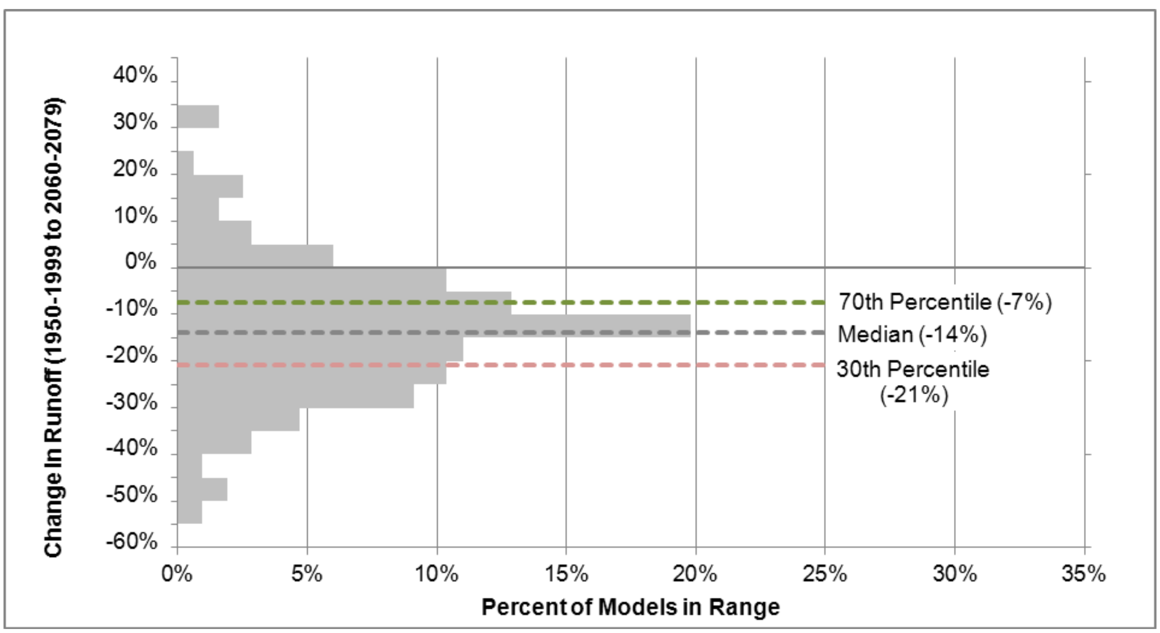
Effect of Climate Change on Water Supply

The sensitivity of future AVC water supplies to climate change was investigated as part of this EIS. Various runoff projections representing different climate change levels were converted to streamflow and used to investigate key water supplies for AVC and the ability of AVC to meet water demands in the future.

Several climate models and future energy use scenarios have been developed by multiple governments and other entities to evaluate potential effects on temperature, rainfall, runoff, etc., resulting in hundreds of different climate projections. The analysis in this EIS examined 112 monthly simulated runoff projections for two streamflow locations, the Arkansas River near the Arkansas River at Cañon City gage, and the Fryingpan River upstream from the Fryingpan River near Thomasville gage (see Appendix C.2). Reclamation developed these future runoff projections based on results of several climate models (Reclamation 2011d). The study period representing current runoff was 1950–1999 and future runoff is 2060–2079.

The percent change between simulated current and future runoff was calculated for all 112 projections (Figure 4–2). Runoff projections for the Fryingpan River range from a 30 percent increase in runoff to a 50 percent decrease in runoff. For this analysis, runoff projections were selected that best represented mean annual runoff changes in the 70th percentile, 50th percentile (median), and 30th percentile of the 112 projections (see Appendix C.2). Percentiles describe the percentage of data that is less than a specific value (see Chapter 3 – *Water Quality*). Based on the projected reduction in runoff volume associated with each of the three percentiles, a corresponding percentage reduction in runoff was identified by comparing the projection with existing conditions in the Fryingpan Basin (Figure 4–2). These reduced runoff percentages are referred to in this EIS as the 7% Reduced, 14% Reduced, and 21% Reduced runoff scenarios. Runoff reductions in the Arkansas Basin for each scenario are similar to those in the Fryingpan Basin (8 percent, 15 percent, and 21 percent, respectively).

For each reduced runoff scenario, streamflow was calculated to assess effects to future Fry-Ark West Slope water supplies (Boustead Tunnel diversions), Fry-Ark East Slope water supplies, and non-Fry-Ark water supplies (see Appendix C.2). Figure 4–3 shows how the runoff scenarios would affect streamflow in the Fryingpan River. Annual streamflow volume would be reduced under all reduced runoff scenarios. The timing in peak flows would also shift from June to May and away from the June peak instream flow (bypass) requirements.



Data Source: Reclamation 2011d

Figure 4–2. Summary of Simulated Annual Change in Runoff at Fryingpan River near Thomasville Gage

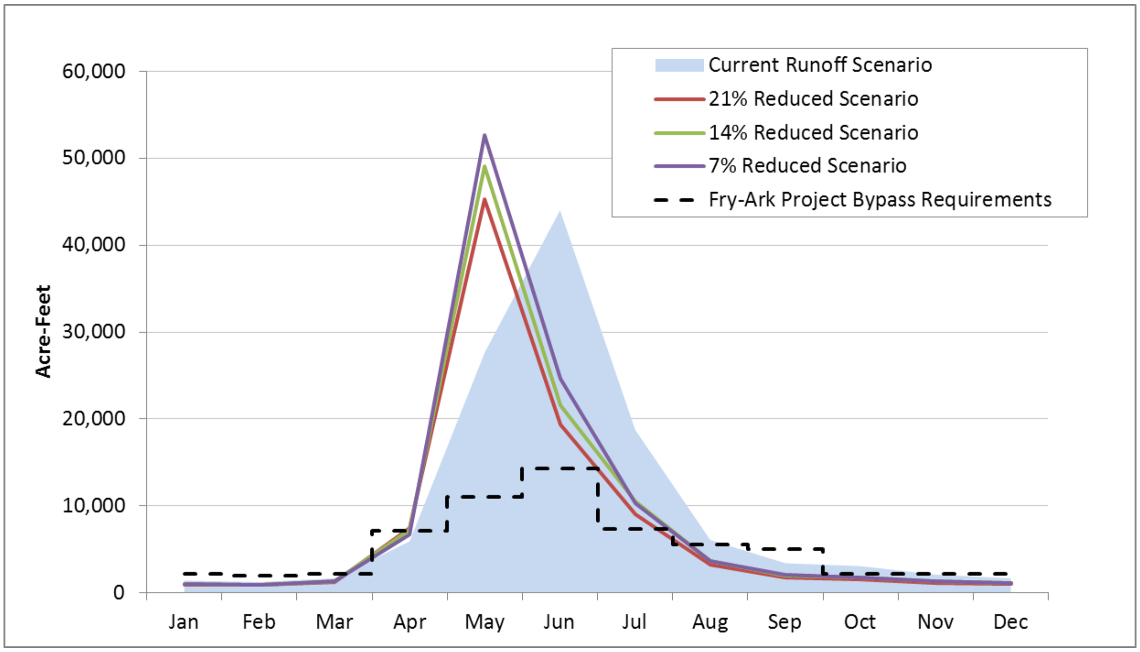


Figure 4–3. Average Monthly Native Fryingpan River Streamflow

Reductions in future Boustead Tunnel diversions and Fry-Ark and non-Fry-Ark East Slope water supplies due to reduced runoff appear in Table 4–3. Decreases in water supplies were used to analyze the ability of the No Action Alternative and an AVC alternative to meet future demand.

Table 4–3. Potential Changes in Future AVC Water Supplies

Hydrologic Scenario	Boustead Tunnel Diversions		Fry-Ark East Slope Supply		Non-Fry-Ark Supply	
	Annual Average Diversion (ac-ft)	Annual Change (%)	Annual Average Supply (ac-ft)	Annual Change (%)	Annual Average Supply (ac-ft)	Annual Change (%)
Current Conditions	60,686	--	23,387	--	4,970	--
7% Reduced	51,163	-16	19,758	-16	4,459	-10
14% Reduced	47,083	-22	13,665	-42	4,146	-17
21% Reduced	42,459	-30	6,423	-72	3,775	-24

Fry-Ark releases for the No Action Alternative would be less than current conditions releases in the 14% Reduced and 21% Reduced scenarios (Table 4–4). Because of the complexities of groundwater modeling, this analysis did not evaluate the effects of climate change on groundwater supplies. It is likely that groundwater supplies would be reduced under climate change scenarios due to lower precipitation and streamflow, and increases in water use by native vegetation. Thus, overall demand shortages for the No Action Alternative would be greater than shown in the table, likely similar to or greater than the AVC alternative.

Water delivered through AVC would be less than the current conditions hydrology scenario in all climate change scenarios for an AVC alternative (Table 4–4). Less water, or shortages, in either the No Action or AVC alternatives would likely require AVC participants to secure additional non-Fry-Ark supplies sometime in the future to meet full AVC deliveries. These additional water supplies would likely combine additional permanent agricultural transfers, additional use of reusable return flows, or temporary leases from a leasing program or other AVC participants with excess supply. For scenarios in which shortages would occur in only a few years (7% Reduced and 14% Reduced scenarios), temporary leases would be more appropriate. For the 21% Reduced scenario, shortages would occur more frequently, and a more permanent supplemental supply would be more appropriate. Environmental effects of securing these additional supplies were not analyzed in this EIS. The use of the Master Contract would be important to hold excess long-term supplies for severe dry conditions, as seen in 1977 of the 21% Reduced Scenario simulation for both direct and cumulative effects. The extra storage allows non-Fry-Ark supplies to be available to AVC when Fry-Ark supply is depleted and there is no exchange potential in the river.

Analyses were also conducted for cumulative effects scenarios. Results were comparable to the direct effects analysis, with slightly less water supply and slightly higher shortage levels.

Table 4–4. Summary of Simulated Annual AVC Deliveries and Shortages – Direct Effects Analysis

Hydrologic Scenario	No Action Alternative (Fry-Ark releases only)			AVC Alternative		
	Average Annual Deliveries (ac-ft) (1)	Average Annual Change (%)	Percent of Years with Shortage	Average Annual Deliveries (ac-ft) (2)	Average Annual Change (%)	Percent of Years with Shortage
Current Conditions	5,130	0	0	10,260	0	0
7% Reduced	5,130	0	0	10,154	1.0	8
14% Reduced	5,122	0.2	2	9,976	2.7	10
21% Reduced	4,844	5.6	20	8,944	12.8	48

Notes:

(1) The No Action Alternative analysis only considers Fry-Ark supplies used for well augmentation; thus, annual demand was simulated as 5,130 ac-ft per year.

(2) The AVC alternative was simulated with full AVC demand of 10,260 ac-ft per year.

Surface Water Hydrology

Surface water hydrology resources include streams and major reservoirs within the study area. Water supplies evaluated in the EIS included transmountain diversions and native East Slope supplies for AVC and Master Contract participants. This section describes methods used to evaluate surface water hydrology effects, and the direct and cumulative effects on streamflow and reservoirs. Appendix D.4 and Appendix D.5 describe surface water hydrology effects in more detail.

Summary

Arkansas River Basin streamflow and reservoir operations within the study area were simulated with EIS alternatives using the Arkansas River Daily Simulation Model (Daily Model). Additional spreadsheet analyses were used to assess effects outside the Daily Model simulation area (Figure 4–4). Significance criteria were applied to the simulation results to describe the range of surface water hydrologic effects.

Direct and indirect effects on average annual streamflow in the Arkansas River would be negligible to minor (greater than 2 percent change) for all alternatives (Table 4–5). Several alternatives would cause moderate (greater than 10 percent change) streamflow decreases in 1 or 2 wet year months at the Lake Fork Creek below Sugar Loaf Dam and Lake Creek below Twin Lakes gages due to decreases in reservoir storage and spills (Table 4–6). Occasional moderate effects would occur downstream from Pueblo Reservoir during some winter and spring months in dry and normal years (Table 4–6). The alternatives would affect streamflow by diverting water supplies into AVC and bypassing the Arkansas River, and/or by exchanging water into Master Contract excess capacity accounts.

Direct effects on average monthly streamflow at the Fountain Creek at Pueblo gage would be negligible to minor for all alternatives compared to No Action. Moderate increases in winter and early spring Fountain Creek streamflow would occur in dry years.

Direct and cumulative effects on all average monthly Pueblo Reservoir storage contents would be negligible to minor (greater than 2 percent change) for all alternatives. JUP North Alternative effects on Pueblo Reservoir would increase in normal and dry years, when decreases in storage contents would be moderate (Table 4–6). The lack of Master Contract storage in this alternative would require increased use of Fry-Ark storage to meet AVC demand. The Master Contract Only Alternative would create minor increases in Pueblo Reservoir storage contents because AVC participants would use less Fry-Ark water. AVC Participants in the Master Contract Only Alternative would use non-Fry Ark Project supplies more efficiently (via a Master Contract account) for surface water deliveries or well augmentation.

Holbrook Reservoir would have moderate decreases in storage contents for all alternatives except JUP North during normal and dry years, although these decreases are due to complexities in modeling assumptions and not necessarily attributable to AVC.

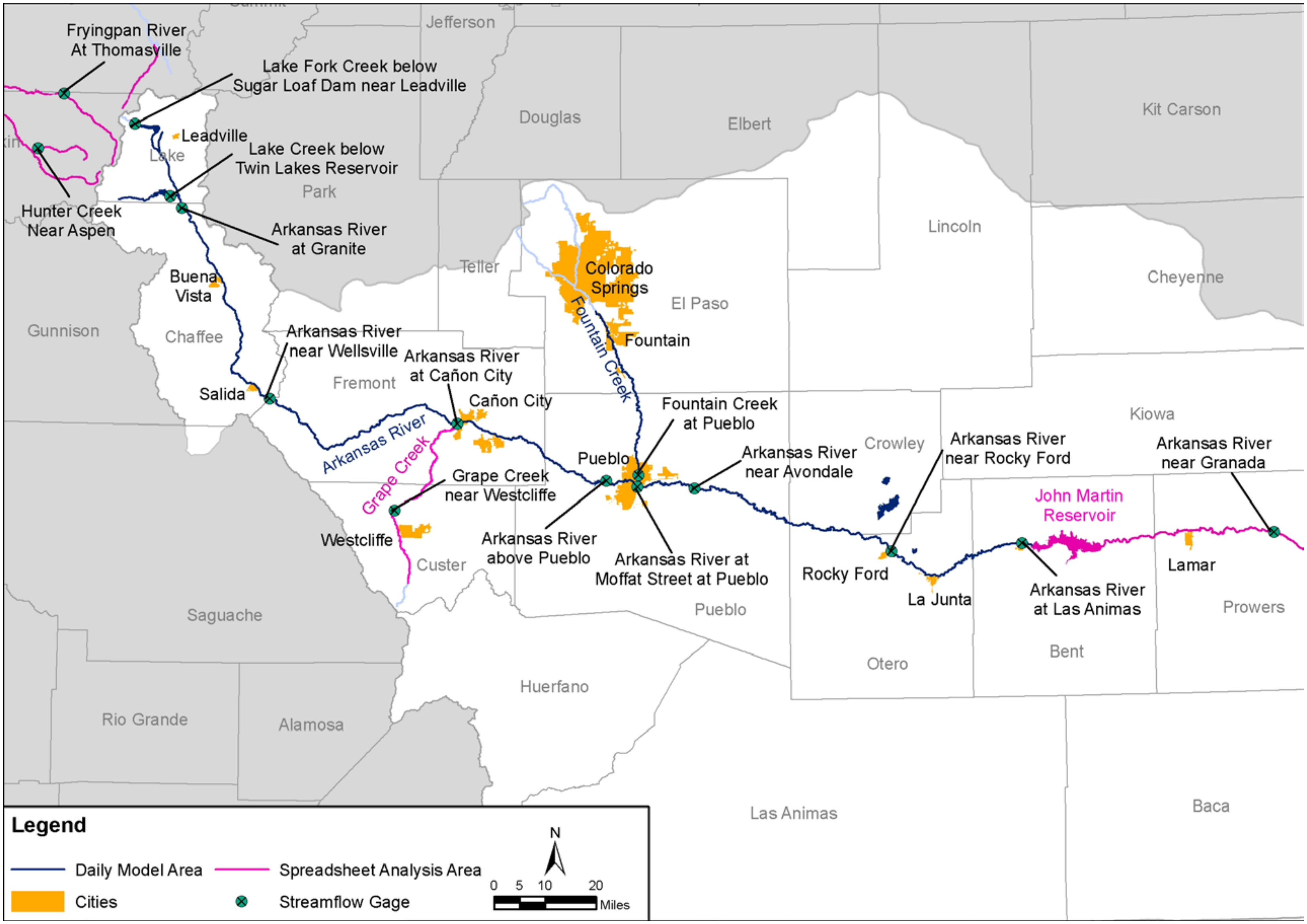


Figure 4–4. Surface Water Hydrology Analysis Areas

Table 4–5. Summary of Surface Water Hydrology Annual Direct and Indirect Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
◉	◐	⦶	=	⊖	◒	●
Increase ↔ Decrease						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Average Annual Streamflow at Gages (1)						
Lake Fork Creek	⦶	⦶	=	⦶	⦶	⦶
Lake Creek below Twin Lakes	=	=	=	=	=	=
Arkansas River at Granite	=	=	=	=	=	=
Arkansas River near Wellsville	=	=	=	=	=	=
Arkansas River at Cañon City	=	=	=	=	=	=
Arkansas River above Pueblo	⊖	⊖	⊖	⊖	=	=
Arkansas River at Moffat St.	⊖	⊖	=	⊖	⊖	=
Arkansas River near Avondale	=	=	=	=	=	=
Arkansas River near Rocky Ford	=	=	=	=	=	=
Arkansas River at Las Animas	=	=	=	=	=	=
Arkansas River near Granada	=	=	=	=	=	=
Fountain Creek at Pueblo	=	=	=	=	=	=
Grape Creek near Westcliffe	=	=	=	=	=	=
Fryingpan River near Thomasville	=	=	=	=	=	=
Hunter Creek near Aspen	=	=	=	=	=	=
Average Annual Reservoir Storage (1)						
Turquoise Lake	=	=	=	=	=	=
Twin Lakes	=	=	=	=	=	=
Pueblo Reservoir	=	=	⊖	=	=	⦶
Holbrook Reservoir (2)	◒	◒	=	◒	◒	◒
John Martin Reservoir	=	=	=	=	=	=

Note:

(1) Effects are assessed in comparison to the No Action Alternative.

(2) Moderate effects on Holbrook Reservoir during certain months are not direct effects of AVC/Master Contract operations; rather, the effects result from the following:

- Modeling assumptions on Colorado Springs operations at Holbrook Reservoir are sensitive to small changes in the quantity and timing of streamflow and reservoir storage in the Lower Arkansas River Basin (see Appendix D.4).
- Holbrook Reservoir storage contents are low particularly in simulated existing conditions and No Action Alternative. A small change in volume could result in a large percent change and trigger a moderate significance level in the modeling.

Table 4–6. Summary of Surface Water Hydrology Monthly Direct and Indirect Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
◎	◐	⦶	=	⊖	◒	●
Increase ↔ Decrease						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Lake Fork Creek Gage Monthly Streamflow (1)						
Maximum average increase	⦶	⦶	⦶	⦶	⦶	◐
Maximum average decrease	(2)	(2)	◒	(2)	(2)	(2)
Maximum normal year increase	⦶	⦶	(2)	⦶	⦶	⦶
Maximum normal year decrease	(2)	(2)	(2)	(2)	(2)	(2)
Maximum wet year increase	◐	◐	(2)	◐	◐	◐
Maximum wet year decrease	⊖	⊖	◒	⊖	⊖	⊖
Maximum dry year increase	(2)	(2)	(2)	(2)	(2)	(2)
Maximum dry year decrease	(2)	(2)	(2)	(2)	(2)	(2)
Lake Creek below Twin Lakes Gage Monthly Streamflow (1)						
Maximum average increase	⦶	=	⦶	⦶	⦶	=
Maximum average decrease	⊖	=	=	⊖	⊖	⊖
Maximum normal year increase	⦶	⦶	=	⦶	⦶	⦶
Maximum normal year decrease	⊖	⊖	=	⊖	⊖	⊖
Maximum wet year increase	=	=	◐	=	=	=
Maximum wet year decrease	◒	◒	=	◒	◒	◒
Maximum dry year increase	◐	◐	⦶	◐	◐	◐
Maximum dry year decrease	⊖	=	=	=	=	⊖
Arkansas River above Pueblo Gage Monthly Streamflow (1)						
Maximum average increase	(2)	(2)	(2)	(2)	⦶	=
Maximum average decrease	⊖	⊖	⊖	⊖	⊖	⊖
Maximum normal year increase	(2)	(2)	(2)	(2)	⦶	⦶
Maximum normal year decrease	◒	◒	⊖	◒	⊖	⊖
Maximum wet year increase	⦶	⦶	(2)	⦶	◐	⦶
Maximum wet year decrease	⊖	⊖	⊖	⊖	⊖	⊖
Maximum dry year increase	(2)	(2)	(2)	(2)	⦶	=
Maximum dry year decrease	◒	◒	◒	◒	⊖	◒
Arkansas River at Moffat St. Gage Monthly Streamflow (1)						
Maximum average increase	(2)	(2)	(2)	(2)	(2)	=
Maximum average decrease	⊖	◒	⊖	⊖	⊖	⊖
Maximum normal year increase	◐	⦶	⦶	◐	=	⦶
Maximum normal year decrease	◒	◒	⊖	◒	◒	◒
Maximum wet year increase	⦶	⦶	=	⦶	⦶	⦶
Maximum wet year decrease	⊖	⊖	⊖	⊖	⊖	⊖
Maximum dry year increase	(2)	(2)	(2)	(2)	=	⦶
Maximum dry year decrease	◒	◒	◒	◒	◒	◒
Pueblo Reservoir Monthly Storage (1)						
Maximum average increase	=	(2)	(2)	=	⦶	⦶
Maximum average decrease	(2)	=	⊖	(2)	(2)	(2)
Maximum normal year increase	(2)	(2)	(2)	(2)	(2)	⦶
Maximum normal year decrease	⊖	⊖	◒	⊖	⊖	(2)
Maximum wet year increase	=	=	(2)	=	=	=
Maximum wet year decrease	⊖	⊖	⊖	⊖	=	=
Maximum dry year increase	(2)	(2)	(2)	(2)	(2)	⦶
Maximum dry year decrease	⊖	⊖	◒	⊖	⊖	(2)

Note:
(1) Effects are assessed in comparison to the No Action Alternative. Only streamflow gages with moderate or major decreases are shown in this table. Additional monthly effects are in Appendixes D.4 and D.5.
(2) No increases or decreases occur.

Methods

This section describes methods used to analyze effects, and the criteria for determining significance of effects on surface water hydrology.

Modeling and Assumptions

The Daily Model was used to investigate operations and effects of proposed water development projects within the Arkansas River Basin using a 1982–2009 hydrologic study period. The Daily Model is an extension of the model developed for the SDS EIS (MWH 2008). The Daily Model was updated and modified, and independently evaluated for this EIS. Information added to or modified from the original model includes extension of the study period and adjustment of certain model constructs and parameters to accommodate additional data.

The Daily Model has the ability to do the following:

- Examine operational feasibility of alternatives.
- Examine extent of the hydrologic affected environment.
- Develop simulated time-series hydrology to compare each alternative's effects on streamflow and reservoir contents.

The Daily Model simulates the Arkansas River Basin from its headwaters to the Arkansas River at Las Animas gage, including major tributaries. An underlying assumption of the Daily Model is that any changed water rights (change-in-use, alternate point-of-diversion and exchanges) are operated in accordance with Colorado water law to prevent injury to senior water rights or the ability of Colorado to meet terms of the Compact. For example, AVC and Master Contract operations would not directly affect senior agricultural water rights within the basin. Therefore, simulated diversions for water rights are curtailed in the model based on water right priority date to maintain historical flow at the Arkansas River at Las Animas gage, which prevents downstream senior water right holders from being injured by upstream changes.

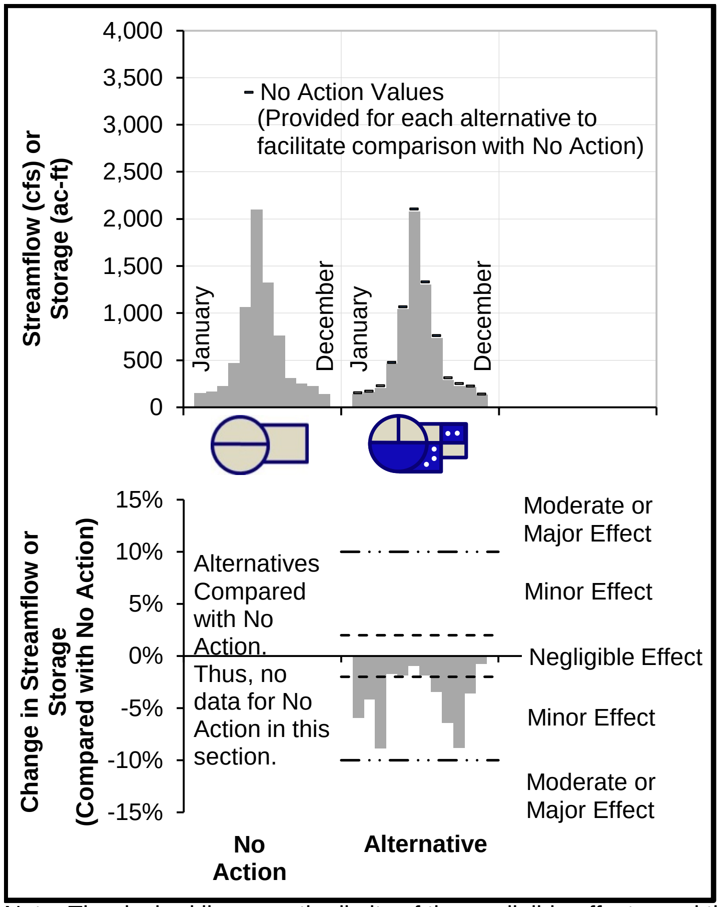
Other approaches and assumptions of the Daily Model include the following (see Appendix D.3 for a complete discussion on Daily Model approaches and assumptions):

- Historical hydrology (basin runoff) is indicative of future hydrology.
- Future agricultural demands would be the same as their historical diversions.
- Municipal demand is simulated for existing and future conditions.
- Increasing trends in Fountain Creek runoff would continue in the future.
- Spills of non-Fry-Ark water stored in Pueblo Reservoir excess capacity accounts are governed by Article 13 of Contract No. 5-07-70-W0086, as amended, between Southeastern and the United States (see Appendix D.3 for how Article 13 is applied in the Daily Model).
- Current minimum flow requirements and flow programs continue to be operated.

Daily Model outputs were used in water quality, groundwater hydrology, and aquatic life modeling (see Figure 4–5 for key to results discussion). The Daily Model was not used to analyze water supply yields. The historical water supply yield analysis for the Fry-Ark Project is presented in Appendix D.2. Daily Model development, calibration, and verification details are in Appendix D.3. Alternatives simulation in the Daily Model, including alternative specific assumptions, is described in Appendix D.4. The effects of alternatives on transit loss, or streamflow lost to groundwater seepage or evaporation, were analyzed using Daily Model outputs and are described in Appendix D.5.

Hydrologic effects on the West Slope and Grape Creek analysis areas (Figure 4–4) were calculated using a spreadsheet model developed for this EIS. The West Slope model quantifies effects on West Slope streams using simulated transmountain imports from the Daily Model, and historical streamflow and transmountain imports. The Grape Creek model quantifies effects from additional water accruing to the stream from agricultural dry-up. These models are described in Appendix D.5.

Hydrologic effects on the Arkansas River between John Martin Reservoir and the Colorado-Kansas state line (Figure 4–4) were calculated using a spreadsheet mass balance model developed for this EIS. The mass balance model simulates John Martin Reservoir accounts and major downstream diversions on a monthly basis. The mass balance model is described in Appendix D.5.



Note: The dashed lines are the limits of the negligible effects, and the dot-dashed lines are the limits of moderate or major effects.
Figure 4–5. Key for Presentation of Monthly Hydrology or Water Quality Results

To characterize effects of the alternatives under a range of conditions, results in this section and throughout this chapter are presented for normal, dry, and wet years, as well as overall annual and monthly averages. To be consistent with other definitions of normal, dry, and wet years currently being used, especially with ongoing streamflow program development through Pueblo, these classifications were based on the Natural Resources Conservation Service’s *Colorado Basin Water Supply Outlook Report* “most probable” forecast at the Arkansas River at Salida gage (Natural Resources Conservation Service 2011, Appendix D.3). The year type determination used 1966–2009 data. Wet years were defined as the wettest 30 percent of years in the period of data; dry years were the driest 30 percent. Normal years were all remaining years (Appendix D.3). Typical normal (2005), wet (1997), and dry (2004) years were identified by selecting a representative year from each hydrologic range, attempting to select more recent years when possible. Additional information on the selection process is in Appendix D.3.

Criteria for Determining Significance of Effects

Table 4–7 lists significance criteria used to describe the intensity of surface water hydrologic effects. These criteria were applied to overall annual streamflow and storage, overall average monthly streamflow and storage, and normal, wet, and dry year average monthly streamflow and storage to characterize effects. Appendix D.4 contains additional information for each gage. All surface water hydrology effects would be long-term. Effects of surface water hydrology changes on other resources, such as aquatic life and recreation, are described in the appropriate section of this chapter.

Table 4–7. Surface Water Hydrology Effect and Intensity Description

Effect Intensity	Intensity Description [1]
Negligible	The alternative would change streamflow or reservoir contents, but the change would be unmeasurable or of imperceptible consequence. The change would be considered unmeasurable or imperceptible if it is within the stated accuracy of the hydrologic model used to calculate the change. The Daily Model has an average annual percent error of less than 2 percent at most gages, and the average monthly percent error is generally less than 2 percent (see Appendix D.3).
Minor	The alternative would cause a measureable change to streamflow or reservoir contents, but the change is within the accuracy of USGS streamflow measurements. The accuracy of USGS streamflow measurements is generally within 10 percent (as described by USGS for “good” streamflow gages (2010c)). For consistency, this same percentage is used for reservoir effects.
Moderate	The alternative would cause a measurable change to streamflow or reservoir contents greater than 10 percent, but would not likely cause an adverse effect with regional consequences, such as affecting Colorado’s ability to meet Compact terms or affect the ability of senior water right holders to divert water (based either on quantity of water or stage at diversion structure)..
Major	The alternative would cause a measurable change to streamflow or reservoir contents greater than 10 percent, and would likely cause an adverse effect with regional consequences. The change would affect Colorado’s ability to meet Compact terms or affect the ability of senior water right holders to divert water (based either on quantity of water or stage at diversion structure).

Note:
(1) Except for “major” effects, surface water hydrology does not use “beneficial” or “adverse” to describe changes in streamflow or storage contents. Rather, the terms of “increase” and “decrease” are used. Descriptions of how changes in hydrology affect specific resources are presented in those resource sections.

Results

The direct and cumulative effects of alternatives on surface water hydrology are described in this section. Detailed displays of effects are presented for selected gages using graphs and tables, and are further described in the text. Gages discussed in the text were selected to represent and highlight effects through stream segments. Additional discussion and results are presented in Appendixes D.4. and D.5.

During the Draft AVC EIS public review period, the simulated existing conditions Colorado Springs Utilities exchanges into Pueblo Reservoir were found to be inconsistent with actual current exchanges. Several changes were made to the Daily Model to revise these exchanges.

The revised exchanges caused small changes in streamflow for existing conditions and the No Action and action alternatives. Lake Fork Creek and Lake Creek surface water hydrology effects would change more than other stream segments, although effects would continue to be mostly negligible to minor, similar to the Draft AVC EIS. Surface water hydrology effects at the Arkansas River above Pueblo gage would continue to be negligible to moderate, and proposed mitigation would not change. The level of reservoir effects would not change.

Other resource area effects were reviewed using the revised surface water hydrology. Slight surface water hydrology changes would not cascade into other resource areas; water quality, aquatic life, recreation, and vegetation effects would be similar to the Draft AVC EIS.

Because the level of effects and required mitigation would not be affected by the revised exchanges, values presented in this Final EIS were not changed from the Draft EIS. The changes made to the Daily Model to better simulate Colorado Springs Utility exchanges, and how the various resource areas would be affected are disclosed in Appendix D.6.

Direct Effects

The AVC and Master Contract excess capacity accounts could decrease or increase flow in the Arkansas River and Fountain Creek, depending on arrangement in the alternatives. The Interconnect contract would not affect surface water. The Interconnect only provides Pueblo Dam outlet redundancy to participants, including the Pueblo Fish Hatchery, in case of short-term outages. Table 4–8 and Table 4–9 summarize average annual surface water hydrologic direct effects.

Table 4–8. Summary of Average Annual Streamflow Direct Effects

Gage	Existing Condition	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Average Annual Streamflow (cfs)								
Lake Fork Creek below Sugar Loaf Dam	18	18	19	19	18	19	19	19
Lake Creek below Twin Lakes	192	192	192	192	193	192	192	191
Arkansas River at Granite	390	390	391	390	390	391	390	390
Arkansas River near Wellsville	712	712	712	712	712	712	712	711
Arkansas River at Cañon City	741	729	730	730	730	730	730	729
Arkansas River above Pueblo	646	627	611	611	614	611	625	624
Arkansas River at Moffat St.	637	619	606	606	609	606	606	616
Arkansas River near Avondale	953	941	933	933	933	933	933	941
Arkansas River near Rocky Ford	495	502	500	499	496	500	500	505
Arkansas River at Las Animas	311	314	316	315	312	316	316	318
Arkansas River near Granada	184	186	187	186	183	187	187	188
Fountain Creek at Pueblo	164	170	173	173	170	173	173	173
Grape Creek near Westcliffe	39	40	40	40	40	40	40	40
Fryingpan River near Thomasville	113	113	113	113	113	113	113	114
Hunter Creek near Aspen	42	42	42	42	42	42	42	42
Average Annual Streamflow Effects Compared to No Action Alternative (cfs (%))								
Lake Fork Creek below Sugar Loaf Dam	---	---	1 (5.6)	1 (5.6)	0 (0.0)	1 (5.6)	1 (5.6)	1 (5.6)
Lake Creek below Twin Lakes	---	---	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	0 (0.0)	-1 (-0.5)
Arkansas River at Granite	---	---	1 (0.3)	0 (0.0)	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)
Arkansas River near Wellsville	---	---	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	-1 (-0.1)
Arkansas River at Cañon City	---	---	1 (0.1)	1 (0.1)	1 (0.1)	1 (0.1)	1 (0.1)	0 (0.0)
Arkansas River above Pueblo	---	---	-16 (-2.6)	-16 (-2.6)	-13 (-2.1)	-16 (-2.6)	-2 (-0.3)	-3 (-0.5)
Arkansas River at Moffat St.	---	---	-13 (-2.1)	-13 (-2.1)	-10 (-1.6)	-13 (-2.1)	-13 (-2.1)	-3 (-0.5)
Arkansas River near Avondale	---	---	-8 (-0.9)	-8 (-0.9)	-8 (-0.9)	-8 (-0.9)	-8 (-0.9)	0 (0.0)
Arkansas River near Rocky Ford	---	---	-2 (-0.4)	-3 (-0.6)	-6 (-1.2)	-2 (-0.4)	-2 (-0.4)	3 (0.6)
Arkansas River at Las Animas	---	---	2 (0.6)	1 (0.3)	-2 (-0.6)	2 (0.6)	2 (0.6)	4 (1.3)
Arkansas River near Granada	---	---	1 (0.4)	0 (0.1)	-3 (-1.4)	1 (0.4)	1 (0.6)	2 (1.3)
Fountain Creek at Pueblo	---	---	3 (1.8)	3 (1.8)	0 (0.0)	3 (1.8)	3 (1.8)	3 (1.8)
Grape Creek near Westcliffe	---	---	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Fryingpan River near Thomasville	---	---	0 (0.0)	0 (0.0)	0 (0.1)	0 (0.0)	0 (0.1)	0 (0.1)
Hunter Creek near Aspen	---	---	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Table 4–9. Summary of Average Annual Reservoir Storage Direct Effects

Reservoir	Existing Condition	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Average Annual Reservoir Storage (ac-ft)								
Turquoise Lake	94,700	94,300	94,900	94,600	93,800	95,000	95,000	95,000
Twin Lakes	108,200	107,100	107,300	107,300	107,100	107,300	107,300	107,400
Pueblo Reservoir	203,300	198,800	200,800	197,200	182,000	201,100	202,500	209,100
John Martin Reservoir	124,200	127,400	128,800	129,000	128,500	128,900	129,000	129,400
Average Annual Reservoir Storage Effects Compared to No Action Alternative (ac-ft (%))								
Turquoise Lake	---	---	600 (0.6)	300 (0.3)	-500 (-0.5)	700 (0.7)	700 (0.7)	700 (0.7)
Twin Lakes	---	---	200 (0.2)	200 (0.2)	0 (0.0)	200 (0.2)	200 (0.2)	300 (0.3)
Pueblo Reservoir	---	---	2,000 (1.0)	-1,600 (-0.8)	-16,800 (-8.5)	2,300 (1.2)	3,700 (1.9)	10,300 (5.2)
John Martin Reservoir	---	---	1,400 (1.1)	1,600 (1.3)	1,100 (0.9)	1,500 (1.2)	1,600 (1.3)	2,000 (1.6)

AVC generally decreases streamflow in the Arkansas River downstream from Pueblo Reservoir by conveying water supplies in the pipeline rather than in the Arkansas River. Simulated average annual deliveries through AVC would be approximately 10,300 ac-ft per year (about 2 percent of annual average streamflow at the Arkansas River above Pueblo gage). Monthly AVC flow is summarized in Figure 4–6. For all AVC alternatives except JUP North, AVC water supplies would be composed of approximately 25 percent Fry-Ark supplies and 75 percent non-Fry-Ark supplies, on average. For the JUP North Alternative, which does not include the Master Contract, AVC water supplies would be composed of 75 percent Fry-Ark supplies and 25 percent non-Fry-Ark supplies. The composition of AVC supplies would affect Fry-Ark storage in Pueblo Reservoir, as described later in this section.

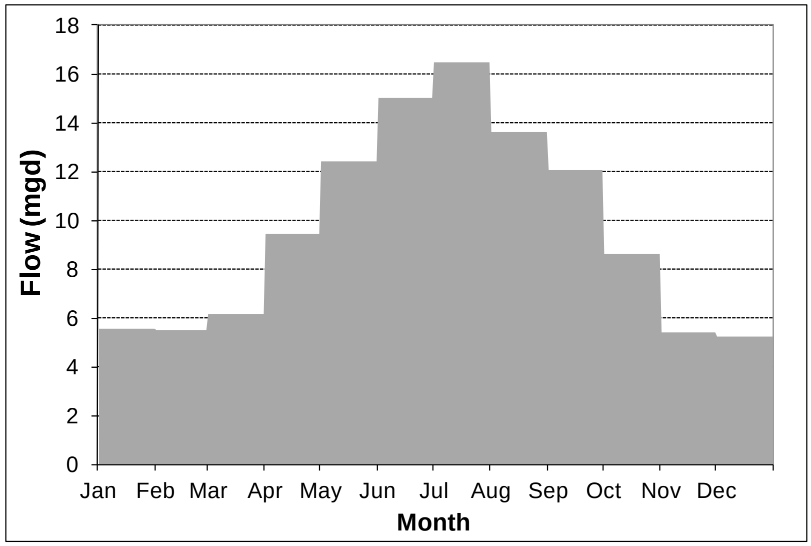


Figure 4–6. Simulated Monthly AVC Flow

Exchanges to Master Contract excess capacity accounts would typically decrease streamflow in a portion of the Arkansas River downstream from Pueblo Reservoir by diverting streamflow into Pueblo Reservoir storage, in exchange for an equal amount of water, such as return flows, entering the river farther downstream. Master Contract excess capacity accounts could also increase streamflow in the Arkansas River below Pueblo Reservoir by releasing water into the river for groundwater augmentation and decreasing groundwater pumping and river depletions. Increases in Fountain Creek streamflow could result from water supplies, such as return flows, sent down Fountain Creek for exchange into Pueblo Reservoir.

In general, the AVC and Master Contract excess capacity accounts could both increase and decrease storage contents in Pueblo Reservoir, depending on configuration of the alternatives. AVC could decrease storage in Pueblo Reservoir by using more Fry-Ark water to meet AVC participant demand, instead of AVC participants relying on downstream supplies to meet groundwater augmentation requirements. Master Contract excess capacity accounts could increase Pueblo Reservoir storage contents for two reasons: (1) additional water stored in excess capacity accounts, and (2) Master Contract participants using more of their non-Fry-Ark Project supplies (via a Master Contract account) for surface water deliveries or groundwater augmentation, leaving more Fry-Ark water in storage. Total simulated average monthly storage in Master Contract storage accounts in Pueblo Reservoir for the Comanche North Alternative is summarized in Figure 4–7. Storage in Master Contract storage accounts for the other AVC alternatives that include the Master Contract exhibit similar storage patterns.

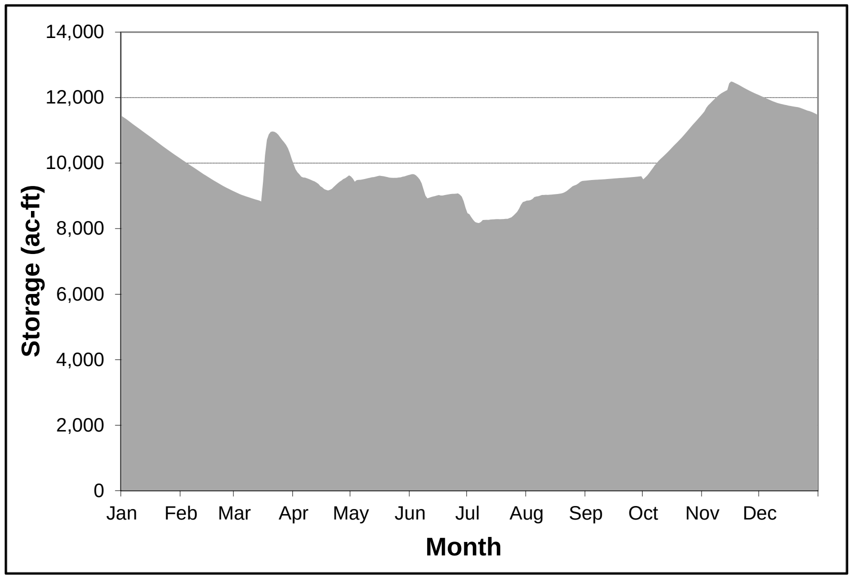


Figure 4–7. Simulated Average Monthly Storage in Master Contract Accounts for Comanche North Alternative

Streamflow Direct and indirect streamflow effects are discussed according to geography.

Upper Arkansas River Basin Gages The No Action Alternative would slightly increase or decrease streamflow in the Upper Arkansas River Basin compared to existing conditions, depending on month and year (Appendix D.4 and D.6). Average monthly streamflow direct effects at Upper Arkansas River Basin gages (see Figure 4–4 for gage locations) would be negligible for most months for all alternatives compared to No Action. Minor decreases in streamflow would occur during some winter and spring months during normal and wet years. Several alternatives would cause moderate streamflow decreases in 1 or 2 wet-year months at the Lake Fork Creek below Sugar Loaf Dam and Lake Creek below Twin Lakes gages due to decreases in reservoir storage and spills (Appendix D.4 and D.6). Direct effects on Grape Creek from agricultural dry-up associated with alternatives would be negligible.

AVC would indirectly affect Upper Arkansas River Basin streamflow by changing Pueblo Reservoir storage, which could affect timing of releases from Upper Arkansas River Basin reservoirs. The Master Contract would directly affect Upper Arkansas River Basin streamflow when participants exchange water in excess capacity storage to locations upstream from Pueblo Reservoir. Direct effects on the Upper Arkansas Voluntary Flow Management Program are shown in Table 4–10, and the significance of these effects is described in later sections of this chapter.

Table 4–10. Percent of Time Upper Arkansas Voluntary Flow Management Targets Are Met

Period	Existing Condition	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Overall	95.1	95.3	95.3	95.4	95.4	95.3	95.3	95.1
Fish Habitat [(1)]	95.3	95.5	95.5	95.6	95.6	95.5	95.5	95.3
Rec-reation [(2)]	93.7	93.8	93.9	94.0	93.9	94.0	94.0	93.9

Notes:
(1) Target flow of 250 cfs between August 16 and June 30.
(2) Target flow of 700 cfs between July 1 and August 15.

Lower Arkansas River Basin Gages The No Action Alternative would have less streamflow compared to existing conditions at the Arkansas River above Pueblo gage because of higher simulated demands. More exchanges are made through this segment to Pueblo Reservoir to help meet demands.

Photo 4–2. Typical midsummer streamflow at the Arkansas River above Pueblo gage (737 cfs)

Direct effects on average monthly streamflow at the Arkansas River above Pueblo gage would typically be negligible to minor for all action alternatives compared to No Action. Small changes in streamflow would occur in all alternatives, although small changes could cause minor effects (Figure 4–8), especially between August and March when streamflow is low. Decreases in average streamflow depth corresponding to these effects would be about 1 inch, or 3 percent, compared to an average streamflow depth of about 3 feet. Streamflow effects would increase during winter months in normal and dry years when base flows would be low, causing moderate effects (Figure 4–9, Figure 4–11, and Figure 4–12). Decreases in streamflow depth would be less than 3 inches. During wet years, all alternatives except the JUP North Alternative would cause minor to moderate increases in streamflow during some months (Figure 4–10).

Direct effects on the Pueblo Flow Management Program are shown in Table 4–11, and the significance of these effects is described in later sections of this chapter. Effects of streamflow changes on geomorphology are discussed in the Chapter 4 – *Geomorphology* section.

Memoranda of Agreement between Southeastern and AVC and Master Contract participants would require participation and compliance with Southeastern's commitments in the Pueblo Flow Management Program, as outlined in the Six Party Intergovernmental Agreement (City of Pueblo et al. 2004a, 2004b). This commitment would be further clarified in proposed future contract(s), as outlined in best management practices (Appendix B.5).

AVC alternatives other than River South would decrease flow in the Arkansas River at the Arkansas River above Pueblo gage by diverting water supplies into AVC at Pueblo Dam. AVC deliveries would also replace some groundwater pumping in the fall and winter, causing fewer groundwater augmentation releases from Pueblo Reservoir during this period. Exchanges into Master Contract storage by Lower Arkansas River Basin and Fountain Creek Master Contract participants would also decrease streamflow. Effects of the River South and Master Contract Only alternatives would be negligible for most months as AVC participant water supplies would not be diverted at Pueblo Dam, but would pass through this stream segment for diversion downstream.

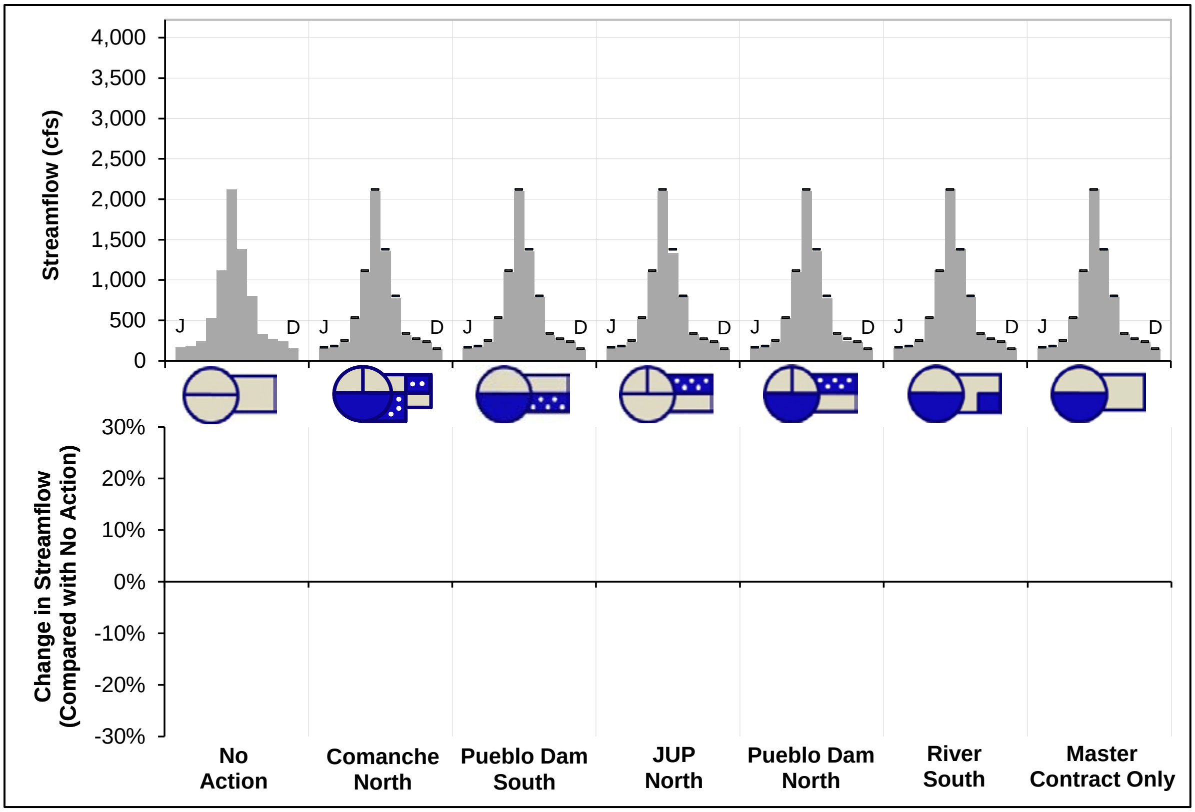


Figure 4–8. Simulated Average Monthly Streamflow – Arkansas River Above Pueblo Gage – Direct Effects

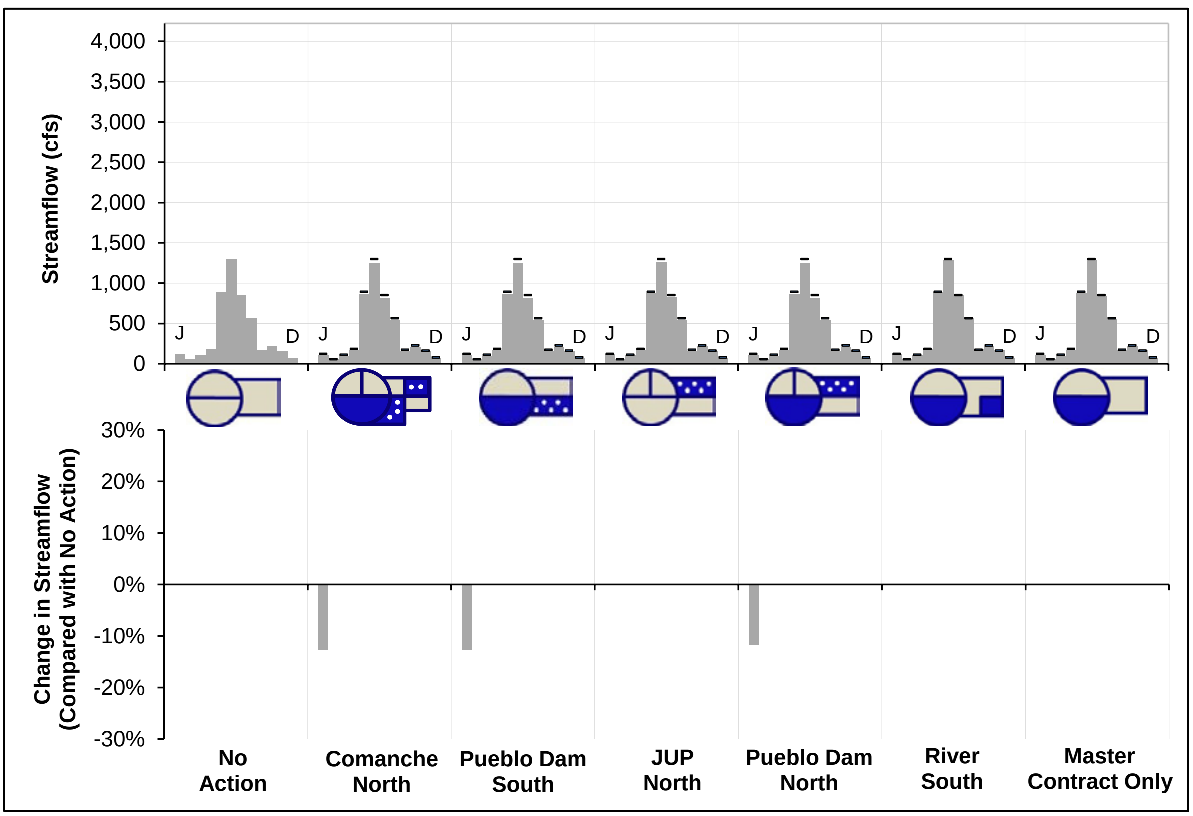


Figure 4–9. Simulated Normal Year (2005) Monthly Streamflow – Arkansas River Above Pueblo Gage – Direct Effects

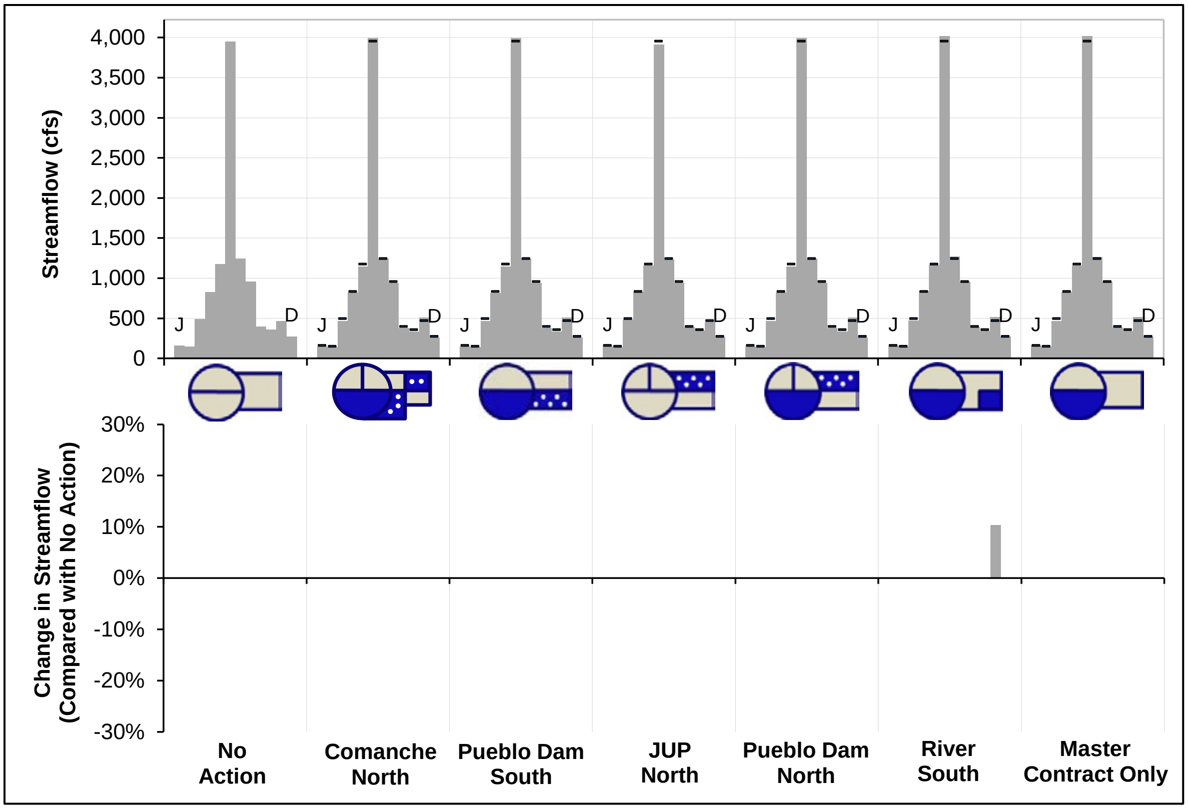


Figure 4–10. Simulated Wet Year (1997) Monthly Streamflow – Arkansas River Above Pueblo Gage – Direct Effects

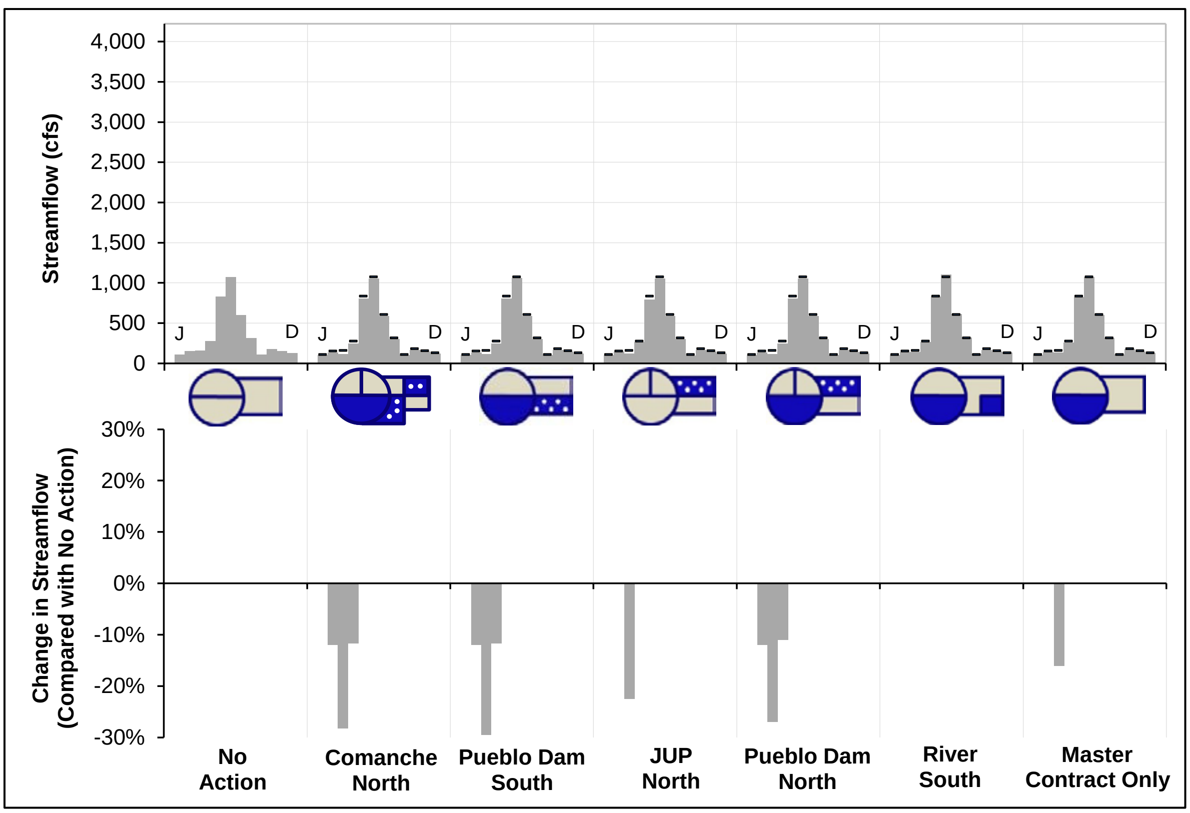


Figure 4–11. Simulated Dry Year (2004) Monthly Streamflow – Arkansas River Above Pueblo Gage – Direct Effects

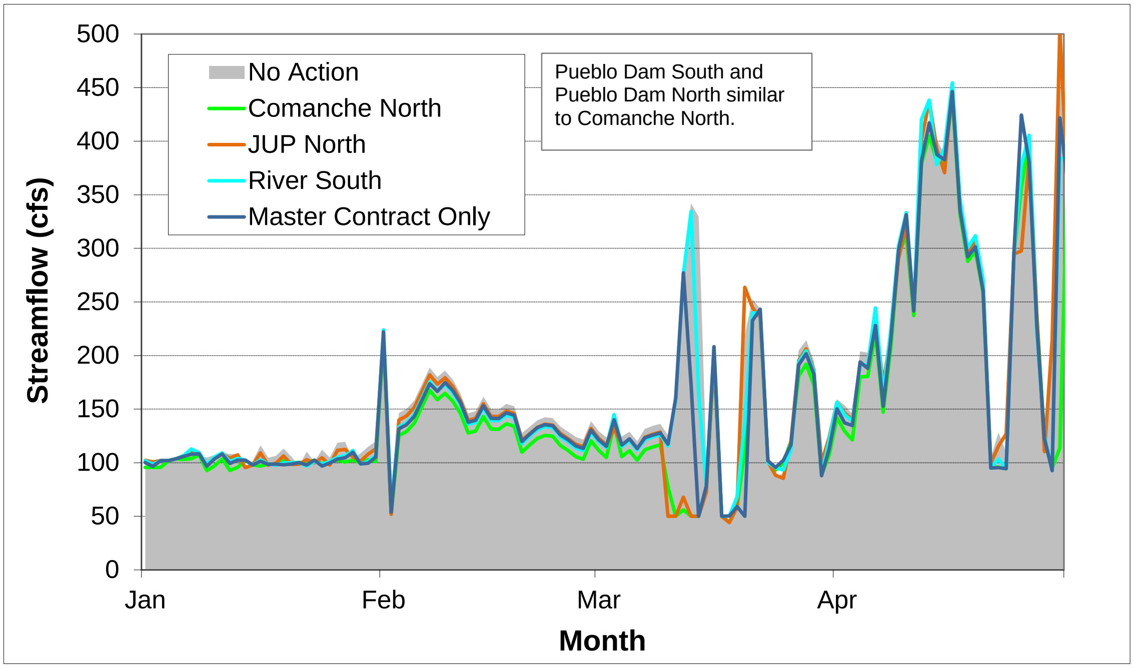


Figure 4–12. Simulated Winter and Spring Dry Year (2004) Daily Streamflow – Arkansas River Above Pueblo Gage

Table 4–11. Percent of Time Pueblo Flow Management Targets are Met

Period	Existing Condition	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Overall	89.2	89.3	88.8	88.5	88.3	88.8	90.3	89.4
Summer	94.7	95.4	95.6	95.5	95.1	95.6	96.3	95.5
Winter	78.3	77.0	74.9	74.6	74.4	75.0	78.2	77.0

Streamflow would gradually increase farther downstream at other Lower Arkansas River Basin gages (see Figure 4–4 for gage locations) under the No Action Alternative compared to existing conditions, although increases would be small (less than 20 cfs) at the Arkansas River at Las Animas gage. Direct effects on average monthly streamflow would be predominately negligible compared to the No Action Alternative, with some minor effects depending on the month. AVC effects would lessen downstream due to the decreasing quantity of AVC water supplies bypassing the river as deliveries are made to participants. Exchanges into Master Contract storage would also decrease farther downstream as the river passes various points of exchange.

Direct effects on monthly streamflow in the Arkansas River near Granada gage would be negligible to minor for most months for all alternatives (Figure 4–13). In many months, streamflow would increase compared to the No Action Alternative. Decreases in streamflow for the JUP North Alternative is caused by a decrease in John Martin Reservoir inflow during wet years. For example, during the wet year of 1995, John Martin Reservoir inflows decrease in July (Figure 4–14) compared to the No Action Alternative. The JUP North Alternative would generally cause minor reductions in Pueblo Reservoir storage contents, allowing the reservoir to capture more native flow during wet years like 1995 that would otherwise have been stored in John Martin Reservoir.

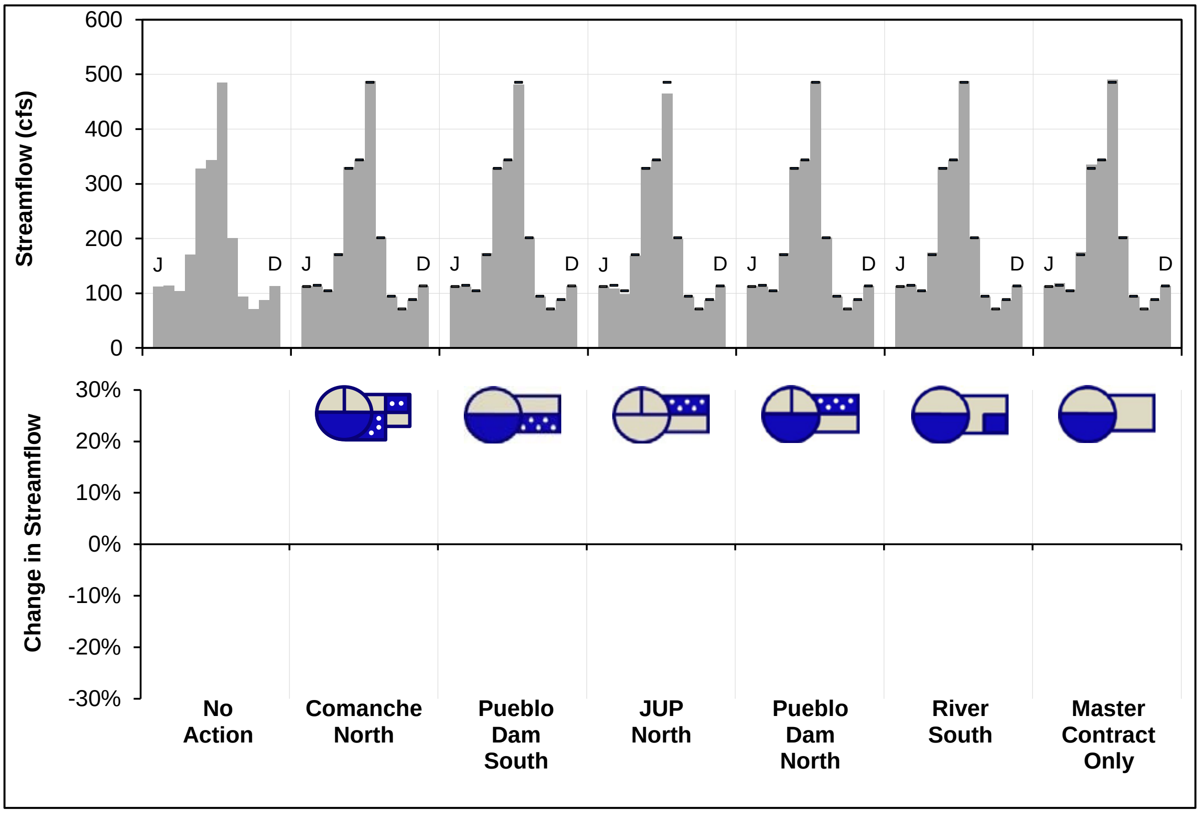


Figure 4–13. Simulated Average Monthly Streamflow – Arkansas River Near Granada Gage – Direct Effects

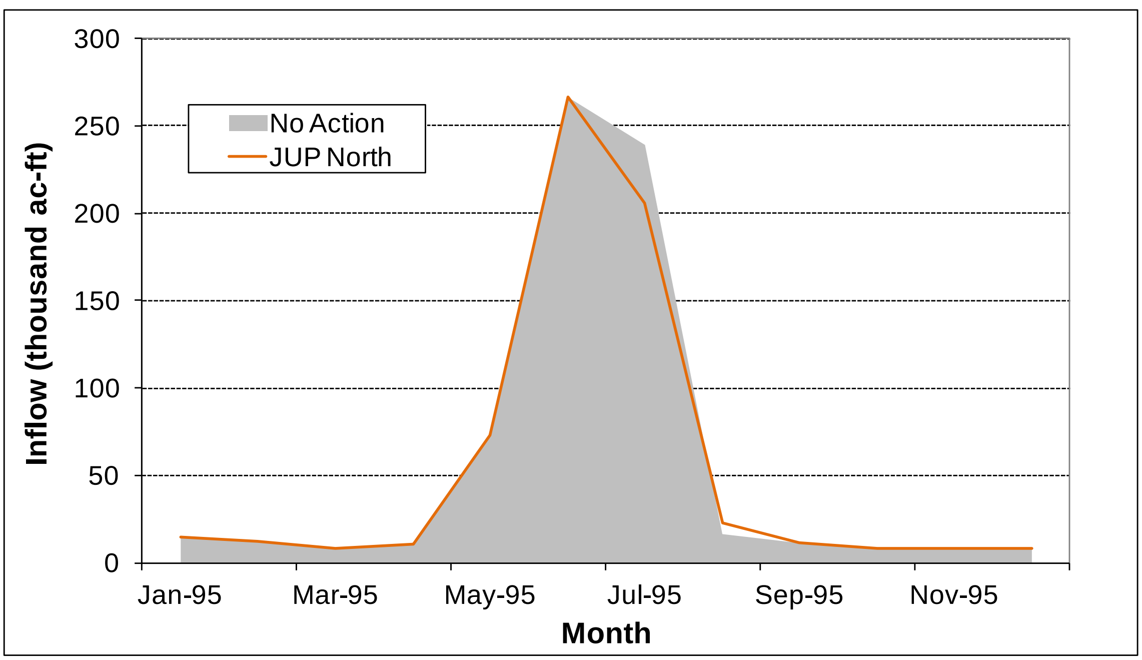


Figure 4–14. Simulated 1995 John Martin Reservoir Inflow for No Action and JUP North Alternatives

Fountain Creek Basin Gages The No Action Alternative would increase streamflow on average by 4 percent to 6 percent compared to existing conditions, due to future demand and resulting return flows. Direct effects on average monthly streamflow at the Fountain Creek at Pueblo gage would be negligible to minor for all alternatives compared to No Action. Small increases in streamflow would result from all alternatives, although small changes would cause minor effects (Figure 4–15, Figure 4–16, and Figure 4–17), especially in winter and early spring months. These effects would increase in dry years, when winter and early spring effects would be moderate (Figure 4–18).

Streamflow increases at the Fountain Creek at Pueblo gage for alternatives other than JUP North would be directly caused by decreased groundwater pumping and river depletions compared to the No Action Alternative. The JUP North Alternative lacks Master Contract excess capacity accounts; therefore, effects would be negligible because groundwater pumping for this alternative would be similar to the No Action Alternative.

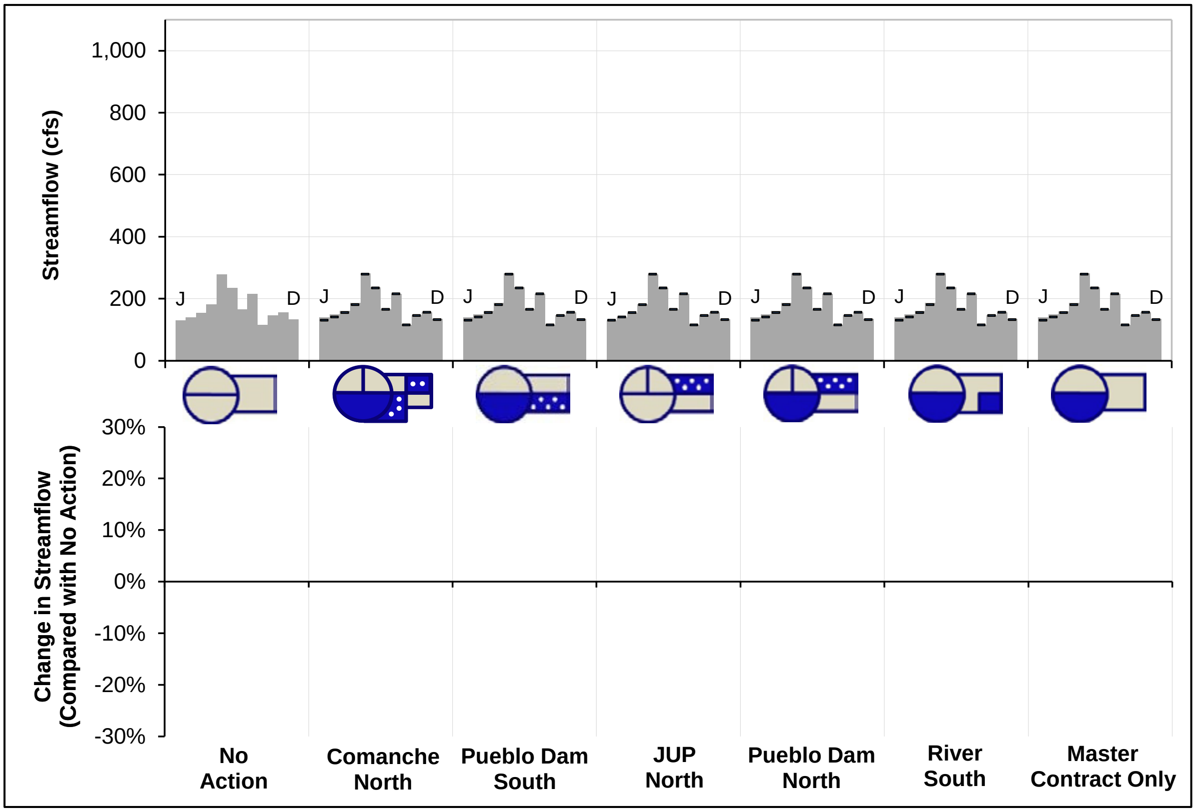


Figure 4–15. Simulated Average Monthly Streamflow – Fountain Creek at Pueblo Gage – Direct Effects

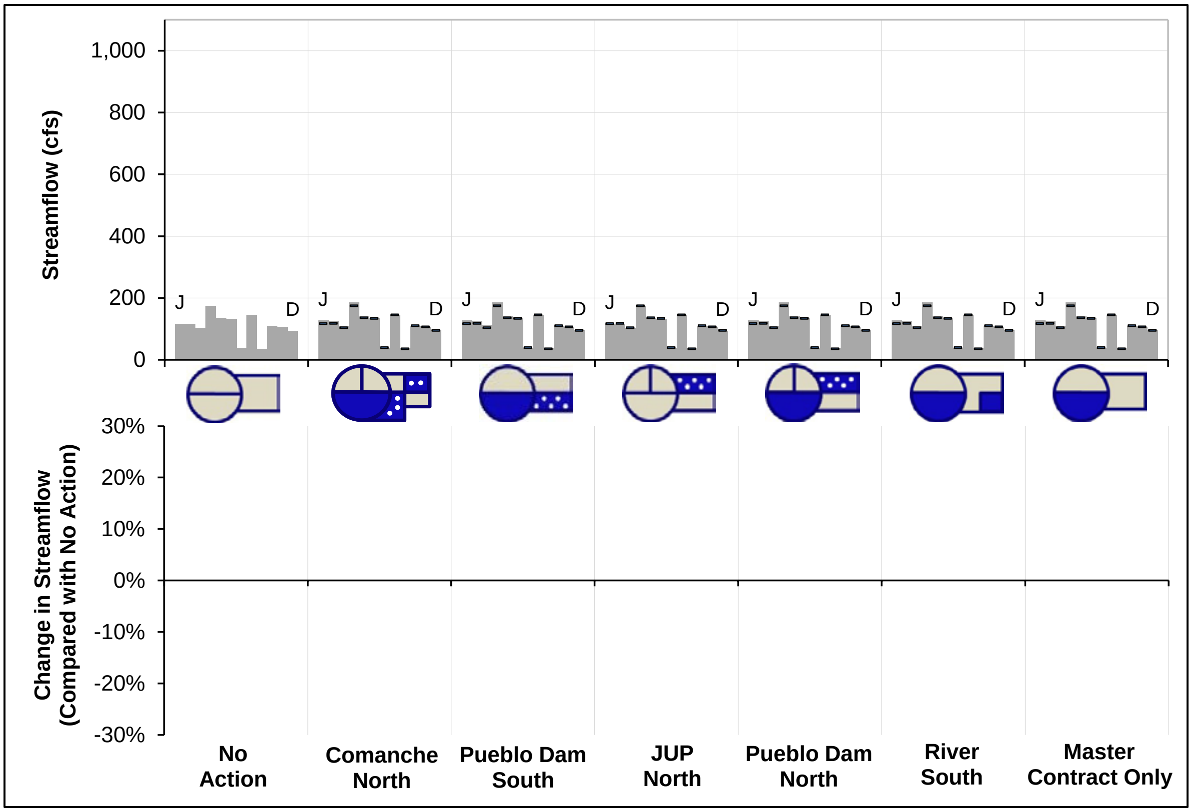


Figure 4–16. Simulated Normal Year (2005) Monthly Streamflow – Fountain Creek at Pueblo Gage – Direct Effects

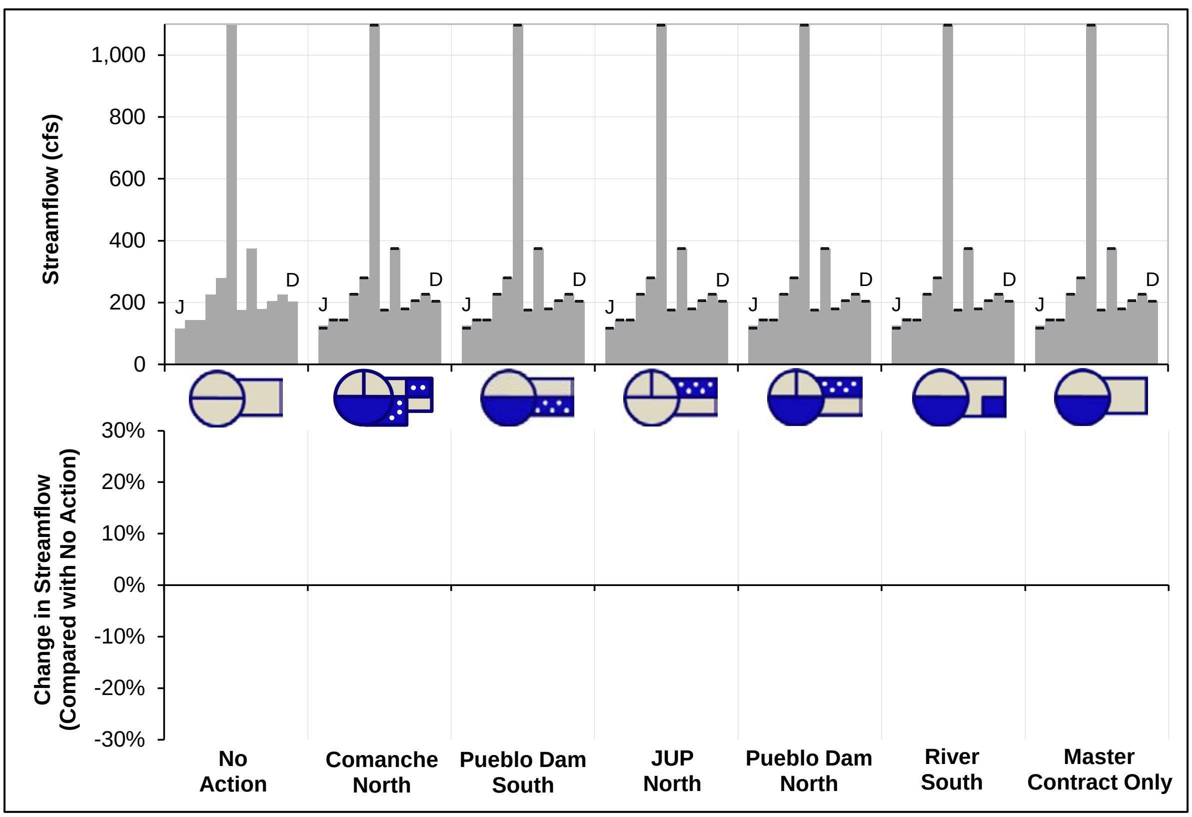


Figure 4–17. Simulated Wet Year (1997) Monthly Streamflow – Fountain Creek at Pueblo Gage – Direct Effects

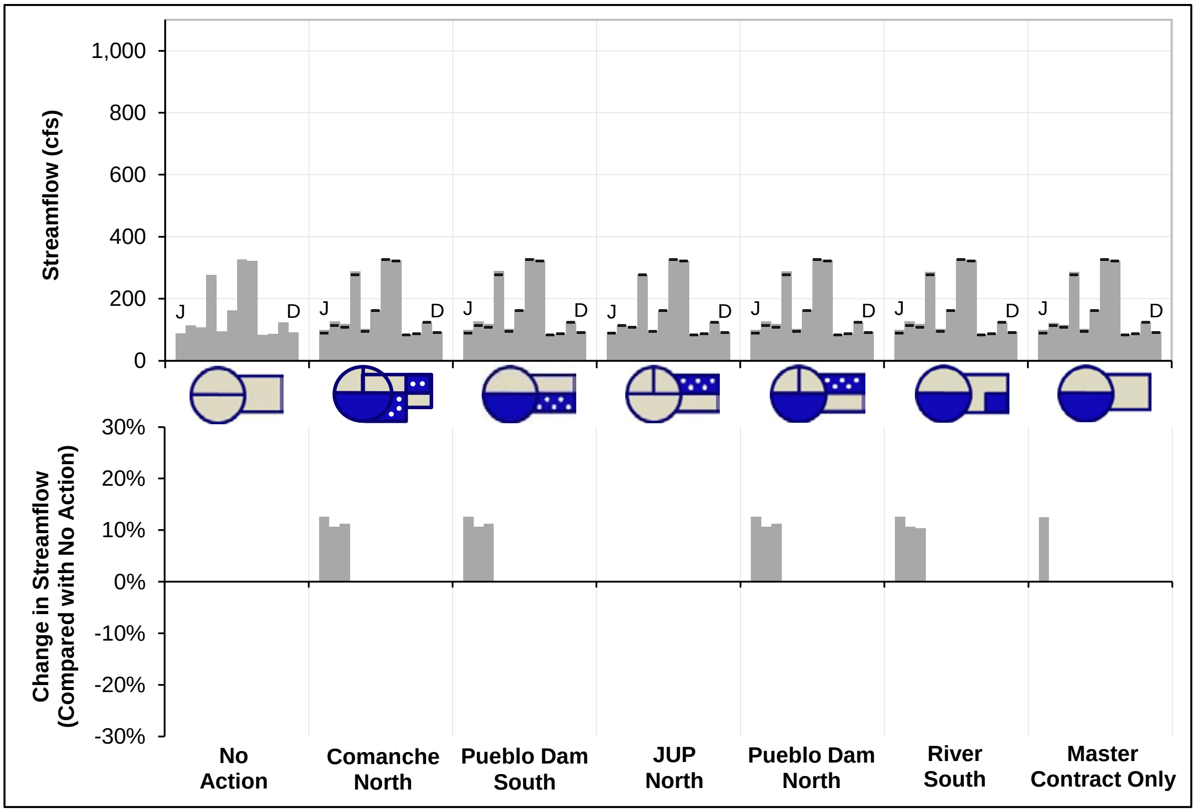


Figure 4–18. Simulated Dry Year (2004) Monthly Streamflow – Fountain Creek at Pueblo Gage – Direct Effects

West Slope Gages The No Action Alternative would not substantially change streamflow on the West Slope compared to existing conditions, although occasional small decreases could occur. Direct effects on average monthly streamflow in Hunter Creek near Aspen would be negligible for all alternatives and all months compared to No Action. Direct effects on average monthly streamflow at the Fryingpan River near Thomasville gage would be negligible for all alternatives during all months except July and August with the JUP North Alternative. The JUP North Alternative would cause minor streamflow decreases in July and minor streamflow increases in August as a result of increased use of Fry-Ark allocations under this alternative, which would increase Boustead diversions earlier in the season during wet years to fill Fry-Ark storage space (see Appendix D.5). Diversions would be less late in the summer, causing higher streamflow.

Transit Loss All alternatives negligibly affect the amount of transit loss (water lost to seepage and evaporation). Changes in streamflow would affect transit losses in the river. Although average volumetric transit losses each year would decrease as average annual streamflow decreased, the average percentage of streamflow lost to transit would increase (see Appendix D.5).

Reservoir Storage The No Action Alternative would decrease Turquoise Lake and Twin Lake storage contents compared to existing conditions, although most changes would be less than 3 percent. Direct effects of action alternatives on average monthly Turquoise Lake and Twin Lake storage contents and reservoir water surface elevation would be negligible for all months compared to the No Action Alternative. The AVC and Master Contract would indirectly affect

Upper Arkansas River Basin reservoirs by changing timing of releases to and exchanges from Pueblo Reservoir. Occasional minor increases would occur in Turquoise Lake storage contents in wet and dry years for most alternatives compared to the No Action Alternative.

The No Action Alternative would decrease Holbrook Reservoir storage compared to existing conditions (see Appendix D.4). All alternatives except JUP North would cause moderate decreases in Holbrook Reservoir storage contents during normal and dry years, although these decreases are due to complexities in modeling assumptions and not necessarily attributable to AVC, as explained in Table 4–5.

No Action Alternative storage contents in Pueblo Reservoir would be lower than existing conditions because of higher municipal demand. Most changes would be less than 5 percent. Direct effects of the action alternatives on average monthly Pueblo Reservoir storage contents would be negligible to minor compared to the No Action Alternative. Negligible changes in storage contents would result from most alternatives (Figure 4–19 and Figure 4–20) except the JUP North and Master Contract Only alternatives. The JUP North Alternative would cause minor decreases in Pueblo Reservoir storage contents, and the Master Contract Only Alternative would cause minor increases. JUP North Alternative effects would increase in normal and dry years, when decreases in storage contents would be moderate. Pueblo Reservoir storage effects for specific years, as well as effects on other Lower Arkansas River Basin Reservoirs, are shown in Appendix D.4.

Photo 4–3. Pueblo Reservoir (water surface at 4,870.54-foot elevation and corresponding storage of 214,222 ac-ft)

The JUP North Alternative would create minor and moderate decreases in Pueblo Reservoir storage contents compared to the No Action Alternative because the lack of Master Contract excess capacity accounts would prevent AVC participants from exchanging return flows and non-Fry-Ark Project supplies into Pueblo Reservoir for diversion to AVC. More Fry-Ark storage would be used to meet AVC demand, drawing down the reservoir. In the No Action Alternative, most AVC participant demands would be met with groundwater pumping, which could be augmented with return flows and non-Fry Ark Project water, requiring fewer releases from Fry-Ark storage in Pueblo Reservoir.

The Master Contract Only Alternative would cause minor increases in the amount of water stored in Pueblo Reservoir compared to the No Action Alternative for two reasons: (1) additional water would be stored in excess capacity accounts, and (2) participants could use more of their non-Fry Ark Project supplies (via a Master Contract account) for surface water deliveries or augmentation, leaving more Fry-Ark water in storage.

Direct effects on average monthly Pueblo Reservoir water surface elevation would be negligible to minor. Negligible changes in storage contents would occur in most alternatives except the JUP North and Master Contract Only alternatives (Figure 4–21).

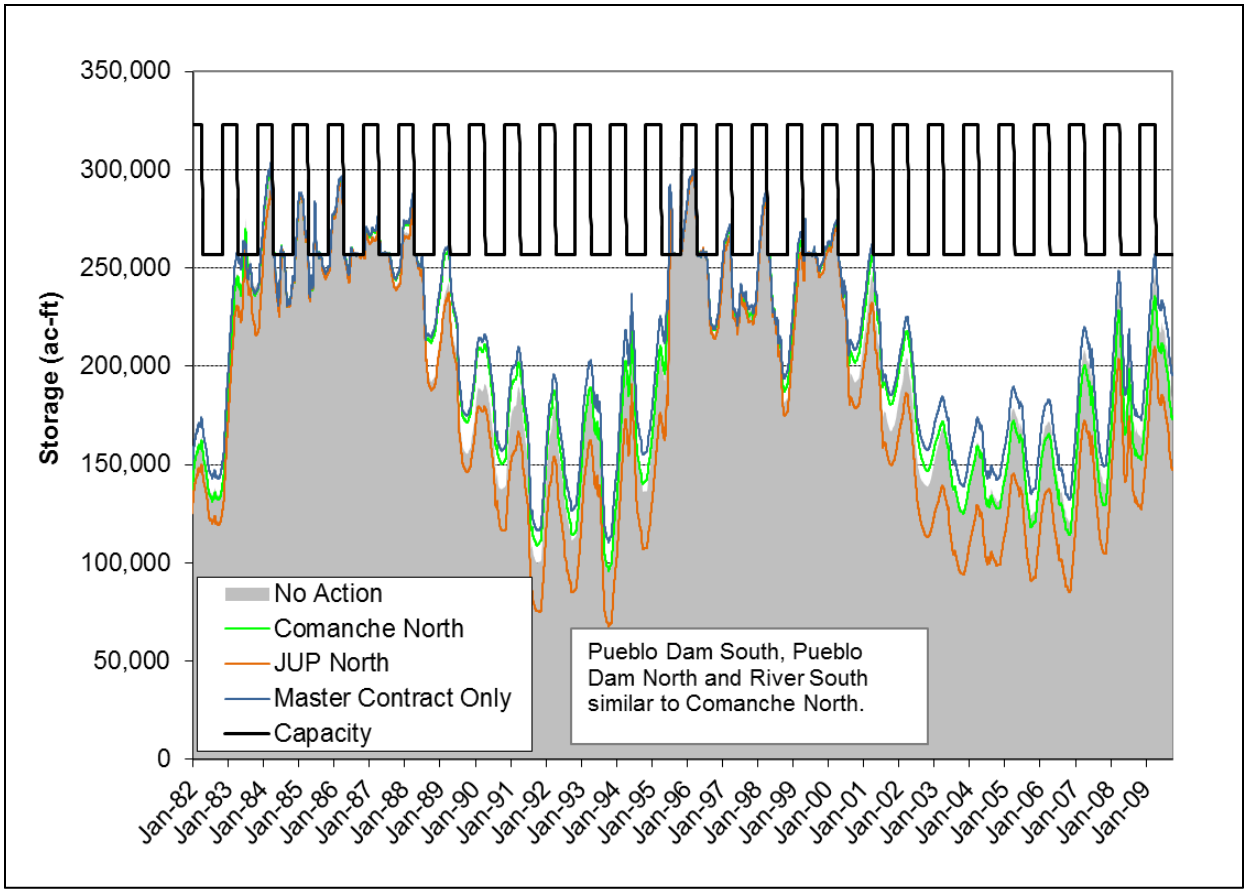


Figure 4–19. Simulated Daily Storage Contents – Pueblo Reservoir – Direct Effects

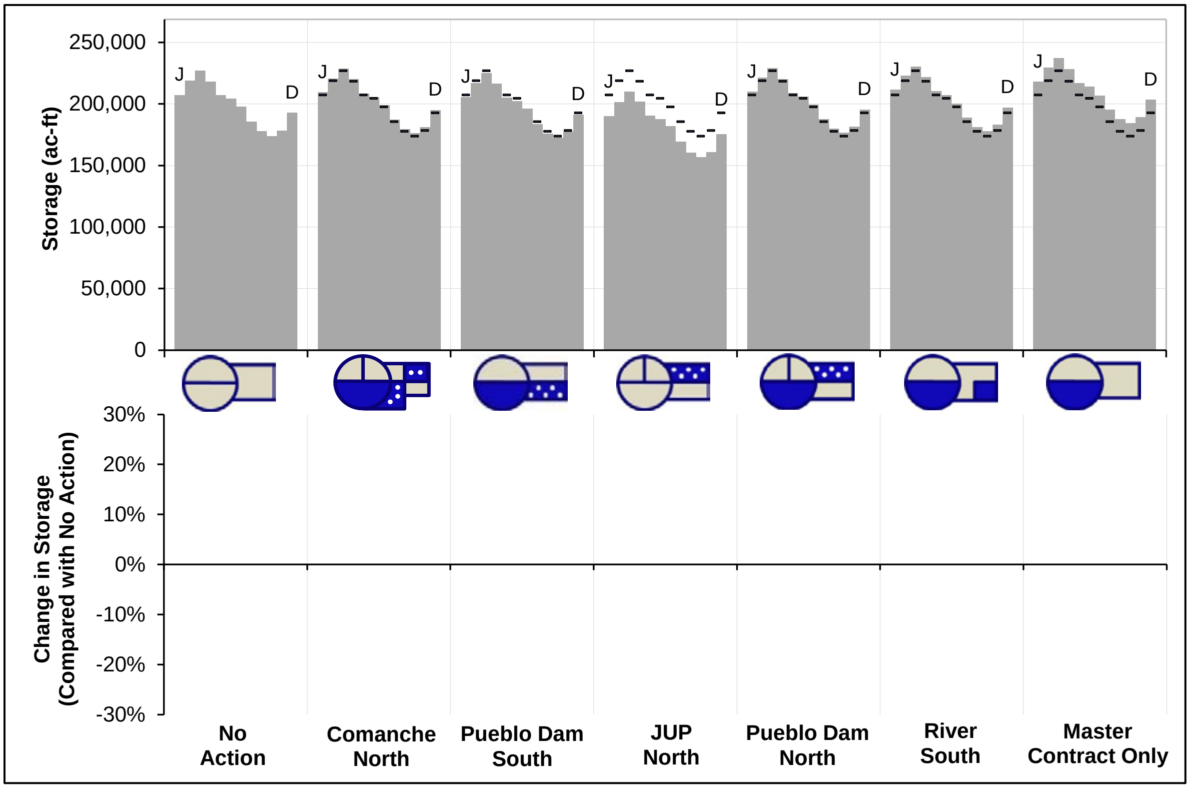


Figure 4–20. Simulated Average Monthly Storage Contents – Pueblo Reservoir – Direct Effects

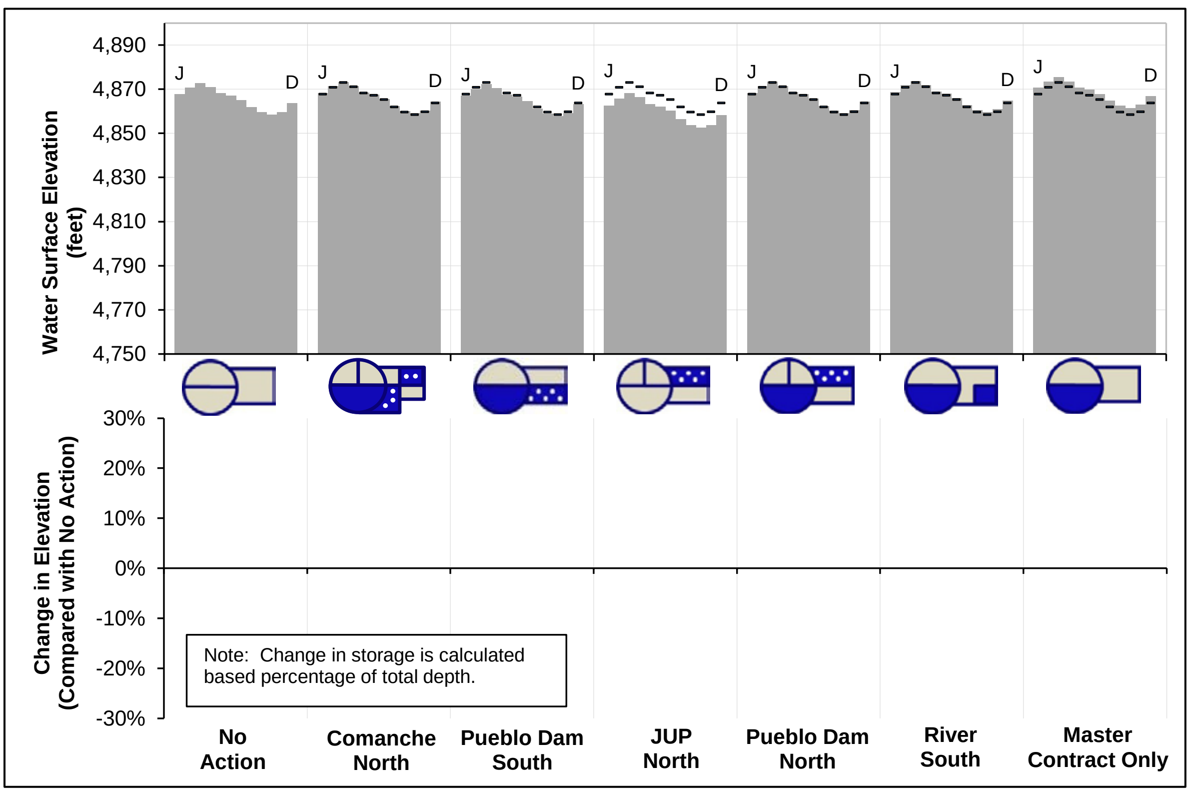


Figure 4–21. Simulated Average Monthly Water Surface Elevation – Pueblo Reservoir – Direct Effects

Cumulative Effects

In general, reasonably foreseeable actions, excluding climate change, together with the alternatives, would decrease streamflow in the Arkansas River compared to the direct effects analyses. This decrease in Arkansas River streamflow would be caused by increased municipal demand and exchanges associated with reasonably foreseeable actions (for example, Colorado Springs demand and SDS exchanges into Pueblo Reservoir excess capacity accounts). An increase in Colorado Springs return flows would increase streamflow in Fountain Creek compared to direct effects. Incremental effects of the AVC and Master Contract, however, would not be substantially different than direct effects (Table 4–12). The reasonably foreseeable actions are included in all alternatives in the cumulative effects analysis, including the No Action Alternative, and typically would have greater effects on Arkansas River and Fountain Creek streamflow than the AVC and Master Contract.

Cumulative effects on average monthly storage contents for all reservoirs would be negligible to minor. Reservoir storage contents would be low compared to direct effects due to increased demands. Cumulative effects, by percentage, would be similar to those described under direct effects (Table 4–12).

Climate change is projected to affect precipitation and runoff patterns, and could decrease average streamflow in the Arkansas River in all alternatives, including the No Action Alternative. The decrease in Arkansas River Basin streamflow may decrease Fry-Ark Project East Slope yields. Decreases in streamflow would also affect volume and frequency of exchanges in the river basin. Decreases in exchange potential would, at times, prevent Master Contract participants from exchanging non-Fry Ark Project supplies into Master Contract accounts, resulting in operations similar to the JUP North Alternative (as described under direct effects), which uses more Fry-Ark supplies and decreases Pueblo Reservoir storage contents. The JUP North Alternative would already use most of its Fry-Ark allocation; therefore, any decrease in non-Fry Ark Project supplies would reduce AVC yield.

Mitigation Measures

To mitigate moderate effects of occasional low streamflow immediately below Pueblo Reservoir, and the effects of this low streamflow on water quality and aquatic life, Reclamation would limit excess capacity contract operations when streamflow is less than 50 cfs, as measured by adding streamflow at the Arkansas River above Pueblo gage to fish hatchery return flows from the current hatchery discharge point.

Reclamation would provide coordination assistance with participants in managing storage and water releases in a manner that could assist in augmenting low streamflows in the Arkansas River downstream from Pueblo Reservoir to the Fountain Creek confluence. Reclamation will not modify operations that would impact Fry-Ark Project yield.

Reclamation would provide $50,000 for habitat improvements downstream from Pueblo Reservoir to mitigate moderate streamflow effects and minor aquatic life effects of an action alternative during low-flow periods in the Arkansas River. Design and location of improvements would be coordinated between Reclamation and Colorado Parks and Wildlife after a Record of Decision has been signed, including site-specific NEPA compliance.

Table 4–12. Summary of Average Annual Streamflow and Reservoir Storage Cumulative Effects

Gage	Existing Condition	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Streamflow (cfs) [1]								
Lake Fork Creek below Sugar Loaf Dam	18	13	13	13	13	13	13	14
Lake Creek below Twin Lakes	192	174	176	176	176	176	175	174
Arkansas River near Wellsville	712	689	690	690	690	690	689	689
Arkansas River above Pueblo	646	494	481	481	482	481	494	492
Arkansas River near Rocky Ford	495	494	492	491	490	492	491	495
Arkansas River at Las Animas	311	305	306	306	304	306	305	306
Arkansas River near Granada	184	173	174	174	172	174	173	174
Fountain Creek at Pueblo	164	270	271	271	270	271	271	271
Reservoir Storage (ac-ft) [1]								
Turquoise Lake	94,700	87,000	87,000	86,700	85,900	86,900	86,500	87,600
Twin Lakes	108,200	99,100	98,900	99,000	98,800	98,900	99,100	99,000
Pueblo Reservoir	203,300	156,100	154,900	152,600	145,500	154,600	155,600	164,900
John Martin Reservoir	124,200	127,500	128,500	128,700	128,300	128,700	127,600	128,100
Streamflow Effects Compared to No Action Alternative (cfs (%)) [1]								
Lake Fork Creek below Sugar Loaf Dam	---	---	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (7.7)
Lake Creek below Twin Lakes	---	---	2 (1.1)	2 (1.1)	2 (1.1)	2 (1.1)	1 (0.6)	0 (0.0)
Arkansas River near Wellsville	---	---	1 (0.1)	1 (0.1)	1 (0.1)	1 (0.1)	0 (0.0)	0 (0.0)
Arkansas River above Pueblo	---	---	-13 (-2.6)	-13 (-2.6)	-12 (-2.4)	-13 (-2.6)	0 (0.0)	-2 (-0.4)
Arkansas River near Rocky Ford	---	---	-2 (-0.4)	-3 (-0.6)	-4 (-0.8)	-2 (-0.4)	-3 (-0.6)	1 (0.2)
Arkansas River at Las Animas	---	---	1 (0.3)	1 (0.3)	-1 (-0.3)	1 (0.3)	0 (0.0)	1 (0.3)
Arkansas River near Granada	---	---	0 (0.3)	0 (0.2)	-1 (-0.4)	0 (0.3)	0 (0.1)	1 (0.6)
Fountain Creek at Pueblo	---	---	1 (0.4)	1 (0.4)	0 (0.0)	1 (0.4)	1 (0.4)	1 (0.4)
Reservoir Storage Effects Compared to No Action Alternative (ac-ft (%)) [1]								
Turquoise Lake	---	---	0 (0.0)	-300 (-0.3)	-1,100 (-1.3)	-100 (-0.1)	-500 (-0.6)	600 (0.7)
Twin Lakes	---	---	-200 (-0.2)	-100 (-0.1)	-300 (-0.3)	-200 (-0.2)	0 (0.0)	-100 (-0.1)
Pueblo Reservoir	---	---	-1,200 (-0.8)	-3,500 (-2.2)	-10,600 (-6.8)	-1,500 (-1.0)	-500 (-0.3)	8,800 (5.6)
John Martin Reservoir	---	---	1,000 (0.8)	1,200 (0.9)	800 (0.6)	1,200 (0.9)	100 (0.1)	600 (0.5)

Note:
[1] Climate change effects are not included in these values.

Groundwater Hydrology

Methods used to evaluate groundwater level direct, indirect, and cumulative effects are described in this section for both alluvial and consolidated bedrock aquifers. Effects on groundwater quality are discussed in Chapter 4 – *Water Quality* section. Detailed groundwater level analysis methods and results are in Appendix E.1.

Summary

All alternatives would negligibly affect alluvial groundwater levels in the Upper and Lower Arkansas River basins (Table 4–13). Changes in river levels, municipal groundwater pumping, and agriculture dry-up would not substantially affect water table levels along the Arkansas River or Fountain Creek compared to the No Action Alternative.

Effects of groundwater pumping in the Fountain Creek Basin alluvial aquifers would be minor and beneficial for all action alternatives. Excess capacity storage would increase surface water supplies from the No Action Alternative, which would decrease groundwater pumping needs and increase the water table level. Effects on basement flooding in the Fountain Creek Basin would be negligible. The No Action Alternative would decrease water table levels, compared to existing conditions due to additional groundwater pumping from these sources to meet demands.

Effects on groundwater levels in the Dakota-Cheyenne aquifer (consolidated bedrock aquifer) would be negligible because municipal pumping decreases would be small compared to continued agricultural use, and would be localized near existing municipal wells.

Table 4–13. Summary of Groundwater Hydrology Direct and Indirect Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
⊙	◐	⦶	=	⊖	◒	●
Beneficial ↔ Adverse						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Groundwater [(1)]						
Groundwater Level – Upper Arkansas Alluvium	=	=	=	=	=	=
Groundwater Level – Lower Arkansas Alluvium	=	=	=	=	=	=
Groundwater Level – Fountain Creek Alluvium	⦶	⦶	⦶	⦶	⦶	⦶
Groundwater Level – Consolidated Bedrock Aquifers	=	=	=	=	=	=

Note:
(1) Effects are assessed compared to the No Action Alternative.

Methods

Methods used to analyze effects, and the criteria for determining significance of effects on groundwater hydrology, are described in this section. Differing methodologies and levels of information were used to analyze groundwater hydrology in alluvial and consolidated bedrock aquifers in the Upper and Lower Arkansas river basins.

Effects Analyses

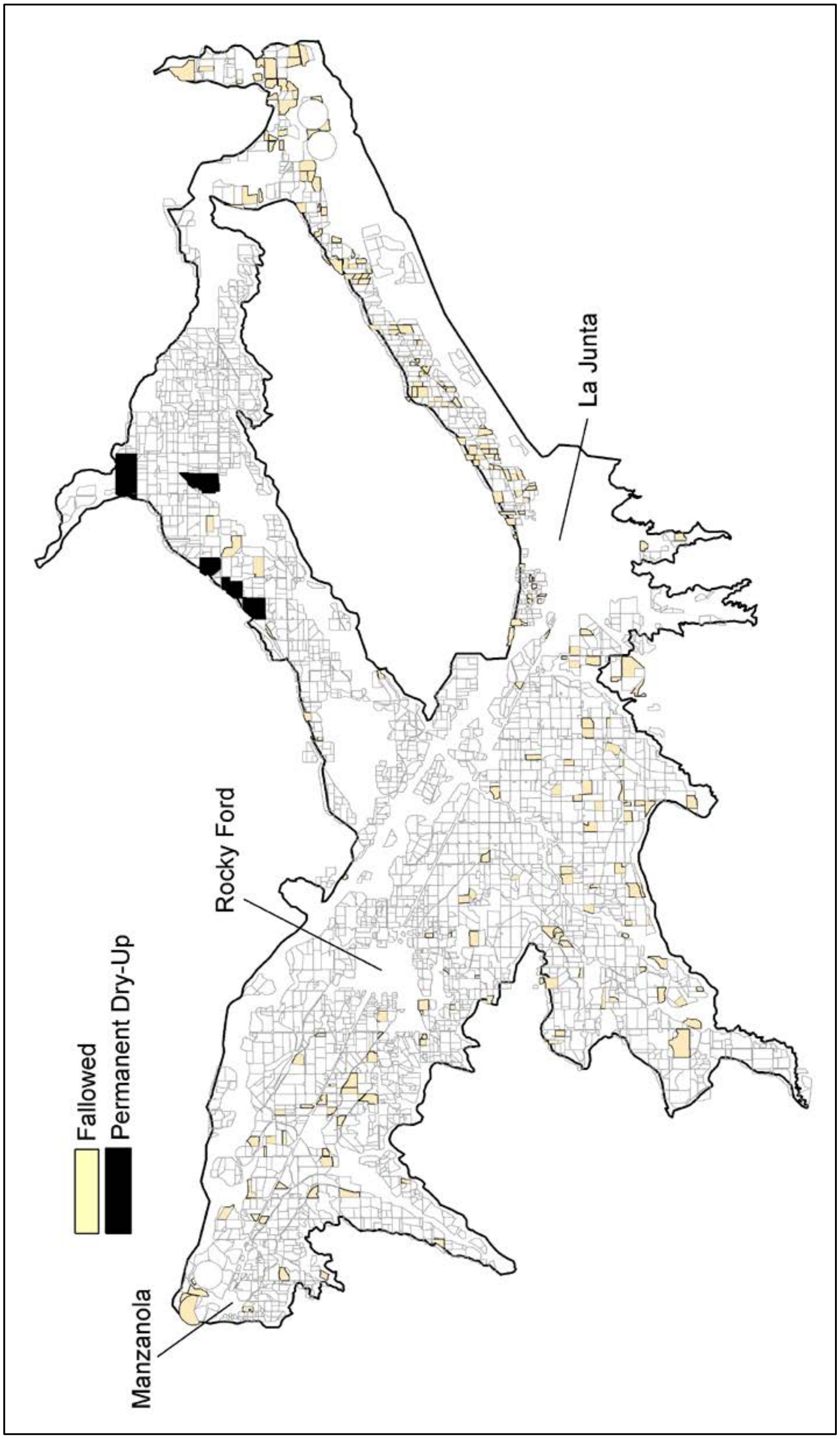
Upper Arkansas River Basin and Fountain Creek groundwater analyses evaluated the effects of changes in river levels and groundwater pumping on alluvial groundwater levels. Effects of changes in river levels on alluvial groundwater levels were calculated using Daily Model output and groundwater flow equations for steady flow (flow does not change with time) in these unconfined aquifers. An equation was also used that describes how water flows between surface water and groundwater sources in a generally horizontal direction (Fetter 1988).

Effects of new groundwater pumping on alluvial groundwater levels were calculated using a steady state equation (aquifer properties do not change with time) for groundwater flow in an unconfined aquifer with recharge, or drainage into the aquifer at various distances from the river. Pumping was assumed to be at a steady rate from a single hypothetical well 400 feet from the river. This assumption represents the highest level of expected effects because pumping from a suitably designed well field with multiple, properly spaced wells, would reduce groundwater drawdown relative to the single-well assumption. Pumping rates from the Daily Model were used for normal, wet, and dry years, as well as the overall average. The surface water source was assumed to remain hydraulically connected with nearby alluvial aquifers to provide a constant water supply, and flow in the alluvial aquifer was assumed to be constant over time.

The Lower Arkansas River Basin groundwater analysis used an existing detailed model developed by Colorado State University (Regional Model) to relate surface water hydrology, groundwater hydrology, water quality, and crop yield (Burkhalter and Gates 2005, 2006; Gates et al. 2006). The Regional Model was used to evaluate water table depth, groundwater return flows and salinity, and crop yield, given changing irrigation patterns (from agricultural fallowing or dry-up) and groundwater pumping (Gates and Bailey 2012). The Regional Model analysis area extends along the Arkansas River between Manzanola and Las Animas (Figure 4–**22**). The model runs on a weekly time step for 1999–2007. Model input includes streamflow values, municipal groundwater pumping rates, and estimates of permanent and short-term agricultural fallowing caused by agriculture-to-urban water transfers.

Specific lands that would be affected by short-term agricultural fallowing were unknown; therefore, model simulations assumed fields within each ditch system were randomly dried during various rotational fallowing periods. Fields of high-value crop types, such as melons, onions, and peppers, were assumed ineligible for short-term fallowing. Field size and attribute data were supplied by the U.S. Department of Agriculture Farm Service Agency and available satellite images.

Effects on consolidated bedrock aquifers were qualitatively assessed. The Dakota-Cheyenne aquifer underlies most of the study area downstream from Cañon City (see Chapter 3 – *Groundwater Hydrology*), and could be affected by decreased municipal pumping in the action alternatives (see Chapter 2). Municipal pumping effects were described qualitatively since Dakota-Cheyenne aquifer use is predominately agricultural, and municipal use makes up a small portion of total withdrawals (see Chapter 3 – *Groundwater Hydrology*).



Source: Gates and Bailey 2012

Figure 4–22. Example of Short-Term Fallowed Fields and Permanent Agricultural Dry-Up in Regional Model

Criteria for Determining Significance of Effects

Table 4–14 lists significance criteria used to describe the intensity of groundwater level effects between the No Action and action alternatives. These criteria were used to characterize effects associated with river stage, groundwater pumping, and irrigation practices.

Table 4–14. Groundwater Hydrology Effect and Intensity Description

Effect Intensity	Intensity Description
Negligible	The alternative would change groundwater levels, but the change would be unmeasurable or imperceptible. The change would be within accuracies of calculation methods.
Minor	The alternative would measurably change groundwater levels, but the change would be small, localized, and of little consequence. Existing wells in the immediate vicinity of effects would continue to operate within historical and existing ranges of groundwater levels.
Moderate	The alternative would have a measureable and consequential effect on groundwater levels. Wells within the immediate vicinity of effects would require modification to continue pumping, or wells within a wide geographic area would operate within existing and historical ranges of groundwater levels, but at a consistently different average groundwater level. Water level changes could affect residential areas (basement flooding condition), but would require no or limited structural changes.
Major	The alternative would have a measurable and consequential change on groundwater levels. Wells within the immediate vicinity of effects would cease to operate, or wells within a wide geographic area would require modifications to continue pumping. Water level changes would affect residential areas (basement flooding condition), and would require widespread structural changes.

Results

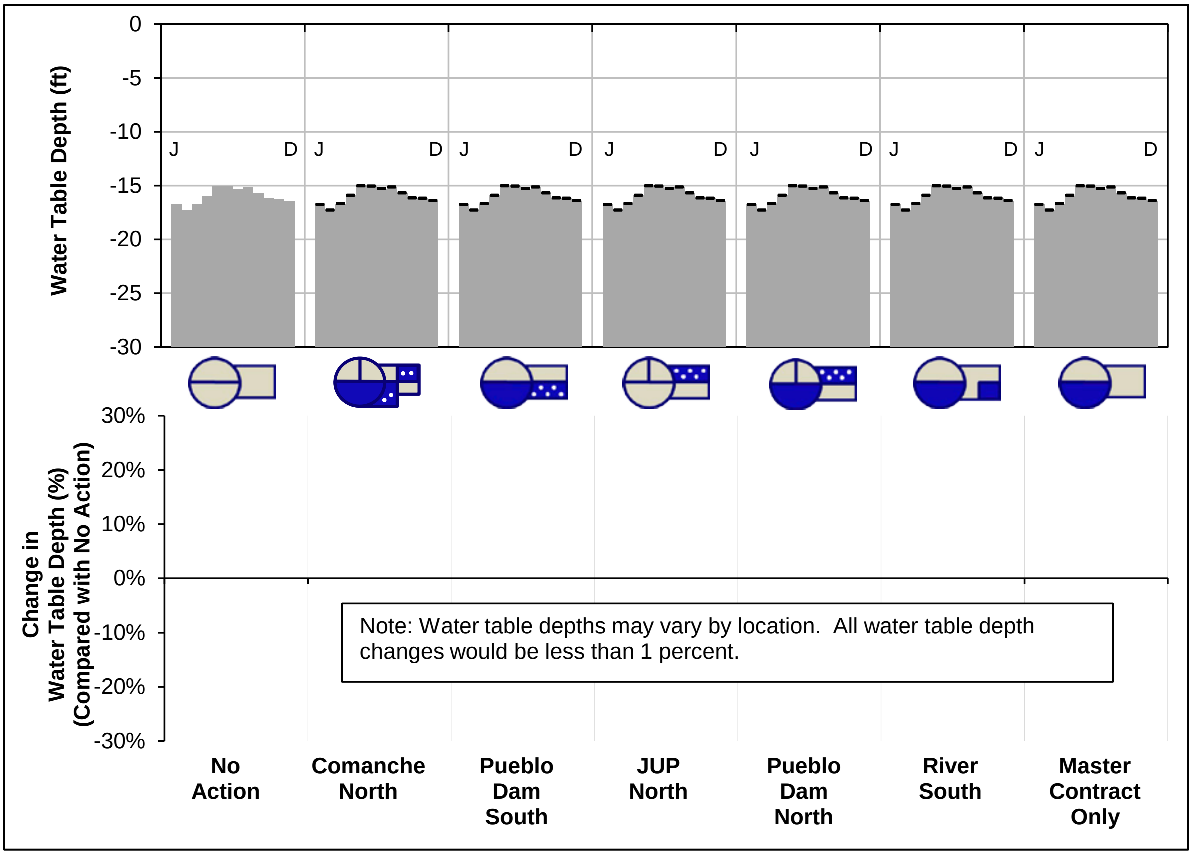
Groundwater effects differ based on location, time of year, and changes in river levels, groundwater pumping, and irrigation levels. The direct, indirect, and cumulative effects of alternatives on groundwater are discussed in this section for various geographic locations. Direct and indirect effects would be caused by changes in reservoir and river operations, groundwater pumping, and any agricultural dry-up associated with the action alternatives. Cumulative effects would be caused by changes in reservoir and river operation and additional groundwater pumping associated with water demand growth. More detailed calculations and results are presented in Appendix E.1.

Direct Effects

The No Action Alternative would decrease water table levels by a maximum of several feet (assuming all additional pumping occurs at a single hypothetical well) in the Upper Arkansas River Basin compared to existing conditions because of additional groundwater pumping by Master Contract participants. However, additional pumping under the No Action Alternative would likely be spread among dozens of typical wells, rather than a single hypothetical well. A typical well in the Upper Arkansas River Basin would have a drawdown of less than 2 inches (assuming the well yields 25 ac-ft/year (Colorado Geological Survey 2003) and is 400 feet from the river). All action alternatives would negligibly affect alluvial groundwater levels in the Upper Arkansas River Basin compared to the No Action Alternative. All action alternatives would change long-term average alluvial groundwater levels less than 1 inch compared to the No Action Alternative and would not adversely affect local wells.

Municipal groundwater pumping and agricultural dry-up would increase in the No Action Alternative compared to existing conditions, and water table levels would decrease less than 1 foot for all years and locations in the Lower Arkansas River Basin. All alternatives would negligibly affect Lower Arkansas River Basin alluvial groundwater levels compared to the No Action Alternative. Monthly average water table depths, averaged across the Regional Model analysis area, are shown in Figure 4–23. Effects on water table depths vary at specific analysis area locations, but all effects would be less than 1 percent and would not adversely affect local wells. Water table depth effects in dry, normal, and wet years would also be negligible.

Water table depth effects in the Lower Arkansas River Basin would be negligible because changes in municipal groundwater pumping between the No Action Alternative and alternatives with AVC deliveries would be small. The No Action and action alternatives would dry or fallow similar amounts of land and would have similar water table depth changes.



Data Source: Gates and Bailey 2012

Figure 4–23. Simulated Average Monthly Water Table Depth in Lower Arkansas River Basin

River level changes in the Fountain Creek Basin would not substantially change alluvial groundwater levels under the No Action Alternative compared to existing conditions. Effects of the action alternatives compared to No Action would be negligible for all months. Fountain Creek streamflow would increase in all action alternatives, compared to the No Action Alternative, but would not adversely affect alluvial groundwater levels.

Additional groundwater pumping demand in the No Action Alternative would decrease water table levels by a maximum of several feet (assuming all additional pumping occurs at a single hypothetical well) in the Fountain Creek Basin alluvial aquifers compared to existing conditions.

However, additional pumping under the No Action Alternative would likely be spread among dozens of typical wells, rather than a single hypothetical well. A typical well in Fountain Creek would have a drawdown of less than 3 inches (assuming the well yields 41 ac-ft/year (Colorado Geological Survey 2003) and is 400 feet from the river). Direct effects of groundwater pumping on groundwater levels would, on average, be minor and beneficial to local wells for all action alternatives compared to the No Action Alternative (for example, groundwater levels would rise). During a typical wet year, effects of groundwater pumping on groundwater levels would be negligible because demand would be met from other sources and pumping would not be needed for all alternatives, including the No Action Alternative. During normal and dry years groundwater pumping would be needed for most action alternatives.

Alluvial groundwater pumping in the Fountain Creek Basin for all action alternatives would be less than the No Action Alternative as a result of increased deliveries of non-Fry-Ark water through the Fountain Valley Conduit (Table 4–15). Master Contract non-Fry-Ark supply availability and/or additional space for temporary excess capacity contract supplies (for example, JUP North Alternative) would increase water supply deliveries to Fountain Creek participants. Decreases in groundwater pumping would raise the water table, and would not adversely affect existing wells operations. Groundwater pumping decreases could be beneficial from reducing pumping energy costs.

Table 4–15. Maximum Simulated Drawdown from Groundwater Pumping in Fountain Creek Basin – Direct Effects

Aquifer	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Drawdown (feet)							
Fountain Creek Aquifer	9.09	1.37	1.27	7.26	1.40	1.56	1.82
Widefield Aquifer	3.27	1.04	0.93	2.60	1.04	1.09	1.37
Windmill Gulch Aquifer	0.71	0.31	0.31	0.59	0.32	0.37	0.37
Effects – Change in Drawdown Compared to No Action Alternative [1] (feet (%))							
Fountain Creek Aquifer	---	-7.72 (-85%)	-7.82 (-86%)	-1.83 (-20%)	-7.69 (-85%)	-7.53 (-83%)	-7.27 (-80%)
Widefield Aquifer	---	-2.23 (-68%)	-2.33 (-71%)	-0.67 (-21%)	-2.23 (-68%)	-2.17 (-67%)	-1.89 (-58%)
Windmill Gulch Aquifer	---	-0.4 (-56%)	-0.4 (-56%)	-0.13 (-18%)	-0.4 (-56%)	-0.35 (-49%)	-0.35 (-49%)

Note:
[1] Negative effects are to be interpreted as a decrease in drawdown, or an increase in groundwater levels.

All alternatives would negligibly affect basement flooding in the Fountain Creek Basin. Water table level increases could increase risk of basement flooding in residential homes, especially in residential areas where the water table depth is generally 10 feet or less. Only a small portion of the Fountain Creek Alluvial Aquifer has a water table that close to the surface. Although the action alternatives would increase water table levels, compared to the No Action Alternative, levels would still be at or below existing conditions and would not increase basement flooding in existing residential areas.

Dakota-Cheyenne aquifer municipal pumping in the No Action Alternative would decrease less than 50 ac-ft compared to existing conditions and would not affect groundwater levels. Effects of decreased municipal pumping in the Dakota-Cheyenne aquifer would be negligible. Municipal pumping in this consolidated bedrock aquifer would decrease 700 ac-ft annually compared to the No Action Alternative. Pumping would decrease as participants switched to AVC water supplies. Dakota-Cheyenne aquifer use is predominately agricultural, and this decrease in municipal pumping would not noticeably affect groundwater levels or the life of this slowly recharging aquifer.

Cumulative Effects

Cumulative effects of changing river levels, groundwater pumping, agricultural dry-up, and climate change on alluvial groundwater levels in the Upper and Lower Arkansas river basins would be negligible, as these effects would be similar in all alternatives, including the No Action Alternative. Climate change is projected to increase temperatures, evaporation, and evapotranspiration, which could make less water available for groundwater recharge. Less recharge would lower groundwater levels and reduce groundwater discharge to streams and rivers. Climate change effects could also decrease surface water supplies in all alternatives, leading to additional municipal and agricultural groundwater pumping compared to existing conditions.

Cumulative effects of groundwater pumping in the Fountain Creek Basin would be minor and beneficial, similar to direct effects. Water table levels would increase, although these effects would be less than half the amount of direct effects. Cumulative demand in the No Action Alternative and action alternatives use Pueblo Reservoir storage and supplies more intensely; therefore, groundwater pumping amounts would be similar. Climate change could affect groundwater levels in Fountain Creek, similar to the Arkansas River. It is uncertain how these effects would counteract other beneficial cumulative effects.

Cumulative effects on consolidated bedrock aquifer water levels would be negligible compared to the No Action Alternative.

Mitigation Measures

No mitigation needs or measures are required for groundwater hydrology effects.

Water Quality

This section compares the alternatives' effects on water quality, including surface water quality in streams and reservoirs, and groundwater quality. Methods used to evaluate water quality effects, and the direct, indirect, and cumulative effects on water quality are described in this section. Appendix F.2 describes the water quality methodology in more detail, and contains results from all simulations, including existing conditions.

Summary

Water quality effects for all alternatives would range from negligible to minor adverse (less than 10 percent change) when compared to the No Action Alternative (Table 4–16). The alternatives would negligibly affect Upper Arkansas River Basin water quality, as streamflow and reservoir changes would be minimal. TMDLs active in the Upper Arkansas River Basin would not be affected adversely.

Effects on Lower Arkansas River Basin water quality would be mostly minor adverse because streamflow and reservoir changes caused by AVC and Master Contract operations would be negligible to minor. Occasional moderate increases in total dissolved solids would occur in dry years. Effects on La Junta's wastewater discharge permit would be minor adverse due to decreases in Arkansas River low flows. Water quality effects in Fountain Creek would be negligible, except minor increases in selenium concentrations.

Effects on Pueblo Reservoir water quality would be mostly negligible, although the JUP North Alternative would cause a minor adverse effect on reservoir and river temperatures. Minor adverse effects on total dissolved solids and selenium concentrations would occur in Lake Meredith and Lake Henry. West Slope water quality would not be affected adversely.

Beneficial effects from reducing total dissolved solids concentrations in AVC participant water supplies would be major for all alternatives that include the AVC pipeline compared to the No Action Alternative. Total dissolved solids concentrations at the River South Alternative river intake would exceed secondary drinking water standards for AVC participants in fall and winter months during dry years. Total dissolved solids concentrations under the No Action and Master Contract Only alternatives would exceed secondary drinking water standards for most AVC participants. All alternatives, including the No Action Alternative, would address current Health Department enforcement orders for radionuclides.

Methods

Methods used to analyze effects, and the criteria for determining significance of effects on water quality, are described presented in this section. The analysis area for water quality is the same as that for surface water hydrology and groundwater hydrology.

Effects Analyses

Water quality effects analyses for several streamflow constituents, streamflow temperature, chronic low flows, reservoirs, groundwater, and AVC participant water supply used various modeling outputs, as described below. Additional details on methods used are in Appendix F.2.

Table 4–16. Summary of Water Quality Direct and Indirect Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
⊙	◐	⦶	=	⊖	◒	●
Beneficial ↔ Adverse						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Upper Arkansas River Water Quality [1]						
Upper Basin TMDL Allocations	=	=	=	=	=	=
Chronic Low Flows	=	=	=	=	=	=
Lower Arkansas River Water Quality [1]						
Total Dissolved Solids	⊖	⊖	⊖	⊖	=	=
Selenium	⊖	⊖	⊖	⊖	=	=
Sulfate	⊖	⊖	⊖	⊖	=	=
Uranium	⊖	⊖	⊖	⊖	=	=
Total Recoverable Iron	=	=	=	=	=	=
Nutrients	⊖	⊖	⊖	⊖	=	=
Temperature – Arkansas River above Pueblo Gage	=	=	⊖	=	=	=
Chronic Low Flows – La Junta	⊖	⊖	⊖	⊖	⊖	⊖
Chronic Low Flows – Other Discharge Locations	=	=	=	=	=	=
Fountain Creek Water Quality [1]						
Total Dissolved Solids	=	=	=	=	=	=
Selenium	⊖	⊖	=	⊖	⊖	⊖
Bacteria	=	=	=	=	=	=
Sulfate and Uranium	=	=	=	=	=	=
Total Recoverable Iron	=	=	=	=	=	=
Suspended Sediment	=	=	=	=	=	=
Nutrients	=	=	=	=	=	=
Chronic Low Flows	=	=	=	=	=	=
Other Water Quality Concerns [1]						
Turquoise Lake and Twin Lakes Water Quality	=	=	=	=	=	=
Total Dissolved Solids – Pueblo Reservoir	=	=	=	=	=	⦶
Dissolved Oxygen and Nutrients – Pueblo Reservoir	=	=	=	=	=	=
Total dissolved solids and Selenium – Lake Meredith, Lake Henry, and Holbrook Reservoir	⊖	⊖	⊖	⊖	⊖	⊖
West Slope Water Quality	=	=	=	=	=	=
Soil Water Salinity – Lower Arkansas River Basin	=	=	=	=	=	=
Salt Loading from Aquifer to River – Lower Arkansas River Basin	⊖	⊖	⊖	⊖	⊖	=
Total Dissolved Solids – AVC Participants Water Supply	⊙	⊙	⊙	⊙	◐	=

Note:
[1] Effects are assessed compared to the No Action Alternative.

Streamflow Water Quality Constituents Streamflow water quality constituents analyzed in this EIS include total dissolved solids, selenium, sulfate, uranium, bacteria, total recoverable iron, and suspended sediment. Some constituents are only evaluated for specific stream segments, as noted below.

Total Dissolved Solids and Selenium A mass balance model, GeoDSS, was coupled with Daily Model streamflow results to evaluate relative total dissolved solids and selenium effects in Fountain Creek and the Lower Arkansas River Basin. GeoDSS is a georeferenced Decision Support System originally developed by Colorado State University to simulate streamflow and water quality in the Lower Arkansas River Basin (Triana et al. 2010). The model includes the Arkansas River from Pueblo Reservoir to the Arkansas River at Las Animas gage and Fountain Creek downstream from Colorado Springs. Figure 4–24 depicts the GeoDSS model study area, including USGS gages, Colorado Division of Water Resources gages, and wastewater treatment facilities.

Changes in total dissolved solids and selenium were assessed using a weekly time step over a 10-year model study period, from 1999 through 2009, based on the original GeoDSS study period (Triana et al. 2010) extended through the Daily Model study period (Appendix F.2). The model assumes changes in total dissolved solids and selenium would be driven mainly by streamflow changes, and that underlying physical total dissolved solids and selenium processes remain relatively unchanged.

Sulfate and Uranium Sulfate and uranium, like total dissolved solids, do not degrade or change form during travel through the Arkansas River Basin. Regression equations were developed to quantify relationships between concentrations of total dissolved solids and these constituents (Appendix F.2). The regression equations were used with the total dissolved solids modeling results to quantitatively describe water quality effects from sulfate and uranium.

Bacteria Effects on water quality from bacteria (*E. coli*) were assessed based on changes in high and low streamflow in Fountain Creek. USGS identified bird feces as the primary source of bacteria in Upper Fountain Creek, which would not be affected by the alternatives (see Appendix F.1). Dilution changes were quantified using chronic low flows for the Fountain. Changes in high streamflow could stir up more bacteria from stream sediment (Garzio-Hadzick et al. 2010), and were quantified using Daily Model streamflow output.

Total Recoverable Iron and Suspended Sediment Effects on water quality from total recoverable iron and suspended sediment concentrations were assessed using Daily Model streamflow output to evaluate dilution changes, and geomorphology effects to evaluate potential contributions to suspended sediment. Total recoverable iron and suspended sediments are associated with high runoff events from tributaries to the Arkansas River, which would not be affected by the alternatives.

Daily Model streamflow output, ambient total recoverable iron concentrations, and water quality standards were used to assess changes in total recoverable iron concentrations. Daily Model results, specifically high flow events, and effects on mobile sediment size described in Chapter 4 – *Geomorphology* were used to assess water quality effects from suspended sediment.

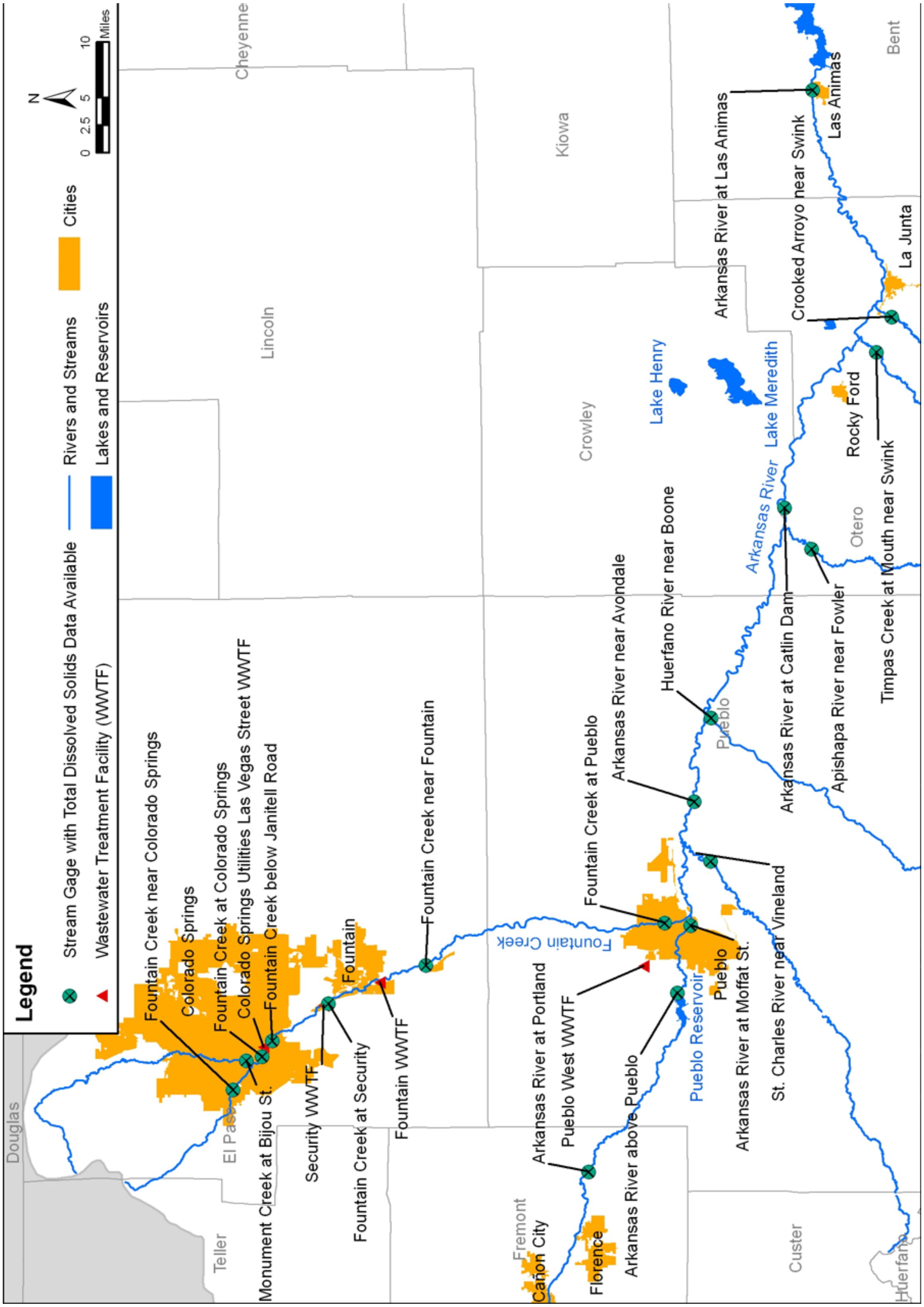


Figure 4–24. Total Dissolved Solids Model Analysis Area and Gage Locations

Nutrients Effects on water quality from nutrients such as nitrogen and phosphorus were qualitatively assessed using the best available information. Water quality standards for nutrients in the analysis area will not be in full effect until 2022, after which available data would be used to evaluate impairment status. It is unlikely that data gathered before 2013 would be used to evaluate impairment because new specific nutrient limits placed on select permitted discharges will not start until July 2013 (Health Department 2012a), after which stream nutrient levels could improve. Select permitted dischargers began gathering data to comply with nutrient limits in March 2013, but these data were not available for this EIS. Because evolving nutrient data and impairment status were unknown at the time of this EIS, it was assumed that effects on water quality from nutrients would be similar to general water quality effects from other constituents.

Streamflow Temperature Sufficient historical temperature data are not available for many Arkansas River Basin gages to adequately assess whether temperature standards are being met (Health Department 2013). The limited data also hinder detailed quantitative temperature effects analyses. Temperature effects on water quality at the Arkansas River above Pueblo gage were therefore qualitatively assessed using results from the USGS Pueblo Reservoir water quality model (see below) and streamflow effects (see Chapter 4 – *Surface Water Hydrology*). This gage is located in the segment between the dam and the Wild Horse Creek confluence that is designated as coldwater for aquatic life. Temperatures of Pueblo Dam river releases were assumed to be similar to temperatures in deeper reservoir locations near the dam. Temperature changes in Pueblo Dam releases were used to assess changes at the Arkansas River above Pueblo gage just downstream from the dam. Streamflow temperature effects in the Upper Arkansas River were qualitatively assessed as streamflow effects would be negligible. Streamflow temperature effects in the Lower Arkansas River downstream from the Wild Horse Creek confluence were qualitatively assessed as this segment is designated as warmwater and would be less sensitive to temperature changes.

Chronic Low Flows Chronic low flow analyses evaluate low flows for wastewater treatment facility discharge permits to assess the ability of streams to dilute constituents. The Health Department calculates chronic low flows as the minimum low flow over a 30-day averaging period occurring every 3 years. The Health Department’s version of the U.S. Environmental Protection Agency’s DFLOW program (Oppelt 2004) was used with Daily Model streamflow output to evaluate chronic low flows.

Monthly chronic low flows were estimated at major wastewater treatment facilities (defined by the Health Department as 1 mgd capacity or greater). Streamflow changes could affect wastewater treatment facility discharge (effluent) limitations and treatment requirements for permitted discharges if decreased chronic low flows cause water quality violations to increase. Minor wastewater treatment facilities (less than 1 mgd capacity per facility) that discharge to surface waters were not evaluated in this EIS because the combined discharge of all these facilities in the analysis area is less than 2.5 mgd and most facilities do not discharge directly into the Arkansas River.

Chronic low flow effects were evaluated using the following sequential process:

1. Chronic low flow decreases of less than 10 percent compared to the No Action Alternative were not evaluated further, as these differences were within the range of Daily Model accuracy for low streamflows (Appendix D.3)

2. Dilution flow was evaluated for chronic low flow decreases that exceeded 10 percent. Dilution flow is the percentage of streamflow at the discharge point that originates upstream from the discharge. The *Colorado Mixing Zone Implementation Guidance* (Health Department 2002) and *Colorado Biomonitoring Guidance Document* (Health Department 2006b) indicate that discharges with greater that 90 percent dilution would not typically have discharge limits based on streamflow.

Chronic low flows and discharge dilutions exceeding the above limits were further evaluated by applying chronic low flow percent differences between the No Action and action alternatives to chronic low flows in current permit water quality assessments. Effects were considered negligible if current permitted effluent limits would not be violated.

Total Maximum Daily Loads Because future permitted discharge limits, ambient water quality, and water quality standards are unknown, the TMDL assessments in this EIS used water quality information from current TMDL documentation to evaluate effects. The median streamflow percent changes of the alternatives compared to the existing conditions simulation were applied to historical median streamflow used to quantify the TMDL. These adjusted median streamflows were then used to adjust the ambient water quality of each alternative. The adjusted median streamflow and water quality values were then used to calculate effects on existing stream load, the TMDL, and load reductions required to meet the TMDL (see Appendix F.2 for additional details).

Reservoir Water Quality Pueblo Reservoir water quality analyses were performed by USGS (Ortiz 2012) using CE-QUAL-W2, a two-dimensional water quality reservoir model (Cole and Wells 2003; Galloway et al. 2008). CE-QUAL-W2 simulates reservoir water temperatures using bathymetric data, a balanced water budget, and meteorological data (Cole and Wells 2003). The model uses water quality equations to simulate reservoir water quality, assuming the in-reservoir processes that affect water quality do not change substantially over time. These processes would not likely change greatly in Pueblo Reservoir; rather, the differences in streamflow and water quality inputs define the difference between alternatives.

The reservoir model used Daily Model hydrologic input data to assess water temperature, dissolved oxygen, dissolved solids, nutrients (nitrogen and phosphorus), iron, and algae. Alternatives were simulated for three consecutive water years (2000–2002) representing a wet, normal, and dry year, respectively. Reservoir site 7B in the model is near the dam (Figure 4–25); results are described below and would be indicative of outlet water quality and quality of Arkansas River releases.

Water quality effects for other major reservoirs were assessed using Daily Model storage volumes, streamflow water quality effects, and water quality standards.

Groundwater Quality Groundwater quality in the Lower Arkansas River Basin was evaluated using the Regional Model (as described in Chapter 4 – *Groundwater Hydrology*), which simulates soil water salinity and effects on crop yield, given changing irrigation patterns (from agricultural fallowing or dry-up) and groundwater pumping (Gates and Bailey 2012). Soil water salinity in the crop root zone was evaluated using estimated water table depth to soil water salinity relationships originally developed in Morway and Gates (2012). Soil water salinity was calculated for agricultural fields using average water table depth during the 9-year simulation period.

Salt loading rates (pounds/week) from groundwater return flows to the Arkansas River were calculated by multiplying the average change in simulated return flow volumes by historical salt concentrations. This approach assumes that changes in streamflow patterns would not immediately affect dissolved salt concentrations in the aquifer next to the river, and the average aquifer salt concentration adequately represents salt concentrations in the Regional Model analysis area during the 9-year simulation period.

Arkansas Valley Conduit Participant Drinking Water Quality The water quality of AVC deliveries for all alternatives was assessed using streamflow and Pueblo Reservoir total dissolved solids. The No Action, River South, and Master Contract Only alternatives drinking water quality was assessed using total dissolved solids values at various Arkansas River gages near river intakes. Drinking water quality of remaining alternatives was assessed using Pueblo Reservoir Site 7B total dissolved solids values, which would be representative of AVC dam intake water quality.

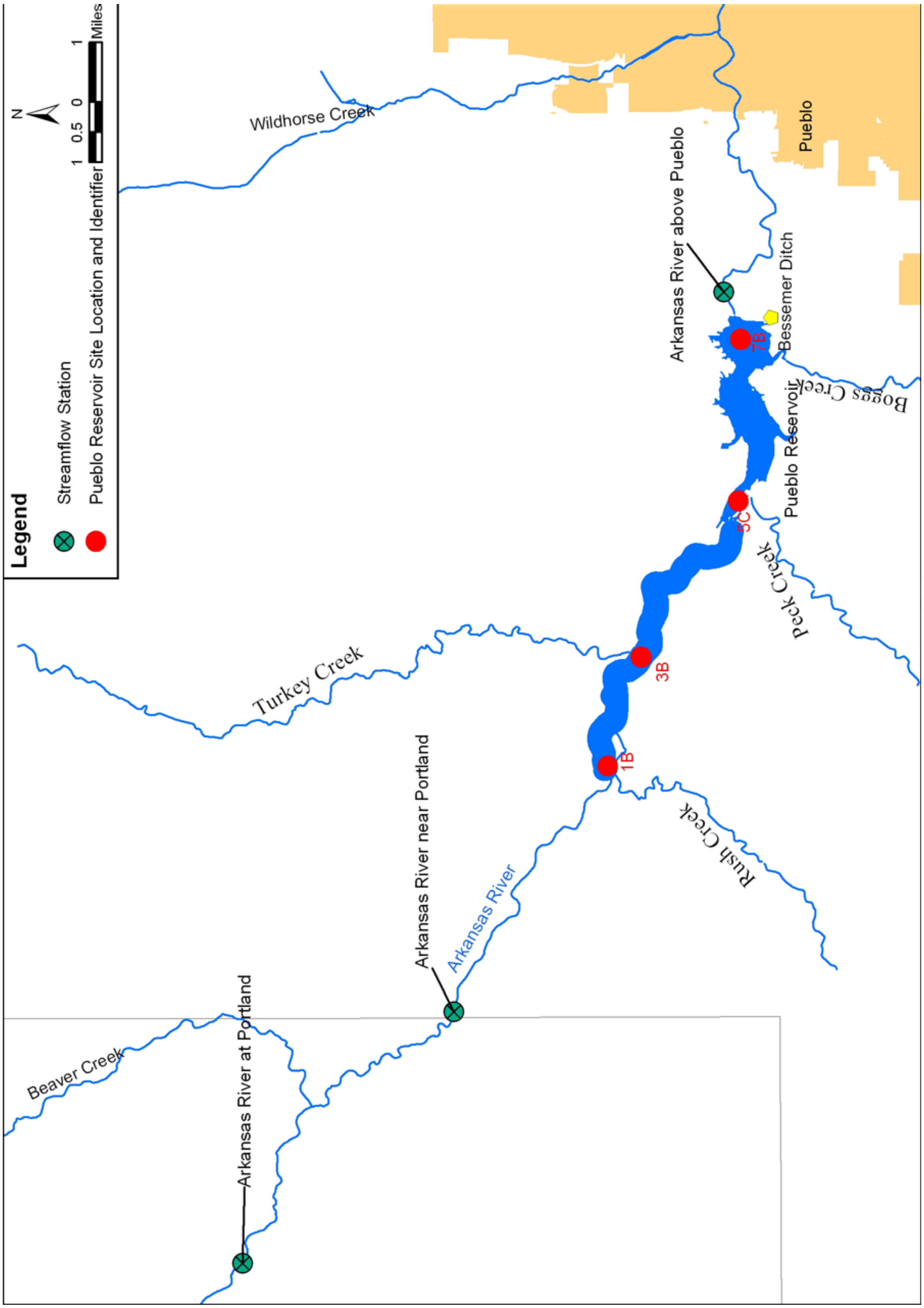


Figure 4–25. Location of Selected Pueblo Reservoir Sites Used in CE-QUAL-W2 Pueblo Reservoir Model

Criteria for Determining Significance of Effects

Table 4–17 lists significance criteria used to describe the intensity of water quality effects. Potential effects on water quality were evaluated for each action alternative compared to the No Action Alternative. Effects were analyzed assuming that best management practices and resource protection measures described in Chapter 2 and Appendix B.5 would be incorporated.

Table 4–17. Water Quality Effect and Intensity Description

Effect Intensity	Intensity Description
Negligible	Chemical, physical, or biological effects on water quality would be below or near detectable limits, and would be within historical or desired water quality conditions.
Minor	Chemical, physical, or biological effects on water quality would be detectable, but would be within 10 percent of historical water quality conditions for stream segments meeting water quality standards. The alternative would not cause a water quality violation, but existing violations would continue. Water and wastewater treatment plants would continue to meet water quality standards without changes to treatment processes.
Moderate	Chemical, physical, or biological effects on water quality would be detectable and the historical baseline would be exceeded by 10-20 percent for stream segments meeting water quality standards. A new water quality violation would not result, but existing violations would continue and increase by less than 5 percent. Slight modifications to water and wastewater treatment plant processes could be needed to meet water quality standards.
Major	Chemical, physical, or biological effects on water quality would exceed the historical baseline by more than 20 percent for stream segments meeting water quality standards (more than 5 percent for stream segments violating water quality standards). A new violation in a water quality standard is likely. Substantial modifications to existing water and wastewater treatment plant processes could be needed to meet water quality standards.

Results

Water quality effects would differ based on constituent, location, and time of year. Direct, indirect, and cumulative effects of alternatives on water quality are compared in this section for various geographic locations.

Direct and Indirect Effects

The alternatives may directly and indirectly affect water quality by changing streamflow, reservoir storage, and groundwater pumping quantities and patterns. Water quality direct and indirect effects evaluated in this section include the following:

- Upper Arkansas River Basin streamflow water quality
- Lower Arkansas River Basin streamflow constituents
- Lower Arkansas River Basin streamflow temperature
- Lower Arkansas River Basin chronic low flows
- Fountain Creek streamflow constituents
- Fountain Creek streamflow temperature
- Fountain Creek chronic low flows
- West Slope streamflow water quality
- Reservoir water quality
- Groundwater quality
- AVC participant drinking water quality

Upper Arkansas River Basin Streamflow Water Quality The No Action Alternative would not increase constituent concentrations or affect water quality in the Upper Arkansas River Basin, including Grape Creek, over existing conditions. All action alternatives would negligibly affect water quality in the Upper Arkansas River Basin compared to No Action. The alternatives would not contribute additional constituents to the river, additional water quality violations would not occur, and streamflow effects would be predominately negligible (see Chapter 4 – *Surface Water Hydrology*), with negligible dilution and temperature effects.

The No Action Alternative would decrease chronic low flows at the Fremont County Rainbow Park wastewater treatment facility, but increase chronic low flows for other major wastewater treatment facilities in the Upper Arkansas River Basin, compared to existing conditions (Appendix F.2). Effects on chronic low flows in the Upper Arkansas River would be negligible for all action alternatives compared to the No Action Alternative (Appendix F.2). Changes to streamflow would be minimal, and would not affect permitted discharges (see Chapter 4 – *Surface Water Hydrology)*. Major wastewater treatment facilities in the Upper Arkansas River Basin include Buena Vista Sanitation District (Figure 4–26), Salida (Figure 4–27), and Fremont County Rainbow Park (Figure 4–28).

The Colorado Water Quality Control Division assigns identification numbers to stream segments for the purpose of assigning water quality standards and assessing impairment status. The Chapter 4 – *Water Quality* section describes effects at specific streamflow gages, which are associated with the following stream segments and identification numbers. Water quality standards for many of these segments are in Appendix F.1.

Gage	Segment	Segment Identification Number
Lake Fork Creek below Sugar Loaf Dam	Lake Fork Creek Below Turquoise Lake	COARUA05
Lake Creek Below Twin Lakes	Lake Creek	COARUA10
Arkansas River at Granite, Arkansas River near Wellsville	Arkansas River between Lake Fork Creek and Pueblo Reservoir	COARUA02c, COARUA03
Arkansas River above Pueblo	Arkansas River between Pueblo Reservoir and Wildhorse Creek	COARMA02
Arkansas River at Moffat St.	Arkansas River between Wildhorse Creek and Fountain Creek	COARMA03
Arkansas River near Avondale	Arkansas River between Fountain Creek and Colorado Canal	COARLA01a
Arkansas River at La Junta, Arkansas River at Las Animas	Arkansas River between Colorado Canal and John Martin Reservoir	COARLA01b
Arkansas River near Granada	Arkansas River between John Martin Reservoir and stateline	COARLA01c
Fountain Creek at Pueblo	Fountain Creek between state highway 47 and Arkansas River	COARFO02b

All action alternatives compared to No Action would have predominately negligible effects on TMDL allocations in the Upper Arkansas River Basin (Table 4–18 and Table 4–19) (see Appendix F.2 for effects on critical condition and median streamflow used in calculating TMDL allocations). The predominate load allocations in current TMDLs belong to nonpermitted point sources or nonpoint sources, such as old mine drainage, that occur upstream from the analysis area. The alternatives would not adversely affect these constituent sources, and streamflow and dilution effects would be predominately negligible (see Chapter 4 – *Surface Water Hydrology*, Appendix D.4, and Appendix F.2). The alternatives would not affect ongoing water quality improvements or planned improvements identified to meet the TMDLs. The TMDL for Lake Creek was not assessed in this EIS. The copper sources are outside the analysis area and would not be affected. Twin Lakes storage volume changes would be negligible (less than 2 percent) and would not affect copper dilution and concentrations (see Appendix F.2 for additional details).

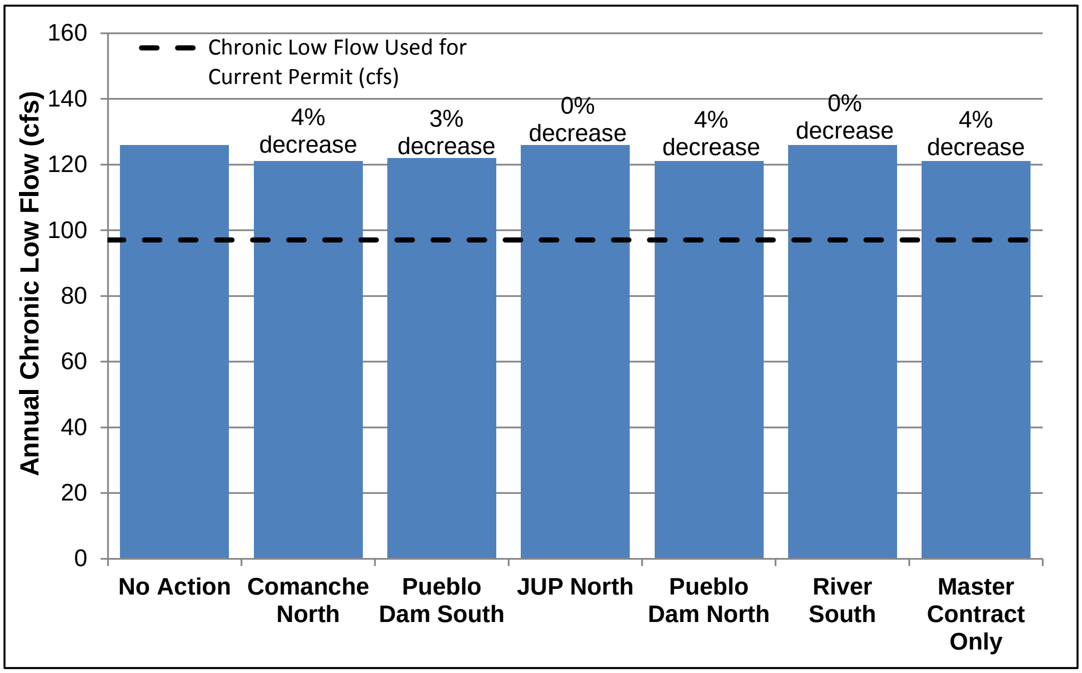


Figure 4–26. Simulated Annual Arkansas River Chronic Low Flow at Buena Vista Sanitation District

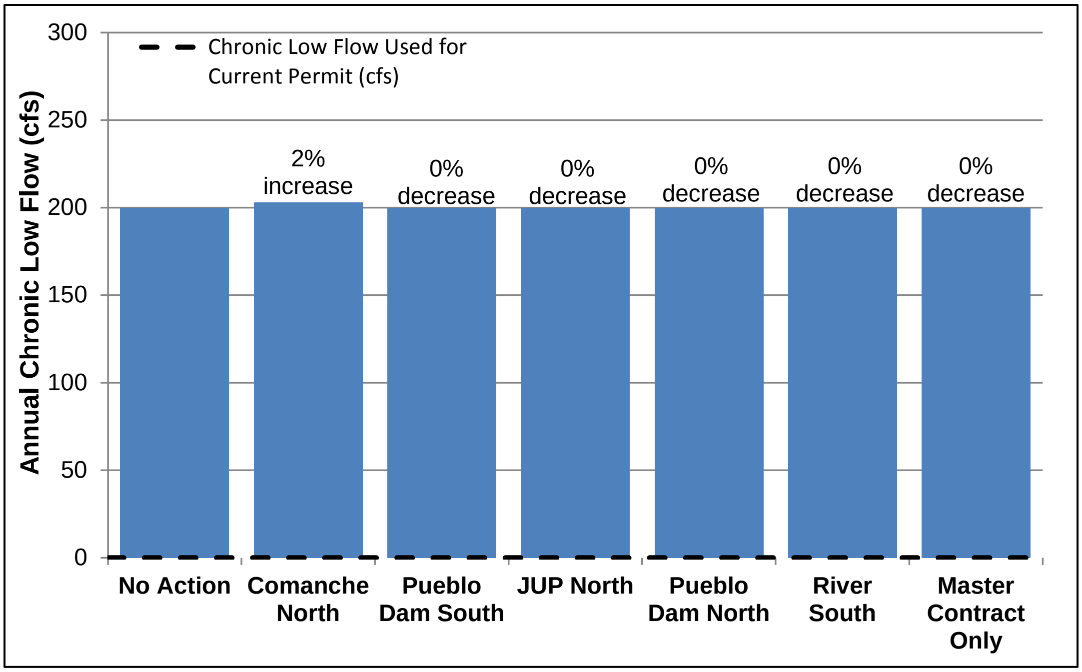


Figure 4–27. Simulated Annual Arkansas River Chronic Low Flow at Salida

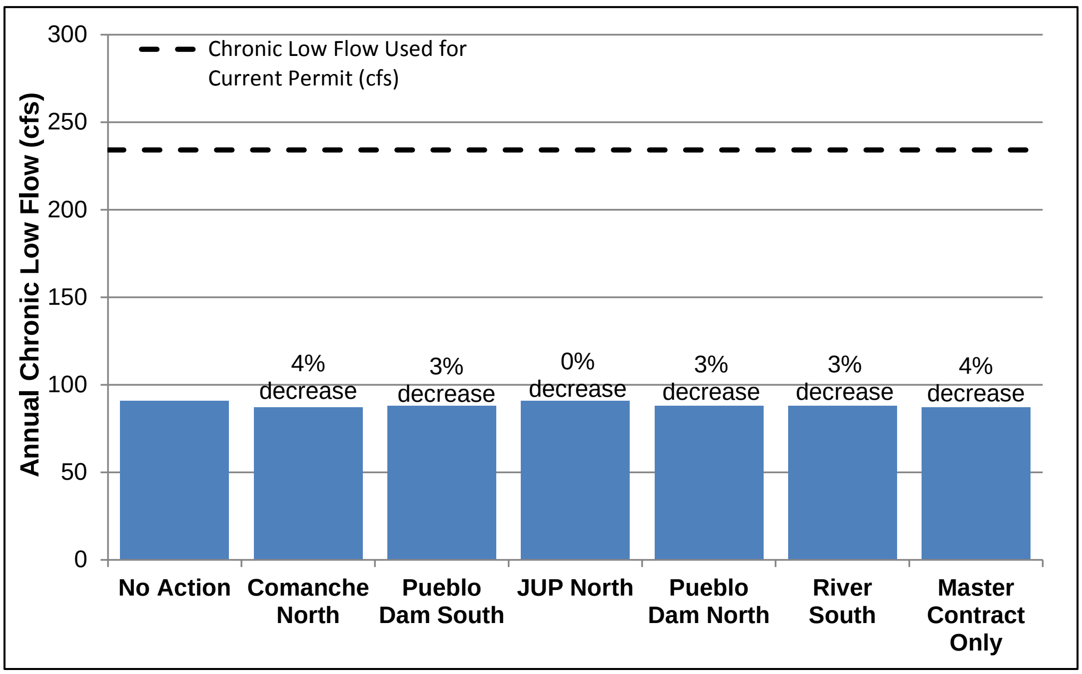


Figure 4–28. Simulated Annual Arkansas River Chronic Low Flow at Fremont County Rainbow Park

Table 4–18. Load Reductions Needed to Meet TMDL for Arkansas River between Lake Fork Creek and Lake Creek (COARUA02c) – Direct Effects

Month	Existing Conditions	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Simulated Load Reduction Needed to Meet TMDL (lbs/day)								
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	0.09	0.08	0.08	0.08	0.07	0.08	0.08	0.09
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Change in Reduction Compared to No Action Alternative [lbs/day (%)]								
Jan	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Feb	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Mar	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Apr	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
May	---	---	0.00 (0.0)	0.00 (0.0)	-0.01 (-12.5)	0.00 (0.0)	0.00 (0.0)	0.01 (12.5)
Jun	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Jul	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Aug	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Sep	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Oct	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Nov	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Dec	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Change in Reduction Compared to Existing Conditions [lbs/day (%)]								
Jan	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Feb	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Mar	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Apr	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
May	---	-0.01 (-11.1)	-0.01 (-11.1)	-0.01 (-11.1)	-0.02 (-22.2)	-0.01 (-11.1)	-0.01 (-11.1)	0.00 (0.0)
Jun	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Jul	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Aug	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Sep	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Oct	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Nov	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Dec	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)

Table 4–19. Load Reductions Needed to Meet TMDL for Arkansas River between Lake Creek and Pueblo Reservoir (COARUA03) – Direct Effects

Month	Existing Conditions	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Simulated Load Reduction Needed to Meet TMDL (lbs/day)								
Jan	0.25	0.26	0.27	0.27	0.25	0.27	0.27	0.28
Feb	1.31	1.33	1.33	1.33	1.33	1.32	1.33	1.34
Mar	0.85	0.88	0.88	0.88	0.85	0.88	0.88	0.89
Apr	0.51	0.50	0.52	0.52	0.49	0.52	0.52	0.52
May	3.13	3.17	3.18	3.18	3.17	3.18	3.18	3.18
Jun	1.43	1.46	1.46	1.46	1.46	1.45	1.46	1.45
Jul	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Nov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	1.06	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Change in Reduction Compared to No Action Alternative [lbs/day (%)]								
Jan	---	---	0.01 (3.8)	0.01 (3.8)	-0.01 (-3.8)	0.01 (3.8)	0.01 (3.8)	0.02 (7.7)
Feb	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	-0.01 (-0.8)	0.00 (0.0)	0.01 (0.8)
Mar	---	---	0.00 (0.0)	0.00 (0.0)	-0.03 (-3.4)	0.00 (0.0)	0.00 (0.0)	0.01 (1.1)
Apr	---	---	0.02 (4.0)	0.02 (4.0)	-0.01 (-2.0)	0.02 (4.0)	0.02 (4.0)	0.02 (4.0)
May	---	---	0.01 (0.3)	0.01 (0.3)	0.00 (0.0)	0.01 (0.3)	0.01 (0.3)	0.01 (0.3)
Jun	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	-0.01 (-0.7)	0.00 (0.0)	-0.01 (-0.7)
Jul	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Aug	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Sep	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Oct	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Nov	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Dec	---	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Change in Reduction Compared to Existing Conditions [lbs/day (%)]								
Jan	---	0.01 (4.0)	0.02 (8.0)	0.02 (8.0)	0.00 (0.0)	0.02 (8.0)	0.02 (8.0)	0.03 (12.0)
Feb	---	0.02 (1.5)	0.02 (1.5)	0.02 (1.5)	0.02 (1.5)	0.01 (0.8)	0.02 (1.5)	0.03 (2.3)
Mar	---	0.03 (3.5)	0.03 (3.5)	0.03 (3.5)	0.00 (0.0)	0.03 (3.5)	0.03 (3.5)	0.04 (4.7)
Apr	---	-0.01 (-2.0)	0.01 (2.0)	0.01 (2.0)	-0.02 (-3.9)	0.01 (2.0)	0.01 (2.0)	0.01 (2.0)
May	---	0.04 (1.3)	0.05 (1.6)	0.05 (1.6)	0.04 (1.3)	0.05 (1.6)	0.05 (1.6)	0.05 (1.6)
Jun	---	0.03 (2.1)	0.03 (2.1)	0.03 (2.1)	0.03 (2.1)	0.02 (1.4)	0.03 (2.1)	0.02 (1.4)
Jul	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Aug	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Sep	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Oct	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Nov	---	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Dec	---	0.01 (0.9)	0.01 (0.9)	0.01 (0.9)	0.01 (0.9)	0.01 (0.9)	0.01 (0.9)	0.01 (0.9)

Lower Arkansas River Basin Streamflow Constituents Total dissolved solids, selenium, sulfate, uranium, and total recoverable iron were evaluated for the Lower Arkansas River Basin.

Total Dissolved Solids and Selenium The No Action Alternative would increase total dissolved solids concentrations through Pueblo (Arkansas River at Moffat Street gage), up to 7 percent, compared to existing conditions (Appendix F.2). Increases in No Action Alternative total dissolved solids concentrations at the Arkansas River near Avondale gage would be up to 5 percent, compared to existing conditions. Streamflow would generally increase downstream from Avondale under the No Action Alternative, which would decrease total dissolved solids concentrations compared to existing conditions (Appendix F.2). Eliminating brine waste discharge from reverse osmosis water treatment plants would also decrease total dissolved solids in the Lower Arkansas River Basin for the No Action Alternative compared to existing conditions. Zero liquid discharge (brine is evaporated in ponds) for reverse osmosis water treatment plants is assumed for all alternatives (see Chapter 2, Appendix B.3).

All alternatives except River South and Master Contract Only would have negligible to minor increases in total dissolved solids concentrations through Pueblo (Arkansas River at Moffat Street gage) compared with the No Action Alternative (Appendix F.2). Occasional moderate increases in total dissolved solids would occur in dry years. In the River South and Master Contract Only alternatives, water supplies for AVC participants downstream from Pueblo would not bypass the city in a pipeline and would not affect streamflow at this gage.

All alternatives would have overall negligible to minor adverse effects on Arkansas River near Avondale gage water quality due to increasing total dissolved solids concentrations, especially in dry year months (Figure 4–29 through Figure 4–31). Total dissolved solids effects would decrease farther downstream as ambient concentrations increase and streamflow effects decrease. Effects on salinity concentrations at the Arkansas River at Las Animas gage would be negligible (Appendix F.2).

The No Action Alternative would slightly increase selenium concentrations through Pueblo (Arkansas River at Moffat Street gage) compared to existing conditions, but not farther downstream in the Lower Arkansas River Basin. All alternatives compared to No Action would have negligible to minor adverse effects on water quality caused by increasing selenium concentrations at the Arkansas River at Moffat St. gage, similar to total dissolved solids effects (Appendix F.2). All action alternatives would affect the 85th percentile selenium concentration at the Arkansas River at Moffat St. gage less than 5.6 percent compared to the No Action Alternative, which is less than a 1 µg/L increase over historical ambient water quality (17.4 µg/L). Although this increase would exceed the water quality standard (17.4 µg/L), more recent data collected by Pueblo indicate that this reach may already exceed the standard (see Appendix F.1).

Negligible to minor adverse effects would occur in all alternatives compared to No Action at the Arkansas River near Avondale gage, with occasional moderate increases in selenium in dry years (Figure 4–32 through Figure 4–34). All action alternatives would affect the 85th percentile selenium concentration at the Arkansas River near Avondale gage less than 2.9 percent compared to the No Action Alternative, which would be less than a 0.5 µg/L increase over historical ambient water quality (16.4 µg/L). Selenium changes in the river would have a negligible effect on recreation uses, such as swimming or fishing. This river segment is currently impaired for selenium, although TMDL allocations have not been assigned. The predominately negligible effect of alternatives compared to No Action on the 85th percentile selenium concentration at the Arkansas River near Avondale gage and gages farther downstream (including Arkansas River at Las Animas) would not increase impairment in this river segment (Appendix F.2). This river segment is also designated as use-protected and is not subject to the state's antidegradation review process, which can limit increases in ambient water quality. Effects on selenium concentrations would decrease farther downstream.

The Arkansas River between Colorado Canal and the Kansas state line is currently impaired for selenium. Effects on ability to meet TMDLs for selenium were not assessed in this EIS because TMDLs have not been completed and approved by regulatory agencies for these segments.

The No Action Alternative would dry-up 11,700 acres of agricultural land compared to existing conditions, which would be a 4 percent reduction in total irrigated lands (about 280,000 acres) in the analysis area. This small reduction in irrigation spread over such a large area would negligibly affect selenium loading into the river. The action alternatives land use changes and effects on selenium loading would be identical to the No Action and would be negligible.

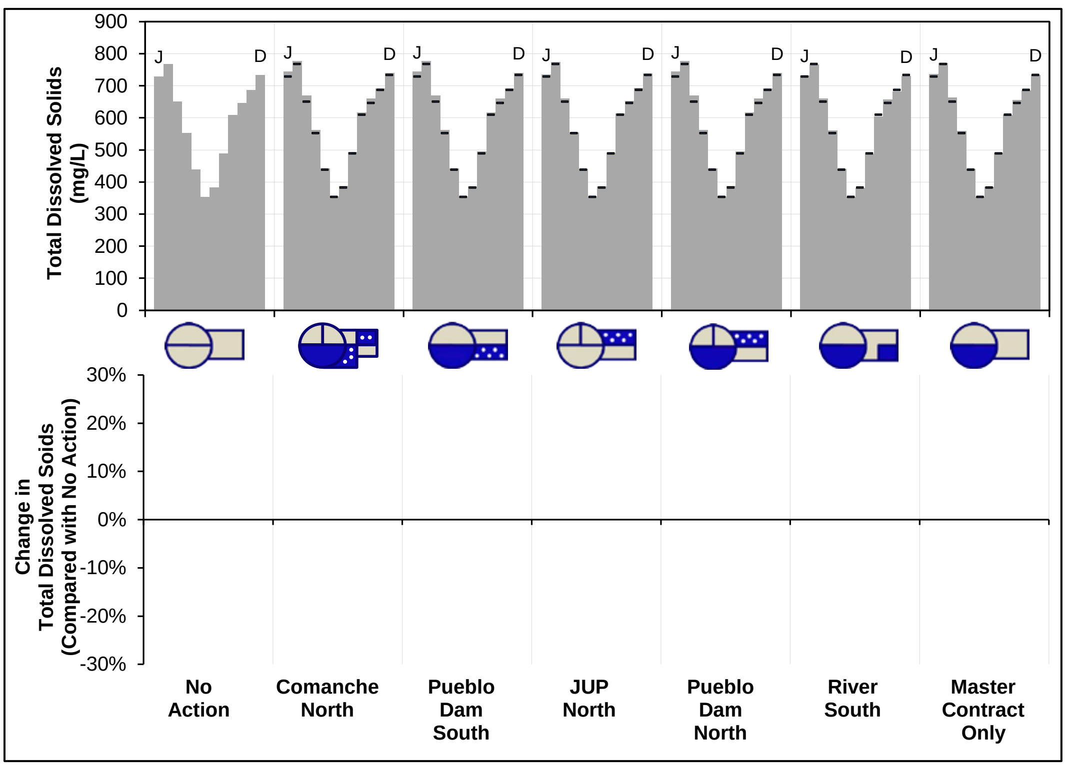


Figure 4–29. Simulated Average Monthly Total Dissolved Solids Concentrations at Arkansas River near Avondale Gage

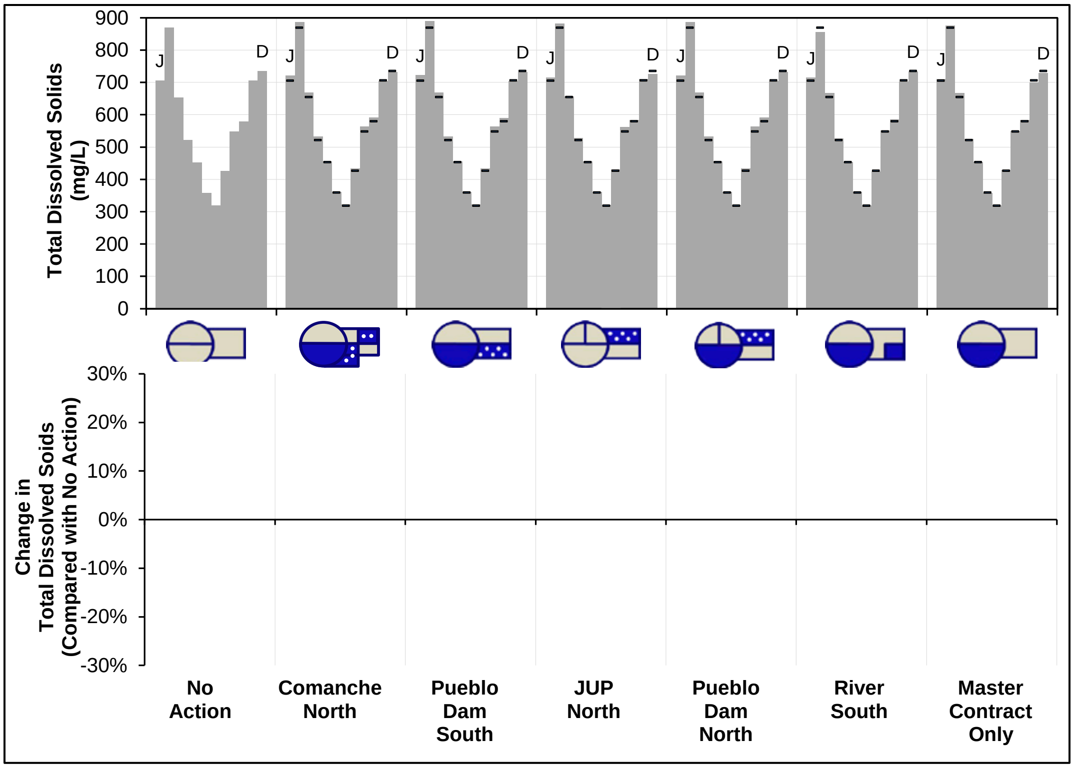


Figure 4–30. Simulated Normal Year (2005) Monthly Total Dissolved Solids Concentrations at Arkansas River near Avondale Gage

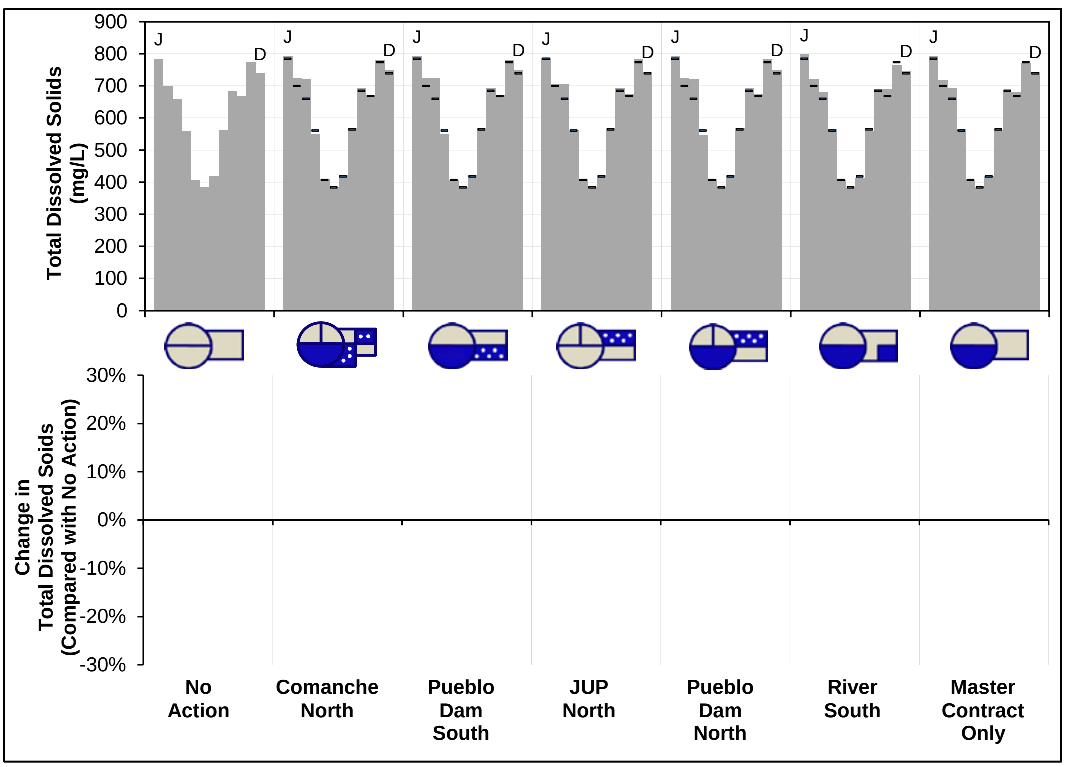
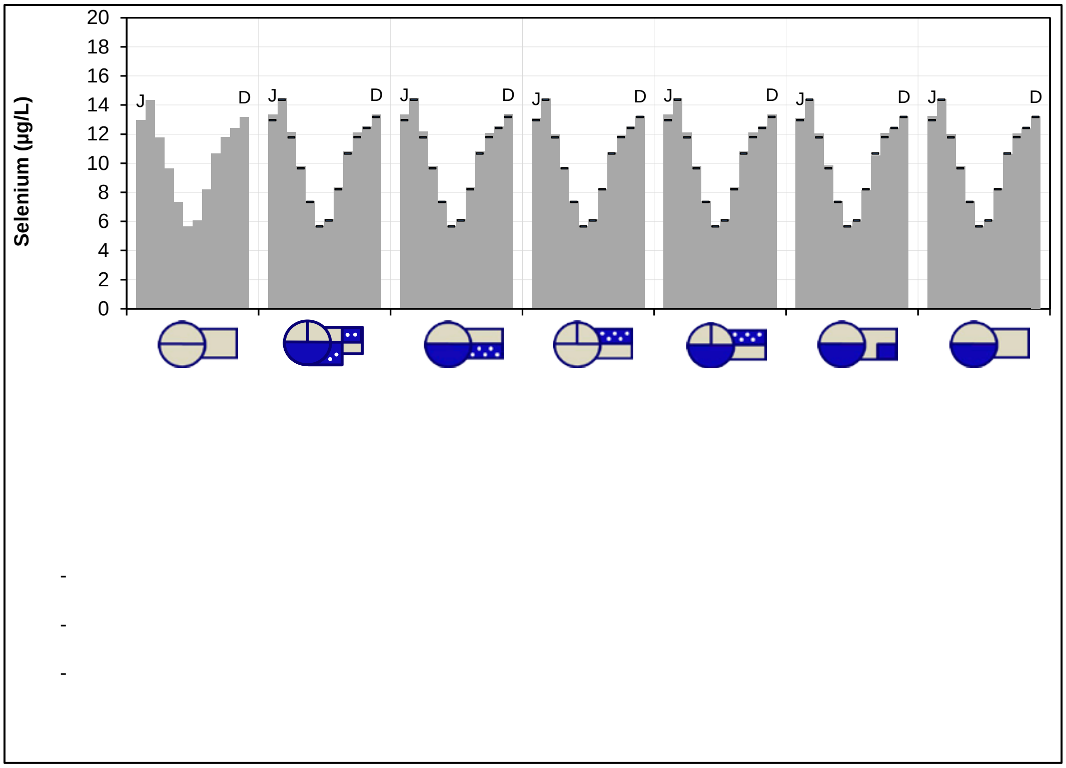


Figure 4–31. Simulated Dry Year (2004) Monthly Total Dissolved Solids Concentrations at Arkansas River near Avondale Gage



F – **vondale Gage**

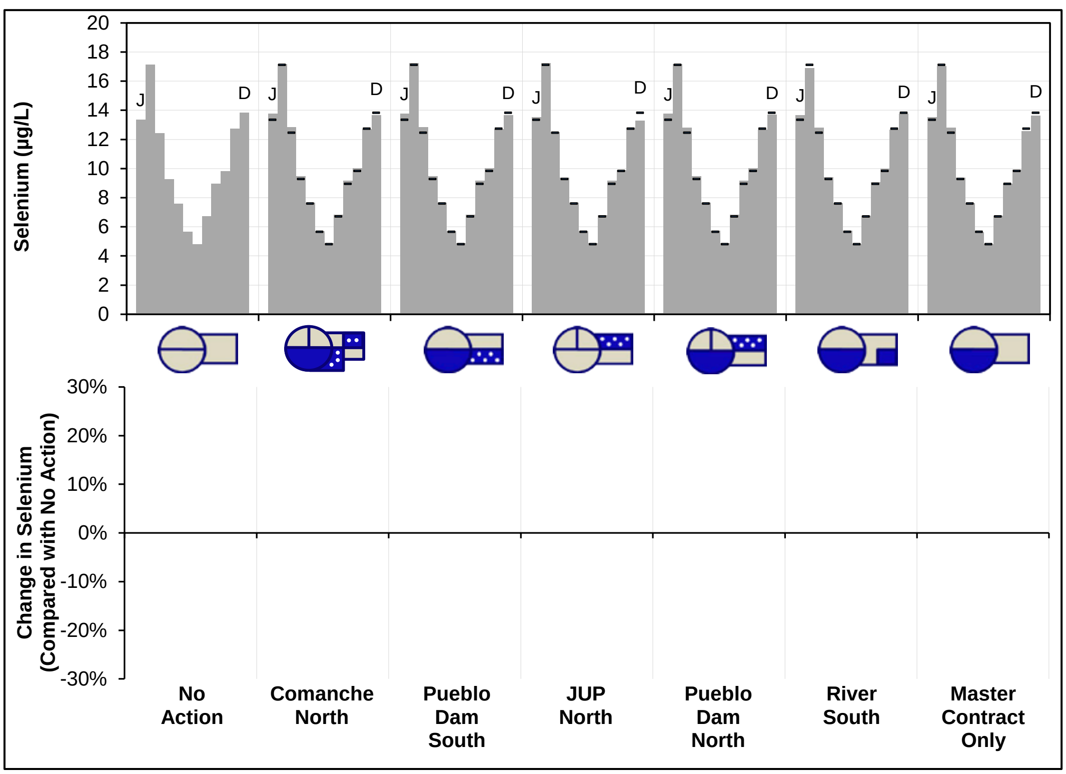


Figure 4–33. Simulated Normal Year (2005) Monthly Selenium Concentrations at Arkansas River near Avondale Gage

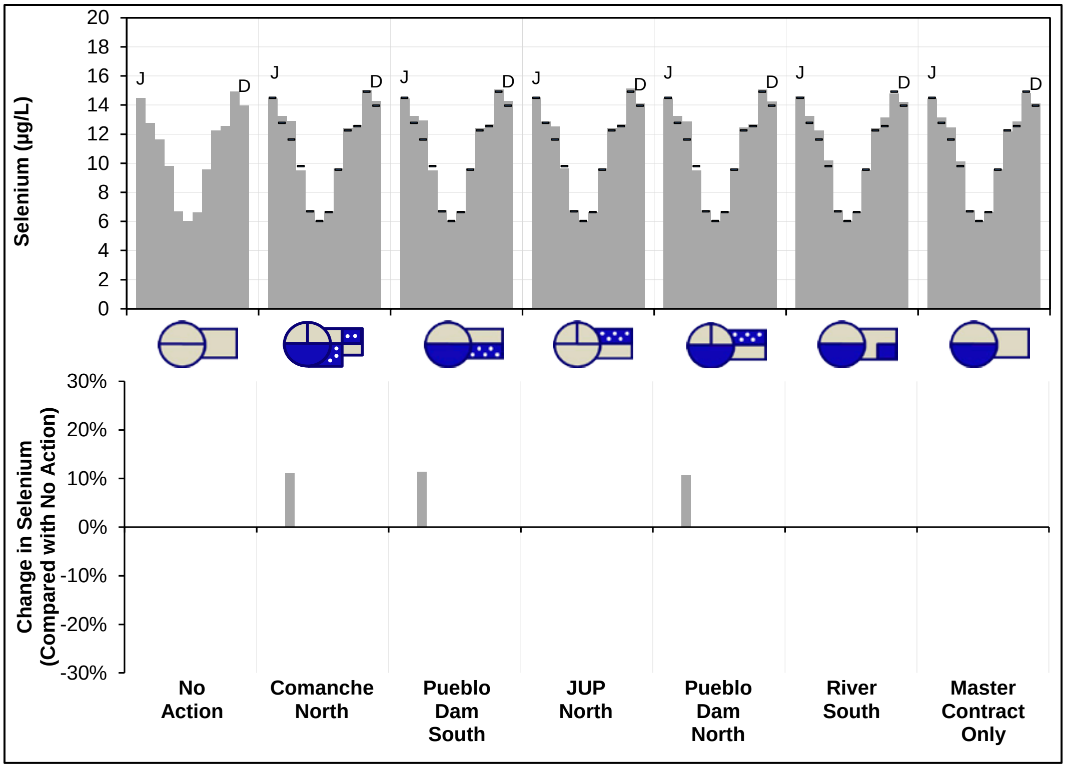


Figure 4–34. Simulated Dry Year (2004) Monthly Selenium Concentrations at Arkansas River near Avondale Gage

Sulfate and Uranium The No Action Alternative would increase sulfate concentrations through Pueblo (Arkansas River at Moffat Street gage) compared to existing conditions, up to about 11 percent in some months (Appendix F.2). Uranium concentrations through Pueblo would increase less than 10 percent under the No Action Alternative compared to existing conditions. Sulfate and uranium concentration changes under the No Action Alternative would decrease farther downstream.

All alternatives would have negligible to minor adverse effects on water quality due to increasing sulfate and uranium concentrations at the Arkansas River at Moffat St. gage, similar to total dissolved solids effects. All action alternatives would affect the 85th percentile sulfate concentration at this gage less than 8.7 percent compared to the No Action Alternative, which would be less than a 14 mg/L increase over historical ambient water quality (152 mg/L) and would not exceed the current water quality standard (250 mg/L) (Appendix F.2). Uranium effects at the Arkansas River at Moffat St. gage would be similar to sulfate.

The Comanche North, Pueblo Dam South, and Pueblo Dam North alternatives would have negligible to minor adverse effects on water quality caused by increasing sulfate concentrations at the Arkansas River near Avondale gage, all other alternatives would have negligible effects (Figure 4–35). All action alternatives would affect the 85th percentile sulfate concentration at the Arkansas River near Avondale gage less than 1.6 percent compared to the No Action Alternative, which would be less than a 5.5 mg/L increase over historical ambient water quality (331 mg/L) (Appendix F.2). This river segment is currently impaired for sulfate, although TMDL allocations have not been assigned. This river segment is also designated as use-protected and is not subject to the state's antidegradation review process. Uranium effects at the Arkansas River near Avondale gage would be similar to sulfate. Effects on sulfate and uranium concentrations would decrease farther downstream. Effects on sulfate and uranium concentrations at the Arkansas River at Las Animas gage would be negligible (Appendix F.2).

The alternatives would not substantially affect sulfate or uranium sources. New impairment designations for sulfate and uranium would not occur, as existing concentrations in unimpaired stream segments are well below water quality standards. However, the Arkansas River between Fountain Creek and the Colorado Canal is currently sulfate impaired, and the Arkansas River between John Martin Reservoir and the Kansas state line is currently uranium impaired. Effects on the ability to meet TMDLs for sulfate and uranium cannot be assessed in this EIS because TMDLs have not been completed and approved by regulatory agencies for these stream segments.

Total Recoverable Iron The No Action Alternative would not adversely affect water quality in the Lower Arkansas River Basin because of iron concentrations compared to existing conditions. Increases in total recoverable iron concentrations in the Lower Arkansas River Basin would be negligible for all alternatives. Natural sources contribute total recoverable iron to the stream, and water quality standards have typically been set to natural levels (Health Department 2011c). All alternatives except Master Contract Only would cause occasional minor decreases in streamflow in this river segment, and could affect dilution of tributary total recoverable iron concentrations. The alternatives would not affect watershed contribution of iron, and increases to iron resuspended from tributaries would be negligible. Ambient quality-based standards would be revised to reflect concentration changes.

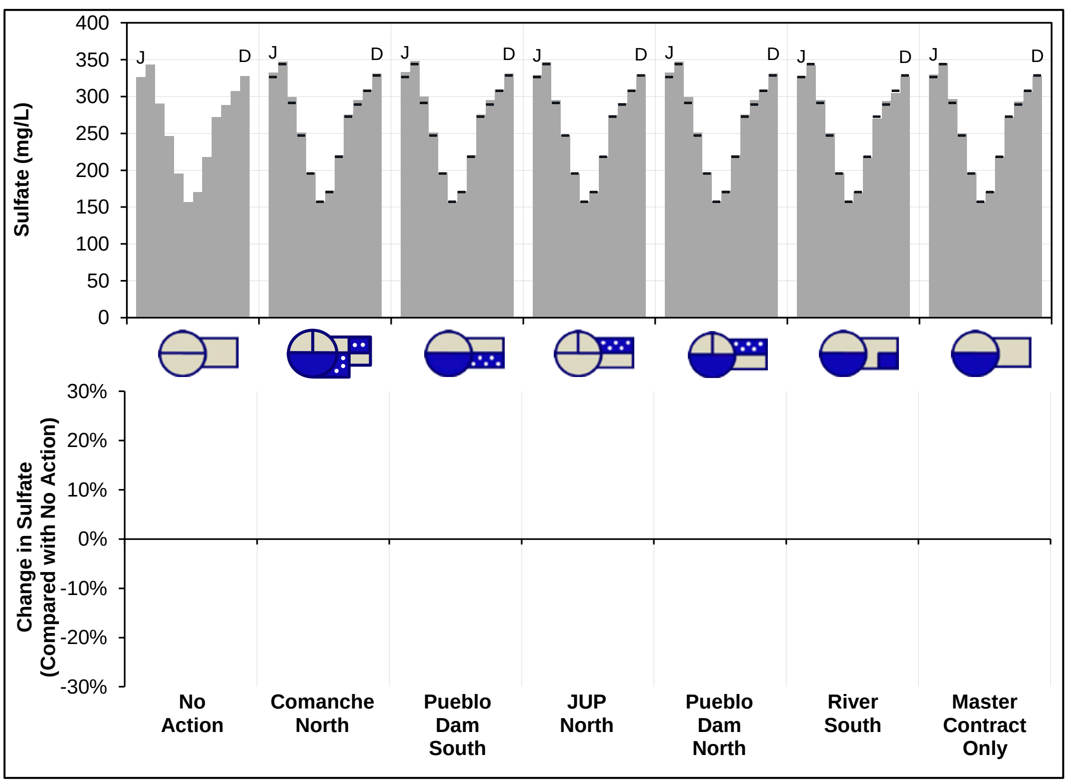


Figure 4–35. Simulated Average Monthly Sulfate Concentrations at the Arkansas River near Avondale Gage

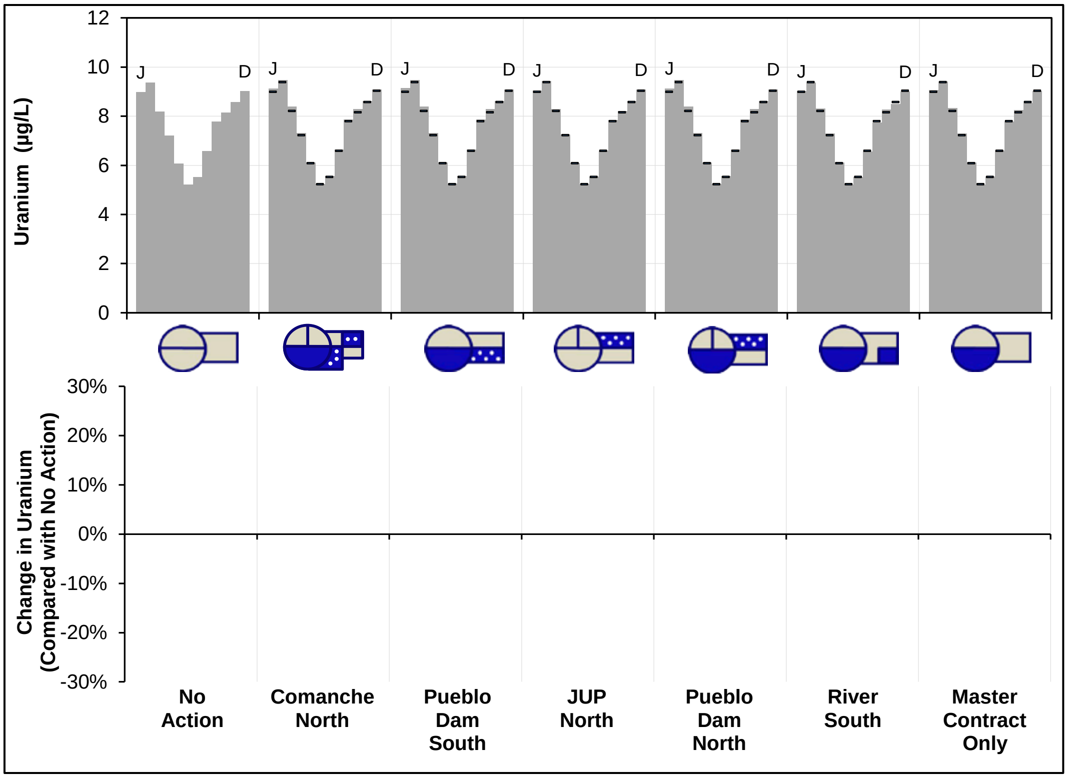
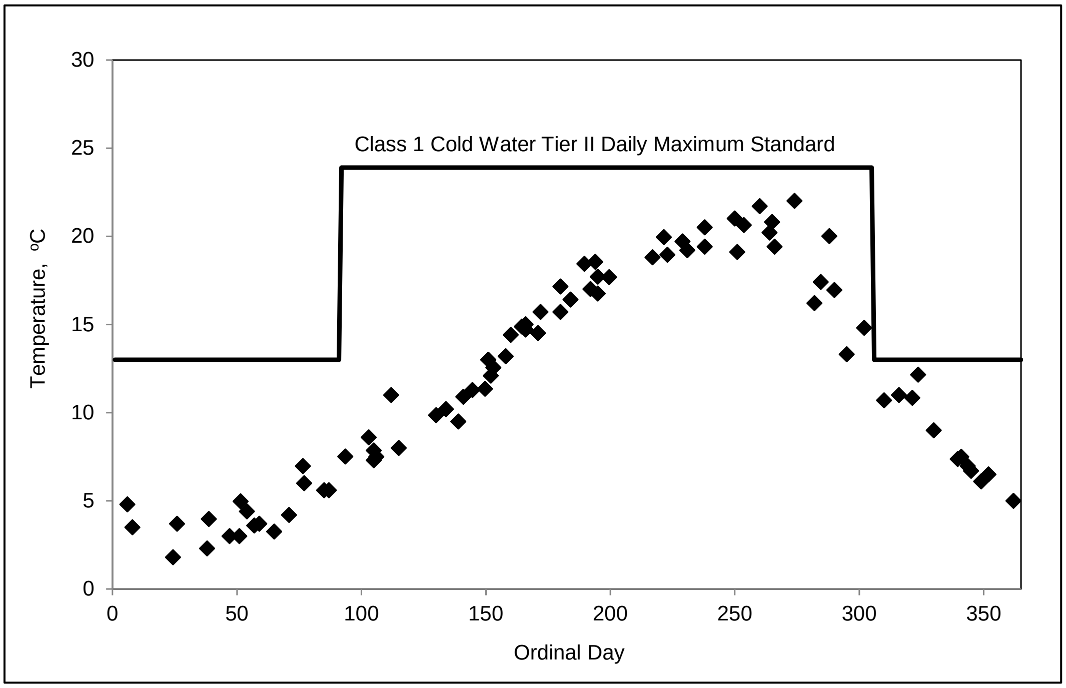


Figure 4–36. Simulated Average Monthly Uranium Concentrations at Arkansas River near Avondale Gage

Nutrients The No Action Alternative would slightly increase nutrient concentrations through Pueblo (Arkansas River at Moffat Street gage) compared to existing conditions. All alternatives would have negligible to minor increases in nutrients concentrations through Pueblo (Arkansas River at Moffat Street gage) compared with the No Action Alternative. All alternatives would have overall negligible to minor adverse effects on Arkansas River near Avondale gage water quality due to increasing nutrient concentrations. Nutrient effects would decrease farther downstream as ambient concentrations increase and streamflow effects decrease.

Lower Arkansas River Basin Streamflow Temperature The No Action Alternative would slightly decrease streamflow temperatures at the Arkansas River above Pueblo gage compared to existing conditions, based on changes in maximum daily average Pueblo Reservoir release temperatures, although changes would be less than 0.5 degrees Celsius (Ortiz 2012). All alternatives except JUP North would negligibly affect streamflow temperature at the Arkansas River above Pueblo gage compared to No Action. Changes in maximum daily average Pueblo Reservoir release temperatures for these alternatives compared to No Action would be less than 0.5 degrees Celsius (Ortiz 2012). Adverse temperature effects would be minor for the JUP North Alternative because of increases in maximum daily average Pueblo Reservoir release temperatures (just over 1 degree Celsius) (Ortiz 2012). Streamflow decreases for all action alternatives in warmer summer months would be negligible to minor (see Appendix D.4) and would have a negligible effect on streamflow temperature. Negligible and minor temperature effects, if added on top of historical values (2000-2011) from various water quality stations in this stream segment (Figure 4–37), would not exceed temperature standards and would not affect the cold water aquatic life designation upstream from the Wild Horse Creek confluence. Streamflow temperature changes for the Lower Arkansas River downstream from the Wild

Horse Creek confluence would be negligible and would not affect the warmwater aquatic life designation.



Data Source: Health Department 2013. Data (2000-2011) from the following water quality stations: Arkansas River Above Pueblo gage, Arkansas River Below Pueblo Reservoir station, Nature Center, Pueblo Fish Hatchery

Figure 4–37. Historical Daily Maximum Temperatures in the Arkansas River between Pueblo Reservoir and Wildhorse Creek Confluence

Lower Arkansas River Basin Chronic Low Flows The No Action Alternative would decrease chronic low flows compared to existing conditions at La Junta. Adverse effects of chronic low flow decreases on La Junta's current discharge permit would be minor for all action alternatives except Master Contract Only, which would be negligible compared to the No Action Alternative. Chronic low flow would decrease more than 10 percent for most alternatives compared to the No Action Alternative (Figure 4–38), and dilution of La Junta's wastewater treatment facility discharge in the Arkansas River would be below 90 percent. Changes in future ambient water quality (defined as the 85th percentile of measured values) would not affect La Junta's current discharge permit because effects on the 85th percentile concentration of several constituents in lower Arkansas River segments would be predominately negligible (Appendix F.2).

La Junta's current permit discharge limits were evaluated by applying percent changes to chronic low flow in the current La Junta permit water quality assessment (12 cfs), and showed negligible effects on most current constituent discharge limits (see Appendix F.2). The assessment showed decreasing chronic low flow would have minor adverse effects on La Junta's free chlorine limit, but effects would be small and near the detectable limit. The assessment also did not account for free chlorine decomposition between the discharge point in King Arroyo and the Arkansas River confluence, which would decrease the effect.

The No Action Alternative would decrease chronic low flows compared to existing conditions at other locations in the Lower Arkansas River Basin. However, decreases in chronic low flow and resulting effects on remaining permitted discharges in the Lower Arkansas River Basin (Pueblo West Metro District, cities of Pueblo, Rocky Ford, and Lamar) would be negligible for all action alternatives compared to the No Action Alternative (Appendix F.2); chronic low flow decreases and increases would be less than 10 percent, or Arkansas River streamflow would adequately dilute the discharge (dilution would be over 90 percent) (Appendix F.2).

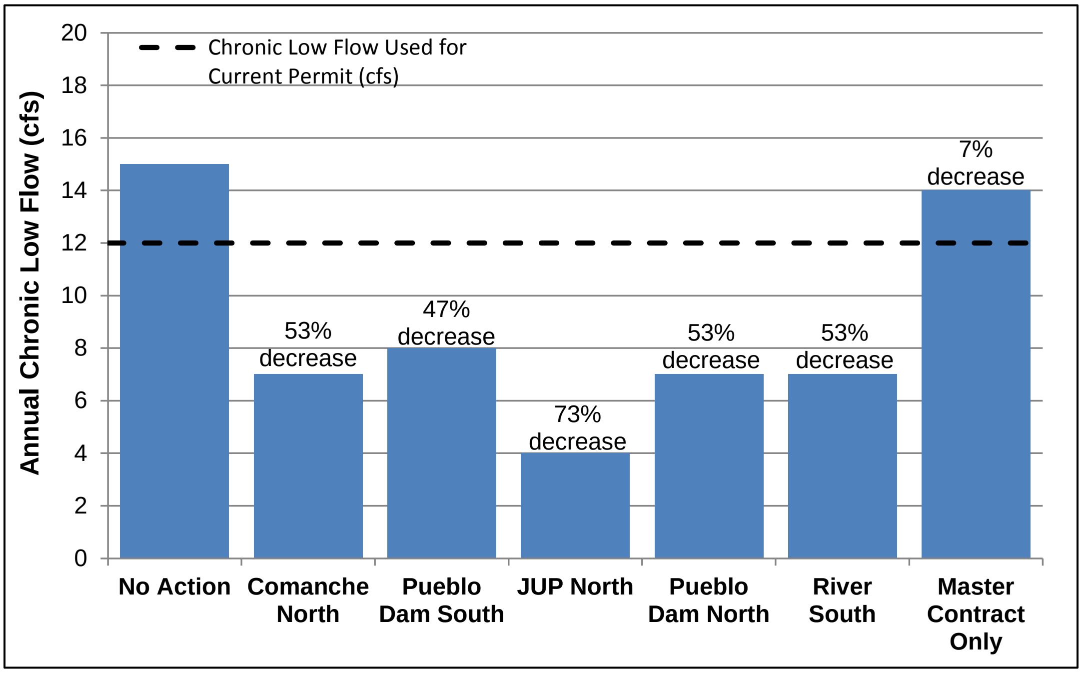


Figure 4–38. Simulated Annual Arkansas River Chronic Low Flow at La Junta

Fountain Creek Streamflow Constituents Total dissolved solids, selenium, sulfate, uranium, bacteria, total recoverable iron, and suspended sediment were evaluated for Fountain Creek.

Total Dissolved Solids and Selenium The No Action Alternative would increase total dissolved solids concentrations in Fountain Creek 6 percent to 11 percent, on average, compared to existing conditions. All alternatives would have mostly negligible effects on Fountain Creek at Pueblo gage total dissolved solids concentrations compared to the No Action, although occasional minor increases would occur in normal years (Figure 4–39 through Figure 4–41).

The No Action Alternative would mostly reduce selenium concentrations compared to existing conditions, although occasional increases would occur. Selenium effects on water quality at the Fountain Creek near Fountain and Fountain Creek at Pueblo gages (Figure 4–42 through Figure 4–44) would be negligible to minor for all alternatives except JUP North compared to the No Action Alternative. The JUP North Alternative effects would be negligible, because streamflows would be similar to the No Action Alternative. Fountain Creek participants would pump similar quantities of groundwater in the JUP North and No Action alternatives, since neither alternative has a Master Contract. All action alternatives except JUP North would increase the 85th percentile selenium concentration at the Fountain Creek at Pueblo gage by less than 1.8 percent compared to the No Action Alternative, which would be less than a 0.3 µg/L increase over historical ambient water quality (16.5 µg/L) and would not exceed the current water quality standard (28.1 µg/L) (Appendix F.1, Appendix F.2).

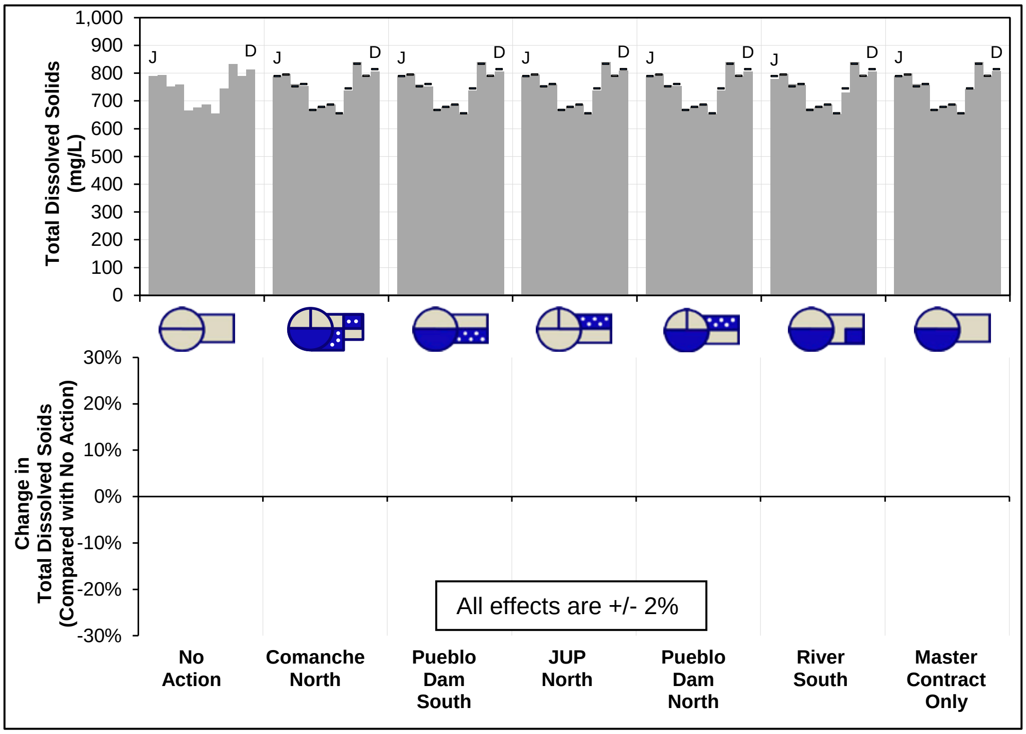


Figure 4–39. Simulated Average Monthly Total Dissolved Solids Concentrations at Fountain Creek at Pueblo Gage

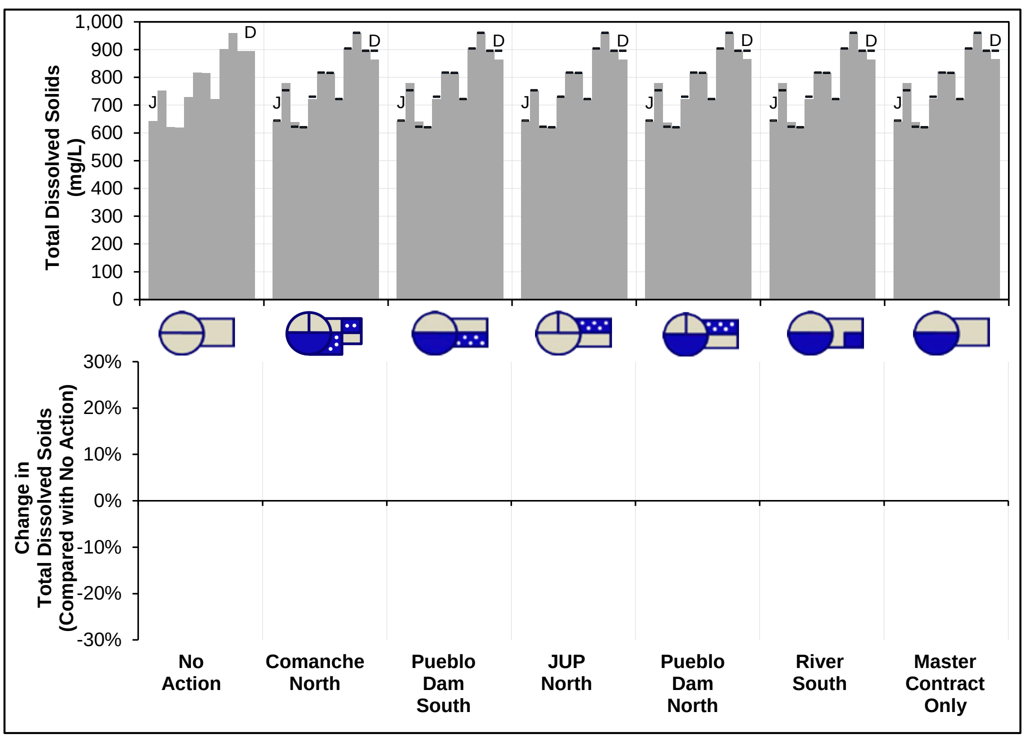


Figure 4–40. Simulated Normal Year (2005) Monthly Total Dissolved Solids Concentrations at Fountain Creek at Pueblo Gage

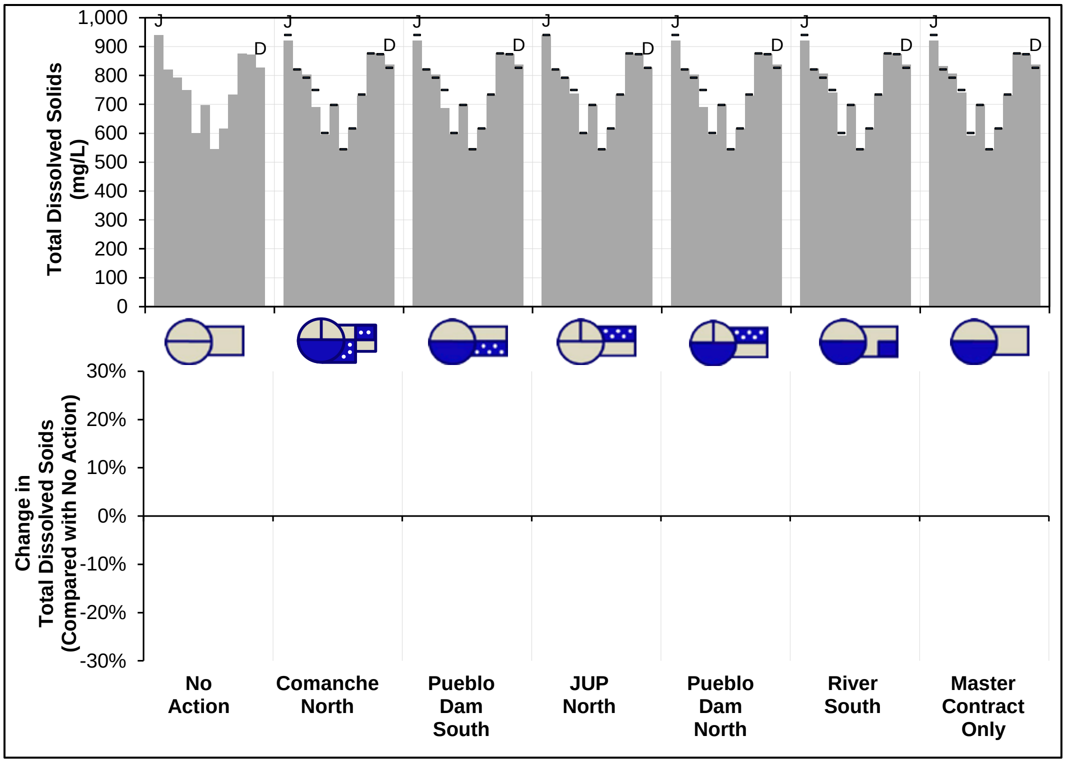


Figure 4–41. Simulated Dry Year (2004) Monthly Total Dissolved Solids Concentrations at Fountain Creek at Pueblo Gage

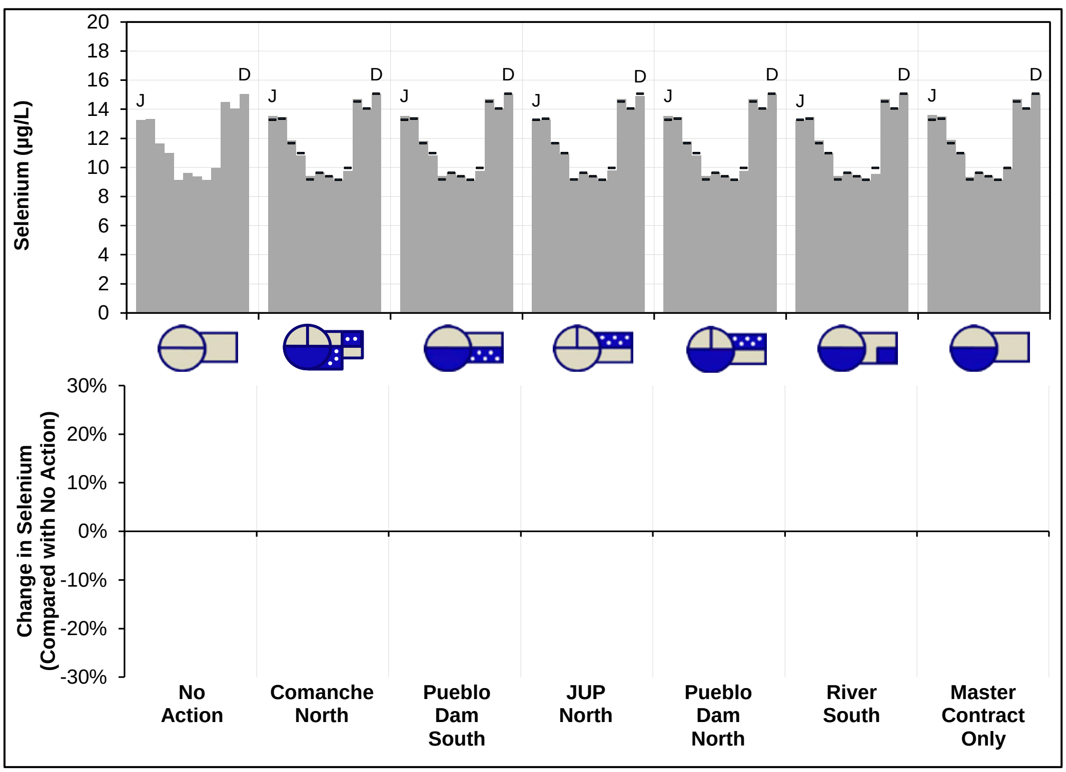


Figure 4–42. Simulated Average Monthly Selenium Concentrations at Fountain Creek at Pueblo Gage

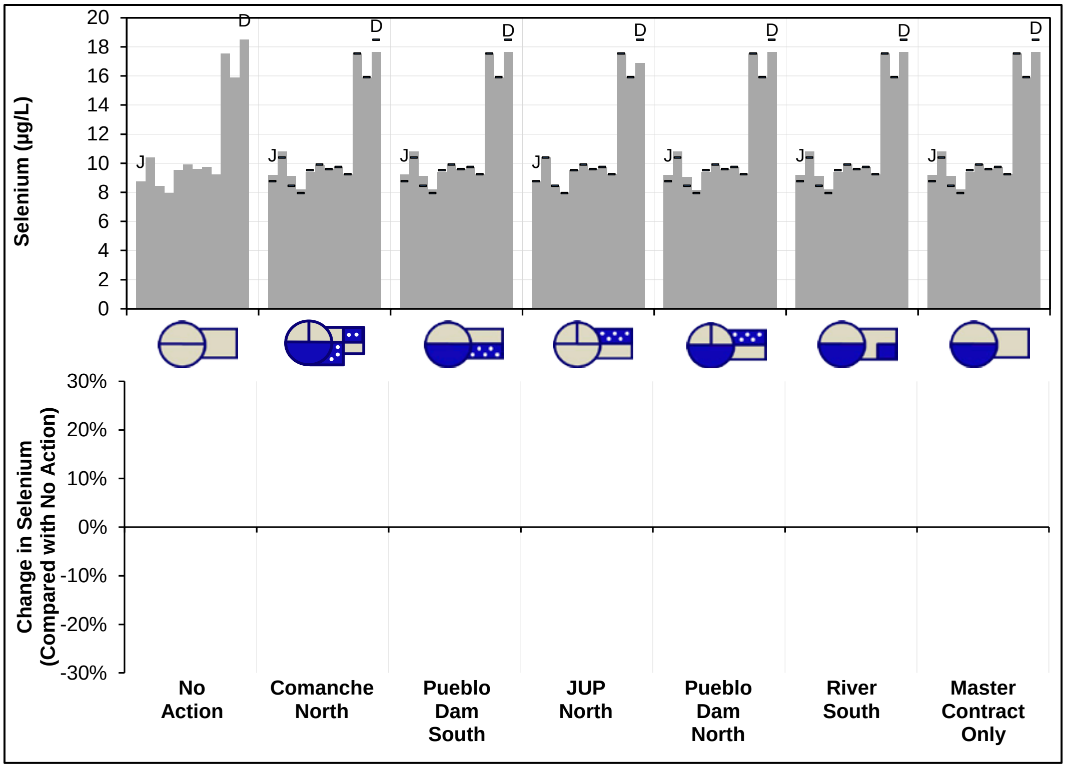


Figure 4–43. Simulated Normal Year (2005) Monthly Selenium Concentrations at Fountain Creek at Pueblo Gage

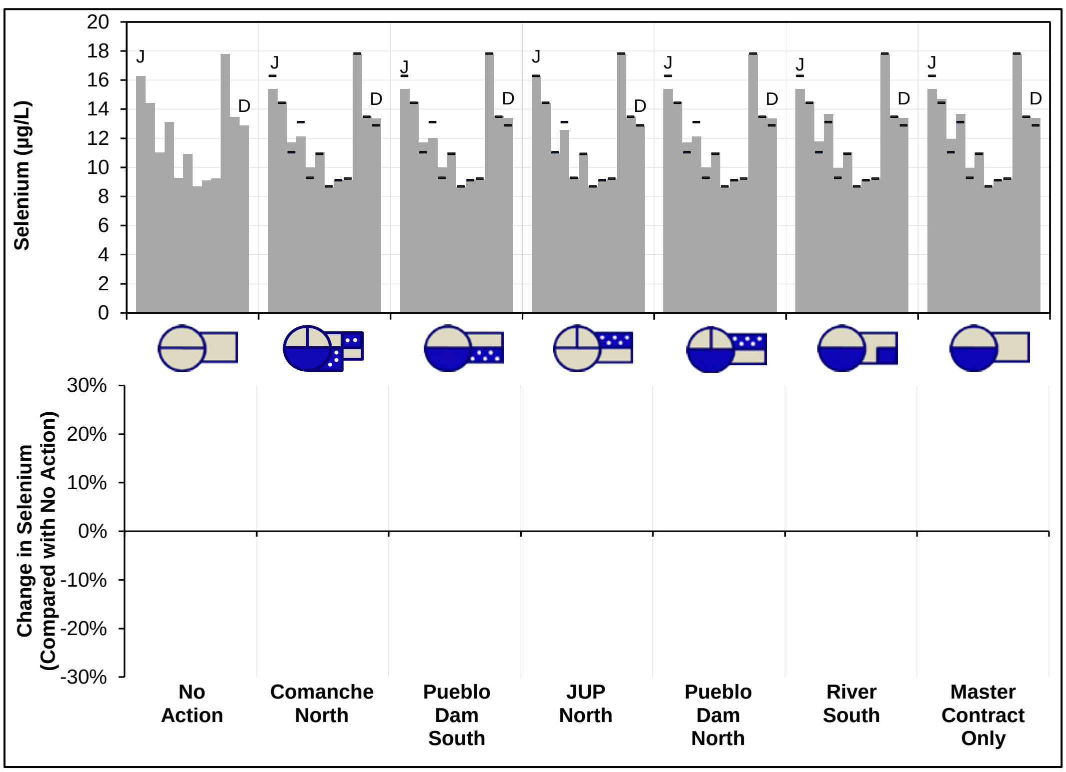
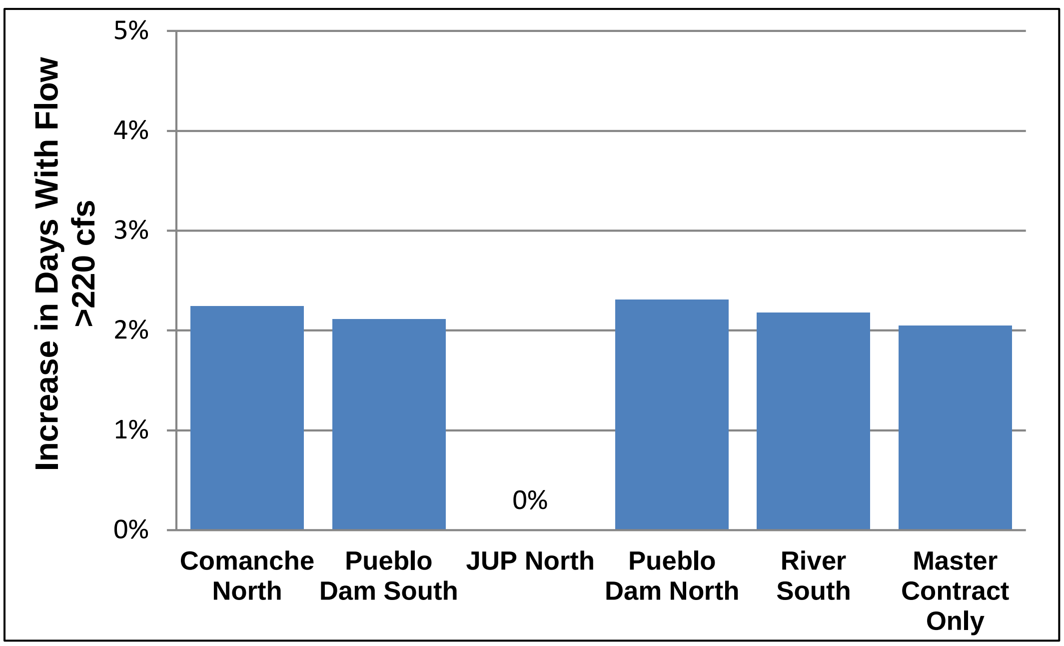


Figure 4–44. Simulated Dry Year (2004) Monthly Selenium Concentrations at Fountain Creek at Pueblo Gage

Sulfate and Uranium Sulfate and uranium effects on water quality in Fountain Creek would be mostly negligible for all alternatives compared to the No Action Alternative. All action alternatives would decrease the 85th percentile sulfate and uranium concentrations at the Fountain Creek at Pueblo gage and would not increase the historical ambient water quality above the current water quality standards (Appendix F.1, Appendix F.2).

Bacteria The No Action Alternative would slightly increase streamflow compared to existing conditions, and would not adversely affect dilution or bacteria concentration, such as *E. coli*. Direct effects on bacteria in Fountain Creek would be negligible for all action alternatives. The action alternatives, compared to the No Action Alternative, would not adversely affect water quality by increasing runoff or nonpoint sources of bacteria, or wastewater return flow concentrations. Dilution of bacteria would not be adversely affected, as the alternatives' effects on Fountain Creek streamflow would be negligible to minor increases (see Appendix D.4). The alternatives would not substantially affect high streamflows in Fountain Creek (Figure 4–45), which could stir up bacteria from stream sediments. High streamflows in Fountain Creek are associated with storm events, which would not be affected by AVC or Master Contract operations. Effects on the ability to meet TMDLs for *E. coli* cannot be assessed in this EIS because TMDLs have not been completed and approved by regulatory agencies for Fountain Creek.



Note: 200 cfs is about the 85th percentile for No Action Alternative streamflow.

Figure 4–45. Increase in Days with High Flows (flow greater than 220 cfs) at Fountain Creek near Fountain Gage

Total Recoverable Iron and Suspended Sediment Increases in total recoverable iron concentrations in Fountain Creek would be negligible for all alternatives. All alternatives, would cause negligible to minor increases in streamflow during most months, and would not adversely affect dilution of tributary total recoverable iron concentrations. The alternatives would not affect watershed contribution of iron, and changes to iron resuspended from tributary sediment would be negligible (see Chapter 4 – *Geomorphology*).

All alternatives would negligibly affect suspended sediment in Fountain Creek. Peak suspended sediment concentrations in Fountain Creek occur during high flows associated with storm events. These high flows would be similar for all action alternatives and the No Action Alternative. Increases in Fountain Creek base flow caused by less groundwater pumping in the action alternatives would not substantially increase channel erosion (see Chapter 4 – *Geomorphology*). Runoff changes associated with increased streamflow could slightly increase suspended sediment concentrations in the No Action Alternative compared to existing conditions.

Nutrients The No Action Alternative would increase nutrient concentrations in Fountain Creek compared to existing conditions. All alternatives would have mostly negligible effects on Fountain Creek at Pueblo gage nutrient concentrations compared to No Action.

Fountain Creek Streamflow Temperature Streamflow temperature effects in Fountain Creek would be negligible for all alternatives. Temperature changes would not affect the warmwater aquatic life designation.

Fountain Creek Chronic Low Flows The No Action Alternative would not adversely decrease chronic low flows in Fountain Creek compared to existing conditions. Effects on chronic low flows in Fountain Creek would be negligible for all action alternatives compared to the No Action (Appendix F.2). Changes to streamflow in Fountain Creek would be negligible to minor increases, and would not affect permitted discharges. Major wastewater treatment facilities in Fountain Creek include the Widefield Water and Sanitation District, U.S. Department of the Army – Fort Carson, Security Sanitation District, and Fountain Sanitation District.

West Slope Water Quality Water quality effects on West Slope streams would be negligible for all alternatives. The alternatives would negligibly affect streamflow on the West Slope, and would not increase constituent sources (Appendix D.5).

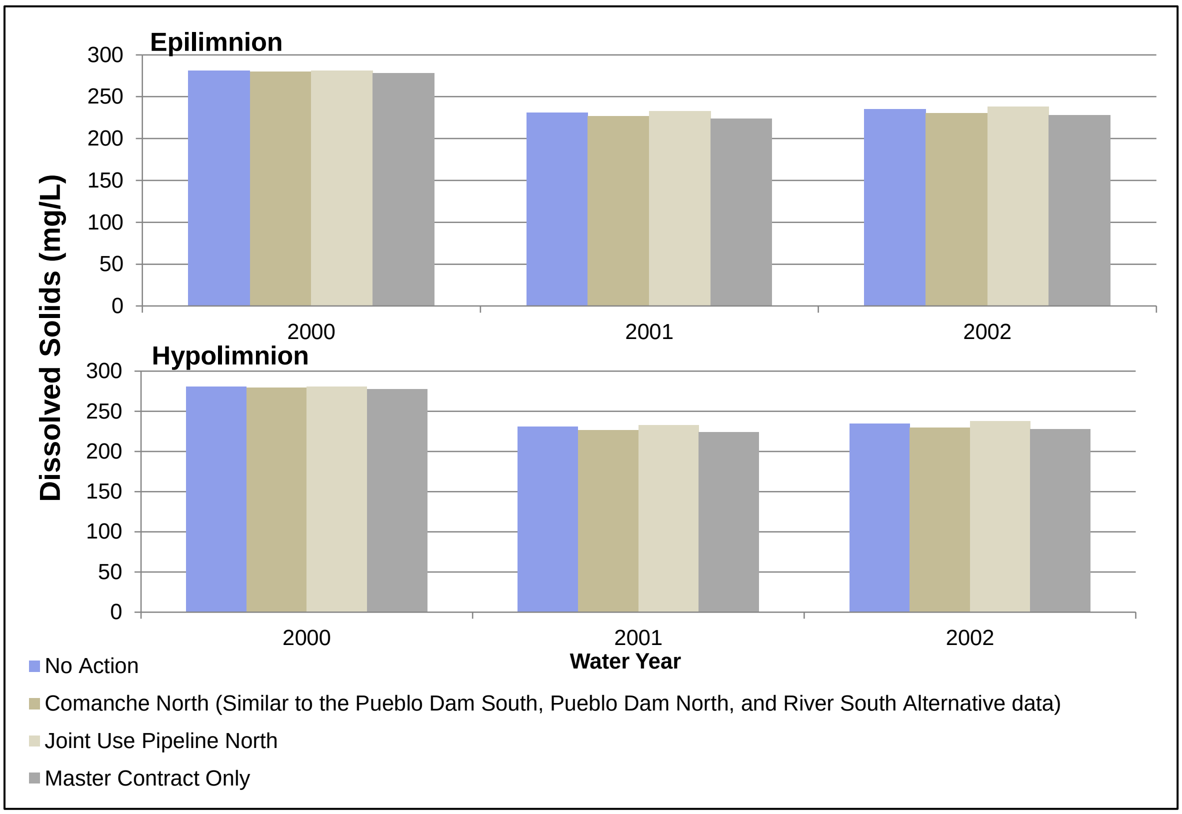
Reservoir Water Quality Reservoir water quality directly affects recreation and fisheries resources in the study area, as well as water supplies for most municipal demand in the Arkansas River Basin. Water quality for Fry-Ark reservoirs and major non-Fry-Ark reservoirs is discussed below.

Turquoise Lake and Twin Lakes The No Action Alternative would not decrease water quality in Turquoise Lake and Twin Lakes compared to existing conditions because changes in storage would be small. All action alternatives would negligibly affect water quality in Turquoise Lake and Twin Lakes compared to the No Action Alternative. The alternatives would not increase quantities of constituents, including nutrients and metals, entering the reservoir. Changes in Pueblo Reservoir operations would indirectly affect Turquoise Lake and Twin Lakes storage volumes (see Chapter 4 – *Surface Water Hydrology)*, possibly affecting constituent concentrations by changing dilution levels. These indirect effects on constituent concentrations would be negligible.

Pueblo Reservoir The No Action Alternative would not decrease water quality in Pueblo Reservoir compared to existing conditions, all constituent concentrations would be well below water quality standards. Effects on water quality due to temperature and dissolved solids concentrations changes would be negligible for all alternatives except Master Contract Only (Figure 4–37 and Figure 4–46). The Master Contract Only Alternative would have a minor beneficial effect on dissolved solids concentrations (concentrations would decrease) as a result of higher storage volumes. Temperature increases in deeper water would be minor for the Master Contract Only Alternative, with no substantial changes in the annual temperature pattern (Ortiz 2012).

All alternatives would negligibly affect Pueblo Reservoir water quality from dissolved oxygen, nutrients, and total-iron concentrations; no new water quality violations would occur. Percent changes in nutrients could be above 10 percent, although concentrations would be small and barely detectable. Total-iron concentrations in deep water could increase during short periods of low oxygen concentration, but effects would be negligible. Total-iron effects would also be higher near the reservoir inlet from Arkansas River sediment deposits (Ortiz 2012).

All alternatives would decrease algae concentrations in Pueblo Reservoir, although the effect would be minor. As simulated, algae concentrations would not pose a health issue or produce taste and odor problems in Pueblo Reservoir (Ortiz 2012).



Source: Ortiz 2012
Figure 4–46. Simulated Annual Median Total Dissolved Solids Concentrations in Pueblo Reservoir at Site 7B

Lake Meredith, Lake Henry, and Holbrook Reservoir Water quality would decrease in Lake Meredith, Lake Henry, and Holbrook Reservoir in dry years under the No Action Alternative compared to existing conditions due to decreases in reservoir storage. Lake Meredith and Lake Henry would have minor adverse water quality effects in all alternatives from increasing total dissolved solids and selenium concentrations compared to the No Action Alternative. As described previously, total dissolved solids would increase for all alternatives in most months at the Arkansas River near Avondale gage, which is upstream from the Colorado Canal intake that delivers water to Lake Meredith and Lake Henry. Selenium concentrations would also occasionally increase at this gage. Intermittent minor decreases in storage for all alternatives at Lake Meredith and Lake Henry (Appendix D.4) could increase total dissolved solids and selenium concentrations. Historically, both reservoirs typically exceed agricultural and drinking water total dissolved solids guidelines and are on the impaired waters list for selenium.

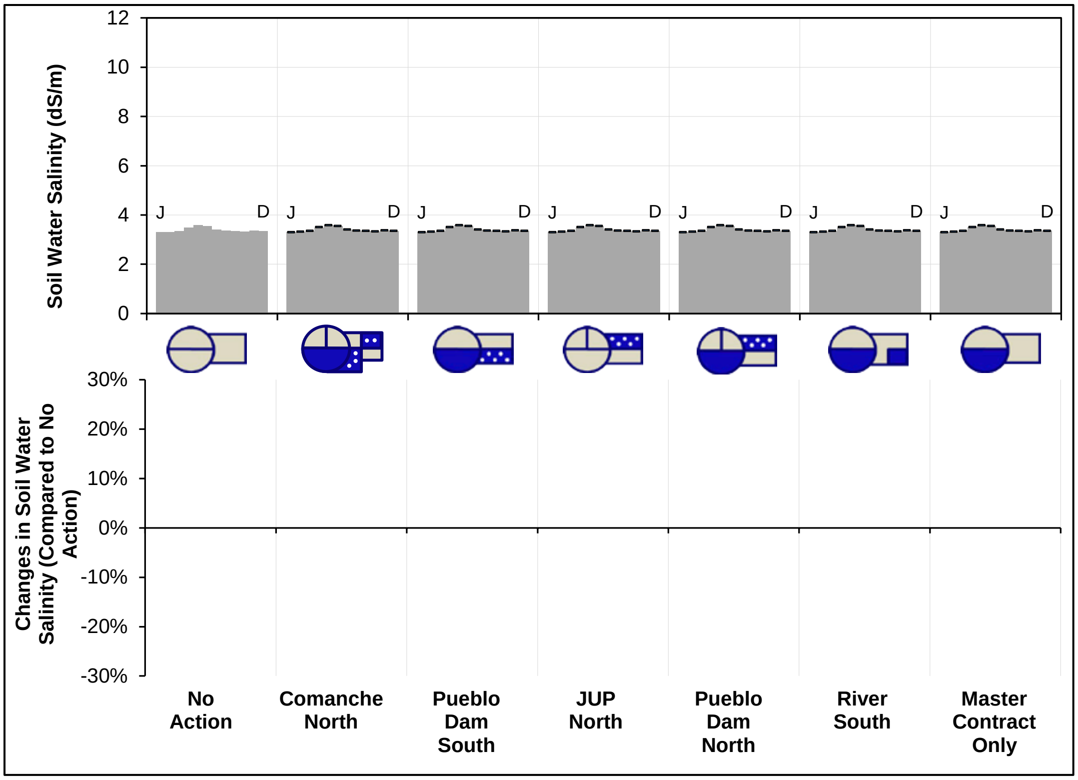
Holbrook Reservoir would have minor adverse water quality effects from total dissolved solids and selenium concentration changes for all alternatives compared to No Action due to minor increases in head gate concentrations and/or moderate decreases in reservoir storage volume in some months.

Groundwater Quality Municipal groundwater pumping and agricultural dry-up would increase under the No Action Alternative compared to existing conditions, and would cause soil water salinity to decrease slightly (Gates and Bailey 2012). Effects on groundwater quality from soil water salinity in Lower Arkansas River crop root zones would be negligible for all alternatives compared to the No Action Alternative (Figure 4–47). Crop yields would not be affected. The No Action and action alternatives would have similar water table depth changes (see Chapter 4 – *Groundwater Hydrology* section).

Municipal groundwater pumping and agricultural dry-up would increase under the No Action Alternative compared to existing conditions, and would increase salt loading from the river to alluvial aquifers (Gates and Bailey 2012). Changes in municipal pumping and agricultural dry-up would cause minor increases to salt loading in summer months from Lower Arkansas River alluvial aquifers to the Arkansas River for most alternatives compared to No Action (Figure 4–48).

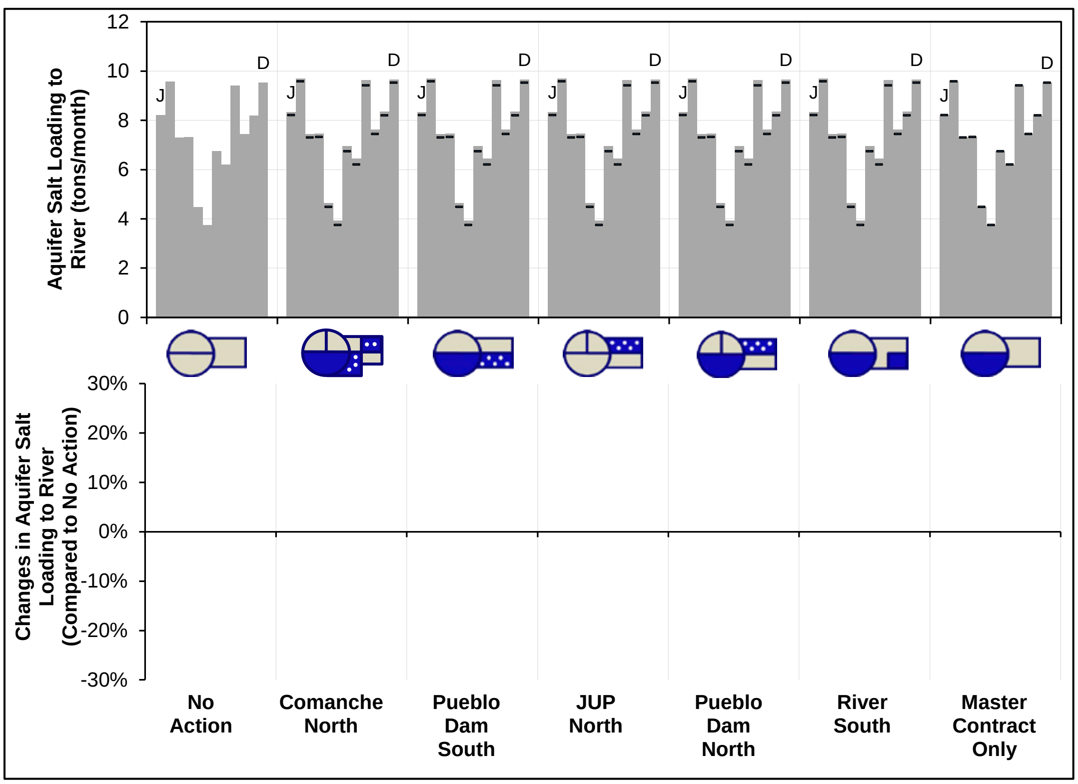
Arkansas Valley Conduit Participant Drinking Water Quality Major beneficial effects would be realized from reducing total dissolved solids concentrations in AVC participant water supplies for all alternatives that include AVC compared to the No Action Alternative. The Master Contract Only Alternative would have water supply total dissolved solids concentrations similar to the No Action Alternative because both would use river diversions and/or groundwater pumping throughout the Lower Arkansas River Basin. Various participants in the No Action and Master Contract Only alternatives without advanced total dissolved solids removal treatment systems, such as reverse osmosis, likely would not meet secondary drinking water total dissolved solids standards. Total dissolved solids concentrations at the River South Alternative river intake would exceed secondary drinking water standards for AVC participants in fall and winter months during dry years.

All alternatives, including the No Action Alternative, would address current Health Department enforcement orders for radionuclides. Effects of the action alternatives compared to the No Action would be negligible.



Data Source: Gates and Bailey 2012

Figure 4–47. Simulated Average Soil Water Salinity in Lower Arkansas River Basin



Data Source: Gates and Bailey 2012

Figure 4–48. Simulated Average Salt Loading from Aquifer to River in Lower Arkansas River Basin

Cumulative Effects

Cumulative effects on Upper Arkansas River Basin water quality would be negligible. The alternatives and development-based reasonably foreseeable actions would not contribute additional constituents to the river, and effects on streamflow would be predominately negligible (see Chapter 4 – *Surface Water Hydrology*). Climate change could cause runoff earlier in the spring, which would change typical temporal water quality patterns. Peak concentration of heavy metals in the Upper Arkansas River Basin, which generally occur during early runoff or peak snowmelt runoff (Ortiz et al. 1998), would be earlier. In general, however, climate change would not be expected to cause substantial changes in water quality, nor adversely affect attainment of water quality standards. Historic mine waste remediation and treatment under EPA's California Gulch Superfund Site project in Leadville would further reduce heavy metal pollution entering the Upper Arkansas River. Changes in streamflow, therefore, would have less cumulative effect on water quality and TMDLs because EPA's actions would reduce the need for Upper Arkansas River streamflow to dilute mine drainage.

All alternatives except River South and Master Contract Only would have negligible to minor adverse cumulative effects on water quality from increasing total dissolved solids, selenium, sulfate, uranium, and nutrients through Pueblo (Arkansas River at Moffat Street gage) compared to the No Action Alternative. Cumulative effects of the River South and Master Contract Only alternatives would be negligible. The alternatives and reasonably foreseeable actions would negligibly affect total recoverable iron concentrations. Cumulative effects for downstream gages would be predominately negligible. The alternatives differ less from the No Action Alternative in the cumulative effects analysis than direct effects because additional development in larger cities (Pueblo and Colorado Springs) would influence streamflow and surface water quality similarly in the cumulative No Action Alternative and action alternatives

Chronic low flow cumulative effects on La Junta's current discharge permit would be minor, similar to direct effects. Climate change effects would be similar to those described for the Upper Arkansas River Basin.

Cumulative total dissolved solids and nutrient effects on water quality at the Fountain Creek at Pueblo gage would be mostly negligible for all action alternatives, with occasional minor increases in concentration. The No Action Alternative would increase total dissolved solids and nutrient concentrations compared to existing conditions, especially in late spring and early summer months. Selenium effects would be negligible to minor for all alternatives. The No Action Alternative would mostly reduce selenium concentrations, compared to existing conditions.

Sulfate and uranium concentration effects on Fountain Creek water quality would be mostly negligible to minor, although average August uranium concentrations would moderately increase for the Comanche North, Pueblo Dam South, and JUP North alternatives. Uranium concentrations would continue to be well below water quality standards. Bacteria concentration increases would be negligible for all alternatives.

Total recoverable iron and suspended sediment cumulative effects on Fountain Creek water quality would be negligible for all alternatives compared to the cumulative No Action Alternative, similar to direct effects. Additional development in the watershed could increase cumulative iron and suspended sediment concentrations in Fountain Creek in the No Action Alternative compared to existing conditions.

Chronic low flow cumulative effects in Fountain Creek would be negligible for all alternatives, similar to direct effects. Climate change effects would be similar to those described for the Arkansas River.

Cumulative water quality effects on West Slope streams would be negligible for all alternatives, similar to direct effects.

All alternatives would have negligible cumulative effects on water quality in Turquoise Lake and Twin Lakes. The alternatives would not increase the load of constituents, including nutrients and metals, entering the reservoir. Cumulative effects on reservoir storage volumes would be mostly negligible for all alternatives compared to the No Action Alternative. Warmer temperatures associated with climate change could increase rates of evaporation and evapotranspiration, slightly increasing constituent concentrations, although this effect would likely be minimal.

Cumulative effects on Pueblo Reservoir water quality from total dissolved solids, dissolved oxygen, nutrients, and iron concentrations would be negligible. The alternatives and reasonably foreseeable actions would cause minor decreases to minor increases in temperature for all action alternatives except JUP North and Master Contract Only, which would have negligible effects on temperature. These temperature effects would vary in depth and in wet and dry years. Algae concentrations would also vary between minor increases and decrease for all alternatives.

Cumulative effects on Lake Meredith, Lake Henry, and Holbrook Reservoir would be similar to direct effects.

Mitigation Measures
No significant adverse effects on water quality were found. The Environmental Review Team would review any future proposed project changes (for example, pipeline routing, new participants, new water supplies, or changes in water rights administration). Any changes warranting additional NEPA or Compact compliance review, adaptive management, or other environmental compliance would be addressed by the Environmental Review Team. The Environmental Review Team would function during final design through one year after AVC and/or Master Contract operations begin, if an action alternative is selected in the Record of Decision.

Geomorphology

Arkansas River or Fountain Creek streamflow geomorphic effects could be caused by changes in streamflow or quantity of tributary sediment load. This section compares the alternatives' effects on sediment transport, erosion, sedimentation, and other processes that could change channel features and stability. These effects could change stream alignment or reduce stream health and water quality.

Summary

Geomorphic effects of the alternatives would be negligible compared to the No Action. Effects on Fountain Creek geomorphic processes, where erosion in Upper Fountain Creek causes sedimentation in Lower Fountain Creek and the Arkansas River, would be negligible (Table 4–20).

Table 4–20. Summary of Geomorphology Direct and Indirect Effects

Major / Moderate / Minor / Negligible (=) / Minor / Moderate / Major — Beneficial ↔ Adverse	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Erosion and Sedimentation – Arkansas River (1)	=	=	=	=	=	=
Erosion and Sedimentation – Fountain Creek (1)	=	=	=	=	=	=

Note:
(1) Effects are assessed compared to the No Action Alternative.

Methods

The geomorphology analysis area is limited to areas most likely to be affected by the alternatives (Figure 4–49), including the Arkansas River from state Highway 115 to Pueblo Reservoir; Fountain Creek from Fountain to the Arkansas River confluence; and Arkansas River from the mouth of Fountain Creek to the Arkansas River near Avondale gage. Various stream features were used to identify stream areas more likely to be affected by streamflow changes. These stream areas are generally shallow and/or contain sand or gravel bed material, and have already evolved as a result of past flow and watershed changes. These areas are at risk for erosion and changes in stream alignment patterns because of changes in streamflow caused by alternatives. The Arkansas River between Pueblo Reservoir and Fountain Creek is not included because the channel is predominately lined or otherwise stabilized and would not be affected by changes in streamflow (Corps 2001).

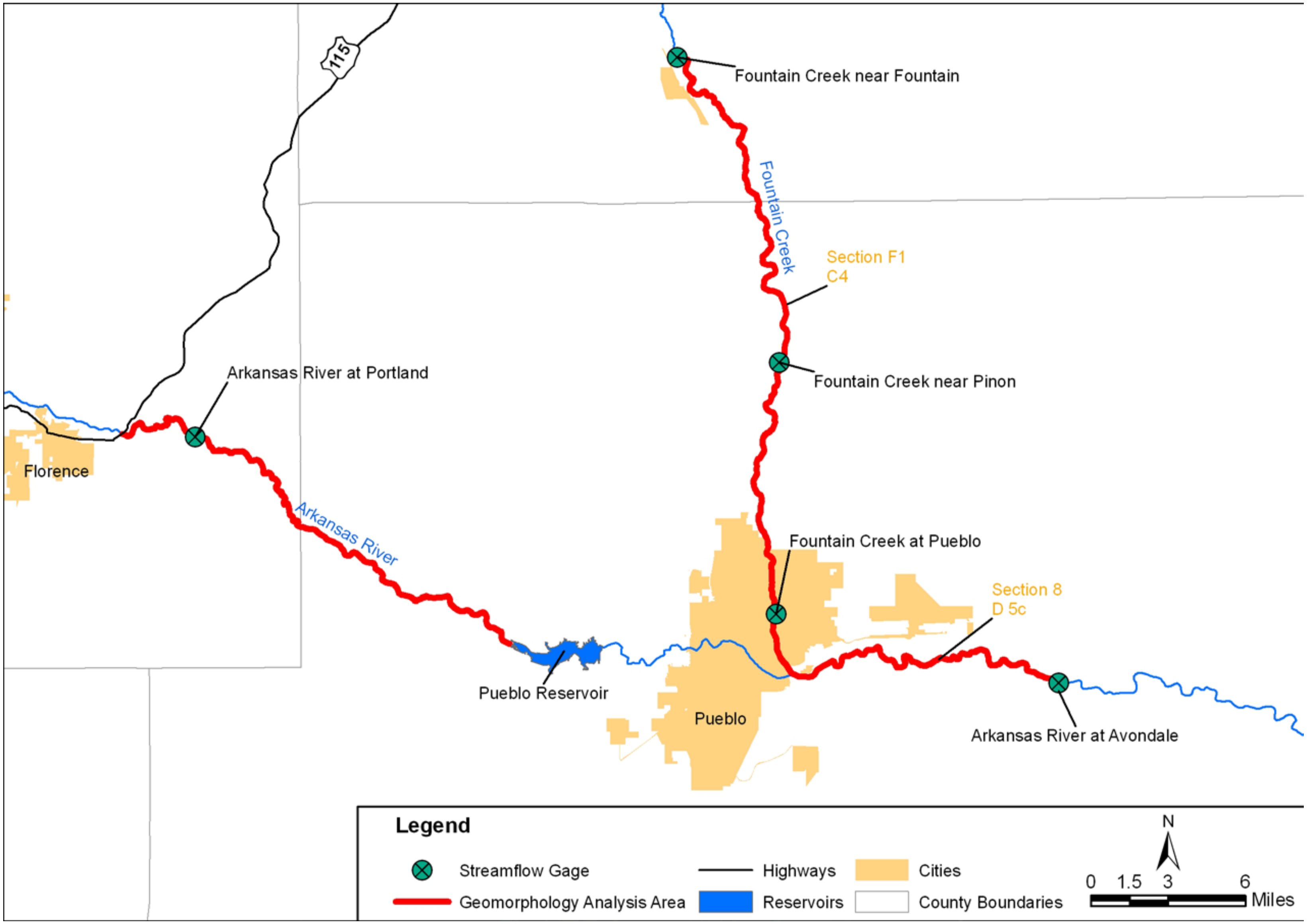


Figure 4–49. Geomorphology Effects Analysis Area

Long-term changes that would occur as streams try to adjust to a new geomorphic equilibrium, or balance between degradation and aggradation, were evaluated using relationships between streamflow, sediment transport, and stream slope (Figure 4–50). Geomorphic equilibrium occurs when the energy from sediment load (Q_s) and sediment size (D_{50}) is balanced with the energy from streamflow (Q_w) and stream slope (S). When conditions change, one or more of these primary stream features changes to keep the scale balanced (achieve geomorphic equilibrium). This relationship was used to evaluate long-term effects associated with connections between these stream characteristics. Other stream characteristics that influence geomorphic equilibrium were also considered, including stream sinuosity and riparian vegetation (could stabilize stream banks and minimize erosion).

Degradation is the erosion of sediment from a channel.

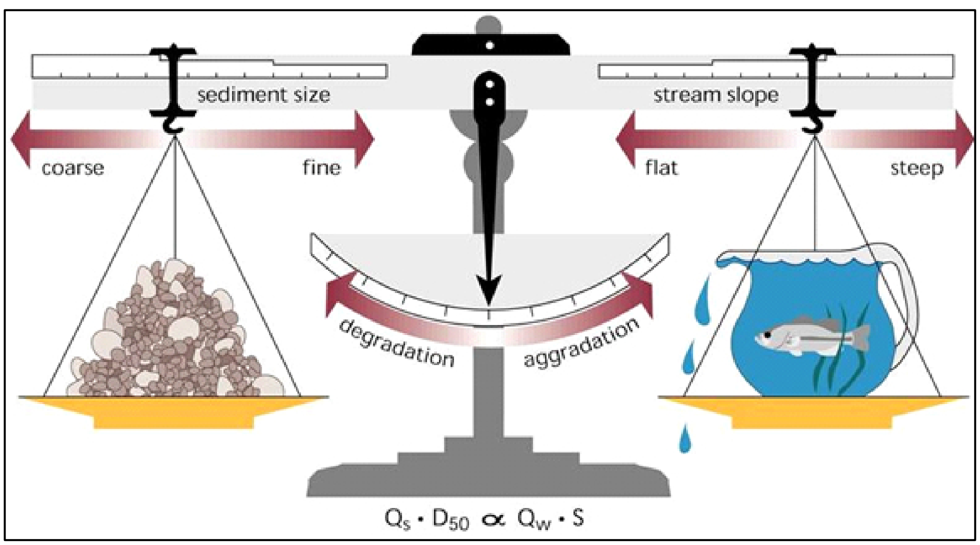
Aggradation is the buildup of sediment in a stream channel causing reduced channel capacity.

Sediment load is the sediment discharge or concentration of sediment within flowing water.

Sediment transport capacity is the amount of sediment that could be moved by flowing water.

Stream sinuosity is the length of a stream segment (following the path of water through curves and bends) divided by the length of valley the stream flows through. Higher sinuosity means a twisted or curvy channel form. Sinuosity could increase and reduce channel slope to offset streamflow increases.

Potential effects on mobile grain size (sediment size) were analyzed as changes in sediment sizes that would be moved by streamflow, which would cause a gradual, long-term geomorphic change. Streamflow changes that would move larger grain sizes would move more channel bed material and cause more erosion. Conversely, less streamflow would move smaller grain sizes and would lead to less erosion and aggradation since less sediment would be moved downstream. Mobile grain size was evaluated using the critical Shields Parameter (Meyer-Peter and Muller 1948; Gessler 1965), which assesses sediment particle sizes that could be moved by simulated streamflow.



Source: Natural Resources Conservation Service 1998
Figure 4–50. Lanes' Balance for Sediment Transport

Base flow (streamflow under low flow conditions) influences long-term gradual sediment transport on Fountain Creek, and affects the finer portion of sediment (suspended load and smaller material in the bed load) (Stogner 2000). Base flow is typically derived from soil moisture, groundwater inflow, and wastewater discharge. Assuming the winter period generally represents flows unassociated with stormwater runoff, base flow was estimated for each alternative as the average daily flow from December through February using results from surface water hydrology analysis.

Long-term effects in this analysis based on geomorphic relationships in Figure 4–50 should be considered estimates of overall effects that may occur over large stream segments. Specific locations of long-term effects in a stream area vary.

Peak flow sediment transport capacity and loadings, which can be large, were not evaluated because the alternatives' effects on flood flows and floodplains would be negligible (MWH 2013a). All alternatives would change peak flood flows in all years less than 2 percent compared to the No Action Alternative, and would not alter the floodplain or other geomorphic characteristics of the river.

Criteria for Determining Significance of Effects

Linear relationships between the percent change in base flow and mobile grain size and the classification of geomorphic effects were assumed in developing the significance criteria in Table 4–21. The intensity of geomorphic effects (minor versus major) was based on professional judgment using knowledge of analysis area streams.

Table 4–21. Intensity of Geomorphology Effects Based on Changes in Base Flow Mobile Grain Size.

Effect Intensity	Intensity Description
Negligible	The alternative would change geomorphic conditions, but the change would be so small that it would be unmeasurable or imperceptible. The change would be within accuracies of calculation methods used to estimate sediment transport and other geomorphic characteristics. Effects on base flow mobile grain size would be less than 5 percent.
Minor	The alternative would cause a measureable change to geomorphic conditions, but the change would be small, localized, and of little consequence. The geomorphic condition would not affect other downstream segments – any changes in sediment transport capacity or other geomorphic characteristics would be limited to a single segment. Effects on base flow mobile grain size would be between 5 and 10 percent.
Moderate	The alternative would cause a measureable and consequential change to geomorphic conditions, but would be limited to existing areas of geomorphic instability and would not affect other downstream locations. Changes in sediment transport capacity or other geomorphic characteristics would be limited to existing locations of geomorphic instabilities. These areas of geomorphic instabilities would be covered under existing plans to improve geomorphic conditions within analysis area streams. Effects on base flow mobile grain size would be between 10 and 15 percent.
Major	The alternative would cause a large, measurable, consequential change to geomorphic conditions. Changes in sediment transport capacity or other geomorphic characteristics would occur consistently at locations outside existing locations of geomorphic instabilities. Geomorphic conditions would be exacerbated over a wide area and introduce new segments of streams to geomorphic instabilities (erosion or sediment deposition) that were previously considered stable and not covered under existing plans to improve geomorphic conditions within analysis area streams. Effects on base flow mobile grain size would be greater than 15 percent.

Results

Direct, indirect, and cumulative effects on geomorphology are discussed in this section. AVC and Master Contract operations would directly and indirectly affect geomorphology due to streamflow changes in sensitive stream segments. These same operations, along with other reasonably foreseeable actions, would cumulatively affect geomorphology.

Direct and Indirect Effects

The No Action Alternative would not adversely affect geomorphology compared to existing conditions. Minor base flow changes in Fountain Creek would not adversely affect mobile grain size. Mobile grain size changes would not substantially alter erosion or sedimentation patterns occurring along all stream segments.

Streamflow differences among the alternatives would generally cause negligible effects on geomorphology compared to the No Action Alternative. Base flow effects are in Table 4–22 and mobile grain size effects are in Table 4–23.

Effects of all alternatives along the Arkansas River, from state Highway 115 to Pueblo Reservoir, would be negligible, with changes in the size of sediment that could be moved ranging from -0.1 to 0.2 percent. Base flow effects along Fountain Creek would be minor for several alternatives, but the change in base flow negligibly affects sediment transport. Mobile grain size changes caused by base flow changes would range from 0.1 to 2.3 percent (less than 0.2 millimeters). Geomorphic effects caused by mobile grain size changes would also be negligible along the Arkansas River from the Fountain Creek confluence to the Arkansas River near Avondale gage.

Table 4–22. Direct and Indirect Geomorphic Effects – Base Flow

Stream Segment	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Base Flow (cfs)							
Arkansas River – CO State Highway 115 to Pueblo Reservoir	397.3	396.7	396.3	399.7	396.7	396.3	396.0
Fountain Creek. – Fountain to Piñon Gage	117.7	124.3	124.3	118.0	124.3	124.3	124.3
Fountain Creek. – Piñon Gage to Pueblo Gage	129.3	135.3	135.3	129.3	135.3	135.3	135.3
Arkansas River – Fountain Creek to Avondale Gage	257.7	260.3	260.0	254.7	260.3	257.7	261.7
Change(1) in Base Flow (%) Compared to No Action Alternative							
Arkansas River – CO State Highway 115 to Pueblo Reservoir	---	-0.2	-0.3	0.6	-0.2	-0.3	-0.3
Fountain Creek. – Fountain to Piñon Gage	---	5.7	5.7	0.3	5.7	5.7	5.7
Fountain Creek. – Piñon Gage to Pueblo Gage	---	4.6	4.6	0.0	4.6	4.6	4.6
Arkansas River – Fountain Creek to Avondale Gage	---	1.0	0.9	-1.2	1.0	0.0	1.6

Note:
(1) Positive changes represent trends toward increased erosion or decreased aggradation; negative changes represent trends toward increased aggradation or decreased erosion

Table 4–23. Direct and Indirect Geomorphic Effects – Mobile Grain Size

Stream Segment	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Mobile Grain Size (millimeter)							
Arkansas River – CO State Highway 115 to Pueblo Reservoir	26.1	26.1	26.1	26.1	26.1	26.1	26.0
Fountain Creek. – Fountain to Piñon Gage	8.5	8.7	8.7	8.5	8.7	8.7	8.7
Fountain Creek. – Piñon Gage to Pueblo Gage	10.6	10.8	10.8	10.6	10.8	10.8	10.8
Arkansas River – Fountain Creek to Avondale Gage	93.3	94.2	94.1	92.3	94.2	93.3	94.6
Change(1) in Mobile Grain Size (%) Compared to No Action Alternative							
Arkansas River – CO State Highway 115 to Pueblo Reservoir	---	-0.1	-0.1	0.2	-0.1	-0.1	-0.1
Fountain Creek. – Fountain to Piñon Gage	---	2.2	2.2	0.1	2.2	2.2	2.2
Fountain Creek. – Piñon Gage to Pueblo Gage	---	2.3	2.3	0.0	2.3	2.3	2.3
Arkansas River – Fountain Creek to Avondale Gage	---	0.9	0.8	-1.1	0.9	0.0	1.4

Note:
(1) Positive changes represent trends toward increased erosion or decreased aggradation; negative changes represent trends toward increased aggradation or decreased erosion

Cumulative Effects

The No Action Alternative would increase base flow and mobile grain size in Fountain Creek, compared to existing conditions. Reasonably foreseeable urban and suburban development in the Fountain Creek watershed, and associated water use and return flows growth, would increase base flow and potentially erosion. The increase in mobile grain size would range from 1.9 millimeters to 2.5 millimeters, which represents an increase of about 1/16 of an inch.

Similarly, base flow and mobile grain size would increase under the No Action Alternative relative to existing conditions along the Arkansas River between Fountain Creek and the Arkansas River near Avondale gage. The increase in mobile grain size would be about 1/2 of an inch (13 millimeters). The SDS EIS (Reclamation 2008) found that cumulative flood flows would increase under the No Action Alternative compared to existing conditions, and would affect Fountain Creek geomorphology.

Cumulative effects on base flow and mobile grain size relative to the No Action Alternative would be negligible for all alternatives (Table 4–24 and Table 4–25). Effects on geomorphology caused by these changes would be negligible. Base flow conditions would be influenced by reasonably foreseeable development and increased water use occurring under both the No Action and action alternatives. Climate change could affect magnitude and frequency of storm events. This could adversely affect peak flows and geomorphology in streams, particularly Fountain Creek.

Table 4–24. Cumulative Geomorphic Effects – Base Flow

Stream Segment	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Base Flow (cfs)							
Arkansas River – CO State Highway 115 to Pueblo Reservoir	420.3	423.0	423.0	423.7	423.0	421.3	419.0
Fountain Creek. – Fountain to Piñon Gage	183.7	185.7	185.7	183.0	185.3	185.7	186.0
Fountain Creek. – Piñon Gage to Pueblo Gage	191.7	193.3	193.0	191.0	193.3	193.7	194.0
Arkansas River – Fountain Creek to Avondale Gage	295.3	296.3	295.7	293.7	296.0	292.7	297.3
Change[(1)] in Base Flow (%) Compared to No Action Alternative							
Arkansas River – CO State Highway 115 to Pueblo Reservoir	---	0.6	0.6	0.8	0.6	0.2	-0.3
Fountain Creek. – Fountain to Piñon Gage	---	1.1	1.1	-0.4	0.9	1.1	1.3
Fountain Creek. – Piñon Gage to Pueblo Gage	---	0.9	0.7	-0.3	0.9	1.0	1.2
Arkansas River – Fountain Creek to Avondale Gage	---	0.3	0.1	-0.6	0.2	-0.9	0.7

Note:
(1) Positive changes represent trends toward increased erosion or decreased aggradation; negative changes represent trends toward increased aggradation or decreased erosion

Table 4–25. Cumulative Geomorphic Effects – Mobile Grain Size

Stream Segment	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Mobile Grain Size (millimeter)							
Arkansas River – CO State Highway 115 to Pueblo Reservoir	26.6	26.7	26.7	26.7	26.7	26.7	26.6
Fountain Creek. – Fountain to Piñon Gage	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Fountain Creek. – Piñon Gage to Pueblo Gage	12.8	12.9	12.9	12.8	12.9	12.9	12.9
Arkansas River – Fountain Creek to Avondale Gage	105.6	105.9	105.7	105.1	105.8	104.7	106.2
Change[1] in Mobile Grain Size (%) Compared to No Action Alternative							
Arkansas River – CO State Highway 115 to Pueblo Reservoir	---	0.2	0.2	0.3	0.2	0.1	-0.1
Fountain Creek. – Fountain to Piñon Gage	---	0.4	0.4	-0.1	0.4	0.4	0.5
Fountain Creek. – Piñon Gage to Pueblo Gage	---	0.4	0.3	-0.2	0.4	0.5	0.6
Arkansas River – Fountain Creek to Avondale Gage	---	0.3	0.1	-0.5	0.2	-0.8	0.6

Note:
(1) Positive changes represent trends toward increased erosion or decreased aggradation; negative changes represent trends toward increased aggradation or decreased erosion

Mitigation Measures

No geomorphic mitigation measures are recommended for the negligible geomorphic effects of the alternatives. Geomorphic changes could occur in Fountain Creek and Arkansas River segments, but would be similar and not additive to existing stream processes. It should be noted that many mitigation measures committed to by SDS participants (including Fountain and Security) in the SDS EIS Record of Decision are designed to minimize effects of erosion in Fountain Creek, which could mitigate potential increases in sedimentation in the Arkansas River downstream from Fountain Creek (Reclamation 2009b).

Aquatic Life

Aquatic life, including fish and benthic invertebrate communities and habitat, were evaluated because they could be affected by changes in streamflow, reservoir storage patterns, water quality, flooding, channel geomorphology, or riparian vegetation. Methods used to evaluate aquatic life effects, and the direct, indirect, and cumulative effects are described in this section. Appendix H describes aquatic life effects methodology in more detail, and contains results from all simulations, including existing conditions.

Summary

Direct and indirect effects on Upper Arkansas River Basin aquatic life would be negligible for all alternatives (Table 4–26). Changes in brown trout and rainbow trout habitat availability, including during important pre- and post-runoff periods identified by Colorado Parks and Wildlife, would be minimal.

Effects on aquatic life, including macroinvertebrates, in the Arkansas River between Pueblo Reservoir and the Fountain Creek confluence would be negligible for all alternatives. For most of the year, changes in habitat availability among the alternatives would be less than 10 percent. Hydrology and water quality changes in this river segment would cause negligible effects on aquatic life.

Aquatic life effects in the remainder of the Lower Arkansas River Basin, including Fountain Creek, would also be negligible for all alternatives. The effects of the alternatives would change flows in the Arkansas River and Fountain Creek, but would maintain flows and connectivity to tributary streams. There would be negligible effects on Arkansas darters as tributary populations would not be affected by the alternatives and migration routes between tributaries would be maintained.

All alternatives except JUP North would negligibly affect aquatic life for Turquoise Lake, Twin Lakes, Pueblo Reservoir, Lake Henry, Lake Meredith, and John Martin reservoirs. The JUP North Alternative would decrease Pueblo Reservoir storage contents, elevation, and surface area throughout the year and would cause moderate adverse effects on habitat for spawning fish and overall fish habitat related to survival and growth. The JUP North Alternative would result in negligible effects for all other reservoirs. All alternatives except JUP North would result in moderate adverse effects to aquatic life for Holbrook Reservoir as a result of moderate decreases in storage, elevation, and surface area during June through November of normal and dry years.

Table 4–26. Summary of Aquatic Life Direct and Indirect Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
⊙	◐	⦶	=	⊖	◒	●
Beneficial ↔ Adverse						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Upper Arkansas River Basin [1]						
Lake Fork, Lake Creek, Upper Arkansas River, Grape Creek	=	=	=	=	=	=
Lower Arkansas River [1]						
Pueblo Reservoir to Wildhorse Creek	=	=	=	=	=	=
Wildhorse Creek to Fountain Creek	=	=	=	=	=	=
Fountain Creek to John Martin Reservoir	=	=	=	=	=	=
John Martin Reservoir to State Line	=	=	=	=	=	=
Fountain Creek [1]						
Security to Arkansas River	=	=	=	=	=	=
Reservoirs [1]						
Turquoise Lake and Twin Lakes	=	=	=	=	=	=
Pueblo Reservoir	=	=	◒	=	=	=
Lake Henry and Lake Meredith	=	=	=	=	=	=
Holbrook Reservoir	◒	◒	=	◒	◒	◒
John Martin Reservoir	=	=	=	=	=	=

Note:
(1) Effects are assessed compared to the No Action Alternative.

Methods

Methods used to analyze effects, and the criteria for determining significance of effects on aquatic life, are described in this section.

Effects Analyses

The analysis area for the aquatic life effects analysis is similar to the Chapter 4 – *Surface Water Hydrology* effects analysis, and includes water bodies potentially affected by changes in streamflow, water quality, flood hydrology, channel geomorphology, or riparian vegetation. Streams and reservoirs referred to in this section are depicted in Figure 4–51.

The Physical Habitat Simulation System (PHABSIM) was used to evaluate how changes in flow with the alternatives could affect fish and habitat availability in streams. PHABSIM is a component of the Instream Flow Incremental Methodology (Bovee 1982). The effects of changes in reservoir storage patterns over time on aquatic life were evaluated using the best available scientific information and professional judgment.

PHABSIM results include habitat versus streamflow relationships for different species and life stages of fish (Table 4–27). These relationships assess habitat availability, expressed as square feet of Weighted Usable Area per 1,000 feet of stream (ft2/1,000 feet.) available over a range of streamflows. Combining this relationship with simulated streamflow data, fish habitat availability was compared among alternatives.

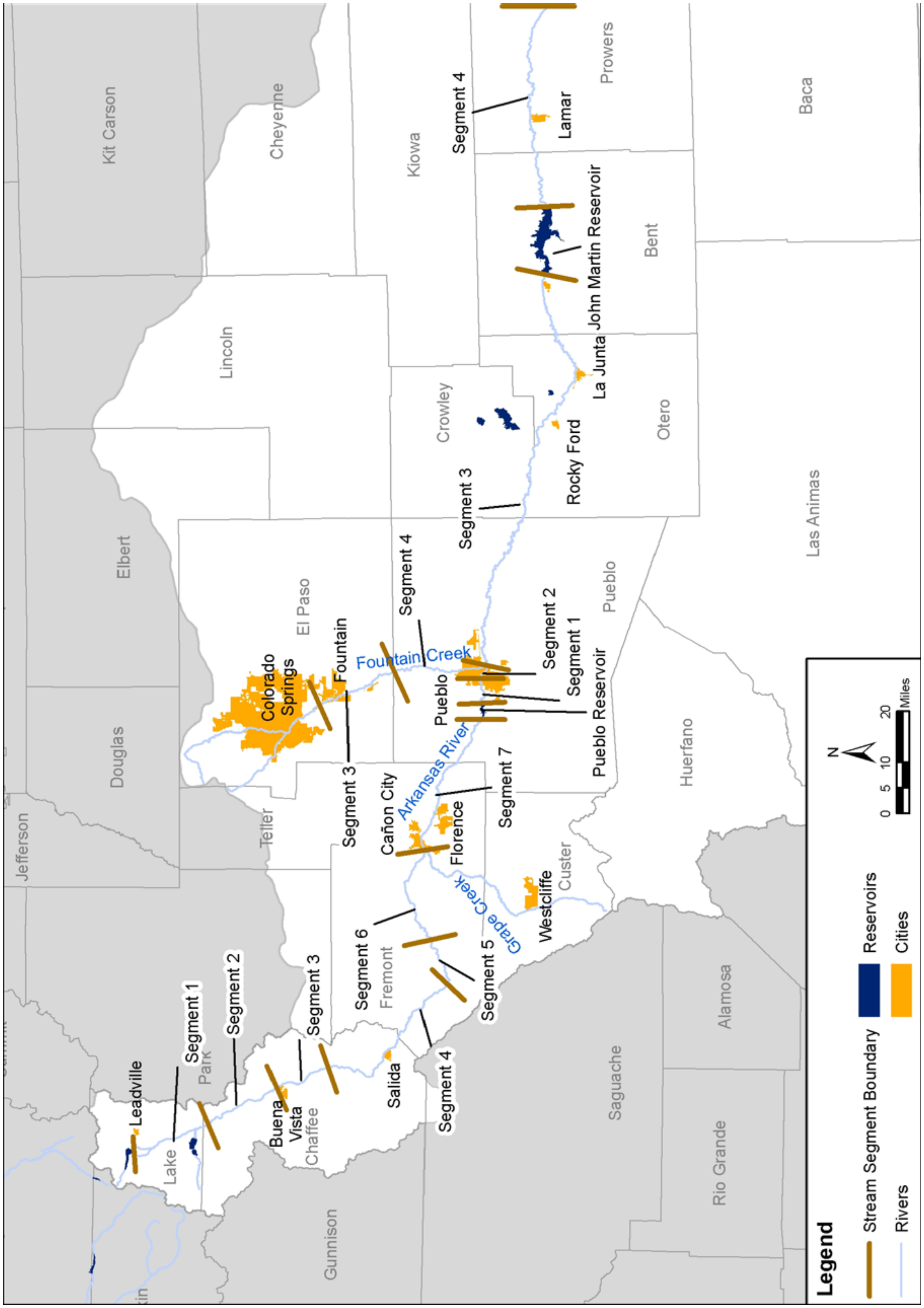


Figure 4–51. Aquatic Life Analysis Area and PHABSIM Stream Segments

Table 4–27. Summary of PHABSIM Modeling for Streams in the Analysis Area.

<table>
<tr><th>Stream Segment</th><th>Species Simulated</th><th>Life Stages Simulated</th><th>Basis for Selection</th></tr>
<tr><td colspan="4">Upper Arkansas River</td></tr>
<tr><td>Segment 1 –
Lake Fork to Granite</td><td rowspan="6">Brown and rainbow trout</td><td rowspan="3">Brown trout
• Adult
• Spawning
• Fry
• Juvenile</td><td rowspan="3">Brown trout are the dominant, self-sustaining, resident species, with all life stages present.</td></tr>
<tr><td>Segment 2 –
Granite to Buena Vista</td></tr>
<tr><td>Segment 3 –
Buena Vista through Browns Canyon</td></tr>
<tr><td>Segment 4 –
Browns Canyon to Coaldale</td><td rowspan="3">Rainbow trout
• Adult
• Spawning
• Fry
• Juvenile</td><td rowspan="3">Rainbow trout are stocked as juveniles or adults, and are not self-sustaining; the spawning and fry life stages are not present.</td></tr>
<tr><td>Segment 5 –
Coaldale to Texas Creek</td></tr>
<tr><td>Segment 6 –
Texas Creek to Cañon City</td></tr>
<tr><td>Segment 7 –
Cañon City to Pueblo Reservoir</td><td colspan="3">No PHABSIM Habitat Simulation Available</td></tr>
<tr><td colspan="4">Lower Arkansas River</td></tr>
<tr><td>Segment 1 –
Pueblo Reservoir to Wildhorse Creek</td><td>Brown and rainbow trout</td><td>Brown trout
• Adult
• Juvenile
Rainbow trout
• Adult</td><td>Brown and rainbow trout are recreationally important species stocked as juveniles and/or adults, and are not self-sustaining; other life stages are not present.</td></tr>
<tr><td>Segment 2 –
Wildhorse Creek to Fountain Creek</td><td colspan="3">No PHABSIM Habitat Simulation Available</td></tr>
<tr><td rowspan="4">Segment 3 –
Fountain Creek to John Martin Reservoir</td><td rowspan="4">Red shiner, sand shiner, plains killifish, flathead chub, white sucker, and channel catfish</td><td>Red shiner, sand shiner, plains killifish
• Adult</td><td rowspan="4">These species and life stages are present in the Arkansas River, have PHABSIM habitat relationships, and represent the habitat requirements for much of the fish community in this segment.</td></tr>
<tr><td>White sucker
• Adult/juvenile
• Spawning
• Fry</td></tr>
<tr><td>Flathead chub
• Adult/juvenile
• Spawning
• Fry</td></tr>
<tr><td>Channel catfish
• Juvenile/fry</td></tr>
<tr><td>Segment 4 –
John Martin Reservoir to Kansas State Line</td><td colspan="3">No PHABSIM Habitat Simulation Available</td></tr>
<tr><td colspan="4">Fountain Creek</td></tr>
<tr><td>Segment 3 –
Security to County Line</td><td rowspan="2">Red shiner, sand shiner, flathead chub, and white sucker</td><td>Red and sand shiner
• Adult</td><td rowspan="2">These species and life stages are present in the Arkansas River, have PHABSIM habitat relationships, and represent the habitat requirements for much of the fish community in this segment.</td></tr>
<tr><td>Segment 4 –
County Line to Arkansas River</td><td>Flathead chub and white sucker
• Adult
• Spawning
• Juvenile/Fry</td></tr>
</table>

PHABSIM simulates habitat availability for distinct segments of stream (Table 4–27; Figure 4–51). In Arkansas River coldwater sections, habitat was simulated for several life stages of brown and rainbow trout, the two more important species managed for recreational fishing (Table 4–27). In Arkansas River warmwater segments, habitat was modeled for sand shiner, red shiner, flathead chub, white sucker, channel catfish, and plains killifish (Table 4–27). These species are all native and present in the Arkansas River, and represent habitat requirements for much of the fish community in this segment. In Fountain Creek, habitat for sand shiner, red shiner, flathead chub, and white sucker was simulated (Table 4–27). These four species are native to Fountain Creek and generally represent habitat requirements for much of the fish community in Fountain Creek.

> **Weighted Usable Area (WUA)** refers to habitat availability and is expressed as ft^2/1,000 ft of stream.
>
> Two Habitat Metrics were used for evaluation in this EIS:
>
> **Minimum Weighted Usable Area (WUA)** focuses on the critically low habitat levels that seasonally occur during the year, which can act as a bottleneck to population size.
>
> **Median Weighted Usable Area (WUA)** focuses on overall habitat availability throughout the year.

Habitat availability was not simulated for three stream segments in the analysis area as no PHABSIM habitat relationships were available (Table 4–27). Habitat relationships were not developed for these three segments because they are largely inaccessible (Upper Arkansas River Segment 7), are short with degraded habitat (Lower Arkansas River Segment 2), or would have minimal changes in flow (Lower Arkansas River Segment 4), and were not identified as needing supplemental habitat information during agency scoping. These segments are all adjacent to modeled segments, and the habitat relationships in the adjacent segments were used to help evaluate effects of alternatives.

Habitat was simulated for normal (2005), wet (1997), and dry (2004) years using daily streamflow output from the Daily Model (Chapter 4 – Surface Water Hydrology). Fish populations are generally influenced by extremes in flow and habitat conditions, which can act as bottlenecks to limit population size. The focus of the effects analysis was to evaluate changes in minimum and median habitat availability for each species and life stage for each year type (normal, wet, or dry). Also, Colorado Parks and Wildlife has identified the pre- and post-runoff periods as particularly important for trout in the Upper Arkansas River.

Relationships between flow changes and changes to macroinvertebrate communities are difficult to quantify. Macroinvertebrate communities usually contain several dozen species with a wide range of habitat preferences, making modeling (such as with PHABSIM) difficult. There can be both beneficial and adverse changes to macroinvertebrates from changes in flow (Dewson et al. 2007). Effects on macroinvertebrates were evaluated using professional judgment based on the best available scientific information.

Suitability of a stream to support aquatic life is also influenced by other aspects of a stream. Flooding, channel geomorphology, sediment transport, water quality, and riparian vegetation influence fish and invertebrate habitat suitability. Results of these resource analyses were incorporated into the aquatic life effects evaluation using professional judgment. Some direct and cumulative effects on water quality were identified in Chapter 4 – Water Quality and were incorporated into the effects evaluation for aquatic life, when appropriate.

Criteria for Determining Significance of Effects

Effects on aquatic life could be beneficial or adverse and range from negligible to major (Table 4–28). Potential effects on aquatic life were evaluated for each action alternative compared to the No Action Alternative. Differences in Weighted Usable Area parameters of less than 10 percent would be unlikely to cause adverse or beneficial effects on aquatic biota. Natural variability in hydrologic and biological data renders a change of less than 10 percent undetectable. If a difference in Weighted Usable Area metrics was more than 10 percent, the change was graded according to professional judgment. The intensity of effects on aquatic life was evaluated for each stream segment and reservoir given PHABSIM output, hydrology, storage contents, other resources, and status of the existing environment, as described in detail in Appendix H. For the PHABSIM output and hydrology, daily, monthly, normal, wet, and dry year types, as well as overall annual and monthly changes were considered. As a result, changes in some individual days, months, or individual year types may warrant a greater or lesser effect intensity designation than the effect based solely on the overall average.

Table 4–28. Aquatic Life Effect and Intensity Description

Effect Intensity	Intensity Description
Negligible	Changes in fish habitat availability and hydrologic parameters from the alternative would be mostly less than 10 percent. The alternative would cause a slight change to a fish and benthic macroinvertebrate community, but the change would be unmeasurable or of imperceptible consequence, and would be well within natural variability.
Minor	Changes in fish habitat availability and hydrologic parameters from the alternative would be more than 10 percent. The alternative would cause a change to a fish and benthic macroinvertebrate community. The change would be measurable, but small and not outside the range of natural variability. There would be no change in species composition for fish and little change in species composition for benthic macroinvertebrates.
Moderate	Effects on fish and benthic macroinvertebrates abundance, habitat, or the natural processes sustaining them would be detectable and readily apparent and sometimes out of the historical range of natural variability. In coldwater streams and reservoirs, there likely would be no change in fish species composition. In warmwater streams and reservoirs, there likely would be changes in the number of less common fish species. For benthic macroinvertebrates, there would be changes in the number of species.
Major	The alternative would cause a substantial and readily apparent effect on abundance and species composition of fish and benthic macroinvertebrate communities outside the range of natural variability.

Results

The direct, indirect, and cumulative effects of alternatives on aquatic life are compared in this section for various geographic locations.

Direct and Indirect Effects

Direct effects would be short-term and limited to disturbances of short stream segments during construction. Most effects on aquatic life would be indirect and long-term, through changes in streamflow or reservoir operation, or suitability of streams to support aquatic life.

Upper Arkansas River Basin – Arkansas River Segments 1 through 7, Lake Fork, Lake Creek, and Grape Creek The No Action Alternative would result in similar streamflow (Appendix D.4) and habitat availability (Appendix H.3) in the Upper Arkansas River Basin as existing conditions, and would not adversely affect aquatic life. Fish habitat availability would change by less than 10 percent for most species, life stages, and year types for the No Action Alternative compared to existing conditions. In Grape Creek, increases in flow during summer months for the No Action Alternative compared to existing conditions would be beneficial to aquatic life.

Effects on aquatic life in the Upper Arkansas River Basin would be negligible for all alternatives compared to No Action as a result of minimal changes to habitat availability, water quality, geomorphology, and riparian vegetation. The average percent increase or decrease in minimum and median habitat availability for all life stages of brown trout and rainbow trout for Upper Arkansas River Segments 1 through 6 was within 2 percent (Appendix H.3). Changes would also be minimal to habitat availability on a daily basis (Appendix H.3), including during the important pre- and post-runoff periods identified by Colorado Parks and Wildlife. No PHABSIM relationships are available for Segment 7; however, evaluation of daily streamflow data for the alternatives at the Arkansas River at Portland gage indicates similar streamflow among alternatives and changes to streamflow similar to upstream segments. For macroinvertebrates, the minimal changes to hydrology indicate that the area of the stream bottom (wetted perimeter) available to support these species would not change substantially with the alternatives. The negligible effects to water quality and geomorphology indicate that these components would not affect the suitability of the streams to support macroinvertebrates.

Changes to daily streamflow would be minimal in the Upper Arkansas River Basin in most stream segments for most days (Appendix H). Larger decreases in daily flows would occur, but these decreases would be short in duration and similar to low flows observed during the pre-runoff period.

All alternatives would cause negligible effects on Grape Creek aquatic life compared to the No Action Alternative. Streamflow effects on Grape Creek from agricultural dry-up associated with the alternatives would be negligible (see Chapter 4 – *Surface Water Hydrology* section). No change in hydrology would occur between the alternatives and No Action, as all alternatives, including the No Action, simulate the transfer of water from the agricultural dry-up.

Lower Arkansas River Basin – Segment 1, Pueblo Reservoir to Wildhorse Creek
Streamflow changes for the No Action Alternative compared to existing conditions in the Lower Arkansas River downstream from Pueblo Reservoir generally would change trout habitat availability less than 10 percent (Appendix H.3) and would not adversely affect aquatic life. In several cases, minimum habitat availability would decrease by more than 10 percent for brown trout, but for only a few days during the winter (Appendix H.3).

Changes to streamflow, habitat availability, and water quality in this stream segment would cause negligible effects on aquatic life for all alternatives. Changes to average monthly streamflow in the Lower Arkansas River Segment 1 for the alternatives compared to the No Action Alternative would be negligible to minor, with minor effects occurring especially between

August and March (Chapter 4 – *Surface Water Hydrology*). Moderate effects to hydrology (reductions in flow greater than 10 percent) were simulated by the Daily Model in January and March of normal years and February through April of dry years for most alternatives. In dry years, flows of approximately 50 cfs during the typical low flow period in early March would be extended from just a few days to more than a week (Appendix H.5, Figure 45) but the single-day minimum flow during this period would change by less than 3 cfs for most alternatives, resulting in similar minimum amounts of habitat availability.

The effects on fish habitat availability in Lower Arkansas River Segment 1 would vary depending on the species, life stage, and year type assessed. Percent changes in brown trout minimum and median habitat availability would be greatest during normal years with increases in minimum adult and juvenile habitat availability between 3 percent and 28 percent, and decreases in median adult habitat availability between 4 percent and 9 percent (Table 4–29). However, for most of the year, changes in habitat availability among the alternatives would be small (Figure 4–52). Changes to habitat availability for brown trout would also be small in dry and wet years (Appendix H.3). Rainbow trout minimum and median adult habitat availability would vary less than 1 percent for all alternatives and year types (Table 4–29, Appendix H.3). Similar to the habitat availability for fish, minimum habitat availability for macroinvertebrates is not expected to change substantially. The low flow period likely represents the minimum amount of stream bottom to support macroinvertebrates. Although the length of the minimum flow period would be extended for a few more days, the absolute minimum flow would not change and there likely would be no change in the minimum habitat on the stream bottom for macroinvertebrates.

All alternatives except River South and Master Contract Only would cause negligible to minor adverse effects on water quality through Pueblo (see Chapter 4 – *Water Quality*), with occasional moderate effects in dry years as a result of increases in total dissolved solids and selenium in this stream segment. These effects would not cause additional violations of standards, would occur infrequently, and would not likely affect aquatic life in this segment. The fish and macroinvertebrate communities in this segment of the river are not sensitive to total dissolved solids and selenium in the range present in the river. Many macroinvertebrate species present in this river segment tolerate much higher levels of total dissolved solids (EPA 2011).

Table 4–29. Normal Year Effects on Habitat Availability in Segment 1 of Lower Arkansas River

Species/Life Stage	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Minimum Habitat Availability (WUA in ft^2/1,000 feet)							
Brown trout adult	12,334	14,203	14,221	15,832	14,048	15,156	12,653
Brown trout juvenile	18,517	21,324	21,351	23,769	21,092	22,755	18,997
Rainbow trout adult	7,852	7,840	7,809	7,813	7,818	7,902	7,853
Increase (+) or Decrease (-) in Minimum Habitat Availability (%) Compared to No Action Alternative							
Brown trout adult	--	+15	+15	+28	+14	+23	+3
Brown trout juvenile	--	+15	+15	+28	+14	+23	+3
Rainbow trout adult	--	-<1	-<1	-<1	-<1	+<1	+<1
Median Habitat Availability (WUA in ft^2/1,000 feet)							
Brown trout adult	31,238	28,475	28,721	30,031	28,779	29,746	29,798
Brown trout juvenile	33,768	33,227	33,264	33,278	33,214	33,818	33,667
Rainbow trout adult	13,844	13,855	13,855	13,848	13,854	13,844	13,848
Increase (+) or Decrease (-) in Median Habitat Availability (%) Compared to No Action Alternative							
Brown trout adult	--	-9	-8	-4	-8	-5	-5
Brown trout juvenile	--	-2	-1	-1	-2	+<1	-<1
Rainbow trout adult	--	+<1	+<1	+<1	+<1	-<1	+<1

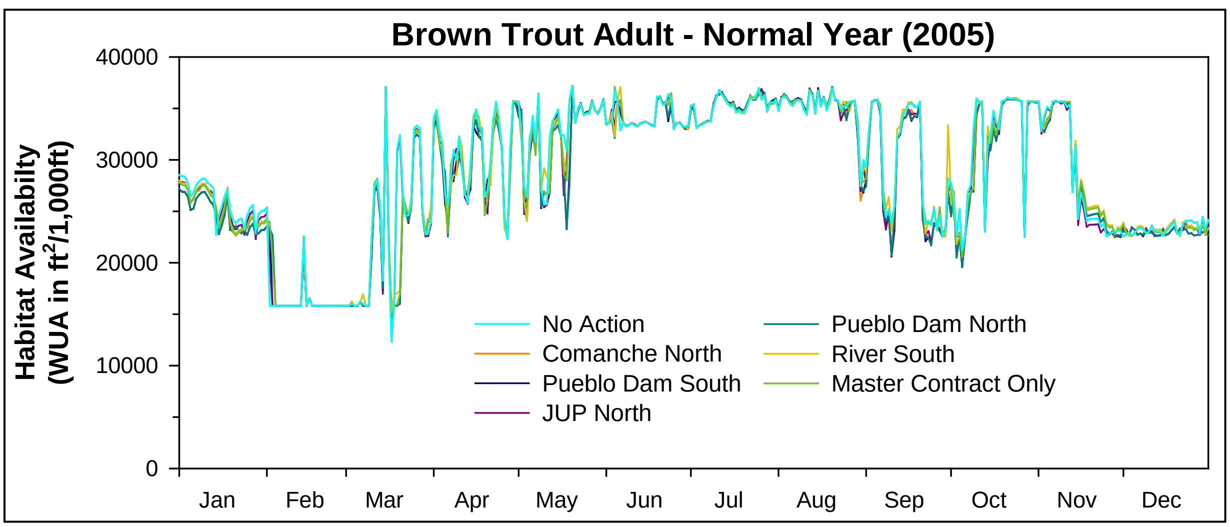


Figure 4–52. Normal Year Brown Trout Adult Habitat Availability in Lower Arkansas River Segment 1

Lower Arkansas River Basin – Segment 2, Wildhorse Creek to Fountain Creek The 2 additional low flow days (<10 cfs) during dry years for the No Action Alternative compared to existing conditions would not adversely affect aquatic life. All alternatives would negligibly affect aquatic life in this stream segment compared to the No Action Alternative. Habitat availability was not simulated in Lower Arkansas Segment 2 because habitat availability versus flow relationships were not available for this short channelized segment of river. Sufficient flows would be needed to support the predominately warmwater fish and macroinvertebrate communities present in this segment. All alternatives would cause 1 additional low flow day (<10 cfs) compared to the No Action Alternative in either normal (from 1 to 2 days) or dry years (from 3 to 4 days). Adding one low flow day in this segment, which is already dewatered for 1 day in normal and dry years for the existing conditions simulation, would likely result in negligible effects for all alternatives compared to the No Action Alternative.

Lower Arkansas River Basin – Segment 3, Fountain Creek to John Martin Reservoir Streamflow changes for the No Action Alternative compared to existing conditions downstream from Fountain Creek generally would change fish habitat availability less than 10 percent for most species (Appendix H.3). Effects on aquatic life from changes in hydrology, water quality, and habitat availability for most species, life stages, and year types would be negligible for all alternatives compared to No Action. Increases or decreases in minimum and median fish habitat availability in Segment 3 of the Lower Arkansas River would generally be less than 5 percent, and would often be less than 1 percent in normal (Table 4–30), wet, and dry years (Appendix H.3).

Lower Arkansas River Basin – Segment 4, John Martin Reservoir to Kansas State Line Changes to mean monthly streamflow for the No Action Alternative compared to existing conditions would be minimal during normal, wet, and dry years, except small increases in flow during August and September of normal years (Appendix D.5). These changes would not adversely affect aquatic life.

Effects on aquatic life in the Arkansas River downstream from John Martin Reservoir would be negligible for all alternatives compared to No Action. Changes in average monthly streamflow at the Arkansas River near Granada gage would be less than 5 percent (negligible to minor) for all alternatives (see Chapter 4 – *Surface Water Hydrology*). These changes in streamflow would cause negligible changes in habitat availability for aquatic life.

Fountain Creek – Segments 3 and 4, Security Gage to Arkansas River Increases in habitat availability from changes to streamflow would be beneficial to aquatic life in Fountain Creek for the No Action Alternative compared to existing conditions. Minimum habitat availability would increase up to 37 percent for several species and life stages during normal and wet years in Fountain Creek for the No Action Alternative compared to existing conditions (Appendix H.3). Increases in fish and macroinvertebrate habitat availability would largely be associated with short-term increases in streamflow during low flow days.

All alternatives would result in negligible effects on aquatic life in Fountain Creek compared to the No Action Alternative. Changes in minimum habitat availability for all fish species and life stages would vary from a decrease of less than 1 percent to an increase of 7 percent compared to the No Action Alternative (Appendix H.3). Changes in median habitat availability for all species and life stages would vary from a 3 percent decrease to a 14 percent increase (Appendix H.3). The percent changes would be greatest for white suckers in Segment 4 (Table 4–31); however, these increases were the result of changes in low amounts of habitat availability (Appendix H.3).

Table 4–30. Normal Year Effects on Habitat Availability in Segment 3 of Lower Arkansas River

Species/Life Stage	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Minimum Habitat Availability (WUA in ft²/1,000 feet)							
Sucker adult/juvenile	234	235	235	237	240	227	233
Sucker spawning	2,196	2,204	2,204	2,198	2,205	2,203	2,197
Sucker fry	2,260	2,233	2,233	2,260	2,255	2,201	2,226
Sand shiner	3,021	3,027	3,026	3,021	3,027	3,030	3,021
Red shiner	2,247	2,247	2,247	2,247	2,247	2,247	2,247
Plains killifish	834	834	834	834	834	833	833
Channel catfish	1,637	1,608	1,608	1,628	1,607	1,609	1,614
Flathead chub	2,441	2,443	2,443	2,441	2,443	2,443	2,441
Increase (+) or Decrease (-) in Minimum Habitat Availability (%) Compared to No Action Alternative							
Sucker adult/juvenile	--	+<1	+<1	+1	+3	-3	-<1
Sucker spawning	--	+<1	+<1	+<1	+<1	+<1	+<1
Sucker fry	--	-1	-1	+<1	-<1	-3	-2
Sand shiner	--	+<1	+<1	-<1	+<1	+<1	-<1
Red shiner	--	+<1	+<1	+<1	+<1	+<1	+<1
Plains killifish	--	+<1	+<1	-<1	+<1	-<1	-<1
Channel catfish	--	-2	-2	-<1	-2	-2	-1
Flathead chub	--	+<1	+<1	+<1	+<1	+<1	+<1
Median Habitat Availability (WUA in ft²/1,000 feet)							
Sucker adult/juvenile	1,185	1,142	1,119	1,170	1,140	1,124	1,142
Sucker spawning	19,377	19,770	19,804	19,272	19,952	19,728	19,647
Sucker fry	5,260	5,338	5,342	5,350	5,348	5,362	5,280
Sand shiner	17,262	17,433	17,531	17,312	17,441	17,507	17,430
Red shiner	5,416	5,427	5,427	5,425	5,433	5,423	5,427
Plains killifish	2,897	2,899	2,897	2,888	2,900	2,906	2,890
Channel catfish	5,649	5,655	5,666	5,622	5,668	5,617	5,668
Flathead chub	25,886	26,258	26,463	26,003	26,273	26,413	26,251
Increase (+) or Decrease (-) in Median Habitat Availability (%) Compared to No Action Alternative							
Sucker adult/juvenile	--	-4	-6	-1	-4	-5	-4
Sucker spawning	--	+2	+2	-<1	+3	+2	+1
Sucker fry	--	+1	+2	+2	+2	+2	+<1
Sand shiner	--	+<1	+2	+<1	+1	+1	+<1
Red shiner	--	+<1	+<1	+<1	+<1	+<1	+<1
Plains killifish	--	+<1	+<1	-<1	+<1	+<1	-<1
Channel catfish	--	+<1	+<1	-<1	+<1	-<1	+<1
Flathead chub	--	+1	+2	+<1	+1	+2	+1

Table 4–31. Normal Year Effects on Habitat Availability in Segment 4 of Fountain Creek

Species/Life Stage	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Minimum Habitat Availability (WUA in ft^2/1,000 feet)							
Sucker adult/juvenile	0	0	0	0	0	0	0
Sucker spawning	27,379	27,362	27,362	27,379	27,362	27,362	27,362
Sucker fry	226	227	227	226	227	227	227
Sand shiner	3,846	3,869	3,869	3,846	3,859	3,864	3,864
Red shiner	485	488	488	485	487	488	488
F. chub adult/juvenile	3,989	4,013	4,013	3,989	4,004	4,008	4,008
F. chub spawning	1,576	1,574	1,573	1,576	1,574	1,574	1,574
F. chub fry	6,697	6,737	6,737	6,697	6,721	6,729	6,729
Increase (+) or Decrease (-) in Minimum Habitat Availability (%) Compared to No Action Alternative							
Sucker adult/juvenile	--	+<1	+<1	0	+<1	+<1	+<1
Sucker spawning	--	-<1	-<1	0	-<1	-<1	-<1
Sucker fry	--	+<1	+<1	0	+<1	+<1	+<1
Sand shiner	--	+<1	+<1	0	+<1	+<1	+<1
Red shiner	--	+<1	+<1	0	+<1	+<1	+<1
F. chub adult/juvenile	--	+<1	+<1	0	+<1	+<1	+<1
F. chub spawning	--	-<1	-<1	0	-<1	-<1	-<1
F. chub fry	--	+<1	+<1	0	+<1	+<1	+<1
Median Habitat Availability (WUA in ft^2/1,000 feet)							
Sucker adult/juvenile	44	47	48	44	47	48	48
Sucker spawning	36,147	34,978	34,954	36,147	34,982	34,986	34,985
Sucker fry	1,326	1,328	1,328	1,326	1,328	1,328	1,328
Sand shiner	24,963	24,730	24,730	24,963	24,730	24,730	24,731
Red shiner	3,408	3,399	3,399	3,408	3,399	3,399	3,399
F. chub adult/juvenile	62,174	62,935	62,967	62,174	62,933	62,965	62,964
F. chub spawning	8,113	8,020	8,005	8,113	8,006	8,006	8,000
F. chub fry	42,805	42,817	42,817	42,805	42,813	42,815	42,815
Increase (+) or Decrease (-) in Median Habitat Availability (%) Compared to No Action Alternative							
Sucker adult/juvenile	--	+7	+8	+<1	+7	+8	+8
Sucker spawning	--	-3	-3	0	-3	-3	-3
Sucker fry	--	+<1	+<1	0	+<1	+<1	+<1
Sand shiner	--	-<1	-<1	0	-<1	-<1	-<1
Red shiner	--	-<1	-<1	0	-<1	-<1	-<1
F. chub adult/juvenile	--	+1	+1	0	+1	+1	+1
F. chub spawning	--	-1	-1	0	-1	-1	-1
F. chub fry	--	+<1	+<1	0	+<1	+<1	+<1

Key: F. = Flathead

Reservoirs Reservoirs evaluated for effects on aquatic life include Turquoise Lake, Twin Lakes, Pueblo Reservoir, Lake Meredith, Lake Henry, Holbrook Reservoir, and John Martin Reservoir.

Turquoise Lake and Twin Lakes Changes in storage contents, elevation, and surface area for the No Action Alternative compared to existing conditions would be minimal for Turquoise Lake and Twin Lakes (Appendix D.4), and these changes would not adversely affect aquatic life for these two reservoirs. Effects on aquatic life in Turquoise Lake and Twin Lakes would be negligible for all alternatives compared to the No Action Alternative based on negligible changes in storage contents, reservoir elevation, and surface area. Changes in mean monthly storage contents, elevation, and surface area for all alternatives compared to the No Action Alternative for Turquoise Lake and Twin Lakes would be negligible.

Pueblo Reservoir Aquatic life in Pueblo Reservoir would not be adversely affected in the No Action Alternative compared to existing conditions. The No Action Alternative would cause slightly lower storage contents, elevation, and surface area in Pueblo Reservoir than under existing conditions, with mean monthly storage changes usually between 2 and 6 percent.

Changes in storage contents, elevation, and surface area in Pueblo Reservoir would result in negligible effects on aquatic life for all alternatives except JUP North. The changes in the storage contents, elevation, and surface area for the JUP-North Alternative would result in moderate adverse effects on aquatic life in Pueblo Reservoir. The percent decrease in overall mean monthly storage, elevation, and surface area for the JUP North Alternative would be up to 10 percent. The decreases in storage during average and dry years for the JUP North Alternative would range from 19 to 27 percent throughout the year with smaller decreases in elevation and surface area. The decrease in storage contents, elevation, and surface area would occur throughout the year, which would decrease spawning fish habitat and overall fish habitat for survival and growth. Changes to water quality constituents would be negligible to minor for all alternatives and would not affect aquatic life.

Lake Meredith and Lake Henry Habitat availability in Lake Meredith would decrease under the No Action Alternative compared to existing conditions. Changes in mean monthly storage contents for Lake Meredith would be greatest in dry years, decreasing for the No Action Alternative compared to existing conditions by 10 to 12 percent during July through November with associated reductions in elevation up to 8 percent and in surface area up to 6 percent. This decrease in storage, elevation, and surface area for the No Action Alternative would not substantially affect aquatic resources compared to existing conditions. Changes in mean monthly storage, elevation, and surface area for Lake Henry would be less than 10 percent for the No Action Alternative compared to existing conditions, and would not adversely affect aquatic life.

Negligible to minor changes in Lake Meredith and Lake Henry storage contents, elevation, surface area, and water quality would negligibly affect aquatic life in these reservoirs. The greatest difference would occur in all alternatives except JUP North, and would be a 3 percent decrease in overall storage during November for Lake Meredith and about a 5 percent decrease in overall storage in November and December for Lake Henry. The greatest differences from the

No Action Alternative in the overall mean monthly elevation and surface area would be less than the historical observed changes in storage. Lake Meredith and Lake Henry would experience minor adverse effects on water quality from increases in total dissolved solids and selenium concentrations for all alternatives, and would cause negligible to minor effects on aquatic life.

Holbrook Reservoir   The No Action Alternative compared to existing conditions would decrease storage, elevation, and surface area from May through December of normal years in Holbrook Reservoir, and would decrease habitat availability. Decreases in mean monthly storage contents during normal years from May through December ranged from 31 to 83 percent for the No Action Alternative compared to existing conditions. Changes to storage contents would result in both increases and decreases of habitat in dry years, habitat changes would be minimal in wet years. Percent changes in mean monthly elevation and surface area were similar to the percent changes in the mean monthly storage contents, but were smaller in magnitude.

All alternatives, except the JUP North Alternative would result in moderate adverse effects to aquatic resources in Holbrook Reservoir, as a result of decreases in storage, elevation, and surface area up to 67 percent from June through November during normal and dry years, compared to the No Action Alternative (Appendix H.3). Effects to aquatic resources from the JUP North Alternative would be negligible as a result of the small changes to storage contents, elevation, and surface area.

John Martin Reservoir   Increases in storage in John Martin Reservoir for the No Action Alternative compared to existing conditions would result in beneficial effects on aquatic life as the increased storage would likely increase habitat for spawning fish and overall fish habitat for survival and growth. Compared to existing conditions, the No Action Alternative would increase storage in John Martin Reservoir during all months for each year type (Appendix D.5). Increases in mean monthly storage would be up to 23 percent in normal years and up to 36 percent in dry years (Appendix D.5).

All alternatives would negligibly affect aquatic life in John Martin Reservoir. Changes in storage contents of John Martin Reservoir would be negligible to minor increases, depending on year type and alternative. Overall changes in monthly storage contents of John Martin Reservoir would be less than or equal to 2.1 percent.

Nuisance Species   One nuisance species, didymo, is not currently found in the waters of the study area and is not expected to be introduced by project activities. Whirling disease is currently present throughout the study area and the project would have no effect on its distribution. Similarly, Asiatic clams are currently present in Pueblo Reservoir and in the lower Arkansas River and New Zealand mud snails are currently present in Fountain creek; the project would have no effect on the distribution of these species.

Zebra and Quagga mussels have been detected in Pueblo Reservoir but have not established extensive populations, possibly due to water quality factors in the reservoir (Claudi and Prescott 2009). The project is not expected to appreciably change water quality conditions in the reservoir and it is likely that the project would have no effect on the establishment of these mussels. If these mussels become established in the future, they may enter the water distribution system associated with the project and could require additional maintenance.

Cumulative Effects

Cumulative changes in hydrology compared to the No Action Alternative would result in negligible effects on aquatic life for all alternatives in the Upper Arkansas River, similar to direct effects. Cumulative streamflow effects would generally be negligible in the Upper Arkansas River Basin, and would generally result in negligible changes in habitat availability.

Climate change may decrease spring runoff flows, cause earlier runoff, and earlier low flows in summer and fall. In the Upper Arkansas River, the decreased spring runoff flows could have short-term benefits to habitat availability for trout, but could have long-term adverse effects on the timing of biological processes in the spring, to channel shape and stability, and to sediment transport that could make the river less suitable to support fish. Decreased summer and fall flows could increase or decrease habitat availability, depending on the timing of the decreased flows and the species and life stages of fish. In the Lower Arkansas River and in Fountain Creek, cumulative effects may be negligible since high flows are related more to storm events than to snowmelt runoff.

Cumulative streamflow changes in Lower Arkansas River Segment 1 would cause negligible cumulative effects on aquatic life for all alternatives, similar to direct effects. Cumulative effects of the alternatives would generally result in little change to habitat availability compared to the No Action Alternative for both brown trout and rainbow trout in Lower Arkansas River Segment 1. The only changes in minimum or median habitat availability greater than 10 percent would occur for adult and juvenile brown trout where a 22 percent increase in minimum habitat availability is simulated for all alternatives except the JUP North Alternative during normal years and a 14 percent increase in minimum habitat availability for brown trout adults is simulated for the Master Contract Only Alternative in wet years

Cumulative aquatic life adverse effects caused by changes in streamflow in Lower Arkansas River Segment 2 would be negligible for all alternatives except River South, where streamflow changes would have a minor effect. Streamflow changes would include an additional day of low flows for all alternatives, except the River South Alternative, which would have 5 additional low flow days during dry years and 1 additional low flow day during normal years. Additional low flows are typically caused by decreases in augmentation requirements between the No Action and action alternatives.

All alternatives would result in negligible cumulative effects on aquatic life in Lower Arkansas River Segment 3. Cumulative effects on minimum and median fish habitat availability would be similar to the direct and indirect effects and generally less than 5 percent. Cumulative effects on water quality would be negligible for this stream segment.

Cumulative effects on aquatic life in Lower Arkansas River Segment 4 (downstream from John Martin Reservoir) would be negligible for all alternatives. Mean monthly cumulative changes in streamflow at the Arkansas River near Granada gage would be less than 5 percent for all alternatives and year types, except during normal years in September, when a decrease of 1 to 2 cfs would results in a 5 to 11 percent decrease in flow.

The Comanche North, Pueblo Dam South, and Pueblo Dam North alternatives would reduce median habitat for both white sucker fry and spawning flathead chub in Fountain Creek, which would be a minor adverse cumulative effect. Cumulative effects of remaining alternatives would be negligible. Minimum and median habitat availability would vary by less than 1 percent for red shiners and sand shiners for all alternatives and year types; however, the cumulative effect of the alternatives would cause substantial variation in habitat availability for white sucker and flathead chub. While minimum habitat would increase 15 percent for white sucker and flathead chub adults for most alternatives, these increases would result from very low levels of habitat for white suckers (0.4 ft^2/1,000 feet) and an increase in flow from 20 to 23 cfs on only 1 day of the year for flathead chubs. Reductions in median habitat availability for white sucker fry would be between 15 and 23 percent for all alternatives except River South and Master Contract Only for Segment 4 during normal years, in part from increases in flow in spring and reductions in fall flows (Appendix H.3). Reductions of Segment 4 median flathead chub spawning habitat availability in wet years of 7, 6, and 16 percent would occur for the Comanche North, Pueblo Dam South, and Pueblo Dam North alternatives, respectively because of increases in streamflow (Appendix H.3).

In the Lower Arkansas River and Fountain Creek, cumulative effects associated with climate change would most likely be negligible as high flows are related more to storm events than to snowmelt runoff.

The negligible to minor changes in storage content levels, elevation, and surface area would cause negligible cumulative effects on aquatic life in Turquoise Lake and Twin Lakes, similar to direct effects. The cumulative storage contents, elevation, and surface area effects of the JUP North Alternative would cause minor adverse effects on aquatic life in Pueblo Reservoir, similar to direct effects. Cumulative effects of all other alternatives would be negligible.

Cumulative effects on aquatic life in Lake Meredith and Lake Henry would be negligible for all alternatives, similar to direct effects. Cumulative effects on mean monthly storage contents, elevation, and surface area of Lake Meredith and Lake Henry would be similar to direct effects and would be negligible to minor. Cumulative effects on water quality would be similar to the direct and indirect effects on water quality. Cumulative effects on aquatic life in Holbrook Reservoir would be negligible for all alternatives compare to the No Action Alternative, as a result of the typically negligible effects to changes in storage contents, elevation, and surface area of Holbrook Reservoir. Cumulative effects on monthly average storage contents of John Martin Reservoir would negligibly affect aquatic life for all alternatives.

Mitigation Measures

To mitigate occasional moderate streamflow and minor aquatic life effects during low-flow periods in the Arkansas River directly below Pueblo Dam, Reclamation would limit excess capacity contract operations when streamflow is less than 50 cfs, as measured by adding streamflow at the Arkansas River above Pueblo gage to fish hatchery return flows from the current hatchery discharge point.

Reclamation would provide coordination assistance with participants in managing storage and water releases in a manner that could assist in augmenting low streamflows in the Arkansas

River downstream from Pueblo Reservoir to the Fountain Creek confluence. Reclamation will not modify operations that would impact Fry-Ark Project yield.

Reclamation would provide $50,000 for habitat improvements downstream from Pueblo Reservoir to mitigate moderate streamflow effects and minor aquatic life effects of an action alternative during low-flow periods in the Arkansas River. Design and location of improvements would be coordinated between Reclamation and Colorado Parks and Wildlife after a Record of Decision has been signed, including site-specific NEPA compliance.

To mitigate moderate reservoir effects in the Lower Arkansas River Basin on aquatic life, the United States would approve expansion of the Pueblo Fish Hatchery near the existing Pueblo Fish Hatchery, if requested and deemed feasible by Colorado Parks and Wildlife, in conjunction with mitigation requirements set forth in the SDS EIS and Fish and Wildlife Mitigation Plan. Hatchery expansion would occur through a mutually acceptable agreement between Colorado Parks and Wildlife and Reclamation, and the location of the expansion and site-specific NEPA compliance would be coordinated between Reclamation and Colorado Parks and Wildlife after a Record of Decision has been signed. The state would be responsible for construction, operation, and maintenance of fish production ponds and associated facilities. This includes providing all water necessary for these ponds, including, but not limited to, water for filling the ponds, and augmenting evaporation from the ponds, in accordance with Colorado state law.

If the JUP North Alternative is selected as the preferred alternative in the Record of Decision, Reclamation and participants would negotiate mitigation for moderate adverse effects to Pueblo Reservoir fisheries, which could include restocking aquatic species at Pueblo Reservoir following times of decline in storage contents.

Recreation

This section describes the alternatives' effects on recreation. Recreation resources primarily include boating and fishing, waterfowl hunting, and use of parks, trails, golf courses, or other facilities. The economic implications of these effects on recreation are described in Chapter 4 – *Socioeconomics* section.

Summary

Alternatives were analyzed for direct, indirect, and cumulative effects on water-based and land-based recreation resources compared to the No Action Alternative (Table 4–32). Effects on water-based recreation resources would be primarily long-term, and were based on changes to streamflows and reservoir levels. Effects on land-based recreation resources would be primarily short-term, and were based on construction disturbance.

Photo 4–4. Water-based recreation at Pueblo Reservoir Marina

All alternatives would have negligible effects on Upper Arkansas River recreation, as changes to streamflows would be minimal. Effects of all action alternatives from streamflow reductions would be negligible on water-based recreation along the Arkansas River through Pueblo. The JUP North Alternative would cause minor adverse effects (detectable but no change in visitor experience) to water-based recreation at Pueblo Reservoir because of decreases in water surface elevation, while the effects of other alternatives would be negligible or beneficial. All alternatives except JUP North would have moderate adverse effects on recreation at Holbrook Reservoir.

Construction activities and noise for the Pueblo Dam North Alternative would cause short-term moderate effects (change in visitor experience) to visitor facilities and use at the Nature and Raptor Center of Pueblo (from construction disturbance to parking areas, trails, and a plaza and garden area). The Pueblo Dam North Alternative would cause short-term moderate effects on trails in the Pueblo area, while the other alternatives that include AVC would cause short-term minor effects. Effects on parks, golf courses, and open space from construction disturbance would be negligible.

Table 4–32. Summary of Recreation Direct and Indirect Effects

Major ⦿ · Moderate ◐ · Minor ⦶ · Negligible = · Minor ⊖ · Moderate ◒ · Major ● Beneficial ↔ Adverse Resource Subtopics	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Water-Based Recreation (1)						
Upper Arkansas River	=	=	=	=	=	=
Pueblo Reservoir	=	=	⊖	=	=	⦶
Arkansas River through Pueblo	=	=	=	=	=	=
Lower Arkansas River	=	=	=	=	=	=
Holbrook Reservoir	◒	◒	=	◒	◒	◒
Fountain Creek	=	=	=	=	=	=
Land-Based Recreation (1)						
Pueblo Area	⊖	⊖	⊖	◒	⊖	=
Lower Arkansas River Basin	=	=	=	=	=	=
Fountain Creek Basin	=	=	=	=	=	=

Note:
(1) Effects are assessed compared to the No Action Alternative.

Methods

This section describes methods used to analyze water- and land-based recreation effects and the criteria for determining significance of effects on recreation.

Effect Analysis

Predicted changes in streamflow were used to evaluate effects on water-based recreational opportunities along the Arkansas River corridor, Grape Creek, and Fountain Creek. Changes to streamflow for normal, wet, and dry years were considered and evaluated for both direct and cumulative effects. In general, lower streamflows would adversely affect kayaking and rafting, while anglers would often prefer reduced high flows for wading. Changes to water levels or flows of less than 5 percent would likely not be apparent to recreation users, and would be unlikely to cause noticeable effects on recreation activities.

Predicted changes to water storage and water surface elevations based on hydrologic modeling were used to evaluate effects on existing recreation facilities and opportunities at Pueblo Reservoir, Turquoise Reservoir, Twin Lakes, Lake Meredith, Lake Henry, Holbrook Reservoir, and John Martin Reservoir. Changes to water surface elevations, along with other factors such as effects on fisheries, were used to assess potential effects on boating and angling opportunities. Small changes in reservoir storage and surface water elevations do not typically translate to measurable recreation effects or changes in the quality or availability of recreation opportunities. This conclusion is supported by surveys conducted at Pueblo Reservoir that indicated there is little sensitivity among visitors to minor fluctuations in water levels (Smith and Hill 2000).

Effects on angling opportunities were based on two factors: (1) effects on the fishery from hydrologic changes, and (2) physical effects on or impediment to use of areas for angling access, such as boat ramps or shoreline access.

Effects on public parks, trails, or other facilities used for recreation were quantified based on the area of short-term effects of pipeline construction and long-term effects from aboveground facilities for each alternative intersecting those resources. Effect calculations were inclusive of all construction activities.

Criteria for Determining Significance of Effects

Significance criteria used to describe the intensity of effects on recreation resources are described in Table 4–33. Potential effects on recreation were evaluated for each action alternative compared to the No Action Alternative. These criteria were applied to direct, indirect, and cumulative effects from construction activities and changing hydrologic conditions.

Table 4–33. Recreation Effect and Intensity Descriptions

Effect Intensity	Intensity Description (1)(2)
Negligible	Changes in recreation resources would be undetectable. Recreation facilities or activities would not be disrupted or noticeably changed.
Minor	Changes in recreation resources would be detectable, although the changes would be slight. The recreation user would be aware of effects associated with the alternative, but the effects would not substantially change existing recreation facilities, activities, or recreation experience quality.
Moderate	Changes in recreation resources would be readily apparent. The recreation user would be aware of effects associated with the alternative and the change to recreation facilities, activities, or recreation experience quality would be diminished. Recreation activity and visitor use would likely decline.
Major	Changes in recreation resources would be readily apparent and would significantly affect recreation facilities, activities, or the recreation experience quality. The recreation user would be immediately aware of effects associated with the alternative and recreation experience quality would be greatly diminished. Recreation activity and visitor use would decline substantially.

Notes:
(1) Short-term effect – Occurs only during construction and up to 1 year after completion
(2) Long-term effect – Continues for more than 1 year after construction

Results

Direct, indirect, and cumulative effects of alternatives on recreation resources and mitigation measures are described in this section.

Direct and Indirect Effects

This section describes water- and land-based direct and indirect effects in the Upper and Lower Arkansas River basins, the Pueblo area, and Fountain Creek.

Upper Arkansas River Basin All alternatives would have negligible effects on boating or angling opportunities on the Upper Arkansas River, including lower Browns Canyon, during the May–September recreation season, since changes to streamflows would be minimal (less than 2 percent decrease). Streamflow changes during low flow periods in late winter (February-March) would also be negligible. These streamflow changes would not alter the ability to meet target flows under the Upper Arkansas Voluntary Flow Management Program, with all alternatives causing less than 0.5 percent variation in the percentage of time target flows would be met (compared to No Action) (see Chapter 4 – *Surface Hydrology* section). Changes in water levels at Turquoise Lake and Twin Lakes under all alternatives would be small, and effects on boating or fishing opportunities would be negligible. No alternatives would alter streamflow on Grape Creek or affect boating opportunities there.

Lake Pueblo State Park Compared to existing conditions, the No Action Alternative would reduce Pueblo Reservoir water surface elevation less than 1.5 feet in normal years and 2 feet in dry years during the summer recreation season. The JUP North Alternative would cause minor adverse effects on water-based recreation (boating and fishing) on Pueblo Reservoir, compared to the No Action Alternative, as a result of decreases in water surface elevation of up to 5 feet during the summer recreation season. Effects of remaining alternatives on water-based recreation would be negligible (with changes in water elevation of less than 3 feet in normal years).

Water surface elevations under the No Action Alternative would exceed 4,888.4 feet (historical maximum) up to 8 days over the 28-year model period compared to 10 days under existing conditions. For all action alternatives, effects of elevated surface water levels on recreational activities would be negligible, since the frequency of higher water levels would be low and higher water levels would likely occur in winter when recreational use, access, and parking needs are reduced. Water surface elevations under the Master Contract Only Alternative would exceed the historical maximum water surface elevation up to 41 days over the 28 year model period. For the other action alternatives, except JUP North, reservoir water levels would exceed the historical maximum elevation 3 to 5 days more than the No Action Alternative over the 28-year model period. The historical maximum water surface elevation would not be exceeded under the JUP North Alternative.

Photo 4–5. Nature and Raptor Center of Pueblo

Compared to existing conditions, the No Action Alternative would meet Pueblo Flow Management Program target flows 4 fewer days during the summer recreation season. All action alternatives would negligibly affect fishing and boating along the Arkansas River downstream from Pueblo Reservoir and through Pueblo. Compared to the No Action Alternative, the action alternatives would slightly change the number of days that meet Pueblo Flow Management Program target flows (see Appendix D.1 for Pueblo Flow Management Program targets). The River South Alternative would slightly increase target flow occurrences. The predicted change in number of days streamflow would be at the preferred volume for boating and fishing for all alternatives would be unlikely to measurably change amount of recreation use or experience quality.

Photo 4–6. Bessemer Ditch and Pueblo area golf course

Memoranda of Agreement between Southeastern and AVC and Master Contract participants would require participation and compliance with Southeastern's commitments in the Pueblo Flow Management Program, as outlined in the Six Party Intergovernmental Agreement (City of Pueblo et al. 2004a, 2004b). This commitment would be further clarified in proposed future contract(s), as outlined in best management practices (Appendix B.5).

Pueblo Area Land-Based Recreation The No Action Alternative would not affect Pueblo area land-based recreation, compared to existing conditions. The Pueblo Dam North Alternative would cause short-term moderate adverse effects compared to the No Action on visitor use at the Nature and Raptor Center of Pueblo from construction-related noise and disturbance near the parking area, plaza, garden and trails. No other alternatives would affect the Nature and Raptor Center of Pueblo.

The Pueblo Dam North Alternative would cause short-term moderate adverse effects on several public trails, while other alternatives would cause short-term minor adverse effects (Table 4–34). The Pueblo Dam North Alternative would affect about 16,000 feet of trails (about 3 miles), the Comanche North and JUP North alternatives would affect about 5,000 feet of trails, and the other action alternatives would affect less than 2,600 feet of trails. Pipeline construction would damage trails, which would need repair following construction, and would cause short-term adverse effects on visitor use from trail closures or reroutes during construction.

The JUP North and Pueblo Dam North alternatives would have a negligible effect on Mitchell Park and two open space areas, while the Comanche North Alternative would have short-term minor effects on City Park and the Elmwood Golf Course due to construction disturbance. The Pueblo Dam South Alternative would have a short-term negligible effect on the Elmwood Golf Course from noise and construction disturbance along the existing Bessemer Ditch and access road. Construction would not affect long-term golf course operations or use.

Table 4–34. Length of Trails Within Alternative Pipeline Alignments

Trail Name	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract
Trail Disturbance (feet)							
Lake Pueblo Trail	0	0	1,275	410	1,350	0	0
Pueblo Boulevard Trail	0	797	200	0	0	0	0
Arkansas River Trail	0	578	0	69	10,710	2,571	0
Fountain Creek Trail	0	0	0	1,253	1,253	0	0
Wildhorse Trail	0	0	0	287	432	0	0
Nature Center Trail	0	0	0	0	599	0	0
Other trails	0	3,773	0	3,137	1,853	0	0
Total (feet)	**0**	**5,149**	**1,476**	**5,156**	**16,197**	**2,571**	**0**
Total (miles)	**0**	**1**	**0.3**	**1**	**3**	**0.5**	**0**

Fountain Creek Basin Effects on recreation in the Fountain Creek Basin would be negligible in all alternatives as surface disturbances and streamflow changes would be minimal.

Photo 4–7. Angling on the Arkansas River

Lower Arkansas River Basin Effects on boating, fishing or other recreation along the Arkansas River in the Lower Arkansas River Basin would be negligible because changes to streamflows would be minimal. All alternatives would cause negligible effects on recreation at Lake Meredith, Lake Henry, and John Martin Reservoir.

At Holbrook Reservoir, all alternatives except JUP North would cause moderate adverse effects on water-based summer recreation from storage reductions of up to about 67 percent in normal years and up to about 33 percent in dry years compared with the No Action Alternative. JUP North Alternative effects would be negligible. While these changes would cause moderate adverse effects on recreational boating and fishing on Holbrook Reservoir, the water level changes would be within the range of historical fluctuations.

All action alternatives would have a negligible effect on parks and golf courses in the Lower Arkansas River Basin. The Comanche North, Pueblo Dam South, and River South alternatives include pipeline segments near or within the Cottonwood Links golf course in Fowler and would have a short-term negligible effect from noise and construction disturbance. Most action alternatives would have a pipeline segment located near or adjacent to the Rocky Ford Country Club (within the County Road EE right-of-way) and the Spreading Antlers Golf Course in Lamar, but would not directly affect either course or its operations. Likewise, construction near a ball field complex in La Junta (along 6th Street) would not directly affect the facility or its use.

All action alternatives with AVC would cross a portion of the Mountain Route of the Santa Fe National Historic Trail between La Junta and Lamar several times. Effects on the trail are not well known at this time since much of the trail has not been mapped. Construction activities could cause short-term effects on the general setting and aesthetics in some portions of the trail corridor, but are unlikely to have long-term adverse effects on the recreational and interpretative opportunities associated with the historic trail as outlined in the *Santa Fe National Historic Trail Comprehensive Management and Use Plan* (U.S. National Park Service 1990). Measures to protect important features and characteristics of the trail would be implemented in accordance with a programmatic agreement between Reclamation, the National Park Service, Colorado State Historic Preservation Office, and other concurring parties. The Historic Properties section provides additional discussion on the Santa Fe Trail and potential impacts.

Pueblo Dam South Alternative construction would negligibly affect access to Bent's Old Fort National Historic Site (located along the Santa Fe National Historic Trail east of La Junta). Noise and construction disturbance may be noticeable to some visitors, but is unlikely to adversely affect their experience. The Pueblo Dam South Alternative pipeline alignment parallels U.S. Highway 50 on the south border of Bent's Old Fort. Because most features at the historic site are north of the Arkansas River, about 0.5 miles from U.S. Highway 50 and the pipeline, construction activities would result in a negligible effect on visitors and recreation.

Cumulative Effects

Compared to the No Action Alternative, the action alternatives would have negligible cumulative effects on boating or angling opportunities on the Upper Arkansas River during the May–September recreation season, since streamflow changes would be minimal. Action alternatives would cause negligible cumulative effects on boating and angling opportunities at Turquoise Lake and Twin Lakes because of small water level changes. No alternatives would cause cumulative effects on Grape Creek boating opportunities since no changes to streamflows would occur. Climate change could reduce streamflow and shift peak flows to earlier in the spring, affecting boating and fishing in the Upper Arkansas River. Higher ambient temperatures could increase demand for high altitude, water-based recreation as more visitors may seek opportunities to "cool off" during summer months.

Cumulative effects of all alternatives on water-based recreation through Pueblo would be negligible. Alternatives would have negligible cumulative effects on water-based recreation at Lake Pueblo State Park, as the small changes in surface water elevation (less than 4 feet) would not be noticeable to most recreationists (Smith and Hill 2000). Reduced Arkansas River streamflow in the No Action Alternative would cause decreased water-based recreational opportunities through Pueblo. Climate change could reduce days that Pueblo Flow Management Program flows would be met, and/or shift peak recreation flows from the summer months to the spring. Depending on the overall hydrological changes, climate change may cause cumulative effects on river recreation opportunities through Pueblo, a change in peak recreation seasons, or both.

Cumulative effects of all alternatives on land-based recreation resources such as parks, trails, open space, and golf courses in the Pueblo area would be negligible. Short-term construction effects of other reasonably foreseeable actions, such as the SDS, would most likely not occur within the same time frame as the proposed alternatives. No other land-based reasonably foreseeable actions (primarily highway projects) would be anticipated to cause cumulative effects on recreation resources.

Cumulative effects of all alternatives on recreation in the Fountain Creek Basin would be negligible since alternatives would not cause water- or land-based effects.

Cumulative effects of all alternatives on recreation along the Arkansas River in the Lower Arkansas River Basin would be negligible because changes in streamflow would be minimal. Cumulative effects of all alternatives on land-based recreation resources such as parks and golf courses in the Lower Arkansas River Basin would be negligible. All alternatives would cause negligible cumulative effects on recreation at Lake Meredith, Lake Henry, Holbrook Reservoir, and John Martin Reservoir from small changes in water levels under the No Action Alternative. Climate change could increase the variability of water levels in Lower Arkansas River Basin reservoirs, increase ambient temperatures, and change runoff patterns, which could shift peak recreation from summer months to the spring and/or fall. In general, these factors would cause cumulative effects on reservoir recreation. The actual effect of climate change on lake levels and recreational use patterns is not known.

Mitigation Measures

Open space areas and parks affected by construction activities would remain open to the extent feasible with consideration for public safety. Safe, reasonable, and short-term detours around construction areas would be created to minimize effects on park or trail users. Limitations in public access would be restored as quickly as possible.

Planned construction work would be advertised in advance to minimize inconvenience to recreation activities.

To mitigate moderate reservoir effects in the Lower Arkansas River Basin on recreation, the United States would approve expansion of the Pueblo Fish Hatchery near the existing Pueblo Fish Hatchery, if requested and deemed feasible by Colorado Parks and Wildlife, in conjunction with mitigation requirements set forth in the SDS EIS and Fish and Wildlife Mitigation Plan. Hatchery expansion would occur through a mutually acceptable agreement between Colorado Parks and Wildlife and Reclamation, and the location of the expansion and site-specific NEPA compliance would be coordinated between Reclamation and Colorado Parks and Wildlife after a Record of Decision has been signed. The state would be responsible for construction, operation, and maintenance of fish production ponds and associated facilities. This includes providing all water necessary for these ponds, including, but not limited to, water for filling the ponds, and augmenting evaporation from the ponds, in accordance with Colorado state law.

To mitigate occasional moderate streamflow and minor aquatic life and recreation effects during low-flow periods in the Arkansas River directly below Pueblo Dam, Reclamation would limit excess capacity contract operations when streamflow is less than 50 cfs, as measured by adding streamflow at the Arkansas River above Pueblo gage to fish hatchery return flows.

Reclamation would provide coordination assistance with participants in managing storage and water releases in a manner that could assist in augmenting low streamflows in the Arkansas River downstream from Pueblo Reservoir to the Fountain Creek confluence. Reclamation will not modify operations that would impact Fry-Ark Project yield

Reclamation would also provide $50,000 for habitat improvements downstream from Pueblo Reservoir. Design and location of improvements would be coordinated between Reclamation and CPW after a Record of Decision has been signed.

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Vegetation and Wetlands

This section compares effects on vegetation and wetland resources, including upland vegetation, wetland and riparian vegetation, sensitive plants, and noxious weeds.

Summary

Overall, alternatives would have negligible to moderate effects on vegetation resources, as shown in Table 4–35. Pipeline construction activities for most alternatives would have short-term minor effects (not affect plant community viability) on upland vegetation present in eastern Colorado following restoration of disturbed areas. For all alternatives, effects on upland plant communities from constructing aboveground structures would be negligible. Permanent vegetation loss for action alternatives would be less than or about the same as No Action.

Wetland and riparian effects from pipeline construction for all alternatives would be mostly minor, except for a moderate effect under the JUP North Alternative. Constructing a water treatment plant in a former water storage basin for the JUP North Alternative would have a long-term moderate effect from the loss of 1 acre of wetlands and a long-term minor effect from the loss of 24 acres of riparian vegetation. There would be no permanent effect on wetlands or riparian vegetation under any other alternative. Wetland and riparian effects under the Master Contract Only Alternative would be negligible. Wetland effects for all alternatives would be minimized by boring under wetland vegetation adjacent to perennial streams (Appendix I). Any wetlands permanently lost would be replaced and temporary disturbances to wetland and riparian vegetation would be minimized, as described in best management practices (Appendix B.5 and Chapter 2 – *Best Management Practices*).

All alternatives except JUP North and Master Contract Only would have negligible effects on wetland and riparian vegetation from hydrologic changes throughout the river and reservoir systems in the analysis area. The JUP North and Master Contract Only alternatives would have minor effects on wetland and riparian vegetation from lower and higher water levels in Pueblo Reservoir, respectively.

Table 4–35. Summary of Vegetation and Wetland Direct and Indirect Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
⊙	◐	⦶	=	⊖	◒	●
Beneficial ↔ Adverse						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Upland Vegetation [(1)]	⊖	⊖	⊖	⊖	⊖	=
Wetland Vegetation [(1)]	⊖	⊖	◒	⊖	⊖	=
Riparian Vegetation [(1)]	⊖	⊖	⊖	⊖	⊖	=
Federal Threatened and Endangered Species [(1)]	=	=	=	=	=	=
Colorado Species of Concern Potential Habitat [(1)]	◒	◒	◒	◒	=	=

Note:
(1) Effects are assessed compared to the No Action Alternative.

No alternatives would affect federally listed threatened and endangered plant species. Pipeline construction under all alternatives would have negligible to moderate effects on potential habitat for state plant species of concern by implementing best management practices. Constructing aboveground permanent structures would have long-term effects on about 18 acres of potential habitat for state plant species of concern only for the JUP North Alternative, although effects would be minimized by implementing best management practices.

Photo 4–8. JUP North Alternative water treatment plant site southwest of the Whitlock Water Treatment Plant in Pueblo

All alternatives would have potential to introduce and spread noxious weeds during construction. All alternatives, except Master Contract Only, would have a greater potential effect than the No Action Alternative due to a greater area of disturbance.

Methods

This section describes methods used to analyze effects on four vegetation resources – upland vegetation, wetland and riparian areas, sensitive plants (federally listed threatened and endangered and Colorado species of concern), and noxious weeds. This section also describes criteria for determining significance of effects on vegetation and wetlands.

Effects Analysis

Vegetation effects from constructing pipelines and other aboveground facilities were evaluated by overlaying the estimated area of disturbance on vegetation maps. A 150-foot disturbance width was assumed for pipeline corridors. The specific 150-foot-wide disturbance area was assumed to be within the defined buffer area identified for each pipeline route, which varies in width by location. Actual resource effects could vary slightly following final design and construction depending on pipeline placement within the buffer area, if an action alternative is selected in the Record of Decision.

Pipeline crossings of perennial streams and associated wetlands would be bored (digging under a feature) to avoid effects (see Chapter 2); thus, wetlands and open waters associated with perennial streams were not included in the construction effects analysis. Perennial streams are defined by the National Hydrography Dataset (USGS 2012b) and include the Arkansas River, Fountain Creek, St. Charles River, Apishapa River, and several other named creeks (see Appendix I).

Projected changes in river stage and reservoir levels during the growing season (May through September) were used to evaluate potential effects on wetland and riparian vegetation. Changes in floodplain groundwater levels resulting from changes in stream stage or from reduced agricultural return flows were evaluated from the groundwater analysis (see Chapter 4 – *Groundwater Hydrology*) and were used to evaluate potential changes to wetland and riparian vegetation.

Effects on potential habitat for sensitive plants, including the federally listed Ute ladies'-tresses orchid and five state plant species of concern (dwarf milkweed, golden blazing star, Pueblo goldenweed, roundleaf four-o'clock, and sandhills goosefoot) were evaluated based on acres of potential habitat disturbed. The presence of sensitive species would be assessed during preconstruction surveys as part of mitigation measures (Appendix B.5).

Effects of the alternatives on the introduction and spread of noxious weeds were based on the relative disturbance area.

Criteria for Determining Significance of Effects

Significance criteria used to describe the intensity of effects on vegetation and wetland resources are in Table 4–36. Potential effects on vegetation and wetland resources were evaluated for each action alternative compared to the No Action Alternative. These criteria were applied to direct and indirect effects from construction activities, changing hydrologic conditions, and cumulative effects. All pipeline construction activities would be considered short-term effects, except where trees would be removed. Effects from constructing aboveground structures would be considered long-term effects, as would changes in streamflow and reservoir storage. Effects were analyzed assuming the best management practices and resource protection measures described in Chapter 2 and Appendix B.5. These would be incorporated in a construction contract if an action alternative is selected in the Record of Decision.

Table 4–36. Vegetation and Wetland Effect Intensity Descriptions

Effect Intensity	Description (1)(2)
Negligible	**Vegetation:** Effects on vegetation (individuals and communities) from the alternative would be barely detectable. Abundance or distribution of plant communities would be slightly affected. Effects would be on a small scale and no species of special concern would be adversely affected. Ecological processes and biological productivity would not be affected. No federally listed threatened or endangered species would be affected. **Wetlands:** The alternative would have long-term effects on less than 0.1 acres of wetlands and there would be no perceptible changes in wetland integrity, continuity, or functions and values.
Minor	**Vegetation:** The alternative would affect abundance and/or distribution of individual plant species in a localized area or a small subsection of a larger plant community, but would not affect viability of regional or local native plant communities. Ecological and biological productivity would be disrupted, but would be reestablished following mitigation. No federally listed threatened or endangered species would be affected. **Wetlands:** The alternative would have long-term effects on 0.1 to 1.0 acres of wetlands. A small change in size, integrity, continuity, or functions and values of wetlands could occur from short-term effects such as construction-related runoff or temporary disturbance; the overall long-term viability of wetlands would not be affected.
Moderate	**Vegetation:** The alternative would adversely affect abundance and/or distribution of individual plant species and communities at regional and local scales, but would not affect long-term viability of native plant communities. Individual or small populations of species of concern would be affected. Only a small portion of known state occurrences of a species of concern would be affected. No federally listed threatened or endangered species would be affected. **Wetlands:** The alternative would have long-term effects on 1.0 to 10.0 acres of wetlands. Effects would be sufficient to cause a measurable change in size, integrity, continuity, or function and values of wetlands and would cause a long-term loss in wetland acreage requiring mitigation. Short-term effects on wetlands would affect functions and values until restored.
Major	**Vegetation:** The alternative would have a significant effect on native plant populations and would also affect a relatively large area. Large populations or a significant number of known state occurrences of a species of concern would be affected. Federally listed threatened or endangered plant species would be adversely affected. **Wetlands:** The alternative would have long-term effects on more than 10 acres of wetlands causing a significant change in size, integrity, continuity, or function and values of wetlands. Short-term effects on wetlands would affect wetland functions and values until restored.

Notes:
(1) Short-term effect – recovers in 3 years or less after alternative implementation
(2) Long-term effect – takes more than 3 years to recover after alternative implementation

Results

Direct, indirect, and cumulative effects of alternatives on vegetation and wetlands, and mitigation measures are described in this section.

Direct and Indirect Effects

This section describes direct and indirect effects on vegetation and wetlands caused by construction activities and hydrologic changes.

Construction Effects Constructing pipelines and associated structures would directly affect vegetation and wetland resources; the amount and type of effects would vary by alternative.

Upland Vegetation Regional pipeline construction under the No Action Alternative would temporarily disturb about 1,200 acres of upland vegetation compared to existing conditions. Temporary upland vegetation disturbance for alternatives with AVC range from 2,999 acres for Pueblo Dam South to 3,228 acres for Pueblo Dam North (Table 4–37). Pipeline construction under all action alternatives would have negligible to minor effects on upland vegetation compared to the No Action because the disturbed areas would be revegetated with similar plant species following construction, as described under the best management practices (Appendix B.5) and should reestablish within three years. All pipeline construction effects would be short-term except for areas of upland woodland that would be disturbed by the Comanche North and Pueblo Dam South alternatives. Effects on upland woodlands dominated by junipers would be long-term because replacement trees would take longer than 3 years to mature. Temporary effects on agricultural lands from alternatives with AVC would range from 1,296 acres for JUP North and Pueblo Dam North to 1,638 acres for Pueblo Dam South.

Table 4–37. Temporary Effects on Upland Vegetation Communities from Pipeline Construction Activities

Construction Activities/Upland Vegetation Communities	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Pipeline Construction Disturbance (acres)							
Upland Grasslands	308	1,274	1,142	1,386	1,410	1,031	308
Upland Grasslands – Cholla Cactus	0	16	6	34	34	6	0
Upland Shrublands	242	325	174	431	458	196	242
Upland Shrublands – Sandhills	9	8	8	8	8	8	9
Upland Woodlands	0	5	1	0	0	0	0
Agricultural Lands	628	1,458	1,638	1,296	1,296	1,748	628
Weedy Disturbed Areas	1	42	30	22	22	26	1
Total Disturbance	**1,188**	**3,128**	**2,999**	**3,177**	**3,228**	**3,015**	**1,188**
Pipeline Construction Effects Compared to No Action Alternative (acres)(1)							
Upland Grasslands	---	966	834	1,078	1,102	723	0
Upland Grasslands – Cholla Cactus	---	16	6	34	34	6	0
Upland Shrublands	---	83-	-68	189	216	-46	0
Upland Shrublands – Sandhills	---	-1	-1	-1	-1	-1	0
Upland Woodlands – Juniper	---	5	1	0	0	0	0
Agricultural Lands	---	830	1,010	668	668	1,120	0
Weedy Disturbed Areas	---	41	29	21	21	25	0
Total Effects Comparison	**---**	**1,940**	**1,811**	**1,989**	**2,040**	**1,827**	**0**

Note:
(1) Negative values indicate less disturbance than the No Action Alternative.

The No Action Alternative would permanently disturb the most upland vegetation through constructing brine evaporation ponds needed for expanded reverse osmosis water treatment at La Junta and Lamar. Effects of all alternatives on upland vegetation from constructing aboveground facilities such as storage tanks, water treatment plants, pumping plants, and other structures would be negligible (Table 4–38). Permanent upland vegetation effects for alternatives with AVC would be negligible and less than permanent upland vegetation disturbance under the No Action and Master Contract Only alternatives. The Comanche North Alternative would have the least amount of permanent disturbance (2 acres) compared to 50 acres for the No Action and Master Contract Only alternatives.

Table 4–38. Permanent Effects on Upland Vegetation Communities from Aboveground Structures

Construction Activities/Upland Vegetation Communities	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Aboveground Structure Disturbance (acres)							
Upland Grasslands	46	1	43	1	9	1	46
Upland Grasslands – Cholla Cactus	0	0	0	0	0	0	0
Upland Shrublands	1	0	0	1	24	1	1
Upland Shrublands – Sandhills	0	0	0	0	0	0	0
Upland Woodlands – Juniper	0	0	0	0	0	0	0
Agricultural Lands	3	1	1	1	1	43	3
Weedy Disturbed Areas	0	0	0	0	0	0	0
Total Disturbance	**50**	**2**	**44**	**3**	**34**	**45**	**50**
Aboveground Structure Effects Compared to No Action Alternative (acres) [(1)]							
Upland Grasslands	---	-45	-3	-45	-37	-45	0
Upland Grasslands – Cholla Cactus	---	0	0	0	0	0	0
Upland Shrublands	---	-1	-1	0	23	0	0
Upland Shrublands – Sandhills	---	0	0	0	0	0	0
Upland Woodlands – Juniper	---	0	0	0	0	0	0
Agricultural Lands	---	0	-2	-2	-2	40	0
Weedy Disturbed Areas	---	0	0	0	0	0	0
Total Effects Comparison	---	**-48**	**-6**	**-47**	**-16**	**-5**	**0**

Note:

(1) Negative values indicate less disturbance than the No Action Alternative.

Wetland and Riparian Vegetation The No Action Alternative would temporarily disturb about 11 acres of wetlands (Table 4–39). Pipeline construction would have temporary negligible to minor effects on wetlands for all action alternatives when compared to No Action (Table 4–39). Wetland disturbance from pipeline construction would be minimized or avoided by boring under perennial rivers and streams. The greatest temporary effect under all alternatives would be on palustrine emergent wetlands. Effects on emergent and scrub-shrub wetlands from pipeline construction would be temporary with on-site wetland restoration expected to take less than 3 years.

Table 4–39. Temporary Effects on Wetlands and Other Waters from Pipeline Construction Activities

Construction Activities/Wetlands and Other Waters	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Pipeline Construction Disturbance (acres)							
Palustrine Emergent	9	26	19	25	25	22	9
Palustrine Scrub-Shrub – Willow	<1	2	2	2	2	2	<1
Palustrine Scrub-Shrub – Introduced	0	1	0	1	1	0	0
Palustrine Scrub-Shrub – Mixed	1	0	0	0	0	1	1
Palustrine Forested – Cottonwood	1	0	0	0	0	0	1
Palustrine Forested – Introduced	0	0	0	0	0	0	0
Total Wetlands Disturbance	**11**	**29**	**21**	**28**	**28**	**25**	**11**
Total Open Water Disturbance	**4**	**5**	**22**	**14**	**14**	**13**	**4**
Pipeline Construction Effects Compared to No Action Alternative (acres) (1)							
Palustrine Emergent	---	18	10	16	16	13	0
Palustrine Scrub-Shrub – Willow	---	2	2	2	2	2	0
Palustrine Scrub-Shrub – Introduced	---	1	0	0	1	0	0
Palustrine Scrub-Shrub – Mixed	---	-1	-1	-1	-1	0	0
Palustrine Forested – Cottonwood	---	-1	-1	-1	-1	-1	0
Palustrine Forested – Introduced	---	0	0	0	0	0	0
Total Wetlands Effects Comparison	---	**18**	**10**	**17**	**17**	**14**	**0**
Total Open Water Effects Comparison	---	**1**	**-18**	**-10**	**-10**	**-9**	**0**

Note:
(1) Negative values indicate less disturbance than the No Action Alternative.

Permanent effects on wetlands from constructing aboveground structures would be negligible for all alternatives, except JUP North, which would have a moderate effect on wetlands (Table 4–40). The proposed location for the JUP North water treatment plant is in a former water storage basin that currently supports wetland vegetation. Constructing the facility at this location would have a permanent effect on over 1 acre of palustrine emergent wetlands.

Table 4–40. Permanent Effects on Wetlands and Other Waters from Aboveground Structures

Construction Activities/Wetlands and Other Waters	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Aboveground Structure Disturbance (acres)							
Palustrine Emergent	0	0	0	1	0	0	0
Palustrine Scrub-Shrub – Willow	0	0	0	0	0	0	0
Wetland Total Disturbance	**0**	**0**	**0**	**1**	**0**	**0**	**0**
Aboveground Structure Effects Compared to No Action Alternative (acres)							
Palustrine Emergent	---	0	0	1	0	0	0
Palustrine Scrub-Shrub – Willow	---	0	0	0	0	0	0
Wetland Total Effects Comparison	---	**0**	**0**	**1**	**0**	**0**	**0**

The No Action Alternative would temporarily disturb about 45 acres of riparian vegetation (Table 4–41). Pipeline construction for all alternatives would have minor temporary effects on riparian vegetation compared to the No Action Alternative (Table 4–41). The greatest effect would be on herbaceous and introduced shrubland riparian vegetation. Effects on these riparian communities from pipeline construction activities would be temporary and revegetation should be rapid. Effects on introduced riparian forests and cottonwood riparian forests would be long-term because mature forests would take more than 3 years to reestablish. Although trees could not be replanted directly on the pipeline alignment (they would hinder maintenance access), they would be replanted in other restored areas. Ecological and biological productivity would be temporarily disrupted, but most riparian vegetation would recover quickly following pipeline construction.

Table 4–41. Temporary Effects on Riparian Vegetation from Pipeline Construction Activities

Construction Activities/Riparian Vegetation	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Pipeline Construction Disturbance (acres)							
Riparian Herbaceous	13	41	23	41	41	27	13
Riparian Shrubland – Willow	1	1	3	1	1	2	1
Riparian Shrubland – Introduced	7	24	21	20	20	23	7
Riparian Shrubland – Mixed	9	6	1	1	1	<1	9
Riparian Shrubland – Greasewood Flat	0	67	7	67	67	7	0
Cottonwood Riparian Forest	7	52	50	50	67	44	7
Introduced Riparian Forest	8	21	20	22	22	21	8
Total Riparian Disturbance	**45**	**212**	**125**	**202**	**219**	**124**	**45**
Pipeline Construction Effects Compared to No Action Alternative (acres) (1)							
Riparian Herbaceous	---	28	10	28	28	14	0
Riparian Shrubland – Willow	---	0	2	0	0	1	0
Riparian Shrubland – Introduced	---	17	14	13	13	16	0
Riparian Shrubland – Mixed	---	-3	-8	-8	-8	-9	0
Riparian Shrubland – Greasewood Flat	---	67	7	67	67	7	0
Cottonwood Riparian Forest	---	45	43	43	60	37	0
Introduced Riparian Forest	---	13	12	14	14	13	0
Total Riparian Effects Comparison	**---**	**167**	**80**	**157**	**174**	**79**	**0**

Note:

(1) Negative values indicate less disturbance than the No Action Alternative.

Effects on riparian vegetation from constructing aboveground structures would be negligible for all alternatives, except JUP North, which would have a minor effect from disturbance of about 24 acres of riparian shrubland and forest (Table 4–42).

Table 4–42. Permanent Effects on Riparian Vegetation from Aboveground Structures

Construction Activities/Riparian Vegetation	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Aboveground Structure Disturbance (acres)							
Riparian Herbaceous	0	0	0	0	0	<1	0
Riparian Shrubland – Mixed	0	0	0	22	0	0	0
Cottonwood Riparian Forest	0	0	0	2	0	<1	0
Total Riparian Effects	**0**	**0**	**0**	**24**	**0**	<1	**0**
Aboveground Structure Effects Compared to No Action Alternative (acres)							
Riparian Herbaceous	---	0	0	0	0	<1	0
Riparian Shrubland – Mixed	---	0	0	22	0	0	0
Cottonwood Riparian Forest	---	0	0	2	0	<1	0
Total Riparian Effects Comparison	**---**	**0**	**0**	**24**	**0**	<1	**0**

Sensitive Plant Species No alternatives would adversely affect federally listed threatened or endangered plant species. Ute ladies'-tresses orchid is the only listed plant species potentially occurring in the analysis area and based on U.S. Fish and Wildlife Service guidelines, construction activities for all alternatives would not occur in potential orchid habitat. The No Action Alternative would temporarily disturb about 11 acres of potential habitat for state sensitive plants (Table 4–43). Action alternatives with AVC would have temporary negligible to moderate adverse effects on potential habitat for state sensitive plant species compared to the No Action Alternative. Plant surveys prior to construction and mitigation measures would be used to minimize effects on sensitive plant species (Appendix B).

Constructing aboveground structures for the Pueblo Dam North Alternative would have a long-term effect on potential habitat for state plant species of concern (Table 4–43). Potential habitat for state plant species of concern that could be affected includes dwarf milkweed, golden blazingstar, Pueblo goldenweed, roundleaf four-o'clock, and sandhills goosefoot. Plant surveys prior to construction would be used to determine if these areas support populations of sensitive plant species. If plants are present, transplanting or other measures would be considered to minimize effects.

Table 4–43. Effects on Potential Sensitive Plant Habitat from Construction Activities

Habitat/Construction Activity	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Sensitive Plant Habitat Disturbance (acres)							
Pipeline Construction	11	137	23	20	49	10	11
Aboveground Structures	0	1	0	0	18	0	0
Total	**11**	**138**	**23**	**20**	**67**	**10**	**11**
Sensitive Plant Habitat Effects Compared to No Action Alternative (acres)							
Pipeline Construction	---	126	12	9	38	-1	0
Aboveground Structures	---	1	0	0	18	0	0
Total	---	127	12	9	56	-1	0

Noxious Weeds Construction activities for all alternatives would potentially introduce and spread noxious weeds. Alternatives with the greatest ground disturbance would have the most potential for introducing noxious weeds. Temporary surface disturbance ranges from about 1,200 acres for the No Action and Master Contract Only alternatives to about 3,000 acres for the other action alternatives. Implementing weed control best management practices described in Appendix B.5 and specific weed control methods, where needed, would minimize establishment and spread of noxious weeds.

Hydrologic Effects Hydrologic changes associated with reduced streamflows and changes in reservoir levels would directly affect vegetation and wetland resources; the amount and type of effects would vary by alternative.

Upland Vegetation Changes in streamflow and reservoir surface elevations for the No Action Alternative compared to existing conditions would not affect upland vegetation communities. For all alternatives compared to No Action, effects on upland vegetation communities from streamflow changes would be negligible as these communities would not be affected by streamflows. Minor changes in reservoir surface elevations for action alternatives would cause negligible to minor effects on upland vegetation, depending on the reservoir and time of year.

Agricultural lands where irrigation water is permanently removed would likely be converted to upland pasture or native grasslands. This change in land use would be beneficial where native vegetation replaces cropland. Where agricultural lands would be dried up on a rotational basis (typically 3 years out of 10), land use and vegetation cover would not change substantially. Effects would be similar for all alternatives, including the No Action Alternative, and would be negligible.

Wetland and Riparian Vegetation Streamflow changes under the No Action Alternative would not substantially affect existing wetland and riparian vegetation along the Arkansas River and Fountain Creek. Hydrologic effects on wetland and riparian vegetation for the Arkansas River and Fountain Creek for all action alternatives compared to No Action would be negligible Predicted changes in streamflow depth would be less than 2.5 inches during normal, wet, and dry years for all alternatives, including the No Action. Minor changes in flow and river stage during the growing season would negligibly affect wetland and riparian vegetation adjacent to the river. Plains cottonwood, peachleaf willow, and sandbar willow are important parts of the riparian corridor along the Arkansas River. These species are fairly deep-rooted and minor changes in streamflow predicted under all alternatives would be unlikely to adversely affect these species. For example, overall average monthly changes in Arkansas River streamflow at the Rocky Ford gage upstream from Bent's Old Fort would range from slightly increased flow of less than 3.5 percent to decreases of less than 1 percent compared to existing conditions during the growing season (see Appendix D.4). Because the magnitude of streamflow changes would be relatively small, measurable effects on riparian and wetland species in the Arkansas River floodplain would be negligible. Although a slight increase in total dissolved solids along the lower Arkansas River is predicted (see Chapter 4 – *Water Quality*), which could give a competitive advantage to saltcedar, the minor increase in total dissolved solids would unlikely affect species composition or increase the spread of saltcedar.

Photo 4–9. Water level fluctuation at Turquoise Lake

Changes in the magnitude and frequency of peak flows would be negligible for all alternatives (MWH 2013a), which would likewise have a negligible effect on wetland and riparian vegetation along the Arkansas River and Fountain Creek. Peak flows help establish and maintain wetland and riparian vegetation. Low peak flows help maintain vegetation by recharging ground water and saturating soils. High peak flows scour away existing vegetation, creating habitat for new establishment of important riparian species including cottonwood, peachleaf willow, and sandbar willow. Small predicted changes in flood flows would not lead to accelerated streambank erosion or vegetation encroachment into the stream channel. Riparian vegetation would continue to have a beneficial effect in moderating the effect of periodic flood events.

Overall average water levels at Pueblo Reservoir would decrease for the No Action Alternative compared to existing conditions, with average high levels decreasing less than two feet during the growing season. Predicted average monthly changes in Pueblo Reservoir water levels during the growing season of plus or minus 1 foot for the Comanche North, Pueblo Dam South, Pueblo Dam North, and River South alternatives would have a negligible effect on wetland and riparian vegetation. For the Master Contract Only Alternative, reservoir levels may rise 2 to 3 feet in normal and dry years, possibly shifting the elevation of riparian and wetland vegetation associated with the tributaries and near the reservoir inlet, causing a minor effect. The JUP North Alternative would decrease Pueblo Reservoir water surface elevation up to 5 feet for normal years compared to the No Action Alternative. A change in reservoir water levels would likely shift the location of wetland and riparian vegetation associated with the tributaries and reservoir inlet to a lower elevation where supporting hydrology is present. This shift may have a minor effect on wetland species composition, but the overall area of wetlands would likely be similar. A lower reservoir level may also have a minor effect on small areas of woody riparian communities; however, reservoir water levels would continue to experience a wide range of fluctuations similar to existing conditions.

During the growing season, projected changes in reservoir levels and effects on wetland and riparian vegetation at Turquoise Lake, Twin Lakes, Lake Meredith, Lake Henry, and John Martin Reservoir would be minimal for the No Action Alternative compared to existing conditions. For all action alternatives compared to the No Action Alternative, the effects also would be negligible. Reservoir level fluctuations from alternatives would remain within the range of normal fluctuation for these reservoirs, which currently experience a wide range of water levels throughout the year. Wetlands near John Martin Reservoir are also supported by irrigation return flows (CDM 2011), which would not change in this area.

The No Action Alternative would require additional groundwater pumping in the Upper and Lower Arkansas River Basins and Fountain Creek Basin. Installation of new wells would have no direct disturbance to wetlands or riparian vegetation. Additional pumping from deep aquifers would not affect wetland or riparian vegetation because vegetation is not supported by deep aquifers. Estimated decreases in alluvial groundwater levels under the No Action Alternative in the Upper Arkansas River Basin and Fountain Creek Basin would be less than 3 inches at a typical well site, and would not affect groundwater levels supporting wetland vegetation near streams. Decreases in groundwater levels of up to one foot in the Lower Arkansas River Basin under the No Action Alternative could have slight effects to wetlands and riparian vegetation depending on the location and depth of an individual well. Groundwater pumped from alluvial wells under the No Action Alternative would be replaced with releases from surface water sources, which may help support wetland and riparian vegetation along streams.

Groundwater levels would decrease less than 1 percent in the Lower Arkansas River Basin and would have a negligible effect on supporting hydrology for wetlands or riparian vegetation. The action alternatives would decrease groundwater levels in the Upper Arkansas River Basin less than 1 inch at a typical well site compared to the No Action Alternative. Wetland and riparian vegetation in the Fountain Creek Basin may benefit slightly under the action alternatives compared to the No Action Alternative because of a decrease in groundwater pumping.

All alternatives would have a negligible effect on wetlands and riparian areas supported by agricultural return flows, most notably near John Martin Reservoir. Transfer of agricultural water rights for municipal water use under all alternatives would permanently dry-up about 2,000 acres of irrigated land at scattered locations in Chaffee, Fremont, Custer, Pueblo, Otero, and Bent counties. Rotational fallowing of about 4,800 acres of irrigated land would occur in Pueblo, Otero, and Bent counties. The decrease in irrigated acres may affect wetland meadows associated with irrigated pastures. Loss or periodic decrease in irrigation return flows from these lands may affect wetland or riparian vegetation bordering these lands or drainage ditches. Because retirement and fallowing of agricultural lands would be similar under all alternatives, including No Action, changes in agricultural return flows and effects on wetlands and riparian areas would be negligible.

Agricultural dry-up would not substantially affect regionally available agricultural return flows that may support wetland and riparian vegetation. Effects on wetland and riparian vegetation from reduced agricultural return flows would be a small percentage of the overall irrigated area in the Arkansas River Basin. However, localized effects are possible depending on site specific conditions, including proximity to other irrigated lands, soils, drainage, and topography. Agricultural return flows along the Arkansas River would remain a major source of hydrologic support for wetland and riparian vegetation under the No Action and action alternatives.

Sensitive Plant Species The federally listed threatened species Ute ladies'-tresses orchid would not likely be affected by hydrologic changes from the No Action or action alternatives. The U.S. Fish and Wildlife Service considers Fountain Creek in El Paso County as having potential habitat for this species based on one historical record from 1896, although the orchid has not been found in El Paso County since that time. For all alternatives, small predicted changes in Fountain

Creek streamflows would not likely affect this species. No other counties within the study area have potential habitat for the orchid or any other federally listed plants.

Colorado plant species of concern in the analysis area are all upland species that would not be affected by changes in streamflows. Although four plant species of concern – dwarf milkweed, golden blazingstar, Pueblo goldenweed, and roundleaf four-o'clock – have been observed in shaley uplands surrounding Pueblo Reservoir, these species generally grow well above the existing water surface and would not be affected by changes in reservoir elevations under any alternative, including the No Action Alternative.

Noxious Weeds In general, hydrologic changes under the No Action Alternative would not increase noxious weed establishment along river systems and around reservoirs in the analysis area compared to existing conditions. Hydrologic changes under the action alternatives would negligibly affect noxious weeds establishing in the same area. For most noxious weeds, small hydrologic changes projected under all alternatives would not increase disturbed areas or conditions favorable for noxious weed invasion. The potential for noxious weed invasion on irrigated agricultural lands converted to dryland pasture or native grasslands would increase under all of the alternatives. Establishment of noxious weed populations on retired or fallowed agricultural lands would be subject to current state and local noxious weed regulations and control mechanisms.

One noxious weed of particular concern within the study area is saltcedar, or tamarisk, which has invaded many riparian areas along the Arkansas River, its tributaries, and reservoirs. The No Action Alternative would not affect the spread of saltcedar from changes in hydrology. Compared to the No Action Alternative, predicted streamflow changes in the Arkansas River under the action alternatives (generally less than 2 inches in stage change) would not measurably change the physical or hydrologic conditions for the spread or establishment of saltcedar. For Pueblo Reservoir, a negligible change in overall reservoir elevations under all alternatives (except the Master Contract Only Alternative) would slightly expose bare soil, which would be suitable for saltcedar. Infestation of saltcedar along the shoreline would be hindered by typical seasonal water level fluctuations. Inundation for more than 3 months typically deters saltcedar from growing and establishing (Tallent-Halsell and Walker 2002).

Photo 4–10. Salt cedar along the Arkansas River near Rocky Ford

Cumulative Effects

Land-based construction disturbances to vegetation and wetland communities under all alternatives would be mostly temporary, which would contribute negligibly to effects from other reasonably foreseeable actions. The long-term loss of vegetation from constructing aboveground facilities would have a minor contribution to vegetation loss from identified reasonably foreseeable actions, such as the SDS and other construction activities, and past actions.

Cumulative effects on the Arkansas River stage above Pueblo Reservoir and below the Fountain Creek confluence would negligibly contribute to wetland and riparian effects. At the Arkansas River above Pueblo gage, the action alternatives compared to the No Action would contribute to river stage change by less than 1.2 inches, with a negligible contribution to wetland and riparian vegetation cumulative effects. Cumulative effects on the Arkansas River stage of up to 11 inches in dry years at the Arkansas River above Pueblo gage with the No Action Alternative compared to existing conditions may adversely affect wetland and riparian vegetation along the river banks. A change in species composition to species that tolerate a greater range of hydrologic conditions is possible.

Cumulative reasonably foreseeable actions with the No Action Alternative would increase flow by 1.2 inches to 1.1 feet at the Fountain Creek at Pueblo gage, which would be a minor beneficial effect on wetlands and riparian vegetation along Fountain Creek. Cumulative effects on stage (generally less than 0.6 inches) and wetland and riparian vegetation on Fountain Creek through Pueblo for the alternatives compared to the No Action Alternative would negligibly affect wetlands and riparian vegetation.

Cumulative changes at the Arkansas River at Rocky Ford gage, with assumed reasonably foreseeable future actions and the action alternatives, would cause minor decreases in average streamflow from April to July (<2 percent) and slightly higher streamflows (<2 percent) in other months compared to the No Action Alternative (Appendix D.4). Lower Arkansas River streamflows during dry years would be slightly less (<3 percent) than the No Action Alternative, but higher than existing conditions during the growing season, which could slightly benefit riparian species (Appendix D.4). It is unlikely that these minor predicted changes in streamflow under cumulative effect conditions and the negligible water quality changes discussed in Chapter 4 - *Water Quality* would adversely affect riparian vegetation.

Changes to surface water elevations in Pueblo Reservoir with reasonably foreseeable actions and the action alternatives would have negligible cumulative effects on wetland and riparian vegetation for all alternatives compared to the No Action Alternative. The surface elevation of Pueblo Reservoir under the JUP North Alternative would have the greatest decrease in a normal year (4 feet). The greatest change in surface water elevation in a dry year (3- to 5-foot decrease) would occur under the Pueblo Dam South, JUP North, and Master Contract Only alternatives. Negligible changes to wetland and riparian vegetation would be expected because existing fluctuations in water levels that limit vegetation along most shorelines would continue.

Cumulative effects on wetland and riparian vegetation from surface elevation changes at Turquoise Lake, Twin Lakes, Lake Meredith, Lake Henry, and John Martin Reservoir would be negligible because of negligible changes to water levels from existing fluctuations.

Mitigation Measures

Implementing mitigation measures and best management practices described in Appendix B.5 would minimize effects on vegetation resources. These include avoiding wetlands and other sensitive plant communities wherever possible, installing erosion control and other measures, revegetating with appropriate plant species, and controlling noxious weeds. The following mitigation measures would avoid, minimize, or compensate for direct effects on vegetation resources, as needed.

Wetland Mitigation Effects on jurisdictional wetlands and waters of the U.S. would require authorization from the U.S. Army Corps of Engineers. A compensatory mitigation plan may be required for the loss of any wetlands and would include methods to replace specific functions of affected wetlands. Any permanent loss of non-jurisdictional wetlands would be replaced.

Plant Species of Concern Mitigation Before construction, rare plant surveys would be conducted during the appropriate flowering period in areas with potential habitat for state plant species of concern. If a population of plant species of concern is found, construction activities may be shifted slightly, where practicable, to avoid plant species of concern. If not practicable, a plan detailing measures and methods to restore habitat or transplant species would be implemented. This plan would include measures appropriate for specific rare plant species and site conditions based on methods developed by the Rare Plant Initiative, Colorado Natural Heritage Program, and other experts.

Wildlife

This section describes the alternatives' effects on land-dwelling wildlife, including federally listed threatened and endangered species; state-listed threatened, endangered, and sensitive species; birds of prey; migratory birds; game animals; and other wildlife resources.

Summary

Pipeline construction activities would have negligible effects on upland habitat for game animals, migratory birds, and small mammals and reptiles for all alternatives (Table 4–44). Direct, long-term effects from constructing aboveground facilities, such as pump stations, water treatment plants and access roads, would be negligible on upland wildlife habitat for all action alternatives.

None of the alternatives would directly disturb suitable habitat for federally listed threatened or endangered, proposed species, or state-listed species of concern. John Martin Reservoir water levels would generally be slightly higher under all alternatives, which would have a minor effect on piping plover and least tern habitat. All alternatives would have a short-term negligible effect on lesser prairie chicken habitat and no effect on known breeding sites (Table 4–44).

Effects on upland state wildlife mammal and bird species of concern would be minor (small and localized) under all alternatives. Pipeline construction would have short-term negligible effects with revegetation of temporarily disturbed lands. Effects on reptiles would be negligible to minor for all alternatives. Negligible to minor effects on upland state sensitive species would occur under all alternatives. Effects on riparian state sensitive species would be negligible for all alternatives because wetland and riparian habitat would be avoided or restored following construction. The minimal projected changes in streamflow in the lower Arkansas River would not appreciably affect riparian vegetation and the bird and wildlife communities that use this habitat.

Table 4–44. Summary of Wildlife Direct and Independent Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
●	◐	⦶	=	⊖	◒	●
Beneficial ↔ Adverse						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Federal Endangered, Threatened, and Species of Concern (1)	⊖	⊖	⊖	⊖	⊖	⊖
State Endangered, Threatened, and Species of Concern (1)	⊖	⊖	⊖	⊖	⊖	⊖
Game Animals (1)	=	=	=	=	=	=
Raptors, Herons, Other Migratory Birds (1)	=	=	=	=	=	=
Birds of Conservation Concern (1)	=	=	=	=	=	=
Small Mammals, Amphibians, and Reptiles (1)	=	=	=	=	=	=

Note:
(1) Effects are assessed compared to the No Action Alternative.

Methods

This section describes methods used to analyze effects on wildlife resources, and criteria for determining significance of effects.

Effects Analysis

The effects analysis combined habitat ranges and distribution data with alternatives maps to evaluate long-term habitat loss and fragmentation, and short-term habitat disturbance and wildlife movement barriers. Data sources included the Colorado Natural Diversity Information Source, the U.S. Fish and Wildlife Service, the Colorado Breeding Bird Atlas, and others.

The analysis supplemented wildlife species range and distribution information with habitat affinities described in the literature and resource information described below to evaluate effects on wildlife with poorly understood habitat. The analysis developed measurement tools using habitat preferences based on mapped vegetation communities (described in Chapter 4 – *Vegetation and Wetlands)*, surface water effects (described in Chapter 4 – *Surface Hydrology)*, data provided by Colorado Parks and Wildlife, and site observations. Wildlife habitat value varies with location, plant cover, availability of nearby water, and other variables. Lands affected by the alternatives, except developed areas, were assumed to have some wildlife value. Wildlife effects associated with changing reservoir water levels were evaluated for all affected reservoirs. The effects analysis for least terns and piping plover habitat at John Martin Reservoir was based on the following assumptions:

- Falling water levels in spring and summer may increase potential available shoreline habitat in areas historically used by nesting terns and plovers.
- Rising water levels in spring and summer may reduce available shoreline habitat in areas historically used by nesting terns and plovers. However, rising water levels may isolate peninsulas creating islands that would have a beneficial effect by protecting nest sites from terrestrial predators (for example, Dinosaur Island).
- Least terns and piping plover frequently return to the same general areas containing suitable habitat in terms of slope, lack of vegetation cover, and soils (suitable aggregate for nesting). Identified nesting areas include Clayton Bay Point, Dinosaur Island, and Shale Point on the north side of the reservoir and Points 5 and 6 on the south side of the reservoir (Figure 4–53).
- Successful nesting largely depends on active management each spring, such as vegetation clearing.

Source: Smith 2012

Figure 4–53. Piping Plover and Least Tern 2012 nest sites at John Martin Reservoir

Criteria for Determining Significance of Effects

Significance criteria used to describe effects on wildlife are in Table 4–45. Significance criteria vary between species depending on habitat requirements, mobility, and regional distribution. The number of animals and their living spaces generally change according to time of year (winter, summer, and migration season) and behavior (breeding, raising young, and searching for food). Some wildlife (such as big game and many bird species) are highly mobile and wide-ranging while others (such as species with specific seasonal or year-round habitat requirements) live in limited, locally restricted areas. Whether a species is wide-ranging or not is important in determining effects. For example, a short-term loss of grassland habitat would have a negligible effect on highly mobile pronghorn, but could have a greater effect on locally restricted roundtail horned lizards.

The significance criteria were applied to direct and indirect construction effects, changing stream and reservoir conditions, and cumulative effects. Pipeline construction activities were considered short term effects (except where stands of trees would be removed). Aboveground structures were considered long-term effects, as were streamflow and reservoir storage changes. The effects analysis assumed that best management practices and resource protection measures in Chapter 2 and Appendix B.5 would be followed for action alternatives. The No Action Alternative would include common best management practices, such as revegetation of temporarily disturbed areas, but would not include implementing a migratory bird management plan as a component of the Fish and Wildlife Coordination Act Report.

Table 4–45. Wildlife Effects and Intensity Descriptions

Effects Intensity	Intensity Description [(1)(2)]
Negligible	Effects from the alternative on a species' population or individuals would be unmeasurable or not noticeable, and would be within the range of natural variability. This effect intensity equals a U.S. Fish and Wildlife Service determination of "no effect" for federally listed species
Minor	Effects from the alternative on a species' population or individuals would be measurable, but small and localized, and not outside the range of natural variability. Simple mitigation measures may be needed. This effect intensity equals a U.S. Fish and Wildlife Service determination of "may affect, not likely to adversely affect" for federally listed species.
Moderate	Effects from the alternative on species, habitats, or the natural processes sustaining them would be detectable over a large area. Breeding animals of concern are present, animals are present during particularly vulnerable life stages, and death or interference with activities necessary for survival could occur occasionally, but are not expected to threaten the species' continued existence. Extensive mitigation measures would be needed. This effect intensity equals a U.S. Fish and Wildlife Service determination of "may affect, likely to adversely affect" for federally listed species.
Major	Effects from the alternative on the viability of a population or individuals would be substantial. Effects on special status species or the natural processes sustaining them would be noticeable. Loss of habitat might affect the future of some special status species. Extensive mitigation measures would be needed, and success would not be guaranteed. This effect intensity equals a U.S. Fish and Wildlife Service determination of "may affect, likely to jeopardize the continued existence of a species" for federally listed species.

Notes:
(1) Short-term effect – following project completion, recovery takes less than 1 year.
(2) Long-term effect – following project completion, recovery takes more than 1 year.

Results

Direct, indirect, and cumulative effects of alternatives on wildlife habitat for federal and state endangered, threatened, and other species of concern; general wildlife; and mitigation measures are described in this section.

Direct and Indirect Effects

Direct and indirect effects on land-dwelling wildlife would vary depending on species' distribution and habitat needs. Wildlife are closely tied to habitat and the plant communities that characterize specific habitats. Thus effects on wildlife generally mirror effects on plants described in Chapter 4 – *Vegetation and Wetlands*.

Short-term construction disturbances and agricultural dry-up would be common to all alternatives. In general, alternatives with the greatest surface disturbance would have the greatest effect on wildlife. Thus, alternatives that include AVC would have greater wildlife effects than the No Action and Master Contract Only alternatives. However, the effect type, duration, and intensity of AVC construction disturbance would be similar for all alternatives in a given location..

Photo 4–11. Shoreline foraging habitat for piping plover and least tern at John Martin Reservoir

Federal Threatened, Endangered, and Candidate Species Proposed facility construction and hydrologic changes to streams and reservoirs would have a minor effect on known piping plover and least tern activity and habitat, including breeding or foraging habitat, at John Martin Reservoir and the Great Plains reservoirs in Kiowa County (Neesopah, Neegronda, Neenoshe, and Neeskah reservoirs). Piping plover are occasionally reported at Holbrook Reservoir, but no nesting has been confirmed in recent years (Nelson 2011). Proposed AVC pipeline routes would be located more than 1.4 miles from piping plover and least tern breeding areas identified by Colorado Parks and Wildlife (NDIS 2011) and more than 2.4 miles from nest sites identified on the north shore of John Martin Reservoir (Nelson 2011). Proposed pipeline routes would be west of Neesopah Reservoir intermittent plover and tern breeding habitat and more than 1 mile from the most recent nesting activity; no nesting has been observed since 1995 (Nelson 2011). If plover or tern nesting is identified near a pipeline route during construction, best management practices would be implemented, such as restricting seasonal construction during the nesting season, and halting ground-disturbing activities and consulting with the U.S. Fish and Wildlife Service and Colorado Parks and Wildlife if threatened or endangered species are encountered.

All alternatives, including No Action, would increase water levels and surface area at John Martin Reservoir during the breeding season in normal, wet, and dry years (Appendix D.5). These increases would be within the normal range of existing seasonal water level fluctuations. Surface water area during the April to August piping plover and least tern breeding season under No Action Alternative would be about 1 percent higher than existing conditions. Under all the action alternatives, the surface water area at John Martin Reservoir would range from about 1 percent higher than the No Action Alternative in April to 4 percent higher in August.

Piping plover and least tern habitat at reservoirs is dynamic and often depends more on water storage patterns and management activities than on actual water levels. Currently, piping plover and least tern nesting success at John Martin Reservoir depends on an interaction of water storage patterns and active management. Water storage patterns determine the base amount of suitable habitat available at the reservoir in any given year. In a normal year, high water levels in the winter and spring would flood and kill plants, which creates and exposes unvegetated nesting habitat for plovers and terns as water levels fall in the spring and summer. This seasonal pattern of reservoir operation would not change under any of the alternatives. In a normal year, water levels increase during the winter and early spring and begin to decline in April and May when piping plovers and least terns arrive at John Martin Reservoir. Water levels continue to decline throughout the remainder of the summer breeding season. While water levels in John Martin Reservoir would be up to 1 foot higher under the action alternatives compared to No Action, and up to about 3 feet higher than existing conditions during some of the summer months, the decline in water levels would follow the same pattern as under existing conditions.

Stable or increasing water levels can reduce the abundance of available natural habitat as a result of vegetation encroachment or flooding along the shoreline (Anteau et al. 2012). In wet and dry years, water levels at John Martin Reservoir are relatively stable and provide very little to no suitable nesting habitat under existing conditions. This condition would continue under all alternatives. In wet years, shoreline habitat would often remain flooded during the nesting season, and rising water levels in the late spring could flood nests. In wet years such as 1997, which experienced heavy spring rains, water levels rose after nest sites were established flooding all plover and tern nests at John Martin Reservoir (Nelson 2011). The action alternatives would not substantially increase the potential for flooding of nest sites during periods of localized flooding such as this. In more typical wet years, reservoir levels would be at or near capacity in the early spring under all alternatives and would recede during the breeding season to expose historic nesting areas. However, in individual wet years, historically used nesting areas may be partially or fully flooded for at least a portion of the nesting season. Corps biologists currently monitor spring and summer water levels and conduct active management activities such as vegetation clearing within known nesting areas, depending on actual water levels just before the nesting season. Biologists working with terns and plovers at John Martin Reservoir have determined that suitable nesting habitat at the reservoir would not be available without this active management under existing conditions and alternatives (Nelson 2012).

In dry years, similar to existing conditions, most shoreline nesting habitat would not flood and vegetation and weeds growing on exposed shore would decrease the suitability of nesting habitat. These conditions would not change substantially under any of the alternatives. However, as previously described, active management at John Martin Reservoir, including clearing vegetation, fencing or caging nests, predator control and beach closures would continue to substantially contribute to piping plover and least tern productivity regardless of reservoir water levels. Since 1996, active management has contributed to 82 percent of plover productivity (77 of 94 fledglings) and 85 percent of tern productivity (159 of 188 fledglings) (Nelson 2011).

Photo 4–12. Least tern

The availability of suitable piping plover and least tern nesting habitat at John Martin Reservoir would remain similar to existing conditions under all the alternatives. Slightly higher water levels at John Martin Reservoir in the spring would continue to decline in the same pattern during the breeding season with minimal risk of nest flooding, except from localized flooding in wet years similar to current conditions. Because suitable piping plover and least tern nesting habitat would remain dependent on active management, even with slightly higher John Martin Reservoir water levels, all alternatives may affect, but are not likely to adversely affect these species. Higher reservoir water levels under all alternatives could benefit nesting shorebirds by maintaining the protective moat around Dinosaur Island later into the summer and discouraging predators from accessing nesting areas, although island restoration and channel deepening efforts by Colorado Parks and Wildlife in 2011 (Nelson 2011; Smith 2012) may have greater value.

Direct effects on the lesser prairie chicken (proposed as a federal threatened species) would be negligible as no construction would occur within 1 mile of any known breeding site. Reservoir water level fluctuations under all the alternatives would also have no effect on this upland species. All alternatives with AVC would temporarily disturb about 97 acres of lesser prairie chicken overall range identified by Colorado Parks and Wildlife south of Lamar. The effect would be short-term, and best management practices would be implemented, such as restoration with native vegetation, restricting seasonal construction during the nesting season, and halting ground-disturbing activities. Reclamation has determined that the proposed actions are not likely to jeopardize the continued existence of the lesser prairie chicken. Reclamation would consult with the U.S. Fish and Wildlife Service should any potential effects on federally listed species be identified during construction.

State Threatened, Endangered, and Species of Concern – Upland Species Construction effects (primarily temporary displacement) on wide-ranging species, such as swift fox, long-billed curlew, ferruginous hawk, Texas horned lizard, massasauga rattlesnake, and mountain plover would be negligible for all alternatives (Table 4–46 and Table 4–47) because most construction activities would affect only a small amount of available habitat in the region, and because best management practices would include preconstruction surveys for both federal and state threatened, endangered and species of concern; seasonal avoidance; and restoration of disturbed lands. Alternatives may affect individuals of each species listed above, but would not likely affect the population or lead toward federal listing as threatened or endangered. Short-term construction effects under all alternatives would negligibly affect grassland habitat for the Colorado blue buckwheat butterfly. Restoration of some retired irrigated agricultural lands to native grasslands would improve or increase wildlife habitat, particularly for the Colorado blue buckwheat butterfly (Photo 4–13). Effects on the Townsend's big-eared bat would also be negligible because potentially suitable habitat would not be disturbed by the alternatives.

Photo 4–13. Colorado blue buckwheat butterfly

Habitat for the triploid checkered whiptail would experience short-term minor effects from pipeline construction under all alternatives (Table 4–46). A long-term loss of about 24 acres of whiptail habitat would occur by constructing aboveground structures under the Pueblo North Alternative, with less than 1 acre of effects for other alternatives. This species has specific habitat requirements, and construction could temporarily displace individuals from available habitat, but would not likely lead toward federal listing as threatened or endangered. Habitat disturbances would be spread over several years, with disturbed areas restored following each pipeline segment construction. The triploid checkered whiptail is a highly mobile species and would likely repopulate restored areas following construction. Other regional whiptail habitat and populations are stable and abundant.

Construction effects on black-tailed prairie dogs and prairie dog associates (such as the western burrowing owl and mountain plover) would be negligible (Table 4–46 and Table 4–47) because the majority of construction disturbance would be short-term with only a small percentage of available habitat in the region affected. Best management practices include preconstruction surveys for state-listed species within upland short-grass prairie and prairie dog colonies; seasonal avoidance, where feasible; and restoration of disturbed lands. Construction may displace individual prairie dogs, but would not measurably affect populations. The amount of prairie dog habitat temporarily disturbed (72 acres for No Action Alternative to 274 acres for Comanche North Alternative) (Table 4–46) would be small relative to regional habitat available. Colorado Parks and Wildlife has identified about 259,000 acres of active prairie dog colonies in southeastern Colorado in 2007 (Odell et al. 2008), indicating the abundance of suitable habitat available for displaced prairie dog associates.

Source: Courtesy of Colorado State University
Photo 4–14. Roundtail horned lizard

Construction would have minor effects on habitat for the roundtail horned lizard and common kingsnake. Individual roundtail horned lizards and common kingsnakes could be killed by construction activities under all alternatives. Specific population data are not available for these species in Colorado, but both species are known to be present in only Otero, Bent, and Las Animas counties. Records indicate the presence of the roundtail horned lizard near Fowler, Colorado. Regional water systems under the No Action and Master Contract Only alternatives, as well as the Pueblo Dam South and Comanche North alternatives, could affect the roundtail horned lizard. Pipelines constructed near La Junta under all alternatives would affect known habitat for the common kingsnake.

State Threatened, Endangered, and Species of Concern - Riparian Species Effects on habitat for riparian state sensitive species would be negligible under all alternatives because species effects would be temporary and relatively small and pipeline disturbances would be restored and revegetated following construction. River and reservoir level changes would also negligibly affect state sensitive riparian species; water levels changes would not substantially differ from current seasonal changes.

Table 4–46. Effects of Pipeline Construction Activities on Upland State Sensitive Species

Upland Species	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Pipeline Construction Disturbance to Upland Habitat (acres)							
Wide-ranging upland species (1)	308	1,290	1,148	1,420	1,444	1,037	308
Triploid checkered whiptail	251	404	183	429	466	204	251
Black-tailed prairie dog/western burrowing owl/ mountain plover	72	274	187	132	132	159	72
Roundtail horned lizard(2)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Common kingsnake(2)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Pipeline Construction Effects Compared to No Action (acres) (3)							
Wide-ranging upland species (1)	---	982	840	1,112	1,136	729	0
Triploid checkered whiptail	---	153	-68	178	215	-47	0
Black-tailed prairie dog/western burrowing owl/mountain plover	---	202	115	60	60	87	0
Roundtail horned lizard(2)	---	n/a	n/a	n/a	n/a	n/a	n/a
Common kingsnake(2)	---	n/a	n/a	n/a	n/a	n/a	n/a

Notes:

(1) Wide-ranging upland species include swift fox, Townsend's big-eared bat, long-billed curlew, ferruginous hawk, Texas horned lizard, massasauga rattlesnake, and Colorado blue buckwheat butterfly.

(2) Habitat acreages in the analysis area are unknown for roundtail horned lizard and common kingsnake.

(3) Negative values indicate less disturbance than the No Action Alternative.

Table 4–47. Effects of Aboveground Structures on Upland State Sensitive Species

Upland Species	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Aboveground Structure Disturbance (acres)							
Wide-ranging upland species (1)	46	3	43	1	9	1	46
Triploid checkered whiptail	1	0	0	1	24	1	1
Black-tailed prairie dog/western burrowing owl/ mountain plover	44	1	1	1	1	1	44
Roundtail horned lizard (2)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Common kingsnake (2)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Aboveground Structure Effects (acres) Compared to No Action (3)							
Wide-ranging upland species (1)	---	-43	-3	-45	-37	-45	0
Triploid checkered whiptail	---	-1	-1	0	23	0	0
Black-tailed prairie dog/western burrowing owl/ mountain plover	---	-43	-43	-43	-43	-43	0
Roundtail horned lizard (2)	---	n/a	n/a	n/a	n/a	n/a	n/a
Common kingsnake (2)	---	n/a	n/a	n/a	n/a	n/a	n/a

Notes:

(1) Wide-ranging upland species include swift fox, Townsend's big-eared bat, long-billed curlew, ferruginous hawk, Texas horned lizard, massasauga rattlesnake, and Colorado blue buckwheat butterfly.

(2) Habitat acreages in the study area are unknown for roundtail horned lizard and common kingsnake.

(3) Negative values indicate less disturbance than the No Action Alternative.

Temporary disturbance of riparian and wetland habitat (including open water) (Table 4–39 and Table 4–41) could affect northern and plains leopard frogs, Couch's spadefoot, and bald eagle. Effects on the northern and plains leopard frogs and Couch's spadefoot would be negligible with restoration of disturbed wetland and riparian habitat. Additionally, effects on wetland habitat at perennial rivers and stream crossings would be avoided by boring under wetlands. The minimal projected changes in streamflow in the lower Arkansas River would not appreciably affect riparian vegetation and associated use by bird and wildlife communities. Riparian and wetland effects are detailed in Chapter 4 – *Vegetation and Wetlands*. Pipeline construction near reservoirs could indirectly disturb nesting snowy plovers; however, the effects would be negligible. Proposed AVC pipeline routes would be west of Neesopah Reservoir, more than 1 mile from any known or potential snowy plover breeding areas at the Great Plains reservoirs.

The No Action and Master Contract Only alternatives would disturb the least bald eagle habitat compared to all other action alternatives (Table 4–48 and Table 4–49). Construction effects on bald eagles would be negligible for all action alternatives. No alternative is within half a mile of any known nest site, there is plentiful foraging and winter habitat in the region, most disturbances would be short-term, and best management practices, including seasonal avoidance and construction buffer areas, would be used. Reservoir and river levels for all alternatives would vary similar to existing wet and dry seasonal changes, with negligible effects on bald eagle habitat.

Table 4–48. Effects of Pipeline Construction Activities on Bald Eagle Habitat

Habitat Type	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Pipeline Construction Disturbance (acres)							
Winter concentration habitat	5	8	8	22	7	5	5
Winter range	33	211	236	217	236	208	33
Winter roost	0	0	1	0	7	11	0
Pipeline Construction Effects Compared to No Action (acres)							
Winter concentration habitat	---	3	3	17	2	0	0
Winter range	---	178	203	184	203	175	0
Winter roost	---	0	1	0	7	11	0

Table 4–49. Effects of Aboveground Structures on Bald Eagle Habitat

Habitat Type	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Aboveground Structure Disturbance (acres)							
Winter concentration habitat	0	0	0	0	1	0	0
Winter range	0	0	0	5	1	1	0
Winter roost	0	0	0	0	0	0	0
Aboveground Structure Effects Compared to No Action (acres)							
Winter concentration habitat	---	0	0	0	1	0	0
Winter range	---	0	0	5	1	1	0
Winter roost	---	0	0	0	0	0	0

Game Animals Effects of pipeline construction on game animals, including mule deer, white-tailed deer, pronghorn, and game birds, would be short-term and negligible after disturbed areas are restored under all alternatives (Table 4–50). Constructing permanent aboveground structures would also negligibly affect game animal habitat abundance and stability of game animal populations (Table 4–51). No alternatives would affect American elk concentration areas or seasonal ranges. No alternatives would affect large game migration corridors identified by Colorado Parks and Wildlife, and local wildlife travel corridors along rivers and streams would be affected only in the short term.

Table 4–50. Effects of Pipeline Construction Activities on Big Game Seasonal Habitat

Species and Seasonal Habitat Type	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Pipeline Construction Disturbance (acres)							
Mule deer concentration	645	2,435	1,472	1,477	1,517	1,506	645
Mule deer winter range	84	252	341	362	439	337	84
Mule deer severe winter range	84	237	284	333	333	333	84
Mule deer summer range	0	47	60	44	122	0	0
White-tailed deer concentration	105	1,846	534	529	529	547	105
Pronghorn concentration	0	0	3	3	3	3	0
Pronghorn winter range	0	0	55	<0.5	30	0	0
Pipeline Construction Effects Compared to No Action (acres)							
Mule deer concentration	--	1,790	827	832	872	861	0
Mule deer winter range	--	168	257	278	355	253	0
Mule deer severe winter range	--	153	200	249	249	249	0
Mule deer summer range	--	47	60	44	122	0	0
White-tailed deer concentration	--	1,741	429	424	424	442	0
Pronghorn concentration	--	0	3	3	3	3	0
Pronghorn winter range	--	0	55	0.5	30	0	0

Table 4–51. Effects of Aboveground Structures on Big Game Seasonal Habitat

Species and Seasonal Habitat Type	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Aboveground Structure Disturbance (acres)							
Mule deer concentration	14	1	1	1	1	1	14
Mule deer winter range	1	0	1	1	32	1	1
Mule deer severe winter range	1	0	1	1	1	1	1
Mule deer summer range	0	1	1	1	31	0	0
White-tailed deer concentration	12	2	1	1	1	1	12
Pronghorn concentration	0	0	0	0	0	0	0
Pronghorn winter range	0	0	0	0	30	0	0
Aboveground Structure Effects Compared to No Action (acres) (1)							
Mule deer concentration	--	-13	-13	-13	-13	-13	0
Mule deer winter range	--	-1	0	0	31	0	0
Mule deer severe winter range	--	-1	0	0	0	0	0
Mule deer summer range	--	1	1	1	31	0	0
White-tailed deer concentration	--	-10	-11	-11	-11	-11	0
Pronghorn concentration	--	0	0	0	0	0	0
Pronghorn winter range	--	0	0	0	30	0	0

Note:
(1) Negative values indicate less disturbance than the No Action Alternative.

The No Action and Master Contract Only alternatives would temporarily disturb big game seasonal habitats less than other action alternatives (Table 4–50 and Table 4–51). The No Action, Pueblo Dam North, and Master Contract Only alternatives would have the greatest long-term disturbance on mule and white-tailed deer habitat. The Pueblo Dam North Alternative would also have long-term effects on a small amount (30 acres) of pronghorn winter range. Most aboveground facilities would be located outside of large game seasonal habitat, but several pipelines would cross large game seasonal ranges. All pipelines would be underground and trenches would be closed daily to the extent practicable to avoid entrapping wildlife or creating barriers to wildlife movement. Best management practices and mitigation measures (as described in Appendix B.5) would further minimize adverse effects. The Fish and Wildlife Coordination Act Report would contain additional information on mitigation measures.

Effects on game birds would be negligible due to the temporary nature of disturbances and restoration of habitat following construction. Short- and long-term effects on woodland and riparian habitat would reduce potential feeding and breeding habitat for game birds, such as wild turkey, and short-term disturbance of upland habitats would displace game birds, such as ring-necked pheasant and northern bobwhite. Habitat losses and disturbance would affect a small percentage of available regional habitat.

Raptors, Herons, and Other Migratory Birds Effects on raptors (birds of prey) and migratory birds would be negligible as a result of best management practices, including preconstruction surveys, seasonal restrictions, use of Colorado Parks and Wildlife raptor nest buffers, restoration of temporarily disturbed areas, and implementation of a migratory bird management plan. The No Action Alternative would not require a migratory bird management plan. Effects on woodland habitat and riparian areas would reduce potential feeding and breeding habitat for birds of prey, herons, and other migratory bird species. The minimal projected changes in streamflow in the lower Arkansas River would not appreciably affect riparian vegetation and associated bird communities. The long-term disturbances of about 24 acres of riparian vegetation under the JUP North and about 1 acre for River South alternatives would have a negligible effect on nesting birds of prey because of implementation of the migratory bird management plan. Construction activities for the Pueblo Dam North Alternative would cross property of the Nature and Raptor Center of Pueblo. Pipeline construction would be approximately 450 feet north of the raptor center and would be buffered by a large intervening hill. Many resident and captive raptors under long-term Raptor Center care have likely become accustomed to human activity and noise; however, a short-term negligible effect on individual wild birds already stressed by captivity would be possible from construction noise. If the Pueblo Dam North Alternative is selected, Reclamation would closely coordinate construction activities with the Raptor Center to minimize effects.

Effects on active heron nesting or nest buffer and feeding areas would be negligible, although herons could be displaced from feeding areas at reservoirs and along the Arkansas River during construction under all alternatives with AVC. Active heron nesting areas have been identified by Colorado Parks and Wildlife upstream from Pueblo Reservoir and upstream and downstream from John Martin Reservoir (NDIS 2011). Construction activities would occur within a small percentage of available foraging habitat.

Birds of Conservation Concern Effects on Birds of Conservation Concern would be similar to those previously described for migratory birds, although effects would be lower in intensity due to more restricted ranges and habitat requirements. Sixteen Birds of Conservation Concern are in Region 18 (Appendix J), eight of which are addressed elsewhere in this section. The analysis area is outside the range of the five remaining Birds of Conservation Concern, leaving three species that may occur in the analysis area. The Lewis's woodpecker and Bell's vireo occur in riparian areas and the lark bunting is an upland grassland species. The effects on these three species would be negligible with use of best management practices, including following a migratory bird management plan during construction and preconstruction clearance surveys, as necessary. A migratory bird management plan and preconstruction clearance surveys would not be required for the No Action Alternative.

Cumulative Effects

All alternatives may cumulatively affect wildlife habitat in combination with reasonably foreseeable future actions, such as pipeline and road construction, urban development, other land disturbances, and climate change. Reasonably foreseeable future actions, together with the alternatives, could result in minor changes to Arkansas River streamflow, but changes are unlikely to measurably affect shoreline and riparian habitat used by wildlife (see Chapter 4 – *Vegetation and Wetlands*).

Proposed future transportation projects would contribute to cumulative habitat loss within native upland, wetland, and riparian wildlife communities. Transportation projects would also further divide habitat and create barriers to wildlife movement. Continued development in Pueblo County would contribute to habitat loss for state-listed species, particularly grassland species such as the burrowing owl, mountain plover, and ferruginous hawk.
Vegetation disturbances from reasonably foreseeable future actions would affect upland habitat and wildlife communities. The estimated acreages of long-term disturbances to upland habitat

for the No Action and action alternatives would have a negligible to minor contribution to regional cumulative effects. Long-term effects on riparian vegetation, primarily under the JUP North Alternative, would contribute to cumulative loss of riparian wildlife communities from reasonably foreseeable actions.

All alternatives would have a negligible contribution to cumulative effects on federally listed species, and negligible to minor effects on some state-listed wildlife species. No alternatives would directly disturb suitable land-based habitat for federal threatened, endangered, and candidate species. Cumulative effects on state-listed wildlife species would depend on habitat lost from reasonably foreseeable actions. By following the best management practices described in Appendix B.5, the alternatives would have a negligible to minor contribution to cumulative effects on state wildlife species of concern.

All alternatives would have a negligible contribution to cumulative effects on wetland and riparian wildlife habitat and species along Fountain Creek and the Arkansas River. Changes to surface elevations in reservoirs with reasonably foreseeable actions and the alternatives would have negligible cumulative effects on water-based wildlife, including piping plover and least tern at John Martin Reservoir. Reasonably foreseeable actions would change water level elevations and surface area, which may change habitat and species makeup of shorebirds, wading birds, and waterfowl at Pueblo, John Martin, and the Great Plains reservoirs.

Climate change would affect wildlife for all alternatives similarly. Predicted higher temperatures, changes in precipitation, and earlier spring runoff could lead to a decrease in wetland and riparian areas or change plant or animal community species composition. Climate change could directly affect wildlife resources through habitat loss, habitat alteration, and displacement of individuals or populations.

Mitigation Measures

Reclamation will complete its coordination with the U.S. Fish and Wildlife Service under the Fish and Wildlife Coordination Act before implementing the selected alternative. The U.S. Fish and Wildlife Service was a cooperating agency and was consulted throughout the AVC EIS process. A draft Fish and Wildlife Coordination Act Report is on file with Reclamation. Fish and wildlife conservation measures recommended in the final Fish and Wildlife Coordination Act Report will be considered by Reclamation and those found to be appropriate will be implemented by Reclamation through construction requirements and contract provisions. The final Report and Reclamation’s response will be made available to cooperating agencies and the public when complete.

Pipelines, water treatment plants, and pump station facilities would be realigned, where feasible, to avoid sensitive wildlife habitat.

Preconstruction surveys by trained observers would identify sensitive habitats and wildlife use before construction to allow implementing best management practices, temporal and spatial restrictions, and implementation of a migratory bird management plan as part of the Fish and Wildlife Coordination Act Report.

If the Pueblo North Alternative is constructed, Reclamation would coordinate closely with the Nature and Raptor Center of Pueblo to minimize effects on captive raptors, such as limiting construction times.

Human Environment

This section describes the alternatives' effects on the human environment, including noise and vibration, visual resources, traffic, and utility services.

Summary

All alternatives include construction that would cause short-term effects on the human environment from noise, vibration, and changes in visual quality, traffic, and utility service. Construction activities would be similar for all alternatives, although differences in effects are based on pipelines and permanent structure locations (Table 4–52). Effects of action alternatives would range from negligible to moderate (readily apparent and require mitigation).

Table 4–52. Summary of Human Environment Direct and Indirect Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
⦿	◐	⦶	=	⊖	◒	●
Beneficial ↔ Adverse						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Noise [1]	⊖	◒	◒	◒	⊖	=
Vibration [1]	=	⊖	⊖	⊖	=	=
Visual [1]	⊖	⊖	⊖	⊖	⊖	=
Traffic [1]	⊖	◒	◒	◒	⊖	=
Utility Services [1]	=	=	⊖	⊖	=	=
Land Use [1]	⊖	◒	◒	◒	⊖	=

Note:
[1] Effects are assessed compared to the No Action Alternative.

Methods

This section describes methods used to analyze effects, and criteria for determining significance of effects on the human environment.

Effects Analysis

Effects on the human environment from elevated noise were evaluated by first reviewing construction and operational activities associated with the alternatives, as described in the Appraisal Report (Reclamation 2012a, 2013a). Information on known decibel ranges for those activities, proximity of sensitive noise receptors (such as residential areas), and duration of activity was then used to evaluate potential effects.

State jurisdiction noise ordinances (Colorado Revised Statutes Section 25-12-103) were reviewed for maximum allowable decibels and potential time limitations for elevated noise (Table 4–53). Noise evaluation criteria were based on land use compatibility and direction and magnitude of noise level changes. Construction activities also may be subject to additional local and/or county noise ordinances.

Table 4–53. Maximum Noise Levels for Land Use Zones

Zones	Maximum Noise (decibels) 7 a.m. to 7 p.m.	Maximum Noise (decibels) 7 p.m. to 7 a.m.
Residential	55	50
Commercial	60	55
Light industrial	70	65
Industrial/construction	80	75

Source: Noise Pollution Clearinghouse n.d.; Colorado Revised Statutes Section 25-12-103.

Vibration effects from excavation and heavy equipment operation were qualitatively evaluated based primarily on structures sensitive to vibration near the construction zone.

Potential effects on visual resources involved assessing proposed facilities relative to views from key observation points, and evaluating short-term and long-term effects on landscape visual quality. Key observation points are locations where facilities may be visible, such as residences, commercial businesses, roads, highways, and recreation and visitor sites. Potential changes in visual quality include noticeably disrupting or screening existing views, introducing visual features in contrast with the landscape, and reducing opportunities to view scenic resources. Because the length of viewing time and manner of viewing dictate the quality of visual resources, these aspects of key observation points also were considered.

Photo 4–15. The human environment (City of Pueblo) includes buildings, streets, and utilities. This is the route of the Pueblo Dam North and JUP North alternatives.

Traffic effects were analyzed by assessing proposed pipelines, water treatment plants, and other facilities in relation to existing highways, rural roads, local routes, and intersections. Construction traffic and disruption of traffic created by short-term construction activities and permanent facility operations were assessed. Short-term utility services effects were evaluated by quantifying utilities in each alternative's pipeline alignment buffer area (see Appendix K). Land use effects within Pueblo County were assessed by quantifying the types of land use within each alternative’s pipeline alignment buffer area. Land use data for areas east of Pueblo County were not available.

Criteria for Determining Significance of Effects

Significance criteria used to describe effects on noise and vibration, visual resources, traffic, and utility services are in Table 4–54.

Table 4–54. Human Environment Effect and Intensity Description

Effect Intensity	Intensity Description (1)(2)
Negligible	**Noise and Vibration:** The natural sound environment and ambient vibration levels would be unaffected, or effects would be at or below detection. Changes would be unmeasurable or of imperceptible consequence to human populations. **Visual Resources:** Effects on visual resources would be an imperceptible change in landform or in facilities observed from key observation points. **Traffic, Utility Services, and Land Use:** Traffic, transportation patterns, utility services, or land use would not be affected, or effects would be small and not appreciably affect existing transportation, utility services, or land use.
Minor	**Noise and Vibration:** Effects on the natural sound environment and ambient vibration would be detectable, although effects would be localized, small, and of little consequence to human populations. Mitigation measures, if needed to offset adverse effects, would be simple and successful. **Visual Resources:** Effects on landforms and visual resources would be perceptible only during construction, or would affect only one or two key observation points. **Traffic, Utility Services, and Land Use:** Effects on traffic, transportation patterns, utility services, or land use would be noticeable, but would not appreciably affect existing transportation, utility services, or land use. Effects would be consistent with typical urban utility construction or maintenance.
Moderate	**Noise and Vibration:** Effects on the natural sound environment and ambient vibration would be readily detectable, with local consequences. Mitigation measures would be required, but would be moderate and would not eliminate adverse effects. **Visual Resources:** Effects on landforms or views of facilities would be readily apparent and would change the character of visual resources from more than two key observation points. **Traffic, Utility Services, and Land Use:** Effects on traffic, transportation patterns, utility services, or land use would be readily apparent and would substantially affect existing transportation, utility services, or land use. Effects would exceed those typical of urban utility construction or maintenance.
Major	**Noise and Vibration:** Effects on the natural sound environment and ambient vibration would be significant and would have substantial consequences to human populations, structures, or biological resources. Extensive mitigation measures would be needed to offset adverse effects, and success would not be guaranteed. **Visual Resources:** Effects on landforms or views of facilities would be highly noticeable and long-term, and would significantly change the character of visual resources from multiple key observation points. **Traffic, Utility Services:** Effects on traffic, transportation patterns, utility services, or land use would be significant and adverse, and would impede transportation, decrease travel safety or public health, and/or reduce regional economic activity.

Notes:
(1) Short-term effect – Effects lasting for the construction period
(2) Long-term effect – Effects lasting longer than the construction period

Results

Direct, indirect, and cumulative human environment effects would be predominately caused by short-term construction activities. Actions to minimize or mitigate effects on the human environment are also described in this section. Detailed maps of alternative pipeline corridors are in the Appraisal Design Report (Reclamation 2012a, 2013a).

Direct and Indirect Effects

This section describes direct and indirect effects of the alternatives on noise, vibration, visual resources, and traffic in the analysis area. Noise and vibration effects specific to wildlife are discussed in Chapter 4 – *Wildlife*, and effects specific to cultural resources are discussed in Chapter 4 – *Historic Properties*.

Noise The No Action Alternative would temporarily increase noise levels compared to existing conditions due to construction activities. Noise effects during construction under all alternatives would be short-term and minor to moderate near construction activities. Long-term effects of pump station and water treatment plant operations on ambient noise levels would be negligible, as machinery would be located mostly within enclosed facilities.

Photo 4–16. Typical construction activities that would cause noise (SDS pipeline installation in Pueblo West)

Direct and indirect effects of all alternatives would include short-term increased noise from construction equipment and traffic, and long-term noise from pump stations and water treatment plants following construction. Typical construction noise would include operating heavy construction equipment operation, such as excavators, backhoes, bulldozers, loaders, tunneling and boring equipment, compactors, pavers, water trucks, front-end loaders, dump trucks, drill rigs, cement pump trucks, cranes, pickup trucks, and other miscellaneous equipment. Noise would be loudest near the point of generation and would decrease away from the source. Frequently, complaints are about construction noise from backup alarms used on vehicles as a safety device. Controlled blasting may be required to excavate rock in some pipeline segments.

Noise from construction equipment (typically up to 90 decibels) would increase noise above ambient levels in many locations, such as residential areas (ambient levels up to 50 decibels). Construction noise would be less noticeable near large agricultural equipment operation (up to 96 decibels), busy urban areas with traffic (ambient levels up to 75 decibels), or other industrial noise sources. Construction noise levels would temporarily exceed maximum allowable levels outlined in state noise ordinances at some locations (Table 4–53).

Although total construction duration would be approximately 6 years (if an action alternative is selected in the Record of Decision and Congress funds construction), construction noise would not be anticipated to last longer than 2 to 4 weeks in any specific area along the pipeline route. The exception would be in areas requiring more complicated construction activities, such as in Pueblo where avoiding or replacing existing underground utilities could extend construction up to 8 to 10 weeks in a neighborhood. Construction duration for permanent facilities, such as pump stations and treatment plants, could be several months. Construction typically would be limited to daytime, Monday through Friday, although construction during nights or weekends might be necessary in some locations to complete work on schedule. Night work would be limited to areas where noise would not affect residents.

Areas most likely to be affected by noise include urban businesses and residential neighborhoods in Pueblo for the Pueblo Dam South, JUP North, and Pueblo Dam North alternatives. These alternatives would run directly through Pueblo, which has a higher population density and more noise receptors than other alignments. Noise effects on residents and businesses in these areas would be short-term and minor to moderate. The River South Alternative avoids most of Pueblo; therefore, noise effects would be short-term and minor. Comanche North includes a section of pipeline on the west side of Pueblo through a city park and golf course, but most of the pipeline would avoid noise effects on residential areas.

A portion of pipeline construction east of Pueblo would be along U.S. Highway 50 and state Highway 96, which currently experience elevated noise levels from traffic. Highway rights-of-way typically have greater ambient noise levels than other locations in rural areas; therefore, construction activities would not substantially increase noise. Alternatives that would have the most construction along existing rights-of-way include Pueblo Dam South and River South. The Comanche North, Pueblo Dam North, and JUP North alternatives divert from the U.S. Highway 50 corridor from approximately La Junta to Las Animas, and would create more noise in comparatively quiet rural areas along the pipeline construction corridor.

All AVC alignments would be routed through or near rural towns, businesses, or residential neighborhoods. To control noise from construction, best management practices would be used, such as rerouting construction truck traffic away from residential streets, if possible, or alternatively, targeting streets with the fewest homes.

Vibration The No Action Alternative would have limited vibration effects on mostly rural areas from construction of pipelines, wells, and other facilities. AVC pipeline construction under the Pueblo Dam South, JUP North, and Pueblo Dam North alternatives would cause a minor short-term level of vibration in the Pueblo urban environment. JUP North and Pueblo Dam North alternatives construction also would generate negligible short-term levels of vibration in communities along the railroad north of U.S. Highway 50. The Comanche North Alternative would avoid most of the built environment in Pueblo with negligible vibration effects. Vibration effects of the River South and Master Contract Only alternatives would be negligible.

Vibration from construction equipment varies based on equipment and construction activity. Vibration effects on surrounding buildings and structures could vary greatly depending on geology, soils, structure sensitivity, and distance between the structure and work zone. Earthwork causes vibrations that spread through the ground and diminish in strength with distance. Pile driving, which is often the greatest source of vibration, would probably not be used and construction techniques would be modified, as feasible, near structures of concern to minimize vibration.

Photo 4–17. Typical vibration effects (drilling rig for geotechnical investigation)

Construction near sensitive structures would be avoided to the extent possible. Vibration is primarily a concern in developed urban areas in the immediate vicinity of construction zones or near truck haul routes. Most construction would be in rural areas without structures sensitive to vibration. For a discussion about vibration effects on sensitive and/or historic structures, see Chapter 4 – *Historic Properties*. Noise and vibration would cease after construction. Permanent facilities, such as pump stations and water treatment plants, would have a negligible long-term effect on vibration.

Visual Resources Construction activities of the No Action Alternative would cause short-term effects on visual resources from construction of pipelines and facilities. Short-term, minor construction-related effects on visual resources would result from all action alternatives except Master Contract Only. Visual effects would include exposed soil and stripped vegetation, dust, construction equipment, nighttime construction lighting, construction access roads, and other construction-related disturbances.

Visual resource effects from pipeline construction would be short-term and minor. Installing underground pipelines requires clearing vegetation, temporary staging areas, excavating trenches, and building access roads. Because proposed construction areas are primarily in rural settings east of Pueblo, where views would be unobstructed, minor visual effects would occur under all action alternatives, depending on the observation point. Disturbed areas would look different than surrounding areas because of changes in plant species and their density, color, and texture. Revegetating cleared areas and restoring pavements and sidewalks after construction would restore visual appearance to near preconstruction conditions (see in Appendix B.5).

Long-term changes in visual resources under the No Action Alternative would include the presence of well fields, pump stations, storage tanks, and other structures. Constructing permanent aboveground facilities would have a minor effect on visual resources for all action alternatives. All alternatives would require constructing or expanding aboveground facilities, such as water treatment plants, pump stations, and storage tanks, adding new artificial features to the landscape. Constructed facilities would be located within sight of some homes and farms. Visual resource changes of the Master Contract Only Alternative would be similar to the No Action Alternative, and would be negligible.

Photo 4–18. View from Pueblo Dam left abutment overlooking the Arkansas River and fish hatchery

A decrease in average water levels of less than 1.6 feet at Pueblo Reservoir between the No Action Alternative and existing conditions would not adversely affect visual quality. Water levels in analysis area reservoirs currently fluctuate seasonally, and these fluctuations would experience additional fluctuations under the action alternatives compared to the No Action Alternative. The predicted decrease in average water levels in Pueblo Reservoir under the JUP North Alternative would have a minor adverse effect on visual quality by increasing the amount of exposed shoreline, while the increase in reservoir storage under the Master Contract Only Alternative would have a minor beneficial effect by reducing shoreline exposure. Pueblo Reservoir average monthly water level changes would range from a decrease of up to 5.4 feet under the JUP North Alternative to an increase of 3.3 feet under the Master Contract Only Alternative. Fluctuations in water levels under the remaining alternatives would be within about 1.4 feet of No Action Alternative water levels, which would have a negligible effect on visual quality at Pueblo Reservoir.

Predicted small changes in water levels in other reservoirs and streams would have a negligible effect on visual resources. Changes in streamflow levels along the Arkansas River and other streams would be less than 2 inches and would not be noticeable.

Permanent conversion of 2,090 acres of irrigated agricultural land to native or perennial grasslands under all alternatives, including the No Action Alternative, would cause a negligible long-term visual change in vegetation type. Visual changes would occur gradually, over several years, as the land transitions from large, maintained agricultural crops or pasture to permanent vegetation with a different species composition. For further discussion on vegetative effects, see Chapter 4 – *Vegetation and Wetlands*.

The intrusion of construction disturbance under all alternatives near the Santa Fe Trail Scenic and Historic Byway and the Santa Fe National Historic Trail would have a short-term minor effect on visual quality that would diminish over time and finally cease after construction areas were revegetated and restored (for additional information regarding effects on the Santa Fe Scenic and Historic Byway and Santa Fe National Historic Trail, see Chapter 4 – *Historic Properties* and *Recreation* sections). For the No Action and Master Contract Only alternatives, visual changes adjacent to the byway would be confined to areas near Lamar and La Junta, where the proposed pipeline would transect U.S. Highway 50. Views of pipeline trenches and construction equipment would be visible from the byway under all alternatives. Although no water treatment facilities would be proposed within the byway corridor or within sight of the existing byway, constructing storage tanks east of La Junta, proposed under the Pueblo Dam South Alternative, would cause long-term minor effects on visual resources. Installation of two small surge tanks and a regulating tank also would have a long-term minor adverse effect on visual quality under the Comanche North Alternative.

Traffic The No Action Alternative would minimally impede traffic in mostly rural areas compared to existing conditions. The Pueblo Dam South, JUP North, and Pueblo Dam North alternatives would cause moderate effects on traffic compared to the No Action Alternative where pipeline alignments would be located in urban areas within Pueblo. These alternatives would have more construction risk relative to affecting the public's use of local streets and intersections affected by the pipeline construction (MWH 2013b). The Comanche North Alternative would minimize use of roads on the west side of Pueblo, with only minor effects on traffic in urban areas. The River South Alternative would also avoid most of Pueblo urban area roads and would have minor effects on traffic. The potential for traffic effects in Pueblo is greater than in rural areas because of higher density of local residents and businesses, limited space for construction work and materials stockpiling, and more utilities. Although best management practices would be implemented to lessen effects on local traffic, temporary traffic detours and delays may occur during construction. Construction may also temporarily affect emergency vehicle access, although alternative emergency access routes would be included in pipeline designs of all alternatives to lessen conflicts.

Traffic disruptions associated with construction would be short-term and localized. Disruptions would be caused by material deliveries, equipment mobilization, and temporary road closures or detours during facilities construction. Construction workers also would contribute to a short-term increase in traffic congestion. Best management practices would include measures such as night time/weekend construction that could be performed without affecting nearby residences; boring under larger and busier roadways, such as highways and major collector streets; and limiting road closure to no more than two city blocks in urban and residential areas. Although construction would be less likely to disrupt traffic in rural areas, minor effects may occur in isolated areas from lack of available alternative routing.

Traffic effects from constructing pumping plants, water treatment plants, and tanks would be negligible. Sites for these facilities would be on properties generally isolated from the traveling public. With the exception of needed construction and/or permanent access roads, traffic disruption and effects would be minimal. In addition, traffic resulting from personnel needed for plant operations would be in rural, isolated areas.

Utility Services The No Action Alternative would not substantially affect utilities in the urban and rural environment compared to existing conditions. Based on miles of major utilities within the pipeline buffer area, the JUP North and Pueblo Dam North alternatives would have the greatest effects on water, sewer, and natural gas utilities within Pueblo's urban environment (Table 4–55) compared to No Action. These alternatives would have more construction risk relative to the occurrence or density of underground utility conflicts and the potential for project disruption or added costs (MWH 2013b). Many of the identified utilities within the broad pipeline buffer area parallel the pipeline route and actual effects to major utilities would be minimized during final design by locating the pipeline to avoid existing buried utilities. However, construction activities may cause short-term minor disruptions in utility service for residents and businesses.

The Comanche North and River South alternatives would disrupt substantially fewer utilities, resulting in negligible effects. The Comanche North pipeline west of Pueblo would be located to avoid major utilities present along roads. The Master Contract Only Alternative would negligibly affect utilities.

Appendix K lists utilities within the analysis area for each alternative alignment in Pueblo County and areas farther east. Other power, telecommunication, and overhead lines could also be affected by the alternatives, but would be of less concern than pipeline construction. All action alternatives with AVC would have a greater potential for affecting utilities east of Pueblo than the No Action (Table 4–56). Rural construction east of Pueblo County, however, would cause minimal utilities disruption.

As a best management practice to minimize effects from utility disruptions, residents and business would be notified in advance of planned interruptions to utility services; any utility disruptions would typically be limited to less than 1 day or less. Irrigation canals, ditches, pipelines, and other irrigation facilities may also experience short-term disruptions. Long-term maintenance and repair activities could also temporarily interrupt utilities throughout pipeline operations. Similar advance notices would be made to residents and businesses during these activities.

Table 4–55. Major Utilities Within Pipeline Buffer Areas – Pueblo County

Utilities	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Major Utilities in Pipeline Buffer Area (miles)							
Water and Sewer	0	7.4	7.6	23.2	24.7	1.8	0.0
Natural Gas	0	2.0	1.6	15.3	15.3	1.4	0.0
Major Utilities Effects Compared to No Action Alternative (miles)							
Water and Sewer	---	7.4	7.6	23.2	24.7	1.8	0.0
Natural Gas	---	2.0	1.6	15.3	15.3	1.4	0.0

Table 4–56. Major Utilities Within Pipeline Buffer Areas – East of Pueblo County

Utilities	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Major Utilities in Pipeline Buffer Area (miles)							
Water and Sewer	0.6	11.2	15.5	16.2	16.2	11.8	0.6
Natural Gas	1.93	4.1	15.8	10.6	10.6	11.2	1.9
Major Utilities Effects Compared to No Action Alternative (miles)							
Water and Sewer	---	10.6	15.0	15.7	15.7	11.2	0.0
Natural Gas	---	2.1	13.8	8.7	8.7	9.3	0.0

Land Use in Pueblo   Potential effects on different land use types in Pueblo County were evaluated because pipeline construction could potentially disrupt normal urban operations or activities. The No Action Alternative would have no land use effects in Pueblo County, but would temporarily affect agricultural and rural land uses during construction. The Pueblo Dam South, JUP North, and Pueblo Dam North alternatives would have a moderate effect on urban land use, while the Comanche North and River South alternatives would have a minor effect. For all alternatives, effects would be short-term and would end after construction, although access for pipeline maintenance could result in periodic effects on existing land use. The Master Contract Only Alternative would have no land use effects in Pueblo County and rural land use effects would be the same as the No Action Alternative. The Pueblo Dam South Alternative would have the greatest effect on residential land uses compared to No Action, with 2.9 miles of pipeline constructed in urban residential areas, while the JUP North and Pueblo Dam North alternatives would each affect about 2.4 miles of urban residential areas (Table 4–57). The JUP North and Pueblo Dam North alternatives would have the most pipeline constructed in commercial, industrial, and governmental lands. The Comanche North Alternative, which bypasses most of Pueblo, and the River South Alternative, which begins east of most of Pueblo urban development, would have the least effect on urban land uses.

Mitigation measures to minimize effects on land use during construction would include advance notice of land use disruptions to residents, business owners, and other land owners. Long-term disruptions from maintenance and repair could also occur to Pueblo County land uses; residents, business owners, and agencies would be notified of these activities as well. Future zoning revisions or land uses should be unaffected by pipeline alignments.

Table 4–57. Pueblo County Land Use within Pipeline Corridor

Type of Land Use	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Land Use within Pipeline Corridor (miles)							
Agricultural	N/A	1.5	0.0	0.5	0.7	0.0	N/A
Commercial	N/A	0.0	0.4	0.6	0.6	0.6	N/A
Industrial	N/A	0.45	0.3	1.1	1.3	0.4	N/A
Residential	N/A	1.06	2.9	2.4	2.4	0.3	N/A
Governmental	N/A	2.36	0.7	4.9	4.6	0.2	N/A

Cumulative Effects

All alternatives would contribute negligibly to noise and vibration effects in combination with existing and reasonably foreseeable actions in the analysis area. Construction projects such as the state Highway 194 overlay, U.S. Highway 287 alternate truck route, and SDS would cause short-term effects from noise and vibration, but it is uncertain if the timing of these projects would overlap AVC construction activities.

The proposed actions and other reasonably foreseeable actions would have a long-term minor effect on visual resource. Reasonably foreseeable actions, such as climate change and the SDS would contribute to decreased water levels in Pueblo Reservoir and long-term minor visual effects from greater exposed shoreline, with a negligible contribution from the alternatives. In addition, construction activities from the alternatives would have a short-term minor contribution to visual effects within urban and suburban development occurring throughout the analysis area.

All alternatives would have short-term minor effects on traffic, utility services, and land use in combination with existing and reasonably foreseeable actions in the analysis area. Pipeline and facility construction from the alternatives, in addition to road construction projects and urban and suburban development, may contribute to short-term increases in traffic, utility service and land use disruptions.

Mitigation Measures

Several mitigation measures have been identified for effects on the human environment. If additional adverse effects are identified during final design or construction that would require further mitigation, appropriate measures such as the following would be developed:

- Provide land owners sufficient advance notice of land use disruptions before construction or maintenance activities.
- Reroute construction traffic away from noise-sensitive streets, where feasible.

- Conduct noisy operations during the same time period, since combined noise levels would not be significantly greater than the level produced if the operations were performed separately.
- Employ construction methods with the minimum vibratory disturbance near sensitive structures.
- Place vibration monitors near sensitive structures to monitor and correct potential effects.
- Announce traffic delays or detours from construction activities in advance of work to minimize disruption in traffic patterns.
- Maintain residential, business, and emergency vehicles access at all times.
- Provide incentives and disincentives for construction contractors to quickly complete work in areas where traffic effects would be greatest.
- Provide land owners sufficient advance notice of land use disruptions before construction or maintenance activities.

Socioeconomics

The regional economic effects evaluated in this section include changes in employment, personal income, and gross regional output of construction and OM&R expenditures; and changes in municipal water quality, agricultural dry-up, and recreation expenditures. Financing analyses that would address how the 35 percent local cost share for AVC construction would be repaid in the future have not been negotiated with Southeastern and the Interconnect applicants (see Chapter 1 - *Proposed Federal Actions*). Future participant water rates are therefore unknown. It is important to distinguish between a regional effects analysis and an analysis of economic feasibility. A regional effects analysis estimates the effect of an action on the regional economy as measured by indicators such as income and employment. An analysis of economic feasibility estimates the benefits and costs of an action to the nation as a whole. A regional effects analysis, which is described below, focuses on the effects of an action to the local area.

Summary

Construction expenditures of action alternatives that include AVC construction would have short-term minor beneficial effects on the regional economy during the construction period (Table 4–13). OM&R expenditures for all alternatives would be less than or equal to the OM&R expenditures under No Action Alternative and would have minor adverse effects on the regional economy over the period of alternative operation. Localized economic effects could be greater or less than estimated, depending on the extent to which direct expenditures occur in the nine county economic region.

Alternatives with a Pueblo Reservoir or JUP AVC intake would have a moderate beneficial effect as reflected through reduced household costs and improved water quality resulting from a reduction in total dissolved solids concentrations. The regional effects associated with reduced household costs cannot be quantified because the level and pattern of spending associated with the saved costs is unknown. However, reduced costs and household benefits from water quality benefits can be estimated and represent a positive effect to the economic region. The River South Alternative would have a minor beneficial effect on water quality and household costs. The Master Contract Only Alternative is the same as the No Action and would have negligible effects on household costs associated with municipal water quality. The River South Alternative household costs would be less than other alternatives with AVC deliveries because total dissolved solids concentrations at the river intake are higher than Pueblo Reservoir concentrations. All alternatives, including No Action, would improve municipal water quality related to radionuclides.

Regional socioeconomic effects caused by agricultural dry-up would be negligible for all alternatives. The action alternatives would have similar agricultural dry-up as the No Action Alternative, and would not affect the regional economy. Regional recreation economic effects for all alternatives would be negligible because effects on location-specific recreation activities would be negligible to minor and would not affect the regional economy.

Table 4–58. Summary of Socioeconomic Direct and Indirect Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
⊙	◐	⦶	=	⊖	◒	●
Beneficial ↔ Adverse						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Socioeconomics						
Construction Expenditures	⦶	⦶	⦶	⦶	⦶	=
OM&R Expenditures	⊖	⊖	⊖	⊖	⊖	=
Municipal Water Quality	◐	◐	◐	◐	⦶	=
Agricultural Dry-up	=	=	=	=	=	=
Recreation	=	=	=	=	=	=

Methods

This section describes methods used to analyze effects, and criteria for determining significance of effects on socioeconomics.

Effects Analyses

The regional economic effects analysis area, or regional economy, consists of Chaffee, Fremont, El Paso, Pueblo, Crowley, Otero, Bent, Prowers, and Kiowa counties in the State of Colorado. The analysis area generally extends beyond those of other resources because of direct effects from construction or operation changes, and indirect effects outside the regional economy to account for the flow of goods, services, and payments to major trade centers.

Expenditures Direct expenditures (Table 4–59) during AVC construction and annual OM&R could affect the regional economy. The expenditures in Table 4–59 represent actual spending patterns that would affect the regional economy and are not the measure of costs that would be used to evaluate economic feasibility. The portion of construction costs that would be spent within the regional economy is estimated to be 45 percent of total costs. OM&R expenditures within the regional economy are estimated to be 88 percent of costs. These percentage estimates were based on professional engineering judgment (Reclamation 2012c). The infusion of construction expenditures into the regional economy would occur only during the construction period (about seven years). Construction expenditures would initially be small but would peak and then trail off as construction is completed. These expenditures would cause a one-time regional economic effect during the period of construction.

Table 4–59. Costs and Expenditures

Alternative	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract
Total Costs [1] ($ million)							
Construction	192	400	495	495	505	475	192 [2]
Annual OM&R	5.0	3.5	3.4	3.8	3.8	4.2	5.0
Regional Expenditures ($ million)							
Construction	86.50	180	222.75	222.75	227.25	213.75	86.50
Annual OM&R	4.4	3.1	3.0	3.4	3.4	3.7	4.4
Master Contract Total Cost (midpoint)	4.0	23.5	23.5	4.0	23.5	23.5	23.5

Source: Reclamation 2012a, 2013a; Appendix B.3
Notes:
(1) 2011 dollars
(2) The Master Contract Alternative construction costs are identical to the No Action Alternative.

Project related expenditures for each alternative were input to a regional input-output model called IMPLAN (**IM**pact analysis for **Plan**ning). IMPLAN uses the U.S. Department of Commerce national input-output model to evaluate flows of commodities used and produced by industries, and was used in this EIS to estimate changes in regional employment, personal income, and output. Social accounts for the regional economy were included in the IMPLAN model database to represent flow of commodities to industry from producers and consumers, as well as consumption of production factors from outside the regional economy. Social accounts were converted into input/output accounts and multipliers for each industry in the regional economy, which account for multiple effects from changes in regional construction and annual OM&R expenditures. IMPLAN is a static model in that purchasing and commodity flow relationships are assumed to remain the same with and without an alternative. Large projects or programs that encompass several states could conceivably affect relationships assumed to be static in the IMPLAN model. IMPLAN is an appropriate regional effects model for use in estimating effects of small to moderately sized projects within a defined geographic area, such as AVC. IMPLAN was used to evaluate the effects from construction and OM&R expenditures, but was not used to evaluate any effects from water quality improvements, agricultural dry-up, or changes in recreation.

The indicators (IMPLAN results) used to measure regional economic effects were:

- change in regional employment (number of full and part-time jobs)
- change in the value of regional personal income
- change in the value of gross regional output produced

Municipal Water Quality Improvements Water quality in the Lower Arkansas River Basin is high in total dissolved solids and radionuclides, and burdens residents with higher costs related to water using appliances and healthcare. Chapter 4 – *Water Quality* describes improvements (decreases) in total dissolved solids and radionuclide concentrations in water supplies delivered to AVC participants. Household residents serviced by AVC would benefit from improved water quality because of lower household costs and cancer rates. Several methods can estimate household benefits of water quality improvements. One frequently used method assumes that benefits from improved water quality must be at least equal to costs imposed on households from poor water quality. Therefore, these costs represent a lower bound of benefits. Another method to evaluate water supply improvement benefits is called benefits transfer, which is based on the use of previously completed benefit studies for a resource similar to the site of interest to estimate a representative benefit for the similar resource. Both approaches were used to estimate water quality improvement benefits. The benefits of radionuclide concentration reductions were estimated separately based on EPA analysis because that category of benefits does not fit into the benefits from general water quality improvements.

To estimate the reduction in household total dissolved solids-induced costs, functions relating total dissolved solids concentration in domestic water to the useful life of household appliances were applied to the number of AVC participant households (water meters were used as proxy for households). For example assuming a 500 mg/L total dissolved solids concentration for water heaters, the function would estimate 9.72 years of useful life. This useful life would then be used to estimate the average annual cost of a water heater per household for AVC participants. The useful life functions were originally developed as part of a total dissolved solids economic damage model used to estimate household costs in the Lower Colorado River Basin for the Colorado River Basin Salinity Control Program (Reclamation 2011e). The appliances used for the analysis in this EIS include household water heaters, faucets, garbage disposals, dishwashers, and clothes washers.

The benefits transfer based estimate of water quality improvement benefits is based on a study of willingness to pay for improved water supplies in Northwest Oklahoma (Piper and Martin 1997). The Northwest Oklahoma study is based on survey results of households indicating their willingness to pay for water quality improvements associated with a new supply. The study estimated a range of benefits from $7.68 to $11.37 per household per month in 1992 dollars for rural households. These benefits represented a willingness to pay, or benefit, for improved domestic water supplies. Using Bureau of Economic Analysis price indices for personal consumption expenditures, housing and utilities, to convert 1992 values to 2011 dollars, results in estimated benefits of $12.94 to $19.16 per month. Using the upper end of the estimate, annual benefits are estimated to be $230 per household per year. A water conservation Colorado State University Extension fact sheet (Waskom and Neibauer 2010) indicated the average household needs 0.4 to 0.5 ac-ft of water per year. Combining the use per household estimates and annual household benefits of $230, water quality improvement benefits are estimated to be $460 to $575 per ac-ft.

Benefits of radionuclide reduction in community water systems were estimated using methods described in EPA's final rule-making for primary drinking water standards for radionuclides (EPA 2000). A national summary benefit-cost analysis was conducted as part of this rule-making on community water systems predicted to be impacted by EPA regulatory actions (EPA 2000). This analysis in the final EPA rule-making was based on radionuclide conditions.

For one condition (systems out of compliance), it was estimated that by meeting the uranium maximum contaminant level of 30 µg/L, 0.9 fatal cancer cases per 10,000 persons would be avoided annually, with an annual benefit of $3 million per avoided case in year 2000 dollars. This value was indexed using the consumer price index to a 2011 value of $3.93 million per avoided case. The population projections of communities under enforcement order to meet radionuclide standards were used to estimate potential benefits of meeting EPA's compliance standards for radionuclides.

Agricultural Dry-Up Some irrigated agricultural land would be permanently dried or temporarily fallowed within the regional economy for the No Action and action alternatives (see Appendix A). Taking irrigated land out of production would convert irrigation water to municipal water to meet future municipal water demands. An estimated average 11,700 acres of irrigated land would be dried each year (includes permanent dry-up and rotational fallowing) and it is assumed these acres would be from lower valued crop land (see Chapter 4 – *Groundwater Hydrology*). Effects of this agricultural dry-up were evaluated against total agricultural land and gross crop value in the regional economy.

Recreation Socioeconomic effects caused by changes in recreational use and patterns were qualitatively assessed using effects of alternatives on streamflow and reservoir storage volumes (Chapter 4 – *Surface Water Hydrology*).

Criteria for Determining Significance of Effects

Significance criteria used to describe the intensity of socioeconomic effects are in (Table 4–60). Potential socioeconomic effects were evaluated for each action alternative as compared to the No Action Alternative. The economic indicators are based on direct, indirect, and potential cumulative effects from construction and annual OM&R expenditures within the regional economy. It should be noted that a negligible regional economic effect could be major for a particular area or town within the regional economy. For example, an alternative potentially could result in a loss or an increase of 100 jobs in a particular town or economic sector like agriculture or manufacturing.

Table 4–60. Socioeconomics Effects and Intensity Description

Effect Intensity	Intensity Description
Negligible	No changes in regional economic indicators, AVC participant water supply quality, or agricultural dry-up would occur.
Minor	Changes in regional economic indicators, AVC participant water supply quality, or agricultural dry-up would be less than 10 percent.
Moderate	Changes in regional economic indicators, AVC participant water supply quality, or agricultural dry-up would be between 10 percent and 20 percent.
Major	Changes in regional economic indicators, AVC participant water supply quality, or agricultural dry-up would be greater than 20 percent.

Notes:
Short-term effect – occurs only during project construction and up to one year after completion
Long-term effect – continues for more than one year after project construction

Results

Direct, indirect, and cumulative effects of alternatives on socioeconomics, along with actions to minimize effects, are discussed in this section.

Direct and Indirect Effects

Constructing, operating, and maintaining pipelines and facilities could directly and indirectly affect socioeconomics because of expenditures in the regional economy. Other socioeconomic resources, such as municipal water quality, agriculture, and recreation, could also be directly and indirectly affected by the alternatives.

Construction and Operations, Maintenance, and Replacement Expenditures The No Action Alternative construction and OM&R expenditures would not greatly contribute to the regional economy, compared to existing conditions. Table 4–61 and Table 4–62 display regional employment, personal income, and gross regional output for all alternatives, including No Action. The No Action Alternative regional economic indicators are less than one percent of the existing conditions IMPLAN regional data baseline indicators. Constructing and maintaining the No Action Alternative could have larger economic benefits on local communities, particularly if expenditures occur in local areas. A portion of these expenditures could affect local wholesale and retail businesses, which could ripple through the local economy.

Construction expenditures of all alternatives except Master Contract Only would have minor beneficial effects to the regional economy, as compared to No Action. The Master Contract Only Alternative would negligibly affect the regional economy as expenditures are similar to No Action. Effects of construction on the regional economy would be short-term, based on construction period, and would decline once construction ends and the regional economy readjust to the loss of these direct expenditures. Benefits of construction expenditures on local communities could vary, and could exceed regional benefits on a percent basis, depending on where expenditures occur in the regional economy.

Table 4–61. Regional Economic Effects from Construction Expenditures

	Existing Conditions [1]	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Economic Indicator Values								
Employment (number of persons)	488,946	489,861	490,851	491,301	491,301	491,351	491,208	489,861
Personal Income ($ millions, 2011 dollars)	31,762	31,806	31,854	31,876	31,876	31,878	31,871	31,806
Gross Regional Output ($ millions, 2011 dollars)	39,427	39,557	39,698	39,762	39,762	39,765	39,749	39,557
Effects - Change in Economic Indicators (compared to No Action Alternative) [indicator value (%)]								
Employment (number of persons)	---	---	991	1,443 (<1)	1,443 (<1)	1,491 (<1)	1,348 (<1)	0 (0)
Personal Income ($ millions, 2011 dollars)	---	---	48	70 (<1)	70 (<1)	72 (<1)	65 (<1)	0 (0)
Gross Regional Output ($ millions, 2011 dollars)	---	---	141	205 (<1)	205 (<1)	212 (<1)	192 (<1)	0 (0)

Notes:
[1] 2010 IMPLAN regional economy baseline indicators

OM&R expenditures for all action alternatives except the Master Contract Only would be less than OM&R expenditures under No Action, and would have a minor adverse effect on the local economy (Table 4–62). As OM&R expenditures for the Master Contract Only Alternative would be the same as No Action, effects would be negligible. If OM&R expenditures represent spending from local water suppliers and users, then OM&R related spending could be at least partially offset by decreased spending in other sectors. For this analysis, OM&R regional effects are based on total expenditures, but may represent an overestimate of minor negative effects relative to the No Action Alternative. Similarly, total Master Contract costs would be paid by project beneficiaries and would likely represent decreased expenditures elsewhere. Regional effects from Master Contract costs are estimated to be zero assuming an offsetting decrease in other local spending. Effects would be long-term because OM&R expenditures would occur annually over the life of the alternative. OM&R expenditures benefits on local communities could vary, and could exceed regional benefits on a percent basis, depending on where expenditures occur in the regional economy.

Table 4–62. Regional Economic Effects from OM&R Expenditures

	Existing Conditions [1]	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Economic Indicator Values								
Employment (number of persons)	488,946	488,994	488,980	488,979	488,983	488,983	488,987	488,994
Personal Income ($ millions, 2011 dollars)	31,762	31,764	31,764	31,764	31,764	31,764	31,764	31,764
Gross Regional Output ($ millions, 2011 dollars)	39,427	39,433	39,431	39,431	39,432	39,432	39,432	39,433
Effects - Change in Economic Indicators (compared to No Action Alternative) [indicator value (%)]								
Employment (number of persons)	---	---	-14 (<1)	-15 (<1)	-11 (<1)	-11 (<1)	-8 (<1)	0 (0)
Personal Income ($ millions, 2011 dollars)	---	---	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Gross Regional Output ($ millions, 2011 dollars)	---	---	-2 (<1)	-2 (<1)	-1 (<1)	-1 (<1)	-1 (<1)	0 (0)

Notes:
[1] 2010 IMPLAN regional economy baseline indicators

Socioeconomic Effect – Municipal Water Quality The No Action Alternative would only slightly decrease total dissolved solids concentrations in drinking water for AVC participants that regionalize with La Junta and its reverse osmosis treatment plant. All other AVC participants in the No Action Alternative would have similar total dissolved concentrations in the drinking water as existing conditions. The Comanche North, Pueblo Dam South, JUP North, and Pueblo Dam North alternatives would have a moderate beneficial effect by reducing household costs due to improvements in water supply total dissolved solids concentrations (Table 4–63). The River South Alternative would have a minor beneficial effect. The Master Contract Only Alternative drinking water quality improvements are the same as the No Action and would have negligible effects. The Comanche North, Pueblo Dam South, and Pueblo Dam North alternatives would avoid the most annual costs associated with water using appliances and would have the most annual benefits (about $500,000 annually). The River South Alternative benefits are less than other alternatives with AVC deliveries because total dissolved solids concentrations at the River South Alternative AVC river intake are higher than Pueblo Reservoir concentrations.

The AVC portion of water supply that would meet demands increases from 8,148 ac-ft at the beginning of the study period to 10,256 ac-ft after 50 years. Using the average use over the study period to represent benefits and a water quality improvement benefit of $575 per ac-ft, water quality related benefits would be about $5.29 annually based on the benefits transfer approach (Table 4–63). The reduced costs/benefits shown in Table 4–63 are not additive because they are different approaches to measuring the same beneficial effect of improved water quality.

Table 4–63. Household Costs from Total Dissolved Solids Concentrations in Water Supply and Annual Benefit from Improved Water Quality

Alternative	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Annual Household Costs ($ million)							
Annual Costs	4.22	3.72	3.72	3.73	3.72	3.89	4.22
Effects - Change in Annual Household Costs (compared to No Action Alternative) [$ million (%)]							
Annual Costs	---	-0.50 (-11.8)	-0.50 (-11.8)	-0.49 (-11.6)	-0.50 (-11.8)	-0.33 (-7.8)	0 (0)
Effects – Change in Household Water Quality Benefits (Compared to No Action Alternative) ($ million)							
Annual Benefit	---	5.29	5.29	5.29	5.29	5.29	0

All alternatives, including the No Action, would meet radionuclide drinking water standards and provide a valuable benefit to communities currently under Health Department enforcement action (Table 4–64). Effects of the action alternative compared to No Action on radionuclide concentrations in drinking water would be negligible, as all benefits are the same.

Table 4–64. Estimated Benefits for Meeting Radionuclide Drinking Water Quality Standards

Alternative	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Benefits from avoided cases per 10,000 ($ million)							
Annual Benefit	1.51	1.51	1.51	1.51	1.51	1.51	1.51

Socioeconomic Effects - Agricultural Dry-Up Compared to existing conditions, the No Action Alternative 2070 agricultural dry-up of 11,700 acres would be about a 4 percent reduction in total irrigated lands (about 280,000 acres) in the analysis area. A reduction in gross crop value based on 11,700 acres of dry-up, compared to existing conditions, would be about $7.7 million annually, assuming lower valued irrigated crops are fallowed, such as corn for silage, and using Colorado Agricultural Statistics (2009 prices and yields for this field crop). It should be noted that gross crop value is not a measure of agricultural benefit, but is an indicator of the importance of production to the local economy. This reduction in gross crop value, compared to the 2007 Agricultural Census of total market value of $660 million for this area, would be about 1 percent of the total value. Regional socioeconomic effects caused by agricultural dry-up would be negligible for all action alternatives because they would have similar agricultural dry-up as the No Action Alternative.

Socioeconomic Effects – Recreation Regional recreation economic effects for all alternatives would be negligible because effects on location-specific recreation activities would be negligible to minor (Chapter 4 – *Recreation*) and would not affect the regional economy.

Cumulative Effects

Compared to the No Action Alternative, action alternatives would have negligible cumulative effects on the regional economy within the analysis area based on the comparison to the whole regional economy. The beneficial effects from the construction expenditures of each alternative would be short term and would not affect the overall regional economy. The OM&R expenditures for all of the alternatives would have a negligible cumulative effect compared to the analysis area's regional economy.

Climate change could affect the regional economy if water supplies are reduced in the analysis area. Lower water supplies would probably reduce agricultural production and result in higher municipal and industrial water rates. This could affect employment and net disposable income within the analysis area.

Mitigation Measures

No mitigation needs or measures have been identified for socioeconomic effects; all adverse effects are minor or negligible.

Environmental Justice

Environmental justice addresses the fair treatment of people of all races and incomes with respect to federal actions that affect the environment. Where effects to a minority or low-income population are identified, the analysis addresses whether the populations could be disproportionately affected by the proposed alternatives and identifies reasonable efforts to avoid any disproportionate effects.

Summary

Construction of the action alternatives would most directly affect those living, recreating, or pursuing other activities in the immediate areas. To the extent these are minority or low-income populations, there is potential for disproportionate adverse effects. Effects on minority and low-income populations under the Comanche North, Pueblo Dam South, River South, and Master Contract Only alternatives would be negligible (Table 4–65) because the affected minority and low-income populations (on a percent basis)would not exceed by five percent the minority and low-income populations affected by No Action and are not disproportionate. The JUP North and Pueblo Dam North alternatives affect more minority population than No Action, but the difference is less than 10 percent and would be minor.

Table 4–65. Summary of Environmental Justice Direct and Indirect Effects

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
●	◐	⦶	=	⊖	◒	●
Beneficial ↔ Adverse						

Resource Subtopic	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Minority Population Effects	=	=	⊖	⊖	=	=
% Below Poverty level	=	=	=	=	=	=

Methods

This section describes methods used to analyze effects, and criteria for determining significance of environmental justice effects.

Effect Analysis

The environmental justice analysis area includes areas that would be affected by alternative pipeline and facilities construction (see Chapter 2). Census data at the census tract level (U.S. Census Bureau 2010) were used to estimate the percentage of minority and low-income populations, and to assess disproportionate effects due to construction (see Appendix L.1). The minority and low-income populations were estimated for each alternative and compared to No Action values.

Criteria for Determining Significance of Effects

The significance criterion used to describe the intensity of environmental justice effects in the analysis area are based on the percentage differences between the average percentages of the total analysis area and alternatives (Table 4–66).

Table 4–66. Environmental Justice Effects and Intensity Descriptions

Effect Intensity	Intensity Description
Negligible	Less than 5 percent difference between percentage indicators of the action alternatives and No Action.
Minor	Between 5 percent and 10 percent difference between percentage indicators of the action alternatives and No Action.
Moderate	Between 10 percent and 20 percent difference between percentage indicators of the action alternatives and No Action.
Major	Greater than 20 percent difference between percentage indicators of the action alternatives and No Action.

Results

Direct, indirect, and cumulative effects of alternatives on environmental justice are discussed in this section.

Direct and Indirect Effects

The percentage of minority population affected by construction activities under the No Action Alternative would be less than the average percentages in the analysis area (Table 4–67). The percentage of low-income population affected by construction activities under the No Action Alternative would be slightly more than the average percentages in the analysis area. Effects on minority and low-income populations under the Comanche North, Pueblo Dam South, River South, and Master Contract Only alternatives would be negligible because the affected populations would not exceed by five percent the No Action averages and are not disproportionate. The JUP North and Pueblo Dam North alternatives would affect more minority population than the analysis area average because of AVC construction through dense, urban areas in Pueblo, but the difference is less than 10 percent and would be minor.

Table 4–67. Percent of Population affected by Construction that are Minorities or Low-Income Households

Effects	Existing Conditions [1]	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Minority population (%)	44.6	41.8	40.9	42.3	45.7	45.7	42.5	41.8
Low-income population (%)	18.7	22.8	16.7	18.2	22.6	22.6	20.0	22.8

Data Source: U.S. Census Bureau 2010
Note:
[1] Existing conditions percentages are the average of the entire analysis area.

Cumulative Effects

The reasonably foreseeable actions that could affect minority and low-income population, such as highway construction, would not be large enough to cause major disproportionate effects. Climate change could affect minority and low-income populations because of reduced water supplies. This could affect employment and net disposable income within the analysis area.

Mitigation Measures

No mitigation needs or measures are needed for environmental justice effects as all effects are negligible or minor.

Historic Properties

This section compares the alternatives' potential impacts[1] on historic properties. Historic properties are any historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the U.S. Secretary of the Interior. The term includes artifacts, records, and remains that are related to and located within such properties.

Summary

Based on a literature search of best available information, AVC construction could have minor (less than 20 properties) to major (more than 40 properties) impacts on historic properties (Table 4–68). It should be noted that the literature search for properties covered buffer corridors wider than potential construction zones. Sixty-five properties have been identified within the Pueblo Dam South Alternative buffer corridor, followed 42 for JUP North and Pueblo Dam North, 26 for River South, 17 for Comanche North, and 3 for Master Contract Only. Three properties have been identified within the No Action Alternative buffer corridor. The Pueblo Dam South Alternative could impact the most historic properties because the pipeline alignment extends through Pueblo where the greatest concentration of known historic buildings and districts are present.

Adverse impacts on most historic properties could be avoided or minimized by adjusting pipeline alignment, or applying other best management practices and mitigation measures. Direct impacts of all alternatives on historic properties within Pueblo could be mostly avoided. The northern pipeline routes appear least likely to affect archaeological properties. Historic properties within Pueblo and John Martin reservoirs have already been affected by changing reservoir levels. Minor reservoir changes under the alternatives would not worsen existing impacts.

Table 4–68. Summary of Historic Properties Direct and Indirect Impacts

Major	Moderate	Minor	Negligible	Minor	Moderate	Major
⊙	◐	⦶	=	⊖	◒	●
Beneficial ↔ Adverse						

	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Known Historic Properties	⊖	●	●	●	◒	⊖

Methods

This section describes methods used to identify historic properties, and analyze potential impacts and criteria for determining the significance of impacts on historic properties.

[1] Reclamation has not completed a determination of effects in consultation with the State Historic Preservation Office or Tribal Historic Preservation Office; therefore, "impacts" will be used in this section rather than "effects". Language specific to consultation will use "effects".

Impacts Analysis

Potential impacts are discussed only for historic properties. Historic properties were identified through a file and literature review conducted by the Colorado Historical Society, Office of Archaeology and Historic Preservation. Districts are groups of buildings or structures that form historic residential or commercial districts. Geographic information system data were used to identify properties that intersect pipeline corridors and facility locations.

The analysis area, or area of potential effect, varies from 100 feet to 600 feet from the pipeline alignment, depending on the alternative. The area of potential effect allows flexibility in pipeline location based on whether the pipeline corridor is in the built environment (such as Pueblo), is included in an existing right-of-way, or is in previously undisturbed areas. A large percentage of the area of potential effect has not been surveyed to identify historic properties as it is private property, and few previous cultural resource compliance inventories have been conducted. A Class I file search, literature list, and predictive model were completed to assess cultural resource potential where surveys have not yet taken place (ERO 2011a). After the preferred alternative is identified, a pedestrian inventory of that alternative would be conducted in accordance with the programmatic agreement (Appendix N).

Criteria for Determining Significance of Impacts

Significance criteria used to describe the intensity of impacts on historic properties are in Table 4–69. While impact intensity is partly based on affected historic resources, adverse impacts could be avoided in most cases. This analysis assumes historic properties recommended as “not eligible” would be determined to be so by Reclamation in consultation with the State Historic Preservation Office. Unevaluated cultural resources or those requiring evaluation (needs data) are considered potential historic properties.

Table 4–69. Historic Properties Impact Intensity Descriptions

Impact Intensity	Intensity Description
Negligible	Impacts would be at the lowest level of detection with neither adverse nor beneficial consequences. The alternative would not adversely affect any historic properties. The determination of effect for Section 106 of the National Historic Preservation Act would be “no historic properties affected”.
Minor	Impacts on known historic properties would number less than 20 and the potential impact on presently unknown historic properties is considered low. National Register District(s) would be affected, but individual contributing properties would not. The determination of effect for Section 106 would be “adverse effect”.
Moderate	Impacts on known historic properties would number between 21 and 40 and the potential impact on additional unknown historic properties is considered medium and would affect National Register District(s), but individual contributing properties would not be affected. The determination of effect for Section 106 would be “adverse effect”.
Major	Impacts on known historic properties would number more than 40 and the potential impact on additional unknown historic properties is considered high and would adversely affect properties contributing to National Register District(s). The determination of effect for Section 106 would be “adverse effect”.

Results

This section describes the direct and cumulative impacts of alternatives on historic properties and actions to minimize those impacts.

Direct Impacts

The number of potentially affected historic properties is listed by resource type in Table 4–70. Historic properties that fall under the federal Historic and Contributing to District categories may be avoided during construction. Adverse impacts on historic linear properties, such as railroads and canals, may be avoided by boring underneath, and adverse impacts on buildings or structures contributing to a district would likely be avoided by placing the pipeline within an adjacent street. Proposed footprints of permanent facilities do not contain known historic properties, except the River South Alternative pumping plant, which is located within the East Corona Park Historic District.

Table 4–70. Listed, Eligible, or Potentially Eligible Historic Properties by Alternative and Resource Type Within Area of Potential Effect

Resource Type	No Action	Comanche North	Pueblo Dam South	JUP North	Pueblo Dam North	River South	Master Contract Only
Historic Properties							
Historic	3	14	31	24	24	22	3
Historic District	0	1	3	3	3	2	0
Contributing to a District	0	0	23	13	13	0	0
Archaeological	0	2	8	2	2	2	0
Total	**3**	**17**	**65**	**42**	**42**	**26**	**3**
Historic Properties Impacts Compared to No Action Alternative							
Historic	---	11	28	21	21	19	0
Historic District	---	1	3	3	3	2	0
Contributing to a District	---	0	23	13	13	0	0
Archaeological	---	2	8	2	2	2	0
Total	---	**14**	**62**	**39**	**39**	**23**	**0**

The No Action Alternative would disturb three properties listed, or eligible for listing, on the National Register of Historic Places, including La Junta's Lincoln House and Snyder House, and the route of the Santa Fe National Historic Trail. These properties could be disturbed by constructing pipelines and treatment facilities to supply water to regional participants.

The Comanche North Alternative would have a minor impact on historic properties. Listed, eligible, or potentially eligible properties impacted total 17 of the 35 cultural resources located in the area of potential effect. The historic properties include 14 historic sites, 1 historic district, and 2 archaeological sites. Resources include six structures; segments of six linear properties including portions of the Otero Canal, Bessemer Ditch, Santa Fe National Historic Trail, and Missouri Pacific Railroad; one segment of the Fort Lyon Canal; and the Atchison Topeka & Santa Fe Railroad. Of the six historic structures, three are listed on either the national or state registers, including the Boone and Manzanola Santa Fe Railroad depots and the Avondale Bridge. The San Juan Avenue Historic District in La Junta is also listed on the National Register of Historic Places. Archaeological resources include two prehistoric sites. Pipelines would be constructed mostly in roads or within road easements in Pueblo; therefore, impacts on buildings and structures would be temporary and indirect, such as from vibration. Stream crossings would not damage bridges.

Pueblo Dam South Alternative impacts on historic properties would be major. Impacted properties listed or properties considered eligible total 65 of 115 cultural resources in the area of potential effect. Historic resources include 8 historic structures (Hasty State Bank, Jackson Barn, Manzanola and Boone depots, St. Patrick’s Church and the Hart/Wilson House in La Junta, Swink Pump House, and the Huerfano Bridge), 3 historic districts, 30 buildings within the built environment of Pueblo that are either individually eligible or contribute to a historic district, 15 segments of linear resources such as railroads and the Bessemer Ditch, the route of the Santa Fe National Historic Trail, and 3 proposed historic districts. Two archeological sites on Bent’s Old Fort National Historic Site could be affected by pipeline construction depending on pipeline placement. Archaeological resources include five prehistoric sites, two historic sites, and the Robinson-Hadley town site. Listed resources include the Boone and Manzanola Santa Fe Railroad depots, St. Patrick’s Church, the Hart/Wilson House in La Junta, and the Huerfano Bridge.

The JUP North Alternative would have a major impact on historic properties compared to the No Action Alternative. Properties listed or properties considered eligible on the National Register of Historic Places impacted would total 42 of 89 total cultural resources in the area of potential effect. Historic resources include the 8 structures affected by the Pueblo Dam South Alternative, 16 linear segments of railroads or ditches, and the route of the Santa Fe National Historic Trail. The JUP North Alternative would affect 3 listed or potential historic districts (1 in La Junta and 2 in Pueblo), and 13 contributing buildings in Pueblo historic districts. Two prehistoric archaeological sites are also found within the area of potential effect. Listed properties include those under the Pueblo Dam South Alternative, and the Avondale Bridge and Pueblo’s First Presbyterian Church.

The Pueblo Dam North Alternative would have a major impact on historic properties. Properties listed or eligible for listing on the National Register of Historic Places total 42 of 98 cultural resources in the area of potential effect. Historic resources include the 8 structures affected by the Pueblo Dam South and JUP North alternatives, 15 linear segments of railroads or ditches, 13 buildings in Pueblo historic districts, the projected route of the Santa Fe Trail, and 3 listed or potential historic districts (1 listed La Junta district and 2 potential Pueblo districts). The prehistoric archaeological sites affected under the JUP North Alternative are also in the area of potential effect. Listed properties would be the same as those under the JUP North Alternative.

The River South Alternative would have a moderate impact on historic properties. Impacted properties listed or eligible for listing on the National Register of Historic Places total 26 out of 65 cultural resources located in the area of potential effect. Historic resources include the 8 structures listed under all previous alternatives, 12 linear segments of railroads or ditches, including the 8 Missouri Pacific segments and 1 Bessemer Ditch segment, the projected route of the Santa Fe Trail, and 2 historic districts (the potential East Corona Park District in Pueblo and the San Juan Avenue District in La Junta). Two prehistoric archaeological sites are also in the area of potential effect. Listed properties would be the same as those found under the JUP North Alternative. The River South Alternative proposed pumping plant is in the East Corona Park Historic District in Pueblo.

Master Contract Only Alternative impacts would be minor. The three properties listed or eligible for listing on the National Register of Historic Places are La Junta’s Lincoln House, Snyder House, and the route of the Santa Fe National Historic Trail. These properties could be disturbed by constructing pipelines and treatment facilities to supply water to regional participants.

Historic Property Potential for Unsurveyed Areas

The areas of potential effect may contain undocumented cultural resources, based on previously recorded cultural resources in the region, the geology, and unrecorded but known sites (ERO 2011a). Potential cultural resources include prehistoric archaeological sites; historic trails, roads, and railroads; and historic buildings and structures.

Prehistoric Archaeological Southern AVC pipeline routes cross more Holocene-age sediments than northern routes, and may contain more undocumented prehistoric sites. Evaluating the geology in the area of potential effect helps predict the likelihood of well-preserved, unrecorded buried sites. Intact buried sites are primarily preserved in Holocene-age sediments because prehistoric occupation mostly occurred during the Holocene Epoch (during the last 10,000 years). Most Pleistocene-age sediments (1.8 million to 10,000 years ago) predate human occupation and typically do not contain buried sites.

The southern routes (Pueblo Dam South, River South, and portions of Comanche North alternatives) primarily cross Holocene-age sediments, except Pleistocene-age sediments near La Junta. The northern routes (Comanche North, JUP North, and Pueblo Dam North alternatives) cross Pleistocene-age sediments from Pueblo to Fowler, Holocene-age sediments between Fowler and Las Animas, and Pleistocene-age sediments between Las Animas and John Martin Reservoir. East of John Martin Reservoir, all alternatives generally share the same alignment along Pleistocene-age sediments, except Holocene-age sediments existing near Dry Creek by Lamar.

The impacts analysis estimated about 75 cultural resources could be present along a pipeline route (not factoring existing towns and buildings), based on two comparable surveys conducted near the EIS study area (the Raton Expansion and Western Frontier pipeline projects). This estimate does not consider the number of cultural resources expected to be buried in Holocene-age landforms. No data exist from the EIS study area to predict the number of buried archaeological resources, although construction monitoring for the Raton Pipeline (which crosses the Arkansas River east of Pueblo) discovered 15 buried archaeological sites, including an isolated find with buried deposits (Anderson 2012). Thirty miles of pipeline corridor were subject to monitoring, indicating a buried archaeological site every two miles.

Historic Buildings and Structures The potential for unrecorded historic sites within the area of potential effect is medium to high, depending on if an alternative crosses built environments or parallels major highway corridors. Historic maps and Government Land Office records indicate several unrecorded historic road and trail segments and military and ranching structures in the Arkansas Valley.

Four unrecorded linear sites, such as trails, canals, or roads, were identified from the file search along the No Action Alternative: three unnamed road segments and one trail segment labeled "Las Animas City to Pueblo." The Comanche North, Pueblo Dam South, and River South alternatives have 18 unrecorded historic resources. The unrecorded resources consist of 15 linear sites: 14 roads that are unnamed or labeled "wagon road" and Fort Reynolds. The JUP North and Pueblo Dam North alternatives include four unrecorded road segments. The Pueblo Dam South, JUP North, Pueblo Dam North alternatives would cross existing towns and could indirectly affect unrecorded or unevaluated buildings, structures, and potential historic districts.

All alternatives could affect unknown cultural resources. As the above discussion demonstrates, an alternative may avoid existing towns and impacts on historic structures or buildings, but may affect archaeological resources along Holocene-age landforms with potential buried archaeological deposits. Holocene-age landforms are found predominately south of the Arkansas River. Since most, if not all, direct impacts on Pueblo historic buildings could be avoided, the northern alignments would affect archaeological historic properties less than southern alignments as more landforms are Pleistocene in age, and are less likely to contain buried archaeological deposits.

Impacts Associated with Reservoir Storage and Operation

Cultural resources in reservoirs could be affected by flooding, being buried in mud, erosion, perishable artifact loss, and unauthorized artifact collection. These impacts would be ongoing and minor reservoir level changes would not further affect these resources.

Pueblo Reservoir, Turquoise Lake, and Twin Lakes Impacts on cultural resources in Pueblo Reservoir, Turquoise Lake, and Twin Lakes would be negligible as a result of minimal changes to reservoir levels. A 2007 programmatic agreement between Reclamation and the State Historic Preservation Office provides for continued Section 106 compliance and impacts determination to cultural resources from Pueblo Reservoir, Turquoise Lake, and Twin Lakes operations and storage contracts (Reclamation 2007). All lands in Pueblo Reservoir, owned by Reclamation, or affected by dam operations, have been subject to full Section 106 compliance through inventory and resource evaluation. The State Historic Preservation Office provided a determination of "no adverse effect" to historic properties within and directly next to Pueblo Reservoir that could be affected by changes in reservoir operations, which would include projected changes of the alternatives. The programmatic agreement shows that Twin Lakes has been adequately surveyed but specifies a resurvey of Turquoise Lake because of the antiquity of the original survey. Resurveying would occur when funding permits and conditions are optimal (reservoir level is low).

Holbrook Reservoir, Meredith Reservoir, and Lake Henry Predicted reservoir storage in Holbrook Reservoir, Meredith Reservoir, and Lake Henry would have a negligible impact on cultural resources. Water levels in these reservoirs currently vary widely seasonally and annually and there would be no new impacts on cultural resources. There are currently no known cultural resources within or around the existing shorelines of these reservoirs (ERO 2006b).

John Martin Reservoir John Martin Reservoir level changes would negligibly affect cultural resources. Average monthly water levels would be about 1 foot higher than existing conditions under the No Action Alternative, while the action alternatives would increase water elevations another 6 inches. The projected slight increase in average water levels would not further affect cultural resources. The Corps, Albuquerque District, in consultation with the State Historic Preservation Office, would determine whether reservoir fluctuations have the potential to impact cultural resources within the maximum pool of John Martin Reservoir. Reclamation in consultation with the Colorado State Historic Preservation Office and the Corps would also review the adequacy of previous inventories and would determine whether additional work is necessary to evaluate potential effects.

Cumulative Impacts

Ground disturbance and construction activities associated with urban and suburban development could affect known or unknown historic properties. Identified reasonably foreseeable actions include ground-disturbing actions such as urban and suburban development, SDS construction, and the U.S. Highway 287 reroute around Lamar, Colorado. Population growth and development are common to all alternatives. Specific impacts on historic properties associated with development are unknown.

SDS facilities that overlap the alternatives would not contribute to cumulative cultural resource impacts. The SDS includes constructing a new Pueblo Reservoir outlet works. In addition, the SDS power line would cross the Bessemer Ditch, a historic property (ERO 2011b), and AVC pipeline alignments. The entire Pueblo Reservoir outlet area has been inventoried for cultural resources and no other potential historic properties except Bessemer Ditch are located within this area (Brandt et al. 2010). The SDS overhead power line would avoid the Bessemer Ditch.

The U.S Highway 287 reroute around Lamar could affect cultural resources. No project information is available on historic properties impacts; cumulative cultural resource impacts are unknown.

Climate change could affect reservoir levels and potentially expose previously inundated cultural sites to erosion.

Mitigation Measures

Compliance with Section 106 of the National Historic Preservation Act would be completed in accordance with the programmatic agreement. Section 106 would not apply to the No Action Alternative because the alternative does not involve a federal undertaking that would trigger the National Historic Preservation Act. Other state or local historic preservation laws may apply.

Reclamation, in consultation with the Colorado State Historic Preservation Office and multiple consulting parties including the National Park Service and certified local governments, prepared a project-specific programmatic agreement that outlines the Section 106 process, including the continued identification of historic properties within the preferred alternative (Appendix N). The agreement would also provide compliance measures for mitigating historic properties that would be affected by constructing the preferred alternative, if an action alternative is selected in the Record of Decision.

Key components of the programmatic agreement (Appendix N), include:

- Identification, documentation, evaluation, determination of effects of cultural resources in the project area
- Development of a treatment plan for unavoidable adverse effects on historic properties
- Protocols for addressing unanticipated discoveries
- Protocols for addressing inadvertent discovery of human remains
- Measures for the curation of collected archaeological materials
- Procedures for addressing disputes among signatories to the programmatic agreement

Indian Trust Assets

The federal Indian trust responsibility is a legal obligation under which the United States “has charged itself with moral obligations of the highest responsibility and trust” toward Indian tribes (*Seminole Nation v. United States* 1942). This obligation was first discussed by Chief Justice John Marshall in *Cherokee Nation v. Georgia* (1831). Over the years, the trust doctrine has been involved in other Supreme Court cases, making it a prominent principle in federal Indian law.

Summary

No Indian Trust Assets were identified in the study area and no effects would occur.

Methods

The federal Indian trust responsibility is a legally enforceable fiduciary obligation of the United States to protect tribal treaty rights, lands, assets, and resources, as well as a duty to carry out the mandates of federal law with respect to American Indian and Alaska Native tribes and villages. In several cases discussing the trust responsibility, the Supreme Court has used language suggesting that the trust responsibility entails legal duties, moral obligations, and the fulfillment of understandings and expectations that have arisen over the entire course of the relationship between the United States and federally recognized tribes.

Assets are anything owned that has monetary value. A legal interest refers to a property interest for which a legal remedy, such as compensation or injunction, may be obtained if there is improper interference. A trust has three components: the trustee, the beneficiary, and the trust asset. The beneficiary is also sometimes referred to as the beneficial owner of the trust asset. In the Indian trust relationship, the United States is the trustee and holds title to Indian Trust Assets for the benefit of a Native American tribe or nation or for an individual Native American. The U.S. Secretary of the Interior manages Indian Trust Assets in accordance with *Principles for the Discharge of the Secretary’s Trust Responsibility* (Department of the Interior 2000).

Assets could be real property, physical assets, or intangible property rights. Assets need not be owned outright, but could include other property interest, such as a lease or a right to use something. Assets cannot be sold, leased, or otherwise alienated without federal approval. While most trust assets are on Indian reservations, they could also be off reservations.

Reclamation contacted representatives of tribal groups with historical ties to the Arkansas River Basin and analyzed relevant treaties. Reclamation requested government-to-government consultation with the Tribes to identify any trust assets or treaty interests in the study area. Reclamation also contacted the Bureau of Indian Affairs Southern Plains, Rocky Mountain, and Southwest Regional Offices about the consultation and to request any comments regarding the proposed alternatives and potential effects to Indian Trust Assets.

Results

No Indian Trust Assets were identified in the study area. No effects would occur with any alternatives. No mitigation measures would be required to minimize effects on trust assets or other tribal resources. Coordination on tribal issues would continue among Reclamation, the State Historic Preservation Office, and interested tribes (see Chapter 4 – *Historic Properties*).

Other NEPA Required Disclosures

This section summarizes unavoidable adverse effects the alternatives would have on the resource areas evaluated in this EIS. The relationship between short-term uses and long-term productivity and the irreversible and irretrievable commitments of resources are also described.

Unavoidable Adverse Effects

Unavoidable adverse effects are environmental consequences of an action that cannot be avoided, either by changing the nature of the action or through mitigation if the action is undertaken. Only resources that would be adversely affected at a minor, moderate, or major level by the proposed action alternatives compared to the No Action are discussed in this section. There are no unavoidable adverse effects on groundwater hydrology, geomorphology, or Indian Trust Assets; thus, these resources are not included in this section.

Surface Water Hydrology

All alternatives would cause minor decreases in streamflow in the Upper Arkansas River Basin during some winter and spring months during normal and wet years due to changes in Fry-Ark reservoir storage volumes. Several alternatives would cause moderate streamflow decreases in one or two wet year months at the Lake Fork Creek below Sugar Loaf Dam and Lake Creek below Twin Lakes gages due to decreases in reservoir storage and spills

The Comanche North, Pueblo Dam South, JUP North, and Pueblo Dam North alternatives would cause a minor decrease in streamflow in Arkansas River flows through Pueblo based upon predicted annual average flows. The alternatives would affect streamflow by diverting water supplies into AVC and bypassing the Arkansas River, and/or by exchanging water into Master Contract excess capacity accounts. Occasional moderate decreases would occur downstream from Pueblo Reservoir during some winter and spring months in dry and normal years. During wet years, all alternatives except JUP North would cause minor to moderate increases in streamflow through Pueblo during some months. The JUP North Alternative typically would have less storage volume in Pueblo Reservoir before and during wet years and would release less from the reservoir.

The JUP North and Master Contract Only alternatives would cause occasional minor decreases in streamflow downstream from John Martin Reservoir.

Small increases in Fountain Creek streamflow for all alternatives except JUP North would cause minor effects, especially in winter and early spring months. These effects would increase in dry years, when winter and early spring effects would be moderate.

The JUP North Alternative would cause minor West Slope streamflow decreases in July and minor streamflow increases in August as a result of increased use of Fry-Ark allocations in this alternative, which would increase Boustead diversions earlier in the season during wet years to fill Fry-Ark storage space.

Occasional minor increases would occur in Turquoise Lake storage contents in wet and dry years for most alternatives compared to the No Action Alternative. The JUP North Alternative would cause minor decreases in Pueblo Reservoir storage contents, and the Master Contract Only

Alternative would cause minor increases. JUP North Alternative effects would increase in normal and dry years, when decreases in storage contents would be moderate. Holbrook Reservoir would have moderate decreases in storage contents for all alternatives except JUP North during normal and dry years

Water Quality

All alternatives except River South and Master Contract Only would have minor adverse effects in some months to water quality from total dissolved solids, selenium, and nutrient concentrations in the Lower Arkansas River Basin. Occasional moderate, adverse increases in total dissolved solids and selenium would occur in dry years. All alternatives except River South and Master Contract Only would have minor adverse effects in some months to water quality from sulfate and uranium concentrations in the Lower Arkansas River Basin.

Effects on La Junta's wastewater discharge permit would be minor adverse due to decreases in Arkansas River low flows.

The changes in Fountain Creek pumping patterns and return flows in all alternatives except JUP North would cause occasional minor, adverse increases in selenium.

Adverse effects on Pueblo Reservoir release temperatures for the JUP North Alternative would be minor. Lake Meredith, Lake Henry, and Holbrook Reservoir would have minor adverse effects on water quality from total dissolved solids and selenium concentrations in all alternatives. All alternatives except Master Contract Only would cause minor increases in Arkansas River salt loading from groundwater return flows.

Aquatic Life

The JUP North Alternative would decrease Pueblo Reservoir storage contents, elevation, and surface area throughout the year and would cause moderate adverse effects on habitat for spawning fish and overall fish habitat related to survival and growth. All alternatives except JUP North would result in moderate adverse effects to aquatic life for Holbrook Reservoir as a result of moderate decreases in storage, elevation, and surface area during June through November of normal and dry years.

Recreation

All action alternatives except Master Contract Only would cause the short-term displacement of recreational use along pipeline corridors and near other facilities. The Pueblo Dam North Alternative would moderately reduce recreation opportunities on trails through Pueblo and at the Nature and Raptor Center of Pueblo during the period of construction. The Comanche North Alternative would have short-term minor effects on City Park and the Elmwood Golf Course in Pueblo due to construction disturbance. The JUP North Alternative would cause minor reductions in recreational opportunities at Pueblo Reservoir because of reductions in reservoir levels. All alternatives except JUP North would have moderate adverse effects on recreation at Holbrook Reservoir.

Vegetation and Wetlands

Pipeline construction activities for most alternatives would have a short-term minor effect (not affect plant community viability) on upland vegetation present in eastern Colorado following restoration of disturbed areas.

The JUP North Alternative would cause the moderate loss of wetlands and waters of the United States and associated wetland functions and values. A short-term loss of wetland functions and values would occur between the time of loss and time the wetland mitigation sites offer the same functions and values. The remaining action alternatives, except Master Contract Only, would cause temporary minor effects on wetlands and riparian vegetation, although mitigation may reduce the effects.

Effects of the Comanche North, Pueblo Dam South, JUP North, and Pueblo Dam North alternatives on state plant species of concern would be moderate compared to the No Action Alternative because of temporary and permanent construction activities.

The JUP North and Master Contract Only alternatives would have minor effects on wetland and riparian vegetation from hydrologic changes in Pueblo Reservoir.

Wildlife

The triploid checkered whiptail, a state sensitive species, would experience minor effects from short-term pipeline construction under all alternatives. Pipeline construction for all alternatives would have minor effects on the roundtail horned lizard and common kingsnake populations, which are both state sensitive species. Proposed facility construction and hydrologic changes to streams and reservoirs would have a minor effect on known piping plover and least tern activity and habitat.

Human Environment

The Pueblo Dam South, JUP North, and Pueblo Dam North alternatives would cause an unavoidable moderate increase in noise levels during construction through Pueblo. The Comanche North and River South alternatives would have minor noise effects. Increased noise levels around some alternatives' components, such as pump stations and water treatment plants, would continue through the planning period; such noise may not be audible beyond the facility's property boundary. Vibration would be felt close to construction equipment, a minor effect, for the Pueblo Dam South, JUP North, and Pueblo Dam North alternatives. Mitigation may lessen these noise and vibration effects.

All alternatives except Master Contract Only would have a minor effect on the visual landscape from constructing permanent, man-made forms, such as water treatment plants, pump stations, and other facilities.

The Pueblo Dam South, JUP North, and Pueblo Dam North alternatives would cause a short-term, moderate increase in traffic volumes during construction because of the pipeline alignment through Pueblo. The Comanche North and River South alternatives would cause minor traffic disruptions during construction. The JUP North and Pueblo Dam North alternatives would result in minor effects on utilities in Pueblo during construction. Mitigation may lessen traffic and utility disruption effects.

The Pueblo Dam South, JUP North, and Pueblo Dam North alternatives would cause a moderate effect to land use in Pueblo County because of the pipeline alignment through Pueblo. The Comanche North and River South alternatives would cause minor land use effects during construction.

Historic Properties

All alternatives may adversely impact resources listed or eligible for listing in the National Register of Historic Places. The number, type, and location of affected resources would vary by alternative, but the Pueblo Dam South, JUP North, and Pueblo Dam North alternatives' impacts would be major, while the River South Alternative would have moderate impacts, and Comanche North and Master Contract Only would have minor impacts. Mitigation may lessen the extent of historic properties impacts.

Relationship Between Short-term Uses and Long-term Productivity

The relationship between short-term environmental uses and maintenance and enhancement of long-term productivity is similar for all alternatives. All alternatives would enhance long-term productivity by supplying water meeting current primary drinking water standards throughout the contract period to AVC participants. This would reduce long-term exposure to radionuclides by residents within communities that currently have radionuclide levels exceeding primary drinking water standards. This reduction in long-term exposure could decrease the residents' risk of cancer. Meeting primary drinking water standards would also permanently address current water quality enforcement actions by the Health Department for these 12 communities (as noted in Chapter 1, 14 communities have been place under enforcement action in the past for radionuclides; however, Hancock, Inc. and Homestead Improvement Association have addressed radionuclide issues).

All alternatives that include AVC, except the River South Alternative, would enhance long-term productivity of AVC participants by providing a water supply that meets all existing secondary drinking water standards, including those for total dissolved solids. This would improve the taste and clarity of water supplies, and extend the life of plumbing, appliances, and fixtures. The No Action and Master Contract Only alternatives would continue using existing water supplies, most of which do not meet secondary drinking water standards for total dissolved solids. The River South Alternative includes AVC, but would divert water from a location in the Arkansas River that does not reliably meet secondary drinking water standards for total dissolved solids.

All alternatives that include AVC would increase the use of surface water supplies, a renewable resource, to meet existing and future water supply needs. The No Action and Master Contract Only alternatives would use higher amounts of Dakota-Cheyenne aquifer groundwater, which is a nonrenewable resource. The alternatives that include AVC would continue to use some Dakota-Cheyenne aquifer groundwater, but at a much lower rate. In all alternatives, water from the Arkansas River would be used beneficially, either directly or as well augmentation for municipal water systems in the Arkansas River Basin. This long-term environmental productivity would continue through the contract period.

All alternatives that include the Master Contract would enhance long-term productivity by providing the Participants with additional storage capacity to meet existing and future water supply needs. The No Action and JUP North alternatives do not include the Master Contract.

For these alternatives, participants would continue to apply for short-term excess capacity storage contracts to store water in Pueblo Reservoir.

All alternatives that include the Interconnect would enhance long-term productivity by providing Interconnect participants with redundancy to water conveyance systems. The No Action, Pueblo Dam South, River South, and Master Contract Only alternatives do not include the Interconnect and thus would not have redundancy in water conveyance systems.

Short-term and long-term environmental uses are discussed in Chapter 4 sections for each resource.

Irreversible and Irretrievable Commitments of Resources

NEPA requires that the environmental analysis identify "any irreversible and irretrievable commitment of resources which would be involved in the proposed action should it be implemented." Reclamation interprets this to mean the use of nonrenewable resources and the effects this would have for the future, such as the destruction of cultural resources, and the loss of production or use of natural resources. These losses are discussed in the previous sections of this chapter.

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Chapter 5 Consultation and Coordination

This chapter describes public involvement activities, agency consultation and coordination, and acknowledges the people involved with this NEPA process.

Public Involvement Program

Photo 5–1. Reclamation Team Leader Signe Snortland answers questions and receives comments at a scoping meeting in Lamar in August 2010

Scoping is an important part of the NEPA process. It serves as the public's opportunity to provide insight and direction to an EIS during its preparation. In 2010, Reclamation began a public involvement program to offer the public, organizations, and governmental agencies multiple ways to learn about and participate in this EIS.

The public involvement process includes the following tasks, several of which are described in this chapter:

- Publishing a Notice of Intent in the *Federal Register* (Reclamation 2010e)
- Holding five formal public scoping meetings in the area potentially affected by the proposed actions
- Preparing and distributing a December 2010 Public Scoping Report (Reclamation 2010d)
- Meeting with federal, state, regional, and local governmental agencies
- Mailing scoping information to agencies, tribes, and the public
- Forming a Cooperating Agency Team
- Issuing news releases and study updates
- Creating and disseminating information and updates via a Web site dedicated to the EIS (www.usbr.gov/avceis).
- Publishing and distributing periodic newsletters – purpose and need (December 2010), alternatives (October 2011), and preferred alternative (June 2013)
- Publishing a Notice of Availability for the Draft EIS in the *Federal Register* (Reclamation 2012d)
- Holding five formal public hearings in the area potentially affected by the proposed actions
- Preparing and distributing responses to public comments as part of this Final EIS (See Appendix P.1)
- Publishing a Notice of Availability for the Final EIS in the *Federal Register* (Reclamation 2013b)

Notice of Intent

A scoping notice was prepared to distribute information to the public on the proposed actions and allow people to express their thoughts and comments. The notice announced the intent to prepare a draft EIS and was published in the July 30, 2010, *Federal Register,* Volume 75, Number 146:44983. The notice summarized the proposed actions, described additional background information, and listed preliminary relevant and significant environmental issues. Dates and locations of public scoping meetings were identified in advance. In addition to publication in the *Federal Register*, a letter from Reclamation inviting participation in the NEPA process and the scoping notice were mailed on August 3, 2010, to about 400 individuals, agencies, Indian tribes, and organizations. The scoping notice was used to solicit initial comments on the proposed actions.

Public Scoping Meetings

The intent of the public scoping meetings was to inform people about the proposed actions and to identify key issues. In addition to the *Federal Register* notice, Reclamation distributed news releases to 231 local and regional news media outlets, governmental agencies and officials, and other potentially interested parties announcing the series of public meetings. The locations and dates for these meetings were as follows:

- Salida, Colorado August 16, 2010
- La Junta, Colorado August 17, 2010
- Lamar, Colorado August 18, 2010
- Fountain, Colorado August 19, 2010
- Pueblo, Colorado August 19, 2010

Photo 5–2. The scoping meeting in La Junta was held at the Koshare Indian Museum

The scoping period ended September 13, 2010. During the public scoping, a total of 10 letters and e-mails were received in addition to oral comments at five public scoping meetings. A total of 167 comments were recorded and grouped into 22 issue categories. All comments were reviewed and compiled in the *Public Scoping Report, Arkansas Valley Conduit and Long-Term Excess Capacity Master Contract Environmental Impact Statement Fryingpan Arkansas Project, Colorado* (Reclamation 2010d), which is available on the EIS Web site.

Cooperating Agency Team

Reclamation established a Cooperating Agency Team to facilitate communication among federal, state, regional, and local agencies. Cooperating agencies provided information based on their special expertise or jurisdiction related to the proposed actions, assisted with analyses, and reviewed draft EIS chapters and analyses. The following organizations and their representatives participated as cooperating agencies (Table 5–1).

Table 5–1. Cooperating Agency Team Representatives

Cooperating Agency	Representative
Bent County	Frank Bryant, Board of Commissioners
	Bill Long, Board of Commissioners
Board of Water Works of Pueblo	Terry Book, Executive Director
	Lee Huffstutter, Division Manager for Transmission, Distribution and Engineering
City of Pueblo	Scott Hobson, Assistant City Manager
	Greg Styduhar, Assistant City Attorney
Colorado Department of Natural Resources	Rebecca Mitchell, Water Policy and Issues Coordinator (now Section Chief for Water Supply Planning for Colorado Water Conservation Board)
Colorado Department of Transportation (Region 2)	Craig Clark, Environmental Project Manager
	Don Garcia, Project Manager
	Lisa Streisfield, Planning and Environmental Manager
	Joe Trevizo, Utilities Engineer
Colorado Division of Parks and Wildlife	Paul Foutz, Native Aquatic Species Biologist, Southeast Region
	Brad Henley, Lake Pueblo State Park Manager
	Doug Krieger, Senior Aquatic Biologist
	Dave Lovell, Assistant Regional Manager, Southeast Region
Colorado Division of Water Resources	Mary Halstead, Chief of Modeling and Decision Support Systems
	Dale Straw, Water Resources Engineer (Retired)
	Bill Tyner, Assistant Division Engineer, Division 2
	Steve Witte, Division Engineer, Division 2
Federal Highway Administration (not a cooperating agency, but requested project updates)	Douglas Bennett, Acting Division Administrator
Fountain Creek Watershed and Flood Control District	Rich Muzzy, Pikes Peak Area Council of Governments Environmental Planning Program Manager
Kansas Division of Water Resources	David Barfield, Chief Engineer
	Chris Beightel, Program Manager, Water Management Services
	Rachel Duran, Environmental Scientist
	Kevin Salter, Interstate Water Engineer
Lower Arkansas Valley Water Conservancy District	Jay Winner, General Manager
Otero County	Jim Baldwin, County Commissioner
	Bryan Bryant, County Economic Development Coordinator
	Keith Goodwin, County Commissioner
	Jean Hinkle, County Administrator
	Kevin Karney, County Commissioner
Prowers County	Jo Dorencamp, County Administrator
	Henry Schnabel, County Commissioner
Pueblo County	Joan Armstrong, Planner
	Ray Petros, Attorney
Southeastern Colorado Water Conservancy District (Southeastern)	Jim Broderick, Executive Director
	Bob Hamilton, Director of Engineering and Resource Management
	Kevin Meador, Project Engineer
	Jean Van Pelt, Project – Program Coordinator
Town of Lamar (not a cooperating agency, but attended meetings)	Josh Cichocki, Water Department Director
Town of Swink (not a cooperating agency, but attended meetings)	Rick Dell, Public Works Director

Table 5–1. Cooperating Agency Team Representatives (continued)

Cooperating Agency	Representative
U.S. Army Corps of Engineers (Albuquerque District) (Corps)	Joshua Carpenter, Environmental Specialist
	Jeremy Decker, Archaeologist
	Karen Downey, Operations Manager
	Gregory Everhart, Archaeologist
	Dana Price, Botanist
	Van Truan, Southern Colorado Regional Division Branch Chief
	Jonathan Van Hoose, Archaeologist
U.S. Environmental Protection Agency (Region 8) (EPA)	Suzanne Bohan, NEPA Program Director
	Julie Kinsey, TMDL Specialist
	Maggie Pierce, NEPA Compliance and Review
	Brent Truskowski, Ecosystems, Wetlands and Watersheds Program Unit
	Melanie Wasco, NEPA Compliance and Review
U.S. Fish and Wildlife Service	Susan Linner, Colorado Field Supervisor
	Brian Sanchez, Fish and Wildlife Biologist

The purpose of the Cooperating Agency Team meetings, agencies involved, and meeting dates and locations are listed in Table 5–2.

Table 5–2. Cooperating Agency Team Meetings

Purpose/Description	Participants	Date	Location
Overview of proposed actions and questions and comments from cooperating agencies	City of Pueblo, Colorado Department of Natural Resources, Colorado Division of Parks and Wildlife, Corps, EPA, Fountain Creek Watershed and Flood Control District, Kansas Division of Water Resources, Pueblo County, Reclamation, Representative for Senator Michael Bennet, Southeastern	8/17/10	Meeting – Southeastern (Pueblo)
Discuss memorandums of agreement, scoping process comments, methods of study and general comments from agencies. Review alternatives with the Colorado Department of Transportation.	City of Pueblo, Colorado Department of Transportation, Colorado Division of Parks and Wildlife, Corps, Kansas Division of Water Resources, Lower Arkansas Valley Water Conservancy District, Pueblo County, Southeastern	11/9/10	Meeting – Southeastern (Pueblo)
Review changes to the work plan, and present proposed actions and purpose and need, alternatives, and hydrologic modeling methods	Bent County, Board of Water Works of Pueblo, City of Pueblo, Colorado Department of Transportation, Colorado Division of Parks and Wildlife, Corps, EPA, Kansas Division of Water Resources, Pueblo County, Otero County, Reclamation, Southeastern	1/10/11	Meeting – Southeastern (Pueblo)
Review responses to comments on draft AVC EIS sections, and distribute additional draft EIS sections and appendixes	City of Pueblo, Colorado Department of Natural Resources, Colorado Department of Transportation, Colorado Division of Parks and Wildlife, Corps, EPA, Kansas Division of Water Resources, Pueblo County, Otero County, Reclamation, Southeastern, Town of Swink	5/17/11	Meeting – Southeastern (Pueblo)
Review and feedback on previous comments, introduce draft AVC EIS Chapter 3, and overview of hydrologic model results.	Bent County, Colorado Department of Transportation, Colorado Division of Parks and Wildlife, Corps, EPA, Kansas Division of Water Resources, Pueblo County, Reclamation, Southeastern	10/19/11	Meeting – Southeastern (Pueblo)
Review and feedback on previous comments, introduce draft AVC EIS Chapter 4	City of Pueblo, Colorado Department of Transportation, Colorado Division of Parks and Wildlife, Corps, EPA, Kansas Division of Water Resources, Reclamation, Southeastern	5/15/12	Meeting – Southeastern (Pueblo)

Table 5–2. Cooperating Agency Team Meetings (continued)

Purpose/Description	Participants	Date	Location
Review and feedback on agency Draft EIS comments	Board of Water Works of Pueblo, City of Lamar, City of Pueblo, Colorado Department of Transportation, Colorado Division of Parks and Wildlife, Corps, EPA, Kansas Division of Water Resources, Pueblo County, Reclamation, Southeastern	1/29/2013	Meeting – Southeastern (Pueblo)
Review and feedback on responses to agency Draft EIS comments	Board of Water Works of Pueblo, City of Pueblo, Colorado Department of Transportation, Colorado Division of Parks and Wildlife, Corps, EPA, Kansas Division of Water Resources, Otero County, Pueblo County, Reclamation, Southeastern, U.S. Fish and Wildlife Service	3/25/2013	Conference Call
Review and feedback on agency draft Final EIS comments and responses	Board of Water Works of Pueblo, Colorado Division of Parks and Wildlife, Corps, EPA, Pueblo County, Reclamation, Southeastern	6/21/2013	Meeting – Southeastern (Pueblo)

Web site

A Web site (www.usbr.gov/avceis) was created to post information about the proposed actions and the NEPA process (Figure 5–1). The Web site included answers to frequently asked questions, newsletters, and served as a mechanism for the public to ask questions, submit comments, and/or be added to the mailing list. The Draft EIS, this Final EIS, all associated appendixes, and the executive summary are also available for viewing or downloading.

Newsletter

Three newsletters were distributed during the EIS phase to more than 490 entities on the mailing list, and made available on the EIS Web site. The first newsletter, published in December 2010 (Reclamation 2010g) (Figure 5–2), presented background information on the proposed actions and gave dates for public scoping meetings. It also described the purpose of and need for the EIS, identified known issues and concerns, and outlined the process to be used in preparing the EIS. Published in October 2011 (Reclamation 2011f), the second newsletter focused primarily on the seven alternatives identified for detailed analysis in the EIS and information about next steps in the EIS process. The third newsletter was published in June 2013 and presented information on the preferred alternative identified in the Final EIS (Reclamation 2013c).

Draft EIS Notice of Availability

An availability notice was prepared to distribute information to the public on the Draft EIS, public comment period, and public hearings. The notice announced the availability of the Draft EIS and was published in the August 29, 2012, *Federal Register*, Volume 77, Number 168:52365. The notice summarized the proposed actions and purpose and need. The notice identified the public comment period and dates and locations of public hearings, and solicited public comments on the Draft EIS.

Public Hearings

The intent of the public hearings was to inform people about the proposed actions and solicit verbal or written public comments on the Draft EIS. The locations and dates for these meetings were as follows:

- Salida, Colorado September 24, 2012 (evening)
- Pueblo, Colorado September 25, 2012 (afternoon)
- Pueblo, Colorado September 25, 2012 (evening)
- La Junta, Colorado September 26, 2012 (evening)
- Lamar, Colorado September 27, 2012 (evening)

The public comment period ended October 30, 2012. During the public comment period, a total of 27 letters and e-mails were received in addition to oral comments at the five public hearings. A total of 200 comments were recorded and grouped into 18 issue categories. All comments were given due consideration and compiled in Appendix P.1.

Figure 5–1. Arkansas Valley Conduit Web Site Homepage

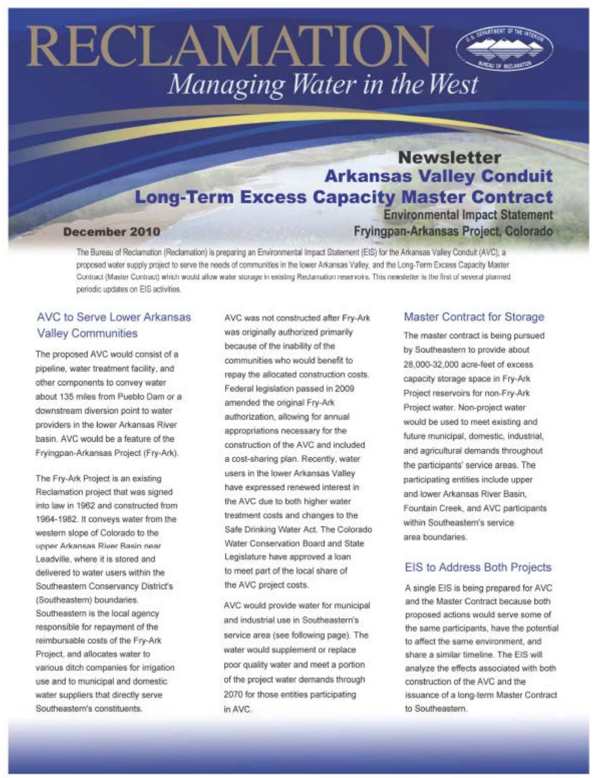

Figure 5–2. December 2010 Newsletter Coverpage

Resource Team

A Resource Team was formed to assist Reclamation in developing plans of study, performing technical evaluations, and evaluating alternatives. Information gathered by the team was used to prepare the EIS. The purpose of these meetings, participants involved, and meeting dates and locations are listed in Table 5–3. The Resource Team comprised staff from Reclamation's Dakotas Area Office, Great Plains Regional Office, Eastern Colorado Area Office, Pueblo Field Office, and Technical Services Center, Southeastern, and a consulting team hired by Reclamation to assist in preparing the EIS.

Table 5–3. Resource Team Meetings

Topics	Participants	Date	Method
Miscellaneous			
Weekly EIS Team conference calls – project management, coordination, and progress	Reclamation, Southeastern, Consulting Team	4/29/10 – 8/6/13	Conference call
Presentation of scoping report to Compact Administration	Reclamation, Southeastern	12/14/10	Meeting
AVC repayment and operations, maintenance, and replacement issues	Reclamation, Southeastern	2/8/11	Meeting
Appraisal level report	Reclamation, Southeastern	1/20/12	Conference call
Purpose and Need			
Purpose and need, No Action Alternative, screening level criteria for alternatives	Reclamation, Southeastern, Consulting Team	7/28/10	Meeting
Current Southeastern planning activities, water conservation plan	Southeastern, Consulting Team	8/17/10	Meeting
EIS overview, Master Contract questionnaire, contracting process and schedule.	Reclamation, Southeastern, Cañon City, Penrose, Widefield, Security, Fountain, Stratmoor Hills, Consulting Team	9/1/10	Meeting
EIS overview, Master Contract questionnaire, contracting process and schedule.	Southeastern, Salida, St. Charles Mesa Water District, Pueblo West Metropolitan District, La Junta, Poncha Springs, Consulting Team	9/10/10	Meeting
EIS overview, Master Contract questionnaires	Southeastern, Consulting Team	10/27/10	Meeting
Interconnect kickoff meeting with participants	Reclamation, Southeastern, Fountain Valley Authority, Colorado Springs Utilities, Pueblo West, Fountain, Board of Water Works of Pueblo, Consulting Team	11/9/10	Meeting
Interconnect purpose and need, engineering	Reclamation, Southeastern, Consulting Team	1/10/11	Meeting
EIS overview, participant information	AVC Participants, Southeastern, Consulting Team	1/25/11	Meeting
Master Contract progress, contracting	Reclamation, Southeastern, Master Contract Participants	2/22/11	Meeting
Interconnect purpose and need, engineering	Reclamation, Southeastern, Interconnect Participants	3/10/11	Meeting
Alternatives – General			
Alternatives screening process, AVC routes and alignments	Reclamation, Consulting Team	10/22/10	Meeting
Screening alternatives process	Reclamation, Consulting Team	11/8/10	Meeting
Engineering and costs	Southeastern, Reclamation, Consulting Team	2/6/12	Meeting
Engineering and costs	Southeastern, Reclamation, Consulting Team	12/20/12	Meeting

Table 5–3. Resource Team Meetings (continued)

Topics	Participants	Date	Method
Engineering/Water Treatment			
Engineering quantity and cost estimation for alternatives, project schedule	Reclamation, Southeastern, Consulting Team	8/31/10	Conference call
Coordination with CDOT U.S. Highway 50 Tier 1 EIS	Colorado Department of Transportation, Southeastern, Reclamation, Consulting Team	9/1/2010	Meeting
EIS progress, appraisal level tasks, alternatives	Reclamation, Southeastern , Consulting Team	9/17/10	Meeting
Biweekly Engineering Team conference calls – Project management, coordination and progress	Reclamation, Southeastern, Consulting Team	9/23/10 – 7/21/11	Conference call
AVC overview, AVC alternatives and operations, and existing Health Department enforcement orders	Health Department, Consulting Team	9/24/10	Meeting
AVC EIS overview, data and analysis methods, water treatment, and current participant water quality mitigation	Health Department, Reclamation, Southeastern, Consulting Team	11/4/10	Meeting
AVC alternatives, demands, appraisal study requirements	Reclamation, Southeastern, Consulting Team	12/1/10	Meeting
AVC EIS status, water treatment requirements	Reclamation, Health Department, Southeastern, Consulting Team	12/22/10	Meeting
Appraisal study, pipeline alignments	Reclamation, Consulting Team	7/26/11	Meeting
Water treatment engineering kickoff meeting	Reclamation, Consulting Team	8/17/11	Meeting
Health Department review process, AVC disinfection strategies, and No Action Alternative	Reclamation, Health Department, Southeastern, Consulting Team	9/13/11	Meeting
Project and schedule update	Reclamation, Consulting Team	10/7/11	Conference call
Draft No Action Alternative and water treatment appraisal analysis	Reclamation, Southeastern, Consulting Team	12/5/11	Meeting
Coordination with CDOT U.S. Highway 50 Tier 1 EIS	Colorado Department of Transportation, Southeastern, Reclamation, Consulting Team	5/15/12	Meeting
Coordination with CDOT U.S. Highway 50 Tier 1 EIS	Colorado Department of Transportation, Southeastern, Reclamation, Consulting Team	7/10/12	Meeting
Review of water treatment plant comments and responses	Reclamation, Southeastern, Board of Water Works of Pueblo, Consulting Team	1/29/13	Meeting
Review of water treatment plant comments and responses	Reclamation, Southeastern, Board of Water Works of Pueblo, Consulting Team	2/20/13	Meeting
Comanche North Appraisal Level Report	Reclamation, Board of Water Works of Pueblo, Consulting Team	5/28/13	Conference Call
Resources – Aquatics			
Project overview, review existing data	Colorado Division of Parks and Wildlife, Service, Consulting Team	6/8/10	Meeting
Initial hydrologic assessment, aquatic resources work plan	Reclamation, Colorado Division of Parks and Wildlife, Consulting Team	11/17/10	Meeting
Resources – Climate Change			
AVC EIS climate change approach	Reclamation, Consulting Team	5/21/10	Conference call
Climate change data and methods	Reclamation, Consulting Team	5/16/11	Meeting
AVC EIS climate change approach	Reclamation, Consulting Team	12/22/11	Conference call
AVC EIS climate change approach	Reclamation, Consulting Team	1/11/12	Conference call
AVC EIS climate change approach	Reclamation, Consulting Team	6/5/12	Conference call
AVC EIS climate change approach	Reclamation, Consulting Team	7/20/12	Conference call

Table 5–3. Resource Team Meetings (continued)

Topics	Participants	Date	Method
Resources – Cultural Resources			
Programmatic agreement and data needs	Reclamation, Consulting Team	5/9/11	Conference call
Cultural resource survey strategies, right-of-entry and state historic preservation coordination	Reclamation, Consulting Team	1/18/12	Conference call
State Historic Preservation Office Programmatic Agreement	Reclamation, SHPO, Corps, Consulting Team	2/28/12	Meeting
State Historic Preservation Office Programmatic Agreement	Reclamation, SHPO, Consulting Team	12/28/13	Conference Call
State Historic Preservation Office Programmatic Agreement	Reclamation, SHPO, National Park Service, Consulting Team	3/11/13	Conference Call
State Historic Preservation Office Programmatic Agreement	Reclamation, SHPO, National Park Service, Consulting Team	Various	Email Coordination
Resources – Hydrologic Modeling			
Hydrologic modeling options	Reclamation, Consulting Team	7/8/10	Conference call
Scope of work for groundwater hydrology and crop yield modeling	Colorado State University, Consulting Team	8/27/10	Meeting
Assumptions regarding Super Ditch scope and operation	Reclamation, Lower Arkansas Valley Water Conservancy District, Southeastern, Consulting Team	1/27/11	Meeting
Daily model presentation and discussion of Fry-Ark and AVC operations	Southeastern, Reclamation, Consulting Team	2/28/11	Meeting
Fry-Ark supplies, storage and demand, daily model and AVC yield analysis	Reclamation, Southeastern, Consulting Team	5/17/11	Meeting
AVC yield analysis	Reclamation, Southeastern, Consulting Team	6/16/11	Conference call
Modeling documentation and draft results	Reclamation, Southeastern, Consulting Team	9/12/11	Meeting
Setup, assumptions, and results of the Arkansas River Daily Model analysis	Reclamation, Kansas Division of Water Resources, Colorado State Engineer's Office, Consulting Team	10/18/11	Meeting
Follow-up on Draft EIS comments	Reclamation, EPA, Southeastern, Consulting Team	11/19/12	Meeting
Resources – Water Quality			
Water quality analysis coordination meetings	Colorado State University, Consulting Team	1/4/2011 – 2/17/2011	Meeting, conference call
Water quality methods	Colorado State University, Reclamation, Consulting Team	7/27/11	Meeting
Preliminary hydrology results, water quality and climate change methods	Reclamation, EPA, Consulting Team	9/1/11	Meeting
Follow-up on Draft EIS comments	Reclamation, City of Pueblo, Southeastern, Consulting Team	11/20/12	Meeting
Follow-up on Draft EIS comments	Reclamation, EPA, Southeastern, Consulting Team	12/18/12	Conference Call
Follow-up on Draft EIS comments	Reclamation, City of Pueblo, Southeastern, Consulting Team	1/29/13	Meeting
Resources – Wildlife			
Project overview	Colorado Division of Parks and Wildlife, Reclamation, Consulting Team	11/18/10	Conference call
John Martin Reservoir wildlife	Corps, Reclamation, Consulting Team	5/13/12	Conference Call

Table 5–3. Resource Team Meetings (continued)

Mitigation			
Fish and Wildlife Coordination Act Report	Colorado Division of Parks and Wildlife, U.S. Fish and Wildlife Service, Reclamation, Consulting Team	5/30/12	Meeting
Fish and Wildlife Coordination Act Report	Reclamation, Southeastern, Consulting Team	12/7/12	Conference Call
Fish and Wildlife Coordination Act Report	Colorado Division of Parks and Wildlife, U.S. Fish and Wildlife Service, Reclamation, Southeastern, Consulting Team	1/25/13	Conference Call
Fish and Wildlife Coordination Act Report	Colorado Division of Parks and Wildlife, Reclamation, Southeastern, Consulting Team	3/7/13	Conference Call
Fish and Wildlife Coordination Act Report	Colorado Division of Parks and Wildlife, Reclamation	5/16/13	Conference Call
Local Permitting	Pueblo County, Reclamation	7/16/13	Conference Call

Federal, State, and Tribal Consultation and Coordination

Consultation and coordination are closely related to scoping and public involvement because these processes integrate the provisions of other environmental statutes and the needs of interested parties. This section describes consultation activities conducted during this EIS and additional coordination and compliance with applicable laws, regulations, and policies.

Endangered Species Act Consultation

Federal agencies are required to consult with the U.S. Fish and Wildlife Service under Section 7 of the federal Endangered Species Act when federally listed species may be affected by an agency action. To initiate the process, Reclamation obtained a list of species from the U.S. Fish and Wildlife Service that may be found in the study area and could be affected by the alternatives. Reclamation then narrowed this list based on the water-based and land-based affected environment. Reclamation transmitted a letter to the U.S. Fish and Wildlife Service on February 4, 2011, identifying a list of threatened, endangered, proposed, and candidate species, and designated or proposed critical habitats that may occur in the study area. U.S. Fish and Wildlife Service concurred with this list in a response to Reclamation on March 8, 2011. Reclamation continued consultation with the U.S. Fish and Wildlife Service on May 30, 2012, to discuss potential effects to federally listed species and preparation of a Biological Assessment. Effects on the identified species are described in Chapter 4 and the Biological Assessment is in Appendix O.1.

Native American Consultation

In accordance with NEPA and related laws, regulations, and policies, Reclamation identified 24 tribes within the Arkansas River Basin who are culturally affiliated with the study area. Appendix M.1 lists tribes located in the area of potential effect and correspondence with these tribes. Comments from tribes were solicited during the scoping process. Reclamation requested that the tribes identify any Indian Trust Assets that could be affected by the proposed actions and invited the tribes to meet and consult on effects (Reclamation 2011g). No tribes responded to this request for continuing direct consultations. Some tribes requested to be kept informed as the process moved forward, and some did not respond.

As alternatives were developed, Reclamation transmitted another letter to the tribes further describing the proposed actions and transmitting the Class I cultural resource report for the area of potential effect (Reclamation 2012e). The tribes were sent a copy of the Draft EIS for review and comment. Reclamation will continue government-to-government consultation with the tribes as the AVC EIS progresses. The Final EIS was sent to the identified tribes.

National Historic Preservation Act Consultation

As a part of identifying historic properties under Section 106 of the National Historic Preservation Act, consultation was initiated with the Colorado State Historic Preservation Office. Additionally, through letters sent to tribes regarding Indian Trust Assets and follow-up letters sent to tribes at the request of the Colorado State Historic Preservation Office, the Cheyenne and Arapahoe tribes of Oklahoma requested additional information. Reclamation will continue government-to-government consultation with the tribes who are culturally affiliated with the study area throughout the EIS process. Tribes have been afforded an opportunity to comment on defining the area of potential effect, invited to be consulting parties and will be afforded an opportunity to review and comment on the cultural resource survey results and any potential mitigation efforts, including development of treatment plans.

Reclamation prepared and transmitted a Class I report (file search) to the Colorado State Historic Preservation Office and 24 tribes and formally initiated consultation on November 4, 2011. A project-specific programmatic agreement, which describes the procedures that will be used for Section 106 compliance during AVC design, construction, and operation, is in Appendix N.1. Reclamation consulted with local and county historic preservation advisory boards during the Section 106 compliance process to further identify potential historic properties. Consulting parties to the executed programmatic agreement include Bent, Kiowa, and Otero counties. The National Park Service is a signatory and consulting party to the agreement. Reclamation has also consulted with the Colorado Department of Transportation and Corps, Albuquerque District, as part of the Section 106 process. Further information on historic properties is in Chapter 4 and the programmatic agreement is in Appendix N.1.

Coordination and Compliance with Other Applicable Laws, Regulations, and Policies

Analyzing and implementing the proposed actions requires consistency, coordination, and compliance with applicable laws, regulations, executive orders, and policies.

Federal Laws, Regulations, and Policies

The following federal laws, regulations, and policies have known application to the proposed actions.

Archaeological Resource Protection Act of 1979   This act protects archaeological resources on federal and tribal lands and requires a permit for removing archaeological resources from these lands. Permits may be issued to educational or scientific institutions only if the removal would increase knowledge about archaeological resources. Project-level compliance with this law would be accomplished through specific environmental commitments for the action alternatives.

Arkansas River Compact Interstate compacts apportion water that can be used by each state from a particular river system. The Compact between Kansas and Colorado apportioned the available water supply and John Martin Reservoir conservation benefits by its provisions. Related to the conservation benefits of John Martin Reservoir, either state could call against the conservation pool up to a certain maximum release rate. These calls were independent of each other, and theoretically one state could release the entire conservation pool without the other state placing a call. This method of "sharing" the conservation pool created inefficiencies that were recognized by both states. In 1980, the Compact Administration adopted a Resolution Concerning an Operating Plan for John Martin Reservoir (a.k.a. the 1980 Operating Plan) which created a system of accounts in John Martin Reservoir, including accounts for water derived from pre-Compact Colorado water rights.

Photo 5–3. John Martin Dam

Under the 1980 Operating Plan, inflows into John Martin Reservoir that are stored in Compact conservation storage are ultimately divided 60 percent to Colorado and 40 percent to Kansas. These inflows include streamflow of the Arkansas and Purgatoire rivers, ungaged inflows, and precipitation directly on the reservoir during periods of Compact conservation storage. When the reservoir is not in Compact conservation storage, inflows, to the extent practical, are measured and released from the reservoir without temporary storage or averaging flows. Water delivered to the permanent pool and offset account does not accrue to Compact conservation storage. Water may also be delivered to John Martin Reservoir under the Pueblo Winter Water Storage Program and the Amity Canal Great Plains water rights.

During times when John Martin Reservoir is not in conservation storage, Colorado is to operate under its prior appropriation system. Kansas is entitled to those flows present at the Colorado-Kansas state line under these conditions. This includes water passed through John Martin Reservoir in excess of District 67 irrigation demands and irrigation return flows. Colorado's Compact compliance with respect to groundwater pumping is evaluated using the annual updates of the H-I Model as required by the United States Supreme Court's approval of the stipulated final decree in Kansas v. Colorado (No. 105 Original), 556 U.S. 98 (2009).

Colorado and Kansas have been in litigation before the U.S. Supreme Court regarding the Arkansas River. The first case was brought in 1902. In a subsequent litigation, the U.S. Supreme Court encouraged the States to form an interstate compact (Colorado v. Kansas (No. 5 Orig), 320 U.S. 383, 392 (1943)).

Clean Water Act of 1977 (as amended) The Clean Water Act is the principal law governing pollution control and water quality for navigable waterways of the United States. Section 402 of the act establishes a National Pollution Discharge Elimination System (NPDES) permitting program to regulate the point source discharge of pollutants into waters of the United States. Colorado administers state-level NPDES programs pursuant to authority delegated by the EPA.

Section 404, administered by the Corps with oversight from EPA, is another permitting program that regulates placing dredged or fill materials into waters of the United States. The Corps issues nationwide permits on a state, regional, or nationwide basis for similar activities that cause only minimal adverse environmental effects both individually and cumulatively. Individual permits may also be issued for specific activities on specific water bodies under Section 404. If the Corps decides that an individual Section 404 permit is required for the proposed actions, a Colorado State Water Quality Certification Permit (Section 401) would also be required.

Endangered Species Act The federal Endangered Species Act of 1973 (16 U.S. Code 1531–1544, 87 Statute 884, as amended) directs conservation of threatened and endangered fish, wildlife and plant ecosystems. The act includes the following:

- authorizes endangered species determination and listing
- prohibits unauthorized taking, possession, sale, and transport of endangered species
- provides authority to acquire land for conserving listed species
- authorizes establishment of cooperative agreements and grants-in-aid to states that establish and maintain endangered and threatened wildlife and plants programs
- authorizes the assessment of civil and criminal penalties for violating the act or regulations
- authorizes the payment of rewards to anyone furnishing information leading to arrest and conviction for any violation of the act

Section 7 of the Endangered Species Act requires federal agencies to prevent any action authorized, funded or carried out by the United States, such as the proposed actions, from jeopardizing the continued existence of listed species or modifying their critical habitat. Several amendments to the original act have been enacted, primarily to continue funding and clarify certain aspects of the act. More notably, the amendments allow recovery plans for listed species, and monitoring plans for species that have recovered and been delisted to be established. Threatened and endangered fish, wildlife and plant species were considered in the effects analysis of this EIS.

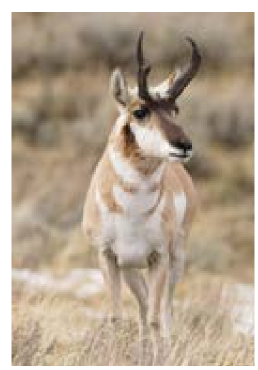

Photo 5–4. Wildlife impacts are addressed in the EIS

Farmland Protection Policy Act of 1995 The purpose of this act is to ensure that impacts on prime or unique farmlands are considered in federal projects. It requires federal agencies to consider alternative actions that could lessen impacts and to ensure that their actions are compatible with state, local government, and private programs to protect prime and unique farmland. The Natural Resources Conservation Service is responsible for administering this act. Farmlands were considered in the effects analysis using key indicators of changes in farm acreage and production. Prime and unique farmlands would be protected to the extent possible during implementation of the proposed actions consistent with the act.

Fish and Wildlife Coordination Act of 1958 (as amended) This act includes a procedural framework to consider in an orderly manner fish and wildlife conservation measures to be incorporated into federal projects and federally permitted or licensed water resource development projects. Agencies that construct, permit, or license projects impacting a water body must consult with U.S. Fish and Wildlife Service and the state agency having jurisdiction over fish and wildlife resources (Colorado Parks and Wildlife). Full consideration must be given to the recommendations made during this consultation process. Section 2 states that fish and wildlife conservation shall receive equal consideration with other project purposes and will be coordinated with other features of water resource development projects. Reclamation has complied with the act through consultation with U.S. Fish and Wildlife Service, providing opportunities for state wildlife agencies to comment and by developing environmental commitments for fish and wildlife. A Fish and Wildlife Coordination Act Report would be completed for proposed federal actions.

Migratory Bird Treaty Act and Executive Order 13186 (January 2001) Under the provisions of this act, it is unlawful "by any means or manner to pursue, hunt, take, capture [or] kill" any migratory birds except as permitted by regulations issued by U.S. Fish and Wildlife Service. U.S. Fish and Wildlife Service has defined "take" to mean "pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture or collect" any migratory bird or any part, nest, or egg of any migratory bird (50 CFR Section 10.12). Migratory bird species were considered in the effects analysis of this EIS. A Migratory Bird Management Plan would be included in the Fish and Wildlife Coordination Act Report.

Native American Graves Protection and Repatriation Act (Public Law 101-601) This act establishes federal policy with respect to Native American burials and graves located on federal or tribal lands. Federal agencies are required to consult with and obtain the concurrence of the appropriate tribes with respect to activities that may result in disturbing and/or removing burials and graves from federal lands or lands held in trust for a tribe. To comply with this act, Reclamation will consult with tribes if any human remains are found on federal land during cultural resource surveys or if human remains would be discovered during AVC construction.

National Historic Preservation Act of 1966 (as amended in 2006) This act establishes protection of historic properties as federal policy in cooperation with states, tribes, local governments, and the public. Historic properties are buildings, structures, sites, objects, and districts, or properties of traditional religious and cultural importance to Native Americans, determined to be eligible for inclusion on the National Register of Historic Places. Section 106 of the act requires federal agencies to consider the effects of proposed actions on historic properties and gives the Advisory Council on Historic Preservation an opportunity to comment. The lead federal agency is responsible for consulting with the SHPO and/or Tribal Historic Preservation Offices, tribes, applicants, interested parties, and local governments regarding federal undertakings. When previously unidentified cultural resources are encountered, the proposed actions include environmental commitments to comply with the act. Reclamation has entered into a programmatic agreement with the SHPO and other consulting parties to ensure that historic properties are taken into account in planning and implementing the proposed actions (see Appendix N.1).

Photo 5–5. Colorado Parks and Wildlife's inspection program at Pueblo Reservoir helps prevent the spread of aquatic nuisance species

National Invasive Species Act of 1996 The purpose of this act is fivefold: (1) to prevent unintentional introduction and dispersal of nonindigenous species into waters of the United States through ballast water management and other requirements, (2) to coordinate federally funded or authorized research, prevention control, information dissemination, and other activities regarding the zebra mussel and other aquatic nuisance species, (3) to develop and carry out environmentally sound control methods to prevent, monitor, and control unintentional introductions of nonindigenous species from pathways other than ballast water exchange, (4) to understand and minimize economic and ecological impacts of nonindigenous aquatic nuisance species that become established, including the zebra mussel, and (5) to create a program of research and technology development and assistance to states in managing and removing zebra mussels. To comply with the act, the proposed actions incorporate design features to minimize invasion of nonindigenous biota and monitor the distribution network for effective prevention of spread.

Rivers and Harbors Appropriation Act of 1899 Under Section 10 of the act, constructing any structure in or over any navigable water of the United States, excavating from or depositing material in such waters, or accomplishing any other work affecting the course, location, condition, or capacity of such waters is unlawful unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of the Army. The proposed actions would be implemented with design measures deemed compatible with the act. However, design features requiring recommendation and approval would be submitted to the Corps for permitting consideration in compliance with the act.

Safe Drinking Water Act of 1974 (as amended) This act gave EPA the authority to set standards for drinking water quality in water delivered by public water suppliers. Reclamation's *Regulatory Overview of the Safe Drinking Water Act* (Reclamation 2003) summarizes present and foreseeable future water quality requirements established by state and federal laws and regulations. It predicts the most likely future water quality standards that would be promulgated for public water systems by 2050. AVC would help participants meet drinking water standards established under this act.

Executive Order 13112 for Invasive Species In 1999, an executive order was issued to prevent the introduction of invasive species and to provide for their control. It directs federal agencies to identify applicable actions and to use programs and authorities to minimize economic, ecological, and human health impacts caused by invasive species. To meet the intent of this order, the EIS includes environmental commitments to prevent and control the spread of invasive species.

Other Executive Orders Executive Order 11988 (Floodplain Management) requires federal agencies to avoid development on floodplains whenever possible or to minimize potential harm to the floodplains. Executive Order 11990 (Protection of Wetlands) directs federal agencies to avoid destruction, loss, or degradation of wetlands. Executive Order 13007 (Indian Sacred Sites) orders federal agencies to accommodate Indian tribes' requirements for access to and ceremonial use of sacred sites on public lands and to avoid damaging the physical integrity of such sites. Executive Order 12898 (Environmental Justice) directs federal agencies to identify and address disproportionately high and adverse human health or environmental effects on minority populations and low income populations. These orders were applied in development of this EIS.

State Laws, Regulations, and Policies

The following state laws, regulations, and policies have known application to the proposed actions. AVC, Interconnect, and Master Contract participants would need to comply with any other applicable state regulatory requirements.

Colorado Water Law and Water Rights The Colorado Constitution mandates the use of the prior appropriation system for regulating surface water and tributary ground water in the state. The system lays out an orderly procedure for securing and administering water rights, and includes the following main components:

1. Water users with earlier water rights (or senior water rights) have priority of use during short supply over those with later water rights (or junior water rights). This is often referred to as "first in time, first in right."
2. Water users appropriate (or take for use) water when it is put to a beneficial use. The water users must have a plan to divert, store, or otherwise capture, possess, and control the water for beneficial use. Beneficial use includes, but is not limited to, irrigation, stock watering, domestic, municipal, industrial, and commercial, power generation, instream flows, and recreation.
3. Water rights are adjudicated (or made legal) in the water court system, giving the water user a legal basis for administrating the appropriated water. Adjudication sets the priority date, amount, point of diversion, type, and place of use for the water right. It also confirms that the water right will not injure existing water right holders. The water court issues a water right "decree" for each adjudicated water right that explains the terms of the adjudication.

Photo 5–6. The Colorado Constitution mandates the *prior appropriation* system for determining water rights in the state

4. Water rights are administered according to the terms and priority date in their decree by the Division Engineer. Division Engineers are assigned to the seven water divisions in Colorado (generally divided by river basins) and report directly to the State Engineer, who serves in the Division of Water Resources, Department of Natural Resources.

The surface water hydrology effects analysis in this EIS included water rights procedures and administration.

List of Preparers

The following individuals (Table 5–4) were directly responsible for preparing this EIS.

Table 5–4. List of Preparers

Name	Responsibilities	Education	Experience
U.S. Department of the Interior, Bureau of Reclamation			
Chuck Borda (retired)	Socioeconomics and environmental justice	B. A. History/Economics M.A. Economics	31 years
Gary Davis	Biological assessment and draft U.S. Fish and Wildlife Coordination Act Report	B.A. Environmental Conservation	28 years
Elizabeth McPhillips	Federally listed species	M.S. Fish and Wildlife Management B.S. Fish and Wildlife Science	32 years
Belinda Mollard	Historic properties	M.A. Anthropology B.A. Anthropology	13 years
Steve Piper	Socioeconomics	B.A. Resource Economics M.A. Resource Economics Ph.D. Resource Economics	21 years
Signe Snortland	Project manager	M.A. Anthropology B.A. Anthropology	41 years
MWH Americas, Inc.			
David Conner	Purpose and need, water quality	B.S. Civil Engineering M.B.A. Governance, Marketing, International Business, Entrepreneurship M.S. Civil and Environmental Engineering	14 years
Joshua Cowden	Project Manager for Final EIS, surface water hydrology, groundwater hydrology, water quality, Draft and Final EIS	B.S. Zoology/Environmental Studies M.S. Environmental Engineering Ph.D. Environmental Engineering	12 years
Lisa Fardal	Surface water hydrology	B.A. Environmental Studies B.A. Biology M.S. Civil Engineering	11 years
Jennifer Gelmini	Water quality	B.S. Civil/Environmental Engineering M.S. Civil/Environmental Engineering	10 years
Gerald Gibbens	Project manager for Draft EIS	B.S. Civil Engineering M.S. Civil Engineering	20 years
William Landin	Engineering coordinator	B.S. Civil Engineering	29 years
Emily McAlister	Draft EIS QA/QC	B.A. Liberal Studies	15 years
Christopher Michalos	Geomorphology, groundwater hydrology.	B.S. Civil Engineering M.S. Civil Engineering	18 years
Edwin Paulson, Jr.	Draft and Final EIS QA/QC	B.A. Applied Mechanics and Engineering Science M.S. Water Resources Engineering	34 years
Jerry Peña, Jr.	Executive project oversight, Draft EIS QA/QC,	B.S. Civil Engineering	26 years
Mark Scott	Alternatives analyses, engineering coordinator	B.S. Civil Engineering M.S. Management Information Systems	30 years
Lesley Siroky	Resource planning, public involvement, purpose and need, alternatives analyses, water quality	B.S. Environmental Engineering	12 years
Enrique Triana	Water quality	B.S. Civil Engineering M.S. Civil Engineering Ph.D. Civil and Environmental Engineering	18 years

Table 5–4. List of Preparers (continued)

Name	Responsibilities	Education	Experience
ERO Resources Corporation			
Nicole Bauman	Human environment	B.A. Communication M.S. Environmental Policy	14 years
Ron Beane	Wildlife	B.S. Wildlife Biology M.A. Biology	30 years
Kathy Croll	Cultural resources	B.A. Anthropology M.A. Anthropology Ph.D. Anthropology	18 years
Mark DeHaven	Project manager	B.A. Business M.S. Natural Resources	34 years
Kevin Gilmore	Cultural resources	B.A. Anthropology M.A. Anthropology Ph.D. Geography	31 years
Clint Henke	Wildlife	B.S. Biology M.S. Environmental Science	16 years
Sean Larmore	Cultural resources	B.A. Anthropology M.A. Anthropology	14 years
Denise Larson	Vegetation and wetlands	B.A. Biology M.A. Plant Ecology	18 years
Bill Mangle	Recreation land use	B.A. History/Political Science M.S. Natural Resource Policy and Planning	11 years
Leigh Rouse	Vegetation and wetlands	B.S. Biology M.S. Botany	23 years
Craig Sovka	Geology	B.S. Geology	18 years
Black and Veatch			
Dan Kugler	No Action Alternative Planning	B.S. Civil Engineering	15 years
Kevin Meador	Water Treatment Facility Planning	B.S. Civil Engineering	33 years
Chris Tadanier	Water Treatment Facility Planning	B.S. Mechanical Engineering M.S. Mechanical Engineering Ph.D. Civil and Environmental Engineering	27 years
GEI Consultants			
Don Conklin	Project manager and technical leader, aquatic resources	B.S. Biology M.S. Water Resources Management/Aquatic Biology	31 years
Jason Mullen	Aquatic resources	B.S. Biology M.S. Fish and Wildlife Management	8 years
Susan Watkins Communications			
Chris Lieber	Public involvement	B.A. Landscape Architecture	3 years
Susan Watkins	Public involvement	B.S. Journalism	39 years
Colorado State University			
Timothy Gates	Water quality	B.S. Agricultural Engineering M.S. Agricultural Engineering Ph.D. Civil Engineering	23 years

Final EIS Distribution

Approximately 500 persons were mailed the Final EIS, or were notified via mail or e-mail regarding the availability of the Final EIS. A full list of persons notified is contained in Appendix M.1.

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